7.0 Potential Environmental Effects

Section Summary: This section addresses potential environmental impacts resulting from construction and development at SUA-1548 license areas. Many of the potential environmental effects, or impacts, have been previously reviewed and approved for the Smith Ranch-Highland license area, but are considered here in relation to the remote satellite areas. Section 7.1 deals specifically with environmental impacts associated with construction activities at the project sites (air, noise, land use, surface water, etc.), while Section 7.2 focuses on environmental effects associated with operations (fugitive dust, wildlife, visual impacts etc.). Radiological effects **for licensed areas** are presented in Section 7.3. Section 7.4 describes non-radiological effects, which have been reviewed in prior license renewals. Section 7.5 presents potential accidents resulting from operations, which have been previously reviewed and approved; however, two new aspects--range fires and associated risks of CBM operations--have been included in Sections 7.5.4 and 7.5.6, respectively.

7.1 Site Preparation and Construction Activities

The major site preparation and construction activities associated with the Smith Ranch SUA-1548 license areas will include the following:

- Construction of new satellite IX plants, offices and maintenance facilities at Reynolds Ranch, North Butte, and Gas Hills;
- Construction of surge ponds and deep disposal wells at the North Butte Remote Satellite;
- Construction of evaporation ponds and disposal wells at the Gas Hills Remote Satellite;
- Construction of new deep disposal wells at Reynolds Ranch;
- Construction of new mine unit wellfields at all facilities;
- Construction of power lines and pipelines to service the Reynolds Ranch Satellite, North Butte Remote Satellite and Gas Hills Remote Satellite;
- Design and development of the Ruth Remote Satellite; and
- Grading and construction of access roads, as required.

The site preparation and construction activities for the Ruth Remote Satellite will include many of the above referenced tasks, but the specific details for the development of Ruth have not been finalized. Details regarding disturbance areas and other impacts for the Ruth Remote Satellite are not provided in this LRA.

Site preparation and construction activities will include topsoil salvaging, site clearing and leveling, building erection, and access road construction. The impacts from wellfield construction activities, including the construction of injection, production, and monitor wells are discussed in Section 7.2 below because these are ongoing activities at the Smith Ranch-Highland license area. This section discusses the short term impacts of initial site preparation and satellite IX plant construction where they differ from the operational impacts.

Environmental impacts of construction of the satellite facilities are estimated based on studies conducted by Cameco. The impacts are also projected based on experience with the current operation and historical construction activities at the Smith Ranch-Highland facilities since 1987.

The area contained within the Smith Ranch contiguous license area, including the Reynolds Ranch satellite, totals approximately 16,200 hectares (40,000 acres). Based on recent calculations of actual and

potential disturbed areas for the rest of the Project life (BLM, 2011), construction and operation activities associated with the development of mine unit wellfields and additional satellite facilities will disturb a total of approximately 760 hectares (1,880 acres), or less than 5% of the total area. Cameco estimates that more than 87% of the total disturbed mine unit wellfield acreage (approximately 660 hectares [1,630 acres]) will be short-term disturbance (one year or less). Final reclamation of areas disturbed will occur during final decommissioning activities for each mine unit.

It is anticipated that a total of approximately 160 hectares (400 acres) used for wellfields, buildings, pads and roads will be disturbed during the operational life of the North Butte Remote Satellite. As restoration, final reclamation and interim surface stabilization occur contemporaneously with development and production, it is expected that no more than approximately 69 hectares (170 acres) will be disturbed at one time. Surface disturbances will include construction of access roads, wellfields, underground pipelines and utilities, facility site grading, construction of surge ponds, and contouring for control of surface runoff. Areas disturbed will be reclaimed during final decommissioning activities.

From the 1950s to the early 1980s, much of the surface area within and adjacent to the Gas Hills Remote Satellite license area was extensively mined for uranium employing conventional underground and surface mining methods. Of the approximately 3,455 hectares (8,538 acres) within the Gas Hills license boundary, approximately 15%, or 518 hectares (1,281 acres), have been previously disturbed by underground and/or surface mining activities. Approximately half of the land surface within proposed Mine Unit 5 and portions of proposed Mine Units 2, 3 and 4 have been disturbed by previous conventional mining and subsequent reclamation. Exploration drilling and associated access road construction completed since the 1950s has disturbed much of the remaining surface within the proposed mine units. Many of the historical drilling access roads still exist.

At least 14,000 exploration boreholes have been drilled within the Gas Hills Remote Satellite license area since the 1950s. It is estimated that this previous drilling disturbed approximately 105 hectares (260 acres), or 27% of the area contained within the five proposed ISR mine units (approximately 393 hectares [972 acres]). Between 1996 and 2011, Cameco drilled 897 boreholes and 20 wells at the Gas Hills Remote Satellite using existing roads to reach the drilling sites.

At least 14 historical open-pit or underground mining operations were located within and adjacent to the Gas Hill Remote Satellite license area. Detailed information on historic disturbances and reclamation activity is illustrated in the WDEQ Permit Appendix D1-Land Use, Plates D1-E and D1-W. Known areas of underground workings include the Thunderbird Shaft west of Mine Unit 5 between Mine Units 3 and 5 (Plate D1-E) and the Atlas Mine Workings west of Mine Unit 3 (Plate D1-W). Areas previously disturbed by mining are summarized in WDEQ Permit Appendix D6-Hydrology, Table D6-1-1, and Plate D6-1.

Modern open-pit and limited underground mining has been conducted in the West Gas Hills area (by Pathfinder and Umetco), the Central Gas Hills area (by Pathfinder), and the East Gas Hills area (by FAP and Umetco). The Veca, A-8, PC, B2/B3, Atlas/Peach, Thunderbird, Rox, and Tee Pit areas were reclaimed between 1989 and 1992 under WDEQ's AML program. Reclamation is ongoing at Umetco's East Gas Hills Mine (WDEQ Permit No. 349C) and Pathfinder's Central Lucky Mc Mine (WDEQ Permit No. 356C). The Two States, Area 9, and Blackstone Slot were reclaimed by AML between 1992 and 1998. PRI completed reclamation activities at the Buss Pit (WDEQ Permit No. 438in 1995).

Cameco estimates that 70% of the total disturbed area (approximately 371 hectares [916 acres]) at the Gas Hills Remote Satellite will be short-term disturbance (one year or less) associated with mine unit construction. The remaining 30% of disturbed acreage (approximately 159 hectares [393 acres]) will be

long-term disturbance associated with proposed evaporation ponds, wastewater deep disposal injection wells, mineral processing and water treatment facilities, mine unit header houses, pump stations and access roads. These disturbances will remain for the life of the Gas Hills Remote Satellite. For the projected 25-year operational life of the Gas Hills Remote Satellite, it is estimated that approximately 159 hectares (393 acres) of the approximately 3,455 hectares (8,538 acres), or 5%, will not be available for wildlife habitat use until final reclamation. At the end of the Gas Hills Remote Satellite operations, the entire 3,455 hectares (8,538 acres) will be returned to the pre-ISR mining use of wildlife habitat and livestock grazing.

Due to the relatively minor nature of disturbances created by ISR, there are only a few areas disturbed to the extent to which subsoil and geologic materials are removed, causing significant topographic changes that need backfilling and recontouring. Generally, surge/evaporation pond construction results in redistribution of subsurface materials, which require replacement and contour blending during reclamation. The existing contours will only be interrupted locally. Changes in the surface configuration caused by construction and installation of operating facilities and access roads will be caused by topsoil removal and storage along with the relocation of subsoil materials used for construction purposes. These surface effects are unavoidable and will last for the duration of the operation, until final decommissioning. Mitigation measures for land surface effects are discussed in Section 5.0 of the ER.

7.1.1 Potential Air Quality Effects of Construction

Construction activities at the SUA-1548 facilities including Smith Ranch and the North Butte, Gas Hills, and Ruth Remote Satellites will cause minimal effects on local air quality. Effects to air quality include increased suspended particulates from vehicular traffic on unpaved roads, and diesel emissions from construction equipment and drill rigs. The application of water to unpaved roads reduces the amount of fugitive dust to levels equal to or less than the existing condition. Diesel emissions from construction equipment are expected to be minimal but long term, as maintenance, employee, delivery and drilling vehicles will be present at the sites for the life of the project. Estimated fugitive dust emissions during construction of ISR facilities are less than 2% of the National Ambient Air Quality Standards for $PM_{2.5}$ and less than 1% 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 new satellite facilities. This increase in TSP will be greatest during the site preparation phase of each satellite facility. Areas disturbed during construction are revegetated with the exception of facility pad areas, roads, and areas covered by the pond liners. Of these, the only significant source of TSP is dust emissions from unpaved roads. Section 7.2.1 (below) discusses specific regulatory issues associated with air quality effects of the operation. As discussed in Section 3.6.6 of the ER, the current and proposed road upgrades at the North Butte and Gas Hills (AML and Dry Creek Roads) should reduce the fugitive dust emissions.

7.1.2 Potential Land Use Impacts of Construction

As discussed in Sections 2.2.2, 2.4.2, and 2.5.2, rangeland, pasture and wildlife habitat are the primary land uses within the SUA-1548 license areas and the surrounding 3.2-kilometer (2-mile) review area. CBM wells and infrastructure are also located on rangeland throughout the North Butte and Ruth license areas. Surface disturbance within a mine unit does not occur at once but is sequenced over several years, depending on the uranium production rate and the availability of mine unit development and construction equipment and personnel. Long-term fencing will be constructed around the mine unit production facilities and processing satellites primarily to prevent sheep and cattle from interrupting production activities and damaging surface installations (production and injection wellheads) while still allowing wildlife forage.

The total land disturbance for the Reynolds Ranch Satellite, including wellfields, facilities and roads, will be approximately 158 hectares (390 acres), with approximately 46 hectares (114 acres) removed from wildlife habitat use until final reclamation. Approximately 5 hectares (12 acres) of BLM-administered surface would be removed from wildlife habitat use until final reclamation. The Reynolds Ranch Satellite license area encompasses approximately 3,351 hectares (8,280 acres), of which approximately 1,748 hectares (4,320 acres) are split estate, (i.e., private surface overlying federal minerals); 294 hectares (726 acres) are BLM surface and minerals; 1,052 hectares (2,600 acres) are fee lands and minerals; and 259 hectares (640 acres) are state lands. Approximately 9% of the surface estate in the project area is managed by the BLM, 83% privately owned, and 8% state, while the mineral estate is 61% federal, 31% private, and 8% state.

The North Butte Remote Satellite license area contains approximately 409 hectares (1,010 acres). The proposed mining units will occupy approximately 154 hectares (380 acres) of which approximately 75 hectares (185 acres), or 60%, will be directly disturbed by ISR related activities during the approximate 15-20 year life of the operation. Construction of the satellite building and associated structures, including roads, at the North Butte Remote Satellite will encompass approximately 6 hectares (15 acres). As a result of site preparation and construction, rangeland and pasture use will be excluded from the area that is under development. CBM facilities within and adjacent to the North Butte Remote Satellite license area will not be affected. Considering the relatively small size of the areas affected by satellite and mine unit wellfield construction activities, the exclusion of grazing from the satellite and mine unit areas over the course of the development and operation of the facility will have minimal impacts on local livestock production.

The Gas Hills Remote Satellite license area contains approximately 3,440 hectares (8,500 acres), which is primarily BLM administered surface. Based on the current production plan, a total of approximately 607 hectares (1,500 acres), or less than 20% of the total area within the license boundary, will be disturbed in phases over the approximate 25-year life of the operation. Because wellfields are reclaimed and vegetated after installation, these areas will be available for wildlife forage throughout the life of the operation. Wellfield areas will be fenced to keep out livestock that could damage wellheads or other wellfield equipment. Acreages that will be excluded from wildlife forage and cattle grazing for the life of the operation include the existing Carol Shop, which will be refurbished for the ISR process and groundwater restoration equipment. The Alternative Satellite building and associated structures will encompass approximately 4.1 hectares (10 acres). The evaporation ponds will exclude approximately 2 hectares (5 to 6 acres).

The Ruth Remote Satellite license area contains approximately 572 hectares (1,414 acres). Currently, two buildings and two lined evaporation ponds from the 1981 R&D operation remain on-site. Topsoil has been stockpiled adjacent to the building disturbance area and the evaporation ponds. A Plan of Operations has not yet been developed for Ruth, so the estimated total land disturbance area from future ISR operations is not known at this time. Cameco will be developing design and operational plans for this satellite operation during the next renewal period and will provide them to NRC upon completion.

7.1.3 Potential Surface Water Impacts of Construction

When storm water drains off a construction site, it can carry sediment and other materials that can potentially impact lakes, streams and wetlands. The EPA estimates that 18 to 135 metric tons (20 to 150 tons) of soil/acre are lost every year to storm water runoff from construction sites. For this reason, storm water runoff is regulated by the WDEQ NPDES (WYPDES). Construction projects exceeding 2 hectares (5 acres) are required to have a large construction storm water permit. Construction projects ranging from 0.4 to 2 hectares (1 to 5 acres) are required to have a small construction storm water permit**.** Currently

(**2011**), North Butte *(WYR104286)* and Smith Ranch *(WYR104157)* have authorization under large construction (North Butte) and large industrial (Smith Ranch) general WYPDES permits. If required, Cameco will seek a modification of the Smith Ranch permit to include the additional Reynolds Ranch satellite license area.

A large construction permit (WY103870) for the Gas Hills Remote Satellite was issued to Cameco on August 24, 2008, but the permit expired in March 2011. Cameco renewed this Gas Hills permit effective December 9, 2011, which again expires March 2016. Prior to construction activities, Cameco will obtain a WYPDES permit for the Ruth Remote Satellite.

Construction activities at SUA-1548 facilities to date have had a minimal effect on the local hydrological system. Construction activities are conducted for control of construction storm water discharges under LQD and WQD regulations contained in Chapter 2, WDEQ, WQD Rules and Regulations. WDEQ requires implementation of procedures that control runoff and the transport of sediment to nearby surface water features during construction activities.

7.1.4 Potential Population, Social and Economic Impacts of Construction

The potential population, social and economic impacts of construction are discussed in ER Sections 3.10 and 7.3. Overall, the Smith Ranch SUA-1548 license area has and will continue to provide positive benefits to the local communities and the State of Wyoming.

7.1.5 Potential Noise Impacts of Construction

Sections 3.7 and 4.7 of the ER provide a summary of the potential noise impacts at the Smith Ranch (SUA-1548) license areas. A noise study conducted at the Smith Ranch-Highland license area evaluated the noise levels from the various equipment common to ISR operation and discussed the nearest receptors and potential effects at each facility.

Increased vehicle travel and the operation of construction equipment at the Reynolds Ranch Satellite and at the North Butte, Gas Hills and Ruth Remote Satellite facilities during the construction phase of the project could result in a slight increase in noise. Noise from construction would not be generated during nighttime hours. Construction activities typically occur over an 8- to 12-hour work day, 5 days/week. Increased noise levels would be intermittent and temporary. The resulting increase in vehicle noise from construction and construction traffic would be barely perceptible over the existing ambient noise.

The EPA has compiled data regarding the noise generating characteristics of typical construction activities, both with and without the use of equipment mufflers. These data, which represent composite construction noise, are presented in **Table 7-1, Noise Range Levels of Typical Construction Equipment**. These noise levels would diminish rapidly with distance from the construction site at a rate of approximately 6 dBA[1] per doubling of distance. For example, a noise level of 84 dBA measured at 15 meters (50 feet) from the noise source to the receptor would reduce to 78 dBA at 31 meters (100 feet) from the source to the receptor, and reduce by another 6 dBA to 72 dBA at 61 meters (200 feet) from the source to the receptor (EPA, 1971). According to the tests conducted by Cameco and assuming a worst-case noise source (PVC chipper), the calculated noise level at a location 3 kilometers (2 miles) from the noise source would be 77 dBA.

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1 The decibel A filter is widely used. dB(A) roughly corresponds to the inverse of 40 dB (at 1 kHz) equal-loudness curve for the human ear. Using the dBA-filter, the sound level meter is less sensitive to very high and very low frequencies. Measurements made with this scale are expressed as dB(A).

Construction of the new satellites and mine units at Smith Ranch and the North Butte, Gas Hills and Ruth Remote Satellite license areas will require the equipment listed in Table 7-1 with the exception of a pile driver. Drilling rigs will also be used during the construction phase of the project.

Layne Christensen Company conducted an in-house occupational health noise analysis for a TH-75E drill rig, which is similar to that which would be used at the Smith Ranch SUA-1548 license areas. Manufactured by Ingersoll Rand, the TH-75E, is a top head drive, reverse circulation, air rotary drilling rig that uses an 8-cylinder, 600-HP deck mounted Cummins KTA-19C engine capable of drilling over 762 meters (2,500 feet) into the earth. The TH-75E is typically used with an Ingersoll Rand 1,000/350 screw-type air compressor. Sound levels (85 to 90 dBA) recorded next to the drilling rig were reported to be above the OSHA/Mine Safety and Health Administration action levels.

7.2 Potential Effects of Operations

7.2.1 Potential Air Quality Impacts of Operations

Past and current uranium extraction operations at Smith Ranch-Highland have resulted in minimal air quality emissions. This will likely be true of operations at the Reynolds Ranch Satellite and the North Butte, Gas Hills and Ruth Remote Satellites. Because the uranium extraction process is performed indoors, and interior modifications are made to existing buildings, air impacts from construction are considered to be minimal and or temporary. Installation of mine unit wellfields is an on-going part of the operation and has been considered in the fugitive dust calculations for operational conditions.

Air pollutants such as nitrogen oxide (NOx) will be emitted from drilling equipment and other vehicles. The NRC completed an air quality study for the Environmental Impact Statement for the Nichols Ranch, WY ISR Project to estimate NOx emissions (NRC, 2011; NUREG 1910 Supplement). The NRC calculated drilling rig emissions for the proposed Nichols Ranch ISR Project wellfield development activities at 8.0×10^{-3} metric tons (8.8×10^{-3} tons) of NOx per well, which was several orders of magnitude less than the NOx emissions from wells drilled for oil and gas exploration and production.

Historically, emissions from ISR operations are significantly lower than conventional mining and milling operations. The primary source of emissions from ISR facilities like the Smith Ranch SUA-1548 license areas will be fugitive dust from vehicular traffic on unpaved access roads and in the wellfield areas and minor emissions from the processing plant and associated equipment. It has been estimated that a total of approximately 344 metric tons/year (368 tons/year) of air particulates are emitted from the operations activities at the Smith Ranch license areas at full-scale production (excluding the Ruth Remote Satellite). More than 99% of this total is from estimated fugitive dust emissions, calculated as worst case without dust control measures applied. The emissions from the Reynolds Ranch Remote Satellite are estimated to be approximately 36 metric tons/year (40 tons/year). The fugitive dust emissions directly correlate with the license area size; that is, the fugitive dust emissions are higher for the Gas Hills Remote Satellite compared to the North Butte Remote Satellite. Fugitive dust emissions from the remote satellites are estimated to range from 100 to 130 metric tons (110 to 140 tons)/year. The proposed road upgrades at North Butte and Gas Hills (AML and Dry Creek Roads) should reduce the fugitive dust emissions. Section 3.6.6 of the ER also discusses fugitive dust emissions.

A breakdown of the emissions from Smith Ranch is as follows.

Process Facility

Actual air emissions from the CPP are very minimal as the processes are aqueous in nature. There will be minor emissions from hot water heaters used in the precipitation circuit, and the two hot oil heaters associated with each vacuum dryer unit. Emissions from the outside hydrochloric and/or sulfuric acid tanks were estimated for this application and found to be negligible. There are no non-radioactive process air emissions from the satellite facilities, as only the IX process takes place at these locations. In summary, the air emissions from the CPP are:

1. Dryer hot oil heaters: 0.065 metric tons/year (0.072 ton/year) $S0_2$
2. Hot water boiler:-0.155 metric tons/year (0.171 ton/year) $S0_2$
3. Acid tanks (HCI and H_20_2): negligible

The EPA considers sulfur dioxide to be a major air pollutant that can have significant effects upon human health. The concentration of sulfur dioxide in the atmosphere can influence the habitat suitability for plant communities as well as animal life. However, the sulfur dioxide releases during the operation of the current Smith Ranch facilities have been negligible at 0.22 metric tons/year (0.24 tons/year). Listed Hazardous Air Pollutants are not released to the atmosphere during operations.

Fugitive Dust

Fugitive dust from vehicular traffic on unpaved roads is the primary emission associated with the Smith Ranch SUA-1548 operations. Fugitive dust is created by traffic on the main access roads, the secondary access roads to the satellites, and traffic within the mine unit areas. Fugitive dust is also generated from trucks delivering supplies and transporting IX resin, yellowcake slurry, chemicals, etc. to process facilities. Employee travel on unpaved roads to the various operating units is also a significant component of the total fugitive dust emissions. Wellfield traffic, including drilling rigs, water trucks, pipe trucks and geophysical logging trucks provides the largest contribution to fugitive dust emissions.

The fugitive dust (PM_{10}) estimates were calculated using the methodology provided in EPA's AP-42 publication (EPA, 1995). The non-SI (**non-**metric) units in the following equations were maintained for consistency with the publication. For reference, the metric conversion from lb/vmt (pounds per vehicle mile travelled) to grams (g) per vehicle kilometer travelled (vkt) is:

1lb/vmt = 281.9 g/vkt

Two equations are provided in EPA Publication AP-42, *Section 13.2.2 Unpaved Roads* as follows:

$$E = k \times \left(\frac{s}{12}\right)^a \left(\frac{W}{3}\right)^b \times \left(\frac{365-p}{365}\right) \qquad (1)$$

$$E = \left[\frac{k\left(\frac{s}{12}\right)^a \times \left(\frac{S}{30}\right)^d}{\left(\frac{M}{0.5}\right)^c} - C\right] \times \left[\frac{365-p}{365}\right] \qquad (2)$$

Where:

E= emission factor (lb/vmt)
C = emissions factor for 1980s fleet exhaust, brake wear and tire wear

a = 0.9 (Industrial Roads, 1.0 Public Roads)
b = 0.45 (Industrial Roads)
c = 0.2 (Public Roads)
d = 0.5 (Public Roads)
k = particle size multiplier –assumed 0.36 (particle ≤10% µm)
s = silt content of road surface material (%) – assume 10%
S = mean vehicle speed (mph)
W= mean vehicle weight (tons)
p = number of days with at least 0.01 inches of precipitation per year – assume 100 days.

Equation 1 is used to estimate emissions from vehicles travelling on unpaved surfaces at industrial sites such as secondary access roads, wellfield roads and other minor roads. Equation 2 provides an estimate of emissions from publicly traveled roads, which include unpaved roads to the license area and the main access road at the ISR facility. Weights were assumed for the various vehicles, and to be conservative, the vehicles were assumed to be fully loaded the entire trip. Again, the most significant emissions source was wellfield traffic followed by employees commuting to the ISR facilities. A summary of the estimated annual fugitive dust emissions (PM_{10}) in metric tons is provided below.

Facility	Employee Travel	Drilling Support	Construction	Operational Support	Operational Supply Support Deliveries	Transport of Resin/Yellowcake Slurry	Total Emissions (metric tons)
Smith Ranch	0	102.7	8.0	30.1	0	0.4	141.2
North Butte	34.5	42.1	5.8	12.5	0.5	1.4	96.9
Gas Hills	54.0	41.4	8.5	12.5	1.5	12.2	129.8

The fugitive dust emission estimates are well below the allowable limits of the State of Wyoming. Actual fugitive dust releases during operations are reduced by use of water spray bars on drilling rig water service vehicles.

7.2.2 Potential Noise Impacts of Operations

Noise-generating activities in the CPP, CPF, Smith Ranch satellites and the North Butte and Gas Hills Remote Satellite facilities are or will be primarily indoors, thus minimizing off-site sound levels. Wellfield equipment (e.g., pumps, compressors) would also be expected to be contained within structures (e.g., satellite facilities), minimizing sound levels to off-site receptors. Administrative and engineering controls are used to maintain noise levels in work areas below OSHA standards and are mitigated by use of personal hearing protection. Traffic noise from commuting workers, truck shipments to and from the facility, and facility equipment is localized, limited to roads and highways in the vicinity of Smith Ranch SUA-1548 facilities, access roads within the sites, and access roads in the wellfields.

Noise levels from a particular source decline as distance to the receptor increases. Other factors, such as the weather and reflecting or shielding, also help intensify or reduce the noise level at a given location. A commonly used rule of thumb for roadway noise is that for every doubling of distance from the source, the noise level is reduced by about 3 dBA at acoustically “hard” locations (i.e., the area between the noise source and the receptor is nearly complete asphalt, concrete, hard-packed soil, or other solid materials) and 4.5 dBA at acoustically “soft” locations (i.e., the area between the source and receptor is earth or has vegetation, including grass) (EPA, 1974). Noise from stationary or point sources is reduced by about 6 to 7.5 dBA for every doubling of distance at acoustically hard and soft locations, respectively. Noise levels may also be reduced by intervening structures; generally, a single row of buildings between the receptor and the noise source reduces the noise level by about 5 dBA, while a solid wall or berm reduces noise levels by 5 to 10 dBA. The topography of the area will also serve to reduce the noise levels.

Mine unit delineation drilling and well installation are the primary sources of noise during ISR operations. The anticipated noise levels for a drilling rig are provided in Section 7.1.5 above.

7.2.3 Potential Land Use Impacts of Operations

As discussed in Sections 2.2.2, 2.4.2, and 2.5.2, rangeland/pasture and wildlife habitat are the primary land uses within the SUA-1548 license areas and within the surrounding 3-kilometer (2-mile) buffer area. CBM facilities and infrastructure are also located on rangeland throughout the North Butte and Ruth Remote Satellite license areas. As with site preparation and construction, rangeland use of some of the land surface will be excluded during the life of the project. Existing and potential CBM facilities will not be affected. Considering the relatively small size of the area affected by operations, the exclusion of grazing from these areas over the life of the Smith Ranch SUA-1548 license will have a minimal impact on local livestock production.

Areas near the Smith Ranch license area are leased for exploration oil and gas drilling into the Niobrara Shale. However, with directional drilling capabilities, multiple oil and gas wells can be drilled from one drill pad, thereby minimizing surface disturbance and interference with ISR operations. It is not anticipated that the ISR activities at Smith Ranch will affect potential oil and gas drilling and/or exploration activities. The target formation (Niobrara) for oil and gas production is considerably deeper (approximately 3,048 to 3,658 meters [10,000 to 12,000 feet] in depth) than the uranium-bearing zone where the ISR operations are focused (approximately 60 to 365 meters [200 to 1,200 feet] in depth). The uranium-bearing zone and Niobrara Formation are separated by the thick, marine Pierre Shale. Although oil and gas production from the Niobrara has been economically successful in the Colorado Denver-Julesburg Basin, oil and gas production potential from the Niobrara in the Powder River Basin is still in early development stages.

Various locations near Smith Ranch are leased for exploration of oil and gas drilling into the Niobrara Shale. Several oil and gas companies have begun enhanced oil recovery (EOR) programs at existing oil fields within Converse County. For example, following environmental approval in 2011, Australia-based Linc Energy planned to start EOR at its Wyoming oilfields by injecting CO_2 into the South Glenrock B Unit 34 in the Powder River Basin. Required CO_2 supplies will initially be delivered to the field operations by trucks until a pipeline system can be built to provide this commodity. Furthermore, new directional drilling capabilities provide a means of developing multiple wells from one drill pad location. Cameco's Smith Ranch operations will not affect existing oil and gas activities, based on current oil company development plans**.**

7.2.4 Potential Geology and Soil Impacts of Operations

7.2.4.1 Geology Impacts of Operations

Geological impacts from ISR operations at SUA-1548 operations have been and are expected to remain minimal. No significant matrix compression or ground subsidence is expected, as the net withdrawal of fluid from the target sandstone is approximately 1%. Also, ISR does not remove any of the formation material from the aquifer thereby negating potential for subsidence. Finally, once production and restoration operations are completed, groundwater levels will return to near original conditions under a natural gradient.

7.2.4.2 Potential Soil Impacts of Operations

LQD regulations require that Cameco perform ISR activities in a manner that minimizes topsoil damage and controls the amount of sediment lost to wind and water erosion (LQD Rules and Regulations Chapter 11, Section 4(a)(iii), and Chapter 3, Section 2(c)(i) through (iii)). The operator must protect topsoil and subsoil from excessive compaction, degradation, and wind and water erosion where stockpiling of topsoil and subsoil is necessary. Surface drainages must be diverted around the operation in an erosionally stable manner and meet certain minimum design standards.

Cameco salvages suitable topsoil from construction of access roads, wellfield staging areas, building sites (including satellite buildings and header houses), permanent storage areas, designed impoundment sites, chemical storage sites and other areas subjected to repetitive vehicular traffic. The topsoil is placed in long-term stockpiles.

Stockpiles, regardless of size, are provided with erosion and sediment control. Such controls may include toe ditches, wattles, etc. Large stockpiles may also be sprayed with a tackifier to inhibit soil erosion. Topsoil stockpiles are seeded using either hydroseeding or crimp mulching as soon as possible after construction with the approved permanent seed mix to minimize loss of erosion (see Section 6.2.4). To further minimize erosion, a fast growing cover crop may also be interseeded with the permanent seed mix on topsoil stockpiles. Interseeding is typically conducted using a broadcast method. In accordance with LQD Rules and Regulations Chapter 3, Section2(c)(i)(D), permanent topsoil stockpiles are identified with a highly visible sign with the designation "Topsoil" in letters at least 15.2 centimeters (6 inches) high.

7.2.5 Potential Cultural Resource Impacts of Operations

In accordance with NRC, WDEQ and SHPO requirements, cultural resource surveys have been conducted on lands comprising the SUA-1548 license areas (see Sections 2.2.4, 2.3.4, 2.4.4, and 2.5.4 of the ER). These surveys have been approved by the BLM, WDEQ LQD, NRC and SHPO. A discussion of the historic and cultural resource studies conducted at the SUA-1548 license areas is provided in Sections 3.8 and 4.8 of the ER. The studies are also provided in Appendix D-3 of the WDEQ permits for Smith Ranch, North Butte and Gas Hills. The studies for the Ruth Remote Satellite are provided in Section 7 (Appendix “D-3”, Archaeology) of the Supportive Information for WDEQ Permit to Mine Application, and in the U.S.N.R.C. Source Material License Application. Cameco’s primary mitigation procedure for cultural resources is avoidance of the identified features. To ensure that no unapproved disturbances of cultural resources occurs, License Condition 9.9 of SUA-1548 requires that work resulting in the discovery of previously unknown cultural artifacts shall cease. The artifacts will be inventoried and evaluated in accordance with 36 CFR Part 800, and no further disturbance of the area will occur until Cameco has received authorization from the NRC to proceed.

7.2.6 Potential Visual and Scenic Impacts of Operations

The Smith Ranch license area is located on private land, with the exception of small parcels of land within the license area which are public lands administered by either BLM or the State of Wyoming. The North Butte Remote Satellite license area is entirely on private land and is not managed by any public agency to protect scenic quality. The majority of the Gas Hills Remote Satellite license area is administered by the BLM; although several tracts of private land are within the license area. The Ruth Remote Satellite license area contains BLM and private lands. The BLM has inventoried visual resources of lands within the boundaries of their respective field offices, including private lands, with their Visual Resource Management (VRM) system. A discussion of the visual and scenic resources and potential impacts and mitigation efforts for the SUA-1548 license areas is provided in ER Sections 3.9 and 4.9, respectively. In

general, adverse effects will be mitigated through the use of non-contrasting building colors and a timely mine unit wellfield reclamation program.

7.2.7 Potential Groundwater Impacts of Operations

7.2.7.1 Groundwater Consumption

Cameco has conducted detailed groundwater **flow** modeling to assess potential cumulative impacts resulting from groundwater consumption associated with ISR activities at Smith Ranch and the North Butte and Gas Hills Remote Satellites. The results of the impacts analysis are presented in Section 4.4 of the ER.

The results of the groundwater modeling predict that the maximum drawdown in the affected aquifers in the vicinity of the Smith Ranch-Highland license area will be approximately 6 meters (22 feet) over the 33-year model period**.** For the entire Smith Ranch SUA-1548 project, the most significant groundwater impact will be the withdrawal and disposal (deep injection, land application and/or evaporation) of approximately 3,106 hectare-meters (25,180 acre-feet) of groundwater over the life of the operation. This volume represents approximately the same amount of water produced (dewatered) from the Kerr-McGee Bill Smith underground uranium mine (located within the Smith Ranch-Highland license area) between 1974 and 1982 and discharged to surface streams. In the case of Smith Ranch SUA-1548 operations, most of the water removed from the wellfield production zones is returned to the groundwater aquifer after treatment. The remaining water removed from the formation (approximately a 1% bleed) is disposed through deep well injection, land application or evaporation.

For the Smith Ranch license area, the consumptive use of groundwater for the remaining life of the operation is estimated to be approximately 2,050 hectare-meters (16,607 acre-feet). Of this amount, approximately 47 hectare-meters (383 acre-feet) are estimated to be from future processing of IX resin at the Highland CPF. The anticipated consumption at the Reynolds Ranch satellite is 105 hectare-meters (855 acre-feet). A portion of the 1% bleed stream may be used in various plant processes, such as eluant make-up, filter backwash, resin washes, plant wash down and other process purposes. The portion of the bleed stream used for these purposes will also be disposed of in the waste disposal system.

For the North Butte Remote Satellite, the greatest volume of water used will occur during the groundwater sweep phase of groundwater restoration at each mine unit. Based on the anticipated production rate and the waste minimization program at the facility, it is estimated that the maximum annual volume of treated groundwater requiring disposal will be approximately 276 million liters (73 million gallons), or 525 liters/minute (140 gallons per minute) average. The deep well injection volume for the life of the satellite operation is estimated to be 273 hectare-meters (2,213 acre-feet). The operational phase will result in a wellfield bleed stream of approximately 1% of the recovery flow, or about 95 to 227 liters/minute (25 to 60 gallons per minute) being removed from the groundwater system ("A", "B" and "C" sand members of the North Butte production sand). This approximate 1% bleed stream will ultimately be disposed of through deep well disposal.

The groundwater sweep phase of restoration uses the greatest volume of water from each mine unit wellfield. The estimated groundwater consumption at the Gas Hills Remote Satellite will be 39 hectare-meters per year (318 acre-feet/year). For a projected 20-year project life, approximately 785 hectare-meters (6,360 acre-feet) of groundwater will be consumed. This approximate 1% bleed stream will ultimately be disposed of via evaporation ponds and/or disposal wells. The results of the groundwater modeling at the Gas Hills Remote Satellite predict maximum drawdowns in the production aquifer of 3 meters (10 feet) at the permit boundary during years 8 and 9, corresponding with the period of maximum groundwater withdrawals.

The Ruth Remote Satellite will be operated similar to the North Butte and Gas Hills Remote Satellites. The groundwater consumptive use at Ruth will be determined once an operational plan, including a water balance, is developed for the remote satellite.

7.2.7.2 Impacts on Ore Zone Groundwater Quality

Before ISR activities are allowed, WDEQ and the EPA must classify and exempt the production zone aquifer from protection under the Safe Drinking Water Act. One of the criteria for exemption is that the water is not currently used as an USDW and will not be used as an USDW in the future. By restoring water quality of the exempted aquifer, Cameco ensures that adjacent, non-exempted aquifers will not be affected in the future.

During ISR operations, water quality affects are usually of greater concern than water consumption because water consumption during production is relatively small. The greatest potential impact to groundwater quality is primarily from the lixiviant, which includes (1) the addition of sodium bicarbonate, **CO_2** and oxygen to the groundwater, (2) the addition of chloride to the groundwater by IX recovery processes, and (3) the interaction of these chemicals with the mineral and chemical constituents of the production zone. The result is that during production, the concentration of most of the naturally occurring dissolved constituents will be appreciably higher than their concentrations in the native groundwater.

Groundwater withdrawal and reinjection will occur throughout the project life and is a critical component of the production and restoration operations. There will be short-term impacts to the quantity and quality of the groundwater within the production zone on a wellfield-by-wellfield basis. Over the long term, the groundwater concentration of some parameters within the production zone may vary slightly compared with initial conditions; however, changes are minimal and will not alter the potential use category of these waters as defined by the WDEQ. Even so, NRC and WDEQ regulations require that post-restoration groundwater quality meets the primary standard of baseline conditions. If baseline is not attainable, Cameco must apply to the NRC for alternate concentration limits, or, for the LQD, demonstrate that the water quality meets the pre-ISR use category.

7.2.7.3 Potential Groundwater Quality Impacts from Accidents

Lixiviant Excursions

Water quality impacts in adjacent aquifers from ISR activities are related to the identification, control, and cleanup of excursions. During production, injection of the lixiviant into the production zone aquifer results in a temporary degradation of water quality compared to pre-operational conditions. Movement of this water out of the production zone and to the monitor well ring is defined as an excursion. Excursions of production fluid 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 allowing movement of the lixiviant out of the ore zone, poor well integrity, or hydrofracturing of the ore zone or surrounding units. Past experience at the Smith Ranch-Highland license area has shown that proper wellfield monitoring and operation provide for timely discovery, control, and recovery of excursions, thereby minimizing groundwater effects**.**

Excursions of lixiviant at ISR facilities have the potential to impact adjacent aquifers with radioactive and trace elements that have been mobilized by the ISR process. The historical experience at Smith Ranch and other ISR uranium operations indicates that the selected excursion indicator parameters and UCL allow detection of horizontal excursions early enough that corrective action can be taken before water quality outside the exempted aquifer boundary is significantly degraded. As noted in NUREG/CR-6733 (NRC, 2001), significant risk from a horizontal or vertical excursion would occur only if it persisted undetected for a long period of time.

As previously stated, both LQD and NRC require restoration of affected groundwater in the production zone following production activities. NRC requires as the primary goal that Cameco return the groundwater in the production zone to baseline water quality conditions, with secondary standards presented in 10 CFR Part 40, Appendix A, Criterion 5B. Constituent concentrations higher than Criterion 5B will require an ACL application.

Successful groundwater restoration has been demonstrated using the methods discussed in Section 6.0 **of this TR**. Therefore, long-term effects on groundwater quality are expected to be minimal.

Surface and Subsurface Releases

The potential for impacts to groundwater and surface water at SUA-1548 license areas as a result of an uncontrolled release of process liquids from a header house, well or pipeline leak during operations is low because there is little surface water near these sites. The uppermost aquifer beneath these sites is greater than 30 meters (100 feet) below the surface. Should a release occur, the immediate effect would be to the surrounding soil. A shallow excursion may result from either a low-rate leak that remains undiscovered or a sudden catastrophic failure. The potential environmental impacts from spills and mitigative measures are discussed in further detail in Section 7.5 below.

Pond Leaks

Leaks from ponds and reservoirs have the potential to impact shallow groundwater aquifers. The Smith Ranch-Highland license area has several ponds, which include the east and west storage ponds at the CPP and the two purge storage reservoirs at Highland. Surge ponds will be constructed at the North Butte Remote Satellite, and evaporation ponds will be constructed at the Gas Hills Remote Satellite.

Section 3.10 of this TR provides a summary of storage pond leak events occurring at the Smith Ranch-Highland license area since the previous license submittal and subsequent design and/or operational changes made to reduce the leak potential. Liner leaks, or seepage in the case of PSR-2, are the primary causes of leakage of fluids into the unsaturated zone. Cameco will be installing deeper monitoring wells at PSR-2 to determine if the shallow aquifer underlying the PSR has been adversely affected. Lessons learned at Smith Ranch and Highland have been applied to the pond designs for the North Butte and Gas Hills Remote Satellites.

7.2.8 Potential Surface Water Impacts of Operations

7.2.8.1 Potential Surface Water and Wetlands Impacts

Mine unit wellfield construction and reclamation activities may potentially impact surface water. The potential to affect surface waters during operation of the SUA-1548 license areas is considered minimal and temporary. The majority of the surface water at SUA-1548 license areas is derived from ephemeral drainages that have water flowing in them only during periods of snowmelt or significant precipitation events. However, intermittent surface water flow is present at the Gas Hills Remote Satellite (WCC and Cameron Spring) and constructed stock ponds at the North Butte Remote Satellite. Constructed stock ponds, which are tributary to Sage Creek and Box Creek are present at Smith Ranch. The potential for affects to surface water is low. During production, restoration, and after reclamation, the surface will be vegetated to minimize temporary effects to surface water quality.

The physical presence of the surface facilities, including the wellfields and associated structures, access roads, satellite IX buildings, office buildings, pipelines, CPP, and CPF facilities and other structures associated with the ISR process is not expected to significantly change peak surface water flows because of the relatively flat topography of the drainages at the sites, the low regional precipitation, the absorptive capacity of the soils, and the small area of disturbance relative to the large drainage area within and

adjacent to the license areas. In areas where these structures may affect surface water drainage patterns, diversion ditches and culverts are used to prevent excessive erosion and to control runoff. In areas where runoff is concentrated, energy dissipaters are used to slow the flow of runoff to minimize erosion and sediment loading in the runoff.

7.2.8.2 Potential Surface Water Impacts from Sedimentation and Erosion

As discussed in TR Section 3.8.3, the primary goal during construction and operation at SUA-1548 licensed areas is to minimize erosion and sedimentation. Preservation of existing vegetation and sequencing the construction activities in progressive phases limits the amount of surface being disturbed. Beyond standard preservation and protection measures as described in Section 3.8.3, BMPs are used to provide erosion/sediment control. The BMP chosen will depend upon the existing situation.

BMPs may include but are not limited to the following:

1. Ditches and Berms – A temporary ditch or ridge of compacted soil at the top or base of disturbed areas, including stockpiles, used to (1) divert storm water runoff away from disturbed upland areas, or (2) capture sediment laden storm water runoff from disturbed areas and route to a protected outlet, sediment trap or basin. Ditches and berms may also be constructed on the contour across slopes, reducing overall slope lengths and diverting captured flows to a controlled discharge location.
2. Conveyance Channel – A permanent designed earthen or vegetated channel that is shaped, sized and surfaced to safely convey concentrated flow without causing excessive erosion.
3. Riprap – Temporary or permanent erosion resistant ground cover of large loose angular stone with filter fabric and/or granular bedding used to (1) protect soil from erosive forces of concentrated storm water runoff, (2) slow the velocity of concentrated runoff and (3) stabilize slopes with seepage problems and/or non-cohesive soils.
4. Outlet Protection – Structurally lined aprons or other energy dissipating devices placed at the point of a concentrated discharge. Outlet protection preserves the integrity of outlet structures, prevents scour from concentrated discharge, and minimizes the potential for downstream erosion by reducing flow velocity and energy.
5. Sediment Trap – A temporary ponded area formed by constructing an earthen embankment or incised basin which is used to detain sediment laden runoff from small disturbed areas (<5 acres) long enough to allow for sediment settling. Discharge is controlled through a protected outlet.
6. Straw Bale Barrier – A temporary sediment barrier consisting of a row of entrenched and anchored straw bales used to (1) intercept and detain small amounts of sediment from disturbed areas of limited extent and (2) decrease the velocity of overland sheet flow.
7. Silt Fence – A temporary sediment barrier consisting of a synthetic filter fabric stretched and entrenched across supporting posts used to (1) intercept and detain small amounts of sediment from disturbed areas of limited extent and (2) decrease the velocity of overland sheet flow.
8. Biobags or Wattles – A manufactured burlap, jute mesh or geotextile wrapped sausage-like barrier used to prevent movement of sediment off of a site or stockpile.
9. Check Dam – A small temporary dam of stone, sand bags, straw bale or alternate material placed across a swale or drainage ditch, typically in series. Check dams are used to reduce the

velocity of concentrated flow, thereby limiting erosive forces. Check dams can also provide very limited sediment capture.

Implementation of BMPs is discussed in Section 3.8.3. The appropriate uses of these BMP controls are summarized in Table 3-19. Typical designs of various BMPs and installation methods are presented on Figure 3.41.

7.2.8.3 Potential Surface Water Impacts from Accidents

Surface water quality could potentially be impacted by accidents such as excessive storm water runoff or a release of process fluids due to a leak. Section 7.5 below discusses measures to prevent and control spills. Process buildings and chemical storage areas are or will be constructed with sumps or secondary containments, and a regular program of inspection and preventive maintenance is performed.

7.2.9 Potential Impacts to Terrestrial and Aquatic Ecology

7.2.9.1 Vegetation

No T&E species have been documented within the SUA-1548 license areas. Therefore, no impacts are anticipated.

As with any surface disturbing activity, weeds will opportunistically occur and periodically need to be controlled. At the Smith Ranch site, weeds, predominantly Canadian thistle (*Cirsium arvense*), are sprayed with a registered herbicide once per year, typically in late spring or early summer, or as advised by the herbicide application instructions. Areas sprayed include road cuts and fills, areas around buildings and fences, and other isolated areas within and around recently constructed wellfields that have been disturbed by construction and operations activities. The herbicide spraying is performed by a certified applicator in accordance with BLM and county weed and pest requirements. The same weed control measures will be implemented at the North Butte, Gas Hills, and Ruth Remote Satellites.

7.2.9.2 Wildlife

Compared with conventional surface mining, ISR poses a lower level of **potential** impact on wildlife, especially big game species such as deer and antelope. Pronghorn antelope are frequently seen grazing within the operational wellfield areas at Smith Ranch. This is primarily because the area of disturbance is limited and temporary. Heavy equipment, such as large earth excavators and haul trucks, are not used, and the number of people involved in an ISR operation is significantly less than a conventional mine.

Adverse effects to wildlife as a result of the Smith Ranch SUA-1548 license areas activities will be minimal for the following reasons:

1. No important big game migration routes or crucial winter habitats have been identified during surveys performed to date.
2. ISR activities disturb relatively small amounts of land surface at one time.
3. Areas disturbed by mine unit construction or operations activities will be revegetated after mine unit well pattern construction and will be available for wildlife use throughout the project life; fencing will be used only to keep livestock out of active production/restoration areas.
4. Livestock restrictive fencing will be limited to relatively small areas and will not significantly impede wildlife movements.
5. Vehicular traffic will be limited with reduced speed limits used for safety purposes and to decrease the likelihood of vehicle and wildlife collisions.

7.2.9.3 Fish and Macroinvertebrates

No aquatic habitat exists at the SUA-1548 license areas that will support fish. Therefore, no adverse effects from construction or operations to fish can occur. The wetland inventory was updated in 2011 at Smith Ranch and is provided as ER Appendix A. During the June 2011 survey, HWA identified 19 potential wetland sites at Smith Ranch. Potential wetlands were delineated in 2010 at the North Butte Remote Satellite license area during the confirmation vegetation survey and are discussed in the North Butte WDEQ Appendix D11, which includes a wetlands determination letter from the USACE. Aquatic habitats in these wetlands may harbor macroinvertebrates.

A jurisdictional wetlands delineation for the Gas Hills Remote Satellite area has not been conducted. However, approximately 11 hectares (28 acres) of potential wetlands were mapped based on the presence of wetland vegetation. Potential wetlands that occur within the license area were delineated based on vegetative characteristics and are shown on the Gas Hills WDEQ Appendix D8-Vegetation Plates D8-1E and D8-1W. Most of this wetland vegetation exists along and within the stream channel of WCC, but wetland vegetation also occurs along the margins of Cameron Spring Reservoir and several small seeps, which issue from the base of the Beaver Divide near the southern boundary of the license area. Aquatic habitats in these wetlands may harbor macroinvertebrates. Disturbance of wetlands and potential aquatic habitats within the production areas will be avoided whenever possible.

A jurisdictional wetlands delineation for the Ruth Remote Satellite license area has not been conducted to date. As described in the Supportive Information for WDEQ Permit to Mine Application and U.S.N.R.C. Source Material License Application, Volume 1, Section 13, electrofishing was conducted in potholes in the Dry Fork drainages. Ephemeral, standing water up to 1.5 meters (5 feet) deep has been documented in the potholes. Results of the electrofishing showed that a small population of plains and fathead minnow were present along with an unidentified species of catfish. Overall, the aquatic habitats for fish and macroinvertebrates at the Ruth Remote Satellite are limited.

In general, disturbances of wetlands within the limits of proposed production areas will be avoided. Should it become apparent that a potential wetland area may be affected by ISR operations, a mitigation plan will be developed for approval by LQD and the USACE. The most likely type of disturbance would be a road and/or pipeline crossing. Prior to disturbance of a potential wetland area, Cameco will contact the USACE for a jurisdictional wetland determination and if needed, a mitigation plan will be submitted to both USACE and LQD for review and approval with the Hydrologic Testing Package for each mine unit.

7.3 Radiological Effects

Exposure pathways to radiological materials at ISR operations are considerably different from pathways associated with conventional uranium mining and milling methods. The environmental advantages of ISR are two-fold. First, the majority of the radioactive daughter products remains underground and are not removed with the uranium. Second, for the production of yellowcake, the use of modern vacuum dryers reduces the potential for radiological air particulate releases typically associated with conventional uranium milling facilities to insignificant levels (USNRC, 1997: FEIS/ NUREG-1508).

Ionizing radiation is ubiquitous throughout the United States and, according to the National Council on Radiation Protection and Measurement, the average background radiation dose to a member of the public in the United States is approximately 300 mrem/year. Dose from naturally occurring sources, which is the largest potential source of public radiation dose within the ambit of NRC's definition of "background radiation," is highly variable (i.e., it can vary by as much as a factor of ten across the country). Dose from "background radiation" results from cosmic radiation sources such as cosmic rays from the sun and supernova explosions and from anthropogenic (human) activities, such as global fallout and surface

nuclear weapons testing, internal dose from ingested or inhaled radionuclides, terrestrial gamma doses, and the largest percentage of dose, which is from radon and its decay products. Indeed, the largest everyday anthropogenic activity causing releases of radon into the atmosphere is farming. As a result, it can be said with confidence that members of the public are exposed to radiation dose all of the time and that, depending on a person's geographic location, exposure can vary greatly.

As the drying and packaging operations at the CPP, as well as those that will be conducted at the refurbished CPF, are conducted under vacuum, the only expected routine emission for the Smith Ranch CPP will be radon gas released from the IX columns and tanks within the buildings and minor releases from the wellfields and surge/evaporation ponds. Radon, a decay product of Ra-226, is dissolved in the lixiviant as it travels through the ore to a production well where it is brought to the surface. The concentration of radon in the production solution and estimated releases are calculated using the methods found in NRC Regulatory Guide 3.59 (NRC, 1987). The details of and assumptions used in these calculations are found in Section 7.3.3 below.

MILDOS-AREA, a dispersion model approved by NRC, is used to model radiological effects on human and environmental receptors (e.g. air and soil) using site-specific radon release estimates, meteorological and population data, and other parameters. The estimated radiological effects resulting from routine site activities are compared to applicable public dose limits as well as naturally occurring background levels.

MILDOS-AREA modeling results for the SUA-1548 license area were included in the 2003 NRC License amendment combining SUA-1511 with SUA-1548 and incorporating the Ruth and North Butte licenses into SUA-1548. The effects of radon releases from wellfields, satellites, CPP, and ponds during production and restoration were modeled using MILDOS-AREA to estimate potential radiological effects caused by air emissions. The 1997 version of the model allows comparison of air concentrations at specific receptor **sites** with the ALC (Allowable Concentrations) given in 10 CFR 20. The annual population doses computed by MILDOS-AREA for the period of maximum emissions of radon indicated a dose of 0.3 person-rem/year from operational activities to persons living within 80 kilometers (50 miles) of the site. Nearby receptors were also assessed using MILDOS-AREA. The highest radon concentration at a license boundary receptor with access to an unrestricted area was 7.99E-05 WL compared to an ALC of 1.10E-03 WL. The Total Effective Dose was predicted to be 2.24 mrem/year at this receptor (downwind of the CPP).

MILDOS-AREA modeling results for the Reynolds Ranch satellite were included in the 2004 NRC Amendment (SUA-1548). The effects of radon release from proposed wellfields and satellite during production and restoration were modeled. The maximum annual TEDE from the Reynolds Ranch satellite was predicted to be 4 mrem/year at the nearest occupied, downwind residence during the period of maximum production activity. This dose is well below the 10 CFR 20 limit of 100 mrem/year.

MILDOS-AREA modeling results for the Gas Hills Remote Satellite were documented in the PRI Gas Hills Amendment Application for NRC Materials License SUA-1511 dated June 1998. The modeling showed that the expected Rn-222 concentrations at the site boundaries and downwind human receptors would be less than the effluent release limit in 10 CFR 20, Appendix B. The 1998 MILDOS evaluation did not include Mine Unit No. 5 because there was insufficient data available to determine whether it will contain economically recoverable reserves.

MILDOS-AREA modeling was performed for the Gas Hills Remote Satellite again in 2014 incorporating the 2012 on-site meteorological data into the analysis. The effects of radon release from the proposed wellfields and satellite during production and restoration were modeled. The Gas Hills MILDOS report and

output data are provided in Appendix M, Radiation Doses from Cameco's Gas Hills Expansion Area In-situ Uranium Leaching Operations.

MILDOS-AREA modeling will need to be conducted for the Ruth Remote satellite once the operations plan has been developed. MILDOS-AREA U.S.N.R.C. Source Material License Application, Volume 1, Section 14 contains MILDOS modeling results only for North Butte because former owner Uranerz planned to process the uranium loaded resin at North Butte.

MILDOS-AREA modeling was performed for the North Butte Remote Satellite in 2011 and revised in 2014 to include on-site meteorological data. The modeling results are discussed in subsequent sections of this TR. The effects of radon release from the proposed wellfields and satellite during production and restoration were modeled. The North Butte MILDOS report and output data are provided in **Appendix K, Radiation Doses from Cameco's North Butte Expansion Area In-situ Uranium Leaching Operations.**

With the addition of Reynolds Ranch and revised water balance, additional MILDOS-AREA modeling was performed for the Smith Ranch operations, and the 2011 modeling results are discussed in subsequent sections of this TR. The effects of radon release from the proposed wellfields and satellite during production and restoration were modeled. The MILDOS-AREA code used weather data from the Glenrock Coal Company, which was the most representative weather data available for the Smith Ranch license area at the time. A meteorological station will be installed at Smith Ranch. After a year's worth of data have been collected from the station, it will be evaluated to determine if the site-specific data is comparable to the regional data used in the modeling. The Smith Ranch MILDOS report and output data are provided in **Appendix L, Radiation Doses from Cameco's Smith Ranch and Reynolds Ranch In-situ Uranium Leaching Operations.**

7.3.1 Potential Exposure Pathways

Release of radon to the atmosphere is considered the only potentially significant radiological exposure pathway for the project**.** There are no routine particulate emissions from the SUA-1548 licensed operations. Liquids released from the facility are treated on site to reduce the concentrations of uranium and radium to those acceptable for release to unrestricted areas as specified in 10 CFR 20 Appendix B Table 11. As mentioned earlier, atmospheric radon is the predominant pathway for effects on human and environmental media. Impacts of radon releases can be expected in all quadrants surrounding the facility, the magnitude of which is driven predominantly by wind direction and atmospheric stability. As a noble gas, radon itself has very little radiological effect on human health or the environment. 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 adverse effects to human health and the environment. All exposure pathways, with the possible exception of absorption, can be important depending on the environmental media affected (**Figure 7.1, Human Exposure Pathways for Known and Potential Sources from the SUA-1548 Project)**.

Within the pressurized downflow IX columns, radon will remain in solution and be returned to the formation. Radon will not be released to the atmosphere from the IX columns under normal operations. The purge water removed from the injection fluid will be routed to a tank at atmospheric pressure and the radon in this tank will be vented to the air outside of the building. In this case it is assumed that all of the radon is released from this solution.

There will be minor releases of radon during the air blow down prior to resin transfer to the resin trailer. The radon released during air blow down and during column filling is vented to the atmosphere. The wellfields are also sources of radon emissions due to loss of pressure on the solution during well work

overs and sampling. Radon loss from well venting is estimated to be less than 1% of the radon **concentration** contained in the process solution.

7.3.2 Potential Exposures from Water Pathways

The solutions in the production zone aquifer are controlled and monitored to ensure that migration does not occur. The overlying and underlying aquifers are also monitored.

The North Butte Remote Satellite facility will have double-lined surge ponds that will be used to store wastewater prior to deep well injection. Double-lined evaporation ponds will be constructed at the Gas Hills Remote Satellite. The surge/evaporation ponds will be double-lined with impermeable synthetic liners. There will be a leak detection system installed to provide a warning if the primary liner develops a leak so that immediate action can be taken to repair the **liner** before it becomes a major problem. The ponds, therefore, are not considered a source of liquid radioactive effluents.

The primary method of waste disposal at the SUA-1548 facilities is deep well injection under the UIC program. Land application is also used at Satellite No. 2 at the Smith Ranch license area.

The CPP, CPF and satellite facility processing buildings are constructed on a curbed concrete pad to prevent liquids from entering the environment. Solutions used to wash down equipment will drain to a sump and be pumped to the wastewater disposal circuit. The curbed pad will be of sufficient size to contain the contents of the largest tank should it rupture. Since no routine liquid discharges of process water are expected, there are no definable water related pathways. Current and future SUA-1548 satellite facilities are or will be constructed with secondary containment features. ALARA analyses of waste disposal facilities is discussed in Section 4.0 of this TR.

7.3.3 Potential Exposures from Air Pathways

7.3.3.1 Source Term Estimates for MILDOS-AREA Modeling

Smith Ranch

The source terms used to estimate radon releases from Smith Ranch and the Reynolds Ranch Satellite, include five wellfields at Smith Ranch, eight wellfields at Reynolds Ranch, and resin transfers at the satellite buildings and CPP. The MILDOS-AREA modeling assumed that the wellfields would operate simultaneously. MILDOS-AREA was used to estimate the radiological effects of shipping resin to Smith Ranch from off-site facilities. Finally, the MILDOS-AREA was used to simulate the radiation effects at Smith Ranch from the operations at Reynolds Ranch and vice versa. The parameters used to characterize and estimate the radiation releases are provided in **Table 7-2, Parameters Used to Estimate and Characterize Source Terms at Smith Ranch.** These variables are used to calculate the source terms provided on page 5 of the MILDOS output reports. The MILDOS report for Smith Ranch-Reynolds Ranch is provided in **Appendix L**.

Gas Hills Remote Satellite

The source terms used to estimate radon releases from the Gas Hills Remote Satellite include four production areas and two satellite facilities. The parameters used to characterize and estimate releases are provided in Table 7-2.1, Parameters Used to Estimate and Characterize Source Terms at Gas Hills Satellite. These variables are used to calculate the source terms provided on page 5 of the MILDOS output reports. The MILDOS report for Gas Hills is provided in Appendix M.

North Butte Remote Satellite

The source terms used to estimate radon releases from the North Butte Remote Satellite include four wellfields and one satellite building. The parameters used to characterize and estimate releases are

provided in **Table 7-3, Parameters Used to Estimate and Characterize Source Terms at North Butte Satellite.** These variables are used to calculate the source terms provided on page 5 of the MILDOS output reports. The MILDOS report for North Butte is provided in Appendix K.

Production Releases

As outlined in Faillace, et al (1997), no particulate materials are released from the production wellfield because the process streams, from production and injection wells to IX columns in the satellite facility, are in a closed-loop circuit. The primary radioactive emission from the process streams of the production wellfield is radon. In the natural environment, radon results from the decay of radium-226 and migrates though the rock or soil by diffusion and convection. In the orebody the primary movement of radon is by advection, rather than diffusion.

The general equation describing the change in radon concentration in the process water of a wellfield can be expressed as:

$$V\frac{dC_{Rn}}{dT} = fS - (L+v)VC_{Rn} - (F_p + F_i)C_{Rn} \quad (1)$$

where

V = volume of water in circulation (L),
C_{Rn}= Rn-222 concentration in the process water (pCi/L),
f = fraction of radon source carried by circulating water (dimensionless),
S = radon source (pCi/d),
L = decay constant of Rn-222 (0.181/d),
v = rate of radon venting from piping and valves during circulation (1/d),
F_p= purge rate of treated water (L/d), and
F_i = water discharge rate from resin unloading of IX column (L/d).

The radon source term, S, can be expressed as

$$S = 10^6 xLE[Ra]ADP \quad (2)$$

where

10^6 = unit conversion factor (cm^3/m^3),
E = emanating power of active ore zone (dimensionless),
[Ra] = Ra-226 concentration in ore zone (pCi/g),
A = area of ore zone or (m^3),
D = average thickness of ore zone (m), and
P = bulk density of ore material (g/cm^3).

The water discharge rate from the resin unloading, F_i, can by calculated by

$$F_i = N_i V_i P_i \quad (3)$$

where

V_i = volume of IX column (L),
N_i = number of IX column unloadings per day, and
P_i = porosity of IX resin material (dimensionless).

Under steady-state conditions, the radon concentration in the process water, C_{Rn}, can be written as

$$C_{Rn} = \frac{10^6 [Rn] ADPELf}{(L+v)V + F_p + F_i} \quad (4)$$

When the pressure is released during transfer of purge fluid to a tank at atmospheric pressure or during resin transfer, radon is readily released into the atmosphere. The amount of radon available for release from the purge is dependent on the water volume purge rate, F_p, and on the radon concentration in the purge liquid, C_{Rn}. By conservatively assuming that available radon in the purge water is released, the annual radon emission is

$$Rn_w = 3.65 \times 10^{-10} C_{Rn} F_p \quad (5)$$

where

3.65×10^{-10} = unit conversion factor (Ci/pCi)(d/year), and
Rn_w = Rn-222 release rate from purge water (Ci/year).

The annual Rn-222 release from the occasional venting from wellheads and leaking transport piping are

$$Rn_v = 3.65 \times 10^{-10} v C_{Rn} V \quad (6)$$

where

Rn_v is the annual radon release from venting (Ci/year).

The annual radon discharge from the unloading of the IX column contents is

$$Rn_x = 3.65 \times 10^{-10} C_{Rn} F_i \quad (7)$$

where

Rn_x is the annual radon release of the IX column contents (Ci/year).

The total annual release of radon from the facility is the sum of Rn_w, Rn_v and Rn_x. The input parameters are provided in Table 7-2, Table 7-2-1, and Table 7-3. Equations 3 through 7 were used to estimate the source term for radon emissions for production in the MILDOS-AREA model.

Restoration Releases

The basic operating processes of the restoration wellfield are similar to those of the production wellfield. Groundwater affected by recovery processes in the production wellfields is restored to its pre-mining levels primarily by groundwater sweep and "pump and treat" (RO treatment and reinjection). Reductants may be added to the reinjection stream to precipitate certain elements and remove them from the groundwater in the formation. Like the production wellfield, no particulate materials are expected to be released from the restoration operations. The primary source of radon release is the process water circulating within and discharged from the restoration operations. The annual radon releases from the restoration wellfield therefore can be calculated by equations 5 and 6.

New Wellfield Releases

Conventional rotary rigs are commonly employed for drilling activities at SUA-1548 license areas. Because exploration drill holes are drilled by using water and drilling additives and sealed with high-viscosity

bentonitic mud to maintain aquifer isolation, no particulates are expected to be released during drilling operations. The only source of radioactive release is the radon release from radium-containing ore cuttings temporarily stored in the open mud pit. During the period when the ore cuttings are exposed in a mud pit, radioactive decay of Ra-226 is producing radon continuously. The amount of radon available for release, or the maximum release rate, in a year as a result of Ra-226 decay from ore cuttings in storage is assumed to be given by the following expression:

$$Rn_w = 10^{-12} EL[Ra]TMN \quad (8)$$

where

Rn_w = Rn-222 release rate from the new wellfield (Ci/year),
10^{-12} = unit conversion factor (Ci/pCi),
[Ra] = concentration of Ra-226 in ore (pCi/g),
E = emanating factor (dimensionless),
L = decay constant of Rn-222 (0.181/d),
T = storage time in mud pit (d),
M = average mass of ore material in the mud pit (g), and
N = number of mud pits generated per year.

The following data were used to determine the radon doses from new wells at Smith Ranch, Gas Hills and North Butte Remote Satellites:

Storage time in the pits = **10** days
Ore material in the pits delineation hole = 1.61E5 g
Ore material in the pits cased hole = 7.06e5 g
Number of pits = varies by year

The quantity of radon released from new wellfields is much less than 1% of the radon released during wellfield production.

Radon-222 Release Summary

A summary of the estimated radon releases (Ci/year) from the Smith Ranch, North Butte and Gas Hills Remote Satellite license areas is provided in tables included in Appendix K, Appendix L, and Appendix M. The estimated radon release values are also found on page 5 of the MILDOS-AREA output reports.

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 wells venting during both production and restoration, and Rn releases during IX column unloading. Radon releases from production and restoration purge water was assumed to occur at the location of the central processing plant. Radon releases from venting were assumed to be at the centroid of the mine unit in question.

The QAJUST factor in MILDOS was used to adjust the timing and fraction of a year that various sources operate. The annual rate of release from a specific resource was varied depending on timing of the release. In all cases, the modeling time step was set to 1 year. For example, a particular mine unit 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 estimate the variation in dose as the project progresses.

7.3.3.2 Potential Receptors

The potential receptors used in the MILDOS-AREA simulations for Smith Ranch, North Butte, and Gas Hills Remote Satellites are presented in Appendix K, Appendix L, and Appendix M and include the license boundaries, nearby residences, and towns and cities within 80 kilometers (50 miles).

7.3.3.3 Miscellaneous Parameters

The MILDOS-AREA simulations for Smith Ranch used weather data (1995-2009) from the Glenrock Coal Company. The Glenrock Coal Company ceased operations in circa 2000, but metrological data were collected at the site until December 2009. A meteorological station will be installed at Smith Ranch. After a year's worth of data have been collected from the station, it will be evaluated to determine if the site-specific data is comparable to the regional data used in the modeling. The MILDOS-AREA simulations for Gas Hills and North Butte used weather data (2012 for North Butte and 2011 for Gas Hills) from the on-site meteorological stations.

The population distribution used in the MILDOS-AREA model to estimate population doses is from the demographic information presented in Sections 2.2.3 and 2.3.3 of this TR and ER Section 3.10.

7.3.3.4 Total Effective Dose Equivalent to Individual Receptors

Smith Ranch – Reynolds Ranch Radon-222 Release Summary

The calculated TEDE at the license boundaries, nearest receptors and cities and towns within an 80-kilometer (50-mile) radius of Smith Ranch are summarized in **Table 7-4, Estimated Total Effective Dose Equivalent to Receptors within 80 kilometers of Smith Ranch.** The north license boundary reported the highest dose of 4.8 mrem/year. The dose rate at the nearest occupied residence (Sunquest Ranch) was 39.5 mrem/year. The highest dose rate at towns and cities within an 80-kilometer (50-mile) radius from Smith Ranch was 0.6 mrem/year at Glenrock and Douglas. Table 7-4 also provides the TEDE at the various receptors for a different radon-222 distribution (10% mine/90% satellite).

Table 7-5, Estimated Total Effective Dose Equivalents to Receptors within 80 kilometers of Reynolds Ranch provides a summary of the dose rates for operations at the Reynolds Ranch Satellite with the different radon-222 distribution and an upper bound purge rate. The highest license boundary dose was 24.8 mrem/year at the east boundary. The dose rate at the nearest occupied residence (Duck Creek Ranch) was 3.9 mrem/year. The highest dose rate at towns and cities within an 80-kilometer (50-mile) radius from Reynolds Ranch was 0.8 mrem/year at Wright.

For the MILDOS-AREA simulations, the annual dose limit (100 mrem/year) provided in 10 CFR 20.1301 was not exceeded for individuals likely to receive the highest dose from operations at Smith Ranch and the Reynolds Ranch Satellite. The radiation dose rates were less than 5 mrem/year for IX resin shipments to Smith Ranch, radiation from Reynolds Ranch operations on Smith Ranch and radiation from Smith Ranch operations on Reynolds Ranch.

Gas Hills Remote Satellite Radon-222 Release Summary

The calculated TEDE at the license boundaries, nearest receptors and cities and towns within an 80-kilometer (50-mile) radius of the Gas Hills Remote Satellite are summarized in Table 7-5.1, Estimated Total Effective Dose Equivalent to Receptors within 80 kilometers of the Gas Hills Remote Satellite. Results of MILDOS modeling indicate that no boundary location is likely to receive greater than the 10 CFR 20 limit of 100 mrem/year TEDE. The maximum modeled dose at any boundary location, 4.45 mrem/year, occurs at the East Boundary, located several hundred meters east of the MU-4 in year 12. The nearest residence (J Ranch) also has the highest predicted dose in year 12 of 0.24 mrem/year. Both dose rates assume 100% occupancy at the modeled location. Potential scenarios of various members of the public, such as a

courier, member of a tour group or a recreational camper at the east boundary location would receive doses far less than 1 mrem in the maximum project year.

Collective dose, expressed in person-rem/year 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 Gas Hills project to the 13,000+ residents within 80 kilometers (50 miles) is approximately 100,000 times lower than the dose to the same population from ubiquitous natural background radiation

North Butte Remote Satellite Radon-222 Release Summary

The calculated TEDE at the license boundaries, nearest receptors, and cities and towns within an 80-kilometer (50-mile) radius of the North Butte Remote Satellite are summarized in Table 7-6, Estimated Total Effective Dose Equivalent to Receptors within 80 kilometers of the North Butte Remote Satellite. Results of MILDOS modeling indicate that no boundary location is likely to receive greater than the 10 CFR 20 limit of 100 mrem/year TEDE. The maximum modeled dose at any boundary location, 58.4 mrem, occurs at the East Boundary, located only 100 meters (328 feet) east of the satellite in the year 2020. In the same year the dose rate at the nearest occupied residence (Pfister Ranch) was 0.53 mrem/year. These dose rates assume 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/year. Other exposure scenarios result in far lower doses.

7.3.3.5 Population Dose

The annual population effective dose commitment to the total population in the region within 80 kilometers (50 miles) of the Smith Ranch, Reynolds Ranch Remote Satellite, Gas Hills Remote Satellite and North Butte Remote Satellite is also predicted by the MILDOS-AREA code. The population effective dose rate within an 80-kilometer (50-mile) radius of the North Butte Remote Satellite was 0.053 person-rem/year and 0.04 person-rem/year at the Gas Hills Remote Satellite. The population effective dose rate within an 80-kilometer (50-mile) radius from Smith Ranch and Reynolds Ranch was 270 and 238 person-rem/year, respectively.

7.3.3.5.1 Compliance with 10 CFR 20.1302 (1)

10 CFR 20.1302 (1) states that it is acceptable to show compliance to public dose limits by demonstrating by measurement or calculation that the TEDE to the individual most likely to receive the highest dose from the licensed operation does not exceed the annual dose limit. Cameco will show compliance with this requirement through one of the two methods outlined below. The first method is to perform a dose assessment using measured effluent concentrations at a monitoring location positioned near the maximum receptor. In regards to radon and radon progeny dose, the dose assessment will be performed using the following equation:

$$D = DCF \sum_i C_i F_i T_i$$

Where:

D = annual dose (TEDE) (mrem/year)

DCF = dose conversion factor for Rn-222 with 100% equilibrium factor with its progeny from 10 CRF 20 Appendix B - 500 mrem/hr per pCi Rn/L

Ci = annual average concentration of Rn-222 in air (pCi/L) measured at the receptor location

Fi = radon equilibrium factor at the receptor
Ti = occupancy factor for the receptor

In the event that a receptor is exposed in multiple locations (e.g. indoors and outdoors), applicable equilibrium and occupancy factors will be used for those locations. For this receptor, currently exposures will be assumed to be indoors as this is the most conservative assumption. If multiple exposure locations are to be used in the future, the NRC will be notified prior to this change.

A dose conversion factor (DCF) has been established using the 10 CFR 10 Appendix B, Table 2, value for radon with daughters present in air (1 × 10-10 µCi/mL or 0.1 pCi/L) and the annual dose of 0.5 mSv/year (50 mrem/year). Therefore, the dose conversion factor for radon-222 with progeny at 100% equilibrium is determined as 0.5 mSv/year (50 mrem/year)) divided by 0.1 pCi/L, or 5 mSv/year per pCi Rn/L.

The annual radon concentration at the receptor will be determined by calculating the average net radon concentration at the receptor location based on semi-annual radon-222 measurements with track etch cups. As this is a private residence, measurements indoors on private property is not a feasible alternative. In an article published by Shiager (1974), it was shown that buildings immediately adjacent to tailings piles had indoor radon concentration in equilibrium with those found outdoors. In FSME-ISG-01 draft guidance, it is stated as acceptable to assume that the indoor radon concentration due to licensee activities is equal to the outdoor concentration.

The equilibrium factor between radon and radon progeny is assumed to be 50% for indoor exposure. This value is based on Regulatory Guide 3.51 and National Council on Radiation Protection and Measurement 160 and is mentioned in FSME-ISG-01 draft guidance as an acceptable default for indoor equilibrium factor. The actual occupancy factor for this receptor will be determined based on an assessment of actual residency time.

Since the Smith Ranch project utilizes a vacuum dryer prior to packaging of yellowcake, the principal radionuclides released from the facility are radon and its associated daughter products. Cameco has identified three general locations that have the potential for release of radon and its daughters. These locations are the CPP or satellite, the header houses, and, to a lesser extent, the wellfields. How the quantity of principal radionuclides released from each of these potential sources will be accounted for at each facility will be discussed in more detail.

CPP or Satellite

Emissions from the CPP or satellite will be determined based on the following assumptions and measurements. The total radon emission from the CPP or satellite will be the sum of the radon released from the vents of the tanks with the potential to contain significant quantities of radon plus the ambient radon in the facilities that is vented through the building's exhaust fans.

Releases of radon from vented tanks will be calculated by measuring the concentration of radon being emitted from the tank vents and the rated capacity of the vent fan. Lucas cells will be used to sample the air in the vent and quantify the concentration of radon at each vent. Only tanks that are considered to be significant sources of radon emissions will be sampled. The use of scintillation cells for the measurement of radon is an approved method, as outlined in Method 115 from 40 CFR 61 Appendix B. While the method describes the use of scintillation cells for underground mining and tailing piles, it can be applied to this application.

Measurements of the radon from tank vents will be performed at a minimum of once a quarter. Samples will be taken during highest predicted concentrations and will be used to determine the effluent of radon from vented tanks. To evaluate the conditions that would represent the highest concentration of radon in the vents, samples will be collected during different stages of the tank's operation. These stages will be filling, emptying, mixing and static. These samples will be collected during the first quarter after approval of this program. After the initial sampling, a single sample will be collected from each vent on a quarterly basis to represent the radon concentration in the tank vent.

Once the concentration of radon in the tank's vent is determined the quantity of radon emitted from the vent can be calculated assuming the manufacturer's flowrate (cf/min) for the ventilation fan associated with the tank vent. Fans will be assumed to be running continuously, and total releases from vented tanks will be calculated and added to total radon released from the plant.

The amount of radon in the CPP or satellite air will be determined using Track Etch cups with quarterly exposures. Semi-annually the quarterly sample results will be averaged to determine the ambient radon concentration in the facilities air. The rate of radon released from the process facility will be based on the manufactures flowrate for each of the exhaust fans. It will be assumed that the fans are operational 100% of the time, which will represent the worst case.

A total radon release from the CPP or satellite will be calculated quarterly based on the sum of the radon released from the tank vents and the ambient radon released as a result of the building ventilation. This release rate will be reported semi-annually in agreement with 10 CFR 40.65.

The history of particulate sampling at the Smith Ranch-Highland project indicates that, as expected, there are not significant quantities of the particulate radionuclides released from the facility. Cameco proposes that for one year, the emission of particulates at the CPP or CPF will be estimated based upon semi-annual isotopic analysis of filters used for particulate samples. The concentrations of the radionuclides reported from the analysis of the filters by an outside accredited lab will be used to calculate the quantity of the particulate radionuclides released from the facility. The exhaust fan rates that are used for the radon estimate will be used for the airborne particulate release calculations. The fans will be assumed to operate 100% of the time. Total effluents for each radionuclide will be reported on a semi-annual basis in agreement with 10 CFR 40.65. If after one year the NRC agrees that these emission rates are insignificant Cameco will submit a written request to discontinue this reporting.

Header Houses

Radon emissions from header houses will be estimated based on the following assumptions and measurements. The concentration of radon in air released from the header houses will be based on radon measurements taken within the header house utilizing Track Etch cups with a quarterly exposure time. Semi-annually the quarterly samples will be averaged and the radon concentration will be used along with the manufacturer's rating on the header house exhaust fan to determine the total radon released from the header house on a semi-annual basis. This assumes that all radon in the header house is released into the environment at a rate of the exhaust fan. The exhaust fans in the header houses are operated on a continual basis.

Four productions and four restoration header houses will be monitored at Smith Ranch-Highland (North Butte and Gas Hills when in production) as described above and the average radon emission per header house will be attributed to the remaining operational header houses in each group. The emissions from the operational header houses will be totaled on a quarterly basis and reported in the semi-annual report consistent with the requirements of 10 CFR 40.65

Wellfield

Injection wells have sealed wellheads and the potential of radon release is minimal. Potential emission of radon in the wellfield is limited to production wells; however, this source is minimal. The release of radon from production wells is considered to be negligible. The submersible pumps are positioned just above the production zone of the wellfield and approximately 450 feet to 700 feet below ground surface with several tens of feet of water above them. These submersible pumps are extracting production fluids containing dissolved radon from the formation and transfer these solutions to the nearest header house through a closed poly line under pressure. This production fluid is the source of the radon measured in the header houses.

The stagnant nature of the fluid above the pump lacks the turbulence to release a significant amount of radon gas into the well bore above the fluid surface. The stagnant water in the well above the pump is raised or lowered within the well bore by atmospheric conditions or changes in pump flow rates. These minor changes in the water level in the wellbore are the only means to exhaust gases from the production wellhead. Given the small volume of gas and the low concentration of radon in this gas, the radon released from the production wells is minor when compared to the quantity released from the CPP/Satellites and the header houses. This source of radon will not be included in the reported quantity of radon released from Crow Butte.

A potential source of radon emitted from the wellheads and piping occurs when the wellheads are opened to the atmosphere to depressurize a wellhead that has become pressurized. Because this situation is transient and very short lived, in addition to being highly localized, emissions from this situation will be measured through the use of grab samples collected with scintillation cells. Sampling of at least one well per quarter will be planned to determine the radon concentration in the gases released during depressurization of the wellhead. These samples will be collected in the airstream being vented from the well. The volume of gas will be calculated based on the casing volume and well pressure. The casing volume will assume the casing diameter and the average length of the casing from ground surface to the top of the screen for the mine area.

The other potential source of radon release from the wellfields is the unplanned releases of process fluid resulting from spills in the wellfield. The amount of radon released as a result of a spill will be estimated based on the volume of fluid released and an estimate of the radon concentration in that fluid. The concentration of radon in the fluid will be based on the calculations used to determine the radon concentration in production fluid by the program MILDOS. While the quantity of radon released as a result of spills in the wellfields is minor this procedure will represent a conservative estimate of the radon released.

The quantity of radon released from the CPP/Satellite, header houses, well venting, and spills will be summarized on a quarterly basis and reported in the semi-annual report consistent with the requirements of 10 CFR 40.65. If the reported radionuclide emission is significantly greater than that anticipated in the license renewal the cause of the unexpected value will be discussed in the report.

In summary, compliance with 10 CFR 20.1302 (1) will be demonstrated by considering both actual and potential public receptors. The actual receptors include local residents. Potential receptors are members of the public who may be at or near the site for greater than 50 hours per year. For the potential receptors, an estimate will be made of the hours spent at or near the site.

The estimate will include:

- Operations Summary
- Model Inputs and Assumptions
- Adjustment of Radon Venting Rate Using Environmental Data
- Meteorological Data
- Receptors and Identification of Maximally Exposed Individual
- Dose Estimate for Compliance Demonstration

7.3.3.6 Potential Exposure to Flora and Fauna

There are two primary potential pathways for radiological exposures to flora and fauna: radon emissions, and accidental spills of wellfield fluids (e.g., lixiviant).

Radon Releases

Radon emissions at satellite facilities that do not process yellowcake slurry or involve drying and packaging 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 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 decay products and calculates surface concentrations.

The potential exists for individual fauna (e.g., small mammals and birds) that are mobile to have contact with higher, but short-term, concentrations of radon than the public due to the potential proximity to releases. However, due to the typical mobility of such animals, it is likely that individuals would receive only an intermittent exposure, as opposed to a constant concentration for the entire year.

Fluid Discharges

There are currently no planned surface discharges from SUA-1548 licensed facilities except for the Smith Ranch Satellite 2 Land Application facility. The primary disposal method for facility wastewaters is via Class I deep disposal wells or evaporation ponds (Gas Hills). Therefore, fluid discharges would be associated with spills, e.g., pipeline breaks or leaks. Spills of this type would be expected to occur within the restricted mine unit wellfield areas and between the wellfields and satellite process facility. Satellite processing buildings, fuel tanks, and chemical tanks are constructed on pads that are engineered to contain spills from a pipe rupture, leaking vessel or inadvertent spill. Therefore, it is unlikely that spills in the processing area would reach soils and vegetation. Cameco operating procedures provide for ongoing monitoring of operational activities and for a rapid corrective action response to spills, which would result in cleanup of the spilled material and, if applicable, removal of contaminated soil and vegetation.

Long-term experience at Smith Ranch 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 facilities would not be expected to significantly affect food source such as vegetation and seeds that local animals depend upon.

7.4 Potential Non-Radiological Effects

7.4.1 Potential Non-Radioactive Airborne Effluents

An ISR facility by design is a self-contained circuit. Wastes generated by the facility are contained and eventually removed for disposal elsewhere. There has not been in the past nor is it anticipated that there will be a significant environmental impact from the non-radioactive airborne effluent releases in the future. Non-radioactive airborne effluents at the SUA-1548 license areas are limited to fugitive dust from access roads and mine unit activities and non-radioactive particulate emissions from the CPP's **area heaters and hot oil heaters**. The emissions from the CPP are permitted under WDEQ AQD Permit No. OP-202.

Fugitive dust emissions will be minimal and dust suppressants will only be used if conditions warrant their use. Cameco's procedures for controlling fugitive dust emissions during construction and operations are detailed in Section 3.8.5 of this TR. When operational, WDEQ AQD Permit No. OP-202 requires annual particulate emission testing of the yellowcake dryer (which is fueled with natural gas) and yellowcake packaging room scrubber exhaust stacks. Currently (January 2012) the Highland CPF is not operational. However, two rotary vacuum dryers will be installed at the CPF once the facility is refurbished, and emissions from the CPF will be similar to the Smith Ranch CPP. The monitoring programs discussed in Section 5.10 are designed to quickly identify adverse conditions that may result during operations. No long-term irreversible effects have been identified and none are anticipated during the next renewal period.

7.4.2 Non-Radioactive Liquid Effluents

There have been no non-radioactive liquid effluents discharged to the environment during the operation of the SUA-1548 license since the last renewal. Section 3.10 presents mitigation measures that have been implemented to reduce the potential for discharges during the next renewal period.

7.5 Potential Effects of Accidents

Accidents involving human safety associated with ISR facilities typically have far less severe consequences than accidents associated with underground and open pit mining methods. ISR provides a higher level of safety for employees and neighboring communities when compared to conventional mining methods or other energy related industries. Accidents that may occur would generally be considered minor when compared to other industries. Radiological accidents that might occur would typically manifest themselves slowly and are, therefore, easily detected and mitigated. The remote location of the SUA-1548 licensed facilities and the low level of radioactivity associated with the process combine to decrease the potential hazard of an accident that would jeopardize the general public.

NRC has previously evaluated the effects of accidents at conventional uranium milling facilities in NUREG 0706 and, specifically, at ISR uranium facilities in NUREG/CR-6733. These analyses demonstrate that, for most potential accidents, consequences are minor as long as effective emergency procedures and properly trained personnel are used. The SUA-1548 licensed facilities are consistent with the operating assumptions, site features, and designs examined in the NRC analyses in NUREG/CR-6733. Cameco has developed emergency management procedures to implement the recommendations contained in the NRC analyses. Training programs have been developed and implemented to ensure that Cameco personnel are adequately trained to respond to potential emergencies. These training programs are discussed in Section 5.5 of this TR.

NUREG 0706 considered the environmental effects of accidents at single and multiple uranium milling facilities. Analyses were performed on incidents involving radioactivity and classified these incidents as

trivial, small, and large. NUREG-0706 also considered transportation accidents. Some of the analyses in NUREG 0706 are applicable to ISR facilities, such as transportation accidents. NUREG/CR-6733 specifically addressed risks at ISR facilities and identified the "risk insights" that are discussed in the following sections.

7.5.1 Potential Accidents Involving Radioactivity

7.5.1.1 Tank or Vessel Failure

A spill of materials contained in the process tanks at ISR facilities present a minimal radiological risk. Process fluids are contained in vessels and piping circuits within the processing buildings. Oxygen, hydrogen peroxide, **CO_2**, propane and fuel are stored in outside storage tanks. Tanks that contain liquids such as fuel, acids, and hydrogen peroxide are bermed or curbed to contain potential leaks. The satellite facilities are designed to control and confine liquid spills from tanks, should they occur. The facility building structures and concrete curbs are designed to contain the liquid spills from leakage or rupture of a process vessel and direct spilled solution to a floor sump. The floor sump system directs 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 process vessels located outside the building. Consequently, such an accident would be of short duration and the remedial procedure is incorporated into the process plant design.

Tanks are constructed of materials suitable for their service. Instantaneous failure of a tank is highly unlikely. Tank failure would be more likely to occur as a small leak in the tank. In this case, the tank would be emptied to at least a level below the leaking area, and repairs or replacement would be made as necessary.

7.5.1.2 Potential Pipe Failure

Rupture of a pipe within the CPP or satellites can be easily detected by operating staff and can be quickly controlled and repaired. Spilled solution will be contained and managed in the same fashion as for a tank failure.

7.5.1.3 Potential Wellfield Spill

The rupture of an injection or recovery line in a mine unit wellfield, or a trunkline between a wellfield and satellite or CPP, would result in a release of injection or production solution which could impact the ground in the area of the break. Piping from the CPP or satellite to and within a wellfield is buried for frost protection. Pipelines are constructed of HDPE with butt-welded joints. Pipelines are pressure tested with water at operating pressures prior to final burial and following maintenance activities that may affect the integrity of the system.

Each mine unit wellfield has several header houses where injection and production wells are continuously monitored for pressure and flow. Individual wells have set high and low flow alarm limits. Monitoring parameters and alarms are observed in the satellite control room via a computer system. Each new header house has a "wet building" alarm to detect the presence of liquids in the building basement. High- and low-flow alarms have been proven effective in the detection of significant piping failures (e.g., failed fusion weld). A discussion of the construction and leak detection features at new header houses is provided in Section 3.6.

Occasionally, small leaks at pipe joints and fittings in the header houses, bellholes or at the wellheads may occur. Until remedied, these leaks may drip process solutions onto the underlying soil. Cameco has implemented a program of continuous wellfield monitoring by roving wellfield operators and periodic inspections of each well that is in service. Small leaks in wellfield piping typically occur in the injection

system due to the higher system pressures. These leaks seldom result in adverse effects. Following repair of a leak, Cameco requires that 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. Affected soil may be removed as appropriate.

7.5.1.4 Potential Lined Pond Failure

Smith Ranch uses two lined holding ponds. Two surge ponds are proposed for the North Butte Remote Satellite. Initially, two evaporation ponds will be installed at the Gas Hills Remote Satellite. Leakage from the ponds could potentially effect soil and groundwater. Existing ponds at Smith Ranch are routinely monitored for leakage. As stated earlier, the ponds to be built at the North Butte and Gas Hills Remote Satellites will be double lined and will have a leak detection system designed to detect potential leaks before they impact the environment.

The ponds leak detection systems will consist of a network of perforated pipes in a permeable granular layer beneath the primary liner with the pipes draining to a collection sump. Should a leak in the liner occur, the water will flow through the permeable layer between the two liner systems, enter a perforated pipe and flow to a sump. The monitoring program for the lined ponds will include either a fluid level sensor in each pond sump with an alarm displayed at the satellite or a daily inspection of each sump by an operator. A trained individual will visually inspect the ponds daily for leaks, liner damage, or embankment deterioration due to erosion, slumps or other defects. The daily pond inspections will be recorded and initialed by the inspector. The environmental monitoring program associated with the leak detection system is discussed in Section 5.10.

7.5.1.5 Potential Lixiviant Excursion

Excursions of lixiviant at ISR facilities have the potential to contaminate adjacent aquifers with radioactive and trace elements that have been mobilized by the mining process. These excursions are typically classified as horizontal or vertical. A horizontal excursion is a lateral movement of mining solutions outside the mining zone of the orebody aquifer. A vertical excursion is a movement of solutions into overlying or underlying aquifers. In the event that an excursion does occur and is accidentally undetected, concentrations of metals such as uranium, arsenic, selenium and Ra-226 are likely to be low due to natural precipitation and adsorption onto clays. This phenomenon occurs because the metals, which are mobilized in the oxidized environment of the production area, are selectively removed from solution via precipitation and adsorption as they move into the reduced environment outside of the oxidized production area. Should an excursion occur, the excursion correction procedures outlined in Section 3.10.2 will be undertaken. Environmental monitoring to detect a lixiviant excursion is provided in Section 5.10.

Hydraulic testing of existing wellfield areas prior to mining in the SUA-1548 license areas has defined the aquifer characteristics for the production zone at the site. The ore-bearing strata are physically and hydraulically separate from overlying and underlying aquifers. The well completion procedures used and the mechanical integrity testing for each injection well performed prior to leach solution injection ensure that injected solutions are contained within the wellfield. The monitoring program for overlying and underlying aquifers is a redundant check to ensure that the injection is controlled. Should an excursion occur, the excursion correction procedures outlined in Section 3.10.2 will be implemented as soon as possible.

Cameco controls the 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 will either be recycled in the plant or sent to the liquid waste

disposal system. When process bleed is properly distributed among the many patterns within the wellfield, the lixiviant is contained within the monitor well ring.

Cameco 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. Monitor wells are installed as discussed in Section 3.5. Monitor wells are sampled twice each month for approved excursion indicators.

The historical experience at Smith Ranch and other ISR uranium operations indicates that the selected indicator parameters and UCL allow detection of horizontal excursions early enough that corrective action can be taken before water quality outside the exempted aquifer boundary is degraded. As noted in NUREG/CR-6733, significant risk from a horizontal excursion would occur only if it persisted for a long period without being detected.

Vertical excursions can be caused by improperly cemented well casings, well casing failures, improperly abandoned exploration wells, or leaky or discontinuous confining layers. Cameco prevents 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 leaks in the confining layers. Aquifer test reports are submitted to the LQD for review prior to initiating mine unit wellfield operations. Well construction and integrity testing is conducted in accordance with LQD regulations and methods approved by NRC, EPA and LQD. Construction and integrity testing methods have been discussed in detail in Section 3.5.2. Well abandonment is conducted in accordance with methods approved and monitored by the LQD and are discussed in detail in Section 3.3.2.

Cameco monitors for vertical excursions in the overlying aquifer using overlying and, where necessary, underlying aquifer monitor wells. These wells are located within the mine unit wellfield boundary at a density of one well per 16 hectares (4 acres). These monitor wells are sampled twice each month for approved excursion indicators.

Excursion parameters (UCLs) for aquifers are near baseline concentrations so that minor changes in water quality are detected and precautionary measures are taken. Because excursion parameters are inert and their movement in groundwater is unimpeded, it is unlikely that, when excursion correction procedures are initiated, chemical parameters other than the excursion indicators would be different from baseline values.

No radiological groundwater degradation should result when a well is in excursion status. In the event that an excursion does occur and is accidentally undetected, concentrations of metals such as uranium, arsenic, selenium and Ra-226 are likely to be low due to natural precipitation and adsorption onto clays. This phenomenon occurs because the metals, which are mobilized in the oxidized environment of the production zone, are selectively removed from solution via precipitation or adsorption as they move into the reduced environment outside of the production zone.

7.5.2 Potential Transportation Accidents

The potential transportation impacts associated with the transport of yellowcake, yellowcake slurry, and uranium-laden resins from ISR operations have previously been assessed by NRC. The NRC has assessed the transport of dried and packaged yellowcake from conventional uranium mills and has reviewed the proposed transportation of yellowcake and uranium-loaded IX resins from central processing facilities in a variety of license applications for new conventional or ISR uranium recovery facilities and license amendment applications for new satellite wellfields from existing licensees. Furthermore, during the review of PRI's license amendment request for the Gas Hills satellite facility, the NRC staff evaluated the impacts of shipping IX resin from the Gas Hills Remote Satellite to and from the Smith Ranch CPP (NRC, 2004). The EA identified that, as the amount of traffic generated from shipping the IX resin to Smith Ranch would be minor compared to the overall traffic volume along the transportation route, it would not be expected to significantly contribute to congestion or accident rates along those roadways. These analyses have demonstrated that the transport of such materials does not pose a significant threat to public health and safety or the environment.

Because loaded IX resins, yellowcake slurry or yellowcake is transported off-site from a satellite or the CPP or CPF, transportation safety must be addressed. If the product is dried yellowcake, the drums are transferred to a truck trailer by a forklift, and the shipment is sealed and treated as a dedicated shipment. If the product is yellowcake slurry or loaded IX resin, it is to be transferred into a designated tanker truck and transported from the satellite to either the CPP or CPF for further processing. At a hypothetical production rate of 40 metric tons (1 million pounds) per year, up to 50 shipments of yellowcake or up to 1,000 shipments of resin could be transported off site each year. In most cases, after leaving the satellite, CPP or CPF, transportation typically is on unpaved roads initially in remote locations and on paved roads later in the shipment. In some cases, unpaved roads may be used for transport from a satellite to the CPP or CPF. By-pass routes are used to the extent practicable so that these shipments do not pass through population centers. Transport conveyances carrying IX resin, yellowcake slurry or dried yellowcake are required to carry the appropriate certifications, and drivers are required to hold appropriate licenses. DOT training requirements are provided in Section 5.6 of this TR.

7.5.2.1 Potential Accidents Involving Resin or Yellowcake Slurry Shipments

Resin is transported from the existing Smith Ranch satellites to the CPP using specially designed sole-use transport trailers on existing roads within the license area. Resin from the Reynolds Ranch satellite will be transported a short distance on County Road 31 (Ross Road). Resin will also be transported from the North Butte Remote Satellite, Gas Hills Remote Satellite, and Ruth Remote Satellite to the refurbished Highland CPF. Yellowcake slurry will also be transported from Gas Hills to the Highland CPF. Furthermore, Cameco has NRC approval to process third-party resin and yellowcake slurry at the Smith Ranch CPP and Highland CPF.

One of the potential additional risks associated with the operation of satellite facilities is the transfer of IX resin to and from the satellite facilities. Resin will be transported to and from the satellite facility in a 15,120-liter (4,000-gallon) capacity tanker trailer. It is currently anticipated that one load of uranium-loaded resin will be transported from the North Butte Remote Satellite to the CPF for elution and one load of barren eluted resin will be returned to the satellite facility on a daily basis. Both IX resin and yellowcake slurry will be transported from the Gas Hills Remote Satellite to the CPF.

Cameco has developed comprehensive transportation plans for the Smith Ranch, North Butte Remote Satellite and Gas Hills Remote Satellite. A transportation plan will be developed for the Ruth Remote Satellite once the plans for the development of this satellite have further progressed. Within these traffic

plans are the proposed transportation routes for resin and yellowcake slurry (Gas Hills) and estimated number of trips based on the anticipated production rates for each facility.

Resin shipments are treated similarly to yellowcake shipments with regards to DOT and NRC regulations. Materials will be handled as LSA-1 shipments for both uranium-loaded and barren eluted resin. Pertinent procedures include:

- 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 placards.
- A bill of lading will be included for each shipment (including eluted resin) indicating that a hazardous cargo is present. Other items identified will 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 eluted resin, the exterior surfaces of the tanker will be surveyed for alpha contamination. Gamma exposure rates will be obtained from the surface of the tanker and inside the cab of the tractor. The survey results will appear on the bill of lading.
- Licensed and trained drivers will transport the resin between the satellite facilities and the CPP/CPF.
- Cameco’s current emergency response plan for yellowcake and other transportation accidents to or from the yellowcake processing facilities is contained in Cameco’s SHEQ MS Volume VIII, *Emergency Manual*. This plan is being revised to include an emergency resin transfer accident procedure. Personnel at the satellite facilities and the CPP/CPF have received training for responding to a resin transfer transportation accident.

For transportation purposes, Cameco treats the eluted resin the same as the uranium loaded resin. It is possible that the eluted resin may be clean enough to be transported as non-radioactive material, as defined by DOT regulations. Operating experience will aid in the determination of the most practical and efficient way of dealing with the shipment of barren resin. Regardless, compliance with 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 loaded resin where the entire tanker contents have been 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 affected by the spill and the subsequent damage to the topsoil and vegetation structure. Areas affected by the removal of soil would be revegetated.

- In the event of a transportation accident involving the resin transfer operation, Cameco will institute its emergency response plan for transportation accidents. To minimize the effects from such an accident, the following procedures will be followed: Each resin hauling truck will be equipped with a radio or cell phone, which can communicate with either the CPP, CPF or the satellite facilities. In the event of an accident and spill, the driver can use the radio or cell phone to summon help.

- A check-in and check-out procedure has been implemented 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 assures reasonably quick response time in case a driver is incapacitated in an accident.
- Personnel at the satellites and CPP/CPF as well as the designated truck drivers have specialized training to handle an emergency response to a transportation accident.
- Each resin transport vehicle is equipped with an emergency spill kit, which the driver can use to begin containment of spilled material.
- Both the satellite and CPP/CPF facilities are equipped with emergency response packages to quickly respond to a transportation accident.

In 2009, NRC staff evaluated the risk of transportation accidents related to shipments of third-party IX resin to the Smith Ranch CPP (NRC, 2009). NRC staff previously evaluated IX resin transportation risks during their review of amendment requests to add Gas Hills, SR-2 and Reynolds Ranch satellite facilities to the SUA-1548 license (NRC, 2004, Jan. 2007, Dec. 2007). NRC staff concluded that if an accident causes the release of resin and entrained water, IX resin, liquids and affected soil would be removed from the spill site and processed through the elution circuit or disposed of at a NRC licensed disposal facility. Disturbed areas would then be reclaimed in accordance with applicable state and NRC regulations. NRC staff also determined that there would be no risk of airborne release of uranium, as it remains ionically fixed to the resin (NRC, 2009).

7.5.2.2 Potential Accidents Involving Yellowcake Shipments

NUREG 0706 concluded that the probability of a truck accident involving shipments of yellowcake in a year is 11% for each uranium extraction facility. This calculation used average accident probabilities (4.0 x 10^{-7}/kilometer for rural interstate, 1.4 x 10^{-6}/kilometer for rural two-lane road, and 1.4 x 10^{-6}/kilometer for urban interstate) that NUREG/CR-6733 determined were conservative. The DOT reported that in 2007 only eight out of 17,000 hazardous material transportation accidents involved radioactive material.

As with resin shipments, yellowcake slurry or dried product shipments are made in accordance with DOT and NRC regulations. Shipments are handled as LSA material and follow the same general shipping procedures as outlined for IX resin shipments in Section 7.5.2.1 above. The shipments meet the minimum packaging (Type IP-1 Industrial Packages) and labeling requirements for the transport of radioactive materials. Standard steel drums meet IP-1 requirements. Labeling requirements are as provided in NRC regulations at 10 CFR Part 71, which are compatible with the internationally accepted International Atomic Energy Agency TS-R-1 transport regulations.

The worst case accident scenario involving yellowcake transportation would be an accident involving the transport truck where the integrity of one or more drums containing yellowcake was breached, resulting in a release to the environment. Unlike IX resin shipments, ISR operators do not typically transport dried yellowcake to conversion facilities but rather contract with transport companies that specialize in shipments of yellowcake. These **contract** companies have extensive emergency response programs including spill response equipment on board, drivers trained in radiological emergency response, constant monitoring of truck location and operating parameters, and standing contracts with environmental emergency response contractors for cleanup of spills. As with IX resin, the primary environmental impact associated with an accident involving the spill of yellowcake would be the salvage of soils affected by the spill and the subsequent damage to the topsoil and vegetation structure.

NRC has approved the shipment of yellowcake slurry from the SUA-1548 satellites to the CPP. Currently, Cameco only plans to produce slurry or loaded resin from the Gas Hills Remote Satellite. The effects of an accident involving yellowcake slurry would not be different from dried yellowcake, with the exception that the contained water in the slurry would prevent windblown contamination of nearby soils and vegetation. Response and cleanup would be the same as described above for resin or dried yellowcake. In 25 years of operation, PRI/Cameco has never experienced an accident involving a yellowcake shipment.

7.5.2.3 Potential Accidents Involving Shipments of Process Chemicals

Potential accidents involving truck shipments of process chemicals to the SUA-1548 facilities could result in a local environmental impact. Spills would be removed and the area would be cleaned and reclaimed. Shipments of the chemicals used in ISR processing in truckload quantities are common to many industries and present no abnormal risk. These chemicals include dry solid sodium carbonate, liquid **CO_2**, liquid oxygen, concentrated sulfuric acid, hydrochloric acid liquid (37%), hydrogen peroxide, sodium hydroxide, and dry solid sodium chloride (salt). The production of yellowcake slurry at the Gas Hill Remote Satellite will increase the number of process chemical shipments to the facility but will reduce the number of resin shipments to Smith Ranch. As most of the spilled material would be recovered or removed, no significant long-term environmental impacts are anticipated from a shipping accident involving these materials.

7.5.2.4 Potential Accidents Involving Shipments of 11e.(2) Byproduct Material

Low level radioactive 11e.(2) byproduct material or unusable contaminated equipment generated during operations will be transported to an NRC-licensed disposal site as needed and at the time of decommissioning. 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. The effects of an accident involving the transportation of such wastes will be mitigated by the emergency response plan for transportation accidents.

7.5.3 Potential Natural Disaster Risk

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

The ISR project areas in both the Powder River Basin and Wind River Basin are in seismic risk Zone 1. The Gas Hills Mining district is located in the south-central portion of the Wind River Basin, which historically has experienced a moderate level of seismic activity compared to the rest of the state and is the most seismically active of the SUA-1548 license areas. Earthquakes have been reported south, northwest and northeast of Jeffery City (Reagor, et al, 1985) in the Wind River Basin. In 1975, a non-damaging magnitude 3.5 earthquake was reported approximately 40 kilometers (25 miles) north of Jeffery City, which places the earthquake within 16 kilometers (10 miles) of the Gas Hills Remote Satellite area. Three active exposed faults in the Wind River Basin and Gas Hills project area have been documented (NRC, 2004). 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 is discussed in detail in Sections 2.2.6, 2.3.6, 2.4.6, and 2.5.6, and Section 3.3.3 of the ER. When applicable, Cameco will use seismic building codes in the design of their ISR structures.

According to the Wyoming Climate Atlas for 1950 to 1994, the State of Wyoming ranks 25th in the number of annual tornadoes (10), 33rd in fatalities (six deaths per million people), 37th in injuries, and 36th in

property damage ($49,339,505) in the US (excerpted from the Wyoming Climate Atlas). The occurrence of severe weather for the SUA-1548 license areas is provided in Section 3.6.1.5 of the ER.

In NUREG/CR-6733, the NRC concluded that the risk from tornadoes is very low at uranium ISR facilities and that no design changes are necessary to mitigate the risk. One recommendation was to locate chemical storage tanks sufficiently far apart that potential leaks caused by tornado damage would not result in reactions between different chemicals mixing together. Cameco has procedures and provides instructions to operating personnel for response and mitigation of natural disasters and associated spills of radioactive and chemical materials. Emergency response procedures will include:

- Notification of personnel of potential severe weather;
- Evacuation procedures;
- Damage inspection and reporting; and
- Cleanup and mitigation of chemical or radioactive material spills.

7.5.4 Potential Range Fire Risk

The following is Cameco's procedure for addressing a potential range fire at the Smith Ranch SUA-1548 license areas. This text is reflected in Cameco's Emergency Preparedness and Response Program – Volume III – Emergency Procedures Manual, Section 3; Fires and Explosions. This policy is the standard program for SUA-1548 operations and will be extended to address the specifics of the remote satellites at North Butte, Gas Hills, and Ruth.

If a grass fire occurs in the immediate vicinity of the CPP, CPF or satellite buildings, management will be immediately notified. The Incident Commander will make a general announcement over the radio and telephone intercom warning employees of the location and nature of the range fire. The Incident Commander will then proceed to the area of the range fire and assess the situation.

A range fire near the CPP, CPF, satellites or the fuel storage area(s) may involve hazardous chemicals and/or radioactive materials. Before attempting to fight a fire, responding personnel must ascertain the location and size of the fire and determine the likelihood of involvement of chemicals or radioactive materials. If these materials may be involved, personnel MUST evacuate the area and consult the instructions for responding to fires in the Chemical Emergency Response Guide, Chapter 11.

Upon assessing the situation, the Incident Commander will determine the appropriate response (i.e., call 911, send employees to fight fire, provide the necessary firefighting equipment, possible site evacuation, etc.). During off-shift hours, the Lead Plant Operator will ensure that senior management is contacted and, if necessary, that 911 is called. During off-shift hours, the Lead Plant Operator is responsible for making decisions until management arrives or the Lead Plant Operator is otherwise instructed by management.

The Incident Commander will maintain radio or visual contact with employees fighting the fire and will keep the main office appraised of the situation. Range fires must be fought in teams of at least two and from the upwind side of the fire.

Equipment will only be operated by those individuals task trained in the operation of those particular pieces of equipment. The Incident Commander or his designee will make the determination as to which personnel will remain on duty at the sites and who is available to assist the first responders (volunteer fire department) with firefighting activities, if requested.

7.5.5 Potential Chemical Risk

NUREG/CR-6733 noted that the scope of the NRC mission includes hazardous chemicals to the extent that mishaps with these chemicals could affect releases of radioactive materials. The use of hazardous chemicals at Smith Ranch is regulated by OSHA.

Of the highly hazardous chemicals, toxics, and reactives listed in Appendix A to 29 CFR §1910.119, none are used at the SUA-1548 facilities. The satellite facilities use oxygen, CO_2, and sodium bicarbonate for addition to the injection solution. Sodium sulfide may be used as a reductant during groundwater restoration activities. Other operations requiring process chemicals described in NUREG/CR-6733 will be performed at the CPP and/or the CPF.

The SUA-1548 license areas construction, operating, and emergency procedures have been developed to implement the codes and standards that regulate hazardous chemical use.

7.5.5.1 Oxygen

Oxygen gas is not flammable but it vigorously accelerates combustion. Materials that normally will not burn, may burn in an enriched oxygen atmosphere. Hydrocarbon materials may form explosive compounds when exposed to an enhanced oxygen environment. The design and installation of the oxygen storage facility is typically performed by the oxygen supplier and meets applicable industry standards. The oxygen is delivered to Smith Ranch SUA-1548 licensed facilities by truck and stored on site under pressure in a cryogenic tank in liquid form. The oxygen is added to the barren lixiviant upstream of the injection manifold. The design and installation of underground and above-ground gaseous oxygen piping, including material specifications, velocity restrictions, location and specifications for valves, and design specifications for metering stations and filters are in accordance with industry standards contained in Compressed Gas Association (CGA) G-4.4. Header houses will be equipped with an exhaust ventilation system.

Combustibles such as oil and grease may spontaneously ignite or explode in oxygen. Cameco contractors and personnel ensure that oxygen service components are cleaned to remove oil, grease, and other combustible material before putting them into service. Acceptable cleaning methods are described in CGA G-4.1. Cameco has developed and implemented emergency response procedures for a spill or fire involving oxygen systems.

7.5.5.2 Carbon Dioxide

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 performed to protect workers from undetected leaks of CO_2 within the CPP.

7.5.5.3 Sodium Carbonate and Sodium Chloride

Sodium carbonate and sodium chloride are primarily inhalation hazards. Soda ash and **CO_2** will be used to prepare sodium carbonate for injection in the mine unit wellfields. Sodium carbonate and sodium chloride are also used for regeneration of IX resin. Dry storage and handling systems will be designed to industry standards to control the discharge of dry material.

7.5.5.4 Sodium Sulfide

Sodium sulfide may be used as a reductant during groundwater restoration. Sodium sulfide is corrosive and will cause severe eye and skin bums. Routes of entry into the body include inhalation, ingestion, and contact with the skin. Under low pH conditions, sodium sulfide can react with water to liberate hydrogen sulfide gas. Sodium sulfide can be flammable in the presence of heat and open flame. Sources of ignition should be avoided. Sodium sulfide will be stored separately from hydrogen peroxide and sulfuric acid.

7.5.5.5 Sodium Hydroxide

Sodium hydroxide, also known as caustic soda or lye, is used to adjust the pH in the yellowcake precipitation circuit. Solid sodium hydroxide or solutions of sodium hydroxide may cause chemical burns, permanent injury or scarring if it contacts unprotected human skin. It may cause blindness if it contacts the eye. Protective equipment such as rubber gloves, safety clothing and eye protection are used when handling the material or its solutions. Dissolution of sodium hydroxide is highly exothermic, and the resulting heat may cause heat burns or ignite flammables. It also produces heat when reacted with acids. Sodium hydroxide is corrosive to some metals, e.g. aluminum, which produces flammable hydrogen gas on contact. Sodium hydroxide is also mildly corrosive to glass, which can cause damage to glazing or freezing of ground glass joints. Sodium hydroxide is stored separately from hydrogen peroxide and sulfuric acid.

7.5.5.6 Hydrogen Peroxide

Hydrogen peroxide is one of the reagents used in the precipitation phase at SUA-1548 licensed facilities. Hydrogen peroxide has replaced anhydrous ammonia as a precipitant. A 50% solution of hydrogen peroxide is added to the acidified uranium-rich eluant to form an insoluble uranyl peroxide compound. Hydrogen peroxide is a strong oxidizer and is a reactive, easily decomposable compound. Its hazardous decomposition products include oxygen and hydrogen gas, heat, and steam. Decomposition can be caused by mechanical shock, incompatible materials including alkalis, light, ignition sources, excess heat, combustible materials, strong oxidants, rust, dust, and a pH above 4.0. When sealed in strong containers, the decomposition of hydrogen peroxide can cause excessive pressure to build up which may then cause the container to burst explosively.

As noted in NUREG/CR-6733, a hydrogen peroxide piping system leak in a process building has the potential to result in localized vapor concentrations in excess of the immediately dangerous to life or health value of 75 ppm within several minutes. A leak in a confined space has the potential to generate lethal concentrations of vapor at an even faster rate. Cameco has incorporated recommendations concerning materials of construction for tanks and piping systems and the use of local ventilation with explosion-proof fans to control vapors in the event of a leak of hydrogen peroxide.

The SUA-1548 licensed operations include the use of hydrogen peroxide at a concentration of 50% contained in a hydrogen peroxide tank with a capacity of 23,000 liters (6,000 gallons). With the design hydrogen peroxide concentration and capacity, Cameco is not subject to the regulatory program for Process Safety Management of Highly Hazardous Chemicals in 29 CFR §1910.119.

7.5.5.7 Sulfuric Acid

Sulfuric acid is used to remove carbonate from the rich eluate in preparation for precipitation with hydrogen peroxide or ammonia. The sulfuric acid is stored in a tank located outside the building and piped to the precipitation circuit. The concentration of sulfuric acid fumes that are immediately dangerous to life and health is 15 mg/m^3. In the risk analysis from NUREG/CR-6733, a spill of 93% sulfuric acid was not deemed a significant inhalation hazard to workers as long as normal air dilution is available from the facility ventilation system. NUREG/CR-6733 also noted that sulfuric acid reacts vigorously with ammonia, sodium carbonate, and water, which are present at the Smith Ranch CPP/CPF. To minimize the potential for chemical reactions in the unlikely event of simultaneous tank leaks, the sulfuric acid storage tank is located away from other process tanks.

The use of sulfuric acid is subject to threshold planning quantities contained in 40 CFR Part 355, Emergency Response Plans for threshold quantities in excess of 450 kilograms (1,000 pounds). The Smith Ranch operations currently include a sulfuric acid tank with a capacity of 23,000 liters (6,000 gallons). Based on the design capacity, Cameco is subject to the Emergency Response Plan requirements.

7.5.6 Potential Accident Risks Associated with Coal Bed Methane Development

The presence of CBM development at the North Butte and Ruth Remote Satellite license areas presents potential accident risks not commonly associated with uranium ISR, including increased risks of methane seepage, explosions and/or fires.

7.5.6.1 Methane Migration and Seepage

Methane gas can reach the surface by naturally occurring seepage along fault lines, fractures, or sandstone layers in areas where coal beds are shallow. Gas migration could also be enhanced during CBM development in areas along a coal outcrop, which are not present on the North Butte or Ruth Remote Satellite license areas. Non-CBM wells that penetrate the coal seam may provide pathways for migration of methane if the casings or plugs are inadequate or faulty or lack isolation through the coal horizons.

The potential for migration of methane in CBM wells is minimized or prevented by the use of the current CBM industry standards for cementing and casing wells that isolate or protect zones from gas or fluid migration.

Risks from methane associated with oil and gas wells, including CBM wells, are controlled through BLM-mandated conditions of approval for the Application for Permit to Drill that address well conditions, casing, ventilation, and plugging procedures appropriate to site-specific CBM development plans. CBM operators must have emergency plans and employee training programs that address fire prevention and control measures.

7.5.6.2 Potential CBM Pipeline Ruptures

CBM development involves the potential for leaks or ruptures of buried gas pipelines. Most ruptures occur when heavy equipment accidentally strikes the pipeline while operating in close proximity. These ruptures may result in a fire or explosion if a spark or open flame ignites the escaping gas.

The CBM operators monitor the pipeline flows by either remote sensors or daily inspections of flow meters. Routine monitoring reduces the probability of effects to health and safety from ruptures by facilitating the prompt detection of leaks. If pressure losses are detected, the wells are shut in until the problem is isolated and addressed.

Materials used in the pipelines are designed and selected in accordance with applicable standards to minimize the potential for a leak or rupture. Pipeline markers are posted at frequent intervals along the pipelines to warn excavators and to reduce the risk of accidental rupture from excavating equipment.

Cameco will work with the CBM operator located on the license areas to ensure that gas collection and transmission lines within proposed development areas are adequately marked to prevent accidental rupture by ISR activities.

7.6 Potential Population, Social and Economic Effects

The potential population, social and economic effects of operations is discussed in ER Sections 3.10 and 7.0. The SUA-1548 license areas are located in rural remote areas, and the potential population and social effects with the continued operation of Smith Ranch and the construction of Reynolds Ranch and the remote satellites will be minimal. In contrast, the potential economic effects of these activities will be positive and will benefit the state of Wyoming and surrounding communities.

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