5 OPERATIONS

Required NRC licenses and amendments, as well as surety agreements, are issued in the name of Crow Butte Resources, Inc. All CBR operations conform to applicable laws, regulations, and requirements of the various regulatory agencies. The responsibilities described below have been designed to ensure compliance and further implement CBR policy of providing a safe working environment through cost-effective maintenance of radiation exposures ALARA.

5.1 Corporate Organization and Administrative Procedures

CBR will maintain a performance-based approach to the management of the environment and employee health and safety, including radiation safety. The SHEQMS encompasses licensing, compliance, environmental monitoring, industrial hygiene, and health physics programs under one umbrella, and it includes involvement for all employees from the individual worker to senior management. This SHEQMS will allow CBR to operate efficiently and maintain an effective environment, health, and safety program.

Figure 5.1-1 is a partial organization chart for CBR that illustrates the operation of the CPF and associated operations and identifies the management levels that play a key part in the SHEQMS that will also apply to the satellite facility. The personnel identified are responsible for the development, review, approval, implementation, and adherence to operating procedures, radiation safety programs, environmental and groundwater monitoring programs, as well as routine and non-routine maintenance activities. These individuals may also serve a functional part of the Safety and Environmental Review Panel (SERP) described in Section 5.2.3.

Specific responsibilities in the organization are described below.

5.1.1 Board of Directors

The Board of Directors for Crow Butte Resources, Inc. has the ultimate responsibility and authority for radiation safety and environmental compliance for CBR. The Board of Directors sets corporate policy and provides procedural guidance in these areas. The Board of Directors provides operational direction to the President of CBR.

5.1.2 President

The President of Crow Butte Resources, Inc. is responsible for interpreting and acting upon the Board of Directors policy and procedural decisions. The President directly supervises the Crow Butte Resources, Inc. (CBR) General Manager. The President is empowered by the Board of Directors with the responsibility and authority for the radiation safety and environmental compliance programs at the Crow Butte facility. The President is responsible for ensuring that CBR operations staff comply with all applicable regulations and permit/license conditions through direct supervision of the CBR General Manager. The President has overall responsibility for approving the MEA facility design including radiological controls (e.g., ventilation systems) and the manner in which the RSO is integrated into this process.

5.1.3 General Manager

The Crow Butte General Manager is responsible for all uranium production activity at the MEA. The CBR General Manager is also responsible for implementing any industrial and radiation safety and environmental protection programs associated with operations. The CBR General Manager is authorized to immediately implement any action to correct or prevent hazards. The CBR General Manager has the responsibility and the authority to suspend, postpone, or modify (immediately if necessary), any activity determined to be a threat to employees, public health, or the environment, or potentially a violation of state or federal regulations. The CBR General Manager cannot unilaterally override a decision for suspension, postponement, or modification if that decision is made by the Safety Health Environment and Quality Manager (SHEQ Manager) or the RSO. The CBR General Manager reports directly to the President.

Deleted: of Nebraska

5.1.4 Director of Safety, Health, Environment, and Quality

The Director of Safety, Health, Environment, and Quality reports directly to the President and is responsible for ensuring that personnel comply with industrial safety, radiation safety, and environmental and quality programs as required by NRC regulations and established in the Cameco program. The Director of SHEQ has the responsibility and authority to terminate immediately any activity determined to be a threat to employees or public health, the environment, or potentially a violation of state or federal regulations as indicated in reports from the RSO. The Director of SHEQ may also serve as Corporate Radiation Safety Officer (CRSO) and if doing so, shall meet the RSO qualifications described in Section 5.1.6.

5.1.5 Safety, Health, Environment, and Quality Manager

The SHEQ Manager is responsible for health and safety and environmental programs as stated in the SHEQMS and for ensuring that CBR complies with all applicable regulatory requirements. The SHEQ Manager is located at the offices of site operations. This manager is responsible for drafting, approving, and updating SHEQMS procedures annually. The SHEQ Manager reports directly to the General Manager to ensure that the environmental monitoring and protection programs are conducted in a manner consistent with regulatory requirements. This position assists in the development and review of environmental sampling and analysis procedures and is responsible for routine auditing of the programs. The SHEQ Manager also has the responsibility and authority to suspend, postpone, or modify any activity determined to be a threat to employees, public health, or the environment or potentially a violation of state or federal regulations. The SHEQ Manager has no production-related responsibilities.

Deleted: As such, the SHEQ Manager has a secondary reporting requirement to the President.

5.1.6 Radiation Safety Officer

Reporting directly to the General Manager of Operations and secondarily to the Director of SHEQ, the CBR RSO is responsible for the development, administration, and enforcement of all radiation safety programs. The RSO is authorized to conduct inspections and to immediately order any change necessary to preclude or eliminate radiation safety hazards and/or maintain regulatory compliance. The RSO is responsible for the implementation of all on-site environmental programs including emergency procedures. The RSO inspects facilities to verify compliance with all applicable requirements in the areas of radiological health and safety. The RSO works closely with all supervisory personnel to review and approve new equipment and

changes in processes and procedures that may affect radiological safety and to ensure that established programs are maintained. The RSO is also responsible for the collection and interpretation of employee exposure-related monitoring including data from radiological safety. The RSO recommends improvements to any and all radiological safety-related controls. The RSO has no production-related responsibilities, maintaining independence from operations personnel.

5.1.7 Health Physics Technician

The CBR Health Physics Technician (HPT) assists the RSO with the implementation of the radiological and industrial safety programs. The HPT is responsible for the orderly collection and interpretation of all monitoring data, to include data from radiological safety and environmental programs. The HPT reports directly to the RSO. Such personnel would be familiar with operations and receive the necessary radiation safety training, including hands-on training (e.g., use of survey instruments for monitoring items removed from the restricted area; see Section 5.7.6 for additional discussions).

5.1.8 ALARA Program Responsibilities

The purpose of the ALARA program is to keep exposures to all radioactive materials and other hazardous material as low as possible, and to expose as few personnel as possible. This program takes into account the state of technology and the economics of improvements in relation to benefits to the public health, safety, and other societal and socioeconomic considerations, and in relation to the use of atomic energy in the public interest.

In order for an ALARA program to correctly function, all individuals, including management, supervisors, health physics staff, and workers, must take part in and share responsibility for keeping all exposures ALARA. This policy addresses this need and describes the responsibilities of each level in the organization.

5.1.9 Management Responsibilities

Consistent with RG 8.31 (NRC 2002a), CBR senior management is responsible for the development, implementation, and enforcement of applicable rules, policies, and procedures as directed by regulatory agencies and company policies. These responsibilities include the following:

1. The development of a strong commitment to and continuing support of the implementation and operations of the ALARA program
2. An Annual Audit Program which reviews radiation monitoring results, procedural, and operational methods
3. A continuing evaluation of the Health Physics Program including adequate staffing and support
4. Proper training and discussions that address the ALARA program and its function to all facility employees and, when appropriate, to contractors and visitors.

5.1.9.1 Radiation Safety Officer ALARA Responsibility

The RSO is responsible for ensuring the technical adequacy of the radiation protection program, implementation of proper radiation protection measures, and the overall surveillance and maintenance of the ALARA program. The RSO is assigned the following:

1. The responsibility for the development and administration of the ALARA program
2. Enforcement of regulations and administrative policies that affect any radiological aspect of the SHEQMS
3. Assistance with the review and approval of new equipment, process changes, or operating procedures to ensure that the plans do not adversely affect the radiological aspects of the SHEQMS
4. Maintenance of equipment and surveillance programs to ensure continued implementation of the ALARA program
5. Assistance with conducting an Annual ALARA Audit, as discussed in Section 5.3.2, to determine the effectiveness of the program and make any appropriate recommendations or changes as may be dictated by the ALARA philosophy
6. Annual review of all existing operating procedures involving or potentially involving any handling, processing, or storage of radioactive materials to ensure that the procedures are ALARA and do not violate any newly established radiation protection practices
7. Conductance of (or designate a qualified individual to conduct) daily inspections of pertinent facility areas to confirm that general radiation control practices, hygiene, and housekeeping practices are in line with the ALARA principle

5.1.9.2 Supervisor Responsibility

Supervisors shall be the front line for implementing the ALARA program. Each supervisor shall be trained and instructed in the general radiation safety practices and procedures. Their responsibilities include:

1. Adequate training to implement the general philosophy behind the ALARA program
2. Directing and guiding to subordinates in ways to adhere to the ALARA program
3. Enforcing rules and policies as directed by the SHEQMS, which implement the requirements of regulatory agencies and company management
4. Seeking additional help from management and the RSO should radiological problems be deemed by the supervisor to be outside their sphere of training

5.1.9.3 Worker Responsibility

Because success of both the radiation protection and ALARA programs are contingent upon the cooperation and adherence to those policies by the workers themselves, the facility employees must be responsible for certain aspects of the program in order for the program to accomplish its goal of keeping exposures as low as possible. Worker responsibilities include:

1. Adhering to all rules, notices, and operating procedures established by management and the RSO through the SHEQMS
2. Making suggestions which might improve the radiation protection and ALARA programs

3. Reporting promptly, to immediate supervisor, any malfunction of equipment or violation of procedures which could result in an unacceptable increased radiological hazard
4. Properly using protective equipment
5. Properly performing required contamination surveys

5.1.10 Subcontractor Management

Like the CPF, CBR will employ subcontractors to accomplish a variety of tasks at the MEA starting with facility construction and continuing into operations. CBR-subcontractor interactions are governed by the Cameco Resources SHEQ Management System, Contractor Management Program, Document Number CR-CMP. The major elements of that program include:

- Development of a Scope of Work that identifies and addresses Safety, Radiation, Environmental, and Quality objectives
- Cameco review of required subcontractor submissions
- Establishment and control of site access
- Training
- Job Hazard Analyses where appropriate
- Communication with the subcontractor
- Documentation
- Change Control
- Emergency preparedness and response
- Roles and responsibilities
- Supervision and Oversight of Contractor Performance
  - Graded approach
  - Inspections and audits
  - Tracking
  - Non-conformances and corrective actions
- Management reviews

5.2 Management Control Program

5.2.1 Safety Health Environment and Quality Management System (SHEQMS)

The SHEQMS formalizes the approach to environmental, health, and safety management to ensure consistency across its operations. The SHEQMS is a key element in ensuring that all employees demonstrate "due diligence" in addressing environmental, health, and safety issues and describes how the operations of the facility will comply with the Cameco SHEQ Policy and regulatory requirements. The SHEQ Manager, with assistance from the RSO and Safety Supervisor, is responsible for drafting, approving, and updating (as needed) the SHEQMS site-specific procedures annually. More frequent updates may be made if site activities and/or conditions warrant such actions.

The SHEQMS:

- Ensures that sound management practices and processes are in place to sustain strong SHEQ performance
- Clearly sets out and formalizes the expectations of management
- Provides a systematic approach to the identification of issues and ensures that a system of risk identification and management is in place
- Provides a framework for personal, site, and corporate responsibility and leadership
- Provides a systematic approach for the attainment of CBR objectives
- Ensures continued improvement of programs and performance

The SHEQMS has the following characteristics:

- The system is certified to meet the ISO 14001 Environmental Management System Standard.
- The system is straightforward in design, is intended as an effective management tool for all types of activities and operations, and is capable of implementation at all levels of the organization.
- The system is supported by standards that clearly spell out CBR expectations, while leaving the means by which these are attained as a responsibility of line management.
- The system is readily auditable.
- The system is designed to provide a practical tool to assist the operations in identifying and achieving their SHEQ objectives while satisfying CBR government requirements.

The SHEQMS uses a series of standards that align with specific management processes and sets out the minimum expectations for performance. The standards consist of management processes that require assessment, planning, implementation (including training, corrective actions, safe work programs, and emergency response), checking (including auditing, incident investigation, compliance management, and reporting), and management review. These standards meet the recommendations contained in RG 8.2 (NRC 1973).

5.2.1.1 Operating Procedures

CBR has developed procedures consistent with the corporate policies, standards, and regulatory requirements to implement these management controls. The SHEQMS consists of the following standards and operating procedures contained in eight volumes:

Volume 1 – *Standards*
Volume 2 – *Management Procedures*
Volume 3 – *Operating Manual* (SOPs)
Volume 4 – *Health Physics Manual*
Volume 5 – *Industrial Safety Manual*
Volume 6 – *Environmental Manual*
Volume 7 – *Training Manual*
Volume 8 – *Emergency Manual*

Written operating procedures have been developed for all process activities including those involving radioactive materials. Where radioactive material handling is involved, pertinent radiation safety practices are incorporated into the operating procedure. Additionally, written operating procedures have been developed for non-process activities including environmental monitoring, health physics procedures, emergency procedures, and general safety.

The procedures enumerate pertinent radiation safety procedures to be followed. A copy of the written procedure will be kept in the area where it is used. All procedures involving radiation safety will be reviewed and approved in writing by the RSO or another individual with similar qualifications prior to being implemented. The RSO will also perform a documented annual review of the operating procedures.

5.2.1.2 Radiation Work Permits

When employees are required to conduct activities of a non-routine nature where there is the potential for significant exposure to radioactive materials and for which no operating procedure exists, an RWP will be required. The RWP will describe the scope of the work, precautions necessary to maintain radiation exposures to ALARA, and any supplemental radiological monitoring and sampling to be conducted during the work. The RWP shall be reviewed and approved in writing by the RSO (or qualified designee in the absence of the RSO) prior to initiation of the work.

The RSO may also issue Standing Radiation Work Permits (SRWPs) for periodic tasks that require similar radiological protection measures (e.g., maintenance work on a specified facility system). The SRWP will describe the scope of the work, precautions necessary to maintain radiation exposures to ALARA, and any supplemental radiological monitoring and sampling to be conducted during the work. The SRWP shall be reviewed and approved in writing by the RSO (or qualified designee in the absence of the RSO) prior to initiation of the work.

5.2.1.3 Record Keeping and Retention

The SHEQMS Volume II, Management Procedures, provides specific instructions for the proper maintenance, control, and retention of records associated with implementation of the program. The program is consistent with the requirements of 10 CFR 20 Subpart L and 10 CFR §40.61 (d) and (e). Records of surveys, calibrations, personnel monitoring, bioassays, transfers or disposal of source or byproduct material, and transportation accidents will be maintained on site until license termination. Records containing information pertinent to decommissioning and reclamation, such as descriptions of spills, excursions, contamination events, as well as information related to site and aquifer characterization and background radiation levels, will be maintained on site until license termination. Duplicates of all significant records will be maintained in the corporate office or other offsite locations.

5.2.2 Performance Based License Condition

This license application is the basis of the Performance-Based License (PBL) originally issued in 1998. Under that license, CBR may, without prior NRC approval or the need to obtain a License Amendment:

1. Make changes to the facility or process, as presented in the license application (as updated)

2. Make changes in the procedures presented in the license application (as updated)
3. Conduct tests or experiments not presented in the license application (as updated).

A License Amendment and/or NRC approval will be necessary prior to implementing a proposed change, test, or experiment if the change, test, or experiment would:

1. Result in any appreciable increase in the frequency of occurrence of an accident previously evaluated in the license application (as updated)
2. Result in any appreciable increase in the likelihood of occurrence of a malfunction of a structure, system, or component (SSC) important to safety previously evaluated in the license application (as updated)
3. Result in any appreciable increase in the consequences of an accident previously evaluated in the license application (as updated)
4. Result in any appreciable increase in the consequences of a malfunction of an SSC previously evaluated in the license application (as updated)
5. Create a possibility for an accident of a different type than any previously evaluated in the license application (as updated)
6. Create a possibility for a malfunction of an SSC with a different result than previously evaluated in the license application (as updated)
7. Result in a departure from the method of evaluation described in the license application (as updated) used in establishing the final SER or the EA or technical evaluation reports (TERs) or other analysis and evaluations for license amendments
8. For purposes of this paragraph as applied to this license, SSC means any SSC that has been referenced in a staff SER, TER, EA, or environmental impact statement (EIS) and supplements and amendments thereof.

Additionally, CBR must obtain a license amendment unless the change, test, or experiment is consistent with the NRC conclusions, or the basis of, or analysis leading to, the conclusions of actions, designs, or design configurations analyzed and selected in the site or facility SER, TERs, EIS, or EA. This would include all supplements and amendments, and TERs, EAs, and EISs issued with amendments to this license.

5.2.3 Safety and Environmental Review Panel

A SERP will determination compliance concerning the conditions discussed in Section 5.2.2. The SERP will consist of a minimum of three individuals. One member of the SERP will have expertise in management and will be responsible for managerial and financial approval for changes, one member will have expertise in operations and/or construction and in implementation of any changes, and one member will be the RSO or equivalent. Other members of the SERP may be employed as appropriate to address technical aspects of the change, experiment, or test in several areas, such as health physics, groundwater hydrology, surface water hydrology, specific earth sciences, and others. Temporary members, or permanent members other than the three identified above, may be consultants.

The SERP is responsible for monitoring any proposed change in the facility or process, changing procedures, and conducting tests or experiments not contained in the current NRC license. As such, they are responsible for ensuring that any such change results in no degradation in the essential safety or environmental commitments of CBR.

5.2.3.1 Safety and Environmental Review Panel Review Procedures

The SERP will implement the following review procedures for the evaluation of all appropriate changes to the facility operations as outlined in the SHEQMS Volume II, Management Procedures. The SERP may delegate any portion of these responsibilities to a committee of two or more members of the SERP. Any committees so constituted will report their findings to the full SERP for a determination of compliance with Section 5.2.2 of this chapter. In their documented review of whether a potential change, test, or experiment (hereinafter called the change) is allowed under the PBL (or Performance Based License Condition [PBLC]) without a license amendment, the SERP shall consider the following.

Current NRC License Requirements

The SERP will review the most current NRC license conditions to assess which, if any, conditions will have an impact on or will be impacted by the potential SERP action. If the SERP action will conflict with a specific license requirement, then a license amendment is necessary before initiating the change. This review includes information included in the approved license application.

Ability to Meet NRC Regulations

The SERP will determine if the change, test, or experiment conflicts with applicable NRC regulations (example: 10 CFR Parts 20 and 40 requirements). If the SERP action conflicts with NRC regulations, a license amendment is necessary.

Licensing Basis

The SERP will review whether the change, test, or experiment is consistent with NRC conclusions regarding actions analyzed and selected in the licensing basis. Documents that the SERP must review in conducting this evaluation include the SER and EA prepared in support of the license renewal application (February 1998) and any SERs, TERs, EAs, or EISs prepared to support amendments to the license. The RSO will maintain a current copy of all pertinent documents for review by the SERP during these evaluations.

Financial Surety

The SERP will review the proposed action to determine if any adjustment to financial surety arrangement or approved amount is required. If the proposed action will require an increase to the existing surety amount, the financial surety instrument must be increased accordingly before the change can be approved. The surety estimate must be updated either through a license amendment or through the course of the annual surety update to the NRC. The NRC incorporates the annual surety update by license amendment.

Essential Safety and Environmental Commitments

The SERP will ensure that there is no degradation in the essential safety or environmental commitment in the license application, or as provided by the approved reclamation plan.

5.2.3.2 Documentation of SERP Review Process

After the SERP reviews a proposed action, it will document its findings, recommendations, and conclusions in a written report format. All members of the SERP shall sign concurrence on the final report. If the report concludes that the action meets the appropriate PBL or PBLC requirements and does not require a license amendment, the proposed action may then be implemented. If the report concludes that a license amendment is necessary before implementing the action, the report will document the reasons why, and what course CBR plans to pursue. The SERP report shall include the following:

- A description of the proposed change, test, or experiment (proposed action)
- A listing of all SERP members conducting the review and their qualifications (if a consultant or other member not previously qualified)
- The technical evaluation of the proposed action, including all aspects of the SERP review procedures listed above
- Conclusions and recommendations
- Signatory approvals of the SERP members
- Any attachments such as all applicable technical, environmental, or safety evaluations, reports, or other relevant information including consultant reports.

All SERP reports and associated records of any changes made pursuant to the PBL or PBLC shall be maintained through termination of the NRC license.

CBR will submit an annual report to the NRC that describes all changes, tests, or experiments made pursuant to the PBL or PBLC. The report will include a summary of the SERP evaluation of each change. In addition, CBR will annually submit any pages of the license renewal application to reflect changes to the license renewal application or supplementary information. Each replacement page shall include both a change indicator for the area of change (e.g., bold marking vertically in the margin adjacent to the portion actually changed) and page change identification (date of change, change number, or both).

5.3 Management Audit and Inspection Program

The following internal inspections, audits, and reports are performed for the Crow Butte Project operations. Similar activities will be performed for the MEA.

5.3.1 Radiation Safety Inspections

5.3.1.1 Daily and Weekly Inspections

The RSO and the facility foreman, or designees, should conduct a weekly inspection of all facility areas to observe general radiation control practices and review required changes in procedures and equipment. The RSO, HPT, or qualified designee should conduct a daily walk-through (visual) inspection of all work and storage areas of the facility to ensure proper implementation of

good radiation safety procedures, including good housekeeping and cleanup practices that would minimize unnecessary contamination. Problems observed during all inspections should be noted in writing in an inspection logbook or other retrievable record format. The entries should be dated, signed, and maintained on file for at least 1 year. The RSO should review all violations of radiation safety procedures or other potentially hazardous problems with the resident manager or other mine employees who have authority to correct the problem. Also, the RSO should review the daily work order and shift logs regularly to determine that all jobs and operations with a potential for exposing personnel to uranium, especially those RWP jobs that would require a radiation survey and monitoring, were approved in writing by the RSO, the RSO staff, or the RSO designee prior to initiation of work.

5.3.1.2 Monthly Reviews

At least monthly, the RSO should review the results of daily and weekly inspections, including a review of all monitoring and exposure data for the month. The RSO should provide to the resident manager and all department heads for their review a written summary of the month's significant worker protection activities that contains (1) a summary of the most recent personnel exposure data, including bioassays and time-weighted calculations, and (2) a summary of all pertinent radiation survey records.

In addition, the monthly summary report should specifically address any trends or deviations from the radiation protection and ALARA program, including an evaluation of the adequacy of license conditions regarding radiation protection and ALARA. The summary should describe unresolved problems and the proposed corrective measures. Monthly summary reports should be maintained on file and readily accessible for at least 5 years.

5.3.2 Annual ALARA Audits

CBR will conduct annual audits of the radiation safety and ALARA programs. The Manager of SHEQ may conduct these audits. Alternatively, CBR may employ qualified personnel from other uranium recovery facilities or an outside radiation protection auditing service to conduct these audits. The purpose of the audits is to confirm that all radiation health protection procedures and license condition requirements are being conducted properly at the Crow Butte Uranium Project facility. Any outside personnel employed for this purpose will be qualified in radiation safety procedures as well as environmental aspects of solution mining operations. Whether conducted internally or through the use of an audit service, the auditor will meet the same minimum qualifications for education and experience as for the RSO as described in Section 5.4.

The audit of the radiation protection and ALARA program is conducted in accordance with the recommendations contained in RG 8.31. A written report of the results is submitted to corporate management. The RSO may accompany the auditor but may not participate in the documentation of conclusions.

The audit report should summarize the following data:

- Employee exposure records (external and time-weighted calculations)
- Bioassay results
- Inspection log entries and summary reports of daily, weekly, and monthly inspections

- Documented training program activities
- Radiation safety meeting reports
- Radiological survey and sampling data
- Reports on overexposure of workers submitted to the NRC
- Operating procedures that were reviewed during this time period

The report on the annual radiation protection and ALARA audit will specifically discuss the following:

- Trends in personal exposures for identifiable categories of workers and types of operational activities
- Whether equipment for exposure control is being properly used, maintained, and inspected
- Recommendations on ways to further reduce personnel exposures from uranium and its daughters

The ALARA audit report specifically discusses the following:

- Trends in personnel exposures
- Proper use, maintenance, and inspection of equipment used for exposure control
- Recommendations on ways to further reduce personnel exposures from uranium and its daughters

The ALARA audit report is submitted to and reviewed by the President and General Manager. Implementations of the recommendations to further reduce employee exposures, or improvements to the ALARA program, are discussed with the ALARA auditor.

Annual audits will be performed to verify implementation of the quality assurance program, as required by Chapter 2, Section 2.9.4 of CBR's SHEQMS Volume IV Annual ALARA Audits (CBR 2011). The audits are reviewed by facility and corporate management. The Quality Assurance/Quality Control (QA/QC) program is audited annually as per part of CBR's Annual ALARA Audits required by Section 5 of Chapter SHEQ-20 of CBR's Volume II of the SHEQMS manual (CBR 2009)

An individual qualified in analytical and monitoring techniques who does not have direct responsibilities in the areas being audited performs the audit. Results of the QA/QC audit are documented with the ALARA Audit. The RSO has the primary responsibility for the implementation of the radiological QA/QC programs at the Crow Butte Uranium Project facilities. CBR's radiation quality assurance program is discussed in Section 2.9 of Volume IV (Health Physics Manual) of the SHEQMS. The results of the audit, including deficient areas, shall be addressed and appropriate practices implemented to ensure correctness and validity of sampling.

The RSO has the ultimate responsibility for ensuring that the NRC radiological standards are being met at the MEA. The Lead Operator at the satellite facility or wellfield operations would have the responsibility for responding to any spill requiring cleanup. Facility operators and

wellfield operators who have received spill response training would conduct the cleanup operations.

The proposed management audit and inspection programs for the satellite facility would be sufficient for the type of operations and number and type of employees. CBR has projected that the staffing level for the satellite facility would be 12 full-time CBR staff members to staff three employees per 12-hour shift (one Lead Operator and two facility operators). These new employees will be needed for the satellite facility, wellfield operations, and maintenance positions. Other staff members working out of the CPF that would occasionally visit the satellite facility and associated wellfield would include the RSO, HPT, Safety Supervisor, SHEQ Manager, as well as various technical and managerial staff members.

5.4 Health Physics Staff Qualifications

CBR project staff is highly experienced in the management of uranium development, mining and operations. The following minimum personnel specifications and qualifications are strictly adhered to.

5.4.1 Radiation Safety Officer Qualifications

The minimum qualifications for the RSO are as follows:

- Education: A bachelor's degree in the physical sciences, industrial hygiene, or engineering from an accredited college or university or an equivalent combination of training and relevant experience in uranium recovery facility radiation protection. Two years of relevant experience are generally considered equivalent to one year of academic study.
- Health Physics Experience: At least 1 year of work experience relevant to uranium recovery operations in applied health physics, radiation protection, industrial hygiene, or similar work. This experience should involve actual work with radiation detection and measurement equipment, not strictly administrative or "desk" work.
- Specialized Training: At least four weeks of specialized classroom training in health physics specifically applicable to uranium recovery. In addition, the RSO should attend refresher training on uranium recovery facility health physics every 2 years.
- Specialized Knowledge: A thorough knowledge of the proper application and use of all health physics equipment used in the uranium recovery facility, the chemical and analytical procedures used for radiological sampling and monitoring, methodologies used to calculate personnel exposure to uranium and its daughters, and a thorough understanding of the uranium recovery process and equipment used in the facility and how hazards are generated and controlled during the uranium recovery process.

5.4.2 Health Physics Technician Qualifications

In addition to the RSO, there should be a minimum of one full-time health physics technician at any full-scale operating uranium recovery facility. The health physics technician should have **one** of the following combinations of education, training, and experience:

- Education: An associate's degree or 2 or more years of study in the physical sciences, engineering, or a health-related field
- Training: A total of at least 4 weeks of generalized training (up to 2 weeks may be on-the-job training) in radiation health protection applicable to uranium recovery facilities
- Experience: One year of work experience using sampling and analytical laboratory procedures that involve health physics, industrial hygiene, or industrial safety measures to be applied in a uranium recovery facility

OR

- Education: A high school diploma;
- Training: A total of at least 3 months of specialized training (up to 1 month may be on-the-job training) in radiation health protection relevant to uranium recovery facilities; and
- Experience: Two years of relevant work experience in applied radiation protection.

The health physics technician should demonstrate a working knowledge of the proper operation of health physics instruments used in the uranium recovery facility, surveying and sampling techniques, and personnel dosimetry requirements.

5.5 Radiation Safety Training

All site employees and contractor personnel at the CPF are administered a training program based upon the SHEQMS covering radiation safety, radioactive material handling, and radiological emergency procedures. The CBR Training Program in the SHEQMS Volume VII, Training Manual, provides requirements for radiation safety training. The training program is administered in keeping with standard radiological protection guidelines and the guidance provided in RG 8.29, RG 8.31, and RG 8.13 (NRC 1996, 2002a, and 1999a). The technical content of the training program is under the direction of the RSO. The RSO or an HPT conducts all radiation safety training. CBR will implement this training program for activities at the MEA.

5.5.1 Training Program Content

5.5.1.1 Visitors

Visitors to the site who have not received training are escorted by onsite personnel properly trained and knowledgeable about the hazards of the facility. At a minimum, visitors are instructed specifically on what they should do to avoid possible hazards in the area of the facilities that they are visiting.

5.5.1.2 Contractors

Any contractors having work assignments at the facilities are given appropriate radiological safety training. Contract workers who will be performing work on heavily contaminated equipment receive the same training normally required of Crow Butte employees as discussed in Section 5.5.1.3.

5.5.1.3 Crow Butte Resources Employees

All CBR employees (and some contractors as noted in Section 5.5.1.2) receive training as radiation workers. The program incorporates the following topics recommended in RG 8.31:

1. Fundamentals of Health Protection
   - The radiologic and toxic hazards of exposure to uranium and its daughters,
   - How uranium and its daughters enter the body (inhalation, ingestion, and skin penetration)
   - Why exposures to uranium and its daughters should be kept ALARA.

2. Personal Hygiene at Uranium Recovery Facilities
   - Wearing protective clothing,
   - Using respiratory protective equipment correctly,
   - Eating, drinking, and smoking only in designated area,
   - Using proper methods for decontamination (i.e., showers).

3. Facility-Provided Protection
   - Ventilation systems and effluent controls,
   - Cleanliness of the work place,
   - Features designed for radiation safety for process equipment,
   - Standard operating procedures,
   - Security and access control to designated areas,
   - Electronic data gathering and storage,
   - Automated processes.

4. Health Protection Measurements
   - Measurement of airborne radioactive materials,
   - Bioassays to detect uranium (urinalysis and in vivo counting),
   - Surveys to detect contamination of personnel and equipment,
   - Personnel dosimetry.

5. Radiation Protection Regulations
   - Regulatory authority of NRC, the Occupational Safety and Health Administration (OSHA), and the state,
   - Employee rights in 10 CFR Part 19,
   - Radiation protection requirements in 10 CFR Part 20.

6. Emergency Procedures.

All new workers, including supervisors, are given specialized instruction on the health and safety aspects of the specific jobs they will perform. Instruction is provided in the form of individualized on-the-job training. Retraining is performed annually and documented. Every 2 months, all workers attend a general safety meeting.

Consistent with Regulatory Guide 8.13, Appendix A, it is CBR policy to accommodate pregnant workers when possible. To that end, CBR uses the following approach to address potential and actual prenatal exposure risks:

Deleted: Consistent with USNRC RG 8.13, Instruction Concerning Prenatal Radiation Exposure (Revision 3, June 1999), all female workers and those supervisors who will work with them will be given specific instruction about prenatal exposure risks to the developing embryo and fetus.¶

- Instructions
  - Give to all female new hires
  - Give to supervisors in charge of female workers
  - Provide prenatal instruction
  - Provide RG 8.13 and its appendix, review with worker
  - Provide opportunity to ask questions
  - Discuss possible effect on job status, which may involve adjustment of work duties as necessary
- Written declaration
  - View prenatal instructions again and review RG 8.13
  - Review worker-specific exposure monitoring (e.g., dosimetry, bioassay where appropriate) following declaration
  - Adjust work duties as necessary

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5.5.2 Testing Requirements

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A written test with questions directly relevant to the principals of radiation safety and health protection in the facility covered in the training course is given to each worker. The instructor reviews the test results with each worker and discusses incorrect answers to the questions with the worker until the worker understands the correct answer. Workers who fail the exam are retested, and test results remain on file.

5.5.3 On-The-Job Training

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5.5.3.1 Health Physics Technician

On-the-job training is provided to HPTs in radiation exposure monitoring and exposure determination programs, instrument calibration, facility inspections, posting requirements, respirator programs and Health Physics Procedures contained in the SHEQMS Volume IV, Health Physics Manual.

5.5.3.2 Refresher Training

Following initial radiation safety training, all permanent employees and long-term contractors receive ongoing radiation safety training as part of the annual refresher training and, if determined necessary by the RSO, during monthly safety meetings. This ongoing training is used to discuss problems and questions that have arisen, any relevant information or regulations that have changed, exposure trends, and other pertinent topics.

5.5.3.3 Training Records

Records of training are kept until license termination for all employees trained as radiation workers (i.e., occupationally exposed employees).

5.6 Security

CBR security measures for the current operation are specified in the Security Plan and Security Threat chapter in the SHEQMS Volume VIII, Emergency Manual. CBR is committed to:

- Providing employees with a safe, healthful, and secure working environment;
- Maintaining control and security of NRC licensed material;
- Ensuring the safe and secure handling and transporting of hazardous materials; and
- Managing records and documents that may contain sensitive and confidential information.

The NRC requires licensees to maintain control over licensed material (i.e., natural uranium ["source material"] and byproduct material defined in 10 CFR §40.4). 10 CFR 20, Subpart I, Storage and Control of Licensed Material, requires the following:

§20.1801 Security of Stored Material

The licensee shall secure from unauthorized removal or access licensed materials that are stored in controlled or unrestricted areas.

§20.1802 Control of Material Not in Storage

The licensee shall control and maintain constant surveillance of licensed material that is in a controlled or unrestricted area and that is not in storage.

Stored licensed material at the CPF would include uranium packaged for shipment from the facility or byproduct materials awaiting disposal. Examples of material not in storage would include yellowcake slurry or loaded IX resin removed from the restricted area for transfer to other areas.

At the satellite facility, licensed stored material would typically include loaded IX resin and byproduct waste awaiting disposal. Lixiviant would be found in production piping in the wellfield and wellhouses, production trunkline to the satellite facility, and within piping located in the satellite building. Loaded IX resin would be placed in a transport truck and temporarily stored in the vehicle until the truck is filled and ready for delivery to the CPF.

5.6.1 License Area and Facility Security

5.6.1.1 MEA Security

Security at the MEA site will be consistent with policies and procedures used at the CBR current operating site. The security systems used at the current site and proposed for the MEA site are sufficient to prevent unauthorized entry into a) controlled areas and b) restricted areas. As defined in 10 CFR 20.1003, a "controlled area" refers to an area outside a restricted area but within the site boundary, to which the licensee can limit access for any reason. A "restricted area" refers to any area to which access is controlled for the protection of individuals from exposure to radiation and radioactive materials.

CBR's security program has acceptable passive controls (such as perimeter fencing for wellfields) and active controls (such as daily inspections and locks on facility buildings). These security measures have been demonstrated to prevent unauthorized entry in controlled areas in accordance with 10 CFR Part 20, Subpart I.

Entrance to the MEA will be via Squaw Mound Road west of the facility. The entrance to the site will be posted indicating that permission is required prior to entry. A gate on the access route

will be locked when not in use. The satellite facility site within the license area will be properly posted in accordance with 10 CFR § 20.1902 (e). The primary and alternate access routes to the satellite facility are shown on **Figure 4.2-1** and discussed in Sections 4.2.1.13 and 7.2.1.

Similar to the existing Crow Butte Operation, other than access through the main gate, there are two means by which members of the public could gain access to the site. First, for those members of the general public traveling public roads adjacent to the license area, access is controlled by perimeter fences on one or both sides of the roads. These fences are posted with signs.

For the abutting ranchers who have leased property to Cameco (lessors), a second approach is used to control access. Prior to putting an MU into production, the area is closed to grazing or haying until the MU has been decommissioned and reclaimed. To accomplish this, Cameco uses a combination of existing and/or new perimeter fencing specific to each MU. Any new perimeter fencing will include appropriate signage advising of access restrictions prior to production.

The Restricted area at the satellite facility refers to *"…an area where access to is limited by the licensee for the purpose of protecting individuals against undue risks from exposure to radiation and radioactive materials"* (10 CFR 20.1003). Proposed restricted areas for the satellite facility are shown on **Figures 5.7-2**. Each radiation area will be posted with a conspicuous sign or signs bearing the radiation symbol and the words "CAUTION, RADIATION AREA" (10 CFR 20.1902). Radiological warnings are posted based upon actual or likely conditions. Actual conditions are determined through area monitoring. Likely conditions are identified based on professional judgment or experience regarding the probability of a radiological condition. When evaluating the likelihood of specific conditions, normal situations and unique situations that can reasonably be expected to occur will be considered.

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Deleted: The security fence surrounding the satellite facility serves as a control for industrial/property protection purposes with the restricted area noted in red on **Figures 1.7-5 and 5.7-2**. Fencing around the wellfield will control access and protect industrial property. Appropriate signage will be placed on all fencing advising of access restrictions.¶

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All visitors, contractors, or inspectors entering the satellite facility site will be required to register at the facility office and will not be permitted inside the facility or wellfield areas without proper authorization. All visitors needing safety equipment, such as hardhats and safety glasses, will be issued the items by company personnel. Inexperienced visitors will be escorted within the controlled area of the facility unless they are frequent visitors who have been instructed regarding the potential hazards in various site areas. All appropriate and necessary safety or radiological training will be provided and documented by the RSO or designee. Training requirements associated with visitors and contractors are discussed in Section 5.5.

The satellite facility will routinely operate 24 hours per day and 7 days per week, so that CBR employees will normally be on site except for occasional shutdowns. The satellite facility structure will be equipped with locks to prevent unauthorized access. All facility personnel are instructed to immediately report any unauthorized persons to their supervisors. The supervisor will contact the reported unauthorized person and make sure that they have been authorized for entry. If the person is unauthorized they will be escorted to the main entrance for departure.

Access by unauthorized personnel to the stored and non-stored licensed materials (pregnant lixiviant solution, loaded IX resin, and byproduct material awaiting disposal) would be controlled by perimeter access gates with locks and site personnel. This would include piping, process vessels, tankage, and any truck vehicle containing loaded IX resin and parked within or near the satellite facility building.

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

CBR maintains and enforces requirements of the SHEQMS, Volume IV Health Physics Manual, which specify access controls and security issues applicable to visitors, contractors and employees, radiological posting, and radiological survey and monitoring requirements associated with activities at the site.

Even without consideration of reduced exposures due to the security measures discussed above, the highest estimated total effective dose equivalent (TEDE), as determined using methods described in Section 7.3.3, for a downwind receptor at the south boundary of the MEA license boundary is 65 (**Figure 4.12-2**). The highest dose rate at occupied residences was 25 mRem/yr for Occupied Resident #2, and for unoccupied residences, 33 mRem/yr for Unoccupied Residence #1: **Figure 4.12-2**). This is based on an occupancy factor of 100 percent or 8,760 hours per year. The average dose rate from the nearby ISR facilities was 2 mRem/yr. It is unlikely that even frequent visitors to the MEA could receive annual doses near the 100 mRem/yr public dose limit. For comparison, exposure to naturally occurring background radiation from cosmic and terrestrial sources is approximately 365 mRem/yr.

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5.6.1.2 Transportation Security

CBR routinely receives, stores, uses, and ships hazardous materials as defined by the U.S. DOT. In addition to the packaging and shipping requirements contained in the DOT Hazardous Materials Regulations (HMR), 49 CFR 172, Subpart I, Security Plans, requires that persons that offer for transportation or transport certain hazardous materials develop a Security Plan. Shipments may qualify for this DOT requirement under the following categories:

§172.800(b) (4) A shipment of a quantity of hazardous materials in a bulk package having a capacity equal to or greater than 13,248 L (3,500 gallons) for liquids or gases or more than 13.24 cubic meters (468 cubic feet) for solids;

§172.800(b) (5) A shipment in other than a bulk packaging of 2,268 kg (5,000 pounds) gross weight or more of one class of hazardous material for which placarding of a vehicle, rail car, or freight container is required for that class under the provisions of subpart F of this part;

§172.800(b) (7) A quantity of hazardous material that requires placarding under the provisions of subpart F of this part.

DOT requires that Security Plans assess the possible transportation security risks and evaluate appropriate measures to address those risks. All hazardous materials shippers and transporters subject to these standards must provide personnel security by screening applicable job applicants, prevent unauthorized access to the hazardous materials or vehicles being prepared for shipment, and provide for en route security. Companies must also train appropriate personnel in the elements of the Security Plan.

Transport of licensed/hazardous material by CBR employees will generally be restricted to moving IX resin from a satellite facility to the CPF or transferring contaminated equipment between company facilities. This transport generally occurs over short distances through remote areas. Therefore, the potential for a security threat during transport in a CBR vehicle is minimal. The goal of the driver, cargo, and equipment security measures is to ensure the safety of the driver and the security and integrity of the cargo from the point of origin to the final destination by:

- Clearly communicating general point-to-point security procedures and guidelines to all drivers and non-driving personnel
- Providing the means and methods of protecting the drivers, vehicles, and customer cargo while on the road
- Establishing consistent security guidelines and procedures that shall be observed by all personnel.

For the security of all tractors and trailers, the following will be adhered to:

- If material is stored in the vehicle, access must be secured at all openings with locks and/or tamper indicators.
- Offsite tractors will always be secured when left unattended, with windows closed, doors locked, the engine shut off, and no keys or spare keys in or on the vehicle.
- The vehicle is to be kept visible by an employee at all times when left unattended outside a restricted area.

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

5.7 Radiation Safety Controls and Monitoring

CBR has a strong corporate commitment to and support for the implementation of the radiological control program at the Crow Butte Uranium Project facilities. This corporate commitment to maintaining personnel exposures ALARA has been incorporated into the radiation safety controls and monitoring programs described in the following sections.

To that end, Cameco is procuring instrumentation and other required equipment and has undertaken a sampling program to evaluate a variety of radiation protection issues raised in the context of the Crow Butte license renewal. The sampling plan identifies the sample type, location, equipment frequency/duration, and LLDs. In addition, the sampling plan presents objectives and purposes, components of the dose assessment, and a decision rule/path forward.

In summary, the sampling plan will provide site-specific data to evaluate:

- Dose to public
- Dose to office workers, lab workers, wellfield workers, and wellfield construction personnel
- Implications to worker dose from in growth of short-lived beta-emitting isotopes

- Implication of short-lived beta-emitting isotopes to contamination control, for both personal contamination and for free release of objects
- Implications of isotope mixtures in establishing the site-specific DAC
- Potential to use radium-226 concentrations in pregnant lixiviant as a component of 10 CFR 40.64 effluent reporting.

As elements of the sampling plan are completed, Cameco will provide data and propose program revisions where necessary for NRC consideration. Following deliberation, appropriate license amendments will be prepared. Where needed, these amendments to the base license will be implemented at the MEA. Because the existing program will continue until the various sampling activities are complete and NRC concurs with appropriate program modifications, the following text reflects current practice.

5.7.1 Effluent Control Techniques

5.7.1.1 Gaseous and Airborne Particulate Effluents

Under routine operations, the only radioactive effluent at the satellite facility will be the release of radon-222 gas from the production solutions. Uranium product will be eluted and processed at the CPF, where a vacuum dryer is used for drying the yellowcake product. Therefore, there will be no airborne particulate effluent from the satellite facility.

The radon-222 is found in the pregnant lixiviant that comes from the wellfield into the satellite facility. The production flow will be directed to the satellite facility process building for separation of the uranium. The uranium will be separated by passing the recovery solution through pressurized downflow IX units. The vents from the individual vessels will be connected to a manifold that will be exhausted outside the satellite facility building through the facility stack.

Venting to the atmosphere outside of the facility building minimizes personnel exposure. Small amounts of radon-222 may be released in the satellite facility building during solution spills, filter changes, IX resin transfer operations, and maintenance activities. The satellite facility building will be equipped with exhaust fans to remove any radon that may be released in the building. No significant personnel exposure to radon gas is expected based on operating experience from similar facilities. Ventilation and effluent control equipment will be inspected for proper operation as recommended in RG 3.56 (NRC 1986). Ventilation and effluent control equipment will be inspected during radiation safety inspections as discussed in Section 5.3.1.

One process area at the proposed MEA where small quantities of airborne uranium particulates have the potential for occurring is the resin transfer station, where minor spills may occur. The loaded IX resin is transferred to a truck for transport to the CPF for completion of uranium recovery. Spills can occur during resin transfer, and this is where exposure to uranium particulates is possible. All spills will be cleaned up as soon as possible to prevent the wet materials from drying and creating the potential for airborne particulates. Spills associated with resin transfer would involve the impregnated resin itself. The uranium is still bound to the resin at this stage, reducing the potential of employee exposure.

5.7.1.2 Liquid Effluents

The liquid effluents from the satellite facility can be classified as follows:

- Water generated during well development - This water is recovered groundwater and has not been exposed to any mining process or chemicals. The water will be discharged directly to the well work-over fluid tank and silt, fines, and other natural suspended matter collected during well development will settle out.
- Liquid process waste - The operation of the satellite facility results in one primary source of liquid waste: a production bleed stream. The production bleed will be disposed of in the DDW permitted under the NDEQ Class I UIC Program.
- Aquifer restoration - Restoration of the affected aquifer following mining operations results in the production of wastewater. The current groundwater restoration plan consists of four activities: 1) Groundwater transfer; 2) Groundwater sweep; 3) Groundwater treatment; and, 4) Wellfield recirculation. Only the groundwater sweep and groundwater treatment activities will generate wastewater.

During groundwater sweep, water would be extracted from the mining zone without injection, causing an influx of baseline quality water to sweep the affected mining area. The extracted water must be sent to the wastewater disposal system during this activity (i.e., deep well disposal injection). Historically Crow Butte has not used groundwater sweep, but this option could be used in the future if warranted. As has been the case with past operations at Crow Butte, it is anticipated that during restoration groundwater at the MEA will be treated using IX and RO. Using this method, there would be no water consumption, and only the bleed has to be disposed, with the rest of the treated water being reinjected.

Groundwater treatment activities involve the use of process equipment to lower the ion concentration of the groundwater in the affected mining area. An RO unit is typically used to reduce the TDS of the groundwater. The RO unit produces clean water (permeate) and brine. Permeate is normally injected into the formation but, under certain circumstances, may be disposed of in the wastewater disposal system. The brine is sent to the wastewater disposal system. There are no plans for land application as an alternate groundwater disposal option.

The existing NRC Source Materials License allows CBR to dispose of wastewater from the CPF by three methods:

- Evaporation from the evaporation ponds
- Deep well injection
- Land application.

At the MEA, CBR proposes to handle liquid effluents from the satellite facility using only deep well injection.

5.7.1.3 Spill Contingency Plans

The RSO is charged with the responsibility to develop and implement appropriate procedures to handle potential spills of radioactive materials. Personnel representing the engineering and operations functions of the Crow Butte Uranium Project facility will assist the RSO in this effort. Basic responsibilities include:

- Assignment of resources and manpower
- Responsibility for materials inventory
- Responsibility for identifying potential spill sources
- Establishment of spill reporting procedures and visual inspection programs
- Review of past incidents of spills
- Coordination of all departments in carrying out goals of containing potential spills
- Establishment of employee emergency response training programs
- Responsibility for program implementation and subsequent review and updating
- Review of new construction and process changes relative to spill prevention and control.

Spills can take two forms within an *in-situ* uranium mining facility: 1) surface spills such as tank failures, piping ruptures, transportation accidents, and other incidents; and 2) subsurface releases such as a well excursion, in which process chemicals migrate beyond the wellfield, or a pond liner leak resulting in a subsurface release of waste solutions.

Engineering and administrative controls are currently in place to prevent both surface and subsurface releases to the environment and to mitigate the effects should a release occur. Where appropriate, similar controls will be instituted for the satellite facility.

Supervisory personnel, satellite facility operators, and wellfield operators receive spill response training for release of radiological and non-radiological materials. In the event of a spill, a designated supervisor (dependent upon location of spill) would take the lead, providing guidance and direction to the facility operators responding to the spill. Supervisory personnel take guidance and direction from the RSO, Safety Supervisor, and SHEQ Manager, as applicable.

Surface Releases

Failure of process tanks - Any failures of process tanks will be contained within the satellite building. The entire building will drain to a sump that will allow transfer of the spilled solutions to appropriate tankage or DDW.

Surface Releases - The most common form of surface releases from ISR mining operations occurs from breaks, leaks, or separations within the piping system that transfers mining fluids between the CPF and the wellfield. These are generally small, short-duration releases because engineering controls detect pressure changes in the piping systems and alert the facility operators through system alarms.

In general, piping from the satellite facility to and within the wellfield will be constructed of PVC or HDPE pipe with butt-welded joints or an equivalent. All pipelines will be pressure-tested at operating pressures prior to operation. It is unlikely that a break would occur in a buried section of line because no additional stress is placed on the pipes. In addition, underground pipelines will be protected from vehicles driving over the lines, which could cause breaks. The only exposed pipes will be at the satellite process facility, the wellheads, and in the wellhouses. Trunkline flows and wellhead pressures will be monitored for process control. Spill response is specifically addressed in the Radiological Emergencies and Emergency Reporting chapters of SHEQMS Volume VIII, Emergency Manual.

CBR spill control programs have been very effective at limiting surface releases from mining operations. CBR has never had a spill that was reportable under 10 CFR 20 requirements. All spills are analyzed for root causes and contributing factors. Periodically, the CBR SERP meets to analyze recent spill events and to determine whether engineering or administrative improvements are indicated to reduce the frequency and magnitude of spills.

Releases Associated With Transportation

The Transportation Emergencies chapter of the SHEQMS Volume VIII, Emergency Manual, provides the CBR emergency action plan for responding to a transportation accident involving a radioactive materials shipment. The chapter provides instructions for proper packaging, documentation, driver emergency and accident response procedures, and cleanup and recovery actions. This chapter currently includes instructions that specifically address the CBR emergency action plan for responding to a transportation accident involving a shipment of eluent or IX resin en route to or from the CPF. Tanker trailers used for transportation of IX resin between the satellite facility and the CPF will meet or exceed DOT and NRC requirements.

The worst-case transportation accident would involve a failure of the tanker, spilling the entire contents of uranium-loaded resin en route to the CPF. The wet resin with the chemically bonded uranium would be confined to the immediate vicinity of the accident and would not become an airborne hazard. The close proximity of any accident to the CPF would ensure the rapid response of cleanup crews to contain and retrieve any spilled material.

Sub-Surface Releases

Well Excursions - Mining fluids are normally maintained in the production aquifer within the immediate vicinity of the wellfield. The function of the encircling monitor well ring is to detect any mining solutions that may migrate away from the production area due to fluid pressure imbalance. This system has been proven to function satisfactorily over many years of operating experience with ISR mining.

At the satellite facility, an undetected excursion will be highly unlikely. A ring of perimeter monitor wells located no farther than 300 feet from the wellfield and screened in the ore-bearing Chadron Aquifer will surround all wellfields. Additionally, shallow monitor wells will be placed in the first overlying aquifer above each wellfield segment. These wells will be sampled biweekly. Past experience at the CPF and other ISR mining facilities has shown that this monitoring system effectively detects lixiviant migration. The total effect of the close proximity of the monitor wells, the low flow rate from the well patterns, and over-production of leach fluids (production bleed) makes the likelihood of an undetected excursion extremely remote.

Migration of fluids to overlying aquifers has also been considered. Several controls are in place to prevent this. CBR will plug all exploration holes to prevent commingling of the Brule and Chadron Aquifers and to isolate the mineralized zone. In addition, mechanical integrity will be tested prior to placing a well into service. This requirement of the NDEQ UIC Program ensures that all wells are constructed properly and are capable of maintaining pressure without leakage. Finally, monitor wells completed in the overlying aquifer will be sampled regularly for the presence of leach solution.

In addition to the spills described above, the accumulation of sediment or erosion of existing soils can lead to potential releases of pollutants. The likelihood of significant sediment or erosion problems is highest during construction activities. If rain (producing runoff) occurs during construction a small amount of the fill may be carried away from the construction area. Significant precipitation during pond and satellite facility construction may produce the same effect. Vegetation cover for erosion control will be established as soon as possible on exposed areas. Little additional suspendable material should be produced during mining operations and restoration activities. Site reclamation in the future with backfilling of ponds, grading the facility site, and replacing the topsoil will also expose unsecured soil for suspension in runoff waters. The sediment load as a result of precipitation during future construction or reclamation activities should not significantly affect the quality of any watercourses because the projected satellite facility location is not crossed by any streams.

Runoff from precipitation events should be controlled to minimize any exposure to pollutants on the site. At the satellite facility, runoff should not be a major issue, given the engineering design of the facilities, as well as engineering and administrative controls. Rainwater entering a pond leading to a pond overflow would be the item of greatest concern. The design and operation of the ponds will preclude a runoff-induced overflow as a realistic possibility. Should there be high runoff concurrent with a pipeline failure, some contamination could be spread depending upon the relative saturation of the soils beneath the leaking area. In any event, only minimal releases of solutions would occur in the event of a pipeline failure, and migration of pollutants due to runoff would be minimal.

5.7.2 External Radiation Exposure Monitoring Program

5.7.2.1 Gamma Surveys

External gamma radiation surveys have been performed routinely at the Crow Butte Uranium Project and will be performed at the satellite facility. The required frequency is quarterly in designated Radiation Areas and semiannually in all other areas of the facility. Surveys will be performed at worker-occupied stations and areas of potential gamma sources such as tanks and filters. CBR establishes a Radiation Area if the gamma survey exceeds the action level of 5.0 mRem in 1 hour at 30 centimeters from the radiation source or from any surface that the radiation penetrates. The probable source is investigated, and survey frequency for areas exceeding 5.0 mRem per hour is increased to quarterly. Records of each investigation are maintained, and the corrective action taken. If the results of a gamma survey identify areas where gamma radiation exceeds levels that delineate a "Radiation Area", access to the area is restricted and the area is posted as required in 10 CFR §20.1902 (a). Designated Radiation Areas will be as defined in 10 CFR 20.1003: Radiation Area means an area, accessible to individuals, in which radiation levels could result in an individual receiving a dose equivalent in excess of 0.005 Rem (0.05 milliSeivert [mSv]) in 1 hour at 30 centimeters from the radiation source or from any surface that the radiation penetrates.

External gamma surveys are performed with survey equipment that meets the following minimum specifications:

- Range - Lowest range not to exceed 100 μR/hr full-scale with the highest range to read at least 5 mR/hr full-scale
- Battery-operated and portable.

The Ludlum Model 3 survey meter with a Ludlum 44-38 probe or equivalent meets these requirements. Gamma survey instruments are calibrated at the manufacturer's suggested interval or at least annually and are operated according to the manufacturer's recommendations. Instruments are checked before each day of use.

Gamma exposure rates will be surveyed in accordance with the instructions currently contained in the SHEQMS Volume IV, Health Physics Manual. Proposed survey locations for the satellite facility are shown on **Figure 5.7-2**. Gamma survey instruments will be checked before each day of use in accordance with the manufacturer's instructions. Surveys are performed in accordance with RG 8.30 (NRC 2002b).

To date, beta surveys of specific operations at the CPF that involve direct handling of aged yellowcake as recommended in RG 8.30, Section 1.4 have been performed in accordance with the instructions in SHEQMS Volume IV, Health Physics Manual. Beta evaluations may be substituted for surveys using radiation survey instruments. As noted earlier, Cameco is evaluating the implications of short-lived beta-emitting isotopes at the CPF and will incorporate the results of that evaluation, as appropriate, into the Radiation Protection Program for both the CPF and the MEA.

5.7.2.2 Personnel Dosimetry

10 CFR §20.1502 (a)(1) requires exposure monitoring for "Adults likely to receive, in 1 year from sources external to the body, a dose in excess of 10 percent of the limits in §20.1201 (a)". Ten percent of the dose limit would correspond to a Deep Dose Equivalent (DDE) of 0.500 Rem. Maximum individual annual exposures at the Crow Butte Uranium Project facilities since 1987 have been well below the limit, with a maximum individual external exposure of 495 mRem in 1995.

CBR determines monitoring requirements in accordance with the guidance contained in RG 8.34 (NRC 1992a). Although monitoring of external exposure may not be required in accordance with §20.1201(a), CBR currently issues dosimeters to all process employees and exchanges them quarterly. The MEA process facility and wellfield operators would be included in this program.

Deleted: CBR believes that it is not likely that any employee working at the satellite facility will exceed 10 percent of the regulatory limit (i.e., 500 mRem/yr).

Dosimeters are provided by a vendor that is accredited by National Voluntary Laboratory Accreditation Program (NVLAP) of the National Institute of Standards and Technology as required in 10 CFR § 20.1501. The dosimeters have a range of 1 mR to 1,000 R. Dosimeters are exchanged and read quarterly.

Results from personnel dosimetry will be used to determine individual DDE for use in determining TEDE in accordance with the instructions currently contained in the SHEQMS Volume IV, Health Physics Manual. External radiation exposure monitoring will be documented on NRC Form 5 or its equivalent.

CBR has data for other external dose parameters such as Shallow Dose Equivalent (SDE) and Lens Dose Equivalent (LDE) for the existing site. As with the DDE, it can be shown that the external doses are all less than 10 percent of the applicable limits. Extremity monitoring is required when the dose to the extremity is higher than the dose to rest of the body. This would be applicable to beta doses associated with aged yellowcake sources as discussed in Section 5.7.2.1.

Cumulative Exposures

Based on the proposed type of operations (i.e., wet process) and historical exposures at the current operations, no significant increase in risks associated with exposure levels are expected for employees that work at the MEA site and the current main operating CPF. The satellite facility will have a full-time staff dedicated to working at that site. However, there may be some employees who would work at both locations for specified periods of time. Regardless of work locations, all CBR employees would be monitored for occupational external exposure if the exposure is likely to exceed 10 percent of the occupational dose limit appropriate for the individual (e.g., adult or declared pregnant woman), as specified in 10 CFR 20 1201 (a). As stated above, all wellfield and facility personnel at the satellite facility will be included in the dosimetry program. The RSO would be responsible for determining the radiological monitoring requirements for all employees based on the facility radiation levels, worker job locations and tasks, and specific licensing requirements. The RSO would be responsible for reviewing the dosimetry results and comparing them with past data and regulatory exposure limits.

5.7.3 Satellite Facility Airborne Radiation Monitoring Program

The proposed airborne sampling location for the satellite facility is shown on **Figure 5.7-2**. The locations of the sampling points for radon, airborne uranium, and gamma surveys are based on experience with similar equipment and operations at the current CBR operations. Factors that would be considered are the stage of the process (some areas more prone to exposure than others), potential known release points associated with the equipment and operations, and airflow patterns (based on current CBR operations). The sites selected are expected to carry the highest potential for exposure (**Figure 5.7-2**). Proposed satellite facility survey and sampling locations address potential releases of radiological contaminants (specific release points in the process and resin storage areas) and in areas where sampling would identify any elevated exposure levels due to inadvertent contamination (i.e., office, change room, and restroom). Sampling points in the process area are similar to those in other proposed satellite facilities. During the first year of operation, CBR will assess the sampling locations and determine whether these locations provide data representative of the concentrations to which workers would be exposed.

The satellite facility would be subject to requirements of the SHEQMS Volume III, Operating Manual, which has a section on the operation of the ventilation system.

Locations of sample points are based, in part, on a determination of airflow patterns in areas where monitoring is needed. Once the ventilation system is installed and operational, and prior to process operations, a portable anemometer would be used to assess the ventilation patterns (i.e., direction and velocity) in the work areas. Specific attention would be given to areas perceived as having a higher risk for releases. Assessments would be made of any different configurations that may be used for the ventilation system. The RSO would work with those designing the ventilation system to minimize worker exposure and to locate monitors at the optimum locations, drawing upon experience from the current CBR operating facilities.

Once the final design has been completed, the RSO and operations staff would assess the most optimum locations for radiological sampling points. Once the facility is constructed and operational, another assessment would be made of the sampling points and results, the need for any changes to the monitoring points and frequency would be determined.

Monitoring locations and planned surveys would be consistent with RG 8.30. The airborne radiation monitoring program would allow for the determination of concentrations of airborne radioactive materials (including radon) during routine and non-routine operations, maintenance, and cleanup. The controls and monitoring program will be sufficient to limit airborne radiation exposures and airborne radioactive releases ALARA and will conform to regulatory requirements identified in 10 CFR Part 20.

5.7.3.1 Airborne Uranium Particulate Monitoring

Airborne particulate levels at ISR facilities that ship loaded IX resin are normally very low because the product is wet. No precipitation, drying, or packaging of source material will be performed at the MEA. Yellowcake will be dried and packaged at the CPF. Therefore, the airborne uranium concentrations should be at or near local background levels. One location near the resin transfer station will be sampled monthly for airborne uranium particulates.

Airborne air particulate area samples will be taken in accordance with the instructions currently contained in SHEQMS Volume IV, Health Physics Manual. The Air Monitoring Chapter implements the guidance contained in RG 8.25 (NRC 1992b). Samples will be taken with a glass fiber filter and a regulated air sampler such as an Eberline RAS-1 or equivalent. Sample volume will be adequate to achieve the LLD for uranium in air. The LLD value for uranium in air would be $5e^{-11}$ µCi/ml, which is 10 percent of the Crow Butte Site-Specific DAC. Samplers will be calibrated at the manufacturer's suggested interval or semiannually with a digital mass flowmeter or other primary calibration standard. Samplers will be calibrated in accordance with the instructions currently contained in SHEQMS Volume IV, Health Physics Manual.

Breathing zones are sampled to determine individual exposure to airborne uranium during certain operations involving potential airborne exposure. Individual breathing zone monitoring may be required infrequently, at times when engineering controls are impracticable or inoperable (non-routine operations). This would include maintenance activities (e.g., tank entry, disconnection of piping, repair of equipment such as pumps) required to maintain or regain control of normal production activities. An RWP is required for activities that carry the potential for significant exposure to radioactive materials and for which there are no SOPs. The RWPs dictate the proper type of breathing zone monitoring and identifies procedures for protection against radiological hazards during the course of the work activity. Certain SOPs require individual monitoring, such as workers transferring resin beads, changing the bicarbonate mix system filter media, and changing deep disposal filter media.

Sampling is performed with a lapel sampler or equivalent. The air filters are counted and compared to the DAC using the same method described for area sampling. Air samplers are calibrated at the manufacturer's recommended frequency or daily before each use using a primary calibration standard.

Airborne uranium will be measured by gross alpha counting of the air filters using an alpha scaler such as a Ludlum Model 2000 or equivalent.

5.7.3.2 CBR Site-Specific DAC

Cameco analyzed the solubility characteristics of Crow Butte yellowcake, and the material was then classified according to the days, weeks, and years (D/W/Y) classification scheme of 10 CFR Part 20. The complete report, provided in **Appendix L,** includes a dosimetry interpretation.

This study showed that the yellowcake produced at Crow Butte was primarily of solubility type D with a relatively low type W component. The resulting Annual Limit on Intake (ALI) and DAC values are therefore 1 μCi and $5.0E^{-10}$ μCi/ml, respectively.

The expected mix of long-lived radionuclides would be predominantly natural uranium with a lesser amount of radium-226. The DAC for radium-226 is $3x10^{-10}$ μCi/ml. The DAC for the mixture would be between the natural uranium DAC and the radium-226 DAC. As noted earlier, Cameco is evaluating this issue at the CPF and will incorporate the results of that evaluation, as appropriate, into the Radiation Protection Program for both the CPF and the MEA.

An action level of 25 percent of the DAC for soluble natural uranium will be established at the satellite facility. If an airborne uranium sample exceeds the action level of 25 percent of the DAC, the cause will be investigated. If a monthly airborne uranium sample exceeds 25 percent of the action level, the sampling frequency would be increased from monthly to weekly until the airborne uranium levels do not exceed the action level for 4 consecutive weeks. The RSO may initiate corrective actions that may reduce future exposures.

No dose is calculated when comparing the measured airborne uranium concentrations to the natural uranium DAC. The purpose for this comparison is to see if the airborne uranium concentration is higher than the administrative action level of 25 percent DAC, which triggers an investigation. If internal doses are required to be estimated pursuant to 10 CFR 20.1202, methods described in Section 5.7.4 of the application will be used.

Per 10 CFR 20.1201 (e), in addition to the annual dose limits, the intake of soluble uranium by an individual is limited to 10 mg in a week in consideration of chemical toxicity. If exposure to soluble uranium exceeds 25 percent of the weekly allowable intake of 10 mg, which would be 2.5 mg/week, then the RSO would investigate the cause of the occurrence and initiate corrective actions that may reduce future exposures. As with any hazardous material handled on the site, the ALARA program would be applied to such potential chemical exposures, as described in Section 2.5 of the SHEQMS Volume III Health Physics Manual.

Any worker likely to receive, in 1 year, an occupational dose in excess of 10 percent of the limits in 10 CFR 20 1201(a) will be monitored. The RSO will use historical and current monitoring and survey data to confirm worker external radiation exposures. The external and internal doses that an individual may be allowed to receive in the current year may be reduced by the amount of occupational dose received or amount of intake while employed by any other person. The record of prior occupational dose that the individual received while performing work involving radiation exposure would be obtained per 10 CFR 20.2104.

All new employees would be asked to provide their past radiological exposure history and to sign an Exposure Release Form so previous radiological exposure history may be obtained. If a complete record of the individual's current and previously accumulated occupation dose is not available, the allowable dose limit for the individual would be reduced by 1.25 Rems (12.5 mSv)

for each quarter for which records were unavailable and the individual worker engaged in activities that could have resulted in occupational radiation exposure. It would also be assumed that the individual would not be available for planned special exposures. Per 10 CFR 20.2104, CBR would not be required to partition historical data between external dose equivalent(s) and internal committed dose equivalent(s).

5.7.3.3 Radon Daughter Concentration Monitoring

Surveys for radon daughter concentrations will be conducted monthly in the operating areas of the satellite facility. Sampling locations will be determined in accordance with the guidance contained in RG 8.25. Section 3.1 of RG 8.25 states "lapel samplers or samplers located within about 1 foot of the workers head may be accepted as representative without further demonstration that the results are representative." Working Level (WL) measurements will be made using the Modified Kusnetz method (ANSI-N13.8-1973), which involves taking a grab sample, typically every 5 minutes, and analyzing the filter for alpha activity. This grab sample will be taken at locations depicted on **Figure 2.9-2** of the amendment application at a height typical of a worker's breathing zone and within the breathing zone of the worker collecting the sample.

Routine radon daughter monitoring will be performed in accordance with the instructions currently contained in the SHEQMS Volume IV, Health Physics Manual. Samplers will be calibrated at the manufacturer's suggested interval or daily before use with a digital mass flowmeter or other primary calibration standard. Air samplers will be calibrated in accordance with the instructions currently contained in the SHEQMS Volume IV, Health Physics Manual.

Results of radon daughter sampling are expressed in WLs where one WL is defined as any combination of short-lived radon-222 daughters in one liter of air without regard to equilibrium that emit 1.3×10^5 MeV of alpha energy. The DAC limit from Appendix B to 10 CFR §§ 20.1001 - 20.2402 for radon-222 with daughters present is 0.33 WL. CBR has established an action level of 25 percent of the DAC or 0.08 WL. The LLD for radon measures would be 0.033 WL, which is 10 percent of the DAC limit. Radon daughter results in areas with an average concentration in excess of the action level will result in an investigation of the cause and an increase in the sampling frequency to weekly until the radon daughter concentration levels do not exceed the action level for 4 consecutive weeks.

5.7.3.4 Respiratory Protection Program

Respiratory protective equipment has been supplied by CBR for activities where engineering controls may not be adequate to maintain acceptable levels of airborne radioactive materials or toxic materials. Use of respiratory equipment at Crow Butte Uranium Project is in accordance with the procedures currently set forth in the SHEQMS Volume IV, Health Physics Manual.

The respirator program is designed to implement the guidance contained in RG 8.15 (NRC 1999b) and RG 8.31 (NRC 2002a). The respirator program is administered by the RSO as the Respiratory Protection Program Administrator (RPPA).

Because airborne uranium concentrations at the satellite facility during typical operations are not expected to exceed action levels, it is not expected that respirator use will be required for normal operation of the satellite facility. However, any time the potential exists for elevated exposures to employees, respirators could be required. For example, certain maintenance activities (e.g., tank

entry, disassembly of potentially contaminated piping and equipment, and welding/grinding on contaminated piping/equipment) and failure of the process building ventilation system could require the use of respirators. The use of respirators at MEA would be determined by SOPs and RWPs for specific tasks. The CBR respirator policy and requirements of respirator use are discussed in detail in the SHEQMS.

5.7.4 Exposure Calculations

Employee internal exposure to airborne radioactive materials at the satellite facility will be determined based upon the requirements of 10 CFR § 20.1204 and the guidance contained in RGs 8.30 and 8.7 (NRC 2002b and 1992c). Following is a discussion of the exposure calculation methods and results.

5.7.4.1 Natural Uranium Exposure

Exposure calculations for airborne natural uranium are carried out using the intake method from RG 8.30, Section 3. The intake is calculated using the following equation:

Field Code Changed

$$I_u = b\sum_{i=1}^{n}\frac{X_i \times t_i}{PF}$$

where:

I_u	=	uranium intake, µg or µCi
t_i	=	time that the worker is exposed to concentrations X_i (hr)
X_i	=	average concentration of uranium in breathing zone, µg/m^3, µCi/m^3
b	=	breathing rate, 1.2 m^3/hr
PF	=	the respirator protection factor, if applicable
n	=	the number of exposure periods during the week or quarter

The intake for uranium is calculated and recorded. The intakes are totaled and entered onto each employee's Occupational Exposure Record.

The data required to calculate internal exposure to airborne natural uranium are determined as follows.

Time of Exposure Determination

One hundred percent occupancy time is used to determine routine worker exposures. Exposures during non-routine work are always based upon actual time.

When calculating radiological exposures for the satellite facility, the occupancy time for "routine" operations would be an exposure period based on actual hours worked (12-hour shift period for facility personnel). This would be considered a 100 percent occupancy time. For such routine exposures (i.e., 12-hour shift period), it is assumed that the worker was exposed to the measured "work area" average concentration of uranium for the entire work period (exposure 100

percent of the time). During part of that exposure period, the worker would be expected to spend some time in non-work areas such as the lunch room, office, restroom, hallways, and other areas. The 100 percent occupancy time approach generally results in a conservative (i.e., higher than actual) estimate of internal exposure to airborne natural uranium because it does not account for time the employee may have spent outside the work area, as described above.

The measured average airborne uranium concentration is multiplied by the time of worker exposure (12 hours) to obtain the estimated average worker exposure for that time period. Routine operations refer to the facilities operating in a normal fashion with no upsets, maintenance activities, or other activities that may result in non-routine and elevated exposures. If a worker works more than the normal 12-hour shifts, the measured average airborne uranium concentration and the total hours actually worked are used to establish exposure levels.

Measured exposures during non-routine work tasks (e.g., maintenance or cleanup) are based on actual time. The results of breathing zone samples collected during maintenance activities or RWPs are from a specific time period and are added to the calculations of routine employee exposures for a given work period. For example, a worker working under a RWP for 2 hours would have exposures based on measurements taken for that time period (actual time), with the exposures for the remaining 10 hours of routine work based on the measured average concentration of airborne uranium.

Airborne Uranium Activity Determination

Airborne uranium activity is determined from surveys performed as described in Section 5.7.3.1.

CBR proposes to institute the same internal airborne uranium exposure calculation methods at the satellite facility that have been used to date at the CPF and which are currently described in the SHEQMS Volume IV, Health Physics Manual. Exposures to airborne uranium will be compared to the site-specific Crow Butte Operations DAC developed in response to NRC comments. The information was provided pursuant to a request for confidentiality by email dated March 14, 2011 with further clarifications submitted by email on April 5, 2011 (ML11102020132). The results show that the average ALI for the Crow Butte Operations yellowcake is 0.98µCi and the average DAC is 4.8E-10µCi/ml. For consistency with the convention used to round values in the regulation, an ALI and DAC of 1µCi and 5E-10µCi/ml will be used. Footnote 3 in Table 1 of Appendix B to 10 CFR 20 states "the specific activity for natural uranium is 6.77 E-7 curies per gram U". This is equivalent to 6.77 E^{-7} µCi/µg of natural uranium. This is the specific activity CBR will use to calculate the mass of uranium from an activity measurement and vice versa.

When required by 10 CFR 20.1202, CBR will use methods in RG 8.30 to estimate internal doses. As an example, the Committed Effective Dose Equivalent (CEDE) can be calculated using Equation 2 in RG 8.30 where:

H_{iE}	=	CEDE from radionuclide (Rem)
I_i	=	is the intake in µCi of Class D natural uranium as determined by the equation in Section 5.7.4.1 of the application
ALI_{iE}	=	Value of the stochastic inhalation ALI for natural uranium from Column 2 of Table 1 in Appendix B to 10 CFR Part 20 (2 µCi)
5	=	CEDE from intake of 1 ALI (Rem)

If an intake (I_i) of 0.5 μCi was determined using the stated equation, the estimate CEDE from this intake would be:

$H_{iE} = 5*0.5/2 = 1.25$ Rem

If an intake (I_i) of 0.5 μg of natural uranium was determined using the stated equation, the estimated CEDE from this intake would be:

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

It should be noted that the weekly limit for soluble uranium in 10 CFR 20.1202 (e) due to chemical toxicity is 10 milligrams (10,000 μg), which would be equivalent to a CEDE of 17 mRem per week or 844 mRem per year. The occupational weekly toxicity limit for Class D natural uranium is more restrictive than the radiological limit.

5.7.4.2 Radon Daughter Exposure

Exposure calculations for airborne radon daughters are carried out using the intake method from RG 8.30, Section 3. The radon daughter intake is calculated using the following equation:

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

Field Code Changed

where:

I_r	=	radon daughter intake, WLmonths
t_i	=	time that the worker is exposed to concentrations W_i (hr)
W_i	=	average number of WLs in the air near the worker's breathing zone during the time (t_i)
170	=	number of hours in a working month
PF	=	the respirator protection factor, if applicable
n	=	the number of exposure periods during the year

The data required to calculate exposure to radon daughters are determined as follows.

Time of Exposure Determination

One hundred percent occupancy time is used to determine routine worker exposure times. Exposures during non-routine work are always based upon actual time. A clarification of the 100 percent occupancy time is presented in Section 5.7.4.1 for natural uranium exposure. This explanation would also apply to radon daughter exposure.

Radon Daughter Concentration Determination

Radon-222 daughter concentrations are determined from surveys performed as described in Section 5.7.3.3. The WL months (WLMs) for radon daughter exposure are calculated and recorded. The WLMs are totaled and entered onto each employee's Occupational Exposure Record.

CBR proposes to institute the same internal radon daughter exposure calculation methods at the satellite facility that have been used to date and which are currently contained in the SHEQMS Volume IV, Health Physics Manual. Exposures to radon daughters will be compared to the DAC for radon daughters from Appendix B of 10 CFR §§20.1001 - 20.2401 (0.33 WL).

The equation above calculates WLMs. If required by 10 CFR 20.1202, CBR can calculate a CEDE from the WLM estimate using Equation 2 in RG 8.30 where:

H_{iE} = CEDE from radionuclide (Rem)

I_i = the intake in WLM of radon-222 and its associated progeny as determined by the equation in this section.

ALI_{iE} = Value of the stochastic inhalation ALI for radon-222 with progeny present from Column 2 of Table 1 in Appendix B to Part 20 (4 WLM)

5 = CEDE from intake of 1 ALI (Rrem)

If an intake (I_i) of 1 WLM was determined using the stated equation, the estimate CEDE from this intake would be:

$$H_{iE} = 5*1/4 = 1.25 \text{ Rem}$$

5.7.4.3 Prenatal and Fetal Exposure

Dose Equivalent to an Embryo/Fetus

10 CFR §20.1208 requires that licensees ensure that the dose equivalent to an embryo/fetus during the entire pregnancy, due to the occupational exposure of a declared pregnant woman, does not exceed 0.5 Rem (5 mSv). Licensees are also required to make efforts to avoid substantial variation above a uniform monthly exposure rate to a declared pregnant woman that would satisfy the 0.5 Rem limit. The dose equivalent to the embryo/fetus is calculated as the sum of (1) the DDE to the declared pregnant woman; and, (2) the dose equivalent to the embryo/fetus resulting from radionuclides in the embryo/fetus and radionuclides in the declared pregnant woman. If the dose equivalent to the embryo is determined to have exceeded 0.5 Rem (5 mSv), or is within 0.05 Rem (0.5 mSv) of this dose, by the time the woman declares the pregnancy to the licensee, the licenses shall be deemed to be in compliance with 10 CFR 20.1208 if the additional dose equivalent to the embryo/fetus does not exceed 0.05 Rem (0.5 mSv) during the remainder of the pregnancy.

Individual Monitoring of External and Internal Occupational Exposure

The dose equivalent to the embryo/fetus is determined by the monitoring of the declared pregnant woman. 10 CFR §20.1502(a)(3) requires monitoring the exposure of a declared pregnant woman when the external dose to the embryo/fetus is likely to receive during the entire pregnancy, from radiation sources external to the body, a DDE in excess of 0.1 Rem (1 mSv). All of the occupational doses in 10 CFR 20.1201 continue to be applicable to the declared pregnant worker as long as the embryo/fetus dose limit is not exceeded. 10 CFR 20.1502(b)(3) requires the monitoring of occupational intake of radioactive material by and assess the committed effective dose equivalent to a declared pregnant woman likely to receive, during the entire pregnancy, a CEDE in excess of 0.1 Rem (1 mSv). Based on this 0.1 Rem threshold, the dose to the

embryo/fetus must be determined if the intake is likely to exceed 1 percent of ALI during the entire period of gestation.

Prior to declaration of pregnancy, the woman may not have been subject to monitoring based on the conditions specified in 10 CFR 20.1502. In this case, CBR will estimate the exposure during the period monitoring was not provided, using any combination of surveys or other available data (for example, air monitoring, area monitoring, and bioassay). Exposure calculations will be performed as recommended in RG 8.36 (NRC 1992d).

External Dose to the Embryo/Fetus

The DDE to the declared pregnant woman during the gestation period will be taken as the external dose for the embryo/fetus. The determination of external dose will consider all occupational exposures of the declared pregnant woman since the estimated date of conception and will be based on the methods discussed in Section 5.7.2. External dose to the declared pregnant woman after declaration for the duration of the pregnancy shall be accomplished by personal dosimetry with monthly exchanges.

Internal Dose To The Embryo/Fetus

The internal dose to the embryo/fetus will consider the exposure to the embryo/fetus from radionuclides in the declared pregnant woman and in the embryo/fetus. The dose to the embryo/fetus will include the contribution from any radionuclides in the declared pregnant woman (body burden) from occupational intakes occurring prior to conception.

The intake for the declared pregnant woman will be determined as discussed in Sections 5.7.3.1 and 5.7.3.2.

5.7.5 Bioassay Program

CBR has implemented a urinalysis bioassay program at the Crow Butte Uranium Project facilities that meets the guidelines contained in RG 8.22 (NRC 1988). The primary purpose of the program is to detect uranium intake in employees who are regularly exposed to uranium. The bioassay program consists of the following elements:

1. Prior to assignment to the facility, all new employees are required to submit a baseline urinalysis sample. Upon termination, an exit bioassay is required from all employees.
2. During operations, urine samples are collected from workers quarterly. Employees who have the potential for exposure to dried yellowcake submit bioassay samples monthly or more frequently as determined by the RSO. Samples are analyzed for uranium content by a contract analytical laboratory. Blank and spiked samples are also submitted to the laboratory with employee samples as part of the Quality Assurance program. The measurement sensitivity for the analytical laboratory is 5 µg/L.
3. Action levels for urinalysis are established based upon Table 1 in RG 8.22.

Elements of the quality assurance requirements for the Bioassay Program are based upon the guidelines contained in RG 8.22. These elements included the following:

1. Each batch of samples submitted to the contract analytical laboratory is accompanied by two blind control samples. The control samples are from persons that have not been occupationally exposed and are spiked to a uranium concentration of 10 to 20 µg/L and 40 to 60 µg/L. The results of analysis for these samples are required to be within ± 30 percent of the spiked value.
2. The contract analytical laboratory spikes 10 to 30 percent of all samples received with known concentrations of uranium and the recovery fraction determined. Results are reported to CBR.

CBR proposes to continue to implement the Bioassay Program described in this section for operations at the satellite facility. The facility and wellfield operators will be included in a personnel dosimetry (exchanged quarterly) and bioassay program, with urine samples collected quarterly. The program will be implemented in accordance with the guidance contained in RG 8.22 and with the instructions currently contained in SHEQMS Volume IV, Health Physics Manual.

5.7.6 Contamination Control Program

CBR will perform surveys for surface contamination in operating and clean areas of the satellite facility in accordance with the guidelines contained in RG 8.30. Surveys for total alpha contamination in clean areas will be conducted weekly. In designated clean areas, such as lunchrooms, offices, change rooms, and respirator cabinets, the target level of contamination is nothing detectable above background. If the total alpha survey indicates contamination that exceeds 250 disintegrations per minute (dpm)/100 cm^2 (25 percent of the removable limit) a smear survey must be performed to assess the level of removable alpha activity. If smear test results indicate removable contamination greater than 250 dpm/100 cm^2, the area will be promptly cleaned and resurveyed.

All personnel leaving a restricted area will be required to perform and document alpha contamination monitoring. In addition, personnel who could come in contact with potentially contaminated solutions outside a restricted area such as in the wellfield will be required to monitor themselves prior to leaving the area. All personnel receive training in surveys for skin and personal contamination. All contamination on skin and clothing is considered removable, so the limit of 1,000 dpm/100 cm^2 is applied to personnel monitoring. Personnel will also be allowed to conduct contamination monitoring of small, hand-carried items for use in wellfield and controlled areas as long as all surfaces can be reached with the instrument probe and the item does not originate in yellowcake areas. All other items are surveyed as described below.

The RSO, the radiation safety staff, or properly trained employees perform surveys of all items removed from the restricted areas with the exception of small, hand-carried items described above. Due to the distance separating the satellite facility and the CPF where the RSO and radiation staff is based, it would be more efficient to have properly trained full-time personnel at the MEA site available to perform surveys for releasing items from the restricted area. Such a person would be the Lead Operator or a facility/wellfield operator trained by the RSO or radiation staff in the use of applicable radiation survey instruments and procedures. These staff members would have received training as operators and the required radiation safety training. They would also be subject to additional hands-on training as to the survey instruments and procedures. The release limits are set by Guidelines for Decontamination of Facilities and Equipment Prior to

Release for Unrestricted Use or Termination of Licenses for Byproduct or Source Materials, (NRC 1987).

Surveys are performed with the following equipment:

1. Total surface activity will be measured with an appropriate alpha survey meter. A Ludlum Model 2241 scaler or a Ludlum Model 177 Ratemeter with a Model 43-65 or Model 43-5 alpha scintillation probe, or equivalent, will be used for the surveys.
2. Portable GM survey meter with a beta/gamma probe with an end window thickness of not more than 7 mg/cm^2, a Ludlum Model 3 survey meter with a Ludlum 44-38 probe or equivalent.
3. Swipes for removable contamination surveys as required.

Survey equipment is calibrated annually or at the manufacturer's recommended frequency, whichever is more frequent. Surface contamination instruments are checked daily when in use. Alpha survey meters for personnel surveys are response checked before each use, with other checks performed weekly. For additional information see Section 3.3.

As recommended in RG 8.30, CBR conducts quarterly unannounced spot checks of personnel to verify the effectiveness of the surveys for personnel contamination. A spot check of the employees assigned to the satellite facility will be conducted, concentrating on facility operators and maintenance personnel. The purpose of the surveys is to ensure that employees are adequately surveying and decontaminating themselves prior to exiting the restricted areas.

The contamination control program for the satellite facility will be implemented in accordance with the SHEQMS Volume IV, Health Physics Manual.

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

5.7.7 Airborne Effluent and Environmental Operational Monitoring Programs

The operational baseline monitoring program is presented in **Table 5.7-1**.

5.7.7.1 Air Particulate Monitoring

Composite airborne particulate samples for natural uranium, radium-226, lead-210, and thorium-230 will be obtained quarterly from air monitoring locations MAR-1 through MAR-5. The quality of sample collection and analysis shall be maintained by adhering to quality control (QC) procedures discussed in Section 5.7.9 and LLC concentration limits discussed in Section 2.9.2.4

The air particulate samplers described in Section 2.9.2 will continue to be used for the operational monitoring program.

5.7.7.2 Radon

The radon gas effluent released to the environment from satellite facility will be monitored at the same air monitoring locations (MAR-1 through MAR-5) that were used for baseline determination of radon concentrations as described in Section 2.9.2. Sampling locations are shown on **Figure 2.9-2**. Monitoring will be performed using Track-Etch radon cups. The cups will be exchanged semiannually to achieve the required LLD. SHEQMS Volume IV, Health Physics Manual currently provides the instructions for environmental radon gas monitoring. In addition to the manufacturer's Quality Assurance program, CBR will expose one duplicate radon Track Etch cup per monitoring period. The quality of sample collection and analysis shall be maintained by adhering to QC procedures discussed in Section 5.7.9 and LLC concentration limits discussed in Section 2.9.2.4.

Monitoring of radon gas releases from the satellite facility building and ventilation discharge points is not deemed to be practicable. Section 3.3 of RG 8.37 indicates that, where monitoring effluent points is not practicable, an estimate can be made of the magnitude of these releases, with such estimated releases used in demonstrating compliance with the annual dose limit. In 10 CFR 20.1302, allowance is made for demonstrating by measurement or calculation that the TEDE to the individual likely to receive the highest dose from licensed operations does not exceed the annual dose limit of 100 mRem.

The satellite facility would use pressurized downflow IX columns, which do not routinely release radon gas except during resin transfer and column backwashing. The design and operation of these systems result in the majority of the radon in the production fluid staying in solution and not being released from the columns. Radon may be released from occasional venting of process vessels and tanks, small leaks in IX equipment, and during maintenance of equipment. Therefore, releases via the vent stacks would not have a consistent concentration of radon or flow rate, making it impracticable to try to use such data for public exposure estimates.

CBR has used MILDOS-AREA to model the dose from facility operations resulting from releases of radon gas (Savignac 2013). MILDOS-AREA outputs are presented in **Appendix M,** and are discussed in Section 7.3.3. In determining the source term for MILDOS-AREA for the satellite facility, radon gas release was estimated at 25 percent of the radon-222 in the production fluid from the wellfields and an additional 10 percent in the IX circuit in the satellite building. The release of radon-222 at this concentration did not result in significant public dose.

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Environmental monitoring and estimated release of radon from process operations will be reported in the semi-annual reports required by 10 CFR § 40.65 and License SUA-1534 License Condition Number 12.1.

5.7.7.3 Surface Soil

Surface soil will be sampled as described in Section 2.9. Surface soil samples will be taken at the monitoring locations (MAR-1 through MAR-5) during operations. Following conclusion of operations, samples will be collected and compared to the results of the PPMP. Samples shall be analyzed for natural uranium, radium-226, thorium-230, and lead-210.

Surface soil will also be sampled at the satellite plant location as described in Section 2.9. Surface soil samples will be taken following conclusion of operations and compared to the results

of the PPMP. The quality of sample collection and analysis shall be maintained by adhering to QC procedures and LLD concentration limits discussed in Section 2.9.6.1.

5.7.7.4 Subsurface Soil

Subsurface soil will be sampled at the facility location as described in Section 2.9. Subsurface soil samples will be taken following conclusion of operations and compared to the results of the PPMP. The quality of samples shall be maintained by following QC procedures discussed in Section 5.7.9 and adhering to the LLC concentration limits discussed in Section 2.9.6.1.

5.7.7.5 Vegetation

Operational Environmental Monitoring Approach

At the existing Crow Butte Operation, Cameco provided long-term data and demonstrated to the NRC that annual vegetation sampling and surface soil sampling at the air monitor locations was not required because increases in concentrations above baseline levels were not occurring.

In light of that experience, Cameco is proposing to employ surrogate media sampling (soil and sediment, addressed above) to identify increasing concentration trends that may require additional dose evaluation and sampling. Given the pathway dynamics, increasing detectable concentrations in the soil and sediment media will occur earlier and to a larger extent than the more attenuated levels present in the contact media (forage, food crops, livestock, and fish).

Vegetation (Forage)

At Marsland, the wind transport/deposition mechanism for contaminants ends up either in the surface soil, surface water, or as folial deposition on forage. Forage may then uptake contaminates in surface soil and shallow subsurface soil. As an alternate approach to operational vegetation (forage) sampling at Marsland, Cameco proposes to use soil samples taken annually from gardens in the AOR as surrogates to identify uptake trends in foliage radionuclide concentrations. If increasing concentrations are noted, Cameco will further evaluate the dose implications and if appropriate propose additional forage sampling for NRC written verification.

Surface water flows at Marsland are not suitable for ongoing monitoring given the highly sporadic nature of flows in the otherwise dry drainages. Sediment is the best media surrogate to track wind transport and dispersion of contaminants in lieu of operational surface water sampling. Cameco proposes to use the annual sediment as surrogates to identify potential uptake trends in foliage radionuclide concentrations. If increasing concentrations are noted, Cameco will further evaluate the dose implications and, if appropriate, will propose additional forage sampling for NRC written verification.

Folial deposition is periodic in nature and occurs only for a portion of each year; any deposited contaminants are either grazed or harvested each year. In contrast, surface soil samples collected yearly accumulate deposited contamination and increase the likelihood that rising trends will be detected.

As an alternate approach at Marsland, Cameco proposes to use the annual surface soil samples collected at the air monitoring locations as surrogates to identify trends in airborne deposition of radionuclides. If increasing concentrations are noted, Cameco will further evaluate the dose

implications and, if appropriate, propose additional forage sampling to NRC for written verification.

5.7.7.6 Food Crops, Livestock, and Fish

Food Crops (garden vegetables)

As an alternate approach to operational food crop sampling at Marsland, Cameco proposes to use soil samples taken annually from gardens in the AOR as surrogates to identify trends in food crop radionuclide concentrations. If increasing concentrations are noted, Cameco will further evaluate the dose implications and, if appropriate, propose additional food crop sampling to NRC for written verification.

Livestock

Similar to the above proposals, as an alternate approach for operational livestock sampling, Cameco proposes to use the approach described above for forage and crops to trigger further evaluation of the dose implications. If appropriate, Cameco will propose additional livestock sampling to NRC for written verification.

Fish

There are currently no plans to collect fish for tissue analysis of radiological constituents. Due to the arid nature of the area in which the MEA is located, the dry drainages that traverse to MEA license boundary do not support a fish population. The two major ephemeral drainages eventually connect to the Niobrara River, which is the nearest stream with permanent water. The river is located south of the license boundary, flowing west to east. The Box Butte Reservoir is located on the Niobrara River approximately 3.5 miles (5.6 km) from the southeastern corner of the MEA license boundary. The Marsland operations will not discharge any liquids to the ephemeral drainages or to any other areas of the proposed operations. Any spills that could occur would be contained per the site spill control plans, and it is highly unlikely that any liquid spills would ever reach the Niobrara River. Therefore, operational sampling of fish is not deemed to be of value.

As an alternative, Cameco proposes that, if upward trends in radionuclide concentrations are observed in sediment samples, further dose evaluation and, if appropriate, operational fish sampling will be proposed to NRC for written verification. This alternative is justified because surface water flow is absent and because contaminant releases will be significantly attenuated due to the distance to Box Butte Reservoir. Unlike the Niobrara River upstream, Box Butte Reservoir is the only location where sufficient fish mass exists to allow sampling and analysis.

5.7.7.7 Direct Radiation

Environmental gamma radiation levels will be monitored continuously at the air monitoring stations (MAR-1 through MAR-5) during operations. Gamma radiation will be monitored using environmental dosimeters obtained from an NVLAP certified vendor. Dosimeters will be exchanged quarterly.

5.7.7.8 Sediment

Upstream and downstream sediment samples will be collected annually at the sample locations described in Section 2.9 and shown in **Figure 2.7-4**. Samples will be collected as described in

Deleted: <#>There are currently no plans to sample vegetation for radiological analyses during operations. In accordance with the provisions of NRC RG 4.14, Footnote (o) to Table 2 requires the following: *Vegetation and forage sampling need to be carried out only if dose calculations indicate that the ingestion pathway from grazing animals is a potentially significant exposure pathway (an exposure pathway should be considered important if the predicted dose to an individual would exceed 5 % of the applicable radiation protection standard.* The applicable radiation standard in 10 CFR 20 is 100 mRem/yr. Five percent of 100 mRem/yr is 5 mRem/yr.¶

Deleted: <#>This pathway was evaluated by CBR's radiological consultant (Savignac 2011b, **Appendix M-2**). MILDOS calculated the radiation dose to individuals within 50 miles (80 km) of the MEA site from vegetables, meat, and milk as population doses in units of person-Rem/yr. Dividing those doses by the population within 50 miles (80 km) and converting the doses to mRem/yr yields the doses in **Table 5.7-2.** The total dose in **Table 5.7-2** is the average dose to humans living within 50 miles (80 km) of the MEA uranium recovery operation that results from the consumption of vegetables, meat, and/or milk that might have been impacted by the release of radon and its decay products on vegetation or forage from uranium *in situ* extraction operations.¶

Deleted: <#>Based on the results of the analy..., as presented in **Appendix M-2,** vegetation or forage sampling at the MEA *in-situ* recovery operations should not be required because the radiation dose calculated for those operations is not considered "important" (NRC terminology in RG 4.14). The average radiation dose to people living with 50 miles (80 km) of the MEA from the vegetation pat ... [22]

Deleted: Livestock,

Deleted: Vegetable

Deleted: For additional background, see the response to RAI 37.A.2, below.

Deleted: RG 4.14 recommends that crops, livestock, and other farm products raised within ~1.86 miles (3 km) of the mill site be sampled at the time of harvest or slaughter. Grab samples ... [23]

Deleted: RG 4.14 requires that fish be collected, if available, from lakes and streams in the project site area that may be subject to seepage or direct surface runoff from potentially contaminated areas ... [24]

Deleted: The results of the MILDOS analysis for vegetation uptake discussed in Section 2.9.5.3 indicate that the potential for fish uptake of ... [25]

Deleted: ephemeral

Deleted: carry sufficient water flow to

Deleted: discussed in Section 2.9, the CBR PPMP will provide for collection of fish samples from the Niobrara River per RG 4.14. This sampling and analysis plan will allow for documentation ... [26]

Section 2.9.7 and analyzed for natural uranium, radium-226, thorium-230, and lead-210. The quality of sample collection and analysis shall be maintained by adhering to QC procedures as discussed in Section 5.7.9 and LLC concentration limits discussed in Section 2.9.7.1.

5.7.8 Groundwater/Surface Water Monitoring Program

5.7.8.1 Program Description

During operations at the satellite facility, a detailed water sampling program will be conducted to identify any potential impacts to water resources of the area. The CBR operational water monitoring program includes the regional evaluation of groundwater, groundwater within the permit or licensed area, and surface water on a regional and site-specific basis. The quality of sample collection and analysis shall be maintained by adhering to QC procedures discussed in Section 5.7.9 and LLC concentration limits discussed in Section 2.9.3.4.

5.7.8.2 Groundwater Monitoring

The groundwater excursion monitoring program is designed to detect excursions of lixiviant into the ore zone aquifer outside of the wellfield being leached and into the overlying water-bearing strata. Monitor wells will be placed in the basal sandstone of the Chadron Formation and in the overlying Brule and Arikaree aquifers. All monitor wells will be completed by one of the three methods discussed in Chapter L, developed prior to recovery solution injection. The development process for monitor wells includes establishing baseline water quality before the initiation of mining operations.

The Pierre Shale below the ore zone is more than 1,200 feet thick and contains no water-bearing strata. Therefore, it is not necessary to monitor any water-bearing strata below the ore zone.

Private Well Monitoring

During operations, on a quarterly basis, all active, operational and accessible private wells located within the MEA license boundary and within 0.62 mile (1 km) of the MEA license boundary will be monitored (**Figures 2.7-6 and 2.9-3**). Groundwater samples are taken in accordance with the instructions contained in SHEQMS Volume VI, Environmental Manual, and samples are analyzed for natural uranium and radium-226. Water well samples will be collected and analyzed as described in Section 2.9.3.1.

Monitor Well Baseline Water Quality

After delineation of the production unit boundaries, monitor wells are installed no further than 300 feet from the wellfield boundary and no further than 400 feet apart or as required by the NDEQ. After completion, wells are washed out and developed (by air-lifting or pumping) until pH and specific conductivity appear stable and consistent with the anticipated quality of the area. After development, wells are sampled to obtain baseline water quality data. For baseline sampling, wells are purged before sample collection to ensure that representative water is obtained. All monitor wells, including ore zone and overlying monitor wells, are sampled three times at least 14 days apart. Samples are analyzed for chloride, conductivity, and total alkalinity as specified in License Condition 10.4. Results from the samples are averaged arithmetically to obtain an average baseline value as well as a maximum value for determination of upper control

Deleted: air flushing

limits for excursion detection. Wells are developed and sampled in accordance with the instructions contained in SHEQMS Volume VI, Environmental Manual.

Upper Control Limits and Excursion Monitoring

After baseline water quality is established for the monitor wells for a particular production unit, upper control limits (UCLs) are set for chemical constituents which would indicate a migration of lixiviant from the wellfield. The constituents chosen for indicators of lixiviant migration and for which UCLs are set are chloride, conductivity, and total alkalinity. Chloride was chosen due to its low natural levels in the native groundwater and because chloride is introduced into the lixiviant from the IX process (uranium is exchanged for chloride on the IX resin). Chloride is also a highly mobile constituent in the groundwater and will show up very quickly in the case of a lixiviant migration to a monitor well. Conductivity was chosen because it is an excellent general indicator of overall groundwater quality. Total alkalinity concentrations should be affected during an excursion, as bicarbonate is the major constituent added to the lixiviant during mining. Water levels are obtained and recorded prior to each well sampling. However, water levels are not used as an excursion indicator. Upper control limits are set at 20 percent above the maximum baseline concentration for the excursion indicator. For excursion indicators with a baseline average below 50 mg/L, the UCL may be determined by adding 5 standard deviations or 15 mg/L to the baseline average for the indicator.

Operational monitoring consists of sampling the monitor wells biweekly and analyzing the samples for the excursion indicators chloride, conductivity, and total alkalinity. License SUA-1534 Condition 11.2 currently requires that monitor wells be sampled no more than 14 days apart except in certain situations. These situations include inclement weather, mechanical failure, holiday scheduling, or other factors that may result in placing an employee at risk or potentially damaging the surrounding environment. In these situations, CBR documents the cause and the duration of any delays. In no event is sampling delayed for more than 5 days.

Excursion Verification and Corrective Action

During routine sampling, if two of the three UCL values are exceeded in a monitor well, or if one UCL value is exceeded by 20 percent, the well is resampled within 48 hours and analyzed for the excursion indicators. If the second sample does not exceed the UCLs, a third sample is taken within 48 hours. If neither the second nor third sample results exceeded the UCLs, the first sample is considered in error.

If the second or third sample verifies an exceedance, the well in question is placed on excursion status. Upon verification of the excursion, the NRC Project Manager is notified by telephone or email within 48 hours and notified in writing within 30 days.

If an excursion is verified, the following methods of corrective action are instituted (not necessarily in the order given) dependent upon the circumstances:

- A preliminary investigation is completed to determine the probable cause.
- Production and/or injection rates in the vicinity of the monitor well are adjusted as necessary to increase the net over recovery, thus forming a hydraulic gradient toward the production zone.
- Individual wells are pumped to enhance recovery of mining solutions.

Injection into the wellfield area adjacent to the monitor well may be suspended. Recovery operations continue, thus increasing the overall bleed rate and the recovery of wellfield solutions.

In addition to the above corrective actions, sampling frequency of the monitor well on excursion status is increased to weekly. An excursion is considered concluded when the concentrations of excursion indicators do not exceed the criteria defining an excursion for three consecutive 1-week samples.

5.7.8.3 Surface Water Monitoring

If available, surface water samples will be collected as described in Section 2.9. Samples will be collected quarterly and analyzed for dissolved and suspended natural uranium, radium-226, thorium-230, lead-210, and polonium-210. Sample locations are shown on **Figure 2.7-4.** The quality of sample collection and analysis shall be maintained by adhering to QC procedures discussed in Section 5.7.9 and LLC concentration limits discussed in Section 2.9.4.5.

Surface water samples will be taken in accordance with the instructions contained in SHEQMS Volume VI, Environmental Manual. Upstream and downstream samples from all locations will be obtained quarterly. Surface water samples are analyzed for the parameters identified in Section 2.9. Surface monitoring results are submitted in the semi-annual environmental and effluent reports submitted to NRC.

5.7.9 Quality Assurance Program

A quality assurance (QA) program is in place at Crow Butte Uranium Project for all relevant operational monitoring and analytical procedures. The objective of the program is to identify any deficiencies in the sampling techniques and measurement processes so that corrective action can be taken and to obtain a level of confidence in the results of the monitoring programs. The QA program provides assurance to both regulatory agencies and the public that the monitoring results are valid.

The QA program addresses the following:

- Formal delineation of organizational structure and management responsibilities. Responsibility for both review/approval of written procedures and monitoring data/reports is provided
- Minimum qualifications and training programs for individuals performing radiological monitoring and those individuals associated with the QA program
- Written procedures for QA activities. These procedures include activities involving sample analysis, calibration of instrumentation, calculation techniques, data evaluation, and data reporting
- QC for onsite analytical instrumentation and sampling. Procedures cover statistical data evaluation, instrument calibration, duplicate sample programs, and spike sample programs. Outside laboratory QA/QC programs are included
- Provisions for periodic management audits to verify that the QA program is effectively implemented; to verify compliance with applicable rules, regulations, and license requirements; and to protect employees by maintaining effluent releases and exposures ALARA.

The SHEQMS developed by CBR is a critical step to ensuring that QA objectives are met. Current procedures exist for a variety of areas, including but not limited to:

1. Environmental monitoring
2. Testing
3. Exposure
4. Equipment operation and maintenance
5. Employee health and safety procedures
6. Incident response procedures

5.8 References

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Savignac, N. 2013. MILDOS-AREA Radiation Doses from Cameco Resources Marsland Expansion Area In-Situ Uranium Recovery Operation. September 24.

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Table 5.7-1 Marsland Expansion Area Operational Effluent and Environmental Monitoring Plan

Type of Sample	Sample Collection			Sample Analysis		
	Number	Location	Method	Frequency	Frequency	Type of Analysis
AIR						
Particulates	3	At or near site boundaries and in sector(s) having the highest predicted concentrations of airborne particulates[a]	Continuous	Weekly filter change or more frequently as required by dust loading	Quarterly composites of weekly samples	Nat-Uranium, Ra-226, Th-230, Pb-210
	1	At or close to nearest residence(s)[a]	Continuous	Weekly filter change or more frequently as required by dust loading	Quarterly composites of weekly samples	Nat-Uranium, Ra-226, Th-230, Pb-210
	1	Control or background location[a]	Continuous	Weekly filter change or more frequently as required by dust loading	Quarterly composites of weekly samples	Nat-Uranium, Ra-226, Th-230, Pb-210
Radon Gas	5	Same locations as air particulates[a]	Continuous using RadTrak type DRNF	Continuous	Continuous	Rn-222
WATER						
Groundwater	One each	Wells (within license boundary and 1 km radius [c] • Private wells • MEA Brule wells • MEA Ore Zone wells	Grab	Quarterly	Quarterly	Dissolved and suspended Nat-Uranium, Ra-226, Th-230, Pb-210, Po-210
Surface Water	Two from each of 3 designated ephemeral drainage sampling points (total of 6 samples)	Surface waters passing through license area (subject to available flow)[b, d]	Grab	Quarterly	Quarterly	Suspended and dissolved Nat-Uranium, Ra-226, Th-230, Pb-210, Po-210
VEGETATION	None	N/A	N/A	N/A	N/A	N/A
FOOD	None	N/A	N/A	N/A	N/A	N/A

Table 5.7-1 Marsland Expansion Area Operational Effluent and Environmental Monitoring Plan

Type of Sample	Sample Collection			Sample Analysis		
	Number	Location	Method	Frequency	Frequency	Type of Analysis
FISH	None	N/A	N/A	N/A	N/A	N/A
SOIL AND SEDIMENT						
Soil	5 or more	At same locations used for collection of air particulate samples[a]	Grab (0 to 5 cm)	Annually	Annually	Nat-Uranium, Ra-226, Pb-210
Sediment	Two from each ephemeral drainage sampling points (6)	Same as surface water sample locations[b, d]	Grab (minimum of 3 samples for each sample composite)	Annually	Annually	Nat-Uranium, Ra-226, Th-230, Pb-210
DIRECT RADIATION						
Continuous	One each	Air monitoring stations[a]	Dosimeter	Continuous	Quarterly	Gamma exposure rate, using Sodium Iodide scintillometer

[a] Figure 2.9-2
[b] Figure 2.7-4
[c] Figures 2.2-4 and 2.9-3
[d] upstream and downstream
N/A = not applicable
MEA = Marsland Expansion Area

Table 5.7-2 Radiation Doses from Vegetation-Pathway to Man within 80 km of the Marsland In-Situ Uranium Recovery Operation

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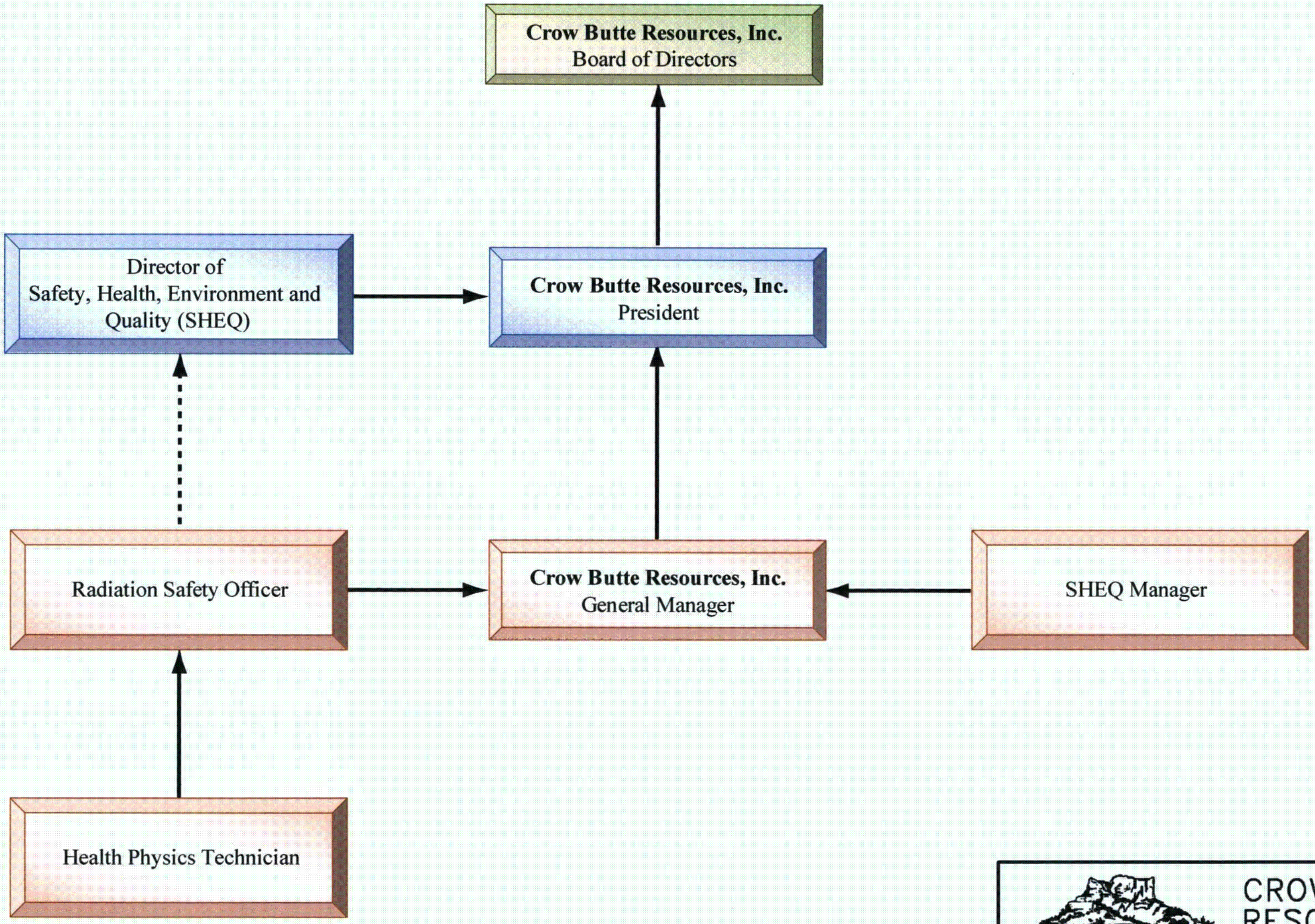

CROW BUTTE RESOURCES, INC.

FIGURE 5.1-1
CAMECO RESOURCES ORGANIZATIONAL CHART

PROJECT: CO001636 MAPPED BY: JC CHECKED BY: JEC

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