CAMECO RESOURCES
CROW BUTTE OPERATION

86 Crow Butte Road
P.O. Box 169
Crawford, Nebraska 69339-0169

December 31, 2014

CERTIFIED MAIL
<u>RETURN RECEIPT REQUESTED</u>

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

Source Materials License SUA-1534
Response to License Condition 9.12

Dear Director:

By letter dated November 5, 2014, the U.S. Nuclear Regulatory Commission renewed Source Material License SUA-1534 issued to Crow Butte Resources, Inc., Crow Butte Uranium In-Situ Recovery Project, Dawes County, Nebraska (TAC J00555).

License Condition 9.12 indicates that the licensee shall provide for NRC review and approval a Quality Assurance Program (QAP). The QAP will address the topics recommended in Regulatory Guide 4.15 (as revised).

Enclosed is the Quality Assurance Program for Crow Butte Resources, Inc.

If there are any further questions or concerns feel free to contact me at (308) 665–2215 ext. 112.

Sincerely,

Doug Pavlick
General Manager

NMSS01
Q004

Enclosure

cc: Deputy Director
Division of Decommissioning
Uranium Recovery and Waste Programs
Office of Nuclear Material Safety and Safeguards
U.S. Nuclear Regulatory Commission
Mail Stop T-8F5
11545 Rockville Pike
Two White Flint North, Rockville, MD 20852-2738

CBO- File

ec: CR-Casper

CROW BUTTE RESOURCES, INC.
d/b/a
CAMECO RESOURCES
CROW BUTTE OPERATION

QUALITY ASSURANCE PROGRAM

December 31, 2014

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1 OBJECTIVES AND ELEMENTS OF A QUALITY ASSURANCE PROGRAM

To define the objectives of a Quality Assurance (QA) program, it is important to first define what quality assurance is and its relationship to quality control.

Quality assurance comprises all those planned and systematic actions that are necessary to provide adequate confidence in the results of a monitoring program. Quality control comprises those quality assurance actions that provide a means to control and measure the characteristics of measurement equipment and processes to established requirements. Therefore, quality assurance includes quality control.

The overall objectives of a QA program are:

- To identify deficiencies in the sampling and measurement processes to those responsible for these operations so that corrective action can be taken, and
- To obtain some measure of confidence in the results of the monitoring programs in order to assure the regulatory agencies and the public that the results are valid.

To achieve these objectives, the QA plan contains the following elements:

- Designation of an individual within the organization as the QA Coordinator. The QA Coordinator should undertake activities such as quality planning, audits and programs to insure reliability and should have the responsibility to assure that the QA plan is being properly implemented.
- A systematic policy for selection and use of measurement and sampling methodology. Where available, this methodology should be approved by the appropriate agency.
- Procedures for the documentation and review of operating procedures and instructions.
- QA audits of acceptance criteria for a QA plan to determine on a systematic basis that all planned activities are being done.

2 ORGANIZATIONAL STRUCTURE AND RESPONSIBILITIES OF MANAGERIAL AND OPERATIONAL PERSONNEL

The structure of the organization as relating to the QA program is shown in Figure 1. The responsibilities of the key QA personnel are as follows:

2.1 BOARD OF DIRECTORS

The Board of Directors has the ultimate responsibility and authority for radiation safety and environmental compliance for Crow Butte Resources, Inc. (CBR) d/b/a Cameco Resources, Crow Butte Operation (CBO). 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.

2.2 PRESIDENT

The President is responsible for interpreting and acting upon the Board of Directors policy and procedural decisions. The President directly supervises the General Manager. The President is empowered by the Board of Directors to have the responsibility and authority for the radiation safety and environmental compliance programs. The President is responsible for ensuring that the operations staff is complying with all applicable regulations and permit/license conditions through direct supervision of the General Manager.

2.3 GENERAL MANAGER

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

2.4 MANAGER OF SAFETY, HEALTH, ENVIRONMENT AND QUALITY (SHEQ)

The Manager of SHEQ is responsible for all, safety, health, environmental and quality programs as stated in the Safety, Health, Environment, and Quality Management System (SHEQMS) and for ensuring that CBR complies with all applicable regulatory requirements. The Manager of SHEQ reports directly to the General Manager. This position assists in the development and review of radiological and environmental sampling and analysis procedures and is responsible for routine auditing of the programs. The Manager of SHEQ has no production-related responsibilities. The Manager of SHEQ also has the responsibility and authority to suspend, postpone, or modify any activity that is determined to be a threat to employees, public health, the environment or potentially a violation of state of federal regulations.

2.5 RADIATION SAFETY OFFICER (RSO)

The 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 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 insure that established programs are maintained. The RSO is also responsible for the collection and interpretation of employee exposure related monitoring, including data from radiological safety. The RSO makes recommendations to improve any and all radiological safety related controls. The RSO has no production-related responsibilities. The RSO reports directly to the General Manager. As such, the RSO has a secondary reporting requirement to the President.

2.6 HEALTH PHYSICS TECHNICIAN (HPT)

The HPT assists the RSO with the implementation of the radiological 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.

2.7 ENVIRONMENTAL LEADERSHIP COORDINATOR

The Environmental Leadership Coordinator is responsible for the development, administration, and enforcement of environmental protection programs. The Environmental Leadership Coordinator inspects facilities to verify compliance with all applicable requirements in the areas of environmental protection. The Environmental Leadership Coordinator is authorized to immediately order any change necessary to preclude or eliminate environmental harm and/or maintain regulatory compliance. The Environmental Leadership Coordinator works closely with all supervisory personnel to review and approve new equipment and changes in processes and procedures that may affect environmental protection and to ensure that established programs are maintained. The Environmental Leadership Coordinator makes recommendations to improve environmental protection-related controls. Responsibilities of the Environmental Leadership Coordinator include the maintenance of appropriate records to document compliance with the regulations and the SHEQMS. The Environmental Leadership Coordinator reports directly to the Manager of SHEQ.

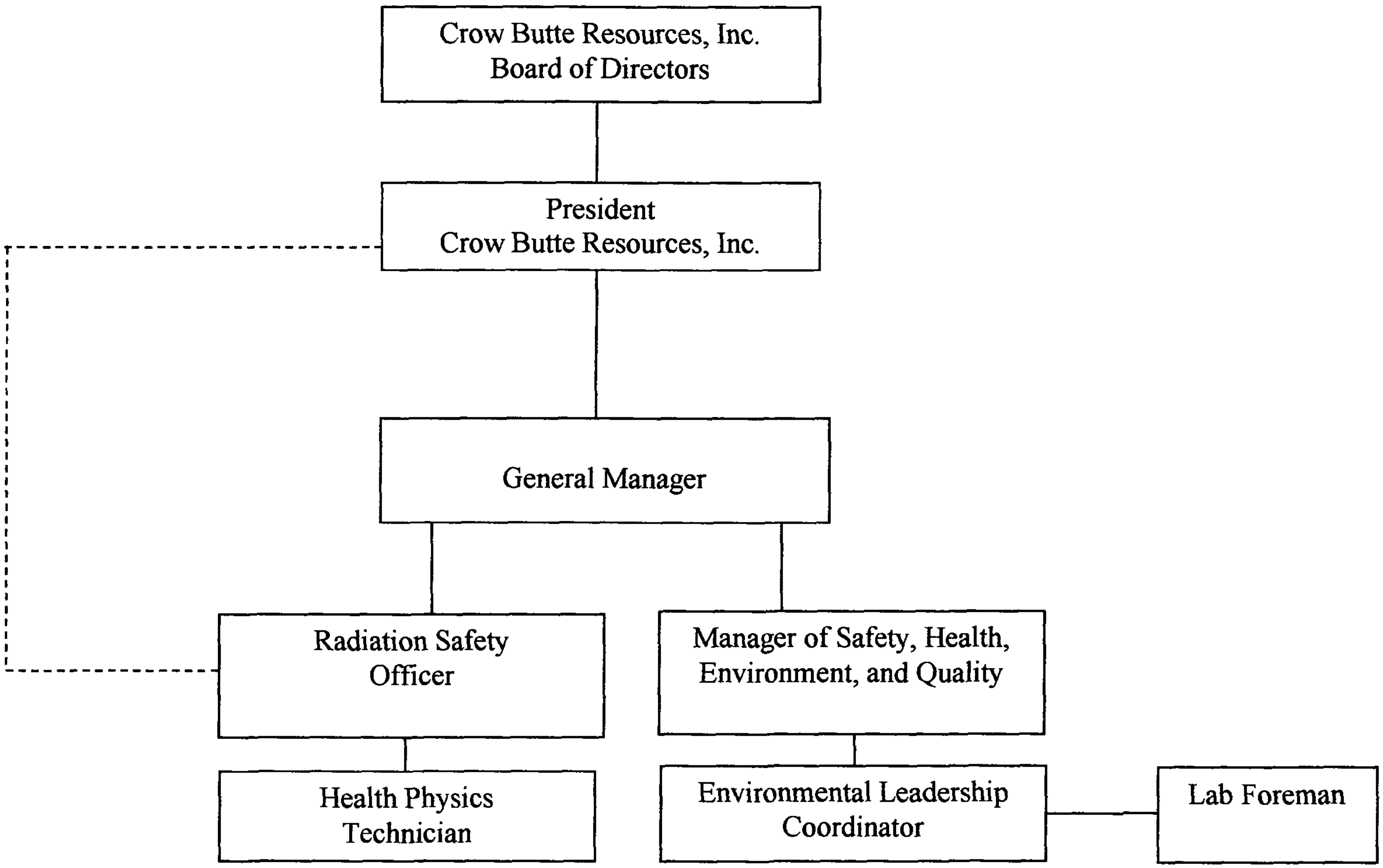
2.8 LAB FOREMAN

The Lab Foreman has direct oversight of the on-site analytical laboratory including implementing laboratory quality assurance procedures. The Lab Foreman is responsible for carrying out any procedures or actions implemented by the General Manager, Manager of SHEQ, or the RSO to correct or prevent radiation safety hazards in the laboratory. The Lab Foreman reports directly to the Environmental Leadership Coordinator.

2.9 QUALITY ASSURANCE COORDINATOR

CBR will conduct audits of the quality assurance program as discussed in Section 12. The Manager of SHEQ may conduct these audits while serving as the Quality Assurance Coordinator. Additionally, CBR may utilize an outside auditing service to provide assurance that all quality assurance procedures and regulatory requirements are being conducted properly at the Crow Butte Uranium Project. Any outside service used for this purpose will be qualified in quality assurance procedures as well as environmental aspects of solution mining operations.

Figure 1: Crow Butte Resources Quality Assurance Organizational Chart



3 QUALIFICATION AND TRAINING OF PERSONNEL

The minimum qualifications of operational personnel involved in the QA program are as follows:

3.1 PRESIDENT OF CBR

Bachelor's degree in engineering or science field and five (5) years' experience or equivalent in mine operations management or a related field.

3.2 GENERAL MANAGER

Bachelor's degree in engineering or science field and three (3) years' experience or equivalent in mine operations management or a related field.

3.3 MANAGER OF SAFETY, HEALTH, ENVIRONMENT, AND QUALITY

Bachelor's degree in science, industrial hygiene, environmental technology or engineering or an equivalent combination of training and relevant experience in uranium mill/solution mining radiation protection. A minimum of 3 years working in environmental protection or related regulatory experience in a similar field.

3.4 RADIATION SAFETY OFFICER

3.4.1 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 UR facility radiation protection. Two years of relevant experience are generally considered equivalent to one year of academic study.

3.4.2 Health Physics Experience

A minimum of one year of work experience relevant to UR operations in applied health physics, radiation protection, industrial hygiene or similar work. This experience should involve actually working with radiation protection and measurement equipment, not strictly administrative or "desk" work.

3.4.3 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 UR facility health physics every 2 years.

3.4.4 Specialized Knowledge

A thorough knowledge of the proper application and use of all health physics equipment used in the UR 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 UR process and equipment used in the facility and how the hazards are generated and controlled during the UR process.

3.5 HEALTH PHYSICS TECHNICIAN

3.5.1 Education

An associate degree or two years or more of study in the physical sciences, engineering or a health related field.

3.5.2 Training

At least a total of four weeks of generalized training (up to 2 weeks may be on the job training) in radiation health protection applicable to UR facilities.

3.5.3 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 UR facility.

3.5.4 Alternate Qualifications and Training

The HPT may also possess the following alternate qualification and training:

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

3.6 ENVIRONMENTAL LEADERSHIP COORDINATOR

Bachelor's degree in science or a closely related field. Minimum of 3 years working in environmental protection or related regulatory experience in a similar field.

3.7 LAB FOREMAN

The minimum qualifications for a Lab Foreman are two years of post-secondary education in Chemistry or Physical science and two years of inorganic laboratory experience. At least one year of this experience should be at a UR facility.

3.8 TRAINING

Personnel performing quality related activities will be trained in the principals and techniques of the activities performed. An on-the-job training program that will be administered by experienced professionals will achieve training of the field personnel.

3.9 TRAINING EVALUATION

On an annual basis, the Manager of SHEQ or a designated outside consultant will observe field and plant personnel in the sample collection and analysis process and evaluate the personnel performance on the basis of adherence to written procedures.

4 OPERATING PROCEDURES

4.1 ADMINISTRATIVE AND OPERATION PROCEDURES

The CBR Quality Assurance Program is implemented through the use of written Standard Operating Procedures (SOPs). These SOPs have been developed for all process activities, including those activities involving radioactive materials, for the Crow Butte Uranium Project. Where radioactive material handling is involved, pertinent radiation safety practices are incorporated into the SOP. Additionally, SOPs contain instructions for performing non-process activities including instrument calibration, environmental monitoring, health physics monitoring, and emergency measures.

Quality assurance and control objectives are met by including the requirements for performance of quality control measures in the appropriate SOP. In some instances, separate SOPs are developed to implement quality measures.

Written SOPs are kept electronically and in the areas of the plant facility where they are used. This allows for easy access by employees. Employees are trained on the appropriate SOPs for their job description when they are initially hired and when any procedure revisions are made.

4.2 TYPES OF PROCEDURES

The SOPs developed by CBR are a critical step to insuring that quality assurance objectives are met. Current SOPs exist for a variety of areas, including but not limited to:

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

7. Laboratory procedures.

The CBR Safety, Health, Environment, and Quality Management System (SHEQMS) are organized into eight volumes. The volumes are as follows:

Volume I, *Standard*
Volume II, *Management Procedures*
Volume III, *Operations Manual*
Volume IV, *Health Physics Manual*
Volume V, *Industrial Safety Manual*
Volume VI, *Environmental Manual*
Volume VII, *Training Manual*
Volume VIII, *Emergency Manual*

Specific SOPs that are used by CBR to implement quality measures are listed throughout this Quality Assurance Program. These SOPs may be revised and/or supplemented with additional SOPs to meet quality requirements as the need arises. The site also has a *Laboratory Procedures Manual* for a quality assurance / quality control program to determine the precision and accuracy of the laboratory analysis performed in the on-site laboratory.

4.3 PROCEDURE REVIEW AND APPROVAL

Written SOPs have been developed, reviewed and approved by the RSO and the responsible managers. The responsible manager ensures that the operational aspects of the SOP are correct and appropriate. All written SOPs are reviewed for radiological protection aspects and approved by the RSO prior to implementation.

SOPs are revised as necessary to meet changing operational and regulatory requirements. Any revisions made to the SOPs are reviewed and approved by the RSO and responsible manager prior to implementation. At a minimum, the SOPs are reviewed and, where necessary, revised, on an annual basis by the RSO. The annual review is documented by the RSO.

The personnel shown in Table 1 are responsible for approvals for each of the SHEQMS volumes.

Table 1
Procedure Approval Responsibility

SHEQMS Volume	**Radiological Protection Approval**	**Final Approval**
Volume I, *Standards*	RSO	General Manager
Volume II, *Management Procedures*	RSO	General Manager
Volume III, *Operations Manual*	RSO	General Manager
Volume IV, *Health Physics Manual*	RSO	RSO
Volume V, *Industrial Safety Manual*	RSO	General Manager
Volume VI, *Environmental Manual*	RSO	SHEQ Manager
Volume VII, *Training Manual*	RSO	SHEQ Manager
Volume VIII, *Emergency Manual*	RSO	SHEQ Manager
Laboratory Procedures Manual	RSO	Lab Foreman

5 INSTRUMENT CALIBRATION

CBR implements a routine maintenance and calibration program for all radiological survey instruments and samplers. This program is implemented through the use of appropriate SOPs. The CBR instrument maintenance and calibration program is based upon the recommendations contained in USNRC Regulatory Guide 4.15, *"Quality Assurance for Radiological Monitoring Programs (Inception through Normal Operations to License Termination) – Effluent Streams and the Environment,"* (Revision 2, 2007) and Regulatory Guide 8.30, *"Health Physics Surveys in Uranium Mills,"* (Revision 1, 2002).

5.1 INSTRUMENT CHECKS

CBR performs checks of radiation survey and counting equipment daily before use. The daily checks consist of a physical check and a response check. CBR also performs checks of counting instruments to determine instrument efficiency and sensitivity.

5.1.1 Vendor Calibration

The physical checks performed on a daily basis include verification that the instrument is properly calibrated, has sustained no physical damage that may interfere with accuracy, and that the instrument battery has adequate power (if appropriate).
The manufacturer or a qualified accredited vendor shall calibrate portable survey instruments, counter/scalers, mass flow meters and/or dry cell calibrators, and calibration sources. Calibration will be performed as recommended in ANSI N323 and ANSI N323A. The ANSI standard requires that radiation detection instruments be performance tested on an annual basis to verify that they continue to meet operational and design requirements. Instruments must be tested for range, sensitivity, linearity, detection limit, and response to overload. The specific calibration requirements for various types of instrument are given in the following sections.

5.1.1.1 Linear and Digital Readout Instruments

Linear readout instruments with a single calibration control for all scales shall be adjusted at the point recommended by the manufacturer. Instruments with calibration controls for each scale must be adjusted on all scales. After adjustment, the instrument must be checked near the end points (approximately 20% and 80% of full scale).

5.1.1.2 Logarithmic Readout Instruments

Logarithmic readout instruments normally have two or more adjustments. The instrument must be adjusted for each scale as recommended by the manufacturer. After adjustment, the instrument must be checked at a minimum of one point on each decade.

5.1.1.3 Surface Contamination Measurement Instruments

Alpha and beta-gamma detection instruments usually consist of a count rate meter and a separate detector. The electronics and the detector may be calibrated together or separately. The detector should be calibrated with the radionuclide to be detected, if possible, or with radionuclides of similar energies. When the instrument is calibrated as an integral unit, a minimum of one point on each scale is calibrated up to approximately 6×10^4 dpm/100 cm^2. When calibrated separately, the count rate meter is calibrated with an electronic pulser. Exchange of detectors is allowed if the response to a calibrated check source is within the range of acceptable counts for the original probe and check source.

5.1.1.4 Radioactive Calibration Sources

Calibration sources that are used to determine instrument operating parameters such as high voltage setting, reliability factor, and efficiency must be calibrated annually by the manufacturer. Depending on the half-life of the radionuclide used for the source, decay correction may also be necessary during use to ensure accuracy. All calibration sources are stored in the Radiation Safety Laboratory and are secured after hours by a locked door.

5.1.1.5 Calibration Records

The calibration vendor shall provide a record of all calibration, maintenance, repair, or modification. Calibration records will be filed with all previous records for the same instrument. In addition, each instrument will be labeled with the following information:

- Date of most recent calibration;
- Initials of calibrator;
- Date that primary calibration is again required;
- Special use or limitations (if applicable);

- Serial number of the instrument.

5.1.1.6 Calibration Frequency

Calibration frequency is annual or at the frequency recommended by the manufacturer, whichever is more frequent. Where instruments are subjected to extreme operational conditions, hard usage, multi-shift use, or corrosive environments, the RSO should consider increasing the calibration frequency. The calibration vendor should provide the as-found calibration condition for each instrument. If greater than 10% of the instruments are out of calibration when received by the calibration vendor, consideration should be given to increasing the calibration frequency.

5.1.2 On-Site Calibration

Regulated air samplers (Eberline RAS-1 or equivalent) and high volume air samplers are calibrated semiannually or at the manufacturer's recommended frequency, whichever is more frequent. Breathing zone samplers are calibrated daily during use. With the exception of breathing zone samplers, air samplers should be labeled with the date of calibration, correction factors (if applicable), and initials of the calibrator. This information is recorded on the daily calibration sheet for the breathing zone samplers.

5.2 FUNCTIONAL TESTS

Functional tests are performed at the mine site to ensure that an instrument is acceptable for use. The functional tests are checks that are often qualitative and consider the physical condition of the instrument (e.g., battery condition) and response of the instrument to a radioactive source. These checks are compared to the known response of the instrument after the most recent calibration to ensure instrument accuracy.

5.2.1 Initial Instrument Checks

Initial instrument checks are performed initially after receipt of the instrument from the calibration vendor. The results of these initial instrument checks are recorded and are used to ensure that a system continues to operate in as-received condition until the next scheduled calibration. These functional tests are also performed after any repair or if the response of the instrument to a known source is questioned.

5.2.1.1 Instrument Reliability Factor

The instrument reliability factor (RF) will indicate whether an instrument is operating properly within the statistical limits of counter reliability. The reliability factor is determined initially after receiving the appropriate type of instrument from the calibration vendor. The reliability factor should also be determined for an instrument that has not been in service for an extended period or for an instrument that has a daily source check count that falls outside the acceptable range. The reliability factor should be between 0.64 and 1.22. This implies that the instrument is operating reliably. A reliability factor between 0.50 and 0.64 or 1.22 and 1.40 will be investigated by the RSO. A reliability factor less than 0.50 or greater than 1.40 is unsatisfactory and the instrument will be removed from service.

5.2.1.2 Acceptable Range

The acceptable range will allow a quick determination that the daily source count performed for a specific instrument is within satisfactory limits. Note that the daily source count must be performed using the same calibrated source that was used to determine the reliability factor.

5.2.1.3 High Voltage Plateau

The instrument high voltage plateau will indicate whether or not the high voltage applied to the instrument detector is set at the appropriate point for maximum sensitivity with minimal influence from background radiation levels. The high voltage plateau is performed initially after receiving the appropriate type of instrument from the calibration vendor. The purpose of this high voltage plateau is to confirm the high voltage selected by the calibration vendor is appropriate. A secondary purpose is to ensure that the setting was not affected by shipment of the instrument. A high voltage plateau should also be performed on an instrument when a new detector is installed or when there is a noticeable degradation in instrument performance as indicated by the daily functional tests. Performance problems would include a decrease in the instrument efficiency over time or erratic results indicated by a daily source check count that falls outside the acceptable range.

5.2.1.4 Lower Limit of Detection (LLD)

The instrument lower limit of detection (LLD) is the smallest concentration of radioactive material that has a 95 percent probability of being detected. The LLD will determine whether the instrument and counting procedures are capable of detecting the presence of radioactive material below the allowable regulatory limits (i.e., allowable air concentrations or removable activity concentrations). The LLD is a determination of sensitivity for a measurement system and is not intended to be calculated for individual samples.

If the LLD is at or above the allowable limit, adjustments will be made to reduce it to an acceptable level. Typically, the counting system LLD should be 10 percent of the allowable limit. In no case should the LLD be above 50% of the allowable limit. Increasing the sample count time, increasing the sample volume, or reducing background levels will lower the LLD.

The LLD is determined initially after receiving the instrument from the calibration vendor. LLD should also be determined for an instrument that has not been in service for an extended period or for an instrument that has required repairs or a high voltage plateau.

5.2.1.5 Minimum Detectable Concentration (MDC)

The LLD is the determination of sensitivity for a measurement system and is not intended to be calculated for individual samples. Minimum detectable concentration (MDC) is a measurement of the detection sensitivity for a single sample based on sampling and counting parameters and should be calculated to ensure adequate sensitivity is achieved for each sample.

5.2.2 Instrument Checks

Regulatory Guide 8.30 specifies requirements for routine maintenance and calibration of radiological surveys instruments. Regulatory Guide 8.30 also references the standards contained in ANSI N323-1978, *Radiation Protection Instrumentation Test and Calibration.* ANSI is in the process of a major revision of this Standard that will result in three separate Standards that apply to radiological instrumentation. The first revision, ANSI-N323A-1997, *Radiation Protection Instrumentation Test and Calibration, Portable Survey Instruments*, was incorporated in this Chapter. Where conflicts arise between Regulatory Guide 8.30 and the ANSI Standard, the Regulatory Guide recommendations have been followed.

5.2.2.1 Calibration Verification

Any survey or counting equipment in use shall have a current calibration sticker in place. Calibration stickers shall be checked before use or daily when in use. Calibration date and due date will be recorded on the appropriate form.

Air samplers shall have a current calibration sticker in place. Calibration stickers shall be checked each day before use of these regulated air samplers. Breathing zone samplers do not require calibration stickers if they are calibrated before each use. Calibration results will be recorded on the appropriate form.

5.2.2.2 Physical Check

Before each use, all instruments and samplers shall be inspected for physical condition. The inspection should include determining whether there are any loose or damaged knobs, buttons, cables, or connectors. Meter movements or displays should be inspected for damage. Instrument cases should be inspected for dents or corrosion. Probes should be inspected for damage such as punctured or deformed probes or probe windows.

An instrument that has any physical damage should not be placed in service. Repairs shall be made and documented.

5.2.2.3 Battery/High Voltage Check

The battery check is performed to determine the condition of the instrument's batteries. This check is important to ensure that there is sufficient voltage being supplied to the detector and the instrument circuitry. The battery check will be performed in accordance with the instructions contained in the appropriate instrument technical manual. If the battery check is unsatisfactory, refer to the technical manual for instruction for replacement of batteries and repeat the check. If results are still not satisfactory, remove the instrument from service until repairs can be made. Repairs shall be made and documented.

High voltage checks shall be performed in accordance with the appropriate instrument technical manual. The purpose of the high voltage check is to ensure that the proper voltage is being applied to the detector. The high voltage setting is provided by the instrument calibration vendor on the calibration certificate or is determined by performing a high voltage plateau.

5.2.2.4 Response Source Check

The response source check is made to ensure that the instrument in use will respond to a known source of radiation. The response check does not result in determination of efficiency or the instrument correction factor. The response check is typically performed before each use and indicates that the instrument has not sustained damage that would prevent it from detecting radiation. An example of a response check would be checking an alpha contamination survey meter at a restricted area access point with a check source.

5.2.2.5 Background Measurement

Background measurements for radiation survey instruments are performed daily or as required. Local background may need to be determined before a particular use, such as performing a gamma radiation survey for characterization of potential contamination.

Background measurements for scaler type instruments are used to evaluate the radiation level in the area where the instrument is located. High background radiation levels will affect the sensitivity of scaler type instruments and will adversely affect the lower limit of detection (LLD).

5.2.2.6 Determination of Efficiency and Correction Factor

Instrument efficiency (E) is determined to check instrument performance when measured with a source of known activity of a particular radioisotope. A correction factor (CF) is determined that allows conversion of instrument cpm to disintegrations per minute (dpm) and is the inverse of the known efficiency (i.e., 1/E).

The instrument dpm Factor may be determined for contamination survey instruments to correct the indicated cpm to dpm per 100 cm^2. This factor is typically determined for instruments that are used for performing total surface contamination surveys since the action levels and regulatory limits are expressed in units of dpm/100 cm^2.

5.2.3 Instrument Check Schedules

Routine checks of radiation survey and counting instruments are made to ensure that the instrument is responding accurately and is in proper condition for field use. The check schedule for each type of instrument based on the guidance contained in Regulatory Guide 8.30. Specific instructions for performing these checks on each instrument are contained in the appropriate instrument technical manual.

5.2.3.1 Radiation Survey Instruments

Radiation survey type instruments include the Ludlum Model 3 Gamma Survey Meter and the Ludlum Model 19 microR Meter or equivalent. These instruments require the following checks at the noted frequency:

- Physical check – Daily when in use;
- Battery Check (if applicable) – Daily when in use;
- Response source check – Daily when in use;

- Calibration verification – Daily when in use;
- Background measurement – Daily when in use, as required.

5.2.3.2 Surface Contamination Instruments

Surface contamination instruments are used to measure alpha and beta-gamma surface contamination levels and include the Ludlum Model 2241 Ratemeter/Scaler Survey Meter. These instruments require the following checks at the noted frequency:

- Response source check – Before each use;
- Battery Check (if applicable) – Daily when in use;
- High Voltage Check (if applicable) – Daily when in use;
- Calibration verification check – Daily when in use;
- Background measurement – Daily when in use, as required;
- Determination of efficiency/correction factor – Daily when in use;
- Determination of instrument reliability factor – Initially after calibration.

5.2.3.3 Scaler Type Instruments

Scaler type instruments are used to analyze the alpha contamination on air filters and loose surface contamination ("smear") samples. These instruments consist of a detector and a scaler and include the Ludlum Model 2000 Scaler or equivalent. These instruments require the following checks at the noted frequency:

- Physical check – Daily when in use;
- Battery Check (if applicable) – Daily when in use;
- High Voltage Check (if applicable) – Daily when in use;
- Calibration verification check – Daily when in use;

- Background measurement – Daily when in use;
- Determination of efficiency/correction factor – Daily when in use;
- Determination of instrument reliability factor – Initially after calibration, after repair or if instrument response is questionable;
- Determination of lower limit of detection – Initially after calibration, after repair or if instrument response is questionable;
- High voltage plateau – Initially after calibration, after repair or if instrument response is questionable.

5.2.3.4 Alpha Survey Meters

Alpha survey meters are used to measure alpha surface contamination levels on skin and equipment and include a ratemeter such as the Eberline RM-19 and the Ludlum Model 12 or 177 Frisker or equivalent. These instruments require the following checks at the noted frequency:

- Response source check – Before each use;
- Battery Check (if applicable) – Weekly;
- High Voltage Check (if applicable) – Weekly;
- Calibration verification check – Weekly;
- Background measurement – Weekly;
- Determination of efficiency/correction factor – Weekly;
- Determination of instrument reliability factor – Initially after calibration.

5.2.4 Beta Calibration

Periodic beta detector calibration checks should be performed using aged yellowcake (i.e., at least 4 months old). The calibration should be performed at the surface and at 2 cm (approximately one inch) from the surface of the yellowcake source.

5.3 POTENTIAL DETECTION PROBLEMS

In the course of performing instrument checks and reviewing records, the RSO or designee will be aware of the following observations that may indicate a detection problem:

- Background drift in a continuous direction, either up or down;
- Alpha background rates greater than 1.0 cpm;
- A calculated LLD that is greater than 50 percent of the appropriate regulatory limit;
- A ratemeter instrument that does not zero;
- A battery check that does not respond;
- Reliability factors greater than 1.40 or less than 0.50;
- A daily response source check that does not fall within ± 20 percent of the calculated mean.

If any of the potential problems listed above are noted, the RSO or designee will remove the instrument from service and investigate until the source of the problem can be determined and corrected.

5.4 RADIOLOGICAL INSTRUMENT CALIBRATION

CBR calibrates radiation survey and counting instruments after each repair. Routine calibration is performed annually or at the frequency recommended by the manufacturer, whichever is more frequent. A qualified instrument calibration vendor performs all calibration of radiation survey and counting instruments.

5.5 AIR SAMPLER CALIBRATION

Proper calibration of air sampling equipment is important to ensure that the total volume of air sampled is accurate. Air sampling is performed at the Crow Butte project and expansion areas to determine environmental and occupational levels of radioactivity in air.

Calibration of field flow rate measurement instruments (typically rotameters) is performed by comparing the flow rate measured by the field instrument with the flow rate measured by a primary standard instrument or a properly calibrated secondary standard instrument. Primary measurements generally involve a direct measurement of the volume based on the physical dimensions of an enclosed space, such as a "frictionless" piston meter (i.e., soap film flowmeter or dry cell calibrator). Secondary standards are reference instruments or meters that trace their calibration to a primary standard, such as a mass flow meter.

Calibration should be performed semiannually as recommended in Regulatory Guide 8.30 or at the manufacturer's recommended frequency, whichever is shorter. Calibration should be performed with air filters in place to properly account for the reduction in flow due to solid material deposited on the filter.

5.5.1 Calibration Using the Soap Film Technique

The soap film technique involves using a graduated buret and a soap solution to measure the volume of air drawn through the buret during a measured time. The pump is started and connected to the buret, which is then dipped into a soap solution to form a bubble. The bubble will move along the buret. The time that it takes the bubble to move between volume graduations is measured, resulting in an indicated flow rate that is corrected to liters per minute (LPM). This measurement is then compared to the volume indicated by the air meter on the sampler. The comparison results in a correction between the indicated and the actual flow rate.

5.5.2 Calibration Using a Dry Cell Calibrator

A dry cell calibrator is a primary air flow calibrator that is a variation on the wet cell technique. The calibrator consists of a flow cell using a near-frictionless piston to measure the volume of air pumped. The flow cell is made of dimensionally stable borosilicate glass with a sensing encoder. The cell dimensions and crystal timing device are NIST traceable which allows use of the unit as a primary standard. Depending on the design flow rates, these units may be used for low and high flow samplers.

5.5.3 Calibration Using a Linear Mass Flow Meter

Linear mass flow meters may be used to calibrate sampling pumps. The linear mass flow meter measures the differential temperature of a gas drawn through a heated capillary tube and is considered a secondary standard.

5.5.4 Adjustment for Pressure and Temperature

Many variables affect the accuracy of air sampling measurements. Two of these are temperature and pressure variations. USNRC Regulatory Guide 8.25 states that corrections to the measured flow rate should be made if there are differences exceeding five percent in either the absolute pressure or absolute temperature between the calibration situation and the sampling situation.

Differences in the absolute pressure are common when calibration is performed at a different altitude (and thus a different air pressure) than that at which the instrument will be used. An example of this would be the calibration of a secondary standard at sea level and then use to calibrate rotameters at a higher elevation. Differences in pressure may be evaluated by comparing the barometric pressure readings at the calibration location with those at the sampling location.

Similarly, differences in temperature between the calibration location and the sample location will adversely affect accuracy of flow meters. Since calibrations are generally made at room temperature (i.e., approximately 72°F), corrections should be made to account for sampling conditions if the ambient temperature is expected to exceed the five percent limit. Based on absolute temperature, five percent of a calibration temperature of 72°F would correspond to an ambient temperature less than 45°F and greater than 98°F.

5.6 SAMPLE ANALYSIS PROCEDURES

5.6.1 Analyzing Area Airborne Uranium Samples

Uranium airborne particulate samples are determined by counting alpha emissions using a scaler ratemeter or equivalent. The scaler is used with an alpha detector such as a Ludlum 43-10, Ludlum 218, Eberline SAC-R5, or equivalent. Some detectors, such as the Eberline SAC-R5, require the use of scintillation paper to detect alpha activity. The analyst should review the specific manufacturer's instruction manual to ensure familiarity with the detector operating requirements.

NOTE: Samples must age for 24 to 48 hours after sampling to allow decay of short-lived radionuclides.

5.6.2 Analyzing Breathing Zone Samples

Because breathing zone samples are typically collected over relatively short durations (i.e., less than a full work shift) it is necessary to utilize longer count times for both background and the sample in order to achieve the desired LLD. It should be noted that Regulatory Guide 8.25 recognizes that breathing zone samples may not be able to detect 10% of the appropriate DAC but that such samples are still acceptable for measuring potential uranium exposure to workers.

5.6.3 Radon Daughter Counting Procedure (Modified Kusnetz)

Radon daughter samples are analyzed using the modified Kusnetz method. Samples are collected on fiberglass or membrane filters using a lapel sampler or equivalent pump pulling a minimum of 2 liters per minute. Samples are collected for exactly five minutes, resulting in a 10 liter sample.

The sample filter is allowed to decay between 40 and 90 minutes after the end of collection before counting. After 40 minutes, only alpha particles from the decay of Po-214 are counted because virtually all of the Po-218 (3.05 minute half-life) has decayed.

The sample is counted with a scaler rate meter and an alpha scintillation detector at a count time determined by the RSO as adequate to meet the LLD requirements of 0.03 WL. The resulting gross counts are divided by the count time to arrive at a count rate (cpm).

Working levels are derived by dividing the count rate, minus background, by the product of the counter efficiency, the volume of air sampled, and the time factor.

The time factor (TF) is dependent on the time elapsed between end of sampling and the beginning of counting. The time factor is based on the assumption that equilibrium existed between Po-218, Pb-214, and Bi-214 at the time of sampling. The time factor relates dpm per liter of air from 40 to 90 minutes after sampling to the decay activity that would be present from an initial concentration of 1 WL.

5.6.4 Analyzing Smear Samples

Smear samples are taken to quantify the amount of removable contamination present on a surface or object. Following sample collection, smears are analyzed using a scaler rate meter and an alpha scintillation detector.

5.6.5 Filter Self Absorption Calculation

Regulatory Guide 8.25 requires that counting results be corrected for self-absorption of radiation by the filter collection media would reduce the count rate by more than 5 percent. The following comparison should be made as necessary as determined by the RSO. The self-absorption is determined using the following formula:

$$\% \text{ Self Absorption} = \frac{C_2 - C_3}{2C_1 + C_2 - C_3} \times 100$$

where:

C_1 = cpm on front of filter
C_2 = cpm on back of filter
C_3 = cpm on front of filter covered by new filter of the same type

The three counts should be performed as quickly as possible at a count time of one minute. The calculated uranium activity must be adjusted if the filter self-absorption is determined to be greater than 5 percent. For example, if the calculated activity is 5.0 E-11 μCi/ml and the filter self-absorption is 15 percent, the actual activity is (5.0 E-11)(1.15) = 5.75E-11 μCi/ml.

5.6.6 Regulated Air Samplers (RAS)

Regulated air samplers are used at the Crow Butte project for measurement of airborne concentrations of particulate radioactivity. CBR calibrates regulated air samplers on a semiannual basis. Calibration is performed using a properly calibrated mass flow meter. As a result of this calibration, the correction factor for the air sampler is determined and is used to ensure accurate total flow determinations are available.

5.6.7 Breathing Zone Samplers

Breathing zone samplers are used at the Crow Butte project for area sampling to determine the concentration of radon daughters in air using the Modified Kusnetz Method. Breathing zone samplers are also used for measuring the concentration of airborne particulate radioactivity in the breathing zone of workers. These samplers are calibrated before each use using a bubbler tube and stopwatch to ensure accurate determination of total volume of air sampled.

5.7 RADIONUCLIDE REFERENCE STANDARDS

Crow Butte uses calibrated radionuclide reference standards (sources) to determine the counting efficiency of instrumentation for a given radionuclide. Non-calibrated check sources are also used to check the response of certain instruments.

5.7.1 Calibrated Standards

Calibrated radionuclide standards that have been certified as traceable to National Bureau of Standards (NBS, now known as the National Institute of Standards and Technology, or NIST) measurements are used for determination of instrument efficiency and correction factor. The instrument efficiency is used to convert the instrument indicated count rate to a concentration of radioactivity. These calibrated standards are used to determine counting efficiencies for all radioactivity measurements that require comparison to a specified concentration of radioactivity per unit volume or area, such as air samples and surface contamination level determinations.

5.7.2 Non-calibrated Standards

Certain radionuclide check sources that are not traceable to NBS measurements are used at the Crow Butte project to indicate that an instrument is responding properly. These non-calibrated check sources include sources that are maintained at restricted area boundaries near survey instruments. The sources are used before each use of the instrument to perform a response check. This response check is performed in addition to the daily determination of efficiency and correction factor.

6 ENVIRONMENTAL AND EFFLUENT SAMPLING

CBR performs environmental and effluent monitoring at the Crow Butte project as required by NRC regulations and CBR's source materials license. Measurements are performed for the following purposes:

- To allow CBR to estimate the maximum annual radiation dose to the public;
- To ensure that the regulatory requirements and license conditions for dose and release limitations and meeting "as low as reasonably achievable" objectives are met;
- To evaluate the performance of effluent controls;
- To evaluate the environmental impact of mining operations; and
- To establish baseline data to aid in decommissioning or remediation efforts.

CBR's environmental and effluent sampling program was prepared in accordance with the guidance contained in Regulatory Guide 4.14, *"Radiological Effluent and Environmental Monitoring at Uranium Mills"*, (Revision 1, 1980). Regulatory Guide 4.14 and 4.15 contain guidance for quality assurance and quality control measures to ensure the accuracy of effluent and environmental sampling and analysis activities.

6.1 SAMPLE COLLECTION

The quality assurance program for environmental sampling is implemented in the following areas:

- Procedures are used which define the details of sample location, sample frequency, number of samples, duration of sampling, sample volume, sample collection methods, and equipment to be used for sample collection.
- Procedures have been prepared for calibration and maintenance of equipment used for measurement. These procedures provide details for the standardization, use and maintenance of the instruments.
- Taking duplicate samples and submitting these to the analytical laboratory makes random control checks. These checks allow evaluation of the performance of the analytical laboratory and to some extent, the validity of sampling procedures. In the event that the results of the

duplicate samples do not agree within predetermined limits, an audit will be performed to determine whether the problem is in the sampling or analysis.

CBR collects samples of environmental media within the NRC license area. Samples are also obtained from the surrounding area. Specific CBR SOPs are used to provide instructions for obtaining each type of environmental sample.

6.1.1 Air Sampling

The airborne effluent and environmental monitoring program is designed to monitor the release of airborne radioactive effluents from the Crow Butte project. To evaluate the effectiveness of the effluent control systems, the results of the monitoring program are compared with the background levels and with regulatory limits.

The accuracy of monitoring data is critical to ensure that the air monitoring program precisely reflects air quality in each phase of the program. Regulatory Guide 4.14 specifies the following lower limits of detection (LLD):

Radionuclides	LLD (µCi/ml)
Natural Uranium	1×10^{-16}
Thorium-230	1×10^{-16}
Radium-226	1×10^{-16}
Radon-222	2×10^{-10}
Lead-210	2×10^{-15}

6.1.1.1 Radon Gas Sampling

The radon gas effluent released to the environment is monitored using Track-Etch radon cups provided by Landauer Corporation. The cups are exchanged on a semiannual basis. In addition to the manufacturer's quality assurance program, CBR exposes two duplicate radon Track Etch cups during each monitoring period.

Radon-222 is monitored continuously at the environmental monitoring locations. Monitoring is performed using Landauer RadTrak detectors. These detectors are an alpha-track radon gas detector using Landauer's Track-Etch® process and are designed to monitor radon exposure for three months to one year. Landauer service includes the RadTrak detector and a comprehensive analysis.

The RadTrak radon detectors are supplied in aluminum bags to prevent radon exposure before deployment. The detectors should not be stored or deployed in any area in which the temperature may exceed 160°F. There is no low temperature limit.

Note: Landauer does not provide the LLD on the analytical result report. The LLD for Track-Etch® detectors is a function of the exposure time and the area of the cup that is analyzed by Landauer. The LLD should be determined in consultation with Landauer before monitoring is performed. If the LLD is above the NRC requirements from Regulatory Guide 4.14, it may be reduced by either employing a longer sampling time or requesting that Landauer analyze a larger portion of the Track-Etch® cup.

6.1.1.2 Air Particulate Sampling

Airborne particulate sampling is performed at the locations specified in the NRC License. The CBO License requires monitoring for at least 2 weeks of every month that the yellowcake dryer is in operation. However, CBO has instituted continuous monitoring at these sites as a best management practice.

Filters are collected for two weeks and then composited for analysis on a quarterly basis. At the end of the calendar quarter, the composite filter samples are submitted to the contract laboratory for radiometric analysis using standard Chain of Custody Procedures. The filters are composited according to location. The composite samples are analyzed for the concentrations of natural uranium, radium-226, and lead-210. The actual volume of air filtered at each station for the quarter is also forwarded to the contract laboratory with the filters. The flow rate on the RAS-1 pumps is calibrated at six-month intervals in order to ensure the accuracy of the volume of air sampled.

6.1.2 Water Sampling

During operations at the Crow Butte project, a detailed water-sampling program is conducted to identify any potential impacts to water resources of the area. CBR's operational water monitoring program includes the evaluation of groundwater on a regional basis, groundwater within the permit or licensed area and surface water on a regional and site specific basis. To evaluate the effectiveness of the effluent control systems, the results of the groundwater and surface water monitoring programs are compared with the background levels and with regulatory limits.

6.1.2.1 Groundwater Monitoring

The groundwater-monitoring program is designed to detect impacts to the local and regional groundwater from mining operations. Potential sources of impacts to the groundwater could be excursion of mining solutions beyond the perimeter of the wellfields or a failure of evaporation pond lining systems. Monitor wells are installed around the wellfield boundaries and the evaporation ponds to monitor for impacts to the local groundwater. Sampling all private wells within one kilometer of the wellfield area boundary monitors impacts to regional groundwater.

Groundwater samples obtained for preoperational, operational, and restoration purposes are critical to meeting environmental protection goals at solution uranium mines. The results of these samples are used to determine pre-mining conditions, to monitor operational environmental protection efforts, and to determine whether restoration activities are successful. In order to ensure the accuracy of these monitoring efforts, strict compliance with groundwater sampling procedures is necessary.

6.1.2.1.1 Water Level Determination

The accurate determination of the static water level in wells provides important information concerning aquifer conditions. Well static water levels are monitored using an electrical measuring line (an "e-line"). The sampler takes e-line readings of all monitor wells before sampling. Significant changes in the water level in overlying aquifers may indicate a vertical excursion of mining solutions. Similarly, changes in the production zone water levels may provide an early indication of the migration of mining solutions from the active wellfield. Water level measurements are also used to determine groundwater gradients in the mining zone to assist operating personnel in managing wellfield balancing.

6.1.2.1.1 Field pH Measurements

Field measurement of pH is used in conjunction with conductivity as an indication that well purging has successfully removed stagnant water from the well casing and formation water is being sampled.

Degasification (such as loss of carbon dioxide), precipitation (such as calcium carbonate), and other chemical and physical reactions may cause the pH of a water sample to change significantly within several hours after the sample is collected. Therefore, immediate analysis of a sample in the field is required.

pH measurements will be performed in accordance with manufacturer's recommendations. The probe should be swirled in the sample to remove any air bubbles adhering to the surface of the probe. A reading is not valid until the reading on the panel is stable for at least ten (10) seconds or bounces around a point for at least ten (10) seconds.

Standardization will be checked daily during regular use. For the range of water quality encountered in well sampling activities, standardization will be performed using a pH 7.00 buffer and a pH 10.00 buffer.

6.1.2.1.1 Field Conductivity Measurements

Field measurement of conductivity is used to indicate when well purging has successfully removed stagnant water from the well casing and formation water is being sampled. Specific conductance meters used in the field are battery operated, and read directly in micromhos (μmhos) or microsiemens (μS) per cm.

The conductivity cell is checked daily during regular use. A standard solution of known electrical conductance that falls in the range of samples to be measured is used to check the cell. For the range of water quality typically encountered, a standard solution of from 500 to 1500 micromhos/cm at 25°C will be used. Instrument calibration will be performed in accordance with the manufacturer's recommendations.

Measurements are performed in accordance with manufacturer's recommendations. The probe is swirled in the sample to remove any air bubbles adhering to the surface of the probe. Conductivity readings stabilize much more quickly than pH readings. The Sampler will ensure that the reading is stable before recording the results.

6.1.2.1.2 Well Purging

Water that remains in the well casing between samples may not be representative of the formation water quality. The quality of water left in the casing between samples may be changed by sorption or desorption from casing materials, oxidation, or biological activity. Purging is required to remove this stagnant water and allow formation water into the well screen.

Purging should be accomplished at a flowrate that is lower than the well development rate. The purge rate should approximate the natural groundwater flow rate (i.e., little change in the well water level during purging) while satisfying time constraints. Purging at too high of a flow rate can result in redevelopment of the well and increased turbidity. In no case should a well be purged at a flowrate high enough to cause the well to pump dry. Purging is deemed complete only when it is determined through field monitoring of pH and conductivity that the water quality is stable.

6.1.2.1.3 Well Sampling

The sample should be taken as soon as the well is adequately purged. If the well was pumped dry during purging, the sample should be obtained as soon as adequate formation water is present in the casing. Do not touch the sampled water with your hands as this could result in contamination of the sample.

Make sure that the water being sampled is very low in visible solids and any contamination that may show up in the analysis. Fill the sampling container(s) completely, so all air is excluded from the container.

Record the time of sample collection and include any remarks as to unusual conditions of the water quality (e.g., odor, color) on the data sheet.

Keep the sample cool and transport it to the laboratory as soon as possible for analysis or filtering, preservation and/or shipment.

6.1.2.2 Surface Water Monitoring

The surface water-monitoring program is designed to detect impacts to the regional surface water from mining operations. Potential sources of impacts to the surface water could be releases of mining solutions, drainage from potentially contaminated areas, or failure of evaporation pond embankments. Surface waters within one kilometer of the wellfield area boundary are sampled.

Samples are collected in the appropriate container(s) and field measurements for pH and conductivity are performed and documented. The sample bottle must be rinsed with the sample water. The bottle is then filled with the mouth of the sample bottle pointed down stream to prevent collecting debris. If samples involve analysis that requires filtration, collect water in a clean bucket for transfer to the filter apparatus. Treatment of sample containers, preservation techniques, holding times, and shipping techniques are identical to those used for groundwater.

6.1.3 Soil and Sediment Sampling

Samples of soil and sediment are collected at the Crow Butte project to monitor radioactivity concentrations in these media. To evaluate the effectiveness of the effluent control systems, the results of the soil and sediment monitoring program are compared with the background levels and with regulatory limits.

6.1.3.1 Soil Sampling

Preoperational surface soil has been sampled. Surface soil samples will be taken at the air monitoring locations following conclusion of operations and will be compared to the results of the preoperational monitoring program.

Preoperational subsurface soil has been sampled at the plant. Subsurface soil samples will be taken following conclusion of operations and will be compared to the results of the preoperational monitoring program.

Soil samples are obtained with a clean auger, spade, or shovel. At the sampling location, remove the vegetation and collect a grab soil sample of the top 15 cm (6 inches) of soil. Samples may also be collected at successive 15 cm intervals for comparison with the decommissioning criteria contained in 10 CFR Part 40 Appendix A, Criterion 6-(6). Samples are placed in appropriate plastic bags. The amount of sample should be sufficient to provide the laboratory with at least 50 grams of soil. This quantity of sample is necessary to meet the LLD requirements. Any non-soil material such as rocks, sticks, vegetation, and large amounts of roots should be removed from the sample. Remove the air in the bag and seal it.

The plastic bags must be clearly labeled at the time of sampling with a permanent marker, identifying the project location, sample site, the depth interval of the sample (e.g. 0-6"), and the sample date. It is important that the type of soil extraction method to be used for the various chemical analyses be clearly identified on the chain of custody to the contract laboratory.

6.1.3.2 Sediment Sampling

Sediment in local surface water features was sampled on a semiannual basis for one year prior to any construction in the area. Operational samples are taken upstream and downstream of the Crow Butte project site to monitor for impacts to the sediments from mining operations.

At the sampling location, collect a grab sample of the stream or impoundment sediment. Remove any vegetation, rocks, or other debris that may be present; place the sample in a plastic bag and seal. After allowing the bag to set, pour off any liquid that has decanted, remove the air, and re-seal the bag. The laboratory requires at least 50 grams of sample to meet the LLD requirements.

The sample bag should be pre-labeled with the sample identification, sample location, sample analysis required, date, and company initials. Prepare a Chain of Custody form and submit the sample to the laboratory.

6.1.4 Vegetation Sampling

Vegetation samples from Crow Butte project were collected on an annual basis in animal grazing areas in the direction of the prevailing wind through 1997. Sampling was normally performed during the summer months. In 1998, routine vegetation sampling was discontinued with NRC approval due to the determination that exposure from grazing animals was not a potentially significant pathway.

Vegetation sampling may be required at some time in the future. Circumstances that would indicate the necessity for vegetation sampling include land application for waste disposal or characterization of impacted areas.

When obtaining vegetation samples, select mainly grasses or leafy plants that would normally be used as forage by domestic and wild animals as opposed to woody plants such as sagebrush. Samples should be comprised mainly of stems, leaves, and fruit and should be representative of the current year's growth. Cut the plants with a trimmer within a few inches of the ground and place in the sample bag until the bag contains a minimum of 8-10 kilograms (wet weight) of vegetation. Do not include any root material. The sample should be representative of dominant vegetation present at the sample location.

The plastic bags must be weighed and clearly labeled at the time of sampling with a permanent marker, identifying the project location, sample site, and the sample date. It is important that the sample wet weight and type of analytical method to be used for the various analyses be clearly identified on the chain of custody to the contract laboratory. Vegetation samples should be submitted to the contract laboratory as quickly as possible.

6.1.5 Direct Radiation Measurement

Environmental gamma radiation levels are monitored continuously at the air quality monitoring stations. Dosimeters that fully meet ANSI N545 performance, testing, and procedural specifications will be used.

The dosimeters are supplied by the vendor before the end of each quarter. Each shipment of dosimeters contains a control dosimeter that measures exposure rates during processing and shipping of the dosimeters and a deployment dosimeter that measures exposure rates while deploying the dosimeters. Before deployment of the dosimeters, the control dosimeter must be placed in a storage area with a low ambient background gamma dose rate. The deployment dosimeter is also placed in the storage area after the dosimeters are deployed.

The dosimeters are deployed at the beginning of each quarter. The dosimeters are clipped onto each survey location with the fastener provided with the dosimeter. Each dosimeter has a tag with an identification number. When exchanging the dosimeters, the dosimeter is replaced with the corresponding dosimeter identification number.

After the dosimeters are collected, care is taken to ensure that they are not exposed to any additional gamma radiation or x-rays. Once the dosimeters are collected, they are returned to the vendor in the original box with the provided shipping label. This label cautions against exposure to radioactive materials or x-rays while in transit.

7 OCCUPATIONAL SAMPLE COLLECTION

CBR performs occupational monitoring at the Crow Butte project as required by NRC regulations and CBR's source materials license. Measurements are performed for the following purposes.

- To allow CBR to determine the annual internal and external radiation dose to employees;
- To ensure that the regulatory requirements and license conditions for dose limitations and meeting "as low as reasonably achievable" objectives are met; and
- To evaluate the performance of exposure controls;

CBR's occupational monitoring program was prepared in accordance with the guidance contained in Regulatory Guide 8.30. Regulatory Guide 4.15 was also consulted for guidance for quality assurance and quality control measures to ensure the accuracy of occupational monitoring activities.

7.1 AIRBORNE URANIUM SURVEYS

7.1.1 Area Samples

Area air samples should be collected during the performance of work duties. Area samples may be used to monitor concentrations in work areas or to determine the effectiveness of the confinement of radioactive materials. For work area monitoring, the location of air samples should be as close to the breathing zone as practical without interfering in the performance of duties. To determine confinement, samplers should be placed in the airflow path near the source of contamination.

At a minimum, airborne uranium samples will be collected as approved by NRC in the source materials license. The frequency of the airborne uranium sampling is weekly in Airborne Radioactivity Areas and monthly in areas not designated as Airborne Radioactivity Areas as recommended in Regulatory Guide 8.30, although this frequency may be modified by specific NRC license conditions. More frequent sampling may be advisable when starting new equipment or facilities. . During yellowcake packaging operations, sampling in the dryer room is continuous. Spot samples may also be collected to verify the adequacy of the sampling procedures or as determined necessary by the RSO

Measurement of airborne uranium is performed by gross alpha counting of the area air filters using an alpha scaler such as a Ludlum L-2000 or equivalent. The analytical results are compared to the derived air concentration (DAC) for soluble (D classification) natural uranium of 5 E-10 μCi/ml from Appendix B to 10 CFR §§20.1001 - 20.2401. This is a conservative method because the gross alpha results include uranium-238 and several of its daughters (notably radium-226 and thorium-230) which are alpha emitters.

Samples should be obtained using the following steps:

- Obtain an Eberline RAS-1 or Hi-Q or Staplex Hi-Vol Sampler or similar equipment and the appropriate glass fiber filters. Ensure that the air sampler has a current calibration as discussed in Chapter 10.
- Record data concerning sample location, start and end time, total time in minutes, flow rate, as found operating status of the air sampler, air sampler identification, location and calibration data on the sampling form.
- Place a filter in the filter holder taking care not to damage or contaminate the filter.
- Place the air sampler at a location where workers could be exposed to airborne particulates at 4 to 6 feet above the floor and at least 1 foot away from walls, cabinets, etc.
- Ensure that the sampling environment is representative of the conditions encountered by workers while performing assigned duties.
- Start the pump and record the start time and the initial flow rate on the sampling form. Ensure that an adequate volume of air is obtained to meet the lower limit of detection (LLD) for uranium (i.e., 10% of the applicable DAC).
- At the conclusion of sampling, record the flow rate, shut off the sampler and record the sampling stop time on the sampling form. Unless the sample period is extremely long, with resulting dust loading on the filter, there should be no change between the initial and final flow rate.
- Carefully remove the filter from the filter holder and place in the sample holding envelope, taking care not to touch or disrupt the particulate material collected on the filter.

7.1.2 Breathing Zone Air Samples

In the plant, breathing zone air samples may be collected periodically. The samples are representative of the air inhaled by the worker. Breathing zone samples for specific jobs are used to monitor the intakes of individual workers performing tasks that have the potential for high airborne exposures. Breathing zone samples may also be collected for an entire work shift, resulting in a composite sample for an employee performing his normal duties. The breathing zone sample, in the latter case, may be used as a means of judging the adequacy of the area air monitoring program. The RSO typically determines under which circumstances a breathing zone sample should be obtained.

Samples should be obtained using the following steps:

- Obtain a lapel sampler (Sensidyne BDX or equivalent). Ensure that it is fully charged and properly calibrated.
- Obtain a glass fiber filter(s), or equivalent, of the proper size and an appropriate filter holder. Place filter in holder and attach to sampler hose.
- Secure the pump to belt and the filter holder to the shirt collar or lapel. Make sure the pump is in the upright position at all times. Consolidate the tubing to minimize restriction of motion.
- Turn the pump on (recording the time and flow rate) and continue monitoring until the task is completed. Record the time and flow rate at which the job is completed.
- Lapel samplers are to be analyzed within two working days of sampling, where possible. Ensure that the SHEQ Department obtains the filter and information in a timely manner so analysis can be completed.

7.1.3 Natural Uranium Radiometric Analysis

Natural uranium air sample filter(s) must be aged a minimum of three (3) hours in order to eliminate the short-lived radon daughters. These include 214Pb (26.8 min), 214Bi (19.7 min), and 214Po (164 μsec) in the shorter-lived decay chain. A sample counted immediately after collection will not only contain possible uranium ore dust and a possible static charge, but it may also contain radon daughters. Counting the sample too soon after sample collection will result in an overestimation of airborne uranium.

Samples may also be sent as individual samples or as part of a composite sample, to an approved outside vendor laboratory for analysis for specific isotopes.

7.2 RADON DAUGHTER MEASUREMENT

Radon daughter samples are taken in various areas of the plant and offices. The sample locations are near areas where workers are most often present to ensure that the samples are representative of worker exposure. Sampling is performed at a monthly frequency, unless concentrations greater than 0.08 WL are discovered. When concentrations greater than 0.08 WL are discovered, the sampling frequency is increased to weekly. Weekly sampling continues until concentrations of less than 0.08 WL occur for four consecutive weekly samples.

Analysis of radon daughter samples is performed on-site using the Modified Kusnetz Method. Measurement of radon daughters on sample filters is performed by gross alpha counting using an alpha scaler such as a Ludlum L-2000 or equivalent.

In addition to the Modified Kusnetz Method, CBR uses the PRISM II continuous radon monitoring system, which allows "real time" analysis of atmospheres for radon daughter concentrations. The PRISM II is used as a diagnostic tool to allow evaluation of work practices and engineering controls and may not be used for routine monitoring or exposure determination purposes.

7.3 EXTERNAL RADIATION EXPOSURE

7.3.1 Personnel Dosimeters

Occupational exposure to external gamma and beta radiation is measured using personnel dosimeters such as Thermoluminescent Dosimeters (TLD) or Optically Stimulated Luminescence (OSL) dosimeters. With two exceptions, dosimeters must meet NRC requirements, which state that a contract vendor must be certified by the National Voluntary Laboratory Accreditation Program (NVLAP) of the National Institute of Standards and Technology (NIST). The exceptions to this requirement are direct and indirect reading pocket ionization chambers and dosimeters used to measure the dose to extremities. The dosimeters consist of a clip-on badge worn by workers. The badge contains a chip that is constructed of a material that senses total exposure to external radiation. When the chip is properly developed, the radiation dose received by an individual during the period of time that the badge was worn may be determined.

The RSO is responsible for determining the dosimetry requirements based on the facility radiation levels, worker job locations and tasks, and specific licensing requirements. For each category of workers, the RSO must determine whether it is likely that a worker's dose may exceed the criteria from § 20.1502(a). If it is determined that dosimetry is required, the RSO will determine the exchange frequency for the dosimetry (i.e., monthly or quarterly). Contractors, depending upon the task to be performed, may also be issued dosimeters at the discretion of the RSO.

The RSO is responsible for reviewing the dosimetry results and comparing them with past data and regulatory exposure limits. Upon receipt of the dosimetry results from the NVLAP laboratory, the individual exposure records are to be maintained on hard copy and/or a computer system.

The control personnel dosimeters used by the NVLAP processor to subtract background exposure from the personnel badges, are to be stored in areas away from areas where elevated gamma dose rates may be present. It is important that control badges are returned to the NVLAP processor with the personnel dosimeters. In the event that a control badge is damaged, any unused personnel dosimeter may be designated as a control badge as long as it has been stored away from areas where gamma activity is mostly likely to occur.

7.3.2 Gamma Surveys

Gamma surveys are conducted at various locations throughout the facility. Routine gamma surveys are performed as approved by NRC in the source materials license. In areas that meet the criteria for posting as "Radiation Areas", surveys should be performed at least quarterly as recommended in Regulatory Guide 8.30. NRC licensing requirements specific to the facility may require alternate survey frequencies. Gamma surveys are conducted on a semiannual basis at various locations through the plant. These results are used to insure plant areas are properly placarded in accordance with 10 CFR 20. Additional gamma surveys may be performed at the discretion of the RSO or HPT to further characterize gamma dose rates. These surveys can be random, in conjunction with RWPs, to assist in identifying Radiation Areas, or performed before or during routine work, during contaminated waste control, or during upset conditions. Regardless of the purpose of the survey, the same procedure will be utilized to perform gamma surveys.

7.3.2.1 Instruments

- Ludlum Model 19 Gamma Meter calibrated in MicroRoentgen per hour (μR/hr) or equivalent.
- Ludlum Model 3 Gamma Meter with Ludlum Model 44-38 G-M detector or equivalent, calibrated in MilliRoentgen per hour (mR/hr).

7.3.3 Beta Surveys

In addition to gamma surveys, beta surveys should be performed before specific tasks that involve direct handling of large quantities of aged yellowcake (i.e., older than four months) to ensure that extremity and skin exposures for workers performing these operations are not unduly high.

Extremity dosimetry is required by 10 CFR 20.1502 if a worker is likely to receive a dose to any extremity in excess of 1250 mR/qtr or to the eye in excess of 375 mR/qtr.

Beta surveys should be performed before any special maintenance or non-routine operational activity with aged yellowcake to determine protective clothing needs and what portion of the body may be most exposed. If appropriate protective clothing and equipment is used (e.g. heavy rubber gloves, eye protection, etc.) the beta dose rate may not be a significant factor to overall dose. However, the protective clothing and equipment used must be of sufficient density to ensure that significant beta radiation does not reach the skin or the lens of the eye.

7.3.3.1 Instrument

- Ludlum Model 3 Survey Meter with Ludlum Model 44-6 G-M detector, or equivalent equipment.
- The detector must be equipped with a beta shield to perform this survey.
- Surface Contamination

The primary sources of potential surface contamination at in situ leach uranium mines are associated with precipitation, slurry transfer, drying and packaging activities, and filter press activities. The remaining recovery and elution portions of the process do not present a significant surface contamination problem except for dried spills or when special equipment maintenance is required. Any visible yellowcake or production fluid spills must be cleaned up as soon as possible to prevent the potential spread by contact or drying and possible suspension into the air that could pose an inhalation hazard. If contamination is detected in a designated clean area above specified limits, the RSO will be promptly notified and the area will be cleaned. An investigation into the source of the contamination will be performed.

Routine surveys in the process areas consist of both a visual inspection for obvious signs of contamination (i.e. visible yellowcake) and instrument surveys to determine total alpha contamination. If the total alpha survey indicates that contamination is greater than 200,000 dpm/100 cm^2, the area shall be cleaned and resurveyed. This level of contamination has been determined to be low enough to ensure little contribution to airborne radioactivity and is readily visible due to the low specific activity of uranium.

In designated clean areas, such as lunchrooms, offices, and respirator cabinets, the target level of contamination is nothing detectable above background. If the total alpha survey indicates contamination exceeds 250 dpm/100 cm^2 (25% of the removable limit) a smear survey must be performed to assess the level of removable alpha activity. If smear test results indicate removable contamination greater than 250 dpm/100 cm^2, the area must be cleaned promptly and resurveyed.

The RSO will investigate the cause of the contamination and implement corrective action to minimize the potential for a recurrence.

Direct measurement of total contamination is performed using alpha scintillation detectors. Measurement of loose contamination is performed by gross alpha counting of the smears using an alpha scaler such as an Eberline MS-3 or equivalent.

7.4 BIOASSAY PROGRAM

CBR has implemented a bioassay program to monitor for internal exposure to natural uranium. The bioassay program has been prepared in accordance with the guidance contained in Regulatory Guide 8.22, *"Bioassay at Uranium Mills"*, (Revision 2, 2014). All plant personnel are included in the bioassay program. The program is implemented by the RSO.

CBR routinely performs bioassay by urinalysis for natural uranium. A baseline urinalysis is performed on all employees prior to their initial assignment at the plant. Routine bioassay samples are collected at a frequency that is based upon the employee's work assignment. Diagnostic bioassays may be required by the RSO based upon specific work activities. Upon termination of employment, a final urinalysis will be performed on all employees.

Records of bioassay results are maintained to document the sample collection and analysis dates as well as the individual's record to allow the most recent results to be compared to the employee's previous history.

Analysis of bioassay samples is performed at a qualified contract analytical laboratory. CBR submits spike and blank samples with each batch of bioassay samples to monitor the laboratory for accuracy and sample contamination. Analytical results for spiked samples must be within 30 percent of the spiked value. Otherwise, the most recent batch of samples will be re-run. The RSO will conduct an investigation to determine whether the CBR spiking procedure or the analytical laboratory was the cause of the inaccurate results.

Duplicate samples are obtained for submission to a different laboratory to monitor precision. These samples are submitted by CBR on a periodic basis. These duplicate samples are in addition to the duplicate samples analyzed by the analytical laboratory.

8 SAMPLE MANAGEMENT AND QUALITY CONTROL

8.1 SAMPLE HANDLING AND DELIVERY

Chain of Custody (COC) forms should accompany every sample sent to off-site laboratories. The chain of custody should contain at a minimum the type of sample, the sample identification number, the preservation techniques (if any), the name of the sampler, the date and time the sample was taken, the name(s) of individuals who handled the sample and when they passed it on to another person, and the required analysis. Once the laboratory is finished with the chain of custody, it is sent back to the SHEQ Department with the analytical package so it can be filed for future reference.

8.2 CONTRACT LABORATORY QUALITY CONTROL

CBR has implemented a quality control program to determine the precision and accuracy of the monitoring processes. Quality control sampling includes replicate samples to determine precision, spiked samples with a known concentration to determine accuracy, and blank samples to detect and measure contamination of analytical samples.

Inter-laboratory duplicate samples are analyzed by a second laboratory to determine the precision of the original laboratory. In addition, intra-laboratory duplicate samples may be collected and sent to the primary laboratory to assure internal laboratory precision. The RSO selects the locations, media and number of inter-laboratory and intra-laboratory duplicate samples. A minimum of one duplicate sample is collected per sampling period.

In addition to the quality control samples prepared and submitted by CBR to contract analytical laboratories, each qualified laboratory will have an acceptable QA/QC program in place. The CBR QA Coordinator will review the vendors QA/QC Program and will be responsible for approving the use of the vendor. Qualified laboratories will submit verification of participation in the EPA's Quality Control Program and the laboratory certification programs for environmental waters.

8.3 ANALYTICAL SENSITIVITY

8.3.1 Lower Limits of Detection

The NRC in Regulatory Guide 4.14 recommends the lower limits of detection (LLD) for radiological samples. CBR has adopted these LLD values that are appropriate for the samples obtained at the Crow Butte project. The required LLD values are listed in Table 2.

Table 2
Radiological Lower Limits of Detection

Media	Radionuclide	Lower Limit of Detection
Air	Natural Uranium Thorium-230 Radium-226	1×10^{-16} µCi/ml
	Lead-210	2×10^{-15} µCi/ml
	Radon-222	2×10^{-10} µCi/ml
Water	Natural Uranium Thorium-230 Radium-226	2×10^{-10} µCi/ml
	Polonium-210 Lead-210	1×10^{-9} µCi/ml
Soil and Sediment (dry)	Natural Uranium Thorium-230 Radium-226 Lead-210	2×10^{-7} µCi/g
Vegetation, Food and Fish (wet)	Natural Uranium Thorium-230	2×10^{-7} µCi/kg
	Radium-226	5×10^{-8} µCi/kg
	Polonium-210 Lead-210	1×10^{-6} µCi/kg

8.3.2 Non-radiological Detection Limits

Minimum detection levels are necessary for non-radiological samples obtained at the Crow Butte project. CBR has adopted the detection levels listed in Table 3.

Table 3
Non-radiological Detection Limits

Analyte	Detection Level (mg/l)
COMMON IONS	
Calcium	1.00
Magnesium	1.00
Sodium	1.00
Potassium	1.00
Carbonate	0.10
Bicarbonate	0.10
Sulfate	1.00
Chloride	0.10
Ammonia-N	0.05
Nitrite-N	0.01
Nitrate-N	0.01
Fluoride	0.10
Silica	1.00
Total Dissolved Solids	1.00
Total Alkalinity	0.10
Conductivity	1.00 (μmho)
pH	± 0.02 (standard units)
ACCURACY CHECKS (acceptable range)	
Ion Balance	0.95 to 1.05
TDS Balance	0.90 to 1.10
Conductivity Balance	0.95 to 1.05
MINOR AND TRACE METALS	
Arsenic	0.001
Barium	0.100
Boron	0.100
Cadmium	0.010
Chromium	0.050
Copper	0.010
Iron	0.050
Lead	0.015

Table 3
Non-radiological Detection Limits

Analyte	Detection Level (mg/l)
MINOR AND TRACE METALS (continued)	
Manganese	0.010
Mercury	0.001
Molybdenum	0.100
Nickel	0.050
Selenium	0.001
Vanadium	0.100
Zinc	0.010

9 ON-SITE LABORATORY QUALITY ASSURANCE

CBR has implemented a quality assurance /quality control program to determine the precision and accuracy of the laboratory analysis performed in the on-site laboratory. Quality control in the on-site laboratory includes the use of appropriate analytical methods, quality control samples and other internal quality control activities including instrument calibration, analyst training, equipment maintenance, and external quality control.

9.1 ANALYTICAL METHODS

The use of approved standard analytical methods ensures that the quality objectives for operation of the laboratory are met. Table 4 lists the assays that are performed in the on-site laboratory and the analytical method that is used. Specific procedures for each method are described in the *Laboratory Manual* maintained in the laboratory for use by the analysts.

Table 4
On-Site Laboratory Analytical Methods

Parameter	Reference/Method
U_3O_8	"Spectrophotometric Determination of Uranium (VI) with Bromo-PADAP", DA Johnson and TM Florence
	"Standard Methods for Chemical and Atomic Absorption Analysis of Uranium-Ore Concentrate", Sections 9-16, Uranium by Ferrous Sulfate Reduction – Potassium Chromate Titrimetric ASTM C 1022-84.
	EPA 200.7 Inductively Coupled Plasma-Atomic Emission Spectrometry
Alkalinity as $CaCO_3$	EPA 310.1 Titrimetric
Chloride	Standard Methods, 17th Ed. 4500-Cl^- B. Argentometric

Table 4
On-Site Laboratory Analytical Methods

Parameter	Reference/Method
Sulfate	EPA 375.4 Turbidimetric EPA 200.7 Inductively Coupled Plasma-Atomic Emission Spectrometry
Total Dissolved Solids	EPA 160.1 Residue – filterable, Gravimetric, 180°C
pH	EPA 150.1 Electrometric
Sodium	EPA 273.1 Atomic Absorption, direct aspiration EPA 200.7 Inductively Coupled Plasma-Atomic Emission Spectrometry
Calcium	EPA 215.1 Atomic Absorption, direct aspiration EPA 200.7 Inductively Coupled Plasma-Atomic Emission Spectrometry
Vanadium	EPA 286.1 Atomic Absorption, direct aspiration EPA 200.7 Inductively Coupled Plasma-Atomic Emission Spectrometry

9.2 QUALITY CONTROL SAMPLES

CBR uses three types of quality control samples at the on-site laboratory. These samples are duplicate samples, spiked samples, and control standards. Although the quality control samples are primarily used to monitor and control systematic and random measurement errors, they are useful in detecting all types of laboratory error.

9.2.1 Duplicate Samples

Duplicates are taken of the original sample and analyzed in the same way as the original sample. These duplicate samples allow the analysts to determine the precision of the assay. The acceptable limit for the duplicate analysis is ± 10% over the range normally encountered in the laboratory. If the assay is very high or very low, criteria for limits will be determined on a case-by-case basis.

9.2.2 Spiked Samples

Standard addition spikes are the addition of a known amount of analyte to a duplicate sample aliquot. These samples are useful in estimating the accuracy of an assay and in identifying potential interferences. The acceptable limit for spikes is 95 to 105 percent recovery.

9.2.3 Control Standards

Control standards are certified standards whose chemical concentration values are known. They are used for spiking and standardizing reagents. For example, a chloride standard that is sodium chloride with a concentration of 1,000 ± 0.0005 moles per liter is used to standardize the $AgNO_3$ solution which is used in the analysis of chloride. The standard is certified traceable to National Institute of Standards and Technology Standard Reference Material. This standard is also used for preparing chloride spiked samples.

9.2.4 Internal Quality Control Activity Schedule

Analysts will perform a minimum of one duplicate and one spike quality control sample per week per parameter assay.

Reagent blanks will be analyzed whenever new reagents are used and as often as required in specific methods. A reagent blank is the reference base with which the analytical results are compared under the same conditions as the samples to be analyzed, except deionized water is used in place of the sample.

For analysis of metals in water by atomic absorption and inductively coupled plasma-atomic emission spectrometry, calibration standards and blanks are analyzed with each batch of samples. Calibration standards are samples with a known concentration that are used to plot an absorbance versus concentration curve. This curve is used to determine the concentration of the samples being assayed. The standards that are used to prepare the calibration standards are certified and traceable to NIST Standard Reference Material.

9.3 INSTRUMENT CALIBRATION

9.3.1 pH Meter

The pH meter is calibrated daily with pH 7 and pH 4 (or pH 10) buffer solutions. Calibration results are recorded.

9.3.2 Conductivity Meter

The conductivity meter has a set of cell constant and automatic temperature compensation. In order to ensure the accuracy of the instrument, the conductivity of standardized 0.01 molar potassium chloride with a specific conductance of 1413 μmho/cm at 25°C is checked and recorded on a monthly basis.

9.3.3 Turbidimeter

The turbidimeter is calibrated with Formazin, the primary turbidity standard, at least semiannually. All calibration data is recorded.

9.3.4 Balance

The Mettler balance is cleaned and checked annually by a certified technician.

When in use, the balance is checked on a monthly basis with NBS Class S masses calibrated to within 0.025mg or better.
All calibration data is recorded.

9.3.5 Perkin Elmer Atomic Absorption Spectrophotometer Model 3100

The operator can determine whether instrumental parameters are optimized and if the instrument is performing to specifications by using the sensitivity check. The sensitivity check value (in mg/l) is the concentration of an element that will produce a signal of approximately 0.2 absorbance units under optimum conditions at the wavelength listed. This number can be found in the *Analytical Methods for Atomic Absorption Spectrophotometry.*

If the instrument develops a malfunction that cannot be corrected by operator maintenance, a trained specialist will service it.

9.3.6 Optima 8300DV ICP-OES

For daily operations the instrument is calibrated according to the manufacturer's recommended procedures, using mixed calibration standard solutions and the calibration blank. The calibration line should consist of a minimum of a calibration blank and a high standard. Replicates of the blank and highest standard provide an optimal distribution of calibration standards to minimize the confidence band for a straight-line calibration in a response region with uniform variance. If the instrument develops a malfunction that cannot be corrected by operator maintenance, a trained specialist will service it.

9.3.7 Automatic Pipettes

Based upon equating milligrams with milliliters, automatic pipettes will be checked for accuracy by weighing the contents of the pipette on a precision balance. This will be performed and documented periodically as deemed necessary by the Lab Foreman.

9.4 CROSS-CONTAMINATION CONTROL

All glassware used in the laboratory is washed in a solution of tap water with the addition of a low phosphate laboratory grade detergent. The glassware is then rinsed with tap water. The glassware is then final rinsed with deionized water.

A deionized water system consisting of one activated carbon unit and two mixed bed deionizers is used to provide quality deionized water for assay work and glassware final rinsing.

9.5 ANALYST TRAINING

9.5.1 Lab Foreman

The minimum qualifications for a Lab Foreman are two years of post-secondary education in science and two years of inorganic laboratory experience. At least one year of this experience should be at an in-situ uranium facility.

9.5.2 Laboratory Technician

The minimum qualifications for a Lab Technician are a High School Diploma or a minimum of two years of directly related work experience. The Lab Foreman will directly supervise the Laboratory Technicians in the performance of their duties.

9.6 EQUIPMENT PREVENTATIVE MAINTENANCE PROCEDURES

Analysts will become thoroughly acquainted with the instrument operation manuals and will use the proper maintenance procedures as specified by the manufacturers.

9.7 EXTERNAL QUALITY CONTROL

Samples from wellfield monitor wells will be split and analyzed for the excursion parameters (alkalinity, chloride, and conductivity) at the on-site laboratory on a quarterly basis. The sample splits will be sent to a contract laboratory for analysis of the same excursion parameters. The on-site laboratory results will be compared with the contract laboratory results for consistency. The Lab Foreman or QA Coordinator will review the results from each laboratory. If the results are not within 10 percent for all parameters that are greater than 50 ppm or within ± 5 ppm for those parameters with a concentration less than 50 ppm, an investigation will be performed and appropriate corrective action will be taken.

9.8 DATA HANDLING

Production zone and shallow monitor well data will be reviewed for accuracy and reported to the Restoration Supervisor and Environmental Leadership Coordinator. Results of monitor well analysis for excursion indicators will be checked by the analysts to determine whether they are within the range of the upper control limits (UCLs) for that well. Any discrepancies will be investigated. If the data for a particular well falls out of range, it will be immediately reported to the SHEQ Manager or designee.

All process analytical data will be reported to the Operations Manager or his designee.

The Lab Foreman will maintain all original laboratory worksheets and instrument calibration data on file in the on-site laboratory. Records will be maintained for the appropriate duration as discussed in **Section 11.4.**

10 REVIEW AND ANALYSIS OF DATA

The analytical data from the CBR radiological counting laboratory will be reviewed by the RSO. The RSO or the QA Coordinator will also review the environmental and effluent monitoring data from the on-site laboratory and contract laboratories. The RSO or the QA Coordinator will be responsible for evaluating the data, entering the data into the corporate data handling system, and distributing the data to the corporate files and specified personnel. Data review will be properly documented.

The following sections discuss the criteria to be used during the technical evaluation of the data.

10.1 ENVIRONMENTAL DATA CRITERIA

10.1.1 Detection Limit Review Criteria

The reviewer will determine that the detection limits specified in **Tables 2 and 3** have been met.

10.1.2 Accuracy Check Criteria

- The radionuclide content of the various matrices (soil, vegetation, water, and air) should be evaluated for consistency with published data normally found in government reports.
- The radionuclide content of matrices where one would expect radiological constituents to be in secular equilibrium (such as soil) should be evaluated for internal consistency.
- The gross alpha value (if available) should be compared to the sum of the individual alpha emitting nuclides such as natural uranium, radium 226, and thorium 230.
- The cation-anion balance should be between 0.95 and 1.05.
- The ratio of the measured total dissolved solids (TDS) at 180°C to the calculated TDS corrected for bicarbonate decomposition should be between 0.90 and 1.10.
- The ratio of the measured electrical conductance (dilute) with the calculated electrical conductance should be between 0.95 and 1.05.

If the data on a given sample does not meet the above accuracy checks, the RSO will investigate the laboratory and sampling procedures to determine the cause of the discrepancy.

10.1.3 Data Comparison Criteria

The data on a given sample or set of samples will be compared with the data from previous representative samples from the same population. If an individual result falls within the range obtained on previous samples, the result is considered acceptable. If the result falls outside of the range, the data is evaluated for trends or other unusual distribution. The laboratory will then be notified and asked to check all calculations and quality control checks. If no discrepancies are found a new analysis may be requested on the sample provided that the maximum holding time for the sample has not been exceeded. If the maximum holding time has been exceeded, the RSO may then request a re-sample. After analyses have been checked, the laboratory water sampling data are entered into the water quality database.

11 RECORDS

11.1 FIELD RECORDS

Radiological Monitoring Data Sheets and all environmental sampling data sheets will be retained at the plant site. It will be the responsibility of the RSO or designee to assure that all sampling records are kept in an organized and secure manner.

11.2 ENVIRONMENTAL/RADIOLOGICAL ANALYTICAL RECORDS

Analytical data will be retained at the plant site and/or the corporate office. It will be the responsibility of the RSO or the designee to assure that all analytical reports are kept in an organized and secure manner.

11.3 ENVIRONMENTAL/RADIOLOGICAL AUDIT REPORTS

All audit reports shall be maintained at the site. The SHEQ Manager or designee will be responsible to see that all audit reports are kept in an organized and secure manner.

11.4 RECORD STORAGE DURATION

All records will be maintained until such time that the President of CBR authorizes disposal. The minimum storage duration for records containing the results of sampling, analysis, surveys and monitoring, reports of audits and inspections, and investigations and corrective actions is five years. Data used for determination of personnel exposures must be retained until the termination of the NRC Source Materials License.

12 AUDITS AND INSPECTIONS

CBR conducts audits of various programs at the Crow Butte project to ensure the quality of the implementation of the programs. In addition, CBR personnel conduct routine inspections of work areas to check for compliance issues and any other problems. These audits and inspections are summarized in this section.

12.1 QUALITY ASSURANCE/QUALITY CONTROL AUDIT

The QA Coordinator will conduct tri-annually an audit of the radiological monitoring, sampling and analytical QA/QC programs. The QA Coordinator may designate qualified individuals who do not have direct responsibility in the areas being audited to perform the audits. Audit results will be reviewed by the RSO and corrective action taken where necessary.

A tri-annual audit of the water sampling and analytical QA/QC programs will be conducted. The QA Coordinator or a designated qualified consultant, who does not have direct responsibility in the areas being audited, will perform the audits. Audit results will be reviewed by the QA Coordinator and corrective action taken where necessary.

12.2 ALARA AUDIT

Annually a third party will perform a formal audit of the ALARA program and submit a detailed written report to the SHEQ Manager and RSO. 10 CFR §20.1101 (c) and CBR's source materials license require this audit of the occupational and effluent control ALARA programs. The audit will be performed in accordance with the guidance contained in USNRC Regulatory Guide 8.31, *"Information Relevant to Ensuring That Occupational Radiation Exposures at Uranium Mills Will Be As Low As Reasonably Achievable"*, (Revision 1, 2002) and will include a review of the results of the following operational data:

- Bioassay results, including any actions taken when the results exceeded action levels given in Table 1 of Regulatory Guide 8.22.
- Exposure records, both external and internal, showing the time-weighted calculations.
- Training program activities.
- Safety meeting minutes and attendance records.

- Daily inspection log entries and summary reports of the daily and monthly reviews.
- In-plant radiological survey and sampling data.
- Environmental radiological effluent and monitoring data.
- Surveys required by radiation work permits.
- Reports on overexposures submitted to NRC, and
- Reviews of operating and monitoring procedures completed or revised during this period.

Specific attention will be given to air sampling results as recommended in USNRC Regulatory Guide 8.25, *"Air Sampling in the Workplace"*, (Revision 1, 1992). This review will determine whether air sampling results for the previous year are accurate and whether changes should be made to the air sampling program. The review will include the purposes and amount of air sampling, locations, trends, posting, procedures, correction factors, representativeness, and any indicated changes to the air sampling program.

The written ALARA audit report shall be specific in addressing any noticeable trends in personnel exposures for identifiable categories of workers and types of activities. Recommendations to further reduce personnel exposures will be included. The report should also provide data to show that the equipment for exposure control and effluent control is properly used, maintained and inspected.

In addition to reviewing the results of the occupational ALARA program, the audit will review trends in radiological effluent data as recommended in USNRC Regulatory Guide 8.37, *ALARA Levels for Effluents from Materials Facilities"*, (1993). The audit report will include any recommendations to further reduce environmental releases of radioactive materials.

12.3 OTHER REVIEWS

12.3.1 Standard Operating Procedures

The RSO will perform an annual review of all Standard Operating Procedures for radiation safety and environmental protection issues. This annual review will be properly documented. Appropriate operations supervisory personnel will review process procedures in their area of responsibility to ensure that the instructions reflect current operating conditions.

12.3.2 Inspection Reviews

The RSO will perform a monthly review of the daily and weekly inspections and all monitoring and exposure data. The RSO will prepare a written summary of significant worker protection activities, including exposure data, bioassays, and survey data. A discussion of any trends or deviations from the radiation protection and ALARA programs, implementation of license conditions, and unresolved problems and corrective actions, will be included.

12.3.3 Respiratory Protection Program

The RSO or other similarly qualified individual will conduct an annual review of the implementation of the CBR Respiratory Protection Program. The review will include discussions with workers that use respiratory protection to solicit comments on the effectiveness of the program. The review will ensure that the program procedures reflect the requirements of current applicable regulations and accepted standards and that the program is implemented in accordance with the Standard Operating Procedures.

12.4 INSPECTIONS

12.4.1 Daily Inspections

The RSO, HPT or a qualified designated operator will conduct a daily visual walk-through inspection of the plant facility to check for compliance issues and any other problems. These inspections will be properly documented. The results of these inspections will be reviewed with the Operations Manager.

12.4.2 Weekly Inspections

The RSO and the Operations Manager, or their qualified designees will conduct a weekly walk-through inspection of the plant operating areas to observe general radiation safety practices and to review required changes in procedures and equipment. These inspections will be properly documented.

Appendix A

Containers, Preservation Techniques, and Holding Times

APPENDIX A

Parameter	Volume Required (mls)	Preservative	Holding Time	Container
Dissolved Metals	250	Filter (0.45 μm), then add HNO_3 to ph<2	6 months	Plastic or Glass
Total Metals	250	HNO_3 to ph<2	6 months	Plastic or Glass
Alkalinity	100	Cool, 4°C	14 days	Plastic or Glass
Chloride	50	None Required	28 days	Plastic or Glass
Conductance	100	Cool, 4°C	28 days	Plastic or Glass
Fluoride	50	None Required	28 days	Plastic or Glass
Ammonia as N	50	H_2SO_4 to pH<2, Cool, 4°C	28 days	Plastic or Glass
Nitrate + Nitrite	50	H_2SO_4 to pH<2, Cool, 4°C	28 days	Plastic or Glass
Nitrate	50	Cool, 4°C	48 hours	Plastic or Glass
Nitrite	50	Cool, 4°C	48 hours	Plastic or Glass
pH	25	None Required	Analyze immediately	Plastic or Glass
TDS	500	Cool, 4°C	7 days	Plastic or Glass
TSS	500	Cool, 4°C	7 days	Plastic or Glass
Sulfate	100	Cool, 4°C	28 days	Plastic or Glass
Lead-210	1000	HNO_3 to ph<2	6 months	Plastic or Glass
Polonium-210	1000	HNO_3 to ph<2	6 months	Plastic or Glass
Radium-226	1000	HNO_3 to ph<2	6 months	Plastic or Glass
Uranium	1000	HNO_3 to ph<2	6 months	Plastic or Glass
U_3O_8	N/A	N/A	N/A	Glass