# Kiggavik Project
# Environmental Impact Statement

## Tier 3 Technical Appendix 2Q:
## Radiation Protection Plan

**September 2014**

# History of Revisions

| Revision Number | Date | Details of Revisions |
|---|---|---|
| 01 | December 2011 | First Issue with Draft Environmental Impact Statement |
| 02 | September 2014 | Issued for Final Environmental Impact Statement |
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A management plan is a living document which is continually reviewed and revised throughout the life of the Project to ensure it meets health, safety, and environmental performance standards. This process of adaptive management and continual improvement (Tier 2, Volume 2, Section 17) is consistent with the Inuit Qaujimajatuqangit (IQ) principles of Qanuqtuurunnarniq *being resourceful and flexible to solve problems* and Pilimmaksarniq *maintaining and improving skills through experience and practice.*

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# Abbreviations

ALARA ..... As Low As Reasonably Achievable

CNSC ..... Canadian Nuclear Safety Commission

DCVP ..... Design Criteria and Verification Plan

DMS ..... Dosimetry Monitoring Strategy

DRDs ..... Direct Reading Dosimeters

HVAC ..... Heating Ventilation Air Conditioning

IAEA ..... International Atomic Energy Agency

IDLH ..... Immediately Dangerous to Life or Health

LLRD ..... Long Lived Radioactive Dust

mSv ..... milliSievert

NEW ..... Nuclear Energy Worker

NDR ..... National Dose Registry

NORM ..... Naturally Occurring Radioactive Material

OLDs ..... Optically Stimulated Luminescent Dosimeters

PADs ..... Personal Alpha Dosimeters

RCOP ..... Radiation Code of Practice

RnP ..... Radon Progeny

RP ..... Radiation Protection

RPP ..... Radiation Protection Plan

SIN ..... Social Insurance Number

# 1 Introduction

Through AREVA's community engagement events and Inuit Qaujimajatuqangit (IQ) interviews, the company learned that people had questions about radiation (EN-CH OH Nov 2010[1], EN- CH OH Oct 2012[2]) and were concerned about the exposure of workers and the public to radiation (EN-CH OH Oct 2012[3], IQ-RIE 2009[4], EN-RB OH Nov 2010[5]). Ultimately, community members wanted to know what radiation protection plans AREVA will have in place to protect people and the environment (EN-KIV OH Oct 2009[6], EN–BL NIRB Apr 2010[7],EN-BL OH Oct 2012[8]).

A Radiation Protection Plan (RPP) is implemented at uranium mine sites in order to effectively mitigate risks from radiation exposure to workers, the public and the environment. The objective of the Radiation Protection Plan is to fulfill AREVA's Radiation Protection Policy to maintain radiation doses as low as reasonably achievable (ALARA), social and economic factors considered. A RPP is implemented at all phases of the project including exploration, construction, operation, and decommissioning. This RPP describes the program of activities conducted during the operational phase of the Kiggavik Project to manage, control and optimize radiation exposure.

This RPP is organized into five (5) sections. The *Administrative Elements* describes the principles of radiation protection, classification of workers, and describes a key document in the management of radiation protection: the Code of Practice. The subsequent sections are organized around the Deming Cycle for continuous improvement of Plan, Do, Check, Act.

[1] EN-CH OH Nov 2010: *Can you see radiation?*

[2] EN-CH OH Oct 2012: *What is a dangerous amount of radiation?*

[3] EN-CH OH Oct 2012: *What is a dangerous number on the gadgets that would cause you to get sick?*

[4] IQ-RIE 2009: *Uranium is dangerous for people and animals. You can't see uranium like you can other minerals*

[5] EN-RB OH Nov 2010: *How much radiation does a driller receive?*

[6] EN-KIV OH Oct 2009: *If I get a job, how will I know if radiation is affecting me?*

[7][ EN-BL NIRB Apr 2010: *What is the plan to protect people and workers? I would like to see a protection plan put in place for the people and workers.*

[8] EN-BL OH Oct 2012: *What will you do to protect workers' health?*

# 2 Administrative Elements

## 2.1 Radiation Protection Principles

The three major principles of radiation protection are:

- Justification – practices resulting in radiation exposures must have a net benefit,
- Limitation – radiation dose limits are set by regulatory bodies to control individual exposures,
- Optimization – exposures of workers and the general public to ionizing radiation must be optimized considering technical and economic constraints, i.e. seeking to achieve radiation doses which are As Low As Reasonably Achievable (ALARA), social and economic factors considered.

## 2.2 Nuclear Energy Workers

### 2.2.1 Designation of Nuclear Energy Workers

A Nuclear Energy Worker is defined as a person with "a reasonable probability that the person may receive a dose (occupational) of radiation that is greater than the prescribed limit for the general public" (i.e. one milliSievert per year: 1 mSv/y). NEWs are informed in writing of their NEW designation and a written acknowledgement is obtained from the worker and kept in their training file.

NEW workers are informed of their radiation dose levels, in writing, on a quarterly basis. Their dose results are recorded in the National Dose Registry, maintained by Health Canada.

### 2.2.2 Dose Limits

Each NEW worker is informed of the risks associated with radiation to which the worker may be exposed in the course of their work, and the applicable dose limits, during radiation protection training. NEW workers are limited to a maximum annual effective dose of 50 mSv in a 1 year dosimetry period, not to exceed 100 mSv in a 5 year dosimetry period. Practically in uranium mining an annualized dose limit of 20 mSv per year is used for dose planning purposes.

In the control of an emergency and the consequent immediate and urgent remedial work, the regulations limit the effective dose to 500 mSv.

Pregnant NEW are limited to 4 mSv for the balance of their pregnancy, once notification has been made to their employer. The relaxation of normal dose limits in emergency situations does not apply to pregnant workers.

### 2.2.3 Obligations of Nuclear Energy Workers

NEWs are obliged to provide information required to identify them to the National Dose Registry (i.e. given name, surname, previous surname, SIN, sex, date and province and country of birth) and to release their dose histories for the current 1 and 5 year dosimetry periods. The purpose and use of this information is described to the NEW during radiation protection training. The collection, use and storage of this information are described within the Radiation Protection program. NEWs are obliged to provide written acknowledgement once they have received information regarding the risks associated with exposure to radiation and dose limits.

### 2.2.4 Pregnant Nuclear Energy Workers

Pregnant NEWs are informed of the risks associated with radiation to which the worker may be exposed in the course of their work, including the risks associated with the exposure of embryos and fetuses to radiation, in writing. Females are informed of their obligation to inform their employer, in writing, when they become pregnant and are informed of the applicable effective dose limit of 4 mSv for the balance of the pregnancy.

The classification of workers, their dose limits and levels and obligations is done in accordance with CNSC's Radiation Protection Regulations and Uranium Mines and Mills Regulations, Nunavut's Mine Regulations and AREVA's internal policies.

## 2.3 Code of Practice

A Code of Practice (COP) is a practical application of the As Low As Reasonably Achievable (ALARA) principle. The Radiation Code of Practice (RCOP) is a document, required by the CNSC under the Uranium Mines and Mills Regulations. Discrete values for radiological parameters above which intervention may be required to maintain worker doses and workplace radiological levels ALARA are defined within the COP and corresponding mitigative measures are identified.

A preliminary COP for the Kiggavik Project is included as Attachment A. It will be finalized at the time of licensing. Within the COP(s) are Action Levels and Administrative Levels. Action levels are only defined for total effective dose. Specifically, the Action Levels and the related mitigative measures ensure that regulatory dose limits are not jeopardized. Administrative Levels are identified along with corresponding responses and reporting requirements for the following radiological parameters:

- Worker Effective Dose;
- Gamma Levels or Worker Gamma Exposure;
- Radon Progeny Levels;
- Long- lived Radioactive Dust Derived Air Concentrations;
- Uranium in Urine; and
- Underground Ventilation Air Quality and Quantity.

The COP is a governing document in the administration of the radiation protection and as such is a primary reference for Radiation Protection staff in the execution of radiation protection programs. The COP is a regulatory requirement and complies with the Uranium Mines and Mills Regulations and Nunavut's Mines Regulations.

# 3 Planning Elements (PLAN)

## 3.1 Radiation Protection Standards

AREVA Resources Canada Inc. requires a documented RPP for all ongoing activities which have the potential for a worker to receive a radiation dose resulting from their work activity in excess of 0.30 mSv/a above natural background. The following are the primary list of standards used in RPP development for the Kiggavik Project.

### 3.1.1 AREVA Standards, Directives and Guidelines

- AREVA Nuclear Safety Charter
- AREVA Radiation Protection Directive

### 3.1.2 Radiation Protection Program Standards

- IAEA Safety Guide No. RS-G-1.1, Occupational Radiation Protection
- IAEA Safety Guide No. RS-G-1.6, Occupational Radiation Protection in the Mining and Processing of Raw Materials

### 3.1.3 Federal Regulations and Guidelines

- Nuclear Safety and Control Act
- Uranium Mines and Mills Regulations
- Radiation Protection Regulations
- Packaging and Transport of Nuclear Substances Regulations
- Canadian Guidelines for the Management of Naturally Occurring Radioactive Material (NORM)
- Regulatory Guide G-129 Keeping Radiation Exposures and Doses As Low As Reasonably Achievable

### 3.1.4 Nunavut

- Safety Act and General Safety Regulations

## 3.2 Radiation Protection by Design

AREVA evaluates potential radiation exposure in the design of new facilities for the processing of radioactive materials. Radiation protection professionals are included in the design and design review processes. It is during the project design phase that there is greatest opportunity to optimize radiation exposures by engineering effective control features into facility designs, and by selecting appropriate mining methods to address hazards during mineral extraction.

For the Kiggavik Project, a radiation protection Design Control and Validation Plan (DCVP) was prepared for the mill design to provide targets for workplace nominal radiological levels and advice on how to achieve the targets. Target development considered the relevant aspects of the Kiggavik Project, especially anticipated ore grades and mining and milling techniques, as well as best practices in mining and AREVA experiential knowledge.

The workplace nominal exposure rate objectives set for the Kiggavik mill are:

- 1.5 uSv/h for gamma radiation
- 0.03 WL for radon progeny
- 0.1 DAC for long-lived radioactive dusts

AREVA has proposed the nominal exposure rate objectives, as stated above, as a design criteria for designing the mill. Typically, only personnel classified as Nuclear Energy Workers (NEWs) work routinely in radiation exposure areas, however, these areas of the facility are not restricted to NEW. Non-NEW personnel, contractors, or visitors may occupy these areas, for various reasons, for durations which will not result in their exceeding the public dose limit.

## 3.3 Dose Assessment

Preliminary assessments of radiation dose are conducted prior to each project phase using experience gained on previous projects as well as using predictive tools such as radiation modeling software. Preliminary assessments are used in the planning of radiation exposures. Assessments are periodically updated as operational experience is gained.

Dose assessments have been completed for workers and contractors at the Kiggavik Project as well as members of the public where radioactive materials may be transported or temporarily stored. The dose assessments are based on established targets for worker and/or public doses as well as the associated radiological levels. The assessments determine an individual's:

- anticipated effective dose and dose from each component (i.e. radon progeny, long lived radioactive dust and gamma rays);

- designation as NEW or non-NEW (if applicable);
- dosimetry device(s) to be issued to workers; and
- National Dose Registry code to be used for workers.

Radiological area monitoring of workplaces, and dosimetry monitoring of NEW and non-NEW staff, will be conducted to confirm dose assessment assumptions.

It is anticipated that radiation exposures during open-pit mining, and subsequent milling of uranium ores at the Kiggavik Project will result in annual doses of less than 5 mSv/year, with average doses of less than 1 mSv/year.

Assessments of potential exposures to the general public confirm that no member of the general public is anticipated to receive a radiation dose greater than 1 mSv/year. The phrasing "member of the general public" is taken from the Radiation Protection Regulations under the Nuclear Safety and Control Act to describe people (i.e. workers or others) not expected to receive doses exceeding 1 mSv/a.

Assessments also indicate if an individual should take part in any other applicable programs at the Kiggavik Project (e.g. the Uranium in Urine Program, Respiratory Protection Program, specific radiation protection training, etc.).

Dose assessments comply with obligations to CNSC's Radiation Protection Regulations and Uranium Mining and Milling Regulations, Nunavut's Mines Regulations, the National Dose Registry (NDR) and applicable licensing requirements.

## 3.4 Radiation Protection Procedures

Radiation protection procedural documents are written to:

- describe the activities conducted to execute the RPP, and
- Provide workers with job-specific advice relating to radiation protection.

A list of the radiation protection procedures is provided in Attachment B. The procedures reference lower tiered documents called Work Instructions, which provide the working level detail in the execution of tasks.

## 3.5 Personal Protective Equipment

Two types of respirators may be used for radiation protection at the Kiggavik Project; powered air purifying respirators and passive air purifying respirators. Where respirators are used, personal alpha

dosimeters (if issued) are removed and the doses due to airborne radioactive contaminants are calculated by an approved method. The Kiggavik Project does not rely on the use of respirators to meet radiation protection objectives; respirators are used preventatively as part of good ALARA practice.

Respirators may routinely be required for access inside the yellowcake drying and packaging enclosures. Further, the Radiation Protection Supervisor may require the use of respiratory equipment for personnel entering areas where elevated radon progeny and/or long-lived radioactive dust concentrations have been documented or are anticipated. The program for selecting, using and maintaining respiratory protective equipment for the purposes of radiation protection is described in a Respiratory Protection Program procedure.

## 3.6 Radiation Work Permits

The Radiation Work Permit system is implemented in accordance with the Code of Practice for the operation. The permitting system is designed to track non-routine radiation exposures to persons conducting non-routine work in restricted areas of the site.

The system:

- Identifies areas with elevated exposure rates through postings;
- Requires non-routine occupancy of restricted areas to involve radiation protection staff;
- Requires a brief dose assessment to be conducted for the planned work;
- Allows the identification of the hazard to the workers by radiation protection staff;
- Limits occupancy time based on expected dose;
- Requires staff plan their work to minimize dose;
- Ensures proper protective equipment is used; and,
- Ensures appropriate staff is aware, and approves of the dose implications of work conducted.

## 3.7 Emergency Preparedness and Response

The Kiggavik Project Emergency Response Plan integrates radiation protection considerations into emergency preparedness and response functions. In the event of a situation which is immediately dangerous to life or health (IDLH), radioactivity would be a secondary hazard only. There is no foreseeable circumstance involving uranium-bearing radioactive materials at the Kiggavik site which would result in an emergency situation as a result of their radioactive properties.

Similarly, environmental spill response plans consider treatment of radioactive materials in an integrated fashion. Environmental spill responders are trained in radiation protection. In the event of

an environmental spill involving radioactive materials, there is no foreseeable circumstance involving uranium-bearing radioactive materials at the Kiggavik site which would result in a situation where an environmental component is acutely endangered as a result of their radioactive properties.

# 4 Radiation Protection Program (DO)

## 4.1 Dosimetry Monitoring

Dosimetry monitoring is conducted to document worker exposures to radiological components. The premise of radiation protection is to maintain worker doses to radiation As Low As Reasonable Achievable (ALARA). A procedure for the Kiggavik Project is designed to ensure worker doses from each radiological component are determined (or estimated), recorded, evaluated and monitored in an appropriate manner.

Dosimetry monitoring is required under the Radiation Protection Regulations and the Uranium Mining and Milling Regulations under the Nuclear Safety and Control Act. Licensees are required to record the dose received by and committed to each person who performs duties in connection with any activity that is authorized by the act or who is present at a place where that activity is carried on. Dosimetry monitoring demonstrates compliance with dose limits defined by federal regulations, territorial regulations and other regulatory instruments, e.g., license conditions.

At engagement events, people had questions about how workers will be monitored for radiation (EN-CI OH Nov 2012[9]).

The Dosimetry Monitoring Strategy (DMS) Procedure addresses both the site regular workforce and other persons (e.g. contractors and visitors) who access “Radiation Areas” of the Kiggavik Project. A distinction is made between Nuclear Energy Workers (NEW) and non-NEW staff. Dosimetry monitoring of NEW staff is a regulatory requirement necessitating routine regulatory reporting. Dosimetry monitoring of non-NEW staff is conducted for internal control purposes. Dosimetry monitoring for non-NEW workers is not routinely be reported to regulators but suitable records are maintained on file.

This DMS address radiation doses from gamma radiation, radon progeny (RnP) and long-lived radioactive dusts (LLRD). Since dose from LLRD is already accounted for, and given the current recognized uncertainty of the uranium in urine measuring techniques in providing estimates of committed doses, uranium in urine monitoring is included as a radiological monitoring tool rather than a dosimetric tool.

[9] EN-CI OH Nov 2012: *Does everyone wear the radiation monitors?*

Methods of dose monitoring at the Kiggavik Project include the use of:

- Optically Stimulated Luminescent Dosimeters (OLDs) provided by an outside licensed dosimetry service provider for determination of deep and shallow gamma radiation dose;
- Personal Alpha Dosimeters (PADs) provided by an outside licensed dosimetry service provider for determination of radon progeny (RnP) and long lived radioactive dust (LLRD), used on an individual or group basis;
- Direct reading dosimeters (DRDs) for estimation of gamma radiation dose, used on an individual or group basis;
- Worker occupancy and area monitoring data for estimation of RnP and LLRD dose;
- Dose data from workers conducting similar activities for the estimation of gamma radiation, RnP or LLRD doses;
- Historical occupational information for the estimation of gamma radiation, RnP or LLRD doses; and
- Pre-work dose estimation and planning.

## 4.2 Radiological Levels Area Monitoring

Through public engagement in communities it was found that monitoring of radiation is important to people (EN-CI OH Nov 2012[10], EN-BL OH Nov 2013[11], EN-BL NIRB Apr 2010[12]).

Radiological levels of gamma radiation, radon progeny (RnP), and long-lived radioactive dust (LLRD) is monitored routinely throughout the Kiggavik Project in order to detect potentially abnormal radiological conditions promptly, estimate worker doses, and document radiological conditions. Radiological monitoring is also conducted to validate the assumptions used in dose assessments, for example, radon monitoring will be monitored during the construction phase to validate the prediction that radon exposures will be minimal.

A network of monitoring locations, parameters and frequencies is established for each of the Kiggavik Mill, Open Pit Mines, Underground Mine, and Associated Facilities in the Routine Radiological Monitoring Schedule procedure. This procedure complies with applicable federal and territorial regulations, identifies sample locations, parameters and frequencies; states instrument

[10] EN-CI OH Nov 2012: *Are there people monitoring the environment and radiation every day?*

[11] EN-BL OH Nov 2013: *Radiation exposure to workers. How do we keep people safe?*

[12] EN-BL NIRB Apr 2010: *Will measures be put in place to prevent exposure?*

requirements and sampling methods; referred to Administrative Levels and mitigative measures; and, identifies reporting responsibilities and methods.

## 4.3 Radioactive Contamination Control

Contamination control measures are in place to minimize the spread of radioactive materials into unintended locations. Methods used to identify and quantify radioactive contamination, determine the acceptability of the contamination relative to defined limits, and record and communicate results is given in a Procedure specifically addressing radioactive contamination control.

Radioactive contamination control measures apply to areas of the Kiggavik Project where radioactive materials may be found, exclusive of the sources on site, and to the off-site shipment or arrival of suspected contaminated material or equipment. Components of the contamination control program include:

- Maintenance of radioactive contamination within on-site areas at acceptable levels;
- Limitation of radioactive contamination of materials sent off-site and received on-site; and
- Limitation of radioactive contamination of materials transferred between areas on site.

Directives regarding preventative and mitigative measures are provided in a Procedure specific to contamination control for site staff. The procedure describes:

- Preventative measures to minimize incidental transfer of contaminated materials;
- Mitigative measures in the event of an upset condition;
- Area designations; and,
- Removal of materials.

These radioactive contamination control measures comply with CNSC's Nuclear Substances and Radiation Device's Regulations and Packaging and Transport of Nuclear Substances Regulations, Nunavut's Mines Regulations and internal AREVA commitments.

## 4.4 Bioassay Sampling for Uranium in Urine

The bioassay program for the determination of uranium in urine is described in the Bioassay Sampling for Uranium in Urine procedure. In this context, bioassay refers to the determination of radioactive material deposited in the human body by measuring the quantity of such material in excreta. The procedure involves the measurement of uranium in the urine.

Analysis of uranium concentrations in excreta, particularly urine, can be used to estimate intakes of uranium and estimate corresponding dose. In uranium mining, dose estimation from urinalysis is used on an exceptional basis rather than a routine basis. For routine monitoring of inhalation exposures, Personal Alpha Dosimeters (PADs) or workplace air monitoring is generally used where anticipated exposures warrant dosimetric monitoring. Urinalysis is primarily used as a monitoring tool to validate the effectiveness of respiratory protection programs.

Bioassay sampling of workers for uranium in urine is part of the routine radiological monitoring program at the Kiggavik Project. The samples are conducted to identify potential abnormal intakes of uranium as workers may be potentially exposed to uranium of varying solubilities. Within the Code of Practice, triggering administrative levels are set conservatively, commensurate with the potential hazard from the uranium compounds. All NEW workers at the Kiggavik Project's mill, open pits or underground mines are candidates for the uranium in urine monitoring program.

## 4.5 Management of Radioisotopes

The Kiggavik Project uses a number of nuclear substances and radiation devices. The nuclear substances or radiation devices may be used for instrument calibration, material analysis, flow and density measurement, level indication or for exploration activities. Under an operating license issued by the CNSC pursuant to the Nuclear Substances and Radiation Devices Regulations AREVA Resources Canada Inc. would be authorized to import, possess, use, store, transfer and dispose of nuclear substances in quantities which would not exceed the possession limits identified in a controlled document, which would list the Authorized Nuclear Substances and Radiation Devices.

The amount of radioactivity for the nuclear substance, or nuclear substance within a radiation device, would not exceed:

- the possession limit for unsealed sources, or
- the maximum activity per sealed source or device approved by the CNSC.

The Management of Radioisotopes procedure, and a suite of work instructions, together with the radiation protection program is prepared pursuant to Section 3, General Requirements of the Nuclear Substances and Radiation Devices Regulations and the Nunavut's Mines Regulations. The Management of Radioisotopes Procedure address: authorization; regulatory requirements; authorized radioisotopes; inventory of radioisotopes; supervisory responsibilities; qualifications and training; theft, loss, unauthorized use; emergency procedures; submissions and approvals.

## 4.6 Ventilation Monitoring

### 4.6.1 Mill and Surface Facilities

For the purpose of the radiation protection program, ventilation monitoring consists of monitoring the systems established to protect workers from airborne radiological hazards. Monitoring includes measuring airflow volumes and velocities in the mill HVAC, process ventilation, and scrubber systems. Monitoring results are compared to design specifications to determine system performance. Radiation protection personnel measure ventilation parameters in the investigation of process upsets which have resulted in elevated airborne radiological levels.

### 4.6.2 Underground Mine

Underground mine ventilation at the Kiggavik Project is monitored as part of the radiation protection program's routine radiological monitoring schedule, or in response to an upset or a request made by the Mining Department. This is done to ensure that concentrations of radiological and non-radiological contaminants in ventilation air shall be as low as reasonably achievable complying with CNSC's Uranium Mines and Mills Regulations, Nunavut's Mines Regulations and AREVA's internal commitments.

The COP developed for underground mining provides performance criteria for the establishment, operation and maintenance of the underground ventilation systems and identifies corresponding responses and reporting requirements. The Mine Manager has the responsibility for the underground ventilation system and no alterations or modifications, including the starting or stopping of fans, is made to the ventilation system without permission.

## 4.7 Shipping Radioactive Materials

The Shipping Radioactive Materials procedure addresses the various requirements for shipping radioactive materials such as uranium concentrate (yellowcake); mill tailings, laboratory and geology samples; and radioactive devices and sources. The procedure is developed to comply with the CNSC's Packaging and Transport of Nuclear Substances Regulations and the Transportation of Dangerous Goods Regulations and NU Mines Regulations.

The responsibility for supervising the preparation for shipment of radioactive material rests with the Radiation Protection Department.

## 4.8 Training

The local people are unfamiliar with radiation and radiation protection practices and want to ensure that personnel working at the mine receive radiation-specific training (EN-CH OH Nov 2010[13,14,15], EN-AR OH Nov 2010[16], EN-RB OH Nov 2010[17], EN-KIV OH Oct 2009[18], EN-BL EL Oct 2012[19]). Comprehensive radiation protection training programs, completed on site, address concerns such as those listed from public engagement.

At the Kiggavik Project the Radiation Protection training requirements for site staff are identified in the RP Training procedures.

- *Specific Radiation Protection Training Programs*

Radiation protection training programs are established to ensure that workers who are likely to be exposed to radiation receive instruction on various topics, as appropriate, depending on considerations such as the radiation risk, the type of mining or milling processes employed, and the job of the individual. Training programs are delivered to the following workers:

- Occupationally exposed workers and those assigned responsibilities in the Radiation Protection program;
- Senior Management;
- Non-NEW whose work may have an impact on the level of exposure of other workers;
- Workers involved directly with radiation sources;
- Supervisors;
- Female workers; and
- All first response personnel, technical experts and representatives of appropriate authorities.

[13] EN-CH OH Nov 2010: *Do you worry about getting pregnant if you work at the mine?*

[14] EN-CH OH Nov 2010: *Can you see radiation? What do you use to detect it, large or small detectors?*

[15] EN-CH OH Nov 2010: *How long can they work around radiation?*

[16] EN-AR OH Nov 2010: *When considering the product, from the ground to shipping, how much radiation is given off and does it change? What is a Sv? Is radiation warm? Like the sun?*

[17] EN-RB OH Nov 2010: *What are the risks with radiation?*

[18] EN-KIV OH Oct 2009: *If I get a job, how will I know if radiation is affecting me?*

[19] EN-BL EL Oct 2012: *Are you teaching radiation safety at the site?*

### 4.8.1 Occupationally exposed workers and those assigned responsibilities in the Radiation Protection program

Workers who may be occupationally exposed to radiation and persons assigned responsibilities in the Radiation Protection Program receive general radiation protection information and training which includes (but is not limited to):

- The principles of radiation protection (limits and optimization);
- Basic quantities and units in radiation protection,
- The properties of and hazards associated with radioactive materials;
- The purpose and methods of estimating workers; radiation doses, including the use of individual monitoring and measurements;
- The proper practices to eliminate, limit or control radiation doses to workers, including personal hygiene and basic techniques of dose reduction, such as shielding, distance and time;
- The persons to be contacted on matters of radiation, health and safety;
- The obligations of workers under the regulations issued by the regulatory body;
- The health effects of radiation exposure; and
- The meaning of warning signs.

### 4.8.2 Senior Management

Senior management is trained in the risks associated with ionizing radiation, the basic principles of radiological protection, their main responsibilities regarding radiation risk management and the principal elements of the radiation protection program.

### 4.8.3 Non-NEW whose work may have an impact on the level of exposure of other workers

Workers who may not be occupationally exposed but whose work may have an impact on the level of exposure of other workers or non-NEW are provided with basic information on radiation protection principles. They are trained in how to take account of radiation protection requirements in their activities so as to optimize the protection of other people.

### 4.8.4 Workers involved directly with radiation sources

Training of workers directly involved with radiation sources includes relevant information that emphasizes procedures specific to the worker's job assignment. Particular attention is paid to contractors to ensure that they are provided with necessary information and training. Training for

workers addresses topics at a level of detail commensurate with the workers' job assignments and the potential hazard. The training covers the following topics as appropriate:

- Potential health hazards associated with the work;
- Safe working methods and techniques- the dos and don'ts in the facility;
- Actions to be taken after an accidental physical contact with radioactive substances or acute intake of radionuclides;
- The applicable health surveillance plan, the reasons for it and the need for notification of any health problems that may affect fitness for work;
- The proper selection, use, care and maintenance of instruments and equipment for radiation protection and individual dosimeters;
- The function and purpose of engineering protective measures such as ventilation systems and dust suppression systems, and the need for the immediate reporting of any breakdown to the appropriate person;
- The license or registration and the local operating instructions and their application to the operation of the facility;
- The means of contacting key individuals such as the Radiation Protection Supervisor, the Health Department, the representative of the regulatory body and the representative of the workers; and
- Emergency plans.

### 4.8.5 Supervisors

Supervisors receive additional training to enable them to fulfill their supervisory obligations, such as:

- More advanced training in radiation protection;
- Training in the review of workers; exposures and doses; and
- Observation of job practices.

### 4.8.6 Female workers

Training involving specific requirements related to female workers who may enter radiation areas include:

- Providing adequate information on the health risks due to their occupational exposure, whether normal exposure or potential exposure, adequate instruction and training on protection and safety, and adequate information on the significance for protection and safety of their actions;
- Providing to those liable to enter radiation areas appropriate information on:
    - The risk to the embryo or fetus due to exposure of a pregnant woman

    - The importance for a female worker of notifying her employer as soon as she suspects that she is pregnant
    - The risk to an infant ingesting radioactive substances by breast feeding
- Providing to those workers who could be affected by an emergency plan appropriate information, instruction and training; and
- Keeping records of the training provided to individual workers.

### 4.8.7 All first response personnel, technical experts and representatives of appropriate authorities

A training program developed for responding to transport accidents involving packages containing radioactive material is given to all personnel included in the emergency plan. This includes all first response personnel, technical experts, and representatives of appropriate authorities. Training covers:

- The planning basics,
- Responsibilities, capabilities, and duties of the organizations involved;
- Procedures for alerting and notifying key organizations and persons;
- Methods for warning and advising the public;
- Intervention levels for exposure and contamination;
- Protective measures;
- Procedures for response actions;
- Resources and medical and public health support;
- Procedures for training, exercises and updating plans; and
- Public information.

Training programs meet requirements of the CNSC Uranium Mines and Mills Regulations, Nunavut's Mines Regulations and corresponding licensing requirements.

# 5 Monitoring Elements (CHECK)

## 5.1 Review

Monitoring results generated from the various programs conducted under the Radiation Protection program including dosimetry monitoring, radiological levels monitoring, contamination control, bioassay, etc., are reviewed and compared to appropriate reference levels defined within program documents such as the Code of Practice to keep worker doses and workplace radiation levels ALARA.

## 5.2 Reporting Requirements

Reporting requirements and frequencies are described within the Radiation Protection program documentation. Frequency of reporting of dosimetric and radiometric results to regulatory authorities is determined at the time of licensing, but is typically conducted on a quarterly basis.

## 5.3 Change Management and Document Control

Proposed changes to facilities at the Kiggavik Project are reviewed for impact to worker radiation protection. Changes to quality documents are controlled via a site-wide quality document system.

# 6 Continuous Improvement and Corrective Actions (ACT)

## 6.1 Non-Conformances and Corrective Actions

The Kiggavik site will have a site wide procedure on non-conformance in place to identify, document, investigate, mitigate, correct and prevent further non conformances related to program commitments. Within the Radiation Protection program a non-conformance is defined as a failure to fulfill a commitment or requirement of the program. As non-conformances are not of equal consequence to the effectiveness of the Radiation Protection program they are divided into three classes:

- Class I - a deficiency indicative of a loss of control, or potential loss of control, of the effectiveness of the Radiation Protection program.
- Class II - a deficiency that impacts the effectiveness of the Radiation Protection program.
- Class III - a deficiency that does not affect the performance of the Radiation Protection program but is counter to good radiation protection practice or impacts on Radiation Protection program objectives.

## 6.2 ALARA

Radiation protection practice has its foundation in the As Low As Reasonably Achievable (ALARA) principle. Optimization of radiation protection is integral to the radiation protection program elements implemented for the Kiggavik Project. Additionally, an ALARA system procedure is developed to describe the application of ALARA to overall radiation protection program management. The procedure describes how the ALARA principle is applied through the implementation of management control over work practices, personnel qualification and training, control of occupational and public exposure to radiation, and planning for unusual situations. “Optimization of radiation protection” is, in practice, the radiation protectionist’s phrase for “continuous improvement.”

## 6.3 Program Review

The Radiation Protection program is reviewed annually by Radiation Protection personnel to identify deficiencies and areas for improvement. An Internal audit process is implemented to demonstration program adherence to standards, and to enhance the effectiveness and efficiency of the Radiation Protection program.

## 6.4 Objectives and Targets

Objectives for program improvement, with measureable targets, are set annually and approved by the General Manager.

# 7 References

AR OH (Arviat Open House). November 2010. From “Part 5 – Kivalliq Community Information Sessions (Round 2, 2010)” December 2011; in Appendix 3A: Public Engagement Documentation, Part 5.

BL EL (Baker Lake Elders Society (Qilautimiut)). October 2012. Notes from workshop on Significance. Oct 30, 2012; in Appendix 3A: Public Engagement Documentation, Part 2.

BL NIRB (Baker Lake - Nunavut Impact Review Board). April 2010. From “Public Scoping Meetings Summary Report, April 25-May 10, 2010, for the NIRB’s Review of AREVA Resources Canada Inc.’s Kiggavik Project (NIRB File No. 09MN003)”; in Appendix 3A: Public Engagement Documentation, Part 11.

BL OH (Baker Lake Open House). October 2012. From “Kivalliq Community Information Sessions 2012 Report.” May 2013; in Appendix 3A: Public Engagement Documentation, Part 6.

BL OH (Baker Lake Open House). November 2013. From “Kivalliq Community Information Sessions 2013 Report.” May 2014; in Appendix 3A: Public Engagement Documentation, Part 7.

CI OH (Chesterfield Inlet Open House). November 2012. From “Kivalliq Community Information Sessions 2012 Report.” May 2013; in Appendix 3A: Public Engagement Documentation, Part 6

CH OH (Coral Harbour Open House). November 2010. From “Part 5 – Kivalliq Community Information Sessions (Round 2, 2010)” December 2011; in Appendix 3A: Public Engagement Documentation, Part 5.

CH OH (Coral Harbour Open House) October 2012. From “Kivalliq Community Information Sessions 2012 Report.” May 2013; in Appendix 3A: Public Engagement Documentation, Part 6.

KIV OH (Kivalliq Communities Open House). October 2009. From “Part 4 – Kivalliq Community Information Sessions (Round 1, 2009)” December 2011; in Appendix 3A: Public Engagement Documentation, Part 4.

RIE (Rankin Inlet Elders). 2009. Excerpt from socio-economic focus group conducted by Susan Ross and Linda Havers. April 3, 2009; in Appendix 3B: Inuit Qaujimajatuqangit Documentation, Attachment D.

RB OH (Repulse Bay Open House). November 2010. From “Part 5 – Kivalliq Community Information Sessions (Round 2, 2010)” December 2011; in Appendix 3A: Public Engagement Documentation, Part 5.

# Kiggavik Project
# Final Environmental Impact Statement

## Tier 3 Technical Appendix 2Q:
## Radiation Protection Plan

## Attachment A: Preliminary Code of Practice

**September 2014**

# Table of Contents



# List of Tables

# Attachment A Preliminary Code of Practice

## A.1 Purpose

A Code of Practice (COP) is a practical application of the As Low As Reasonably Achievable (ALARA) principle. Discrete values for radiological parameters above which intervention may be required to maintain worker doses and workplace radiological levels ALARA are defined and corresponding mitigative measures identified. Administrative Levels establish indicators of radiation protection performance to facilitate internal control. Action Levels are applied as prescribed in the Nuclear Safety and Control Act and regulations to identify a potential loss of control of radiation protection program. The system of Administrative Levels supports the Action Levels by triggering prompt follow-up and mitigative measures commensurate with the abnormal conditions encountered. The Administrative Levels correspond to situations which are well below regulatory dose limits.

The COP is a governing document in the administration of the radiation protection program and as such is a primary reference for Radiation Protection staff in the execution of radiation protection programs. A COP is a regulatory requirement under the Uranium Mines and Mills Regulations.

## A.2 Scope

This Code of Practice (COP) pertains only to the Kiggavik Mill and Open Pits; a separate COP will be developed for underground mining, prior to the commencement of this activity.

**Action Levels** are defined for:

- Individual total effective dose

**Administrative Levels** are defined for:

- Individual total effective dose
- Worker uranium in urine analyses
- Workplace gamma exposure rates
- Workplace radon progeny levels
- Workplace long-lived radioactive dust derived air concentrations
- Worker gamma exposure doses

Administrative Levels and Action Levels defined for individual total effective dose are applicable under routine circumstances. A further provision with respect to total effective dose is included for non-routine circumstances. Administrative Levels defined for workplace radiological levels apply to the routine network of radiological sampling locations defined by the routine radiological monitoring schedule, excluding restricted and unoccupied areas. COP Administrative Levels, while useful in evaluations, do not apply to monitoring conducted for investigative or engineering control purposes.

General provisions are included for:

- Restricted area access and safe work permit system;
- Use of respirators; and
- Medical surveillance.

## A.3 Applicable To

The COP is applicable to all persons at Kiggavik Project. Persons with individual responsibilities include:

- General Manager
- SHEQ Manager
- SHEQ Director
- Mine Manager
- Mine General Supervisor
- Mine Supervisors
- Mill Manager
- Mill Supervisors
- Surface General Supervisor
- Mine Maintenance Supervisors
- Radiation Protection Supervisor
- Radiation Protection Technician

## A.4 Regulatory Consideration

A Code of Practice is required by the *Uranium Mines and Mills Regulations* under *the Nuclear Safety and Control Act*. In addition to the approvals required under the Kiggavik Project Quality Management System, approval of this document is also required from the Project Officer assigned by the Canadian Nuclear Safety Commission (CNSC).

This Code of Practice is intended to be consistent and/or comply with:

- Nuclear Safety and Control Act;
- Uranium Mining and Milling Regulations;
- Radiation Protection Regulations;
- Regulatory Guide G-129 Keeping Radiation Exposures and Doses "As Low As Reasonably Achievable";
- Regulatory Guide G-228 Developing and Using Action Levels; and
- Regulatory Guide G-218 Preparing Codes of Practice to Control Radiation Doses at Uranium Mines and Mills.

## A.5 Definitions

Action Level – A specific dose of radiation or other parameter that, if reached, may indicate a loss of control of part of a licensee's radiation protection program and triggers a requirement for a specific action to be taken. If an action level value is reached, there must be a determination of the nature and cause, actual or potential consequences of the accident, mitigative actions conducted to return to normal conditions, measures to prevent future reoccurrence and a documentation of the accident. An action level has specific regulatory obligations under the Nuclear Safety and Control Act and Regulations. An action level exceedance is also considered a Non-Conformance under Procedure 735, Kiggavik Project Non-Conformance.

Administrative Levels - A specific dose of radiation or other parameter that, if reached, may indicate intervention is necessary to maintain worker doses or workplace radiological levels as low as reasonably achievable (ALARA). A series of Administrative Levels is defined for each pertinent radiological parameter which may range from below the design objective up to the Action Level. Administrative Levels are established for internal control purposes. An uppermost Administrative Level excursion, unexpectedly exceeded, may also be considered a Non- Conformance.

Restricted Area – An area or location where radiological levels are expected to exceed the workplace exposure rate objectives. A restricted area may be identified by design, e.g. ore stockpile, or through operational experience, e.g. sample storage area. In addition, restricted areas include all areas of the mine or mill where the gamma radiation dose rate to any person remaining in the area exceeds 25 µSv/h. Posting of signs identifies these areas. Work in restricted areas, other than routine duties, is controlled under the safe work permit system.

Radiation Area – An area where radioactive materials are routinely used or stored. Radiation areas include the mill, open pits, geology lab, bombi garage, heavy duty shop and ore pads. Radiation areas exclude the mine offices and coffee rooms, services shop, Kiggavik Camp, Dry and other locations where radioactive material is not used or stored.

Routine – Routine duties include any activity which typifies normal work activities required by a person's position. This includes preventative maintenance activities, inspections and sampling which

occurs in otherwise restricted areas. For example, mill maintenance routinely services mill equipment, mine operators routinely access the ore pad, mechanics routinely service vehicles, and geologists routinely sample ore bearing rock.

Non-Routine – Non-routine activities are typified by unexpected mechanical failures, substantial equipment overhauls, or work within reaction vessels (confined spaces). An evaluation of each worker position at Kiggavik Project has been conducted with respect to expected radiation dose. The intent of identifying non-routine work in restricted areas is to account separately for dose not considered in the initial dose assessment separately.

## A.6 Code of Practice

### A.6.1 Administrative Levels and Action Levels

Monitoring of workplace radiological levels and worker dosimetry monitoring is conducted in accordance with the Routine Radiological Monitoring Schedule (RRMS) and Dosimetry Monitoring Strategy (DMS), respectively. Resultant values are compared to Action Levels and Administrative Levels identified herein. The described responses are conducted as appropriate. Reporting is conducted as indicated in Section 6.4. Practically, the mitigative and reporting provisions of the COP with respect to Action Levels and to Administrative Levels are triggered once AREVA Resource Canada Inc. (ARC) supervisory staff becomes aware of an exceedance through the indicators of its RP framework.

**Action Levels** are only defined for total effective dose. Specifically, the Action Levels are set to 1 mSv/week and 5 mSv/quarter. These Action Levels were derived from the regulatory annual dose limits applied to shorter time periods: i.e., 50 mSv/y ÷ 50 weeks/y = 1 mSv/week, and 20 mSv/y ÷ 4 quarters/year = 5 mSv/quarter. These Action Levels and the related mitigative measures ensure that regulatory dose limits will not be jeopardized over the year.

**Administrative Levels** are identified along with corresponding responses and reporting requirements in tabular form for radiological parameters as follows:

- Table A: Individual total Effective Dose
- Table B: Gamma Radiation Exposure Rates: Mill
- Table C: Radon Progeny Levels: Mill
- Table D: Long-Lived Radioactive Dust Derived Air Concentrations: Mill
- Table E: Uranium in Urine
- Table F: Worker Gamma Exposure: Surface Mines
- Table G: Radon Progeny Levels: Surface Mines
- Table H: Long-Lived Radioactive Dust Derived Air Concentrations: Surface Mines

Administrative Levels for individual total effective doses are based on the facility design and reflect the commitments made through the licensing process. The Administrative Levels for the workplace radiological parameters are derived from the Administrative Levels set for individual total effective doses and reflect the facility design objectives.

As per current industry experience, the applicability of Action Levels and Administrative Levels is limited to unexpected situations. Situations for which the excess may be planned and controlled (e.g., non-routine worker doses corresponding to a specific task carried out under a safe work permit), or situations for an area that is not occupied by workers, are not considered as unexpected situations.

### A.6.2 Safe Work (Short and Long) Permit System

A safe work (short and long) permit system is in place to control non-routine exposure for entry to restricted areas. Under this system, the individual total effective dose to any worker due to multiple entries into the subject areas or locations is limited to 5 mSv per year. Safe work permit doses are controlled under the system of Administrative Levels. Specifically, each entry will be planned such that the radiation dose for a “short stay” or a “long stay” does not exceed 0.05 and 0.2 mSv, respectively.

### A.6.3 Other Types of Entry Into Restricted Areas

Authorization is granted for a worker to enter or remain in any part of the mine and its associated facilities to which access is otherwise restricted or prohibited if entry is necessary in order to:

- Respond to an emergency; or
- carry out mitigative measures designed to reopen that part of the mill or mine and its associated facilities in accordance with this COP and to re-establish the ventilation.

Such authorizations require that:

- The name of the worker, the period and particulars of the entry, the reasons for the entry, the actual dose received, and the protective measure taken is documented, maintained, and made available to the worker and the representative;
- all practicable measures to minimize the radiation dose to the worker are taken;
- the worker is instructed in any additional measures to be taken for minimizing the radiation dose; and
- workers are provided with training in ALARA practices during their Advanced Radiation Protection training courses required of all Nuclear Energy Workers.

Specific dose control work instructions are provided for the Mill and Mines which describe measures for protecting the health and safety of employees required to enter these areas, minimizing their exposure to radiation, and ensuring that adequate preventative measures are in place. Training in these instructions is mandatory for workers who are required to enter restricted areas.

### A.6.4 Reporting and Notification

When an **Action Level** has been reached the CNSC Project Officer is notified of the occurrence in writing within 24 hours. An investigation is conducted to validate the associated monitoring results. A report is prepared by the Radiation Protection Supervisor following the incident which describes the nature and cause of the incident, the actual consequences of the incident, mitigative measures implemented to restore control, and measures to prevent a future recurrence when possible. Reporting for an excess of an Action Level is also considered a Non-Conformance.

Reporting of workplace radiological levels which exceed **Administrative Levels** is conducted through routine circulation of daily monitoring results to appropriate persons. Exceeding values are flagged, as appropriate, on the daily report. When notification to the CNSC is indicated for a given Administrative Level, notification is provided in writing within 48 hours of ARC Supervisory staff's awareness of the occurrence. An uppermost administrative level excursion, unexpectedly exceeded, may also be considered a Non-Conformance.

Reporting of worker dose information, in writing, to individual workers is conducted on a quarterly basis.

### A.6.5 Personal Protective Equipment

The General Manager or his designate may stipulate the nature and type of personal protective equipment to be worn during entry to any part of the facility. When a powered, air-purifying respirator is used, the protective device will be considered to reduce exposures to long-lived radioactive dusts by 90%.

Every worker working in an area where the gamma dose rate to a worker may exceed 100 µSv/h must be provided with a suitable dosimeter giving a direct reading.

### A.6.6 Medical Surveillance

Annual medical check-ups are conducted for all Nuclear Energy Workers (NEW) at Kiggavik Project.

### A.6.7 Uranium in Urine

Workers at Kiggavik Project are subject to bioassay sampling for the determination of uranium in urine in accordance with the specific procedure 753, *Bioassay Sampling for Uranium in Urine.*

### A.6.8 Posting

A copy of this Code of Practice is available to all workers through the Integrated Quality Management System (IQMS) database in addition to a posted copy at the mine. A controlled copy is linked to the database and controlled copies are circulated in accordance with the COP Distribution list. Additionally, uncontrolled copies may be obtained from the Radiation Protection Group. The Radiation Protection Group maintains bulletin boards with pertinent radiation protection information.

With respect to radiological levels, the following posting requirements apply.

- All areas exceeding gamma radiation exposure rates of 25 µSv/h must be equipped with posted signs designating a radiation area and indicating dose rate.
- All areas exceeding radon progeny levels of 0.1 WL must be equipped with posted signs designating a radiation area and identifying the "Airborne Radiation" hazard.
- All areas exceeding long-lived radioactive dust levels above the D.3 Administrative Level identified in Table D and above the H.1 Administrative Level identified in Table H must be equipped with posted signs designating a radiation area and identifying the "Airborne Radiation" hazard.

Further discussion and instruction regarding postings identified in Procedure 747, ALARA.

**Table A** **Individual total Effective Dose (mSv) Effective Dose in mSv Relative to the 5 mSv per Year Dose Target.**

| Admin. Level | Value | Mitigative Action | Notification |
|---|---|---|---|
| A.1 | 0.4 mSv per month | Workers who unexpectedly exceed this level are identified at the *Worker Exposure Meeting* and notified thereafter. When a worker exceeds this level twice (or more) in a given quarter, his/her quarterly exposure must be reviewed jointly by the worker's General Supervisor and the RP Supervisor in the context of the quarterly dose target and the worker's remaining working period for the quarter. The written outcome of this review must be addressed in the next *Worker Exposure Meeting*. | RP Supervisor<br>Mine Gen. Supervisor<br>SHEQ Manager<br>Mine Manager<br>Mill Manager |
| A.2 | 1.25 mSv per quarter | Workers who unexpectedly exceed this level are identified at the *Worker Exposure Meeting* and notified thereafter. Thereafter, each subject worker is notified and a review of each worker's case relative to planned exposures must be carried out jointly by the worker's Gen. Supervisor and the RP Supervisor in the context of the annual dose target and the worker's remaining working period for the year. This review must involve the worker and address work practices, understanding of specific radiation protection issues (including higher exposure workplaces and the use of shielding), and training. Following this detailed review, a written plan to re-align the subject worker exposure relative to the annual dose target of 12 mSv must be submitted for approval to the General Manager. The detailed review and the related mitigative plan approval must be completed within two weeks. Upon approval, the mitigative plan must be communicated to the worker and the Occupational Health and Safety Committee (OHC), and be implemented. Moreover, the mitigative plan must be addressed in (and attached to) the next *Worker Exposure Meeting*. | RP Supervisor<br>Mine Gen. Supervisor<br>SHEQ Manager<br>Mine Manager<br>Mill Manager<br>Mill Ops Gen Supervisor<br>Mill Main Gen Supervisor<br>Gen Supervisor, Site Services and Security<br>General Manager<br>SHEQ Director |
| A.3 | 2.5 mSv per mid year | Same mitigative actions as in the 3.0 mSv per quarter action level. | As per A.2 and,<br>CNSC |

NOTE:

In addition to the above Administrative Levels for individual total effective dose, **Action Levels** are set at 1 mSv/week and 5 mSv/quarter. Any indication of worker doses (potential or actual) in access of these Action Levels shall be immediately reported to the RP Supervisor or his designate, who will conduct the necessary investigation, mitigative measures, and reporting as required following the Kiggavik Project Non-Conformance Procedure.

## Table B Workplace Gamma Radiation Dose Equivalent Rates (µSv/h) – Administrative Levels: Mill

| Admin. Level | Value | Mitigative Action | Notification |
|---|---|---|---|
| B.1 | Greater than 1.0 and up to 1.5 | i) Resample within 48 hours.<br>ii) Determine the cause and undertake mitigative action where reasonably practicable. | RP Supervisor<br>Mill Ops. Gen. Supervisor<br>Mill Main. Gen. Supervisor<br>Gen Supervisor, Site Services and Security<br>SHEQ Manager |
| B.2 | Greater than 1.5 and up to 2.5 | i) Resample within 24 hours.<br>ii) Determine the cause and undertake mitigative action where reasonably practicable. | RP Supervisor<br>Mill Ops. Gen. Supervisor<br>Mill Main. Gen. Supervisor<br>Gen Supervisor, Site Services and Security<br>SHEQ Manager<br>Mill Manager<br>OH&S Committee |
| B.3 | Greater than 2.5 and up to 10 | i) Same mitigative actions as for B.2 above. | RP Supervisor<br>Mill Ops. Gen. Supervisor<br>Mill Main. Gen. Supervisor<br>Gen Supervisor, Site Services and Security<br>SHEQ Manager<br>Mill Manager<br>OH&S Committee<br>General Manager |
| B.4 | Greater than 10 | i) Resample immediately.<br>ii) Determine the cause and undertake mitigative action where reasonably practicable.<br>iii) Work practices to be approved by the Radiation Protection Supervisor.<br>iv) Restrict access to employees wearing direct reading dosimeters.<br>v) Post “Gamma Radiation Warning“sign(s) | RP Supervisor<br>Mill Ops. Gen. Supervisor<br>Mill Main. Gen. Supervisor<br>Gen Supervisor, Site Services and Security<br>SHEQ Manager<br>Mill Manager<br>OH&S Committee<br>General Manager<br>SHEQ Director<br>CNSC |

NOTES:

- For this purpose, gamma doses are estimated from DRD readings.
- Preventative measures refer to measures that account for time, distance and shielding from radioactive sources. Wherever these measures may be not practical, mitigative actions may also refer to posting.

## Table C Workplace Radon Progeny Levels (WL): Mill

| AdminLevel | *Value* | Mitigative Action | Notification |
|---|---|---|---|
| C.1 | Greater than 0.03,and up to 0.06 | i) Resample within 24 hours.<br>ii) If level is confirmed by resampling, investigate to determine the cause and undertake mitigative action where reasonably practicable. | RP Supervisor<br>Mill Ops. Gen. Supervisor<br>Mill Main. Gen Supervisor<br>Gen. Supervisor, Site Services and Security<br>SHEQ Manager |
| C.2 | Greater than 0.06, and up to 0.1 | i) Resample within 24 hours.<br>ii) If level is confirmed by resampling, determine the cause and undertake mitigative action where where reasonably practicable.<br>iii) Post an *"Airborne Radiation"* warning sign.<br>iv) Restrict access to essential work.<br>v) Resample every 24 hours until condition returns to below 0.03. | RP Supervisor<br>Mill Ops. Gen. Supervisor<br>Mill Main. Gen Supervisor<br>Gen. Supervisor, Site Services and Security<br>SHEQ Manager<br>Mill Manager<br>OH&S Committee<br>General Manager |
| C.3 | Greater than 0.1 | i) Resample immediately to confirm the value is persistently above 0.1.<br>ii) Determine the cause and undertake mitigative action.<br>iii) Post sign (s) indicating *"Airborne Radiation"* warning and stating that written permission from mill General Supervisor must be received before entering.<br>iv) Restrict access immediately to mitigative action and inspection work.<br>v) Work practices, including requirements for use of respirators, to be approved by the Radiation Protection Supervisor.<br>vi) Resample every 24 hours until condition returns to below 0.03. | RP Supervisor<br>Mill Ops. Gen. Supervisor<br>Mill Main. Gen Supervisor<br>Gen. Supervisor, Site Services and Security<br>SHEQ Manager<br>Mill Manager<br>OH&S Committee<br>General Manager<br>SHEQ Director<br>CNSC |

## Table D Workplace Long-Lived Radioactive Dust Derived Air Concentrations (D.A.C.*): Mill

| Admin. Level | *Value* | Mitigative Action | Notification |
|---|---|---|---|
| D.1 | Greater than 0.05, and up to 0.1 | i) Resample within 48 hours of the result being known.<br>ii) Determine the cause and undertake mitigative action where reasonably practicable. | RP Supervisor<br>Mill Ops Gen. Supervisor<br>Mill Main Gen Supervisor<br>Gen. Supervisor, Site Services and Security<br>SHEQ Manager |
| D.2 | Greater than 0.1, and up to 0.2 | i) Start a resample within 24 hours of the result being known.<br>ii) Determine the cause and undertake mitigative action where reasonably practicable. | RP Supervisor<br>Mill Ops Gen. Supervisor<br>Mill Main Gen Supervisor<br>Gen. Supervisor, Site Services and Security<br>SHEQ Manager<br>Mill Manager<br>OH&S Committee |
| D.3 | Greater than 0.2 and up to 0.6 | i) Determine the cause and undertake mitigative action where reasonably practicable.<br>ii) Resample every 24 hours until condition returns to below 0.2 DAC. | RP Supervisor<br>Mill Ops Gen. Supervisor<br>Mill Main Gen Supervisor<br>Gen. Supervisor, Site Services and Security<br>SHEQ Manager<br>Mill Manager<br>OH&S Committee<br>General Manager |
| D.4 | Greater than 0.6 | i) Determine the cause and undertake mitigative action.<br>ii) Post sign (s) indicating "Airborne Radiation" warning and stating that written permission from area Supervisor must be received before entering.<br>iii) Work practices, including requirements to wear respirators, must be approved by the RP Supervisor.<br>iv) Resample every 24 hours until condition returns to below 0.2 DAC. | RP Supervisor<br>Mill Ops Gen. Supervisor<br>Mill Main Gen Supervisor<br>Gen. Supervisor, Site Services and Security<br>SHEQ Manager<br>Mill Manager<br>OH&S Committee<br>General Manager<br>SHEQ Director<br>CNSC |

NOTES:

- A Derived Air Concentration (1.0 DAC) is the concentration of a contaminant in the air that would result in an exposure which would reach the regulatory annual dose limit (20 mSv) of intake if continuously exposed for a work year.
- The analysis of the air filters for determining the LLRD levels is conducted after a period of decay in order to remove the contribution from radon progeny and thoron progeny
- Mitigative actions refer to measures that minimize the emission or re-suspension of LLRD.

## Table E Uranium in Urine Concentrations (μg/L)

| | Admin. Level | *Value* | Mitigative Action | Notification |
|---|---|---|---|---|
| First Sample | E.1 | Greater than 10 | i) Resample at the earliest opportunity.<br>ii) If two successive samples are in this range, discuss work and hygiene habits with employee and his supervisor.<br>iii) Investigate the possibility of equipment failure and take corrective action if required. | Employee<br>RP Supervisor |
| Second Sample | E.2 | Up to 10 | i) Advise the employee.<br>ii) No additional sample required for the period. | Employee<br>RP Supervisor<br>Mine Gen. Supervisor<br>SHEQ Manager<br>Mine Manager |
| | | Greater than 10 and up to 100 | i) Advise the employee.<br>ii) The RP Supervisor will discuss work and hygiene habits with the employee and his Supervisor.<br>iii) Investigate possible causes of elevated uranium level and take any actions found to be practicable to limit future intake of uranium. | Employee<br>RP Supervisor<br>Mine Gen. Supervisor<br>SHEQ Manager<br>Mine Manager<br>OH&S Committee<br>General Manager<br>SHEQ Director |
| Second Sample | E.3 | Greater than 100 | i) Advise the employee.<br>ii) The RP Supervisor will discuss work and hygiene habits with the employee and his General Supervisor. Nurses from the Kiggavik health centre must be involved.<br>iii) Remove the employee from work areas where exposure may be significant.<br>iv) Resample at the earliest opportunity.<br>v) Check for albumen in urine.<br>vi) Investigate cause of elevated uranium in urine levels and take appropriate corrective action to limit future intake of uranium. | Employee<br>RP Supervisor<br>Mine Gen. Supervisor<br>SHEQ Manager<br>Mine Manager<br>OH&S Committee<br>General Manager<br>SHEQ Director<br>CNSC |

## Table F Worker Gamma Radiation Dose mSv/day or mSv/week: Surface Mines

| Admin. Level | Value | Mitigative Action | Notification |
|---|---|---|---|
| F.1 | Greater than 0.05 and less than or equal to 0.1 mSv in a day<br>Or<br>Greater than 0.2 and less than or equal to 0.4 mSv in a week | i) The Mine Manager and the RP Supervisor or designates will review the radiation protection aspects of the work practice, and ensure its suitability in light of worker dose targets. | RP Supervisor<br>Mine Gen. Supervisor<br>SHEQ Manager<br>Mine Manager |
| F.2 | Greater than 0.1 mSv in a day<br>Or<br>Greater than 0.4 mSv in a week. | i) The Mine Manager and the RP Supervisor or designates will review the radiation protection aspects of the work practice, and ensure its suitability in light of worker dose targets.<br>ii) Worker dose must be reviewed daily or weekly as appropriate. If indications of a potential dose target excursion, extra preventative measures involving shielding, time and distance shall compensate for potential worker dose target excess. | RP Supervisor<br>Mine Gen. Supervisor<br>SHEQ Manager<br>Mine Manager<br>OH&S Committee<br>General Manager<br>SHEQ Director |
| F.3 | 0.4 mSv per month | i) Same mitigative actions as for B.2 above. | RP Supervisor<br>Mine Gen. Supervisor<br>SHEQ Manager<br>Mine Manager<br>General Manager<br>SHEQ Director<br>CNSC |

NOTES:

- For this purpose, gamma doses are estimated from DRD readings.
- Preventative measures refer to measures that account for time, distance and shielding from radioactive sources. Wherever these measures may not be practical, mitigative actions may also refer to posting.

## Table G Workplace Radon Progeny Levels (WL): Surface Mines

| AdminLevel | Value | Mitigative Action | Notification |
|---|---|---|---|
| G.1 | Greater than 0.03,and up to 0.1 | i) Resample within 24 hours.<br>ii) If level is confirmed by resampling, investigate to determine the cause and undertake mitigative action where reasonably practicable. | RP Supervisor<br>Mine Gen. Supervisor<br>SHEQ Manager |
| G.2 | Greater than 0.1, and up to 0.5 | i) Resample within 24 hours.<br>ii) If level is confirmed by resampling, investigate to determine the cause and implement preventative measures where reasonably practicable.<br>iii) Post an *"Airborne Radiation"* warning sign. | RP Supervisor<br>Mine Gen. Supervisor<br>SHEQ Manager<br>Mine Manager<br>OH&S Committee |
| G.3 | Greater than 0.50 and up to 1 | i) Resample as soon as possible to confirm the reading.<br>ii) If the level is confirmed, designate the workplace as a restricted area with controlled access. Suspend normal operations in the subject workplace until conditions return to less than 0.03 WL.<br>iii) Investigate to determine the cause and implement preventative measures.<br>iv) Post *"Airborne Radiation"* warning sign. | RP Supervisor<br>Mine Gen. Supervisor<br>SHEQ Manager<br>Mine Manager<br>OH&S Committee<br>General Manager<br>SHEQ Director |
| G.4 | Greater than1.00 | i) Resample as soon as possible to confirm the reading.<br>ii) If the level is confirmed, designate the workplace as a restricted area with controlled access. Suspend normal operations in the subject workplace until conditions return to less than 0.03 WL.<br>iii) Investigate to determine the cause and implement preventative measures.<br>iv) Post *"Airborne Radiation"* warning sign. | RP Supervisor<br>Mine Gen. Supervisor<br>SHEQ Manager<br>Mine Manager<br>OH&S Committee<br>General Manager<br>SHEQ Director<br>CNSC |

## Table H Workplace Long-Lived Radioactive Dust Derived Air Concentrations (D.A.C.*): Surface Mines

| Admin. Level | Value | Mitigative Action | Notification |
|---|---|---|---|
| H.1 | Greater than 0.1, and up to 0.3 | i) Resample within 24 hours.<br>ii) If level is confirmed by resampling, investigate to determine the cause and undertake mitigative action where reasonably practicable. | RP Supervisor<br>Mine Gen. Supervisor<br>SHEQ Manager<br>Mine Manager |
| H.2 | Greater than 0.3, and up to 0.6 | i) Resample as soon as possible to confirm reading.<br>ii) If level is confirmed, designate the workplace as a restricted area with controlled access. Suspend normal operations in the subject workplace until conditions return to less than 0.1 DAC.<br>iii) Investigate to determine cause and implement preventative measures.<br>iv) Post “Airborne Radiation” warning signs.<br>v) Work practices, including requirements for use of respirators, to be approved by RP Supervisor. | RP Supervisor<br>Mine Gen. Supervisor<br>SHEQ Manager<br>Mine Manager<br>OH&S Committee<br>General Manager<br>SHEQ Director |
| H.3 | Greater than 0.6 | i) Resample as soon as possible to confirm reading.<br>ii) If level is confirmed, designate the workplace as a restricted area with controlled access. Suspend normal operations in the subject workplace until conditions return to less than 0.1 DAC.<br>iii) Investigate to determine cause and implement preventative measures.<br>iv) Post “Airborne Radiation” warning signs.<br>v) Work practices, including requirements for use of respirators, to be approved by RP Supervisor. | RP Supervisor<br>Mine Gen. Supervisor<br>SHEQ Manager<br>Mine Manager<br>OH&S Committee<br>General Manager<br>SHEQ Director<br>CNSC |

NOTES:

- A Derived Air Concentration (1.0 DAC) is the concentration of a contaminant in the air that would result in an exposure which would reach the regulatory annual dose limit (20 mSv) of intake if continuously exposed for a work year.
- The analysis of the air filters for determining the LLRD levels is conducted after a period of decay in order to remove the contribution from radon progeny and thoron progeny.
- Mitigative action refers to measures that minimize the emission or re-suspension of LLRD.

# Kiggavik Project
# Final Environmental Impact Statement

## Tier 3 Technical Appendix 2Q: Radiation Protection Plan

## Attachment B: Typical Radiation Protection Procedures

**September 2014**

# Attachment B Typical Radiation Protection Procedures

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|---|---|---|
| **Radiation** | 740 | Routine Radiological Monitoring Schedule |
| | 741 | Dosimetry Monitoring Strategy |
| | 742 | Radioactive Contamination Control |
| | 743 | Ventilation Monitoring |
| | 744 | Dose Control for Uranium Milling |
| | 745 | Dose Control for Open Pit Mining |
| | 746 | Dose Control during Transportation of Uranium Concentrates |
| | 747 | ALARA |
| | 748 | Management of Radioisotopes |
| | 749 | Contamination Control for Site Staff |
| | 751 | Radiation Protection Training |
| | 752 | Shipping Radioactive Materials |
| | 753 | Bioassay Sampling for Uranium in Urine |