Kiggavik Project

Environmental Impact Statement

Tier 3 Technical Appendix 2H

Ore Storage Management Plan

December 2011

TABLE OF CONTENTS

LIST OF TABLES

1 INTRODUCTION

The AREVA Resources Canada Inc. (AREVA) Ore Storage Management Plan (Plan) will be in effect for the operating phase of the Kiggavik Project. The Plan is intended to apply to the Kiggavik Project located approximately 80 km west of Baker Lake, Nunavut.

1.1 PURPOSE AND SCOPE

The purpose of the Plan is to provide consolidated information on ore storage management, including strategies for controlling dust, worker doses, and runoff from the Project ore stockpiles.

This document has been prepared at a conceptual level appropriate for inclusion as a component of the Kiggavik Environmental Impact Statement (EIS). Further details are to be developed during the licensing phase.

1.2 RELATED DOCUMENTS

EIS documents containing information relevant to this plan include:

- Tier 2
    - Volume 2 Project Description and Assessment Basis
    - Volume 4 Atmospheric Environment
    - Volume 8 Human Health; and
- Tier 3
    - Technical Appendix 2D Conceptual Design for Ore and Special Waste Pads and Ponds.
    - Technical Appendix 5F Mine Rock Characterization and Management

2 ORE STORAGE FACILITIES AND OPERATIONS

There will be two areas where uranium ore will be stockpiled: the Kiggavik ore stockpile and the Sissons transfer stockpile. The Kiggavik ore will be fed to the mill via an adjacent mill ore stockpile while material from the Sissons transfer pad will be hauled in ore trailers to the Kiggavik stockpile.

2.1 KIGGAVIK ORE STOCKPILE

At the Kiggavik site, the ore pad will be located between the pit area and the mill. Ore from the Kiggavik open pits will be transported to the ore stockpile in haul trucks, while ore from Sissons will be delivered in end-dump ore trailers. Ore will be scanned by an ore truck scanner and stockpiled by source and grade. The design average mill ore feed grade is 0.4% U, however the actual grade of ore delivered by a truck is expected to vary from 0.2% to 0.8%, approximately.

The capacity of the ore pad will be sufficient to stockpile ore produced from different pits by grade without overlapping. In order to maintain the selectivity made during mining, each stockpile on the ore pad must have sufficient separation to avoid mixing of material and safely access each stockpile for loading, hauling, ripping and restacking.

The Kiggavik ore pad is sized to accommodate approximately 1,000 kt of ore, which is equivalent to approximately 650,000 m^3 stockpiled volume. This volume of ore is expected to be reached on the stockpile during the first year of mining prior to mill commissioning. Over the life of the Project the stored tonnage will vary as mining progresses from mine rock zones to ore zones.

Adjacent to the main ore stockpiles will be mill ore stockpiles located near the mill front end and used for daily mill feed and ore blending. The pad will be large enough for accommodate several days production with flexibility to change blends on short notice. The mill ore pad will have one high wall side (2 m) to allow proper mixing of the ore and cleanup. Ore will be moved from the main stockpiles to the mill stockpiles as required. Dedicated loading equipment will be used for blending and millfeed and separate equipment used to move the ore to the mill ore pad.

The design for the ore pad and sedimentation ponds for Kiggavik includes a double liner system with leak detection. Due to the permafrost foundation conditions, the liners will be constructed on a rockfill pad. The minimum thickness of the rock pad will be 1.5 m.

Typically the double liner system for the ore pad will be installed on the surface of the pad. The liner will be covered with a prepared soil layer and surfaced with a coarse granular material to protect the liner from vehicular traffic. The pad will be surrounded by a perimeter ditch designed to contain any water reporting to the pad and general grading will be designed to drain into the sedimentation ponds. Both the pad and the perimeter ditch will meet existing Construction Guidelines for Pollution Control Facilities at Uranium Mining and Milling Operations (SERM, 2000).

If economic cut-off grades are lowered or the mill experiences an unanticipated slow-down, it is possible that the ore pad may be insufficient to accommodate the ore produced. In this case, the ore mining rate will be reduced to below the milling rate. If during mining of East Zone, it is evident that ore pad capacity will be exceeded, an area within the Type 3 mine rock pad will be designated for low grade ore, and the ore will be temporarily stored in the designated area. Management and mitigation measures, as described in Section 4, would apply to the temporary storage area.

Due to the extensive liner system underneath the Kiggavik ore pad, it is unlikely that sections of the ore pad will be progressively reclaimed. The ore pad will be fully decommissioned during final Kiggavik site decommissioning. Any contaminated materials and fill will be placed in the Main Zone TMF and covered.

2.2 SISSONS SITE

Ore mined at the Sissons site will be hauled to Kiggavik for milling. Two transfer pads are proposed at the Sissons site for temporary storage prior to hauling; one pad is located near the End Grid decline, while the other will be north of the Andrew Lake pit. The pads will be designed to safely stockpile 500 t of ore, approximately. Design features of the Sissons pad and collection pond will be identical to that of the Kiggavik stockpile (Section 2.1).

Activities at the Sissons stockpiles will include haul truck dumping, ripping, re-stacking, and loading ore trailers. If economic cut-off grades are lowered or the rate of haulage to Kiggavik is reduced (e.g. due to severe weather) it might be necessary to increase the size of the transfer pad. Alternatively the ore mining rate may be temporarily reduced until sufficient stockpile capacity is available.

Progressive reclamation of ore pad and drainage structures will be implemented where possible. It is likely that the ore pad near the Andrew Lake pit will be decommissioned following completion of mining in the pit. Any contaminated materials and fill will be placed in the mined-out pit and covered

3 ORE CHARACTERIZATION

Typical chemical assays for ore from each deposit are shown in Table 3.1-1. These assays indicate that the Kiggavik and Sissons deposits tend to be primarily U-bearing, with fewer impurities than ores typically found in the Athabasca Basin.

Table 3.1-1 Typical Ore Assays

Analyte	Units	Typical Assay Average				
		Main Zone	Centre Zone	East Zone	Andrew Lake	End Grid
U	ppm	4,570	5,683	744	4,625	2390.6
As	ppm	2.2	20.4	3.0	7.1	19.4
Cd	ppm	1.0	1.4	1.0	1.0	1.1
Co	ppm	16.8	16.4	8.5	7.1	15.8
Cr	ppm	64.0	179.7	53.6	444.7	133.4
Cu	ppm	38.1	63.5	6.1	13.7	115.9
Mo	ppm	113.5	9.6	1.9	19.7	19.5
Ni	ppm	47.3	69.7	18.9	73.4	80.5
Pb	ppm	199.8	226.8	47.5	184.5	114.5
Se	ppm	3.0	0.2	1.5	1.2	12.7
V	ppm	484.4	410.0	233.1	526.5	230.8
Zn	ppm	26.8	86.6	29.1	20.9	46.3
SiO_2	% (w/w)	NA	NA	NA	64.4	63.1
Al_2O_3	% (w/w)	17.4	19.3	18.0	17.1	18
Fe_2O_3	% (w/w)	2.6	3.7	6.7	4.0	5.9
MgO	% (w/w)	3.3	2.9	1.3	2.4	3.1
CaO	% (w/w)	0.4	1.1	0.1	0.4	0.5

NA: not assayed

Mineralogical studies indicate that the primary phases include quartz (SiO_2), microcline ($KAlSi_3O_8$), illite ($(K,H_3O)(Al,Mg,Fe)_2(Si,Al)_4O_{10}[(OH)_2,(H_2O)]$), and chlorite ($(Mg,Fe)_3(Si,Al)_4O_{10}(OH)_2.(Mg,Fe)_3(OH)_6$) with possible trace amounts of hematite (Fe_2O_3).

The most common uranium-bearing minerals are pitchblende ($[U^{+4}_{1-x},U^{+6}_{x}]O_{2+x}$) and coffinite ($U(SiO_4)_{1-x}(OH)_{4x}$) with minor amounts of uranophane ($Ca(UO_2)_2(SiO_3)_2(OH)_2.5H_2O$) and autunite ($Ca(UO_2)_2(PO_4)_2.10\text{-}12H_2O$).

Typical sulphur content is similar to that of Type 3 mine rock (see Technical Appendix 5F), ranging from <0.1% S to 1.0% S. This material has some potential for acid generation and metals leaching. All drainage from the stockpile will be contained and treated.

4 ORE STOCKPILE MANAGEMENT PRACTICES

4.1 THERMAL AND STABILITY CONSIDERATIONS

Protection of permafrost and considerations for thaw-induced differential settlement of foundations have been included in the conceptual design of the pads (see Technical Appendix 2D). Therefore, it is not expected that the stockpile will influence the thermal conditions of the surrounding ground.

Conservative assumptions regarding the thermal condition of the piles have been used. Operationally, it has been assumed that the stockpiles will freeze and therefore ripping activities will be required. In terms of the stability analysis, it has been assumed that the pile will not freeze since thawed material generally has less strength. In actuality, it is expected that the thermal condition of the stockpile will vary seasonally and based on the duration of stockpiling.

4.2 DRAINAGE MANAGEMENT

All drainage from the ore pads will be collected and either treated or, at Kiggavik, recycled for use in the mill. Since the stockpiles are placed on lined pads, drainage will result from direct rainfall and snowfall only. Management of drainage from the ore pad does not rely on permafrost encapsulation and, for the purposes of the water balance, it has been conservatively assumed that the pile will not freeze or otherwise store water. Therefore potential future climate change is not expected to affect stockpile drainage management. The collection ditches and ponds have been designed to contain drainage during a Probably Maximum Precipitation (PMP) event.

Predicted average ore stockpile runoff quantities are shown in Table 4.2-1.

Table 4.2-1 Predicted Average Ore Stockpile Runoff

Month	Kiggavik Ore Stockpile (m^3)	Andrew Lake Ore Stockpile (m^3)	End Grid Ore Stockpile (m^3)
January	8	2	1
February	8	2	1
March	0	0	0
April	47	11	3
May	582	142	45
June	9,249	2,212	693
July	4,797	1,127	353
August	2,484	572	179
September	2,119	479	150
October	621	140	44
November	23	5	2
December	8	2	1
Annual Total	**19,946**	**4,695**	**1,470**

During operation of the mill, drainage from the Kiggavik ore stockpile will be recycled, where possible, to the mill via the purpose-built-pit (PBP) for use as process water. Any drainage not recycled will be treated in the Kiggavik Water Treatment Plant. Prior to mill commissioning, drainage will be treated in the water treatment plant prior to discharge. The mill terrace will be graded towards the Kiggavik open pits, such that contingency storage within the pits is available in case of liner or pond failure.

Drainage from the Andrew Lake and End Grid ore stockpiles will be treated in the Sissons Water Treatment Plant.

Predicted quality of the collected drainage is shown in Table 4.2-2. Actual drainage quality will be dependent on the amount of ore contained on the pad, the amount of precipitation, and the extent of infiltration through the stockpile. The quality has been estimated based on leach tests of high grade Type 3 mine rock samples (see Technical Appendix 5F) and bench-marking against the McClean Lake Operation. For each constituent of potential concern the highest concentration available from these two sources was taken as a conservative estimate.

Table 4.2-2 Predicted Average Ore Stockpile Drainage Quality

Parameter	Units	Predicted Value
Aluminum	mg/L	0.180
Ammonia (As N)	mg/L	8.700
Antimony	mg/L	0.002
Arsenic	mg/L	9.600
Barium	mg/L	0.026
Cadmium	mg/L	0.006
Calcium	mg/L	85.5
Chloride	mg/L	32.1
Cobalt	mg/L	0.098
Copper	mg/L	0.137
Iron	mg/L	0.870
Lead	mg/L	0.046
Magnesium	mg/L	9.973
Manganese	mg/L	1.300
Molybdenum	mg/L	0.499
Nickel	mg/L	0.359
pH	-	8.000
Potassium	mg/L	11.030
Radium-226	Bq/L	6.575
Selenium	mg/L	0.240
Sodium	mg/L	14.243
Sulfate	mg/L	409.2
Uranium	mg/L	9.440
Vanadium	mg/L	0.002
Zinc	mg/L	0.230

4.3 DUST MANAGEMENT

The primary mechanism for dust generation from the stockpiles will be vehicular traffic and material handling. Potential environmental effects from dust are presented in Volume 4. Operational practices, such as dust suppression, minimizing the amount of vehicle traffic and minimizing re-handling in ore stockpiles will assist in reduction of dust.

Dust generation from the ore pads will be monitored. Proposed dust suppression consists of water spray; however, approved chemical dust suppressants may be applied if dusting is higher than anticipated.

AREVA is committed to implementing a Dust Management follow-up program. This program will include monitoring of dust levels and pilot testing various dust suppressants for efficacy, cost, potential interaction with the mill process and potential environmental effects. The pilot program will be initiated at AREVA's McClean Lake Operation in advance of Kiggavik commissioning.

4.4 ORE ACCOUNTING

A metallurgical accounting system will be in place to track uranium mined, milled, and shipped. Ore accounting will include predictions of ore tonnages based on short-term mine planning and probing, measurement of ore tonnage and grade by the overhead scanners, and regular surveys of the stockpile. Ore fed to the mill will be measured by weightometers within the Crushing and Grinding circuit.

4.5 RADIATION PROTECTION

Workers using heavy equipment, such as loaders and dozers, will be involved in ripping and blending activities on the ore pad as well as feeding ore to the mill. A number of radiation protection measures will be implemented to minimize worker exposures, as follows.

Protection from External Hazards

The control of worker exposure to external gamma radiation is achieved primarily through design features of heavy equipment and operational practices, and includes time, distance and shielding.

- The intrinsic shielding provided by the equipment itself will reduce gamma radiation levels to the operator while working in the cab
- Additional shielding in the form of lead may be added to the equipment as required, ie. a sheet of lead added under the floor of the dozer to reduce gamma rays from the ore stockpile floor.
- Time spent outside vehicles will be minimized
- Wherever possible, the worker and sources of external gamma radiation are distanced from each other, ie. the blending pile should be positioned away from the high grade ore stockpile.

Protection from Internal Hazards

The control of worker exposure to radon and radon progeny, and long lived radioactive dust is achieved primarily through design features and operational practices and includes containment, ventilation and housekeeping.

- Dust suppression with water may be required at certain times of the year to minimize radon and particle migration;
- Windows of mining equipment will be kept closed and positive pressure ventilation systems will be utilized in vehicle cabs;
- Air filtration devices and weather stripping in vehicles will be maintained in good order; and
- Interiors of vehicles will be cleaned frequently.

<u>Worker Awareness</u>

- A detailed radiological Code of Practice will limit worker radiation exposures
- Daily radiation monitoring by the Radiation Department with results posted and available to workers
- Radiation Protection will monitor and provide advice for specific jobs as required
- Mill feed/Loader workers will wear direct reading dosimeters that will allow them to monitor their accumulated gamma dose throughout the shift
- Radiation protection training will be given to all radiation workers with additional training to supervisors
- A complete and comprehensive radiation dosimetry service will be provided for all radiation workers
- Reporting of quarterly and annual individual worker radiation doses to the workers, management and the regulatory agencies

Mill Supervision will organize work in a manner that minimizes worker radiation exposures based on the following procedures:

- Meetings will be held with supervision and radiation protection to review worker doses with respect to past and upcoming work;
- Worker doses, estimated by direct reading dosimeters, will be recorded and reviewed by supervision and radiation protection staff daily;
- Non routine activities will be identified, an assessment of protection dose conducted an a safe work permit issued, as required. (The safe work permit describes any constraints, and specialized equipment or procedures required for the non-routine activity.

The primary source of exposure to workers will be from external gamma radiation. Predicted doses to the Mill Feed/ Loader operators are summarized in Table 4.5-1 and presented in detail in Volume 8.

Table 4.5-1 Predicted Doses to the Mill Feed / Loader Operators

	Gamma	Radon Progeny	Long Lived Radioactive Dust	Total Effective Dose
Average Dose (mSv/a)	0.71	0.3	0.18	1.19
Maximum Dose (mSv/a)	2.65	0.61	0.30	3.56

4.6 OCCUPATIONAL HEALTH AND SAFETY

The primary hazards associated with ore stockpiles are traffic-related. The stockpiles will have haul truck, ore trailer, loader, and grader activities on-going for much of the life of the Project. Surveyors, radiation protection, safety and environment personnel will also access the area periodically. Therefore, traffic management will be key to ensuring a safe work environment on the stockpiles. Safety practices will include:

- Radio contact upon entering stockpile area
- No non-necessary personnel in the area during haulage campaigns from the Sissons site
- Specific training module for those employees required to access the stockpile area
- Sign posting and lighting

5 ALTERNATIVES

Alternative locations for the ore stockpiles were considered during the planning of the site layouts. The proposed locations were chosen based on operational considerations and to minimize worker exposures.

Alternative methodologies for ore stockpiling are limited. The need for an in-pit tailings management facility (TMF) drives the need for a larger ore stockpile during the first year of mining as the ore from the first TMF must be removed prior to mill commissioning. TMF alternatives are assessed in more detail in Technical Appendix 2A. Alternatives considered include:

- An above ground TMF. However, above-ground tailings facilities were deemed to have greater potential for long-term effects on the environment and a greater risk of long-term liability.

- A temporary above-ground TMF whereby tailings are stored above-ground until an in-pit TMF is available. This would allow the mill to begin commissioning as soon as the first ore is mined and reduce the ultimate size of the stockpile. However, operational difficulties and issues with re-handling tailings were considered flaws in this alternative.

- A purpose-built pit used as an initial TMF. This would allow the mill to begin commissioning as soon as the first ore is mined and reduce the ultimate size of the stockpile. However, it is considered better practice to place tailings back into a mined-out open pit.

6 REFERENCES

6.1 LITERATURE CITED

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