DECOMMISSIONING OF A FORMER URANIUM MINE AND MILL IN NORTHERN SASKATCHEWAN, CANADA

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ABSTRACT

The Cluff Lake Project is a former uranium mine and mill in northern Saskatchewan, Canada. Over 60 million pounds of uranium concentrate were produced in just over twenty years of operation, ending in 2002. The Project is owned and operated by AREVA Resources Canada Inc., part of the AREVA Group, the world leader in nuclear energy development, and increasingly, a provider of other forms of electricity generation systems with low CO_2 emissions. During operation, the facilities at the Cluff Lake Project included open-pit and underground mines, a mill, a tailings management area (TMA) with a two-stage liquid effluent treatment system, a residential camp area and various other support and site infrastructure facilities.

Decommissioning when operations have concluded is both an AREVA Group corporate commitment and a regulatory requirement. The purpose is to conduct all necessary activities including the removal or stabilization of all constructed structures and the reclamation of disturbed areas to meet the following objectives:

- Environment is safe for non-human biota and human use;
- Long-term adverse effects are minimized;
- Reclaimed landscape is self-sustaining; and,
- Restrictions on future land use are minimized.

In addition, any restrictions on land use should not prevent traditional land use including casual access for trapping, hunting, and fishing as the primary site activities.

The Cluff Lake decommissioning project has four major stages which include planning, physical decommissioning activities, post-decommissioning and follow-up monitoring, and transfer of the site to the Provincial Institutional Control Program (ICP).

1. INTRODUCTION

The Cluff Lake Project is a former uranium mine and mill facility located in the northern part of the Province of Saskatchewan, Canada. AREVA Resources Canada Inc. (AREVA) is the sole owner and operator of the Cluff Lake Project. The company, with it's head office in Saskatoon, Saskatchewan, is part of the AREVA Group. The AREVA Group, headquartered in France, is the world leader in nuclear energy development and, increasingly, a provider of other forms of electricity generation systems with low CO_2 emissions.

In addition to the Cluff Lake Project, AREVA is the majority owner and operator of the McClean Lake Operation and Midwest Project in northern Saskatchewan, and the Kiggavik and Shea Creek exploration projects. The Kiggavik Project is a proposed uranium mining project in Nunavut, Canada, and the Shea Creek Project is an advanced exploration project near Cluff Lake. AREVA also has significant minority

ownership in the McArthur River, Key Lake and Cigar Lake projects, all located in the Athabasca Basin of northern Saskatchewan, and an active uranium exploration program. The Athabasca Basin, and the project locations, is shown in Figure 1.

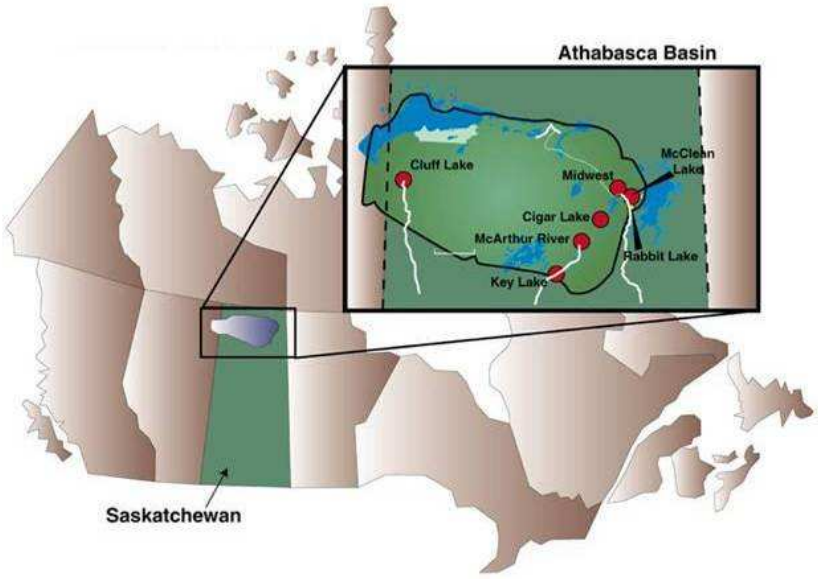

Figure 1. Location of the Cluff Lake Project within the Athabasca Basin of northwestern Saskatchewan.

The Athabasca Basin is a sandstone formation about 400 km in the east-west direction and 200 km in the north-south direction. The sandstone overlies the Pre-Cambrian basement rock, with a sandstone thickness of about 1200 m in the center and becoming progressively shallower towards the perimeter. The sandstone is covered by shallow glacial till deposits. Uranium ore bodies are found at, or near, the unconformity interface between the sandstone and the basement rock.

The region is part of the Canadian Shield, characterized by boreal forest, rock outcrops, and shallow lakes and streams. The Project is served by an all weather road from the south. It is about 200 km to the nearest community and 900 km by road to Saskatoon. The site also has an airstrip for transport of staff.

The Cluff Lake Project is located in a unique geological phenomenon known as the Carswell Structure, a circular upheaval of metamorphic rock that thrust to the surface of the earth some 400 million years ago, possibly the result of a meteorite impact. This zone, some 40 km in diameter, contained commercially viable veins of uranium mineralization on its margins or near the faulted contact with the Athabasca sandstone.

The Cluff Lake orebodies were first discovered in the mid 1960s. Mining activity commenced in 1980 and ceased in 2002. During its 22 years of operation the Cluff Lake Project produced 62 million pounds of U_3O_8. During operation the facilities included open-pit and underground mines, a mill, a tailings management area with a two-stage liquid effluent treatment system, a residential camp area and various other support and site infrastructure facilities. Figure 2 provides an overview of the site during operation. It can be seen that decommissioning planning could be developed by the division of the site into the following four major areas: TMA, mining area, mill area and residential camp area.

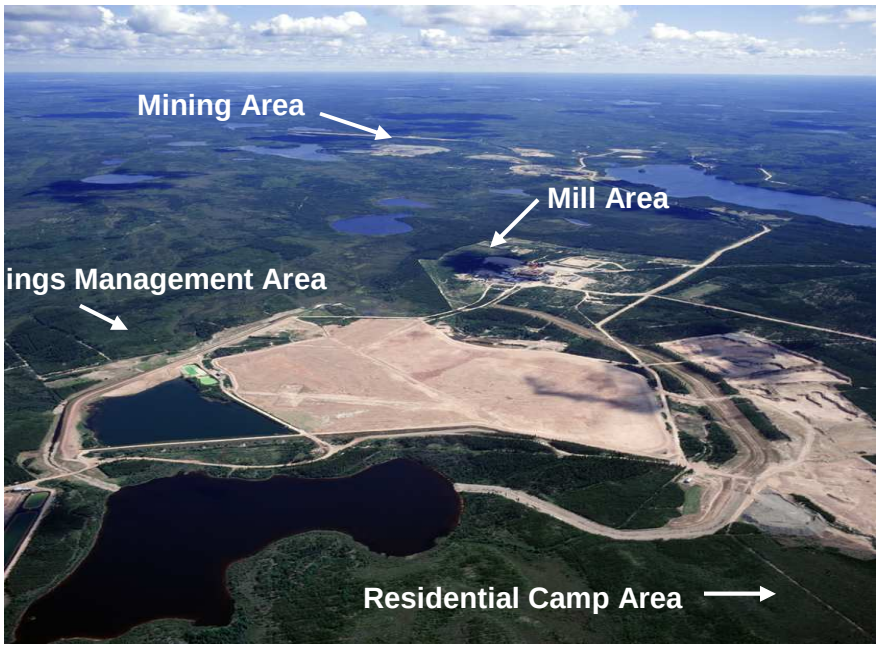

Figure 2. Aerial view of the Cluff Lake Project in 1999 during operations showing the four major areas of the site.

2. FOUR MAJOR STAGES OF THE PROJECT

The Cluff Lake decommissioning project has four major stages which include planning, physical decommissioning activities, post-decommissioning and follow-up monitoring, and transfer of the site to the Provincial Institutional Control Program (ICP). Each of these stages is outlined below.

2.1 Planning

Decommissioning when operations have concluded is both an AREVA Group corporate commitment and a regulatory requirement. The purpose is to conduct all necessary activities including the removal or stabilization of all constructed structures, and the reclamation of disturbed areas, to meet the following objectives:

- environment is safe for humans and non-human biota;
- long-term adverse effects are minimized;
- reclaimed landscape is stable and self-sustaining; and,
- restrictions on future land use are minimized.

These objectives will allow the traditional uses of hunting, fishing and trapping to be safely undertaken at the site. The decommissioning project is also designed to minimize the need for long term maintenance and monitoring through institutional control.

The starting point for detailed decommissioning planning was the preliminary decommissioning plan approved by the Canadian Nuclear Safety Commission (CNSC) and Saskatchewan Ministry of the Environment (SMOE) as the basis for the financial assurance provided by AREVA for the Cluff Lake Project. A preliminary decommissioning plan and financial assurance are a condition of the operating license for all Canadian uranium mines. The financial assurance, in the form of an irrevocable letter of

credit for 33.6 M$ held by the Province, assures the availability of funds for future decommissioning, should the operator (in this case AREVA) not meet their obligations.

Detailed decommissioning planning was initiated through a project description submitted by AREVA in 1999, prior to the end of operations. This triggered an environmental assessment, specifically a Comprehensive Study Report (CSR), under the Canadian Environmental Assessment Act (CEAA).

The Cluff Lake decommissioning plan as presented in the CSR was subjected to intensive review and discussion through a five year assessment under CEAA.

Key reviewers included:

- Federal Regulatory Agencies including the Canadian Nuclear Safety Commission (the Responsible Authority under CEAA), Environment Canada, Natural Resources Canada, Health Canada, Fisheries and Oceans Canada and the Canadian Environmental Assessment Agency
- Several Provincial Regulatory Agencies coordinated by Saskatchewan Ministry of Environment
- Community interest groups
- Members of the public

Several alternative methods were considered for the decommissioning of each of the major areas. The preferred options presented in the CSR were to construct soil covers to reduce water infiltration on the TMA and Claude Waste Rock Pile which has acid generating properties, and flood two open pits and two underground mines. The mill and associated infrastructure would be demolished and disposed within a backfilled pit.

One of the key objectives of the Cluff Lake decommissioning plan was to protect the quality of surface water into the future. It was proposed that success of the decommissioning would be judged by comparison to pre-agreed objectives for water and sediment quality. Surface water will meet Saskatchewan Surface Water Quality Objectives (SSWQO) with exception of iron which is naturally elevated in the groundwater fed lakes of the area. At the time of CSR writing, there were no SSWQOs for uranium, molybdenum or cobalt; therefore, site specific criteria were agreed upon based on scientific literature. A series of benchmarks for sediment quality were considered as well as pertinent information available in the scientific literature. Additionally, radiological clearance criteria have been developed which are protective of the public and ensure the safe traditional use of the area after decommissioning.

For the CSR extensive hydrogeological modelling was conducted to select the most appropriate environmental options. This included the development of a regional groundwater flow model, extensive waste rock sampling and testing, tailings characterization and contaminant transport modelling. Modelling offered a methodology to quantitatively compare the principal alternatives for each area and provided an opportunity to assess and minimize the key sources of potential environmental impact. Environmental effects were compared through the use of ecological risk assessment techniques. This assessment included risk to biota as well as to humans taking into consideration the predicted post-decommissioning use patterns. In summary, the study indicated potential risks to some aquatic species in Island Lake (the first lake to receive treated effluent) as a result of sediment accumulations of copper, molybdenum and uranium. This is no surprise as Island Lake has been the immediate downstream receptor for discharged effluent throughout the twenty two years of operation. The current biological status of Island Lake represents an altered, but functioning, aquatic community which will only improve as decommissioning proceeds since effluent discharge has ceased. Modelling indicates the risks will be eliminated within 10 to 50 years of final decommissioning.

For terrestrial animals, the analysis quantified the risk to wildlife from drinking water, foraging for food, and ingesting soil/sediment. Potential risk was identified for muskrat, otter, waterfowl and moose in Island Lake area from molybdenum, uranium and, to a lesser extent, selenium. As for aquatic species, these risks quickly decrease after decommissioning.

There were no risks predicted for humans living in the area after decommissioning.

Upon completion of the CSR, the CNSC forwarded the report to the Federal Minister of the Environment for further public consultation and a decision. In early 2004, the Minister approved the project to proceed, with conditions, on the basis that the project, with appropriate mitigation measures would not cause significant adverse environmental effects. Upon completion of the environmental assessment process, licensing of decommissioning activities could proceed.

The planning stage was concluded in mid-2004 with the issuance of a decommissioning license by the CNSC and approval of the detailed decommissioning plan by SMOE. The top tier licensing document is the Detailed Decommissioning Plan. It describes the project design and how it reflects the objectives in the CSR, and AREVA's commitments. It is supported by lower tier documents such as detailed work packages.

2.2 Physical Decommissioning Activities

Decommissioning activities at the Cluff Lake Project commenced immediately after the decommissioning license was issued in 2004. The majority of the physical decommissioning work was completed by September of 2006. These activities were performed in accordance with the top level regulatory document, the Detailed Decommissioning Plan (DDP) and, as required, were performed in accordance with detailed work packages approved by the regulators. Detailed work packages were prepared to describe the design and physical activities to be performed for final decommissioning of the Claude Mining area (including backfill of the Claude Pit and the re-slope and cover of the Claude Waste Rock Pile), the Dominique Janine (DJ) Mining area, cover of the Tailings Management Area (TMA), the demolition of the Mill area and the Ancillary Facilities. These work plans also described QA/QC, health and safety, radiation protection, and environmental protection activities associated with specific decommissioning activities.

Figure 3 illustrates decommissioning of the area associated with open pit mining of the Claude ore body. The mined out pit was used for disposal of waste rock from the two underground mines, and for disposal of contaminated materials from site operations. Figure 3 shows the partially backfilled pit prior to decommissioning. The main decommissioning activities were to complete backfilling of the Claude pit with waste rock and the mill demolition wastes, re-slope the waste rock pile for long term stability, cover the pit and pile with a minimum 1 m thick till cover, and finally, revegetate. Native grasses and legumes were seeded to quickly provide erosion resistance for the waste rock pile, while native trees were planted on the cover of the backfilled pit.

Figure 3. Mining area with Claude pit and Claude Waste Rock Pile in 1999 (top panel) during operations and in 2008 (bottom panel) after physical decommissioning.

The DJ mining area consisted of two open pits and an underground mine. The first open pit resulted in an adjacent waste rock pile, while most of the waste rock from the second open pit was used to back fill the first one. The main decommissioning activities were to relocate the waste rock pile and the upper portion of the waste rock in the backfilled pit to Claude pit, to seal the underground mine access, and to revegetate by planting native trees. The underground mine will gradually flood; the open pits were flooded by pumping from nearby Cluff Lake. A second underground mine in another area was also sealed and will flood naturally.

Mill dismantling took place over two summer periods with disposal of the wastes during backfilling of Claude pit. The area was then planted with native trees.

Figure 4 illustrates decommissioning of the TMA. The operational TMA consisted of two areas for deposition of thickened tailings slurry, an area for decanting tailings water, and a two stage water treatment plant with a liquids storage pond between stages. The main decommissioning activities were installation of a till cover over the tailings, dismantling of the first stage water treatment plant and backfilling of the liquids pond, and buttressing the main dam for long term stability. The area, of approximately 70 hectares, was then seeded with a native grass and legume mixture.

The D ore body was the first ore body to be mined at the Cluff Lake Project. Open pit mining of the D ore body resulted in the creation of D Pit and its associated waste rock pile. D Pit has been flooded for 28 years and the surrounding area has been revegetated.

A number of previously disturbed areas such as unused roads and borrow pits were planted with native tree seedlings. A total of 800,000 tree seedlings have been planted at the Cluff Lake Project to aid and accelerate natural revegetation of the site.

Currently at the Cluff Lake Project, a portion of the Germaine Camp and associated infrastructure (power generation, domestic water and sewage systems, and maintenance equipment) remains to support a small number of AREVA personnel. These personnel perform minor maintenance activities in support of the physical work, complete a small amount of outstanding decommissioning work and carry out field activities required for either compliance with the routine environmental monitoring program or the Follow-up Program. A geology/exploration crew, currently performing exploration activities at the West Athabasca joint venture property (Shea Creek) is also housed at the camp during the summer months. Also remaining in standby, at the TMA is the Secondary Treatment System (STS) water treatment plant which has been left as a contingency radium treatment plant (Figure 4). Remaining ancillary facilities include some roads and the airstrip.

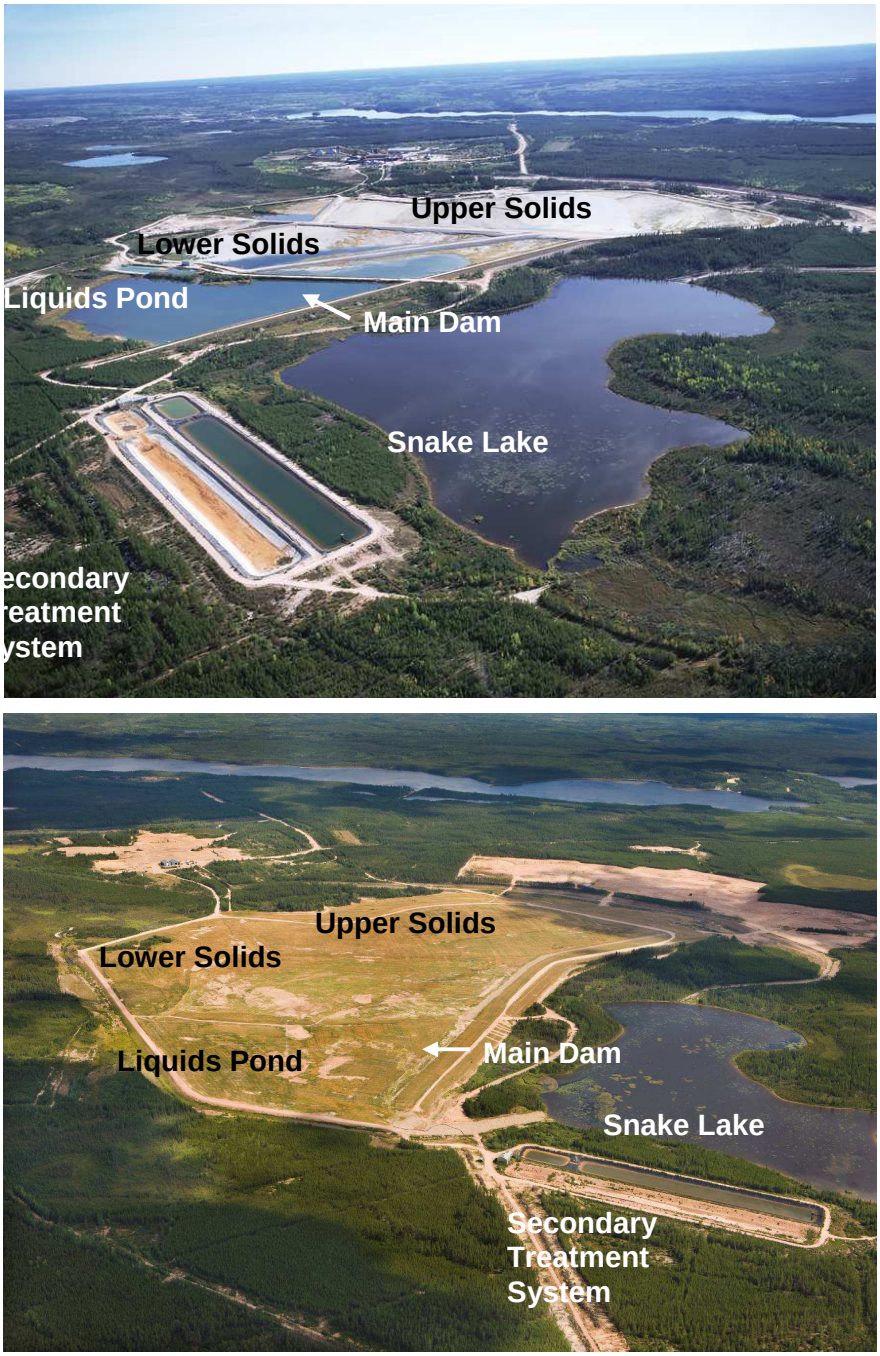

Figure 4. Tailings Management Area in 1999 (top panel) during operations and in 2008 (bottom panel) after physical decommissioning.

Worker doses to radiation continued to be monitored throughout the decommissioning process. A plot of yearly worker average effective doses is illustrated in Figure 5.

As anticipated, worker doses from all components have dropped significantly as decommissioning and reclamation work has progressed. The average total effective dose in 2004 was 0.15 mSv compared to

0.002 mSv in 2010. By comparison, the average total effective dose in 2000 (during operations) was 2.12 mSv.

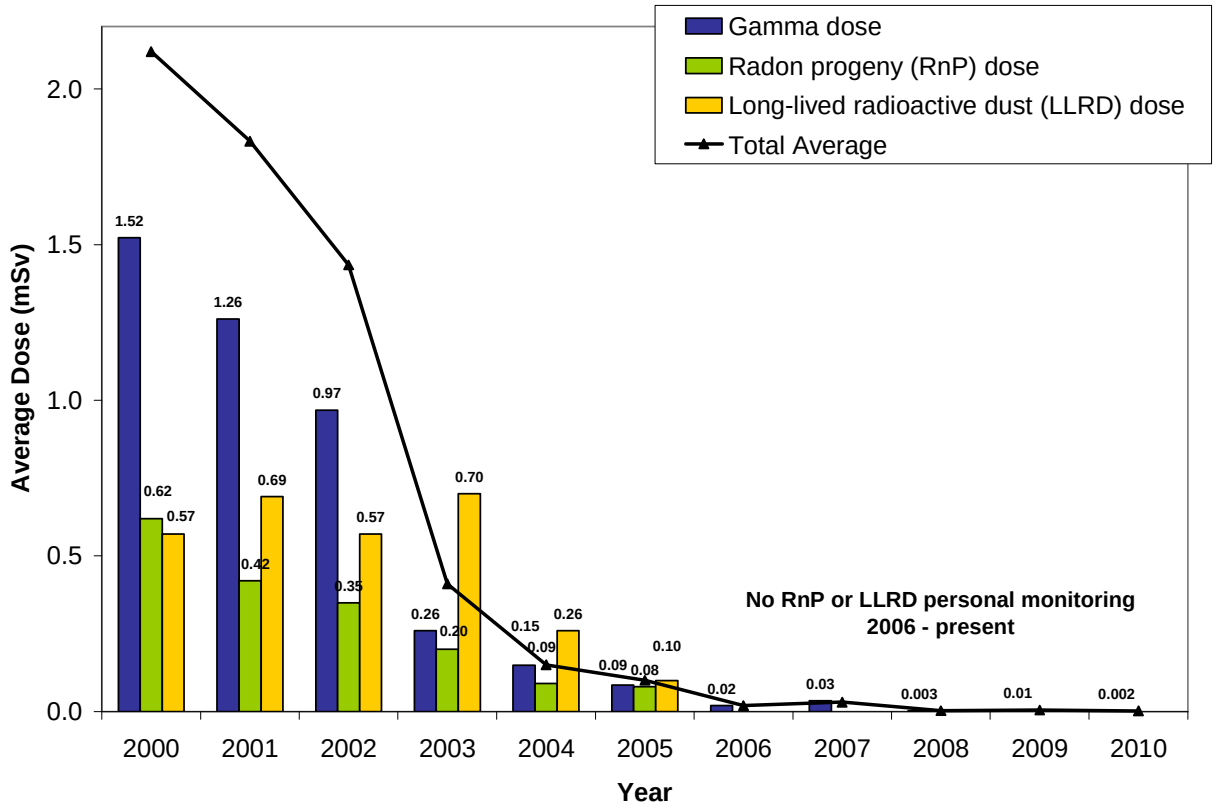

Figure 5. Yearly summary of worker dose by radiation component.

Since the commencement of decommissioning in 2004, worker doses from radiation have dropped to near background levels, well below the 1 mSv/a dose limit for members of the public. Individual gamma dosimetry has been continued, to demonstrate that doses remain well below the 1 mSv/a dose limit for members of the public and for workers carrying out their duties at the site over the course of a year.

2.3 Post-decommissioning Monitoring and Follow-up Program

AREVA has implemented an Environmental Management System (EMS) at Cluff Lake that is certified to the ISO 14001 standard and draws from the experience gained while implementing the EMS program at AREVA's McClean Lake Operation. The EMS is designed to meet the requirements of the CNSC, SMOE and ISO 14001, as well as internal requirements.

Monitoring data collected over the coming years will form the basis from which to evaluate the success of the decommissioning work, and to determine if further measures are required or if transfer to the Province can be considered.

2.3.1 Routine monitoring

The Cluff Lake Project collects and analyzes samples for compliance monitoring on a routine ongoing basis. The key components of the routine environmental monitoring program are:

- Air quality and meteorological monitoring;

- Surface water, groundwater, minewater monitoring;
- Soil cover monitoring to determine water infiltration through the soil covers;
- Lake sediment, water quality, limnology, benthic invertebrates, fish;
- Soil and lichen sampling; and,
- Sanitary sewage works and potable water monitoring.

Results of routine monitoring are reported to federal and provincial regulators in annual reports. There is also a regulatory requirement to compile a comprehensive Status of the Environment report every five years.

2.3.2 Follow-up program monitoring

As a result of technical uncertainties arising from the review of the Comprehensive Study Report, AREVA was required to develop a Follow-up Program to conduct specific additional studies. These studies are focused on developing and validating mathematical models for potential long term contaminant transport by natural processes, and demonstrating long term environmental protection at the decommissioned site. They encompass four areas:

- Performance of the cover at the Claude Waste Rock Pile and long term groundwater contaminant transport performance for the mining area
- Performance of the cover at the TMA, and long term groundwater contaminant transport for the TMA area
- Long term contaminant transport performance at the Island Lake sediments and downstream fen. Island Lake was the receiving water body for treated effluent discharge during mining and milling operations. A fen is located immediately downstream of the lake. Surface water sampling results and mass balance calculations show that the lake sediments and fen acted as a sink for contaminants present in the treated effluent, including uranium, molybdenum and selenium
- Integration of these studies to assess future quality of surface water bodies, terrestrial environment, aquatic biota and terrestrial wildlife through ecological risk assessment to determine if the predicted risks were appropriate.

Future work includes continuation of post-closure monitoring to assess soil cover performance, confirm long-term groundwater and surface water protection and demonstrate physical stability of decommissioned landforms.

2.3.3 Radiological clearance program

Various areas at the Cluff Lake Project have been affected, or potentially affected, by transporting, handling or storing uranium ore or other radioactive materials during operational activities. Once areas with elevated radioactivity have been remediated, re-graded, and revegetated, there is low potential for future disturbance or transport of contaminated material by means such as wind or water.

A formal radiological clearance program is underway for these areas. Comprehensive gamma radiation surveys of previous operational areas have been conducted by AREVA, and a third party verification of the results contracted by the CNSC. After some further analyses of the data, and further consultation with groups representing potential future users of the site for traditional purposes, a final report will be prepared.

2.4 Return of the Cluff Lake Site to the Province

AREVA has a lease from the Province of Saskatchewan for the Cluff Lake site; site activities are regulated through the CNSC decommissioning license and SMOE decommissioning approval. This arrangement will continue until AREVA has advanced the monitoring program to the point where application can be made to enter the site into the ICP for the long-term management of decommissioned mine and mill sites on Crown land. The ICP framework ensures the health, safety, and well-being of future generations, provides certainty and closure for the mining industry, and recognizes obligations by the province, and national and international obligations for the storage of radioactive materials. It is implemented through the provincial Reclaimed Industrial Sites Act and accompanying Regulations.

The two primary components of the ICP are:

- The Institutional Control Registry and
- The Institutional Control Funds, specifically the Monitoring and Maintenance Fund and the Unforeseen Events Fund.

The Registry will maintain a formal record of closed sites, manage the funding, and perform any required monitoring and maintenance work. In the case of a decommissioned uranium mining and milling site, it will reference the related CNSC documentation and decisions. The Monitoring and Maintenance Fund will pay for long-term monitoring and maintenance and the Unforeseen Events Fund will pay for unforeseen future events including damage resulting from floods, tornadoes, and earthquakes. In order to enter the site into the ICP, AREVA will need to demonstrate that the decommissioning objectives have been met through information submitted to the Registry and provide the required funding amounts to the Institutional Control Funds.

3. CONCLUSIONS

AREVA's Cluff Lake Project had a successful operating life of over 20 years. Decommissioning has now advanced to carrying out extensive environmental monitoring and follow-up programs to assess the outcome of the physical decommissioning activities.

Monitoring of air, surface water, groundwater, sediment, benthic invertebrates, fish, soil and vegetation will continue through decommissioning, similar to the operational period, to ensure that environmental compliance is maintained. In addition to the regular compliance monitoring program, results from the Follow-Up Program studies will be used to assess the validity of the assumptions used in the planning and ensure the mitigative measures are performing as designed. In the event that the mitigation is not having the desired effect, AREVA will be responsible for further action to achieve the decommissioning objectives.

In the event that the monitoring indicates the site is performing effectively and observed trends support modelling predictions, AREVA will file an application for abandonment which will require a new Environmental Assessment. Return of the site to the Province, through the Institutional Control Program, represents the final end point for the successful decommissioning of the Cluff Lake Project.