

DECOMMISSIONING OF THE CLUFF LAKE URANIUM MINE, SASKATCHEWAN, CANADA

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Abstract

The Cluff Lake uranium mine and mill are located in the Athabasca Basin of northern Saskatchewan, approximately 900 km north of Saskatoon, Saskatchewan. Uranium mining and milling operations commenced in 1980 and ceased at the site in 2002 after more than 20 years of production. During operation, facilities included open pit and underground mines, a mill, a tailings management area, a residential camp, and various other support infrastructure. In the time since the completion of mining and milling at Cluff Lake, AREVA Resources Canada Inc. (AREVA) has focused on decommissioning activities at the site.

A decommissioning license was granted by the Canadian Nuclear Safety Commission (CNSC) in 2004 and the majority of the physical decommissioning then occurred between 2004 and 2006. This work included mill demolition, decommissioning of the open pits, and covering of the waste rock pile and tailings management area. From 2006 to 2013, personnel remained on site for post-decommissioning activities and follow-up monitoring. The Cluff Lake Project reached a milestone in 2013, when the remainder of site clean-up work was completed, a permanent site presence was discontinued, and the site access restrictions were removed. AREVA now conducts routine environmental monitoring of the Cluff Lake Project through quarterly campaigns, where a small team is mobilized to site from Saskatoon to collect the required environmental data. The first full year of campaign monitoring occurred in 2014 and proved to be an effective method for environmental monitoring. In addition to campaign monitoring, AREVA is completing an environmental assessment follow-up program for the Cluff Lake Project under the Canadian Environmental Assessment Act (CEAA). An overview of the decommissioning history for the Cluff Lake Project site, with a focus on the transition to campaign monitoring, and the next steps for the site will be discussed.

Keywords: Uranium mine decommissioning, environmental monitoring, revegetation, tailings, waste rock, pit lakes.

1. Introduction

1.1. Project overview

Located in the Athabasca Basin of northern Saskatchewan, Canada, the Cluff Lake project, owned by AREVA Resources Canada Inc. (AREVA), is a decommissioned uranium mine and mill site. The mine site is located approximately 900 km north of Saskatoon, Saskatchewan, and approximately 75 km south of Lake Athabasca (**Figure 1**)

Uranium mining and milling operations commenced in 1980 after ore deposits were discovered in the mid-1960s, and ceased in 2002. The Cluff Lake produced 28 million kilograms of uranium concentrate (U_3O_8) over the 22-year operating life of the mine from five ore bodies, using either underground or open pit techniques.

The facilities at Cluff Lake included open pit and underground mines, a mill, a tailings management area (TMA) with a two-stage effluent treatment system, a residential camp, an airstrip and various other support and site infrastructure facilities. The site consists of four major development areas, as outlined in **Table 1**.

1.2. Decommissioning regulation

The decommissioning of the Cluff Lake project is governed by a number of federal and provincial acts, regulations and policies [1,2,3,4]. The federal government has responsibility for the regulation of matters relating to nuclear energy, including uranium mines, under the *Nuclear Safety and Control Act*. Licensing for the various stages of a uranium mining and milling project, including decommissioning, is the responsibility of the Canadian Nuclear Safety Commission (CNSC). The Cluff Lake project is also subject to a number of provincial acts and regulations and is regulated provincially by the Saskatchewan Ministry of Environment (SMOE).

Uranium mining companies in Saskatchewan are required by the SMOE and the CNSC to develop decommissioning and reclamation plans, including financial assurance. Planning for the decommissioning of the Cluff Lake project began in 1998. Decommissioning requires a license from the CNSC, and the process of securing this license triggered the requirement for a federal environmental assessment (EA). AREVA submitted a comprehensive study report (CSR) for decommissioning to regulatory agencies in 2000. The CSR was approved in April 2004, and authorizations were received to proceed with physical decommissioning activities. Since the submission of the CSR, AREVA has maintained and routinely updated a detailed decommissioning plan based on the estimated remaining decommissioning and monitoring costs. The detailed decommissioning plan serves as the primary reference in the decommissioning license from the CNSC.

In 2007, the Province of Saskatchewan legislated the *Reclaimed Industrial Sites Act* and the *Reclaimed Industrial Sites Regulations* to put into effect an institutional control program (ICP). The ICP outlines the process for long-term monitoring of sites where activities have ceased and decommissioning has been completed and approved, and the eventual transfer of the site back to the province. AREVA's decommissioning activities at Cluff Lake are working towards the goal of transferring the site into the ICP.

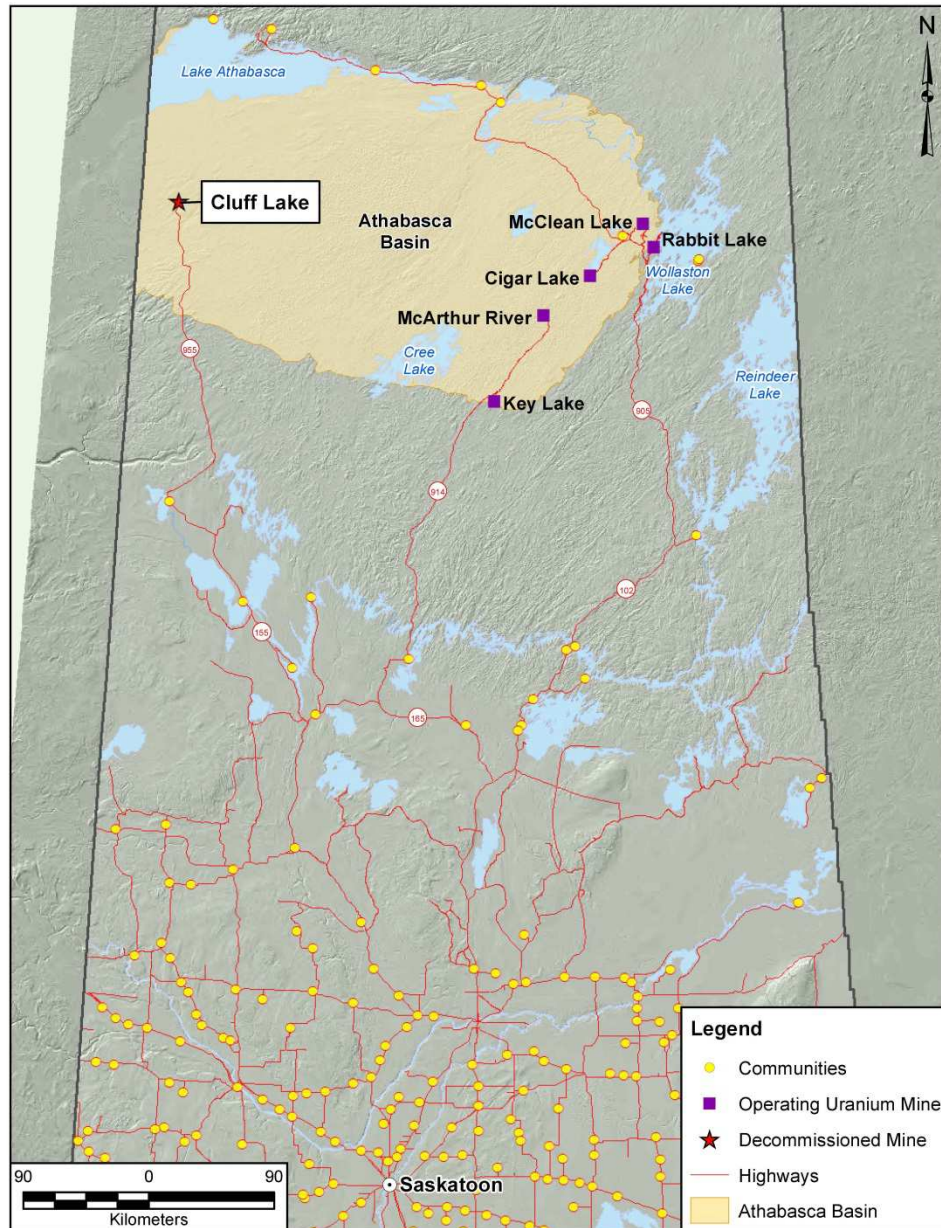


Figure 1 Location of the Cluff Lake Project

2. Decommissioning objectives

AREVA's key objective for decommissioning is to remove, minimize and control potential contaminant sources and thereby minimize the potential for adverse environmental effects associated with the decommissioned property. The decommissioning plan has been designed to reach a project end state where:

- the environment is safe for use by human and non-human biota;

- the reclaimed landscape is chemically and physically stable;
- the landscape is stable and self-sustaining, allowing for the use of the land for traditional purposes such as trapping, hunting and fishing;
- potential constraints on future land use are minimized.

Table 1 Major development areas at the Cluff Lake Project

Development Area	Associated Infrastructure
Tailings Management Area	Tailings management facility, primary and secondary treatment systems, settling pond, adjacent borrow area
Mill Complex	Mill infrastructure and warehouses
Mining Area	D, Claude, Dominique-Janine North (DJN) and Dominique-Janine Extension (DJX) open pits, OP, Dominique-Peter (DP) and Dominique-Janine (DJ) underground, Claude waste rock locations
Germaine Camp	Residential camp and kitchen facilities

To evaluate the success of the decommissioning program, site-specific objectives were developed in consultation with federal and provincial authorities as well as through public consultation processes. The following criteria are indicators of decommissioning success:

- achieving decommissioning surface water quality objectives (DSWQO) and other accepted decommissioning objectives at surface water and flooded pit locations;
- levels of gamma, radon and long-lived radioactive dust (LLRD) pose no unacceptable risk to traditional land use;
- a stable, self-sustaining landscape;
- reduction of infiltration rates around the TMA and Claude waste rock pile (CWRP) to levels that adequately restrict contaminant movement to groundwater and are suitably protective of downstream surface water receptors;
- return of the site to an aesthetically acceptable state, similar in appearance and land capability to that which existed prior to mining activities, and that poses no unreasonable risk to humans or the environment.
- Meeting decommissioning objectives for surface water quality, sediment quality and site-specific water quality standards for flooded pits as outlined in the CSR.

3. Post-decommissioning and follow-up monitoring (2006-2013)

The majority of physical decommissioning was completed in 2006 and the Cluff Lake project moved into a period of post-decommissioning and follow-up monitoring. AREVA currently

conducts an environmental monitoring program (EMP) as well as separate monitoring to demonstrate that radiological objectives have been met.

Figure 2 shows the EMP components in the TMA and mill areas, while **Figure 3** shows the mining area. The Germaine camp area, not shown in these images, is located south of the TMA and domestic landfill in **Figure 2**.

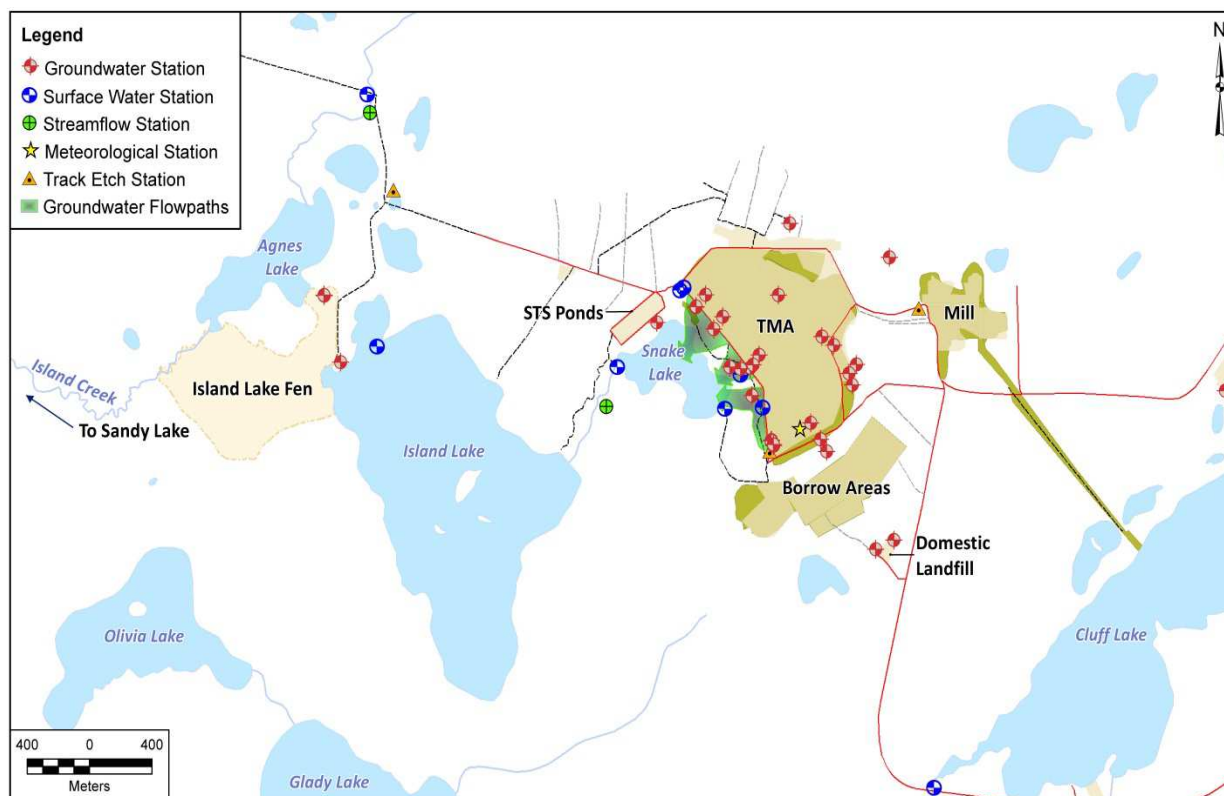


Figure 2 TMA and mill locations showing monitoring used in the EMP. Groundwater flowpaths are indicated with arrows.

3.1. Environmental monitoring program

The purpose of the EMP is to monitor the effectiveness of mitigative measures and demonstrate compliance with licensing conditions and decommissioning objectives. The sampling program outlined in the EMP is also a condition of the approval to operate pollutant control facilities issued by the SMOE.

The EMP specifies sampling locations and frequencies for surface water, groundwater, pit water quality, water level monitoring, cover monitoring, meteorological data, air quality monitoring and routine inspections. The EMP also contains requirements for monitoring environmental effects to sediment, benthic invertebrates, fish, water quality and limnology, which are collected every five years and evaluated in a status of the environment (SOE) report.

3.2. Pre-decommissioning baseline characterization

Post-operational baseline studies to characterize the wildlife community were conducted in 2005. An intensive study area, local study area, and regional study area were established at the Cluff

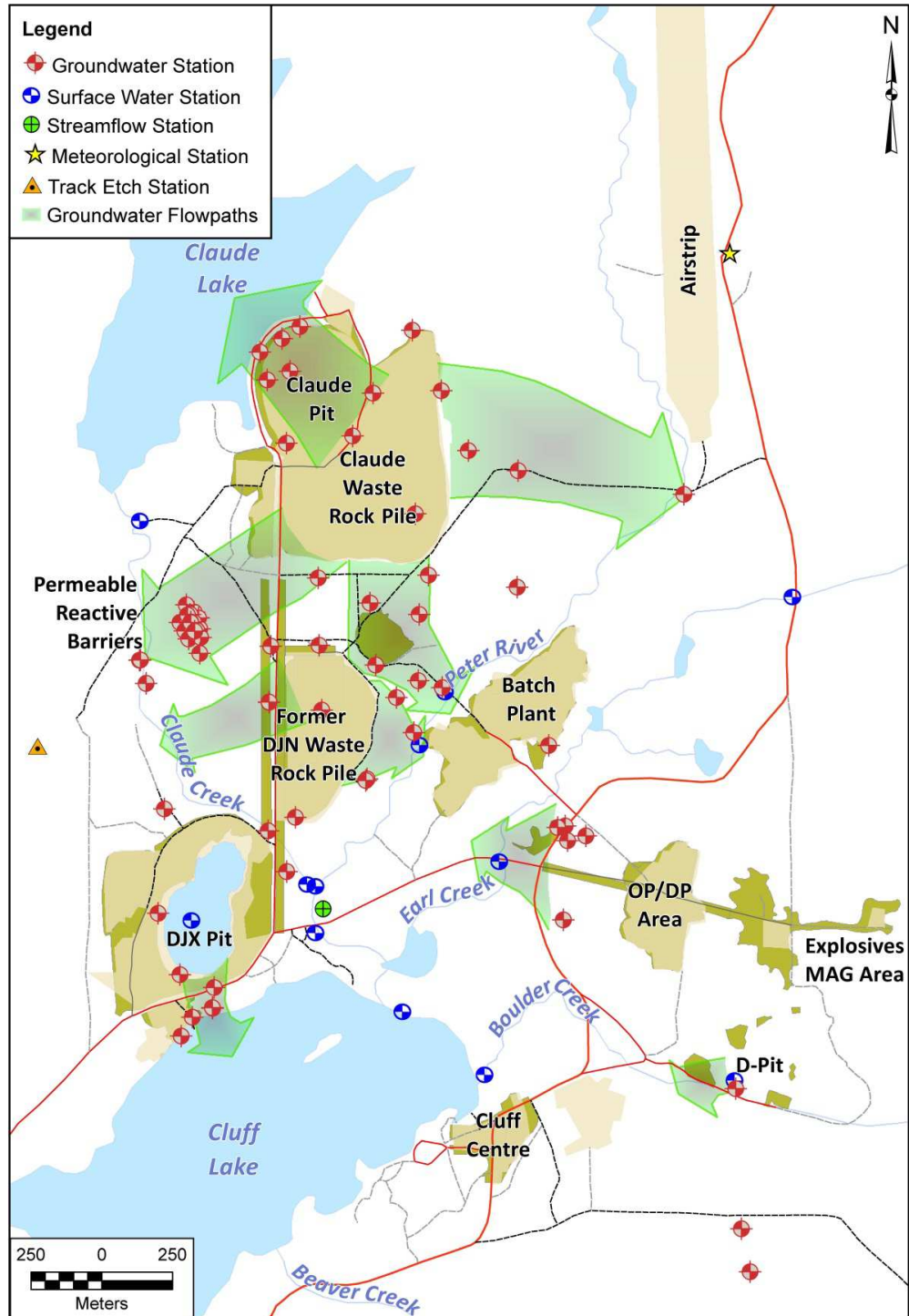


Figure 3 Mining area locations showing monitoring used in the EMP. Groundwater flowpaths from source to receptor are indicated with arrows.

Lake site along with two control watersheds that were not impacted by mining and milling activities. A focus of the study was determining the presence of moose and muskrat, which were identified as the two species most at risk in the study area.

A number of aquatic baseline studies were completed in 2004. The Cluff Lake project area consists of two major drainage areas. The Island Creek drainage area carried treated effluent from the secondary treatment system, discharged at Snake Creek, through Island Lake, the Island Lake Fen, and Island Creek to Sandy Lake. The drainage path can be seen in Figure 2. The Cluff Creek drainage area collects flow through a series of tributaries in the mining area that drain towards Cluff Lake. Cluff Creek drains from Cluff Lake and passes through several small lakes prior to discharging in the Douglas River. Figure 3 shows the tributaries in the mining area (which include Claude Creek, Peter River, Earl Creek and Boulder Creek) and their drainage into Cluff Lake.

The aquatic environment was characterized by evaluating differences in the physical components, such as limnology, water, sediment, and fish tissue chemistry, with biological components such as benthic invertebrate communities and fish populations. Aquatic baseline studies were conducted on several exposure stations in the Island Creek drainage area and Sandy Lake. Reference stations were established at four locations. Additional aquatic studies took place in 2005, 2006 and 2009.

4. Transition to campaign monitoring (2013-present)

In April 2012, AREVA submitted an updated version of the EMP to regulatory agencies to prepare for campaign monitoring. A transition to quarterly campaign monitoring to complete the EMP sampling was identified as a cost-effective method for completing the sampling, as a permanent site presence would no longer be required. A small permanent staff remained on site to complete the first year of sampling and advance site clean-up activities throughout 2013.

In the summer of 2013, site clean-up activities included demolition of the remaining camp and warehouse buildings, decommissioning of the secondary treatment system plant and settling ponds, removal of site culverts, and the disposal of demolition waste and any potentially contaminated materials.

Earthworks also occurred at the TMA and Claude pit areas. Site clean-up activities were completed by September 2013. As of the fall of 2013, AREVA no longer has a permanent site presence at Cluff Lake. The airstrip has been closed and site access restrictions have been removed. The first campaign monitoring program took place in December 2013.

5. Campaign monitoring implementation and field work

In its first two years, campaign monitoring has proven to be an effective method of collecting the EMP samples. Campaigns generally occur in February, June, September and December with the June and September programs being the largest.

State Of the Environment (SOE) sampling was also scheduled for 2014. The SOE program is a comprehensive sampling and evaluation program conducted in five-year cycles. In addition to the campaigns, three SOE programs took place at site for the collection of sediment, fish, benthic

invertebrate, terrestrial vegetation, surface water quality and limnology data. Other programs that occur periodically on site include cover monitoring inspections, a revegetation sampling program, geotechnical inspections, regulatory inspections, LiDAR surveys and gamma surveys. Aerial photos were collected in 2014 to assess the progress of decommissioning over time. Figure 4 shows a comparison of the TMA from 2004 to 2014, and Figure 5 shows the Claude pit and CWRP for the same time period.



Figure 4 Aerial photographs of the TMA over time. The photo on the left is from 2004, during physical decommissioning. The photo on the right, from 2014, shows the decommissioning work and establishment of vegetation.



Figure 5 Aerial photographs of the Claude Pit and Claude Waste Rock Pile over time. The photo on the left is from 2004, during physical decommissioning. The photo on the right, from 2014, shows the decommissioning work and establishment of vegetation

6. Campaign monitoring challenges and lessons learned

Cluff Lake is a remote site, which presents challenges in planning field programs. The site has no cellular service, and communication is through satellite phone and radio. With the closure of the airstrip, crews now mobilize to the Cluff Lake project from Saskatoon, which is 900 km south of the site. The closest community to the Cluff Lake Project is 260 km south of the site, and the

final portion of the highway from this community to the site is a gravel road. A detailed emergency response plan and health and safety plan are completed prior to every program. Crews must be prepared with all necessary field and safety equipment and spare supplies in the event of an equipment breakdown.

Since the removal of site access restrictions in the fall of 2013, challenges have also been faced with vandalism to monitoring equipment, particularly dataloggers. Potential solutions for protecting or modifying dataloggers are currently being explored.

Overall, the sampling program was successfully completed in 2014 and 2015 with few issues. Campaign monitoring has proven to be a successful and cost-effective option for completing the EMP.

7. Path forward

Campaign monitoring will continue on a quarterly basis in 2016 and AREVA is completing an optimization of the EMP. This optimization will rationalize monitoring requirements and consider a reduction to monitoring program elements. Cost reduction measures such as automating data collection will be explored.

AREVA's eventual goal is to transfer the Cluff Lake project site into the provincial ICP. As monitoring results demonstrate the achievement of decommissioning objectives, the EMP will be gradually optimized into a long-term monitoring program (LTMP). The LTMP is envisioned to comprise periodic geotechnical inspections to monitor stability, together with a minimal complement of environmental sampling to continue to assure compliance with the decommissioning objectives. It is expected that the frequency of site monitoring will diminish with time.

8. Conclusions

Many lessons have been learned from the Cluff Lake project over the 17 years since the planning for decommissioning began. Starting with the end of a project in mind is essential for successful decommissioning of a mining and milling site. The EA phase defines the evaluation of options for decommissioning, the selection of preferred alternatives and the establishment of post-decommissioning objectives. Routine environmental monitoring verifies the compliance with post-decommissioning objectives while addressing uncertainties from the EA. Decommissioning during the operational period and maintaining a detailed decommissioning plan are also key contributors to success. Decommissioning in a jurisdiction with an ICP in place is advantageous. The decommissioning period can span many years, from planning to transfer into the ICP. Over this time, it is essential to maintain corporate knowledge.

Maintaining a continuous site presence in the long term is costly. Campaign monitoring at the Cluff Lake project has been shown to be an effective method of conducting EMPs in the later stages of post-decommissioning and follow-up monitoring.

9. References

- [1] Government of Canada (2012) Canadian Environmental Assessment Act, viewed 8 May 2015, <http://laws-lois.justice.gc.ca/eng/acts/C-15.21/index.html>.
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