Canadian Nuclear Society
Waste Management, Decommissioning and Environment Restoration
For Canada's Nuclear Activities: Current Practices and Future Needs
Ottawa, Ontario Canada May 8-11, 2005

ENVIRONMENTAL ASSESSMENT, CONTINUAL IMPROVEMENT AND ADAPTIVE MANAGEMENT WITHIN THE AREVA SUSTAINABLE DEVELOPMENT FRAMEWORK

Arden Rosaasen
Scott Frostad
AREVA/COGEMA Resources Inc., Saskatoon, Saskatchewan, Canada

ABSTRACT

COGEMA Resources Inc. (which is part of the AREVA Group) is a Canadian company with its head office in Saskatoon, Saskatchewan. It owns and operates mining and milling facilities in northern Saskatchewan, which produce uranium concentrate. The McClean Lake Operation commenced production in 1999 and its environmental management system represents an integrated approach to environmental assessment, continual improvement and adaptive management based on operational results.

In Canada, sustainable development is promoted through the application of the *Canadian Environmental Assessment Act* (CEAA). Environmental Assessment (EA) is a planning tool, which incorporates environmental considerations before irrevocable decisions are taken. The basic tenet of the Act is the determination of whether the potential environmental effects of a project are adverse, significant and likely, taking into consideration mitigation measures. Thus, project planning and design entails an iterative process that incorporates mitigation measures to minimize potentially significant adverse effects. As part of the EA process conservative approaches are taken to predict potential effects.

Several important elements are generated through the EA process including: a set of environmental effects predictions, a compliance and environmental effects monitoring program, a follow-up program to address uncertainties in the prediction of environmental effects, and the identification of contingency measures that could be implemented should non-conservative assumptions be identified in the original assessment framework. The challenge is to integrate each of these elements into the environmental management framework of the operating facility and develop an iterative mechanism to evaluate operational performance relative to what was originally predicted.

In Saskatchewan, a requirement of operational licenses is the periodic evaluation of the "Status of the Environment" surrounding operational facilities. These periodic evaluations, conducted every three to five years, provide a useful mechanism to evaluate the operational performance of a facility, facilitate continual improvement and outline adaptive management objectives, when necessary. This provides an iterative basis for effective continual improvement and adaptive management throughout the life of the project. The framework is commensurate with AREVA sustainable development principles to limit the environmental effects of waste and emissions from our activities. The concepts of continual improvement and adaptive management are discussed and examples drawn from the AREVA McClean Lake Operation to illustrate how the EA elements can be integrated into an operational environmental management framework.

I. INTRODUCTION

The AREVA Group places sustainable development at the heart of its business strategy. In the area of environment, the principles adopted include innovation in advanced environmental protection technologies, managing the consumption of natural resources in a responsible way, and limiting and managing environmental risks and effects of waste emissions from our activities. COGEMA Resources Inc. (COGEMA), a member of the AREVA Group, has implemented the environmental principles of this strategy within its environmental management system.

COGEMA operates uranium mining and milling facilities in the Athabasca Basin of northern Saskatchewan, Canada. Canada's most recent and modern uranium milling facility is located at the McClean Lake Operation. The McClean Lake Operation is jointly owned by COGEMA Resources Inc. (70%), Denison Mines Ltd. (22.5%) and the Overseas Uranium Resources Development Co. Ltd. (OURD) (7.5%) with COGEMA Resources Inc. as the operator. AREVA's aim in nuclear energy and electricity distribution is to provide a comprehensive scope of services in every aspect of the nuclear fuel cycle, from nuclear power reactor supply and services, to electricity transmission and distribution. COGEMA Resources Inc. forms part of the AREVA Mining Business Unit, which operates at the front end of nuclear fuel cycle.

Mill operation at McClean Lake commenced in late June of 1999 and has been operating at or above design production levels since January 2000. In the current configuration, the mill is processing stockpiled ore at a current production rate of 6,000,000 lbs U_3O_8 per year. Planning calls for the future processing of ore from the Midwest and Cigar Lake mine sites. The operating life of the milling facility is expected to be approximately 40 years.

The McClean Lake Operation environmental management system represents an integrated environmental protection approach encompassing three main processes: EA, adaptive management, and continual improvement. Within this approach, decisions are precautionary, with the degree of conservatism reflective of the level of uncertainty that exists at the time of the decision.

I.A Environmental Assessment

In Canada, sustainable development is promoted federally through the application of the *Canadian Environmental Assessment Act*, and provincially through the Saskatchewan *Environmental Assessment Act*. Environmental Assessment (EA) is implemented as a planning tool, which incorporates environmental considerations before irrevocable decisions are taken. The basic tenet of the legislative framework is the determination of whether the potential environmental effects of a project are adverse, significant and likely, taking into consideration mitigation measures.

Thus, project planning and design entails an iterative process that incorporates mitigation measures to minimize potentially significant adverse effects. As part of the EA process conservative approaches are taken to predict potential effects.

The iterative nature of the EA process is illustrated in Figure 1. Project feasibility initiates the process and is exemplified by the project description, which is filed with the provincial and federal regulatory authorities. A determination is made as to the necessity and scope of the EA. The resulting project specific guidelines outline the requirements of the assessment.

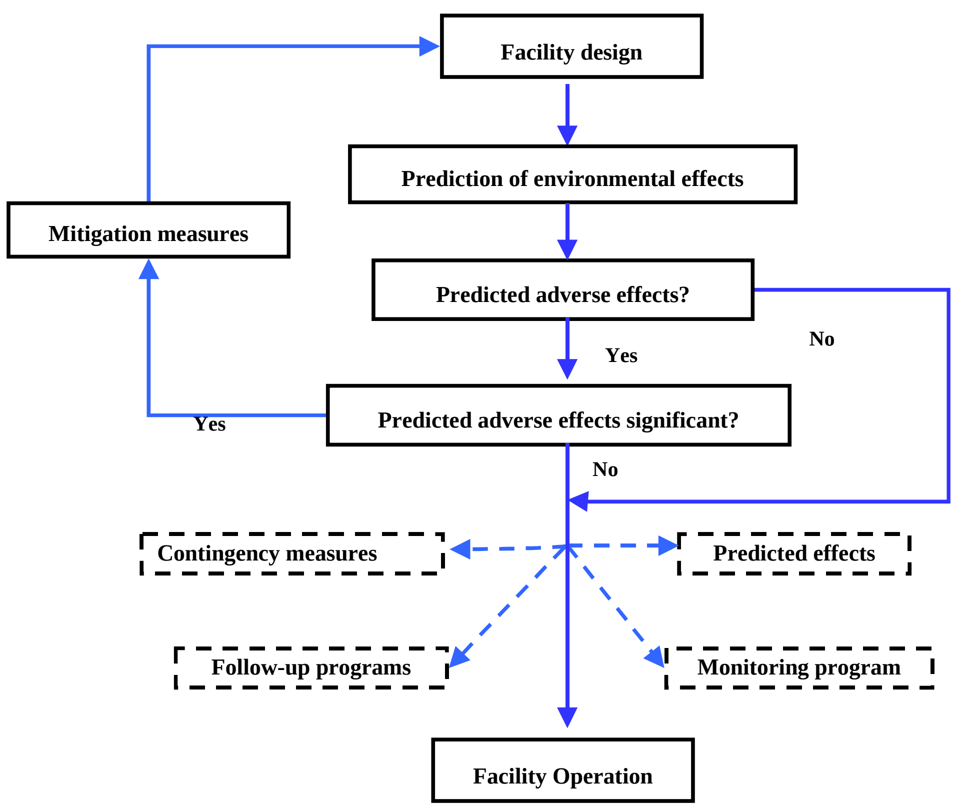

Figure 1: Environmental Assessment Framework

The EA identifies potential effects, evaluates their potential significance as an adverse effect, and requires the identification of mitigation measures if significant adverse effects are determined to be likely. The process is iterative, incorporating mitigation measures, the re-evaluation of facility design, and the reassessment of potential effects until an acceptable project design is achieved.

The iterative nature of the evaluation of the project generates several significant elements that flow from the assessment. These elements include:

- An outline of predicted effects of the project;
- A monitoring program incorporating regulatory compliance regimes and receiving environment monitoring requirements;
- A framework for a follow-up program to verify the effectiveness of mitigation measures and the accuracy of the EA predictions, and
- Possible contingency measures proposed for potential unforeseen effects.

Each of the elements developed during the EA process needs to be integrated into the environmental management system for the facility operation.

I.B Adaptive Management and Continual Improvement

Figure 2 illustrates how each element developed during the EA process is integrated into an environmental management system for an operation that incorporates both adaptive management and continual improvement.

During facility operation, adherence to compliance monitoring requirements identified during the EA, ensure operational performance standards are maintained. Environmental Effects Monitoring (EEM) in the receiving environment conducted iteratively through time within comprehensive study designs provides the information necessary to determine operational related effects, and their geographical extent and magnitude. EEM incorporates monitoring endpoints that represent key ecosystem features, and as such, the programs are robust to ascertain potential unforeseen effects.

Actual effects determined through EEM are evaluated against the effects originally outlined in the EA. The iterative evaluation through time allows the identification, tracking and comparison of actual effects. The awareness of actual effects provides the necessary feedback and operational impetus to implement continual improvements. Results that indicate unforeseen or incremental effects beyond those predicted in the EA provide a basis to determine if a trend would, over time, lead to a significant adverse effect. The results also provide the basic information necessary to develop adaptive responses and facilitate detailed design of contingency measures to mitigate the significance of incremental adverse effects.

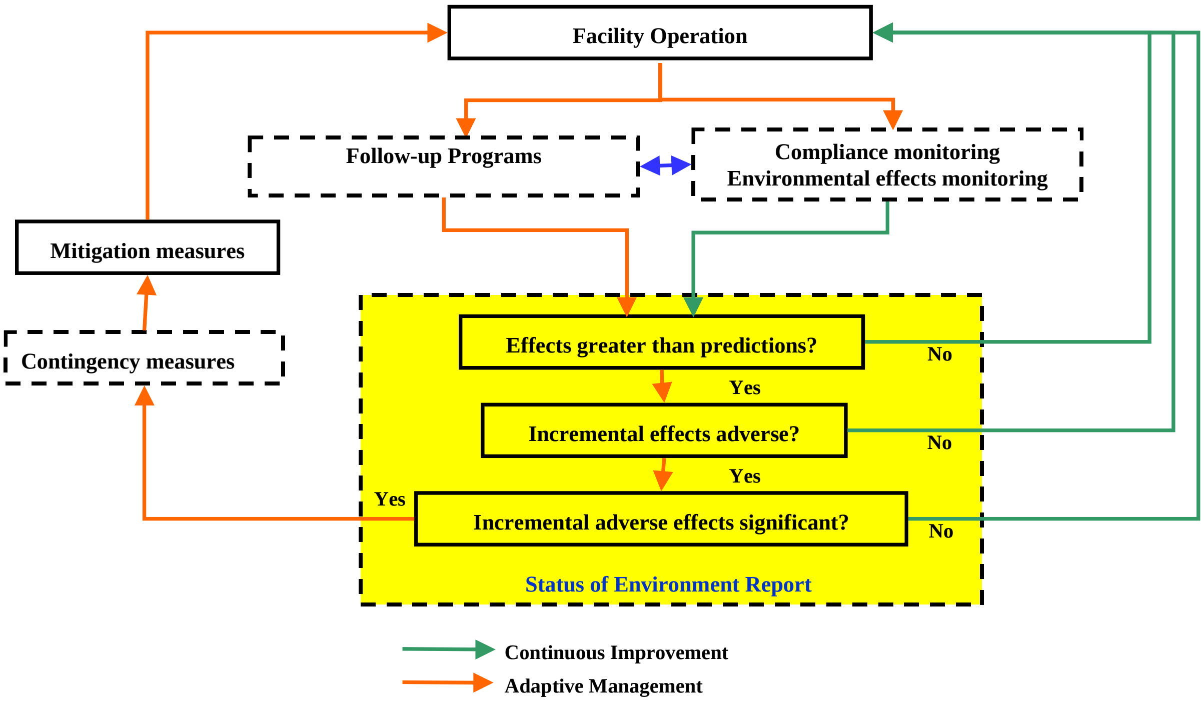

Figure 2: Continual Improvement and Adaptive Management Framework

Follow-up programs are a unique element of the EA process, with a fundamentally different purpose from compliance monitoring programs. Follow-up programs are tailored to verify the accuracy of predictions. The nature of the information generated by the follow-up program relates to refining and verifying the assumptions of the assessment methodology and thereby both validating the predicted effects and reducing uncertainties in EA predictions. The feedback from the follow-up program in refining and verifying the assumptions of the assessment methodology also provides the basis for continual improvement in both the facility operation and the monitoring and follow-up programs themselves. Unforeseen or incremental effects beyond those predicted, which indicate the future development of significantly adverse effects, provide the information necessary to identify additional mitigation measures or implement contingency measures identified during the EA, to mitigate the development of significant adverse effects.

Thus, the McClean Lake Operation’s integrated environmental protection approach features an iterative, systematic process for continual improvement of practices. The approach builds on the outcomes of EA predictions and of operational and follow-up programs to provide a robust defense against the development of significant adverse effects. The Status of the Environment Reports, which are iterative throughout the operational period on a three-year basis, provide an appropriate forum to ensure monitoring and follow-up programs are appropriately focussed, and that results are documented, and communicated.

As a case study, an overview of the McClean Lake Operation monitoring program and key elements of follow-up programs are discussed below within the framework of how adaptive management and continual improvement are implemented to achieve the sustainable development principles set out by the AREVA Group.

II. ENVIRONMENTAL MANAGEMENT AT McCLEAN LAKE OPERATION

McClean Lake site is located in the Athabasca Basin area of northern Saskatchewan (Figure 3) approximately 700 km north of Saskatoon and 350 km via air north-east of the town of La Ronge.

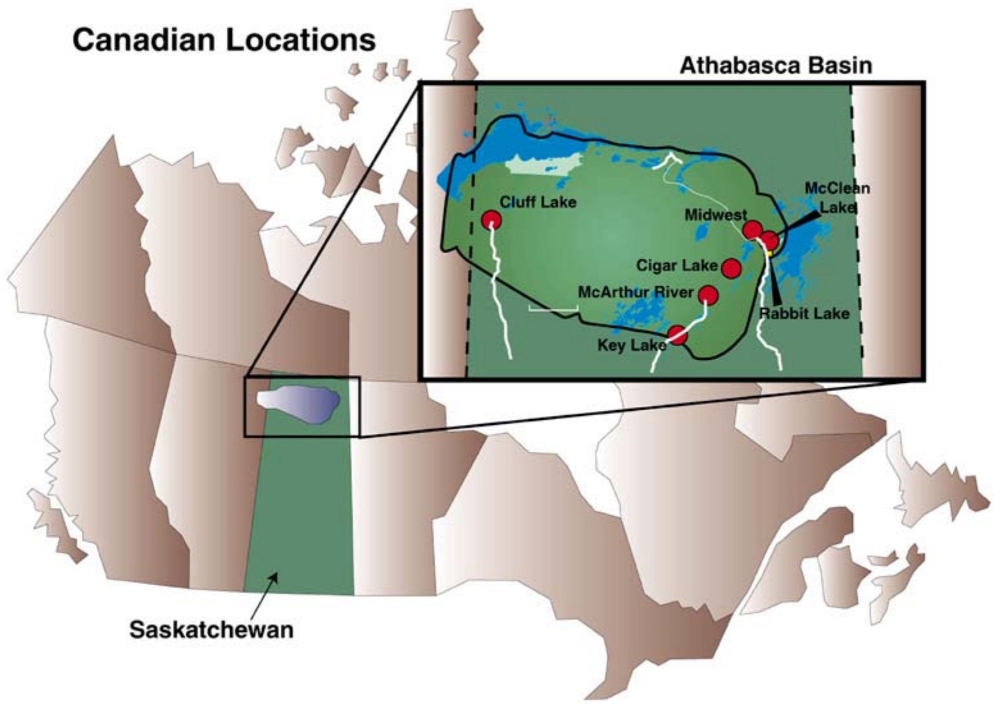

Figure 3: Location of McClean Lake Operation in Athabasca Basin

Access to the site is by means of an all-weather road connecting with the provincial road system about 18 km south-east of Points North, a small service and freight forwarding facility located close to the Midwest Project site. Workers commute to and from the site by aircraft, landing at Points North and by bus from Points North to the mine site. While at work, workers reside in the camp facilities on site. The nearest permanent community is Wollaston Lake, about 50 km via air from the mine site on the opposite (east) side of Wollaston Lake. The main facilities and operations at the existing McClean Lake Operation are as follows (Figures 4 to 6):

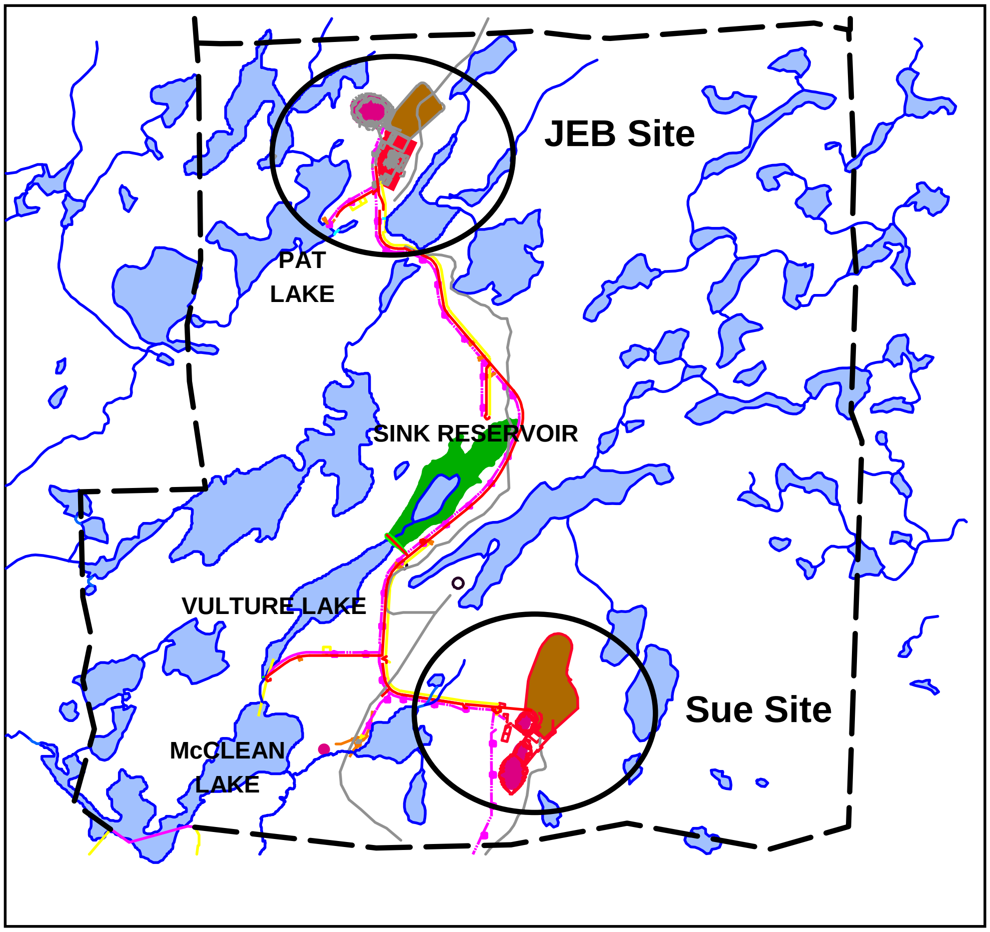

Figure 4: McClean Lake Operation Facility Layout

- At the JEB site, the JEB Mill and the JEB tailings management facility (constructed at the JEB open pit mine), are located in the northern part of the lease area.
- At the Sue site, the depleted Sue C open pit mine was allowed to partially flood after the deposit of special wastes from the Sue C and JEB mines. The water level in the pit is currently being drawn down to facilitate the development of the smaller Sue A and B deposits which are licensed for mining but have yet to be developed. EA approval has also been obtained for the future disposal of Cigar Lake waste rock in the Sue C pit.
- There are also various support facilities and infrastructure for waste management (e.g., waste rock, waste water, other wastes, hazardous substances, air emission control) and site infrastructure, such as roads, electricity distribution, and camp facilities.

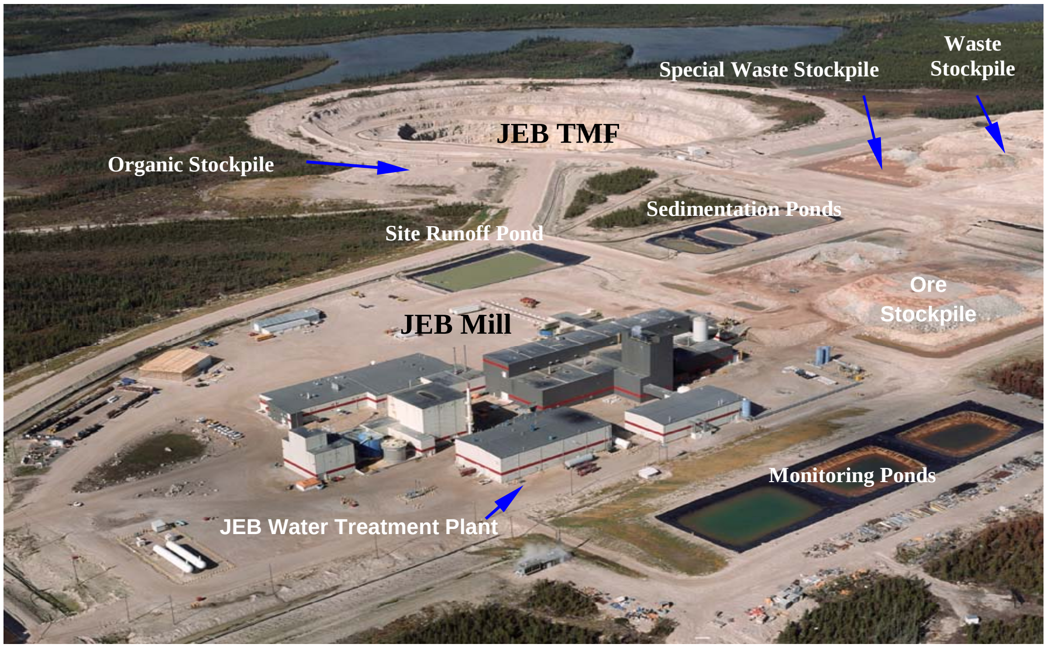

Figure 5: JEB Site Facility

Figure 6: Sue Site Facility

- All treated water is released through a single system at Sink Reservoir, shown shaded in Figure 4, and then to the adjacent Vulture Lake. These together form the Sink/Vulture Treated Effluent Management System (S/V TEMS).
- Mined ore is stockpiled at the Sue site and transported periodically to the JEB site for feed to the mill. A 12 km haul road connects the Sue and JEB sites. The camp facilities are located adjacent to the haul road near the JEB site. All project activities occur within the lease area, with the exception of environmental monitoring activities, which extend outside of the lease area and transportation of materials to and from the site.

At the McClean Lake Operation, environmental risk management of mining and milling waste emissions is exemplified within the environmental protection Code of Practice. This Code of Practice encompasses areas of treated effluent quality and discharge, tailings preparation and tailings facility operation, and atmospheric emissions. Several examples of the implementation of EA elements within the operational environmental management system are provided below, beginning with treated effluent management.

II.A Treated Effluent Management

II.A.i Effluent Quality

At the McClean Lake Operation, treated effluent is managed through effluent quality “Administrative” and “Action’ levels, established to maintain regulatory requirements, and minimize operational effects. Action levels are established commensurate with the definition of “Action Levels” in the General Nuclear Safety and Control Regulations, issued under the *Nuclear Safety and Control Act*, and are intended to prevent a loss of control of effluent Quality. Administrative levels are used internally to identify a deviation from normal or expected operating conditions, and are intended to ensure water treatment plant operation consistently results in effluent quality which is equal, or better, than that which formed the basis of the original EA predictions. In general, the resultant action required following an exceedence of an administrative or action level include the following principal steps:

- An investigation of the cause and potential effects;
- A response to mitigate potential effects;
- Corrective and preventative actions; and
- For action level, and regulatory limit exceedences, should there be any, reporting to regulatory agencies.

The Environmental Code of Practice administrative and action levels for selected parameters are set below regulatory discharge limits. The water treatment plant effluent administrative levels are set to ensure that total loadings of constituents of concern from the operation are maintained below the mean loadings predicted in the EA. The mean predicted cumulative loadings for each year of operation, and on a cumulative annual basis, are used as administrative levels.

The *Fisheries Act* Metal Mining Effluent Regulations (MMER) include requirements for effluent toxicity testing and the requirement to conduct Environmental Effects Monitoring (EEM). EEM consists of water and sediment quality monitoring studies, and biological monitoring studies to examine the effects of effluent discharge on fish populations, fish tissue, and the benthic invertebrate community. As part of the effluent and water quality monitoring studies, sublethal toxicity testing is conducted twice yearly, for a fish species, an invertebrate species, a plant species, and an algal species.

The requirement for EEM is not new, since such programs are already required both through the CNSC operating licence, and the Status of Environment (SOE) requirements of the Saskatchewan Environment (SE) licence. Although broadly similar, there are differences in detail amongst the various regulatory requirements for EEM programs.

II.A.ii Effluent Discharge

The Environmental Code of Practice also outlines Administrative and Action Levels to manage treated effluent discharge. The operational objectives are to:

- Minimize water quality and flow regime fluctuations,
- Minimize the augmentation of streambed erosion, and
- Meet Saskatchewan Surface Water Quality Objectives (SSWQO) in Collins Creek, downstream of McClean Lake east basin.

The operational objectives are implemented by:

- curtailing treated effluent discharge when a natural flood condition exists, and
- under low flow and normal flow conditions, maintaining a five to one ratio of natural stream flow to treated effluent added in the Collins Creek receiving environment.

The first criterion ensures that during natural flood events, treated effluent discharge does not augment stream erosion. The second criterion minimizes fluctuations in downstream water quality, and ensures surface water quality objectives are met in Collins Creek at the outlet of McClean Lake east basin. As part of the EA, COGEMA set an objective for McClean Lake Operation to achieve SSWQO for all constituents of concern where objectives were available. This objective is applicable at the outlet of McClean Lake east basin. It is addressed in the Environmental Code of Practice by the application of administrative and action levels for water quality monitoring results at a monitoring station in McClean Lake east basin, upstream of the outlet.

As outlined above, the Environmental Code of Practice provides management tools which establish a comprehensive set of administrative and action levels to maintain regulatory requirements, and minimize operational effects. An exceedence of an administrative or action level initiates a logical sequence of investigation, mitigation, corrective and preventative actions, and reporting. The application of administrative and action levels to effluent quality and discharge has resulted in treated effluent quality consistently better than predicted in the EA, and accepted as the basis for project approvals and licences. When combined with the comprehensive receiving environment environmental effects monitoring program, these management tools provide the means to minimize operational effects and verify the accuracy of EA predictions related to surface water quality and protection of the aquatic environment during the operational phase of the McClean Lake project.

II.B Follow-up Program

Follow-up programs determine if the environmental effects of the project, including cumulative effects, are as predicted in the EA. It is also a tool to confirm whether the mitigation measures are effective, and to determine if any new mitigation strategies are required. The McClean Lake project EA is based on actual operational data combined with conservative assumptions, where appropriate, so that uncertainties in prediction are not likely to underestimate the potential for significant adverse effects. Thus, the follow-up programs at McClean Lake Operation focus on specific areas or parameters identified during the EA that can further refine the assessment methodology and/or improve the accuracy of predictions. This is attained through focused data collection and an iterative interpretation process.

The follow-up programs at the McClean Lake Operation primarily focus on verifying long-term performance of tailings disposal in the JEB Tailings Management Facility (TMF) and waste rock disposal in the Sue C pit. An overview of each of the follow-up programs is outlined below.

II.B.i Tailings

Two key uncertainties identified during the EA of the project were the long-term behavior of constituents of concern in tailings and the long-term hydraulic conductivity and groundwater flow through the tailings mass. The Tailings Optimization and Validation Program provides important findings with respect to these uncertainties. The objective of the follow-up program is to consolidate these findings through laboratory testing and, in parallel, regular in-situ sampling. Peer review of the work in refereed journals provides a final review step.

The follow-up program for the tailings is closely linked to the current Tailings Optimization and Validation Program (TOVP).

II.B.ii Waste Rock

Potential effects to nearby surface water bodies as a result of waste rock disposal in the Sue C pit are predicted to be far into the future. Since there may be no indication of waste rock contaminant release within the timeframe of the post-decommissioning monitoring phase, validation of waste rock contaminant transport predictions will focus on monitoring the behaviour of in-pit waste rock pore water chemistry, and the additional collection and interpretation of hydrogeology data. Monitoring will be conducted to confirm that waste rock pore water concentrations, in combination with hydrogeology data, result in performance within the predicted envelope of values with respect to contaminant transport to the overlying pit water and to receiving surface water bodies.

II.B.iii Hydrogeological Modelling

A follow-up program was identified based on the results of the qualitative and quantitative evaluation of the local study area and site-specific hydrogeology. The follow-up program includes research-type and ongoing activities, with the objectives of improving the robustness of model predictions and optimizing the monitoring (i.e., parameters, location, frequency, etc.) as data continues to be collected. Ongoing activities are based on monitoring, field data acquisition and modelling methods already used for the EA of the McClean Lake project, while research-type activities involve new methods or methods not routinely used for the McClean Lake project.

The proposed program is mainly dedicated to minimizing uncertainties related to the following:

- The variability of the sandstone hydraulic conductivity,
- The hydraulic relationship between lakes and groundwater, and
- The validation of flow predictions in a fractured environment.

II.B.iv Waste Water

Although the waste water assessment methodology is robust, there is a need to continue to document waste water source characteristics and receiving environmental effects to verify the accuracy of the predicted residual effects. The elements necessary to achieve these objectives are currently in place in the existing environmental monitoring plan.

II.C Contingency Measures

II.C.i Related to Tailings Management

A contingency plan would only require implementation if an unforeseen circumstance developed, which resulted in a significant increase in the predicted long-term mass flux of constituents dissolved in groundwater to the potential receptors in the surface water aquatic environment. The principal contingency applicable to the natural surround tailings system is an hydraulic cage, consisting of a high hydraulic conductivity zone constructed around the Tailings Management Facility. The hydraulic cage option was selected as the primary contingency based on its simulated effectiveness in reducing the mass flux from the JEB TMF. The hydraulic cage system would serve to reduce the amount of flow through the area between the hydraulic cage and the tailings mass. The reduction in flow in the area inside the cage would reduce the amount of solute that is transported by groundwater away from the tailings.

The preferred hydraulic cage construction method would involve excavating and backfilling a drift around the TMF. The drift would be accessed from the surface by a ramp. Standard mining techniques are available to excavate a drift around the JEB TMF and backfill it with coarse aggregate in order to create a zone with hydraulic conductivity a few orders of magnitude higher than the surrounding aquifer.

The hydraulic cage is not an operational contingency. The hydraulic cage is only a suitable contingency to be installed after decommissioning of the tailings facility, if predictions at that time suggest that future loading to the environment would be unacceptable.

II.C.ii Related to Waste Rock Management

Contingency measures have been considered in the event that the assumptions and the predicted long-term effects related to waste rock management are found to be incorrect based on operational monitoring and follow-up program results. In the event that the predicted long-term Sue C pit water quality is considered unacceptable, an alternative cover design can be implemented that can further reduce the flux of constituents of concern into the overlying pit waters. As well, Sue C pit lake could be treated to encourage the formation of a chemocline in the deep bottom waters to create an additional diffusion barrier to prevent movement of constituents into the upper oxygenated surface waters.

If pore water concentrations of constituents of concern in the waste rock are significantly higher than predicted and an unacceptable level of constituents are predicted to be transported to the surface water receiving environment, then a “pump and treat” contingency measure can be implemented. This involves locating a collection sump down-gradient of the groundwater inflow so that the pit will essentially act as a large dewatering well. The groundwater flowing through the placed waste rock will displace contaminated pore water toward the collection sump. The sump water will be pumped to the WTP for treatment. This flushing process can be further improved, if necessary, by installing a network of injection wells within the waste rock, which could facilitate the possibility of adding chemicals to allow in situ treatment of waste rock pore water with the objective of further reducing the leachable mass of constituents of concern.

Modifying the in situ waste rock properties should be considered if long-term monitoring results indicate significantly higher than predicted groundwater flow through the placed waste rock (which may result in an unacceptable level of contaminant transport to the receiving environment). For instance, a modifying agent (e.g., silica gel) could be injected into the waste rock pore spaces to reduce the hydraulic conductivity of the placed waste rock and subsequently the groundwater flow through the waste rock.

Injection of reagents within the waste rock is not an operational contingency. This will have no impact on operations and is only a suitable contingency to be carried out after decommissioning of the Sue C pit, if predictions at that time suggest that future loading to the environment from the Sue C Pit would be unacceptable.

The focus of the follow-up program over the next several years will be to collect information to determine whether the long-term predictions are conservative. If not, the potential contingency measures will be investigated in more detail. It is noted that the amount of special waste currently deposited in Sue C is less than 10% of that projected in the performance assessment for future projects. The periodic reviews of the follow-up program and/or future licensing decisions will provide opportunity to ensure that the follow-up program continues to be satisfactorily implemented.

III. SUMMARY

Thus, in Canada, COGEMA Resources Inc., has implemented the environmental principles of the AREVA sustainable development strategy within its environmental management system. The McClean Lake Operation environmental management system represents an integrated environmental protection approach encompassing EA, adaptive management, and continual improvement. Within this approach, decisions are precautionary, with the degree of conservatism reflective of the level of uncertainty that exists at the time of the decision.