Kiggavik Project

Environmental Impact Statement

Tier 3 Technical Appendix 5M

Aquatic Effects Monitoring Plan

December 2011

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1 INTRODUCTION

Pursuant to the aquatic effects assessment outlined in the Kiggavik Project Environmental Impact Statement (EIS) Volume 5, AREVA Resources Inc. (AREVA) will design and implement an Aquatic Effects Monitoring Program (AEMP) which takes into account the range of Project activities and potential project-environment interactions identified in the EIS as being of concern for aquatic Valued Ecosystem Components (VECs). The purpose of the AEMP will be to monitor sensitive components of the aquatic environment and their associated project activities (e.g., effluent release) in order to assess potential ecological risks so that appropriate actions can be taken to mitigate possible adverse effects. In addition, the AEMP will address any mitigation measures to be implemented to protect and minimize effects on the aquatic environment.

In addition to the issues identified in the EIS, the AEMP will be designed to incorporate the terms and conditions of a number of permitting and regulatory considerations. These include the guidelines prepared by the Nunavut Impact Review Board (NIRB) in relation to the development of the Kiggavik Project EIS, and the subsequent AEMP; as well as the prospective Class A Water License issued by the Nunavut Water Board; and the Fisheries Authorization that would be issued by the Department of Fisheries and Oceans in relation to DFO's policy on the management of fish habitat. Additionally, the Project will be required to comply with the Metal Mining Effluent Regulations (MMER) which stipulate discharge limits for deleterious substances, and require routine monitoring of Mine water effluent (MMER; Government of Canada 2002, 2006). In association with the MMER, the Project will also be required to conduct Environmental Effects Monitoring as specified in the regulations and guidelines administered by Environment Canada (EC). The AEMP will therefore be designed in consideration of the objectives and requirements set out in the MMER.

2 OBJECTIVES

The specific objectives of the AEMP as outlined by the Nunavut Water Board (NWB) will be to determine the short- and long-term effects in the aquatic environment resulting from the Project, evaluate the accuracy of effects assessment predictions, assess the effectiveness of planned mitigation measures, and identify additional mitigation measures to avert or reduce environmental effects. In addition, the primary stated objective of EEM is to evaluate the effects of mining effluent on fish, fish habitat, and the use of fisheries resources (EC 2002).

The particular focus of the Kiggavik Project Aquatic Effects Monitoring Program will be in relation to the primary VECs identified in the Project EIS for the Aquatic Environment. These include hydrology, hydrogeology, water quality, sediment quality, aquatic organisms, fish populations, and fish habitat. The intent of the AEMP will be to function as an integrated monitoring program which considers a variety of pathways identified as pertinent to the aquatic VECs including:

- the possible effect of water extraction, storage and discharge on the downstream environment;
- alteration of drainage patterns and construction of diversion channels by project infrastructure;
- dewatering of the Andrew Lake Pit; increase in contaminants and radioactive material in groundwater and surface water;
- effects of discharges from Project wastewater treatment plants;
- effects from the deposition of dust and metals; aquatic habitat loss and/or alteration from Project development activities; and
- effects on fish due to blasting in or near water bodies; and other potential effects described in the EIS.

3 DESIGN CONSIDERATIONS

The aquatic environmental monitoring programs at the Kiggavik and Sissons Mines will be designed to take into account special issues in Northern Canada and will be developed in consultation with interested stakeholders. The AEMP will incorporate the results of Traditional Knowledge studies and will emphasize issues and concerns that are relevant to sensitive northern ecosystems. The AEMP will also be subject to adaptive management; in other words, it will not be a static document, but rather will be updated as necessary and as new information or findings become available. Therefore, the scope of the AEMP may change over the life of the Project, as the Project moves from construction into operations then to closure and post-closure. Changes to the AEMP will be done in a consultative manner with key stakeholders and regulatory agencies.

Monitoring and sampling techniques, and analytical procedures and data analysis techniques employed in the AEMP will be consistent with those used during the baseline collection programs, as much as possible. Field and laboratory procedures will include quality assurance/quality control measures for all aspects of sampling and analysis including data acquisition; water, sediment, and aquatic biota sampling; and during the data analysis and reporting phases. Components of the AEMP will be developed according to a common, statistically-based study design incorporating regulatory guidance and current scientific principles related to aquatic monitoring. The assessment of data and information collected during future monitoring programs will be compiled into periodic aquatics monitoring reports which will be submitted to the appropriate regulatory agencies for review.

4 POTENTIAL MITIGATION ACTIVITIES

A number of mitigation activities are planned in order to reduce the effects of the Project on aquatic VECs. These include a variety of Project environmental design features, specialized mitigation, and environmental protection plans (i.e., sediment and erosion control plans), as well as fish habitat compensation plans. The information presented below provides a summary of mitigation measures which will be implemented to limit changes to hydrology, hydrogeology, water quality, sediment quality, aquatic organisms, fish populations, and fish habitat. Because effects to individual VECs are potentially accumulative in response to an alteration of another component of the aquatic environment (i.e., a change to water quality can subsequently affect the health of fish and other aquatic organisms), a single mitigation activity may serve to limit effects to a range of aquatic VECs. Therefore the list of mitigation activities planned for the aquatic environment is described collectively for all aquatic VECs:

- The site footprint for the Kiggavik and Sissons Mine and associated infrastructure will be minimized and situated such that natural drainage areas and watershed boundaries are maintained. This will reduce effects to flow rates and water levels in the aquatic environment.
- The site water system will be designed to recycle water where applicable, and water use will be minimized to limit withdrawal requirements and discharge quantities.
- The design of the Water Treatment Plant (WTP) will focus on the production of effluent that meets or exceeds all appropriate regulations, such as the Metal Mining Effluent Regulation (MMER), as well as site-specific discharge limits. This will reduce potential accumulative effects to sediment quality, and fish and aquatic organism health.
- Water will be discharged into large waterbodies to reduce effects on sediment quality, water quantity, and downstream aquatic ecosystems.
- The proposed tailings management plan has been designed to avoid interaction between tailings and natural water bodies, to maximize the use of mine workings for long-term management of tailings, and to ensure the long-term protection of terrestrial, aquatic, and human environments.
- The tailings treatment system in the mill and the Tailings Management Facilities will be designed to minimize the release of constituents of potential concern (COPC) into the aquatic environment.
- Diversion channels will be designed to intercept freshwater from upslope areas, divert it around development areas, and reintroduce it to natural stream channels further downstream. This will limit effects to flow patterns, downstream flow rates, and minimize potential of erosion.

- During decommissioning, the ground surface will be recontoured and natural flow patterns will be restored to help maintain pre-mining flow patterns and conditions, waterbody characteristics and natural aquatic ecosystems.
- Sedimentation ponds associated with the surface water diversion channels will be designed with a control structure so that evaporative losses can be minimized and sufficient water can be returned to the downstream environment to maintain aquatic ecosystems.
- Best management practices have been incorporated into the Project design to control surface water runoff and minimize the potential for erosion and effects to water quality and aquatic ecosystems.
- Measures will be taken to minimize the amount of dust generated at the two mine sites and along the main haul road between the mine sites. This will reduce the deposition of particulates and metals into local waterbodies.
- Scrubbers are being considered for installation on emissions from the sulphuric acid plant, and NOx control systems are being considered for installation on the oil-fired power generators and/or product driers to mitigate the release of acid generating materials to the atmosphere. This will limit the potential for lake acidification and successive effects to aquatic organism health.
- Snow fences will be constructed to limit snow drifting on site and therefore prevent potential elevated flow rates, erosion, and subsequent effects to the aquatic ecosystem during the spring freshet immediately downstream of site.
- Andrew Lake pit will be dewatered during the construction phase and refilled with water during the closure phase at a rate such that effects to water quality and sediment quality are minimized. Only water that meets discharge criteria will be released directly to the environment.
- During project construction the Andrew Lake Pit area will be dewatered after the spring freshet and before freeze-up (July/August) to reduce the volume of water that will require pumping and to ensure that Andrew Lake water levels do not exceed the annual peak level.
- DFO procedures for water withdrawal from ice-covered waterbodies in the Northwest Territories and Nunavut will be followed. Specifically, no more than 10% of the under-ice volume will be withdrawn from a lake during one ice covered season.
- In-water construction will follow standard protocols and best management practices.
- Use of a turbidity curtain to separate construction activities from the surrounding lake environment will limit total suspended sediment (TSS) released during the installation of the water intake structures, the effluent diffuser structures, and construction of the Andrew Lake Pit berm.
- Fish salvage will be completed before in-water construction activities associated with the development of the Andrew Lake Pit are initiated in order to minimize the potential for fish mortalities due to stranding. Salvaged fish will be returned to Andrew Lake outside of the construction area.
- Fish habitat compensation will be implemented as a result of the construction of the berm at Andrew Lake and dewatering the north-east end of the lake. Following consultation with DFO staff on the issue of determining appropriate compensation options, AREVA has

prepared a FHCP that proposes to replace the area of lost habitat with a similar amount of shallow, seasonal use habitat.

- Roads constructed in association with the Project will be designed so that natural flow paths intercepted by the route are preserved with adequately designed cross-drainage structures (i.e., culverts). Construction of stream crossings will be completed in such a way that potential effects to fish and fish habitat are mitigated.
- Fish habitat compensation will be implemented for the culvert installation's footprint on the natural stream bed. In consultation with DFO, AREVA has prepared a FHCP that proposes to identify and improve limiting habitat types for each affected stream.
- An erosion and sediment control plan will be developed in association with Project construction activities taking place in or near waterbodies in order to reduce possible effects to water quality and fish habitat from surface water runoff and associated erosion. This plan will be developed prior to the start-up of construction, and will be followed throughout the duration of the construction. This plan will specify the erosion and sediment control measures that will be put into place by the construction contractors to prevent the entry of sediment into waterbodies. Potential erosion control measures include minimizing the disturbed area, stabilizing exposed soil, and re-vegetating slopes. Sediment control measures will focus on intercepting sediment-laden runoff that has escaped the erosion control measures. Sediment control measures may include the use of silt fences, turbidity curtains, filter barriers, or control ponds. The selection of the best measures to control erosion and remove sediment will depend on the construction activity, local site conditions, and recommendations made by DFO and other regulatory agencies. The sediment and erosion control plan will be prepared in consultation with the construction contractor, DFO and other interested parties. The control measures will be inspected regularly by the construction contractors or AREVA during the course of construction. Necessary repairs will be made if any damage occurs.

5 SCOPE OF POTENTIAL MONITORING PROGRAMS

Three basic types of monitoring are planned following the key issues raised in the EIS; compliance monitoring and inspection, follow-up monitoring, and Environmental Effects Monitoring. Cumulative effects monitoring is not proposed for the aquatic environment because the potential effects of the Project on the receiving environment do not extend beyond the local assessment area and, therefore, do not overlap with other regional projects.

5.1 COMPLIANCE MONITORING AND INSPECTIONS

Compliance monitoring and inspections are programs that are designed to confirm that the approved environmental design features and all appropriate construction design standards have been implemented as per the EIS. As each project component is constructed, the component will be inspected to ensure construction issues are managed and that the completed work has met the approved design standards. A check list will also be developed to show that agreed-upon environmental design features are constructed as required. Compliance monitoring and inspections will be primarily focussed on the Project Footprint area covered by the Kiggavik and Sissons Mine Sites, as well as any associated Project infrastructure (i.e., utility corridors, roads, water intake and treated water discharge structures, and airstrip). Compliance monitoring will extend throughout the life of the Project.

5.2 FOLLOW-UP MONITORING

Follow-up monitoring will consist of programs that are designed to verify key inputs to the effects assessment, such as whether the predicted quality of the discharged water from the WTP is attained. In addition, it includes fish habitat compensation monitoring to ensure that DFO's no-net-loss objective has been achieved. Thus follow-up monitoring is used to confirm that where no effects were predicted that this is indeed the case and that the level of uncertainty related to impact predictions is reduced. Similar to compliance monitoring, follow-up monitoring is primarily associated with the Project Footprint area, but will include a number of monitoring activities in downstream waterbodies as well (i.e., monitoring of fish and aquatic organisms in the receiving environment).

5.3 ECOLOGICAL EFFECTS MONITORING

As per subsection 36(3) of the *Fisheries Act*, the implementation of an Environmental Effects Monitoring program is required of all operating metal mines in Canada. The national EEM program is carried out under the Metal Mining Effluent Regulations and is administered by Environment Canada. The key components of EEM include effluent characterization and water quality monitoring studies, as well as a biological monitoring component. The EEM study area is comprised of areas anticipated to be influenced by mining related activity (exposure areas) and those areas beyond any mining influence (reference areas).

The effluent and water quality component of EEM requires regular monitoring of effluent quality and water quality in the receiving environment, as well as periodic laboratory testing of effluent for acute and sublethal toxicity to fish and other aquatic organisms. The effluent and water quality component of EEM is intended to support the interpretation of biological data. The biological monitoring studies focus on identifying potential effects of effluent release to fish populations and fish health as well as to fish prey resources (i.e., benthic invertebrate surveys) and the usability of fisheries resources by humans (i.e., fish tissue content studies) (EC 2002).

Each EEM cycle includes the submission of a study design, field studies (monitoring), and a reporting component. Initiation of the first EEM biological monitoring study occurs 1-2 years after the Mine becomes subject to Section 7 of the MMER. Effluent and water quality monitoring is conducted on an on-going basis (quarterly), while the biological monitoring study is completed periodically (usually every third year). Successive EEM programs are designed to build on the results of earlier studies and require more or less extensive monitoring, depending on effects identified. Preliminary studies attempt to identify possible biological effects in near-field environments (i.e., close to the point of effluent discharge). If biological effects are identified in the near-field, and subsequent studies verify those effects, then an attempt is made to evaluate magnitude and extent, and assess effluent-related causes (EC 2002).

The Kiggavik Project AEMP will be designed to incorporate the biological and chemical monitoring parameters identified in the EEM guidance documents and will be adapted as required, taking into account the results of respective EEM studies and the guidelines set out in the MMER. After completion of the EEM Study Design and field sampling component, the field data are interpreted and the results submitted to the identified Environment Canada Authorization Officer. Environment Canada will then review and provide feedback on study designs and interpretive reports.

6 POTENTIAL MONITORING ACTIVITIES

This section provides an overview of the potential monitoring programs planned in relation to the identified project effects on aquatic valued ecosystem components as well as any relevant regulatory considerations. This information can be used as a framework for the eventual development of the detailed Kiggavik Project AEMP. A concise summary of potential monitoring activities is also provided in Table 6.0-1 for each aquatic VEC to complement the information presented below.

6.1 HYDROLOGY

Key issues identified for surface hydrology included changes to streamflow rates and lake levels and volumes that may affect other components of the aquatic, terrestrial, and socioeconomic environments. Specific activities include the dewatering of ponds and standing water during site clearing and pad construction, dewatering the pit area of Andrew Lake, freshwater withdrawal from lakes, the collection of site and stockpile drainage, and the discharge of treated effluents.

During construction, and through operations and decommissioning, water levels, flow rates and waterbody volumes can be monitored at locations potentially affected by project activities. These include Andrew Lake, Siamese Lake, Mushroom Lake, Judge Sissons Lake, and their outflow channels as a continuation of the baseline hydrology monitoring program.

Staff gauges can be installed on Andrew Lake, Siamese Lake, Mushroom Lake, Judge Sissons Lake, and their outflow discharges. Levels can be recorded on a regular basis during construction and through to decommissioning. Continuous water levels sensors can also be installed in these lakes and streams during the open water season to obtain detailed water level data. These efforts would be a continuation of the existing baseline monitoring program and would provide measurements of changes to water levels at the waterbodies potentially affected by project activities. The monitoring would commence at the start up of the construction phase of the Project. Continuous water level sensors would be installed during the active flow period during all phases of the Project. Staff gauges would be recorded on a monthly basis.

To monitor flow from waterbodies potentially affected by project activities, instantaneous discharge measurements can be taken at Andrew Lake Outflow, Siamese Lake Outflow, Mushroom Lake Outflow, and Judge Sissons Lake Outflow. These flow rates can be used to develop and maintain stage-discharge rating curves so that water level data can be used to estimate continuous discharge. This monitoring would commence at the start up of the construction phase of the Project and would be completed as required to build and maintain stage-discharge rating curves.

Monitoring of water withdrawal rates from Mushroom and Siamese Lakes will be completed on an on-going basis to verify that the volume of water extracted from Mushroom and Siamese Lakes does not exceed the limits specified in the water license. This monitoring will commence when Siamese and Mushroom Lake water intakes begin their operation and will be continually monitored for the duration that water is being withdrawn from the supply lakes.

Under-ice volumes can be confirmed by annual ice thickness measurements at Siamese Lake, Mushroom Lake, and ice road lakes. This monitoring would provide measurements of waterbody volumes and ice thicknesses of potentially-affected lakes. The monitoring would commence at the start up of the construction phase of the Project and would be completed annually during the month of April when minimum under ice volumes are expected to occur. This monitoring would occur during all phases of the project.

Monitoring of locations prone to ice jamming (i.e., culvert crossings along the Kiggavik-Sissons haul road) and removal of ice jams if necessary can be completed to ensure that the flow paths intercepted by the road are preserved and that stream crossings are not washed out as a result of an ice blockage. This monitoring can be initiated during break up the first spring after culvert installation along the haul road is complete and can be carried out on a weekly basis each spring during ice break-up.

6.2 HYDROGEOLOGY

Key issues for hydrogeology identified in the EIS included changes to ground water quality and potentially surface water quality as a result of tailings and mine rock management activities.

Monitoring of water quality in lakes and streams adjacent to and downstream of the Kiggavik and Sissons Mine sites can be completed during the spring freshet each year during the operational life of the Project to confirm that COPC do not increase in area lakes and streams as a result of tailings management or mine rock management activities.

Groundwater monitoring will be carried out in the rock mass surrounding the proposed Tailings Management Facility (TMF) to track chemistry and pressures as the excavation base penetrates the permafrost base and as the pit is filled with tailings material. This will allow changes in ground temperature and pressure gradients (i.e., flow direction) as well as water quality in the deep, sub-permafrost groundwater to be tracked over the construction and use of the TMF. This monitoring would be initiated prior to the TMF development and would be carried out from planning and design through operations, and finally into post closure. It is anticipated that a minimum of 9 groundwater monitoring wells will be installed in the Kiggavik site area (i.e., 3 wells per TMF, one up-gradient and two down-gradient) and 6 wells in the Sissons site area.

As the monitoring system will be operating in a deep permafrost environment, it will need to operate at temperatures well below 0°C. Pressure monitoring below permafrost will be carried out regularly using electronic transducers that are connected to the surface via an electrical wire. Regarding water sampling it is considered that a viable method will be to use a closed pipe system that can be used with an antifreeze fluid in the permafrost interval.

Investigations into the chemical and physical properties of tailings and mine rock will be continued as part of a Tailings Optimization and Validation Program (TOVP) and a Mine Rock Optimization and Validation Program (MOVP). These programs will provide further insight into the geochemical and physical characteristics of the materials to validate the proposed long-term management plans.

6.3 WATER QUALITY

Key issues for water quality identified as a result of the aquatic effects assessment include changes to surface water chemistry from treated effluent discharge from the Kiggavik and Sissons Water Treatment Plants (WTP), increased dust emissions and subsequent deposition of metals and particulates as a result of mine construction and operation, and acid deposition resulting from increased air emissions. Potential alteration to surface water chemistry from these sources may affect the aquatic organisms residing in local assessment area (LAA) waterbodies.

In order to meet MMER routine compliance responsibilities, effluent discharge rates will be continually documented. Wastewater and effluent water quality will likewise be analysed and documented regularly throughout the duration that the mine operation is subject to the MMER. Effluent chemistry parameters measured will include the deleterious substances identified under MMER (arsenic, copper, cyanide, lead, nickel, zinc, total suspended solids, radium 226, and pH) as well as other metals, nitrogen compounds, alkalinity, and hardness. This monitoring will be completed according to the schedules set out in the Metal Mining Effluent Regulations and the Metal Mining EEM Guidance Document and will extend for the duration that the Mine operation is subject to the MMER.

Under MMER, the Mine will also be required to conduct routine acute lethality testing of effluent on Rainbow Trout and Daphnia magna at least once per month during the time effluent is being discharged to Judge Sissons Lake (MMER; Government of Canada 2002, 2006). This monitoring would commence once the Mine becomes subject to MMER and would be completed according to the protocols described in the regulations and guidelines.

An additional stipulation of EEM requires that sub-lethal toxicity testing of effluent water be completed to identify any potential effects of mine water discharge on aquatic organism health. These tests measure the sublethal effects (i.e., survival, growth, and reproduction effects) of effluents on freshwater organisms under controlled laboratory conditions. Sublethal toxicity testing is conducted using aliquots of effluent collected during sampling for effluent characterization. These studies would be implemented according to the guidelines specified in the MMER. Testing typically occurs twice each calendar year for the first three years beginning six months after the Mine operation becomes subject to MMER.

Water quality in each section of Judge Sissons Lake receiving treated effluent, as well as at the outlet of Judge Sissons Lake, will be monitored on a seasonal basis to verify effects predictions related to changes in water quality for a period of one to two years. Water quality parameters will be consistent with those monitored during baseline surveys as well as those used as input variables through the modeling process (including field parameters [i.e., pH, conductivity, dissolved oxygen, temperature], physical parameters [e.g., total suspended solids {TSS}], major ions and total dissolved solids [TDS], total and dissolved metals, total and dissolved nutrients [e.g., total phosphorus, nitrogen compounds, and total organic carbon]).

Ongoing water chemistry monitoring will be carried out in conjunction with legislated EEM in Judge Sissons Lake. The EEM samples will be collected quarterly as indicated in the Metal Mining EEM Guidance Document, and will be analyzed for the same variables as required for effluent characterization, as well as a number of additional field and lab measured parameters. AEMP Monitoring will commence at the time that the WTPs begin discharging effluent to Judge Sissons Lake, and would be completed monthly throughout operations and closure phases of the project. Sampling would be structured to capture the potential seasonal variation in water chemistry parameters (i.e., open water and under-ice conditions). Follow-up monitoring could be scaled back to once per year during post closure. EEM water quality monitoring will be completed for the duration that the Mine is subject to the MMER.

Water quality in lakes and streams adjacent to and downstream of the Mine site LAA will be monitored to confirm that metals and radionuclide concentrations, TSS and acid deposition, as well as lake acidification are not increasing above predicted or acceptable levels due to air emissions and the deposition of dust from Project related activities. This monitoring would occur during the spring freshet each year for two years following the start of mining operations, and periodically thereafter, during the operational and closure phases of the Project.

Monitoring of locations prone to ice jamming (i.e., culvert crossings along the Kiggavik-Sissons haul road) and removal of ice jams, if necessary, would be completed to ensure that potential ice blockages at stream crossings do not cause the overlying road to wash out. The potential inflow of sediment to the stream system associated with a road washout could potentially alter the chemistry of stream water and have adverse effects on the aquatic ecosystem, especially fish habitat. This monitoring can be initiated during break up the first spring after culvert installation along the haul road is complete, and can be carried out on a weekly basis each spring during ice break-up.

A water quality monitoring program will be completed during in water construction activities (i.e., during the construction of the Andrew Lake Pit berm) to routinely assess the integrity and function of the sediment/turbidity curtain which will be installed to limit increased turbidity. Based on other projects involving in-water excavation and construction, the monitoring program may consist of: daily inspections of turbidity curtain, visual observation of fish in the vicinity of the turbidity curtain, daily (morning and afternoon) collection of water samples for monitoring of turbidity and TSS, and increased frequency of sampling in the event that a breach in the turbidity curtain is detected.

During the closure phase of the project, monitoring of water chemistry parameters of the re-flooded Andrew Lake Pit will be carried out to determine whether or not the dyke separating Andrew Lake from the re-flooded mine pit should be breached and the two waterbodies re-connected. This monitoring would be initiated at decommissioning and should be carried out until water chemistry of the pit reaches a stable equilibrium.

6.4 SEDIMENT QUALITY

The key issue identified for sediment as a result of the project is the potential for changes to sediment chemistry from the release of treated effluent from the Kiggavik and Sissons Water Treatment Plants and other project effects described in section 6.3. Effluent discharge can affect water quality in the receiving environment and subsequently affect the sediment through processes such as settling and absorption. Contaminant levels in sediment can have an effect on biota that reside in sediment, as well as wildlife that may incidentally ingest sediment while feeding on other aquatic biota.

Periodic follow-up monitoring of sediment quality can be carried out to confirm that effects from air and dust emissions on sediment quality (i.e., changes to metals, radionuclide concentrations, and lake sedimentation rates) are not increasing above predicted levels in lakes adjacent to and downstream of the Mine site LAA. Bottom sediment sampling can be completed at a subset of the water quality sampling stations where fine sediments accumulate to evaluate the effects of the Project on sediment quality. Sediment quality parameters would include particle size distribution, total organic carbon, and concentrations of nutrients and metals. Sediment quality monitoring would occur in the fall prior to freeze-up, every third year during the operational and closure phases of the Project, and once every five years during the post closure phase. The monitoring would commence at operations start up and could potentially be completed in conjunction with the EEM benthic invertebrate community survey.

While sediment quality is not a regular component of the Environment Canada EEM program, monitoring of sediment may be required by the Canadian Nuclear Safety Commission (CNSC) in addition to the usual EEM chemical monitoring parameters. This monitoring would likely be combined with the EEM benthic monitoring survey which is usually completed every third year.

6.5 AQUATIC ORGANISMS AND FISH HABITAT

Key issues for aquatic organisms and fish habitat identified in the EIS include toxicity effects to aquatic biota from treated effluent discharge; and potential effects resulting from the alteration, disruption, and/or loss of fish habitat from Project development activities. In addition, runoff from project construction activities occurring in or near surface waterbodies have the potential to adversely affect water quality and fish habitat in the affected systems.

Under MMER, AREVA is required to conduct EEM to determine if effluent release is having an effect on the health of aquatic organisms in the receiving environment. One aspect of the EEM program involves quantifying effects to fish habitat through comparison of benthic invertebrate prey communities collected from areas exposed and unexposed to effluent. This is done by collecting benthic invertebrates in the exposure area and reference area and involves comparison of a number of biological indices (e.g., density, taxa richness, Simpson's Evenness Index, and Bray-Curtis Similarity Index) to determine potential effects of effluent on the benthic invertebrate community. Samples from both the exposure and reference areas would be collected from an ecologically relevant area and season and would be completed as part of the regular EEM cycle as specified under MMER.

Because effects to aquatic organism health are potentially accumulative in response to changes in water and sediment chemistry, results of the additional monitoring activities described for these components (i.e., monitoring of effluent quantity and quality) can also be considered useful in determining subsequent effects to the health of benthic invertebrate and plankton species.

Monitoring of locations prone to ice jamming (i.e., culvert crossings along the Kiggavik-Sissons haul road) and removal of ice jams if necessary will be completed to monitor and mitigate any potential blockages to the movement of fish to seasonal use habitat areas as a result of ice jams occurring at culvert crossings along the Kiggavik-Sissons haul road. This monitoring can be initiated during break up the first spring after culvert installation along the haul road is complete and can be carried out on a weekly basis each spring during ice break-up.

A compliance and effectiveness monitoring program will be carried out to show that the compensation works implemented in association with identified fish habitat losses resulting from Project development activities have been built as specified and approved. The Fish Habitat Compensation Plan (FHCP) will specify in detail the mitigation and/or compensation that will be required to address the expected losses of fish habitat related to the Project. Once the approved compensation measures have been constructed, they will be inspected to confirm that that they are functioning effectively and as designed. The intent of this monitoring will be to confirm that the compensation works identified in the FHCP meet the DFO requirement that the Project results in "no-net-loss" of fish habitat. Monitoring will be conducted between 1 and 5 years after the completion of compensation works, and will be carried out until it can be demonstrated that the compensation measures are working effectively (e.g., fish are using the area).

6.6 FISH POPULATIONS

Key issues for fish populations identified in the EIS include; possible effects from blasting in or near water which can damage the internal organs of fish, kill or injure fish eggs and larvae, and alter fish behaviour; and the potential for toxicity effects to fish from treated effluent discharge from the Kiggavik and Sissons Water Treatment Plants.

To ensure that blasting activities do not harm fish populations, monitoring programs can be developed and carried out on site at locations away from fish-bearing waterbodies to calibrate and refine the ground vibration and instantaneous pressure charge (ICP) models which were developed during the EA process to establish the set back distances required to protect fish populations. This monitoring would provide site-tested ground vibration and IPC setback distance thresholds, prior to blasting programs commencing near sensitive waterbodies. If blasting must occur during the timeframe that Arctic grayling spawning occurs in the Andrew Lake outlet stream, then additional monitoring of fish behaviour can be conducted to assess whether there are any potential residual effects from blasting which are not resolved by adherence to the vibration and ICP setback thresholds. This monitoring would be primarily observational; the stream would first be surveyed (visually) to confirm that fish are indeed present during blasting (i.e., they have not moved out of the stream due to disturbance) and secondly, that the behaviour of individuals occupying the stream during the spawning period is not altered (i.e., fish are not startled by the shock of an explosive). If disturbance is noted, setback distance thresholds and charge size selection may have to be reassessed.

Under MMER, AREVA is also required to conduct EEM to determine if effluent release is having an effect on fish and fish habitat in the receiving environment. Effects on fish are assessed through comparison of adult fish exposed to effluent with unexposed fish. The fish survey is conducted to determine if there have been changes in indicators of fish growth, reproduction, condition, and survival as a result of effluent release. According to EEM guidelines, changes in these indicators would be assessed by collecting fish species found in the exposure and reference area, and comparing (where possible) measurements of length, weight, age, liver weight (an indicator of energy storage), maturity, gonad weight, fecundity (a measure of reproduction), and egg weight. Effects of effluent discharge would then be assessed by comparing results for fish collected in the exposure area with those from fish collected in the reference area. This monitoring would be implemented according to the schedule and protocols identified in the EEM guidance documents.

Effects on the use of fisheries resources are assessed by comparing mercury concentrations in edible fish tissue against fish health consumption guidelines. This component is designed to determine if effluent has an effect on fish usability as measured by tissue metal content, with particular attention paid to tissue mercury concentrations.

Table 6.0-1
Summary of Potential Monitoring Activities Planned for Aquatic VECs

Section Number	Section Name	Monitoring Type: Compliance, Environmental, Follow-up	Description of Monitoring Required	Rationale for Required Monitoring	When Does Monitoring Commence?	Required Duration of Monitoring
6.6	Hydrology	Follow-up	Installation and monitoring of staff gauges and continuous water level sensors in Andrew Lake, Siamese Lake, Mushroom Lake, Judge Sissons Lake, and their outflow channels.	To provide measurements of changes to water levels at the waterbodies potentially affected by project activities	At construction start-up.	Staff gauges will be recorded monthly and sensors will be installed during the active flow period during all phases of the project.
6.6	Hydrology	Follow-up	Measurements of instantaneous discharge at Andrew Lake Outflow, Siamese Lake Outflow, Mushroom Lake Outflow, and Judge Sissons Lake Outflow.	To provide measurements of flow from waterbodies potentially affected by project activities. These flow rates can be used to develop and maintain stage-discharge rating curves so that water level data can be used to estimate continuous discharge.	At construction start-up.	As required to build and maintain stage-discharge rating curves.
6.6	Hydrology	Compliance	Monitoring of water withdrawal rates from Mushroom and Siamese Lakes.	To verify that the water volumes extracted from Mushroom and Siamese Lakes do not exceed the limits specified in the water license.	Once Siamese and Mushroom Lake water intakes begin operation.	Continually, for the duration that water is being withdrawn from Siamese and Mushroom Lakes.
6.6	Hydrology	Follow-up	Monitoring of lake under-ice volumes from annual ice thickness measurements at Siamese Lake, Mushroom Lake, and winter ice road lakes.	To confirm that estimated waterbody volumes and ice thicknesses of potentially affected lakes are within the expected range.	At construction start-up.	Annually during the month of April when ice thickness is greatest; throughout all phases of the project.
6.6	Hydrology	Compliance	Monitoring of locations prone to ice jamming (i.e., culvert crossings along the Kiggavik-Sissons haul road) and removal of ice jams if necessary.	To identify and remove any potential ice blockages at stream crossings which could impede the flow of water through culverts.	During break up the first spring after the installation of culverts along the haul road.	Ice break-up will be monitored weekly during spring break up each year.
7.7	Hydrogeology	Compliance; Follow-up	Water quality monitoring of lakes and streams adjacent to and downstream of the Mine areas.	To confirm that COPC do not increase as a result of tailings management of mine rock management activities.	At the start-up of the project operations phase.	Annually during spring freshet during the operational life of the project.
7.7	Hydrogeology	Follow-up	Groundwater monitoring in the rock mass surrounding the proposed TMF as the excavation base penetrates the permafrost base, and as the pit is filled with tailings material.	To track changes in ground temperature pressure gradients (flow direction) and water quality in the deep, sub-permafrost, groundwater.	Prior to the project development.	All phases; from planning and design, through operations, and finally into closure.
7.7	Hydrogeology	Follow-up	Monitoring of the chemical and physical properties of tailings and mine rock through the continued development and implementation of the Tailings Optimization and Validation Program (TOVP) and Mine Rock Optimization and Validation Program (MOVP).	To address unforeseen circumstances that could result in a significant increase in the mass flux of solutes to the receptors.	Prior to the project development.	On-going programs during operation with reporting every 5 years.
8.7	Water Quality	Compliance	Monitoring of wastewater/effluent discharge rates.	Routine monitoring of treated effluent quantity for compliance purposes.	Once the mine becomes subject to MMER (i.e., once effluent discharge rates exceed 50 m3 per day and/or deleterious substances are discharged into Judge Sissons Lake).	Monthly as part of MMER compliance monitoring for the duration that the Mine is subject to MMER.
8.7	Water Quality	Compliance; EEM	Wastewater/effluent discharge quality will be analyzed and documented regularly.	Routine monitoring of treated effluent quality for compliance purposes.	MMER routine effluent water sampling will begin when the Mine becomes subject to MMER; EEM effluent characterization samples must be taken no later than six months after the mine becomes subject to MMER.	Monthly as part of MMER compliance monitoring, and four times each calendar year for EEM sampling for the duration that the Mine is subject to MMER;
8.7	Water Quality	Compliance	Routine acute lethality testing of effluent on Rainbow Trout and Daphnia magna.	For compliance purposes to verify that effluent water is not acutely lethal to fish and aquatic organisms.	Upon which time the Mine becomes subject to MMER.	Monthly as part of MMER compliance monitoring during the time that effluent is being discharged to the environment; or immediately if a deposit occurs outside the normal course of events.

Table 6.0-1
Summary of Potential Monitoring Activities Planned for Aquatic VECs

Section Number	Section Name	Monitoring Type: Compliance, Environmental, Follow-up	Description of Monitoring Required	Rationale for Required Monitoring	When Does Monitoring Commence?	Required Duration of Monitoring
8.7	Water Quality	EEM	Sub-lethal toxicity testing of effluent water.	To identify any potential effects of mine water discharge on aquatic organism health. These tests measure the sublethal effects (i.e., survival, growth, reproduction effects) of effluents on at least three freshwater organisms under controlled laboratory conditions and are conducted using aliquots of effluent collected during sampling for effluent characterization.	The first effluent sample will be collected, and sublethal toxicity testing conducted, no later than six months after the mine is subject to MMER.	Twice each calendar year for the first three years to fulfill EEM program requirements.
8.7	Water Quality	Follow-up; EEM	Monitoring of water quality in each section of Judge Sissons Lake receiving treated effluent, as well as at the outlet of Judge Sissons Lake.	Routine monitoring of water chemistry parameter for EEM purposes and to confirm predictions and model inputs made in the EIS.	For follow-up monitoring, water chemistry sampling will begin when WTPs start up. For EEM purposes, the first sample collected will be taken no later than six months after the mine becomes subject to MMER.	For follow-up purposes, water chemistry will be monitored on a seasonal basis for a period of two years following operations startup to verify effects predictions related to changes in water quality. For EEM purposes, monitoring will be conducted four times each calendar year, at least one month apart for the duration that the Mine is subject to MMER.
8.7	Water Quality	Follow-up	Water quality monitoring in lakes and streams adjacent to and downstream of the Mine LAA.	To confirm that predicted effects of air and dust emissions on water quality (i.e., changes to metals and radionuclide concentrations, TSS and acid deposition levels, and lake pH) are not increasing above expected levels.	At operations start-up.	During spring freshet for two years following the start of mining operations, and then periodically thereafter during the operational and closure phases of the Project.
8.7	Water Quality	Follow-up	Monitoring of locations prone to ice jamming (i.e., culvert crossings along the Kiggavik-Sissons haul road) and removal of ice jams if necessary.	To identify and remove any potential ice blockages at stream crossings which could cause a culvert to overflow and stream water to wash over the road. The potential inflow of sediment to the stream system associated with a washout could alter water quality of seasonal use aquatic habitats.	During break up the first spring after the installation of culverts along the haul road.	Ice break-up will be monitored weekly during spring break up to ensure that any associated erosion does not affect water quality.
8.7	Water Quality	Compliance	Water quality monitoring during in water construction activities.	To confirm that turbidity and total suspended sediments (TSS) levels associated with potential sediment influx from in-water construction activities do not increase such that local fish populations are adversely affected.	At start-up of in-water construction activities.	The duration of monitoring required will be determined in consultation with DFO.
8.7	Water Quality	Compliance	Monitoring of water chemistry parameters of the re-flooded Andrew Lake Pit.	To determine if and when the dyke separating Andrew Lake from the re-flooded mine pit should be breached and the two waterbodies connected. If water quality is good then the two water bodies could be connected. If water quality is poor or unsuitable for fish use, the waterbodies should remain unconnected.	Upon completion of flooding of the mine pit.	Every one to three years until water quality in the flooded pit stabilizes.

Table 6.0-1
Summary of Potential Monitoring Activities Planned for Aquatic VECs

Section Number	Section Name	Monitoring Type: Compliance, Environmental, Follow-up	Description of Monitoring Required	Rationale for Required Monitoring	When Does Monitoring Commence?	Required Duration of Monitoring
9.7	Sediment Quality	Follow-up	Sediment quality monitoring in lakes adjacent to and downstream of the Mine LAA.	To confirm that effects of air and dust emissions on sediment quality (i.e., changes to metals and radionuclide concentrations, and lake sedimentation rates) are not increasing above predicted levels.	At operations start-up.	Every third year in the fall prior to freeze up during the operational and closure phases of the Project, and every fifth year in the fall prior to freeze up during the post closure phase.
10.7	Sediment Quality	EEM	Monitoring of sediment quality in Judge Sissons Lake.	To identify potential effects of effluent discharge on sediment quality in the receiving environment in Judge Sissons Lake and to support the interpretation of the EEM benthic invertebrate survey data.	The first EEM biological monitoring study will be completed approximately 1-3 years after the Mine becomes subject to MMER.	EEM sediment sampling will be completed during the biological monitoring component of the EEM program (usually every third year) and will be collected concurrently with benthic invertebrate community survey data collection.
10.7	Aquatic Organisms and Fish Habitat	Follow-up	Monitoring of locations prone to ice jamming (i.e., culvert crossings along the Kiggavik-Sissons haul road) and removal of ice jams if necessary.	To identify and remove any potential blockages to the movement of fish to seasonal use habitat areas as a result of ice jams occurring at culvert crossings along the Kiggavik-Sissons haul road.	During break up the first spring after the installation of culverts along the haul road.	Ice break-up will be monitored weekly during spring break up to ensure that seasonal use aquatic habitat areas remain accessible to fish.
10.7	Aquatic Organisms and Fish Habitat	EEM	Monitoring of benthic invertebrate communities in reference and exposure areas of Judge Sissons Lake.	To identify potential effects of effluent release effects on fish habitat through comparison of benthic invertebrate prey communities collected from areas exposed and unexposed to effluent.	Initiation of the first EEM biological monitoring study will occur approximately 1-3 years after the Mine becomes subject to MMER.	Every 3 years once the Mine is subject to MMER.
10.7	Aquatic Organisms and Fish Habitat	Follow-up	Effectiveness monitoring of works developed to compensate for the loss of fish habitat as a result of Project development activities.	To confirm that the works outlined in the Fish Habitat Compensation Plan have been constructed as specified and approved, and that they are functioning effectively (i.e., that the Project result in "no-net-loss" of fish habitat).	Following implementation of approved fish habitat compensation works.	Monitoring will be conducted between 1 and 5 years after the completion of compensation works and will be carried out until it can be demonstrated that the compensation measures are working effectively (e.g., fish are using the area)
11.7	Fish Populations	Follow-up	Monitoring to calibrate and refine the ground vibration and instantaneous pressure change models developed during the EA process at locations away from fish-bearing waterbodies.	To provide Sissons Mine site-tested ground vibration and IPC setback distance thresholds near fish sensitive waterbodies.	Prior to the blasting programs commencing in the Andrew Lake and main zone pits.	Prior to and during blasting activities.
11.7	Fish Populations	Follow-up	Monitoring of fish populations in Andrew Lake outlet stream during blasting activities associated with mining the Andrew Lake open pit.	To assess whether there are any potential behavioural effects from blasting on spawning Arctic grayling which are not resolved by adhering to vibration and ICP setback thresholds. This monitoring would be necessary only if blasting must occur during the sensitive Arctic grayling spawning and egg incubation period.	At the beginning of the Arctic grayling spring spawning period in Andrew Lake outlet stream.	Monitoring should occur concurrently with blasting activities for the period of one month to six weeks long from early to mid-June to early to mid-July (Arctic grayling spawning period) until it can be shown that blasting effects on Arctic grayling spawning behavior are negligible.
11.7	Fish Populations	Environmental Effects Monitoring	Monitoring of fish growth, reproduction, condition, and survival in reference and exposure areas of Judge Sissons Lake.	To identify potential effects of effluent release on fish populations and fish health.	Initiation of the first EEM biological monitoring study will occur approximately 1-3 years after the Mine becomes subject to MMER.	Every 3 years once the Mine is subject to MMER.
11.7	Fish Populations	Environmental Effects Monitoring	Monitoring of mercury concentrations in fish tissues in reference and exposure areas of Judge Sissons Lake.	To identify potential effects of effluent release on the usability of fish resources by humans.	Initiation of the first EEM biological monitoring study will occur approximately 1-3 years after the Mine becomes subject to MMER.	Every 3 years once the Mine is subject to MMER.

7 REFERENCES

Environment Canada. 2002. *Metal Mining Guidance Document for Aquatic Environmental Effects Monitoring*. EEM/2002. Environment Canada, Ottawa, ON. June 2002.

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