FIFTY YEARS ENVIRONMENTAL RECORD AT ELLIOT LAKE, ONTARIO CANADA

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ABSTRACT

Rio Algom Limited carries out care and maintenance of their uranium properties in the Elliot Lake area that were decommissioned and reclaimed during the 1990s. This included 10 underground mines, 8 metallurgical plants and 7 tailings areas. These historic mines were first developed in the mid-1950s to supply uranium to the United States and Britain for defence through Eldorado Mining and Refining. Seven were shut down by the early 1960s when the United States did not renew the contracts and did not reopen. Quirke, Panel and Stanleigh re-opened in the early 1980s to supply uranium for nuclear power plants. Stanleigh, the last operating mine, closed in 1996. Decommissioning and reclamation proposals were prepared for all sites and environmental assessments were completed for all of the properties in the late 1980s and 1990s. The decommissioning plans included the demolition of all surface facilities, sealing of the mine openings, and reclamation of the sites. The mine and mill sites were cleaned up, contoured and vegetated. Reclamation options were reviewed for each tailings area with the final closure plans including the flooding of 4 tailings areas, the covering and vegetation of 2 tailings areas and direct vegetation of 1 tailings area. In all cases, dams were either built or upgraded to meet Canadian Dam Safety Guidelines. Acid mine drainage has been curtailed at all of the flooded tailings areas with effluent treatment limited to polishing for radium 226 removal. The covered and vegetated sites are physically stable but continue to produce acidity which is treated at 2 lime treatment plants. The environmental assessments projected that for the selected reclamation plans, the area's ecology can be effectively protected, and that there are no impediments to the restoration of the entire Serpent River Watershed. Environmental monitoring has shown that the reclaimed sites are performing as expected, and that healthy aquatic communities are present in all major waterways in the region.

This paper will describe the reclamation activities and environmental changes over the 50 years since the mines were first opened.

1. INTRODUCTION

Uranium was first discovered in the Elliot Lake area in 1953. There was a rush to develop the uranium mines with a total of twelve mines and 11 mills brought into production over a period of 3 years (1955 to 1958) [1] (see Figure 1). Rio Algom acquired the majority of the Elliot Lake mines and mills as shown on Table 1.

TABLE 1 - Rio Algom Limited, Summary of Elliot Lake Uranium Operations

Mine		**Mill**	**Tailings Area**		
Mine Site Or Tailings	**Operating Period**	**Capacity t/day**	**Size Ha**	**Closure Method**	**Million Tonnes Stored**
Buckles	1957-1958	Ore to Spanish and Lacnor	-	-	-
Milliken	1958-1964	2720	-	Tailings to Stanleigh	-
Lacnor	1957-1960	2720	27	Soil cover, vegetated	2.7
Nordic	1957-1968	3000	107	Direct Vegetation	12
Sheriff Park	1958 - 1964	No mine/mill	12	Soil and water cover	0.15
Stanleigh	1958-1960 1983-1996	2720 5000	352	Water covered	20
Spanish American	1958-1959	1810	5	Water covered	0.5
Panel	1958-1961 1979-1990	2810 3000	123	Water covered	15
Quirke I and II	1956-61 1968-1990	2720 4080-6360	192	Water covered	42
Pronto	1955-1960	1360	47	Direct vegetation and paper mill sludge cover for fines	2.1

All of the tailings are potentially acid generating. In the 1950s environmental practices for tailings would place them near the mills where gravity flow was possible, often in lakes and depressions. However, not being engineered for prevention of acid generation, the tailings could not all be kept under water, and by the early 1960s, untreated acidity from the exposed tailings areas were having a significant impact on the water quality of the upper Serpent River system. This watershed draining to Quirke Lake covers 300 km^2 with a mean annual flow of about 6 $m^3 s^{-1}$. By the late 1960s, acidic discharges from the historical dewatering of six mines and effluents from five tailing areas had reduced the pH in Quirke Lake to <5.0 with radium 226 levels of >0.7 Bq L^{-1} [2]. The non-operating tailings basins with exposed tailings had become acidic and these acid drainages were also affecting the water quality and fisheries in several downstream lakes.

During the 1970s, the energy crisis created a new demand for uranium and Quirke, Panel and Stanleigh were reopened and expanded. The new mines were subject to environmental assessments and hearings. These new operations adopted modern waste management and effluent treatment practices, which combined with mitigation

Figure 1

SITE LOCATION MAP

SOURCE: Basemap adapted from Energy, Mines and Resources Canada, 1986

0 10 mi

0 10 km

activities at the closed mines, resulted in improving conditions within the entire Serpent River watershed. By 1985, 4 mills were operating with a design capacity of almost 30,000 tonnes per day. By this time it became clear that permanent closure of the mines was imminent. Low uranium prices and low uranium ore grades[1] made Elliot Lake production costs uncompetitive with the mines discovered in Northern Saskatchewan and Rio Algom began to investigate options for the closure of the mines and tailings areas. The challenge after 40 years of mining was to upgrade the historic sites, and reclaim the newer ones to achieve a robust long term management solution for the tailings basins. In total, these comprised 9 tailings basins covering about 10 km^2 and containing about 200 million tonnes.

2. ENVIRONMENTAL PROCESS

From 1994-1996 the closure of the operating mines was subjected to a Federal environmental assessment. For the 5 mining operations on the North Limb (Quirke, Panel, Denison, Stanrock and CanMet Mines) the assessment focused on the tailings areas. A Federal Environmental Assessment Review Panel was formed by the Minister to conduct the process. Over a period of about 2 years, the Panel held meetings to scope issues for the hearings; prepared project-specific guidelines for the assessment; solicited review comments from the public and regulators; held public hearings; and, prepared a final report in June 1996. The Panel endorsed the proponents' proposals [5], adding a number of conditions they recommended to be included in the Decommissioning Licences. These conditions were broad ranging, and included provisions for financial assurance, detailed monitoring, research, and community involvement.

The historic mines – these include: Lacnor, Nordic, Buckles, Pronto, Milliken, Sheriff Park and Spanish American – had all been closed from 1958 to 1968. Although the historic mines were not directly included as part of the project reviewed by the Panel, the cumulative effects from these operations were addressed in both environmental and radiological pathways analyses and included in the Serpent River monitoring program.

In 1996-1997 Stanleigh also conducted an environmental assessment [4,6,7]; similar in scope to those previously completed for Quirke and Panel and included active public participation programs.

Rio Algom retains a Radioactive Waste Facility Operating License issued from the Canadian Nuclear Safety Commission. This licence authorizes the possession and management of the radioactive tailings at all of Rio Algom's closed mines in the Elliot Lake area.

The Canadian Nuclear Safety Commission is the lead agency responsible for nuclear facilities. It was recognized early in the decommissioning process that there are a

[1] Ore grade at Panel and Quirke was in the range 1.8 to 2.2 pounds per ton U, with the average about 2.1. Stanleigh ranged from about 1.6 to 2.1 with an average of about 1.9.

number of other federal and provincial agencies with responsibilities related to the decommissioning of mines. To facilitate the regulatory review and approval process, the Elliot Lake Joint Review Group, consisting of the Canadian Nuclear Safety Commission, Environment Canada, Fisheries and Oceans Canada, Ontario Ministry of the Environment, Ontario Ministry of Natural Resources, Ontario Ministry of Labour, and the Ontario Ministry of Northern Development and Mines was established. The Canadian Nuclear Safety Commission is the lead agency and distributes relevant documentation submitted by the mining companies and collates comments and concerns from the Joint Review Group for response by the mining companies. This process has worked very well to ensure that all regulatory agency concerns can be addressed in a timely way and that duplication of effort is minimized. Only after all concerns have been addressed is approval granted.

3.0 RECLAMATION PROGRAM

Decommissioning plans were reviewed with regulators, the public, and scrutinized through formal environmental assessment hearings. The guiding principles for the decommissioning plans were drawn from the Atomic Energy Control Board "Regulations on Uranium and Thorium Mining", "Policy on the Decommissioning of Nuclear Facilities (Regulatory Document R-90)" and "Regulatory Objectives, Requirements and Guidelines for the Disposal of Radioactive Wastes- Long-Term Aspects (Regulatory Document R-104)".

The mine and plant sites were all demolished and the mines sealed. Detailed surveys identified all areas where contaminated soils were present. The prime contamination found was residual hydrocarbons (fuel, oil and grease) and gamma radiation from tailings spills and waste rock. Criteria for clean up were set by the provincial and federal regulators. Hydrocarbon contaminated soils were excavated to the concentration standards for soils. Excavations to the soil standards used visual and odour criteria. Confirmation sampling for the bottom and walls of the excavation according to the guidelines ensured targets were met prior to backfilling with clean material. All of the contaminated soil was disposed of in mine ventilation raises selected after a geological review of known faults and elevations to select raises with no lateral openings to the mine. A 50-foot plug of clean material was placed in the bottom of the raise and the contaminated soil was placed on this, followed by a second 50-foot plug of clean material and the surfaces contoured to minimize water ingress.

The gamma criterion required all grid areas to be less than 1 $\mu Sv\ h^{-1}$. With the clean-up completed, all sites were graded and vegetated leaving essentially no evidence of previous mining activity. Post-remediation gamma surveys indicate that properties have average gamma fields less than 0.1 $\mu Sv\ h^{-1}$ above background [2,3].

Each tailings area was assessed separately to develop an optimum closure strategy. In total, for the Rio Algom tailings areas, 4 were flooded and 4 vegetated. Soil covers were applied to selected areas to facilitate vegetation. The five water treatment plants have been left in place, however for the flooded basins, it is expected that these

treatment plants can be decommissioned in the future. The vegetated tailings basins Lacnor, Nordic and Pronto, will continue to produce acid drainage and will require interim treatment which will span from as little as 50 years at Pronto to perhaps more than 100 years at Nordic [4]. Specific reclamation strategies for the Rio Algom Mines are reviewed below.

The historic tailings deposits at Spanish American, Lacnor, Nordic, and Pronto were contained by non-engineered waste rock structures erected during the mine operating period in the 1950's and 60's. As part of the final decommissioning process in the 1990's, hydrological and geotechnical reviews were completed for all of the sites. Following these reviews, the retention dams and flood conveyance facilities were subjected to an engineering review. Improvements were designed and implemented for all of the sites to up upgrade the facilities to the same standards applied to the recently operated mines.

3.1) The Buckles Mine was a small mine that operated from 1957 to 1958 and supplied ore to the Lacnor and Spanish American mills. The mine has flooded, the head frame dismantled, the shaft sealed and the mine site reclaimed. There are no residual environmental issues with this mine. Buckles Creek residues were associated with the Nordic operation and are discussed below.

3.2) The Milliken Mine and mill operated from 1958 to 1964. The mill tailings were co-disposed with the Stanleigh tailings. Remedial works at Milliken included: cleanup of spilled tailings and contaminated soils; dismantling of the mine and mill buildings; capping of the mine openings, and vegetation of the mine site.

3.3) Sheriff Park provides a community walking trail around a wetland containing a small tailings spill from the Milliken Mine which drained to the Sheriff Park wetland. The Park area is about 35 hectares, 12 of which comprises the tailings area. These tailings were covered where exposed, and left in place as the wetland ecosystem was not materially impacted by the tailings and water quality was steadily improving. The area is routinely monitored as part of the Serpent River Watershed Monitoring Program (SRWMP) and continues to perform well. Total radium in 2003 averaged 0.07 Bq/L compared to the Metal Mining Effluent Regulation reference of 0.37 Bq/L.

3.4) The Lacnor Mine and mill operated from 1957 to 1958 producing 2.7 million tonnes of tailings that were discharged to the Lacnor tailing basin. The former lake/wetland area was dammed to create a 27 ha tailings area. The tailings were acidic by the early 1960s and acidic discharge water overflowed to the Nordic tailings basin. During the early 1980s, the tailings area was vegetated however much of the vegetation died off as a result of acidic salts migrating to the surface. Rio Algom reclaimed the mine site and tailings basin in the late 1990s. Remedial works at Lacnor included: cleanup of spilled tailings and contaminated soils; dismantling of the mine and mill buildings; capping of the mine openings; vegetation of the mine site; and reclamation of the tailings area. The tailings area works upgraded the

containment dams in accordance with Canadian Dam Safety Guidelines (CDSG), and vegetated the tailings area through the application of a waste rock barrier to act as a capillary break, followed by a layer of soil and vegetation. The basin is now fully reclaimed however acidity is still produced from the exposed sulphide mineralization in the tailings above the water table. The acidic runoff from the site is directed to the Nordic effluent treatment plant.

3.5) The Nordic Mine and mill operated from 1957 to 1968 producing 12,000,000 t of tailings which were discharged to the 107 ha tailings area. The tailings area is comprised of 2 basins: the Nordic Main; and the West Arm. The Nordic Main tailings area is unique to Elliot Lake in that this is the only tailings area founded on a deep deposit of pervious sands and gravels. As a result, the area is well drained and seepage into the groundwater table is a significant concern. The West Arm tailings basin is typical of the other rock rimmed tailings basins in the area. Surface drainage from the West arm, runoff from Lacnor and Nordic main are collected and treated at the Nordic lime treatment plant. Seepage from the West Arm is also intercepted and pumped to treatment. Remedial works at Nordic included: cleanup of spilled tailings and contaminated soils; dismantling of the mine and mill buildings; capping of the mine openings; vegetation of the mine site; and reclamation of the tailings area. The Nordic tailings area was vegetated in the 1970s and much of the vegetation has prospered with numerous invading plants and large trees. The West Arm tailings vegetation program was largely unsuccessful, as with Lacnor, acidic salts caused vegetation to die. The West Arm was reclaimed in the same fashion as Lacnor with a layer of rock to prevent the upward migration of acidic salts.

There were three significant issues at Nordic: the requirement to treat acidic drainage over the long term; highly acidic seepage in the “Nordic Plume” that was by passing the collection system and discharging to Buckles Creek; and tailings and radium precipitates in the Buckles Creek wetland.

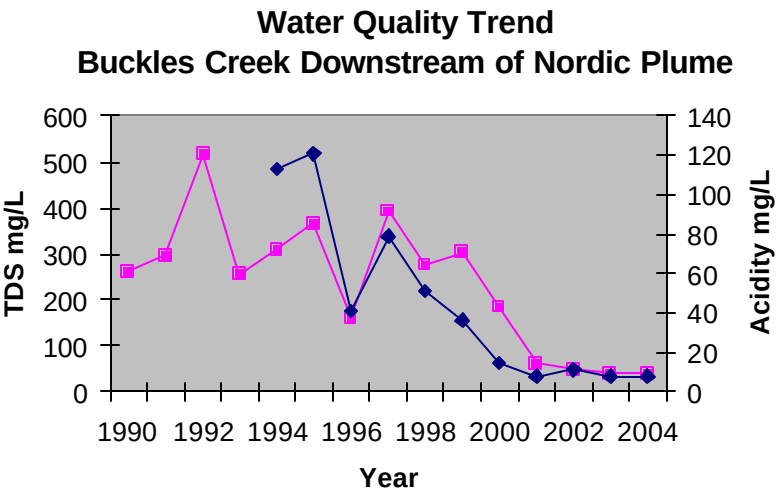
The Nordic treatment plant and North Nordic settling basin have treated acidic runoff for 30 years and treatment is expected for at least an additional 100 years. The system has a large storage capacity and can manage treatment sludge production over this period.

The Nordic plume remediation measures completed in the late 1990s included the deepening of the seepage collection ditch and lowering of the water level in the collection ditch to below Buckles Creek. These measures stopped the migration of the plume to Buckles Creek and water quality has shown dramatic improvement (see Figure 2).

The Buckles Creek wetland area contains tailings from historic spills and radium precipitates from the first barium chloride treatment of the Nordic effluent in the mid 1960s. Studies in the 1970s indicated the precipitates and tailings were releasing radium 226 into the creek. A portion of the precipitates concentrated in a beaver

pond were covered and a clean water by-pass ditch constructed to isolate Buckles Creek from the residual tailings and precipitates.

Figure 2 Buckles Creek and influence of the Nordic Plume prior to control measures



This has effectively reduced radium levels in Buckles Creek. However, since 2000 time a seasonal peak in radium is being observed in late summer. Low levels of total dissolved solids and sulphate in the overlying water and bacterial reduction of sulphate in the swamp sediments is believed to contribute to high radium in the pore water of the sludges. Work will be done this year to improve the ditching and install a sand berm to isolate the waste area and reduce the amount of run-off water in contact with the waste. Based on past performance at this site, isolation is expected to be an effective control.

3.6) The Stanleigh Mine operated from 1958 to 1960 and again from 1983 to 1996 producing 20 million tonnes of tailings that were discharged into the 352 ha Stanleigh Tailings Area, a former lake basin. Remedial works at Stanleigh included: cleanup of spilled tailings and contaminated soils; dismantling of the mine and mill buildings; capping of the mine openings; vegetation of the mine site; and reclamation of the tailings area.

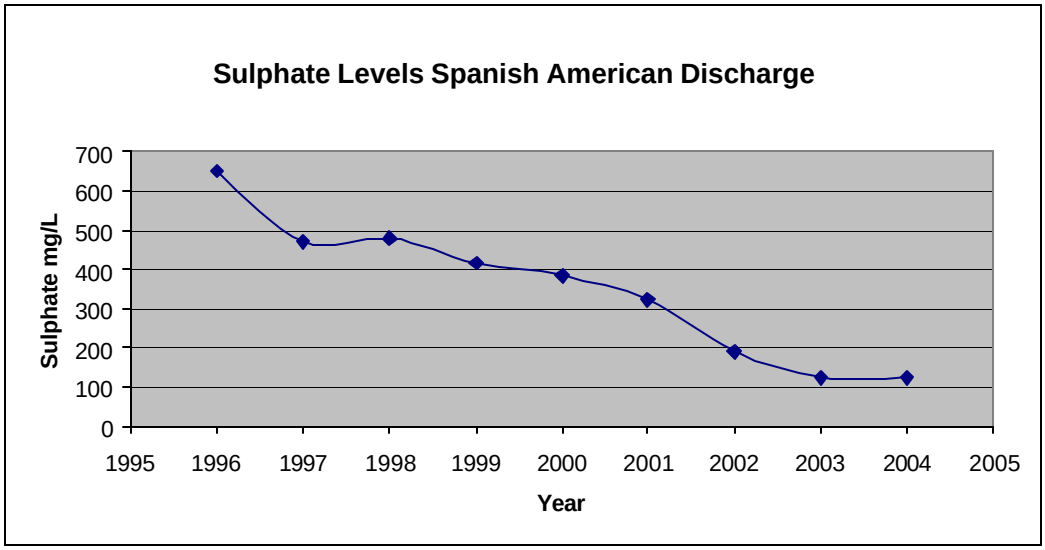
When the mine closed in 1960, the tailings area discharge became acidic and lime treatment was initiated in the late 1960s. This treatment plant was replaced in 1983 with a new plant at the outlet of the basin. It included lime addition for pH adjustment, barium chloride addition for radiumcontrol and dual media gravity filters for suspended solids control. The closure option selected for the tailings at Stanleigh was flooding. Flooding effectively eliminated dust, radon emission and future acid production and was readily achieved at Stanleigh through the upgrading and raising of the perimeter dams. Since flooding was completed, no acidity has been produced

and treatment is provided for radium 226. In 2004, radium levels in the influent to treatment average 0.5 Bq/L and were reduced to 0.12 Bq/L after treatment.

At Stanleigh there is a small discharge of acidic seepage from Dam A. Tailings upstream of this dam were acidic prior to flooding and acidic pore water is expected to continue to flush for the foreseeable future, although it will become neutral in time. The seepage discharges to the Sheriff Park wetland and has no measurable effect.

3.7) The Spanish American Mine and mill operated from 1958 to 1959 and produced 0.5 million tonnes of tailings that were discharged into a former lake basin. By the mid-1960s these tailings were acidic and drained into the Denson Tailings Area. Remedial works at Spanish American included: cleanup of spilled tailings and contaminated soils; dismantling of the mine and mill buildings; capping of the mine openings; vegetation of the mine site; and flooding the tailings area. To avoid building an impoundment structure, the tailings above the natural water level were moved within the basin to below water. The relocation resulted in the initial release of acidity that was neutralized both during and after the relocation program. Since flooding was completed, no acidity has been produced and the salinity in the basin has rapidly dropped as the neutralized acidic salts are flushed from the basin (see Figure 3).

Figure 3 Spanish American outfall sulphate levels from 1996-2004

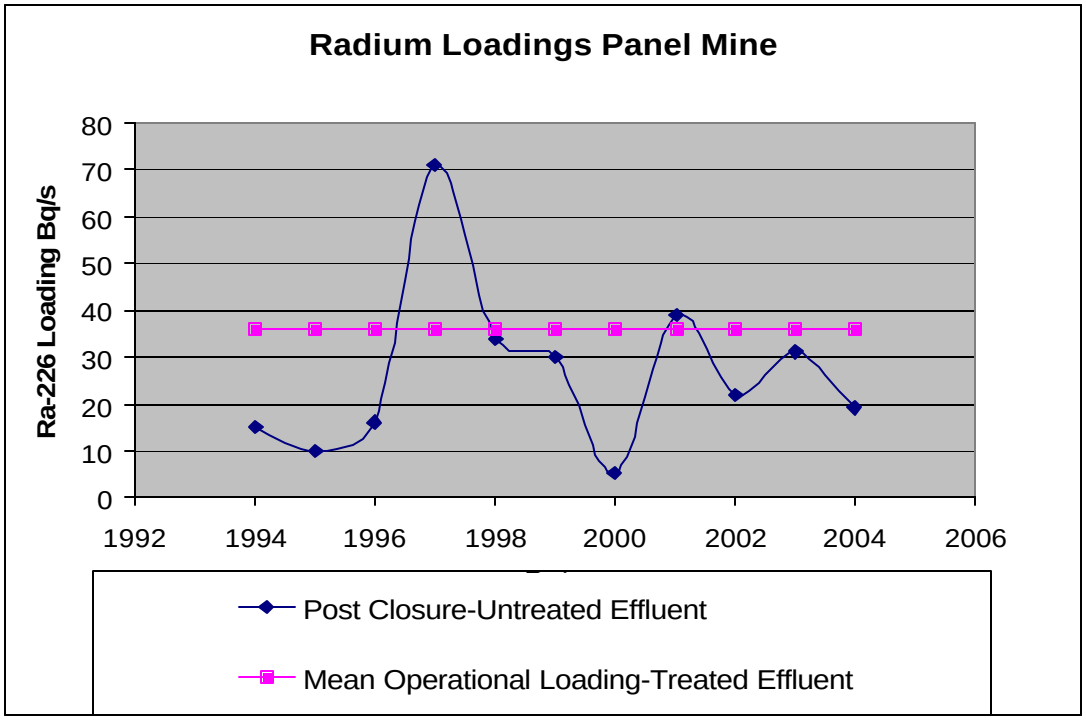


3.8) The Panel Mine and mill operated from 1958 to 1959 and again from 1979 to 1990 and produced 15 million tonnes of tailings that were discharged into 2 former lake basin/wetland areas. By the mid-1960s these tailings were acidic and drained into Rochester Creek. From the late 1960s, these areas were treated with lime and barium chloride. With the construction for the re-opening of the mine in 1979, a new treatment plant was constructed to treat all discharges from the North and South basin. Remedial works at Panel Mine included: cleanup of contaminated soils and

spilled tailings from the Panel lagoon; dismantling of the mine and mill buildings; capping of the mine openings; vegetation of the mine site and; reclamation of the tailings area. The closure option selected for the tailings at Panel Tailings area was flooding. Flooding was achieved in the North basin by constructing one new containment dam and raising the existing containment dams. The South basin was already flooded. Since flooding of the basins, acidity has been flushed from the water cover and treatment is now only required for radium.

Radium 226 levels in the Panel water cover have increased as expected as sulphate levels have dropped. Radium levels in 2004 were 0.57 Bq/L with an average loading of 19 Bq/s in 2004. This loading is in line with the modelling projections completed for the environmental assessment, which indicate loading would be in the range of 10-19 Bq/s [2]. The objective for closure is to maintain radium 226 loadings from the water covers at less than those in treated effluent discharges during the operating phase. At Panel Mine the operational loading was 36 Bq/s [2]. Closure criteria have been met however in the interim, Rio Algom continues to operate the Panel treatment plant for radium 226 removal (reduced from 0.57 Bq/L to 0.22 Bq/L in 2004).

Figure 4 Panel tailings trends in radium 226 loading in the water cover



3.9) The Quirke Mine (I and II) and mill operated from 1956 to 1961 and again from 1968 to 1990 and produced 42 million tonnes of tailings that were discharged into a former lake basin and wetland area. By the mid-1960s these tailings were acidic and draining into the Serpent River. These areas were treated with lime and barium chloride from the late 1960s onwards. A new treatment plant was constructed in 1980. Remedial works at Quirke Mine included: spilled tailings and contaminated soils cleanup; dismantling of the mine and mill buildings; vegetation of the mine site;

and reclamation of the tailings area. The closure option selected for the tailings at Quirke Tailings area was flooding. At Quirke, the large elevation differences between the West and East made single level flooding of the basin impractical. To achieve flooding, a series of flooded cells with cross dykes were built. Water cascades from cell to cell primarily by subsurface flow beneath the dykes, and acidic porewater is being flushed from cell to cell down the basin. By 2004, all acidity had been effectively flushed from the upper cells 14 and 15 and residual acidity remained only in the lower cells 16 and 17. Lime demand to neutralize the flushed acidity has dramatically dropped and it is expected all acidity will be flushed from the basin over next few years.

In winter 2004, a decision was made to install a till and sand cover over Cell 14 tailings and then re-establish the water cover. The purpose of the till cover was to reduce the amount of seepage occurring under the dyke. The reduction of seepage reduces the total water moving through cell 14 and should act to further reduce radium loadings. Radium 226 levels in untreated water at Quirke have increased especially in the upper cells where sulphate levels have dropped: in 2004, untreated water was 0.84 Bq/L with an average loading of 77 Bq/s, which is less than half of the operational loading. This loading is in line with the modelling projections completed for the environmental assessment, which indicated loading would be in the range of 40-96 Bq/s [2]. The objective is to achieve radium 226 loadings from the water cover at less than those in treated effluent discharges during the operating phase. At Quirke Mine the operational loading was 200 Bq/s [2]. Closure criteria have been met however in the interim, Rio Algom continues to operate the Quirke treatment plant to remove radium (reduced from 0.84 Bq/L to 0.094 Bq/L in 2004). This is because the concentration of radium remains higher than the Metal Mining Effluent Regulation limits and are therefore problematic without a loading-based authorization.

Photo shows till cover being applied at Cell 14

3.10) The Pronto mine and mill operated from 1955 to 1960 producing 2.1 million tonnes of tailings that were discharged to a 47 ha wetland tailings area. The Pronto area is located 35 km south of Elliot Lake on the North shore of Lake Huron. In 1960, the mill was converted to process copper ore from the Pater Mine and the mill operated this way until 1970. Upon closure of the copper mine in 1970, the basin became acidic and Rio Algom constructed a treatment plant to treat discharges from the site. Remedial works at Pronto included: cleanup of spilled tailings and contaminated soils; dismantling of the mine and mill buildings; capping of the mine openings; vegetation of the mine site; and reclamation of the tailings area.

The tailings basin at Pronto was vegetated in the 1980s but vegetation was not successful due to the upward migration of acidic salts. Rio Algom has since covered the tailings with waste paper mill sludge and vegetated the site. The paper mill sludges consist of clayey soil with residual lime, paper fibres and bio-solids. The sludge has proven to be an excellent media for use in vegetating acidic tailings. Mine water discharging from the underground workings is collected with tailings seepage and treated through the lime plant prior to discharge. Acid loadings from the tailings are declining and acidity from the basin should be flushed in the next 50 years at which time the treatment plant could be closed. To date there has been no clear trend in the acidity of the mine water discharging from the mine. It is possible that treatment will need to be extended to treat acidic mine water discharge.

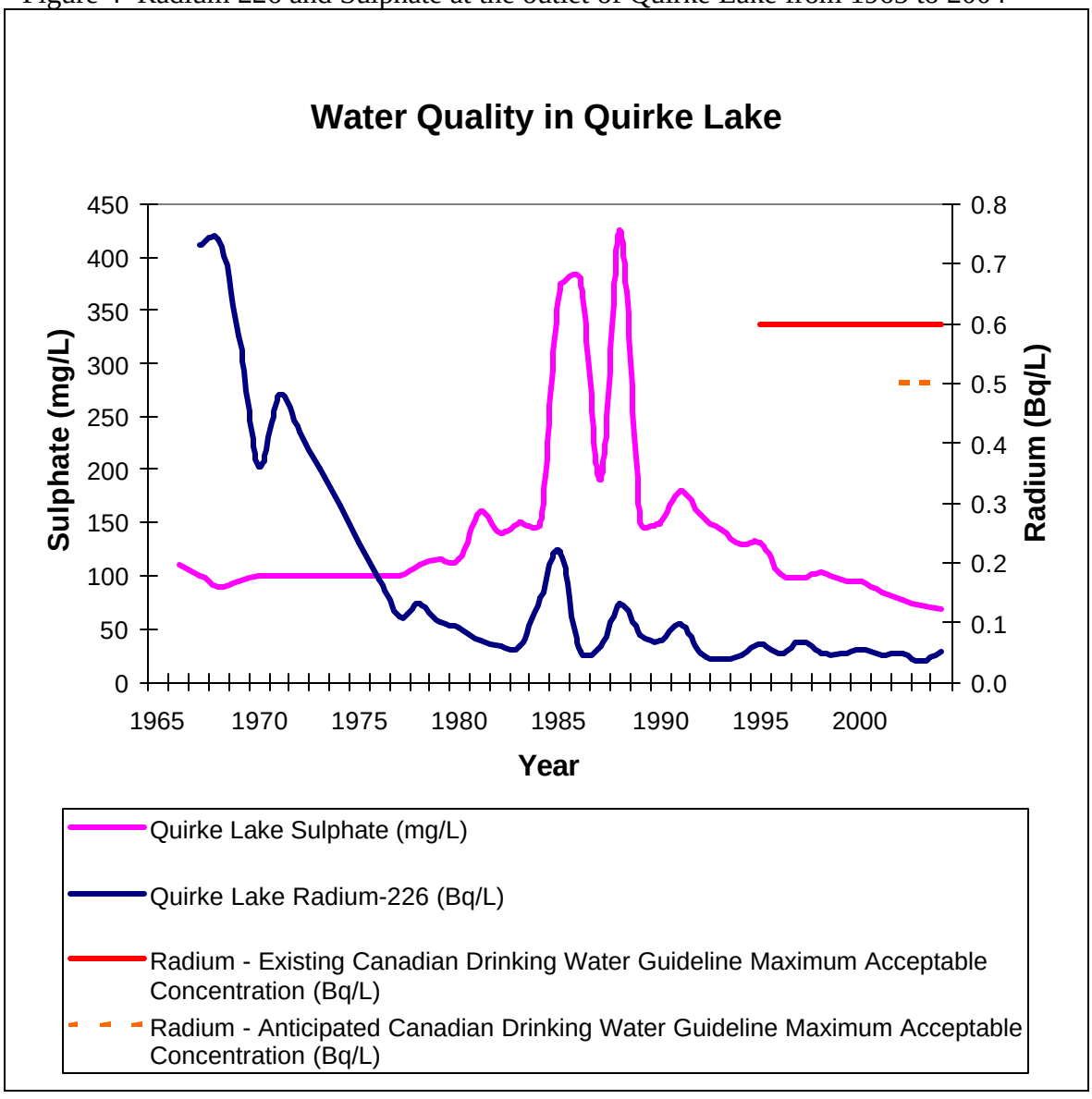
4. PROJECTED ENVIRONMENTAL CONDITIONS

In 1992 detailed modelling and environmental and radiological pathways analysis were completed to characterize sources and assess the potential short-term and long-term effects of decommissioned and reclaimed uranium mines. The pathways analyses were also completed on alternative management options to assess whether proposed plans were indeed optimized (ALARA). A standardized pathways analysis approach was adopted. Dose assessments were conducted for humans and a broad range of biota for heavy metals and radionuclides. Each source was modelled separately, and cumulative impacts were also assessed. Cumulative exposures to radiation were projected to be a small fraction of natural background (typically <50 $\mu Sv\ a^{-1}$). No negative effects were projected to any biota. Water quality was predicted to continue improving throughout the Serpent River system and meet all health-related drinking water standards and surface water quality objectives for the protection of aquatic species. A historical review of sulphate and radium levels in Quirke Lake, the largest lake in the Serpent River system as provided in Figure 4 shows the trend in water quality changes. To date the system has performed as expected and the Serpent River system supports a healthy aquatic ecosystem throughout its length.

5. MONITORING PROGRAM

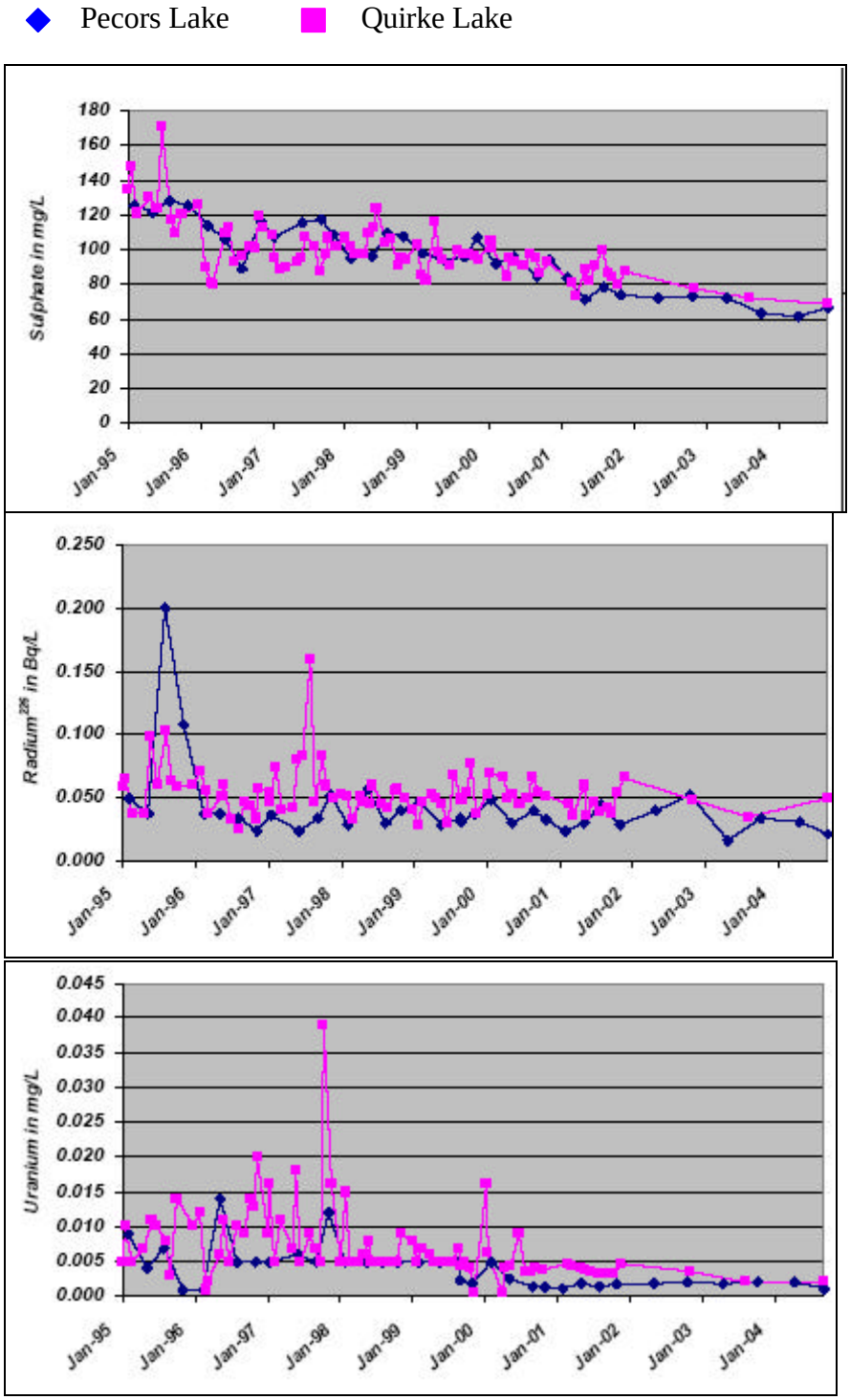
Rio Algom in concert with Denison Mines has prepared a detailed monitoring program titled Serpent River Watershed Monitoring Program and In-Basin Monitoring Program [8]. The program evaluates the effectiveness of mine decommissioning plans relative to conditions predicted; cumulative effects of mine discharges on the Serpent River Watershed; and assesses the long-term trends of environmental quality in the watershed. This program includes standardized procedures for monitoring of all environmental media so that future study results can be directly compared. The graph in figure 4 below shows the dramatic improvement in Quirke Lake from the start of data collection, now 40 years ago.

Figure 4 Radium 226 and Sulphate at the outlet of Quirke Lake from 1965 to 2004



The next series shows the steady reduction in sulphate, radium 226 and uranium at Quirke and Pecors Lake outfalls.

Figure 5 Quirke and Pecors Lake outfalls over 10 years for key parameters



6. LONG TERM CARE

Long term water treatment will be required for acid neutralization at the dry sites, and possibly for radium removal at the water covered sites. Rio Algom has contracted the management, care and maintenance of the sites to Denison Environmental Services. Elliot Lake is a somewhat unique situation in that there are two companies with eight tailings management areas that all discharge treated effluent into the upper Serpent River Watershed. During the decommissioning process it became clear that a common environmental monitoring program and data management system would best serve both the mining companies and the regulators. It naturally followed that with both companies operating similar tailings management areas and treatment plants within the Serpent River basin, that one company could manage all of the properties more efficiently than both operating independently. Denison Mines Inc. formed Denison Environmental Services and a contract was negotiated between Rio Algom and Denison under which Denison manages, operates, and maintains the tailings management areas, effluent treatment plants, environmental monitoring program, and data management. Integration of the overall site management between the companies has resulted in the elimination of duplication of effort and has improved both the environmental monitoring and the economics of maintaining the sites for the long term.

Studies over the last 30 years have shown that under certain conditions, precipitated radium can become mobilized as dissolved radium 226 in water. Focussed studies are underway to explore how the radium is behaving in-situ and how physical conditions can be used to minimize radium 226 releases. Ultimately a natural solution is sought that will provide conditions to minimize radium release and eliminates the need for long term treatment.

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