Federal Environmental Assessment and Review Process

Canadian Environmental
Assessment Agency

DECOMMISSIONING OF URANIUM MINE TAILINGS MANAGEMENT AREAS IN THE ELLIOT LAKE AREA

Report of the Environmental
Assessment Panel

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ELLIOT LAKE URANIUM MINE TAILINGS AREAS
ENVIRONMENTAL ASSESSMENT PANEL

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In accordance with the revised terms of reference issued in July 1994, the Environmental Assessment Panel has completed its review of the proposals to decommission uranium mine tailings management areas near Elliot Lake.

On behalf of the panel, I am pleased to submit this report for your consideration.

Yours sincerely,

David Kirkwood
Chairperson
Elliot Lake Uranium Mine Tailings Areas
Environmental Assessment Panel

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EXECUTIVE SUMMARY

In February 1993, proposals for the decommissioning of four uranium tailings management areas near Elliot Lake, Ontario were referred to the Minister of the Environment for public review by an independent panel.

Rio Algom Limited is seeking licences from the Atomic Energy Control Board (AECB) to decommission its Quirke and Panel waste management areas. Denison Mines Limited is seeking licences to decommission the Denison and Stanrock tailings management areas. The four sites are associated with uranium mines that operated in the last 40 years but are now closed. Together, the four waste management areas contain approximately 130 million tonnes of tailings. Waste management areas associated with nine other mines in the area contain roughly 35 million tonnes of tailings.

A three-member panel, consisting of Mr. David Kirkwood (Chairperson), Dr. Dougal McCreath and Mr. Tom Peters (members), was appointed in September 1993 to conduct the review.

In December 1993, the panel held public meetings in Elliot Lake and Sudbury, and on the Serpent River First Nation Reserve, to receive comments about the scope of issues that should be addressed in the review. Following that, and revision of the panel's terms of reference by the Minister of the Environment, the panel issued the final guidelines document that served as the basis for the environmental impact statements that were completed by both proponents (the two mining companies).

In November 1995, after a period of public review of the environmental impact statements and the receipt of additional information from the proponents, the panel held public hearings in Elliot Lake and Sudbury. In January 1996, public hearings were held on the Serpent River First Nation Reserve, and a final session was held in Elliot Lake. These public hearings provided opportunities for individuals, organizations and government representatives to submit their views and opinions, in both oral presentations and written submissions, on the environmental, technical and socio-economic implications of the decommissioning projects. These hearings greatly assisted the panel in developing its findings.

The panel reached a number of conclusions and formulated a number of recommendations that are presented in Section 8 of this report and that are briefly summarized below.

The tailings of the Elliot Lake uranium mines present a perpetual environmental hazard. The tailings contain sulphide minerals, which generate acid when exposed to air and water concurrently. They also contain various heavy metals, including radioactive isotopes of thorium and radium, the solubility of which is increased when exposed to acidic conditions. Radioactive contaminants are an important public concern.

Given the nature of the long-term hazards of the tailings, the panel has set out a number of recommendations that seek to ensure that effective containment is established for the tailings; that an extensive monitoring, maintenance and research program is developed to ensure proper operation and safety in perpetuity; and that an appropriate management regime is established that includes adequate financial support for the care and maintenance programs, with significant involvement of the local community.

To establish an effective containment system for the wastes, the panel concludes that the tailings must be permanently contained in such a way as to insulate them from concurrent exposure to air and water, and to prevent their dispersion into the environment. In the Elliot Lake environment, the best way to do this is to keep the reactive tailings permanently water saturated.

The panel recommends that the proponents' proposals, designed to achieve such permanent saturation, should form the basis for developing the details of a decommissioning licence. However, the panel also recommends that there be a number of conditions that should be incorporated into the licensing process.

The decommissioning licences should recognize three separate decommissioning phases. In the first short-term phase, the containment systems will be put in place, and their stable operation to design standards will be demonstrated. The transitional phase that will follow must be of sufficient duration to permit the effectiveness of the systems to be verified over a range of climatic and other operating conditions, and any desirable adjustments to be implemented. Only when the long-term phase begins will the proponents be permitted to seek the transfer to government of their management responsibilities.

Given the permanent nature of the hazards presented by the tailings, the panel recommends that an adequate containment system must be supported in perpetuity by effective care and maintenance programs. Such programs must include vigilant monitoring, maintenance, repair and, as necessary, system modification in the light of experience and technological advances. There should also be a capability to repair promptly major failures caused by exceptional unforeseen events.

The longevity of the tailings hazard must also be considered in the context of inevitable uncertainties regarding the detailed behaviour and long-term evolution of the complex ecological systems associated with the areas. The panel recommends that curiosity-driven research be supported as a central and critical element of the long-term monitoring approach, to provide early insights into actual behaviour. In addition, the panel considers that there is an obligation on all parties to ensure that important knowledge that can be gained from these decommissioning projects is disseminated and utilized as widely as possible. Therefore, the panel recommends the creation of a permanent endowment fund to support research associated with the Elliot Lake mine waste facilities.

The panel also believes that the environmental impacts associated with the other mines in the area should be reviewed; it was informed during the hearings that steps to this end are going forward.

In order to ensure that the contain-and-manage programs at each site will be effectively maintained in perpetuity, specific and binding financial and institutional arrangements will be necessary. The financial assurances proposed by the proponents, while partially acceptable, are not fully satisfactory. The panel recommends that there should be "hard" financial assurances made by the proponents.

The panel believes that community involvement is a fundamental part of the perpetual care system. The panel recommends that Rio Algom Limited and Denison Mines Limited be required to take the lead in bringing about the creation of a not-for-profit organization that will focus on matters related to the impact of the tailings areas on the conservation of the Serpent River Basin environment. Among its functions would be the identification and management of the appropriate research programs. The board of this corporation would include representatives of the proponents, the City of Elliot Lake, the Serpent River First Nation, the research community and, possibly, other communities in the area. It is the members of the surrounding community whose long-term interests are directly tied to the waste management areas. Their desire to preserve the environment and safeguard the health and safety of the community will ensure long-term vigilance.

1.0 INTRODUCTION

In February 1993, the Atomic Energy Control Board (AECB) asked the Minister of the Environment to establish an environmental assessment panel to conduct a public review of proposals, for which Rio Algom Limited and Denison Mines Limited had sought AECB approval, for the decommissioning of the tailings and waste management areas of four uranium mines in the Elliot Lake area. Two of the mines are owned by Rio Algom Limited, two by Denison Mines Limited. Production had ceased at all four, and AECB approval had already been given for the dismantling of the underground and surface facilities of the mines themselves, as well as for the mill facilities. The possible environmental impact of the mine tailings had led the AECB to conclude, however, that a public review of the proposals for their decommissioning should be undertaken in accordance with the requirements of the Federal Environmental Assessment and Review Process (EARP) Guidelines Order.

The Canadian Environmental Assessment Agency (CEAA), formerly the Federal Environmental Assessment and Review Office, and the AECB developed initial terms of reference for the review, which were approved by the ministers of the Environment and of Energy, Mines and Resources (now Natural Resources Canada) in July 1993. In August a panel was appointed to conduct the review, consisting of Mr. David Kirkwood (Chairperson), Dr. Dougal McCreath and Mr. Tom Peters (members). Their biographies are found in Appendix A.

Public meetings were held in December 1993 to provide an opportunity for interested organizations, groups and individuals to inform the panel of the range of issues that they thought should be addressed in the course of the review. The panel held these “scoping sessions” in Sudbury and Elliot Lake and on the Serpent River First Nation Reserve.

During the scoping sessions, a complication emerged. The AECB referral, on which the review’s terms of reference were based, related to four particular mines for which AECB licences had been issued, but excluded a number of other uranium mines in the Elliot Lake area. These other mines included certain mines not licensed by the AECB and, thus, considered ineligible for decommissioning licences, as well as the only mine still operating in the area, Stanleigh Mine. There was a consensus among the participants in the scoping sessions, including representatives of the federal and provincial governments, that, despite this technical problem, the situation of these other mines should, in some way, be taken into consideration in the review.

The panel therefore suggested to the Minister of the Environment that its terms of reference be slightly expanded by adding a provision that it “take into consideration . . . the contribution of these four mines... to the cumulative environmental impact resulting from several decades of uranium mining in the Serpent River watershed.” The Minister’s approval of these revised terms of reference was received in July 1994 (Appendix B).

While adjustment of the terms of reference was being considered, the panel continued developing the “guidelines document,” the detailed directive to the proponents (the two mining companies) on the information that should be provided in their environmental impact statements (EISs). The EIS is a document that sets out the details of the proponent’s proposal - the alternatives that it had considered, with an explanation of the reasons for choosing the preferred course; the anticipated environmental impacts; and the measures proposed to overcome or mitigate any adverse impacts. The EIS provides base data for the environmental assessment review, and is supplemented by such additional information as may be made available to the panel by other interested parties as well as by the proponents during the review process.

The guidelines document could not be put into final form until the scope of the review was determined by the Minister’s approval of the amended terms of reference in July 1994. The final text of the guidelines document, which incorporates amendments reflecting comments by the public, was issued in August 1994.

The proponents submitted their completed EISs to the panel, with English and French summaries, for release in early April 1995. The formal commencement of the prescribed public review period was announced on May 29, upon receipt of the Ojibwa translation of the summaries, with a closing date of August 1, 1995. Following review of the EISs and of the public’s comments on their adequacy, the panel announced that it would require further information on the proponents’ plans for the long-term management of the tailings areas before it would be prepared to schedule public hearings. It also listed other matters on which it wanted additional material, but not as a prerequisite to the scheduling of hearings.

Following the receipt of the required material, the panel issued a notice of public hearings to take place in Elliot Lake and Sudbury and on the Serpent River First Nation Reserve in November 1995. Some sessions took place in Elliot Lake and Sudbury as planned, but the other sessions were postponed when the death of an elder caused the members of the Serpent River First Nation to enter a period of mourning. Rescheduled sessions took place on the reserve and in Elliot Lake in January 1996.

A complete list of the hearing dates and participants is provided in Appendix C. Documents referred to above, such as the proponents’ EISs, which are not appended to this report, may be consulted at the registries maintained at the offices of the Canadian Environmental Assessment Agency in Hull, Quebec (Appendix H).

2.0 PROJECT SETTING

For the purposes of this report, the term waste management area (WMA) is used to describe the tailings and waste management areas. In its information, Denison Mines Limited uses the term tailings management area (TMA), while Rio Algom uses the term WMA in its information because its tailings areas include tailings and other wastes. The four WMAs - Quirke, Panel, Denison and Stanrock - are briefly described in Section 2.2.

2.1 ENVIRONMENT OF THE SERPENT RIVER WATERSHED

The Elliot Lake area is located between Sudbury and Sault Ste. Marie in northern Ontario, just north of Lake Huron in the District of Algoma (Figure 1). The area surrounding Elliot Lake is sparsely populated and is characterized by features of low relief, mixed softwood and hardwood forest, and an abundance of lakes, rivers and swamps.

The mine complexes are located in the Upper Serpent River, Pecors and Elliot Lake subbasins, which lie within the Serpent River Basin. The entire Serpent River Basin has a drainage area of 1,376 km^2 and the three subbasins (Upper Serpent, Pecors and Elliot Lake) encompass 853 km^2, more than 17 per cent of which is covered by lake surface. Beginning just to the north of Quirke Mine, the system ultimately discharges into the North Channel of Lake Huron.

The area bounding the mines and around Quirke Lake is dominated by valleys and ridges. The relief around the rim of the tailings basins varies in elevation from about 380 m to 470 m above sea level. The ridges consist of extensive areas of bedrock outcrops or near-surface bedrock covered with varying depths of discontinuous overburden deposits. Bedrock outcrops constitute approximately 45 per cent of the land surface. The valleys tend to form lake basins that generally contain glacial deposits.

The main branch of the Serpent River originates in the northwest end of the watershed at Ten Mile Lake, which drains southward to Dunlop Lake (Figure 2). It then flows east through Quirke Lake, entering Whiskey Lake from the northwest and leaving by the southwest. The Serpent River enters Pecors Lake from the east, flows southward through McCarthy, Sheddon and Camp lakes, then west toward Serpent Harbour and Lake Huron. There are a number of smaller lakes in this flow path, and there is another branch of the river that flows east and south through McCabe, May and Hough lakes into Pecors Lake. The mid-western portion of the basin drains through the Marshland River, having its source above Elliot Lake and Gullbeak Lake. The generally eastern flow carries through Esten, Marshland, Grandeur, Trout and Depot lakes into McCarthy Lake.

The watershed displays typical characteristics of the Canadian Shield and its climate. There are climatic extremes of cold winters and mild summers. There is a thin soil cover over practically unweathered, glaciated bedrock, and there are numerous lakes, ponds and swamps, as well as forested areas. While there are uniform levels of precipitation throughout the year, there are large spring run-offs due to melting snow.

In terms of the biological environment, the Serpent River Watershed supports a diverse ecosystem. Vegetation in the area includes a mixed variety of hardwoods common to the deciduous forest region and conifers common to the boreal forest region. Other vegetation includes common species of blueberries and raspberries.

Of the mammals, the biggest game species in the area is moose. White-tailed deer are found in some parts of the area. Other mammals frequently identified in the area include beaver, red fox, timber wolf, snowshoe hare, black bear, raccoon, marten, muskrat and shrew.

Ruffed grouse is the major game bird in the area. The Blind River District, a short distance to the west, has traditionally been a stopover point for Canada geese on their annual migrations, and, in recent years, this species has established resident populations near the mouth of the Serpent River. Other birds found in the area include the common merganser (a diving duck) and the herring gull.

In terms of aquatic ecology, the Ontario Ministry of Natural Resources currently rates Dunlop, Elliot and Rochester lakes as excellent lakes for naturally reproducing lake trout. Depot, May, McCarthy, Esten, Hough and Quirke lakes are rated as fair lake trout-reproducing lakes. A 1993 survey by the Ministry found 22 different species of fish in Evans, Dunlop, Quirke, Whiskey, McCabe, Pecors, Elliot, Nordic and McCarthy lakes, all of which are common to the area. The proponents also reported that benthic populations have increased in the past 20 years, especially in Quirke, Kindle, Whiskey, Pecors and McCarthy lakes. By comparison, there was a lack of benthic species in May and Hough lakes. This was attributed to the poorer water quality resulting from the operation of Stanleigh Mine, scheduled to close in 1996, and the Stanrock TMA. Other aquatic organisms, such as phytoplankton and zooplankton, have not been studied to the same extent as fish and benthic species.

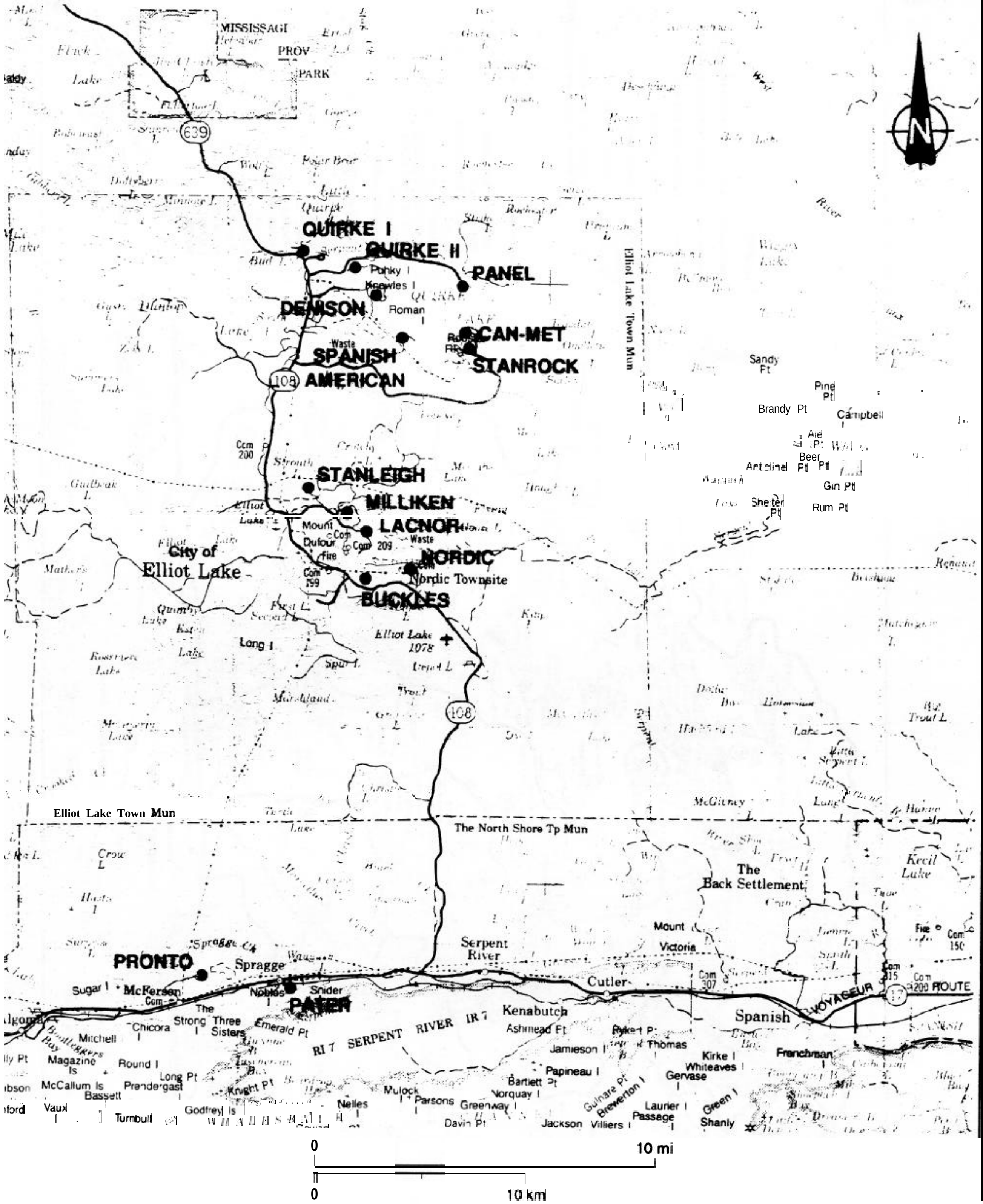
2.2 SHORT SUMMARY OF EACH SITE

The four WMAs that are specifically mentioned in the panel's mandate are all located in the "north limb" portion of the Elliot Lake Mining Camp. Two of the WMAs, Quirke and Panel, are the property of Rio Algom Limited, while the other two sites, Denison and Stanrock, belong to Denison Mines Limited. Each site is briefly described below. Descriptions of each proponent's decommissioning proposal may be found in Section 5.

Quirke WMA

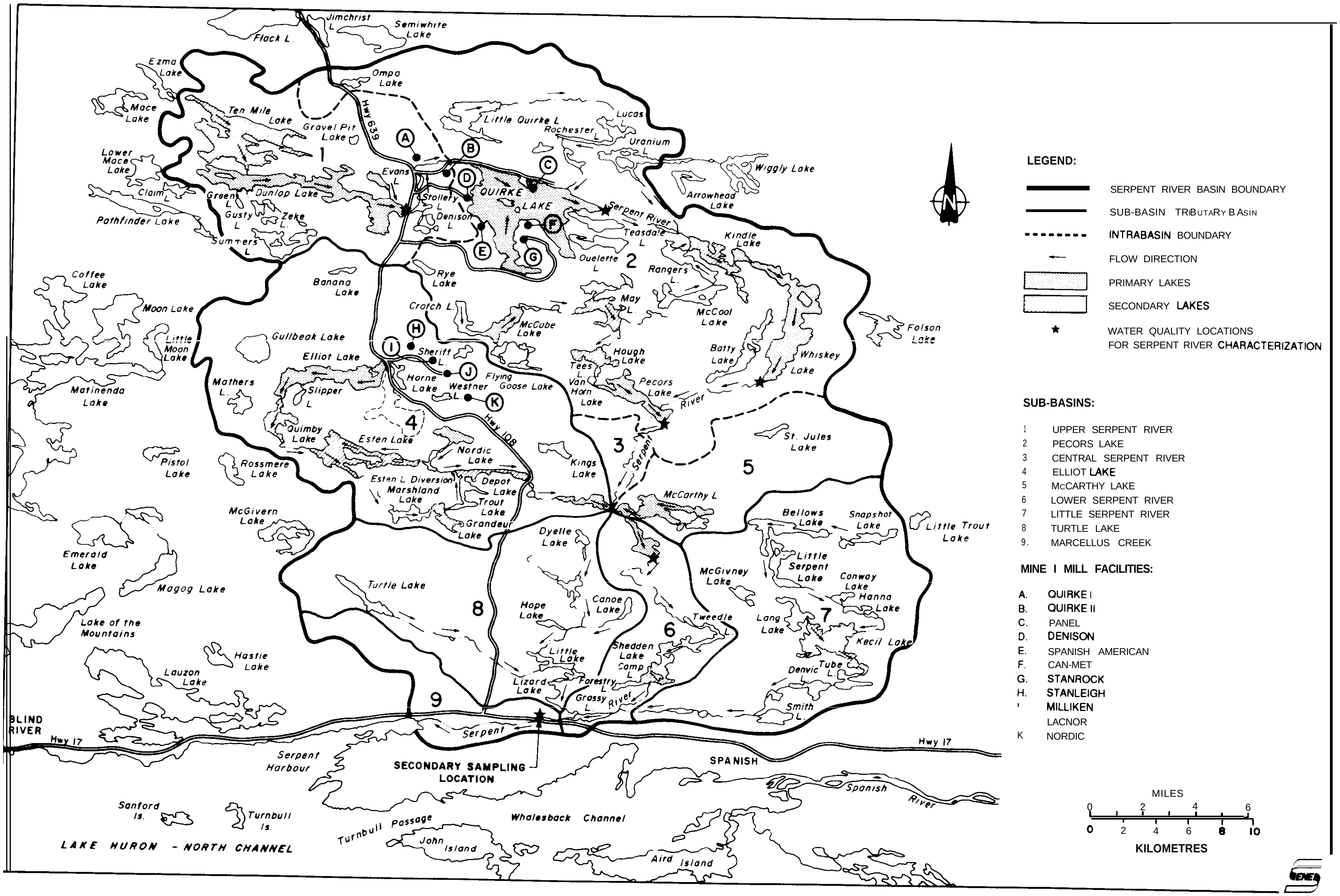
Quirke Mine is located about 16 km north of Elliot Lake (Figure 3). It operated initially from September 1956 to January 1961. Production resumed in 1968 and continued up to the end of August 1990. While in operation, the Quirke underground mine

FIGURE 1: ELLIOT LAKE AND AREA



SOURCE: BASE MAP ADAPTED FROM ENERGY, MINES AND RESOURCES CANADA. 1986

FIGURE 2: SERPENT RIVER BASIN



operated at a capacity of up to 9,000 tonnes per day (tpd), feeding milling facilities that were capable of handling up to 6,300 tpd.

The Quirke WMA lies approximately one km west of the mine and mill complex. The WMA occupies 316 ha of land, 192 ha of which are covered with tailings. Settling ponds 2, 3, and 4 occupy 24 ha in the northeast corner of the site, and the remaining 100 ha consist mainly of exposed bedrock and surficial soil. This WMA contains 46 million tonnes of mine waste, primarily tailings and waste rock with some relatively small amounts of demolition debris and process waste. There are also about 30,000 tonnes of sludge from the Elliot Lake's city water treatment plant within the tailings.

The WMA is a bedrock rimmed basin with eight dams constructed along about 20 per cent of the perimeter. After treatment, the overflow from the basin is discharged into a series of settling ponds before being released into the Serpent River. The subject of effluent treatment is discussed in Section 6.2.3 of this report. Since the closure of the mine in 1990, several dykes have been constructed within the basin to allow the tailings to be flooded, as described in Section 5.2.2. Now that Gravel Pit Lake has been converted to a water reservoir for the Quirke WMA, the only water that flows into the basin is precipitation that falls directly on the watershed, and any surplus water from Gravel Pit Lake.

Panel WMA

Panel Mine is located about 20 km northeast of Elliot Lake, on the north shore of Quirke Lake (Figure 3). During operation, the underground mine had a production capability of 4,000 tpd with a mill throughput design of 3,000 tpd. The mine produced uranium from 1958 to 1961 and, following rehabilitation and upgrading, operated from 1979 until its closure in August 1990.

The Panel WMA, located 1.5 km north of the mine, is estimated to contain 16 million tonnes of tailings. According to Rio Algom's EIS, there have been other solid wastes placed in this WMA, including Low Specific Activity (radioactive) material (LSA), such as operating refuse, demolition debris and approximately 8,000 crushed LSA barrels.

The WMA is divided into two basins: the Main or North Basin occupies the former location of Strike Lake (also known as Frayn Lake) and covers an area of 84 ha; and the South Basin, which covers an area of 39 ha. Tailings in the North Basin are contained within a bedrock basin closed by four dams constructed along about 15 per cent of the perimeter. The North Basin drains via a spillway constructed in the rock rim into the South Basin. The South Basin is contained by two dams and contains a relatively small quantity of tailings deposited between 1958 and 1961. The elevation of the water level in the South Basin is approximately 13 m lower than the water level in the North Basin. Drainage from the basin is discharged after treatment into settling ponds that drain into a small stream leading to Quirke Lake. The closure plan proposed by Rio Algom for this WMA is described in Section 5.2.3.

Denison TMA

The Denison Mine, located 16 km north of the town of Elliot Lake, produced 147 million pounds of uranium in 35 years of operation that ended in 1992. During its operation, the Denison mine and milling complex had a production capacity that ranged from 6,450 to 13,600 tpd.

The Denison TMA is divided into two areas - TMA-1 and TMA-2, located just south of the mine between Quirke Lake and Dunlop Lake. The surface area of the two tailings basins is approximately 258 ha, and they occupy a watershed area of about 458 ha. The TMA occupies the former Smith Lake, Williams Lake, Bear Cub Lake, Stollery Lake and Long Lake basins. Tailings were deposited from the start of operations in 1957 until the early 1960s in an area now known as TMA-2 (Figure 3). In the early 1960s, when TMA-2 essentially became full, tailings were deposited into what is now known as TMA-1. TMA-1 has about 60 million tonnes of tailings, contained by five perimeter dams. TMA-2 originally stored about 3.3 million tonnes, contained by three perimeter dams. Denison Mines reported at the hearings that about half the tailings from TMA-2 have been relocated to underground workings and to TMA-1.

Despite numerous changes in the discharge points, the flow path of the tailings has remained essentially unchanged. Drainage from the central area is in a southward direction and flows into TMA-1, where it is treated and discharged into the Serpent River. The closure plan proposed by Denison Mines for this TMA is described in section 5.3.2.

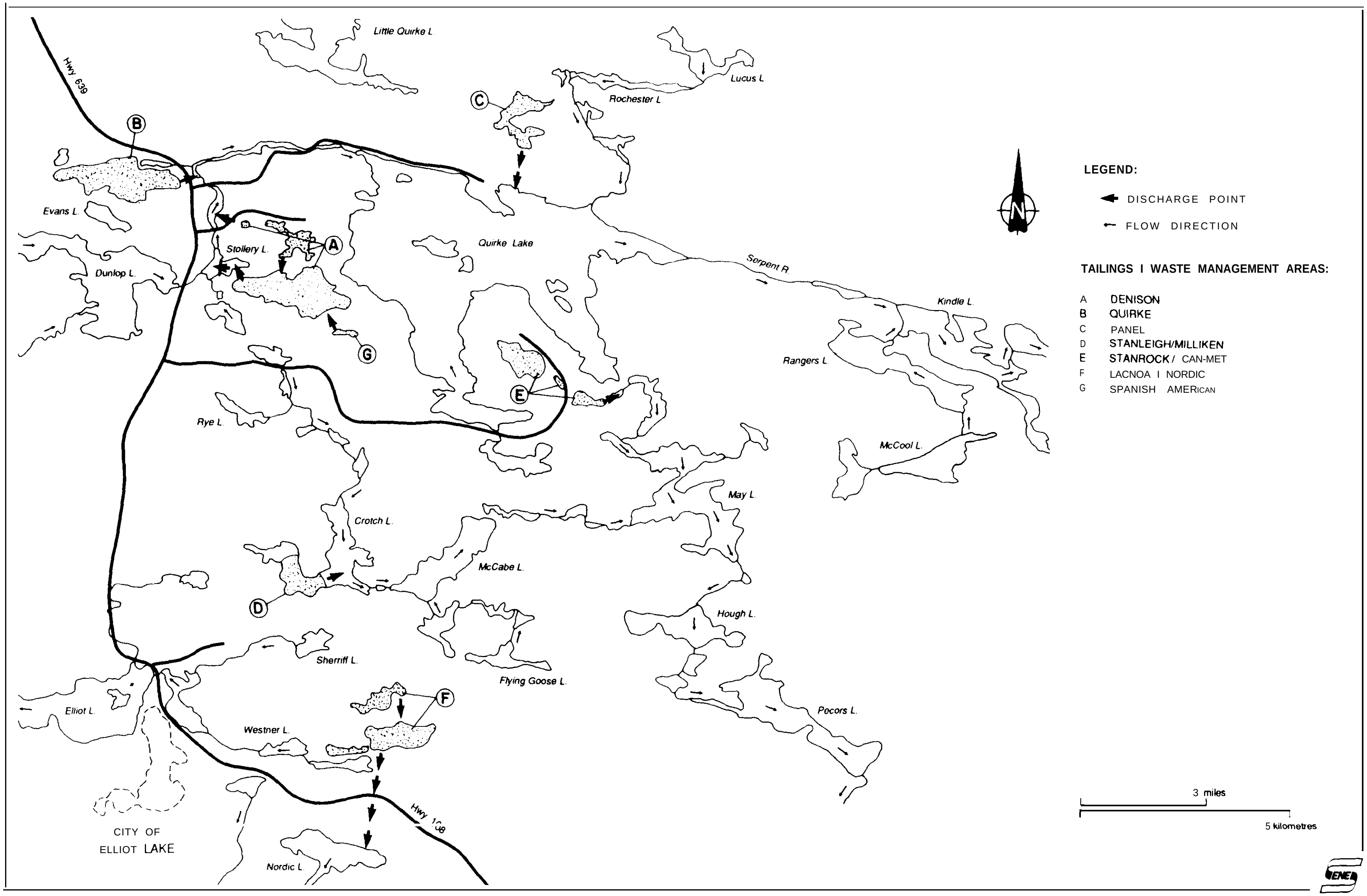
Stanrock TMA

The Stanrock and Can-Met uranium mines are located approximately 21 km northeast of the city of Elliot Lake on a peninsula that extends northwestward from the southern shore of Quirke Lake. The Stanrock TMA was used by both of these mines for tailings deposition. The Can-Met mine and mill commenced production in October 1957 with a design capacity of 2,729 tpd and closed in 1960. The Stanrock mine and mill commenced production in 1958, with a design capacity of 2,995 tpd, and closed in 1964.

The Stanrock TMA is located approximately 0.6 km southeast of the Stanrock mine site (Figure 3). This area was the natural basin of a small lake and currently forms a tailings area of approximately 52 ha containing 5.7 million tonnes of tailings. The basin serves as the head waters for several creeks and marshes that drain to Moose Lake, Orient Lake and on to Half Moon Lake.

During the Can-Met mine's operation from 1957 until 1960, tailings from its mill were discharged into the north side of the Stanrock TMA and were also used to form a starter dyke for Dam A along the eastern perimeter of the basin. Tailings from the Stanrock mill, during its operating period from 1958 to 1964, were placed into the basin from the southern and western rims. No additional tailings have been deposited at this site since that

FIGURE 3: WASTE MANAGEMENT AREAS



time. All nine containment structures for the Stanrock TMA are built from tailings, rather than from sand, gravel and earth fill, like the containment structures of the other WMAs in the area.

Denison reported that there have been two major failures at the Stanrock TMA. In April 1964, a section of the north dam failed allowing about 8,200 tonnes of tailings to wash out of the basin and run as far down as the western arm of Quirke Lake. In June 1964, a decant tower failed and approximately 450,000 tonnes of tailings were released downstream to Moose Lake and further into Orient Creek. The decant structure was subsequently sealed.

Denison Mines' proposal for the decommissioning of this site is described in Section 5.3.3.

2.3 COMMUNITY CHARACTERISTICS

2.3.1 City of Elliot Lake

The city of Elliot Lake is situated between the waterbodies of Elliot Lake and Nordic Lake. Elliot Lake is found on Highway 108 approximately 30 km north of Highway 17 (Figure I). The city's current population is estimated to be 14,300.

Elliot Lake was founded in 1954 as a residential and service centre for the nearby uranium mining industry. Prior to the establishment of the uranium mining industry, there were several hunting and fishing lodges in the area, but little other non-native settlement. Since 1954, the population and economy of Elliot Lake have been strongly affected by the economic fortunes of the uranium mining industry. It has experienced two cycles of population growth and decline, reaching a peak population of 25,000 in the early 1960s, and a smaller peak of 18,000 in 1983.

From 1986 onwards, the declining demand for uranium has resulted in downsizing at the mines around Elliot Lake. Since 1990, approximately 6,300 jobs have been lost in mining and in support and secondary industry. Stanleigh, the last operating mine in the area, is scheduled to close in 1996.

The city administration developed an economic diversification strategy in response to the loss of mining jobs that included establishing Elliot Lake as a centre for retirement living and establishing the area as a four season destination for affordable outdoor recreation. The city is also developing proposals to exploit the research and development opportunities arising from the decommissioning of the mines. One of the City's goals is to become an international centre for research on tailings management.

2.3.2 Serpent River First Nation

The Serpent River First Nation Reserve is located approximately 30 km south of Elliot Lake at the estuary of the Serpent River (Figure 1). Most of the reserve is located along Highway 17 and includes the village of Cutler. The reserve covers an area of about 9,000 ha. The current population of the reserve is slightly less than 300.

There have been aboriginal settlements in the Serpent River watershed for an estimated 10,000 years. Traditionally, aboriginal people followed seasonal patterns of communal gathering and dispersing by moving up and down the river systems, fishing, trapping and hunting. Aboriginal people in the area engaged in the fur trade with Europeans from the 1600s to the late 1800s. Starting in about 1850, a logging industry was established in the region that caused some environmental damage to the rivers.

The establishment of the city of Elliot Lake and the uranium mining industry in 1954 meant that some traditional fishing, trapping and hunting areas and sacred sites were occupied by the city and the mining industry. In the 1960s, a sulphuric acid plant was established on the reserve to service the mines. After the plant's closure, acidic debris and waste remained on reserve land until 1988, when the federal government removed them. Aside from the loss of access to traditional lands, the environmental impacts of the uranium mining industry have also disrupted traditional activities and lifestyles.

Employment of Serpent River community members at the Elliot Lake mines was sporadic, with some employment being created in secondary industries. At the moment, three community members are employed in mine projects. Other sources of employment on the reserve are the band administration, and small businesses. Currently, 5-l 5 per cent of band members maintain an income from traditional practices, and fewer than 5 per cent subsist from the land.

2.3.3 North Shore Community

The Township of the North Shore is an organized municipality in the District of Algoma. The township is composed of the geographic townships of Lewis, Spragge and Long and part of the Township of Striker, and incorporates the villages of Spragge, Algoma Mills and Serpent River (Figure I). The population has declined in recent years due to the mining shut-downs and is estimated to be 720.

3.0 PRIMARY ISSUES

3.1 INTRODUCTION

Four decades of uranium mining activity in the Elliot Lake area have left some 160 million tonnes of finely divided waste rock deposited on the ground surface. This waste contains significant quantities of radioactive isotopes - some with half lives of many millennia - and of heavy metals. Also contained in the waste are substantial quantities of potentially acid-generating sulphide minerals. This vast reservoir of contaminants has been deposited in the upper drainage basin of the Serpent River, a major watercourse flowing into Lake Huron. These contaminants will continue, effectively in perpetuity, to constitute a major environmental hazard.

Mistakes have been made in the handling of these uranium mine wastes in the past, in part because of a lack of public awareness and concern about environmental issues, but in part because of inadequate understanding of the complex relationships between mining and the environment. While our understanding of these matters has improved, it has significant limitations. We cannot accurately foresee the environmental relationships that will involve these tailings in the millennia to come. Hence, in planning for their perpetual management, we are inevitably embarking on what was referred to during the panel's hearings as a major and very long-term experiment.

The public and the panel have focused strongly on the issues of environmental protection that arise from the fundamental nature of the wastes and their toxic contents, particularly the extreme longevity of their hazard potential coupled with the inevitable uncertainties of the future. All the participants in the review, including the proponents, agree that the two proponents are obligated not only to ensure the safe decommissioning of the waste storage areas, but also to make effective and reliable provision for their perpetual care and maintenance. This will require a management system providing for perpetual vigilance and a perpetual capacity to react to future developments.

Perpetual vigilance requires more than adherence to a pre-determined monitoring program. New knowledge can, and must, be gained from this long-term experiment. All parties to the review are in agreement that curiosity-driven research, aimed at deepening our knowledge of the fundamental ecological mechanisms and processes involved, is essential. Lack of such research would not only represent a weakness in the monitoring system, but would also represent a failure to exploit the opportunities for new knowledge to be gained from this very long-term experiment.

As detailed in this report, the panel has concluded that the only feasible way of protecting against the hazards associated with the toxic materials in these uranium wastes is to contain the tailings permanently in such a way as to inhibit their dispersion into the environment. In this regard, it is useful to note here certain conclusions set out in a recent (1992) report by the International Atomic Energy Agency (IAEA), The report, entitled ***Current Practices for the Management and Confinement of Uranium Mill Tailings*** makes the following statements regarding uranium wastes:

> ***The radiological hazards are very long-lived, and the non-radiological hazards virtually never decrease; hence, long- term management is required after the mine has ceased to operate.***
>
> ***It should be recognized that no method of isolation can be complete, nor can any isolating structure be sure to last forever. Thus, the aim of impoundment is to ensure that the rate of escape of pollutants and their rates of transport to the environment remain sufficiently low to ensure that the probability of harm arising is within acceptable limits.***

Within the context of the Elliot Lake wastes, two important points emerge from the foregoing. First, despite an AECB policy directive that decommissioning arrangements should not include perpetual institutional care, no walk-away arrangement is in fact possible for tailings having these characteristics. Secondly, no containment system can work perfectly, and ensure zero emissions of contaminants. Rather, the goal is to contain the rate of contaminant escape "within acceptable limits." This latter point is discussed in Section 3.1.1 below.

3.1.1 Acceptable Limits

In considering the matter of "acceptable limits," the panel recognizes two important criteria. The first is how the contaminant concentration or biotic exposure compares with natural background levels. The second is how it compares with limiting levels established by government, whether in mandatory regulations or in "objectives" (Appendix E).

The fact that some slow escape of contaminants is inevitable for any physical containment system is not as disturbing as it might at first appear. The contaminants in these tailings consist of a number of radioactive isotopes, heavy metals and potentially acid-generating minerals, The two former are found, usually in extremely low concentrations, throughout the natural environment. Thus, there is a natural background level of exposure to such pollutants, the magnitude of which fluctuates both spatially and temporally.

In the panel's view, a rate of contaminant escape leading to exposure levels that are within or comparable to the fluctuations in the general background levels can be considered as acceptable, and, indeed, would give rise to exposure levels indistinguishable from background levels. Beyond this, any continuing escape at rates in excess of limits established by government is clearly not acceptable.

3.2 PRIMARY HAZARD SOURCES AND CONTROLS

Hazards associated with the Elliot Lake uranium mining wastes derive from the potential entry into the environment of unacceptably high fluxes of contaminants, notably acids, heavy metals and radioactive isotopes. In sufficient dose, these contaminants will produce toxicity effects on the biota of the Serpent River area. Thus, the fundamental issue which underlies the safe decommissioning of the WMAs is to ensure that contaminant releases are controlled such that the probability of harm arising is kept within acceptable limits. The particular challenge and obligation for Rio Algom and Denison Mines is to satisfy this requirement, not only for current, but also for future generations.

The movement of contaminants from the WMAs into the environment will depend on three primary factors or mechanisms:

- the process of acid generation within the wastes, and the resulting contaminant mobility, a process generally referred to as Acid Rock Drainage (ARD);
- exposure to ionizing radiation and/or uptake of radioactive elements; and
- the physical security of the waste impoundment systems.

3.2.1 Acid Rock Drainage (ARD)

Throughout the EIS documents submitted by the proponents, and throughout the course of these hearings, it was emphasized by many experts in the field that the most serious underlying problem within the WMAs is that of acid generation. The reasons for this concern include both direct issues of acid contamination and the fact that reduced pH (increased acidity) increases the mobility of heavy metals. The corollary is that, in the experts' opinion, control of acid generation is the primary task and challenge in designing safe and effective decommissioning approaches.

Concerns of the public, however, tended to focus, first, on the issue of radiological processes and protection, and, second on issues of acid generation. While both concerns are clearly valid, the panel is in agreement that the issue of controlling acid generation is primary to the success of any decommissioning approach. This view does not in any way diminish the importance of radiological protection issues, but simply recognizes and emphasizes that unless and until the processes of acid generation are controlled in the WMAs there can be no long-term success in controlling the movement of contaminants out of the WMAs, including the movement of long-lived radioisotopes.

Once removed from their underground environment, sulphide-bearing rocks that are exposed to the effects of air (atmospheric oxygen) and water will undergo oxidation, generating sulphuric acid. In addition, iron oxides are formed which act as oxidizing agents to further enhance the oxidation-acid-generating process. This process results in a major environmental threat known as Acid Rock Drainage (ARD) or Acid Mine Drainage (AMD). While the interactions between the ARD processes and the surrounding ecological system are extremely complex, the main environmental threat stems from two sources:

- creation of highly acidic (low pH) drainage that can cause direct environmental damage; and
- greatly increased solubility, hence mobility, of heavy metals present in the wastes, including long-lived radioisotopes such as thorium and radium.

Thus, the sulphide oxidation-acid-generating process not only represents a potential direct threat, it also forms the primary control on the rate of dissolution of contaminants within the WMAs. It is this rate-controlling function that makes ARD, and the control of ARD, so important as a basic focus for the development of acceptable decommissioning strategies.

The implications and problems of ARD control in protecting the environment from the effects of sulphide bearing wastes have been fully recognized only in the last 20 years or so. Since being identified as a key factor, intensive work has been undertaken on the problem, both in Canada and internationally. Notable among these efforts is the Canadian MEND (Mine Environment Neutral Drainage) program, a seven-year cooperative program of applied research involving the federal government, eight provincial governments, the Canadian mining industry and a number of research establishments. One of the principal research and field sites associated with MEND has been the Elliot Lake area, and, in this regard, the panel has been fortunate in being able to assess directly the applicability of the research results to the WMAs under consideration. The panel has reviewed with care a great deal of information on ARD control that has emanated from this, and other, programs, particularly regarding means of stopping or drastically slowing the ARD process.

At the risk of oversimplification, and while recognizing that every specific situation is different, there are two distinct approaches that have been suggested for long-term control of the ARD process. In both cases, the philosophy is to halt the sulphide oxidation process by removing or limiting access of the sulphide minerals to one of the two key reagents required - atmospheric oxygen and water. One approach attempts to keep the wastes dry, thereby limiting the access of water to the sulphide minerals and thus slowing or stopping the acid-generating process. This approach has been implemented primarily in locations where the wastes are initially dry, the climate is arid, and the topography of the land and the wastes favours attempts to exclude ingress of water in the long term, usually through construction of a shielding soil cover or hard cover over the wastes. Experience at the Andular site in Spain may be considered typical of this approach. The panel has concluded, however, that attempts at ARD control based on this approach would be neither suitable nor feasible for the climatic, topographic or waste conditions at the Elliot Lake WMAs.

The second approach may be thought of as the reverse of the first, depending for its effectiveness on complete saturation of the waste. The underlying principle is that the water, by completely surrounding each sulphide-bearing particle, as well as filling the interstices between particles, largely excludes free oxygen from coming into contact with the sulphides, thereby stopping or drastically slowing the oxidation process. One analogy that has been used is that of the preservation (i.e. lack of oxidation) of submerged shipwrecks, again because of the very slow rate at which free oxygen can be made available in an underwater setting. For the climate, topography and condition of the wastes at Elliot Lake, the panel has concluded that there is now a broadly based consensus in the scientific community that saturation of the sulphide bearing wastes is the most effective method of slowing the processes of acid generation to a virtual standstill, (i.e. slowing these processes to such an extent that the flux of acids and dissolved contaminants to the environment occurs at a rate that can be absorbed or handled without harm). Based on current knowledge, no other credible, feasible method of ARD control has been brought forward. Thus the panel concludes that any effective decommissioning proposal for the WMAs must include saturation of the wastes as a key principle.

3.2.2 Radiological Exposure

Many of the public presentations and submissions made to the panel raised concerns related to the radiological risks associated with uranium mine wastes. It is clear that about 85 per cent of the radioactivity present in the original ore remains in the tailings, primarily in the form of thorium 230 and its decay products, notably radium 226 and radon gas. It is also clear that these materials cannot be “neutralized” using any known technology, and have half-lives measured in millennia such that the potential radiological risk can be considered to last in perpetuity. What is less clear is the nature and degree of that risk. The panel was presented with widely divergent views on this matter, primarily regarding issues of dose rate, total dose, and the correlation of these factors with increased risks to human health. In particular, opinions differ concerning the level of risk associated with the acknowledged very low dose rates represented by the WMAs. The panel has concluded that, while areas of legitimate uncertainty and debate remain, there is no doubt that issues of radiological exposure represent a continuing concern to the Canadian public, and that this is seen by a significant segment of the public as an important, perhaps the most important, potential hazard that must be controlled as part of the decommissioning process.

Exposure of biota to radiation emanating from the wastes could occur in several ways, including direct exposure to gamma radiation at the site, uptake of radioactive particles either at the site or due to off-site transport of these particles by wind, water or biota, and exposure to radon gas either at site or off site. In general, the radiation dose received will be affected by the length of exposure, the distance from the radiation source and the presence of any materials that provide shielding.

Just as differences of opinion exist regarding radiation risk, so, too, are there differences concerning the effectiveness of various methods of controlling this risk. The solubility of heavy metals such as thorium and radium, and hence their potential for off site mobility in water, is increased with increasing acidity, and in the panel’s opinion this lends extra weight to the importance of controlling acid-generating processes in the wastes. Saturation of the wastes for acid control will also decrease radiation hazards, as radon emissions have been shown to decrease as the moisture content of the wastes increases, the water will provide some shielding against ionizing radiation, and water will aid in dust control. Access and land-use controls for the waste storage facilities will be necessary to help limit exposure times and distances, and to avoid future exploitation of the wastes. With respect to access control, the panel notes that any decommissioning approach that depends on a system of surface containment (Section 3.3.3), rather than on “final” disposal in a non-accessible location (Section 3.3.2), will be subject to biotic intrusion. Indeed, if the development of an active ecological system is accepted, or encouraged, as an inherent part of the decommissioning process, then the issue of biological uptake of radiological contaminants, and the potential for subsequent magnification through the food chain, must receive serious attention. (Section 6.2.5)

Several presentations to the panel suggested that control of the potential radiation hazard requires that the wastes be re-mined, the thorium and radium extracted, and then stored in a secure high-level radiological waste facility. The panel does not consider this to be a feasible alternative under current conditions of technology and economics, and is doubtful that any net benefit in terms of risk reduction could be gained.

3.2.3 Security of Waste Storage Facilities

A potential source of hazard is the dispersion of the wastes, or their contaminant inventory, out of the storage facilities and into the environment in an uncontrolled manner. Uncontrolled dispersion could seriously affect the control of acid-generating processes in the wastes (Section 3.2.1) and protection against radiological hazards (Section 3.2.2). Means of ensuring the physical integrity of the storage facilities indefinitely is therefore an essential ingredient of any decommissioning proposal (Section 6.2.1).

3.3 DECOMMISSIONING ALTERNATIVES: THE BASIC OPTIONS

3.3.1 General

The obligation to be met by the decommissioning process is to put into place means of protecting the environment, in perpetuity, from the potential hazards that the uranium mine wastes represent. The particular challenge is to find or devise physical and institutional mechanisms that meet this obligation by ensuring that the wastes remain physically and chemically stable, and that the rate of release of contaminants to the environment remains sufficiently low that the probability of harm arising is kept within acceptable limits, as discussed in Section 3.1.1.

Broadly, the decommissioning alternatives and options presented to the panel can be grouped into two categories:

- **Disposal options,** which seek to remove and isolate the wastes in perpetuity; and

- **Containment options,** which seek to impound and monitor the wastes in perpetuity.

3.3.2 Disposal Options

3.3.2.1 General

The objective of a disposal option is to find a way to permanently eliminate concerns about potential hazards associated with the wastes, by treating them in some way or removing them to a location that is thought to isolate them indefinitely. The potential benefits of a disposal method compared to a containment method might include elimination of the need for perpetual care, with its implied need for dependence on human institutions, and the achievement of an enhanced level of security regarding environmental protection (Section 3.3.3).

Two approaches that might be considered as disposal methods were presented by the proponents: **mine disposal** and **deep lake disposal.** A third approach, comprising thorium-radium extraction from the wastes, followed by permanent disposal, was suggested in several of the submissions to the hearings.

Before summarizing the conclusions of the panel regarding each method, three general points are noted. First, each of these methods would require complete - re-mining of the wastes currently stored in the various WMAs. In the panel's opinion, the environmental impacts of this process would be significant and cannot be ignored. Second, any such method, if feasible, would require several hundred million dollars in funding. While economics are not the primary consideration of this panel, we do not believe it is realistic to anticipate that such funding levels will be obtained from any identifiable source. Finally we would note, as others have done, that in natural ecosystems there is no "away". Materials can be moved from one place to another, or transformed, but cannot be "thrown away". In essence, disposal methods are really means of slowing down the contaminant release rates to the environment to extremely small values.

3.3.2.2 Mine Disposal

The concept of placing all of the wastes back into a deep underground location (i.e. a mine) has a ***prima facie*** appeal based on the thought that this would simply serve to return the materials to their source, where they would cause no further harm. Both proponents have provided an assessment of this alternative, and it was raised in several of the submissions during the hearings.

The fundamental fact that confronts this alternative is that it is physically impossible to replace all of the wastes into the mines from which they were derived - they simply will not fit. The act of breaking rock causes a volume expansion which cannot be reversed, because the pieces cannot be fitted back together. One alternative for placing all of the wastes underground would be to create new mines for this sole purpose, which would then raise the need to find an acceptable disposal site for the newly mined rock. The panel does not consider this to be a realistic alternative. A second alternative would be to utilize other abandoned mines in northern Ontario for this purpose. The cost and difficulty of rehandling, transporting and placing the wastes into distant mines is not justified by the questionable incremental gains.

Conceptually, however, it would be possible to place some proportion of the wastes back underground in the original mines. Prior to full closure of Denison Mine, some tailings were relocated underground. However, the current situation is that the mines are decommissioned, flooded and backfilled in many areas, and have ground support systems that cannot be considered reliable. Re-opening the mines now would require replacement of key services, notably shaft access and ventilation, under extremely difficult and dangerous conditions. The costs would be large and, as noted above, the environmental impacts of rehandling the wastes cannot be ignored. In comparing the hazards, impacts and costs involved against the benefits of partial removal and disposal of the wastes, the panel has concluded that there is no net benefit to be gained in relation to other decommissioning alternatives.

3.3.2.3 Deep-Lake Disposal

Deep-lake disposal of mining waste has received, and continues to receive, serious attention as a means of preventing sulphide oxidation - acid-generation. The Canadian (MEND) program, for instance, has conducted extensive studies of four lakes into which mine tailings have been placed, in one case more than 40 years ago. Their studies indicate that, while this form of subaqueous disposal is effective when considered frorn the technical standpoint of control of acid generation and associated contaminant mobility, this option is generally only favoured if man-made lakes are used. For natural lakes, they conclude that considerable controversy exists. Nevertheless, consideration has been given to the possibility of disposing of all of the Elliot Lake tailings into Quirke Lake. This alternative was reviewed by the two proponents as a possible means of achieving, eventually, a secure and relatively maintenance-free repository that might eliminate long-term concerns of acid generation and radiological hazards to terrestrial biota.

As previously noted, significant environmental impacts would be likely to arise from the process of re-mining the wastes. In addition, although the short- to intermediate-term impacts on Quirke Lake are not fully understood, they are judged to be significant: the proponents' studies indicate that a serious degradation in water quality would occur, affecting the fishery for 30 years or more. The federal Department of Fisheries and Oceans does not support this alternative, and the panel has concluded that this alternative does not represent an acceptable option.

3.3.2.4 Permanent Treatment of Wastes

During the course of the hearings, several suggestions were brought forward concerning the possibility of undertaking some form of treatment of the wastes that would result in their permanent detoxification, either by solidification or entombment or by removal of all active contaminants (sulphides and radioactive materials, in particular). In the opinion of the panel, no credible methods currently exist by which any form of permanent treatment could be realistically undertaken. However, it is also clear that new knowledge is constantly being gained, and will continue to be gained at sites such as Elliot Lake, and that new technologies may emerge that will have some role to play in the permanent stabilization or treatment of uranium mine wastes. Thus, in the panel's opinion, there is some advantage to decommissioning approaches that will not eliminate future consideration and possible incorporation of new insights and new technologies as they emerge.

3.3.3 Containment Options

3.3.3.1 General

The objective of a containment option for decommissioning is to place the wastes in a secure impoundment in such a manner that the environmental and health risks are reduced to an acceptable level, and to provide for long-term monitoring and management of the facilities to ensure, in perpetuity, that acceptable levels of risk are not exceeded. Thus, any containment system should more properly be referred to as a contain-and-manage system, emphasizing that there is no "walk-away" option. The conclusions of a recent (1992) report by IAEA on uranium tailings are significant. As previously noted (Section 3.1), these conclusions state in part:

> The radiological hazards are very long-lived, and the non-radiological hazards virtually never decrease; hence, long-term management is required after the mine has ceased to operate.
>
> It should be recognized that no method of isolation can be complete, nor can any isolating structure be sure to last forever. Thus, the aim of impoundment is to ensure that the rate of escape of pollutants and their rates of transport to the environment remain sufficiently low to ensure that the probability of harm arising is within acceptable limits.

Notwithstanding these cautionary statements, the IAEA goes on to conclude that adequate technology and experience now exist such that:

> ***It is possible to manage uranium mill tailings in a manner that will be acceptable not only to the present, but to future generations.***

In the panel's opinion, for any proposed contain-and-manage decommissioning approach to be credible, it must meet two broad tests of performance adequacy, one in the short to intermediate term (hundreds of years), and the other in the very long term (i.e. indefinitely). Clearly, it is the "in-perpetuity" problem that is most vexing, and this issue is discussed further in Section 3.4. In general terms, the elements of an acceptable containment system must include:

- a physically secure, (i.e. stable and long-lived), impoundment system;
- protection against unacceptable radiological and non-radiological risks; and
- credible provisions for perpetual care.

It is clear that no man-made structure can be guaranteed to "last forever," and, indeed, within the context of geological time and processes, nothing lasts, unchanged, forever. Rather, the goal for man-made impoundment structures should be, first, the provision of a demonstrably very high degree of stability over the intermediate term and, second, the provision of a type of structure that has the inherent ability to perform reliably in a range of changing conditions and for a very long time, with a minimum of (but not zero) human intervention. In the opinion of the panel (Section 6.2.1), the inherent characteristics of well-engineered and carefully constructed embankment dams are such that they are reasonably likely to be capable of exhibiting this performance, although the need for continuing surveillance and vigilance is stressed. In some important ways, such structures mimic and become a part of the natural topography, being composed of local, naturally occurring materials, and resulting in the formation of ponds, lakes or swamps that resemble those found in nature.

As discussed in Section 3.2, the panel is of the opinion that control of contaminant releases from the Elliot Lake wastes to the environment requires that the wastes be impounded in a saturated condition. Intensive management of the wastes must, therefore, be continued until this goal is achieved. Additional measures for the control of potential hazards will be required as noted in Section 3.2.

Credible provisions for perpetual care must be a central part of a contain-and-manage system. In the panel's view, this philosophical stance is not negotiable. However, while accepting the need for continuing future care, it is clearly important to minimize the magnitude of the perpetual care activities required in order to minimize the burden placed on future generations, and to minimize dependence on long-term institutional controls. Hence, acceptable containment approaches should incorporate systems that are likely to meet their performance requirements with minimal human intervention. In the panel's opinion this raises an important guiding principle: to minimize long-term human intervention requirements, the containment systems should work with, and not against, the natural, bio-regional ecological system. In recent years, important work has been done on the precepts of design for what have been termed "living machines," which are devices made up of living organisms of all types, forming an interrelated whole that functions together for the purpose of achieving waste treatment. In short, the "machine" invents itself through the evolution of a natural system best suited to living with and on the specific wastes involved. While the panel is keenly aware that potential problems such as the uptake, biological magnification and off-site movement of contaminants will require continued surveillance, the principle of working with natural ecological systems that can evolve in concert with the environment and thereby minimize the future burden of care remains a valid goal.

Based on the above discussions, the panel concludes that there are four elements that should be incorporated into any proposed contain-and-manage decommissioning system.

- It must be based on the best current knowledge and technology, appropriate to the specific conditions of the site, for minimizing environmental hazards in the short-term and for the foreseeable future.

- To the maximum extent possible, it should rely on passive protective mechanisms which are found in nature, that are consistent with the bio-regional ecosystem, and that are likely to be able to evolve as part of the natural ecology and, hence, to exist, in modified form, in perpetuity.

- All elements of the system must be both robust and flexible. Robustness refers to the ability to continue to perform in an acceptable manner, without modification, in a wide range of operating conditions, such as may occur during extreme events or due to slow changes in the environmental conditions of the facility. Flexibility refers to the ability to change, or be readily modified, in response to changes in such factors as operating conditions, performance objectives, or the advent of new knowledge.

- Finally, the overall system must incorporate clear, unambiguous and sound financial and institutional mechanisms to ensure that vigilance regarding facility operation, appropriate care and emergency preparedness is maintained eternally.

Broadly, two possible forms of contain-and-manage decommissioning were brought forward during these hearings, based on dry **("keep the water out")** or wet ("keep the water in") concepts.

3.3.3.2 Dry Containment

As noted in Section 3.2, an approach that has been followed in some parts of the world has been based on the exclusion of water from the wastes, essentially by entombing them within carefully constructed multi-layered engineered barriers. At the Elliot Lake WMAs, most of the wastes are already saturated, the availability of impervious materials in the immediate vicinity is limited, and the climate is not conducive to achieving permanent hydraulic isolation of the wastes. In the panel's opinion, dry containment does not incorporate the key elements noted in Section 3.3.3.1, and is not considered to be a feasible option for the Elliot Lake WMAs.

3.3.3.3 Saturated containment

As discussed in Section 3.2.1, the panel considers that saturation of the wastes is a highly desirable goal, mainly because

- saturation will slow to a virtual halt the processes of acid generation within the wastes;

- saturation will minimize the rate of release to the environment of radiological and non-radiological contaminants;

- the concept of saturation fits well with the natural climatic, topographic and soil conditions in the Elliot Lake area; and

- saturation approaches which include a free water layer above the waste surface will also help control access, discouraging future human exploitation of the tailings materials.

While the panel is satisfied that saturation provides key benefits for long-term containment, there are several issues that are important to address. First, the fact that an active ecological system will develop in association with any surface containment raises important questions regarding the effects of biological uptake of contaminants. This question must be a direct and primary focus of the continuing, long-term monitoring and research efforts that are part of the perpetual care program. By emphasizing this requirement, however, the panel does not imply that the development of an active ecological system associated with the wastes is necessarily either harmful or undesirable. In fact, a number of researchers have made it clear that, in their opinion, systems such as vegetative wetlands can play a powerfully beneficial role in the natural control of hazards from the wastes. This matter is discussed in Section 6.2.5.

Second, there is the question of the longevity of the surface layer, above the saturated wastes. "Wet cover" approaches use a free water layer or pond above the wastes. The panel believes that a number of the concerns that were expressed during the hearings relate to the fact that water appears to be a rather ephemeral substance, easily lost by processes such as evaporation or leakage. Hence, there was a feeling that greater reliance should perhaps be placed on "hard covers," engineered to resist removal or penetration by natural or man-made events. While these concerns are fully understandable, the panel believes that there are compelling reasons which lead us to be more confident in the longevity of a water cover than that of an engineered hard cover, within the context of a northern Ontario setting, as discussed in Section 6.2.2.

Some confusion exists regarding the apparently different alternatives that have been suggested at Elliot Lake, those of providing either a "wet cover" or a "dry cover" over the waste materials. In reality, the difference is one of degree rather than one of fundamental principle. Ideally, either approach would result in achieving fully saturated conditions in those parts of the underlying waste material that are potentially acid generating, thereby fulfilling the key principle noted above. In the case of water-covered wastes, the mechanism of saturation is clear, and protection against penetration of oxygen into the wastes would be provided by the overlying water barrier. In the case of a so-called dry (soil) cover, the intention would be for the cover material to be non-acid generating, or depleted of acid-generating materials, and for the watertable (saturation surface) eventually to rise above the level of the remaining acid-generating wastes, thus preventing access of free oxygen to the wastes. In both cases, saturation of the potentially acid-generating wastes is the primary goal.

Several presentations to the panel suggested that the use of dry covers, specifically the use of engineered "hard" covers, could also provide additional benefits by preventing human intrusion, minimizing plant growth and controlling water infiltration. While the panel is satisfied that tailings saturation is the key objective, some incremental benefit could be achieved through the use of engineered covers. However, it is not apparent to the panel that the incremental cost of installing such covers would be justified by the benefits. While the issue of human intrusion is of concern, it does not pose hazards of such an immediate or severe nature that they cannot be addressed by other means, such as water-cover barriers, land-use controls (Section 6.2.6) and signage. Excluding or minimizing plant growth is not considered to be either realistic or desirable for these WMAs, at which active ecological systems will develop and are being encouraged (Section 6.2.5). Any attempt to limit water infiltration would be counter-productive to achieving the basic goal of waste saturation.

In summary, the panel has concluded that a decommissioning approach based on the impoundment of saturated wastes is capable of addressing the key points outlined in Section 3.3.3.1, provided that adequate provision is made for perpetual care of the facilities. This issue, termed "the in-perpetuity problem," is discussed in the next section of the report.

3.4 THE IN-PERPETUITY PROBLEM

3.4.1 General

It has been emphasized throughout this report that a primary focus of the panel, and of the public, is the problem of ensuring adequate performance of the decommissioned waste facilities indefinitely. The panel has concluded that there is no currently viable alternative that can provide a fully walk-away, zero-risk solution, and that the in-perpetuity problem must therefore be confronted.

A principal difficulty that we face is the very idea of in perpetuity. There is nothing that we know of on this planet that lasts forever, and to conceive the notion of designing some form of human-made structure or human-made institution to last, in unchanged form, for hundreds of millennia can only be considered as hubris. What then does it mean, to consider designing a system of care that will last essentially forever? The key lies in the concept of evolution - that is in ensuring that the overall physical and institutional system is able to change, adapt and respond to new and unforeseen conditions as they emerge. This ability to evolve, adapt and change is an imperative of design and operation for the waste decommissioning systems.

Naturally, as part of the design process, every reasonable attempt must be made to foresee, and protect against, potentially damaging events or environmental changes. However, such predictions are inevitably made to some degree by looking in a rearview mirror - we predict the future based on the past. The "past" that we utilize for this purpose is often a few hundred years at best whereas the "future" of concern extends for millennia. Thus, we cannot be sure of having accurate predictions of future conditions. Consequently, understanding how to react to actual new conditions as they arise, even recognizing that new conditions exist, cannot be fully done now but can only be done then, in the future. We can, however, ensure as far as possible that the necessary resources will exist in the future to allow appropriate adaptations to be made.

In terms of the institutional systems required, the panel believes strongly that only if key elements of these systems are rooted in the Serpent River Watershed community can they hope to achieve their objective. That is, the community must be an organic part of the perpetual care system, because it is this community whose long-term interests will be inextricably tied to the decommissioned wastes, thus ensuring long-term vigilance.

The provision of perpetual care requires that two elements be put into place; vigilance and preparedness. By vigilance, we refer to the process of continually reviewing facility behaviour and performance standards during both active and passive operational stages, including the important process of continually acquiring new knowledge and insights as the systems develop, mature and evolve. By preparedness, we refer to the ability to react to significant changes in conditions, particularly when such changes require an immediate, emergency response.

3.4.2 Vigilance

The decommissioned waste facilities will be required to perform their protective functions for millennia, during which time there will be changes to the environmental conditions within which they must operate. Some changes will be external to the facilities, such as climate changes, while others will be internal, such as the gradual succession of plant and animal species forming an active ecological system within the waste areas. The panel considers that perpetual vigilance regarding the facilities' performance can only be achieved if the approach incorporates two complementary aspects. One aspect must be a comprehensive program of scheduled facility monitoring and maintenance, with appropriate allowances for contingencies. The second aspect must be curiosity-driven research undertaken as a means of understanding and pro-actively monitoring the facilities' evolution over time.

3.4.2.1 Monitoring and Maintenance

A comprehensive plan for the operation, monitoring, care and maintenance of the waste storage facilities over time must be developed and approved as part of the licensing procedure. The panel fully supports this approach, which reflects prudent and necessary practice for any complex man-made system. Such a plan forms the backbone of an adequate program of vigilance. The details of such a plan, particularly regarding the type and frequency of scheduled monitoring and maintenance operations, appropriate allowances for contingency actions, and reporting/review structures and authority, are most important. Comments on certain aspects to which the panel wishes to draw attention are included in Section 7.

While developing and adhering to a sound plan of monitoring and maintenance is a necessary condition to assure vigilance, it is not sufficient by itself. Such plans and procedures are, of necessity, based on our current understanding of the extremely complex chemical, physical and biological processes associated with waste facilities, and on the use of simplified modelling and other predictive techniques. What will actually happen in the future in these complex systems is not fully understood, and cannot be fully foreseen. To provide a continually improving basis of understanding, and hence a continually improving forecast of behaviour, as well as updated projections of future monitoring and maintenance needs, continuing research is required.

3.4.2.2 Research

In the panel's opinion, one of the most effective monitoring tools available is curiosity-driven research. Appropriate research work will focus enquiring minds on issues related to the Elliot Lake waste storage areas. Enhanced understanding of the fundamental processes at work as the waste areas evolve will provide two key benefits - a sound framework within which to interpret and understand the data flowing from the scheduled monitoring activities, and early indications of factors or processes that had not previously been recognized. The latter factor will not only permit early redirection of monitoring efforts and optimization of monitoring expenditures, but will ensure that knowledge gained from this long-term experiment is available for public benefit and future use.

During the hearings, the panel was gratified to hear that both Rio Algom and Denison Mines fully support the principle of incorporating a sound research component into their approaches for long-term monitoring of the waste storage facilities, and believe in its Importance. All parties to the hearings, both government and private, were equally supportive. In the panel's opinion, creating a separate, dedicated and protected endowment fund to support curiosity-driven research into aspects of uranium mine waste storage should be a condition to be met before a decommissioning program is licensed, as discussed in Section 7.

3.4.3 Preparedness

As part of normal monitoring and maintenance activities, appropriate and reasonable allowances for contingency items will be required. However, beyond these "normal" contingencies, there will be a requirement for the owners of the facilities to be able to react in a timely manner to major, unforeseen events. This will require not only keeping funds available so that prompt action can be taken in response to emergency events, but also ensuring that the necessary equipment and infrastructure are accessible. During the negotiations that will be ongoing as part of the licensing process, definition of the nature, scale and type of emergency preparedness must be fully considered. In this regard, a number of specific issues for consideration are noted in Section 7.

4.0 IDLE SITES

4.1 GENERAL

It was mentioned in Section 1 that the panel's terms of reference had been expanded slightly to permit the situation of certain other mines, additional to the four that are the specific concern of this review, to be taken into consideration in some way. Specifically, the panel was asked to "take into consideration... the contribution of {the four identified} mines... to the cumulative environmental impact resulting from several decades of uranium mining in the Serpent River watershed".

In total, 14 mines have been identified in the area: the Quirke, Panel, Spanish American, Nordic, Lacnor, Milliken, Buckles, Stanleigh, Pater and Pronto mine properties owned by Rio Algom; the Denison, Stanrock and Can-Met mine properties owned by Denison; and the Agnew Lake mine property owned by a subsidiary of Noranda Inc. (Figure 2). Of these sites, 13 are or were uranium mines; the fourteenth, Pater, was a copper mine, but it is included for consideration because its tailings were added to those of Pronto, a uranium mine.

Agnew Lake is in the drainage basin of the Spanish River, a different watershed, and will not be considered further. There is a question as to whether Pronto and Pater should be regarded as within the drainage basin of the Serpent River. However, they are clearly within the Elliot Lake area, and the effluents from their shared tailings drain into Lake Huron's North Channel in the immediate vicinity of the Serpent River outlet. The panel considers it reasonable to regard them as part of its mandate, specified in the passage quoted above.

4.2 CURRENT STATUS

Of the nine mines under consideration (omitting the four designated mines), eight ceased production some years ago; hence the term "idle mines." The ninth, Stanleigh, is still in production but is scheduled to close in the summer of 1996.

In the "north limb" portion of the Serpent River Basin there is a WMA for Spanish American, in addition to those for Quirke, Panel, Denison and Stanrock. Rio Algom reported that the Spanish American mine, which operated briefly in the 1950s, produced less than 500,000 tonnes of tailings. These were placed in a WMA that continues to be actively managed. Apparently, the tailings were treated with lime in 1994, and the effluent is reportedly transferred to the Denison TMA where it receives treatment. There is no separate WMA for the Can-Met tailings. Some were used for dam construction and the remainder were placed in what has become the Stanrock TMA.

In the "south limb" there are WMAs associated with Stanleigh, Nordic and Lacnor. The fully engineered Stanleigh WMA is expected to contain some 20 million tonnes of tailings when operations cease in the summer of 1996. This includes the tailings from 5 million tonnes of ore extracted from the Milliken mine, which operated from 1958 to 1964 and had no WMA of its own. Nordic, where operations ceased in 1968, has a WMA that contains some 12 million tonnes of tailings. Rio Algom indicated that a major program of rehabilitation and revegetation, undertaken at Nordic in the 1970's, has been very successful. The effluent from this WMA is reportedly collected at two sites, combined at one of them, and is treated there. Lacnor, which ceased operation in 1960, has a WMA holding 2 million tonnes of tailings; like that of Nordic, this WMA was the subject of a rehabilitation program in the 1970s. Effluents from this WMA are not treated at the site but are collected and transferred to the Nordic plant for treatment. The fifth "south limb" mine, Buckles, produced only 250,000 tonnes of ore in its one year of operation. These were trucked to either Lacnor or Spanish American for processing.

The two remaining mines, Pronto and Pater, are somewhat remote from the other mines mentioned. Effluents from their combined 4 million tonnes of tailings are treated prior to discharge into the North Channel.

In summary, the eight "idle" mines and Stanleigh have combined tailings that total roughly 35 million tonnes, contained in five WMAs which all have active effluent treatment. Their regulatory status varies, but it appears that only Stanleigh holds an active operating licence from the AECB. The Board initially indicated that, consequently, it was not in a position to receive applications for decommissioning licences for these eight mines. However, review of the legislation revealed that the Board could consider for approval applications by the owners for "Prescribed Substances" licences for these mines. These licences could then provide the basis for applications for decommissioning licences.

The panel was informed that the proponents are, in fact, applying for "Prescribed Substances" licences, with the intention of following up with decommissioning applications. Rio Algom intends to apply for a decommissioning licence for Stanleigh, based on a proposed water cover containment system.

4.3 RELATIVE ENVIRONMENTAL IMPACTS

The two Rio Algom mines referred by the AECB have tailings totaling some 62 million tonnes, and the two Denison mines have a total of about 69 million tonnes. The total of the tailings associated with the other nine mines considered (eight "idle" mines, plus Stanleigh) is approximately 35 million tonnes.

While the environmental impact of uranium mine tailings need not be directly proportional to their tonnage, as the efficacy of their containment is clearly an important factor, the tonnage may be used to provide a general indication of the impact. Using this indicator, the panel concludes that the contribution of the four designated mines to the cumulative environmental impact is a major factor, but that the contribution of the other nine mines, with roughly one quarter of the total tonnage of tailings, is undoubtedly appreciable.

The foregoing discussion does not take into account that all of the nine other mines, whether or not they have an associated WMA, have or had both underground and surface facilities, which may contribute to the overall environmental impact. In most cases, these facilities have already been demolished, but this may have taken place many years ago when there was less awareness and concern about environmental factors. Prudence would suggest that the overall situation at these sites should be carefully reviewed, and not merely the status of the tailings sites.

5.0 DECOMMISSIONING PROPOSALS

5.1 GENERAL

The purpose of this section is to briefly describe decommissioning proposals put forward by the two proponents for each WMA: Quirke, Panel, Denison and' Stanrock. Brief site descriptions can be found in Section 2.2. Analysis of issues related to the design proposals, such as predicted and actual seepage rates, effluent treatment and monitoring, can be found elsewhere in this report.

Both proponents have carried out research and development programs to investigate various procedures that could be used to decommission their tailings areas. The need to meet governmental regulatory obligations to control the rate and quality of the emissions and effluent from these acid-generating radioactive wastes provided primary direction to these programs. In their EISs, both proponents have indicated that they are aware of, and accept, the moral and ethical standards implicit in protecting the health and safety of the Serpent River Watershed natural and human ecosystem.

There are approximately 131 million tonnes of tailings, including a small percentage of mine related waste, contained in the Quirke, Panel, Denison and Stanrock WMAs. The tonnage is about equally divided between the two proponents.

5.2 RIO ALGOM LIMITED

5.2.1 General

Rio Algom has proposed the option of saturating the tailings with water and retaining a water cover as its preferred method of decommissioning its WMAs. Saturating the tailings significantly reduces the rate of oxidation of the sulphides present and, thus, the rate of acid generation, with the accompanying release of metals at the lowered pH. The water cover also acts as a barrier to radioactive emissions and eliminates dust emissions from the surface of the tailings. Rio Algom recognizes that the water-cover option will require long-term monitoring and maintenance to ensure the continued viability and safety of the WMA. In addition, Rio Algom has acknowledged the need for continuous treatment of the discharged effluent as long as needed to meet the requirements set out in the decommissioning licence.

Although the same method has been selected for both the Quirke and Panel WMAs, there are considerable differences in the design and physical layout employed at the two sites.

5.2.2 Quirke WMA

As noted in Section 2.2, the Quirke WMA covers approximately 316 ha and contains about 46 million tonnes of tailings and waste rock in a rock-rimmed basin. During the 1980s, eight dams were constructed to close the intervening gaps between the rock ridges and form the perimeter of the tailings basin. These perimeter dams (Figure 4) - labelled dams L, K1, K2, J, I, G1, G2 and the Main Dam, were designed as engineered low-permeability structures to form the final containment for the WMA. With the exception of the Main Dam and Dam G2, they are all constructed on bedrock. The central portion of the Main Dam is founded on dense granular overburden, while both abutments are founded on bedrock. The granular overburden has been cut off with a low-permeability cut-off wall over the full vertical extent of the overburden. The bedrock underlying the overburden was grouted along with the bedrock exposed at the abutments. Dam G2 is founded, over most of its length, on dense low-permeability glacial till, which overlies the bedrock. The glacial-till foundation is at least as impervious as the dam itself and extends westward under Cell 18, effectively cutting off seepage out of the basin at this point. In order to reduce seepage through the other dams (L, K1, K2, J, I and G1) and to seal up any superficial fissures near the surface, the bedrock below these dams has been drilled and grouted with a bentonite cement slurry.

The shells or support structures containing the impervious core are composed of compacted granular material. The outside or downstream face of the shell has been covered with a 60 cm layer of cobbles and boulders for erosion protection. This construction is typical for dams of this type and is also employed at the dams of the Panel and Denison WMAs.

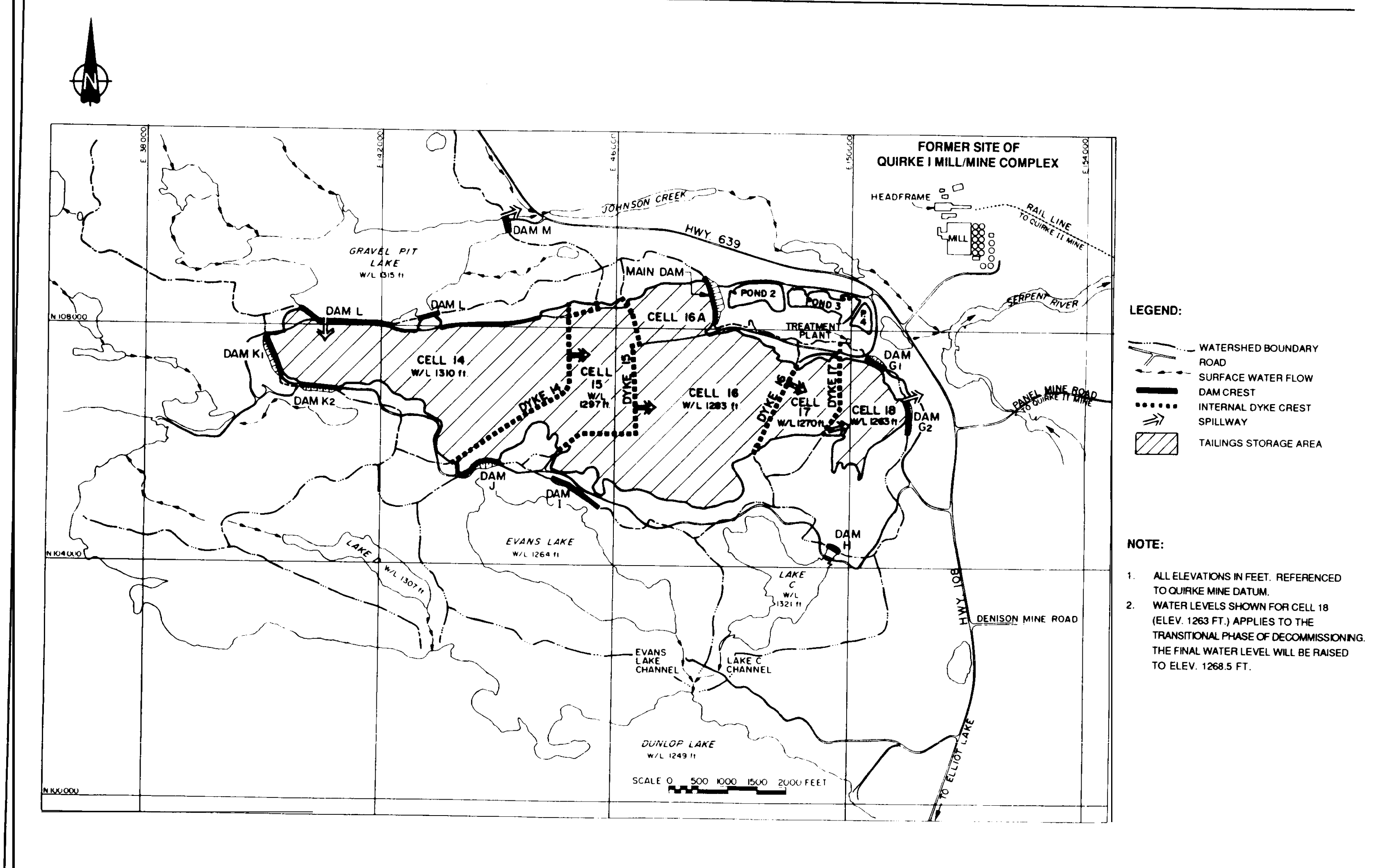
There is a spillway in an abutment of Dam G2. It was constructed in 1983 and is designed to direct the Probable Maximum Precipitation (PMP)[1] flood flow safely from the basin and direct the flow into the natural water courses that intercept the Serpent River. This spillway may be used as the discharge point following the final decommissioning of the facility.

There is a 14 m difference in elevation between the east and west ends of the tailings basin. To provide a water cover over the tailings, Rio Algom developed a terraced design with five internal cells within the Quirke WMA. These cells are shallow ponds that are designed so that natural precipitation entering the tailings area and Gravel Pit Lake area at the west end of the basin will flow into the western end of the basin and eventually discharge down through the internal cells to the east end. Treatment of water prior to release will continue as long as necessary to meet regulatory licensing requirements. Rio Algom estimates this period to be five years.

The internal cells are formed by a series of four internal dams or dykes. The dykes are 3 to 4.5 m in height and are composed primarily of waste rock and glacial till. The upper part of the dyke

[1]Two different terms are used in the EISs to describe the capability of structures to handle peak precipitation events and consequent runoff. "The regional design event," defined as the Timmins Storm of 1961, produced a total of 19.3 cm (7.6 inches) of rainfall over a 12-hour period. This represents the most extreme rainfall event to occur on record, and has a recurrence interval of more than 100 years. "The Probable Maximum Precipitation (PMP) design event" is the most extreme rainfall event that is physically possible. In the Elliot Lake area, the PMP design event has been established as al 2-hour event producing a total of 42.1 cm (16.7 inches) of rain.

FIGURE 4: QUIRKE WMA SITE PLAN



SOURCE: GOLDER ASSOCIATES LTD., 1992

is composed of glacial till, which is expected to act as a low-permeability seepage barrier. Within each dyke, an overflow spillway is provided with an invert elevation set to ensure that a minimum 0.6 m depth of water cover is provided in each cell during overflow periods. All four of the dyke spillways within the Quirke WMA are designed to convey flows resulting from the PMP design event. The spillway cross-section has erosion protection to prevent scouring during peak flows. The outfall slopes of these spillways were flattened and additional erosion protection added to prevent scouring and to provide for energy dissipation of flood flows.

When the final surface contour was established and prior to flooding, limestone was spread and tilled into the top 15 cm of the tailings to neutralize any acid that might have been present. The whole basin was flooded in 1995 after the last dyke, Dyke 17, was completed. Gravel Pit Lake, just west of the Quirke WMA, has been designed to act as a reservoir from which water can be drawn during periods when there is insufficient precipitation to maintain adequate water cover on the tailings. A dam has been constructed between Gravel Pit Lake and Cell 14 with incorporated provisions to control the outflow of water from the lake. The overflow water is designed to flow by gravity through the spillway to Cell 14 and then to the next adjacent cell with its lower elevation - that is from Cell 14 progressively through cells 15, 16 and 17 to 18, from which it will be decanted from the WMA to a treatment plant. After treatment, the decant will pass thorough settling ponds 2, 3 and 4 before exiting to the Serpent River system.

Although some natural aquatic vegetation has started to invade Cell 14 voluntarily, the placing of organic bog material in the shallow water along the shorelines prior to planting appears to accelerate the rate of increase of the aquatic plant population. These plants will serve as a seed source to initiate plant populations in the lower cells as the pond water in the lower cells reaches the required level and quality to permit plant growth.

5.2.3 Panel WMA

The Panel WMA contains approximately 16 million tonnes of tailings in two basins, which cover an area of 123 ha. For the same reasons as at the Quirke WMA, Rio Algom selected the water cover option as the preferred decommissioning method.

Presently, tailings and water in the North or Main Basin are contained within a bedrock perimeter augmented by four dams in the topographically low areas (Figure 5). As at the Quirke WMA, these dams are designed as engineered low-permeability structures. Dams B and E separate the basin from the Rochester Creek watershed to the east while Dams D and H separate the Main Basin from the South Basin. Dam H was constructed at the southwestern end of the North Basin to enable flooding of that area in 1995. The South Basin has two dams, A and F, which complete the containment perimeter. The South Basin was flooded in 1979.

The spillway from the Main to South Basin was constructed in 1992 to safely convey the flows resulting from the PMP design event. The spillway invert is designed to maintain a minimum water cover of 0.6 m over the tailings during overflow conditions. The outflow channel from the spillway to the South Basin is designed to handle the precipitation flow from a Regional Storm.

The drainage from the South Basin passes through a water treatment plant into two lined settling ponds, from which the treated effluent flows to Quirke Lake via a small creek. An emergency spillway is provided in Dam F in the South Basin to prevent overtopping of the dams in extreme flood conditions. Rio Algom expects that the water will require treatment for the next five years.

The only inflow of surface or natural water comes directly from precipitation and the run-off from a small drainage basin. Therefore, make-up water, if required during a prolonged period of drought, would have to be pumped in from an outside source. A water-diversion system diverts the natural flow of water from the 124 ha sub drainage basin north of the Panel WMA to Quirke Lake via Rochester Creek.

In Pond C, below Dam A, an experiment is taking place on tailings deposited in the early years of local milling operations. Referred to as the "Panel wetland study", it provides an example of the potential for research into decommissioning methodologies. The Panel wetland study was undertaken to establish whether the existing natural wetland and water-cover system was treating acid mine drainage, and to evaluate the system's hydrologeochemical and biological controls on acid generation and migration of contaminants associated with the oxidation process. In their submission, the Government of Ontario recommended that this area be reassessed and that consideration be given to separating this area from the balance of Pond C with a berm. The panel supports this recommendation.

5.3 DENISON MINES LIMITED

5.3.1 General

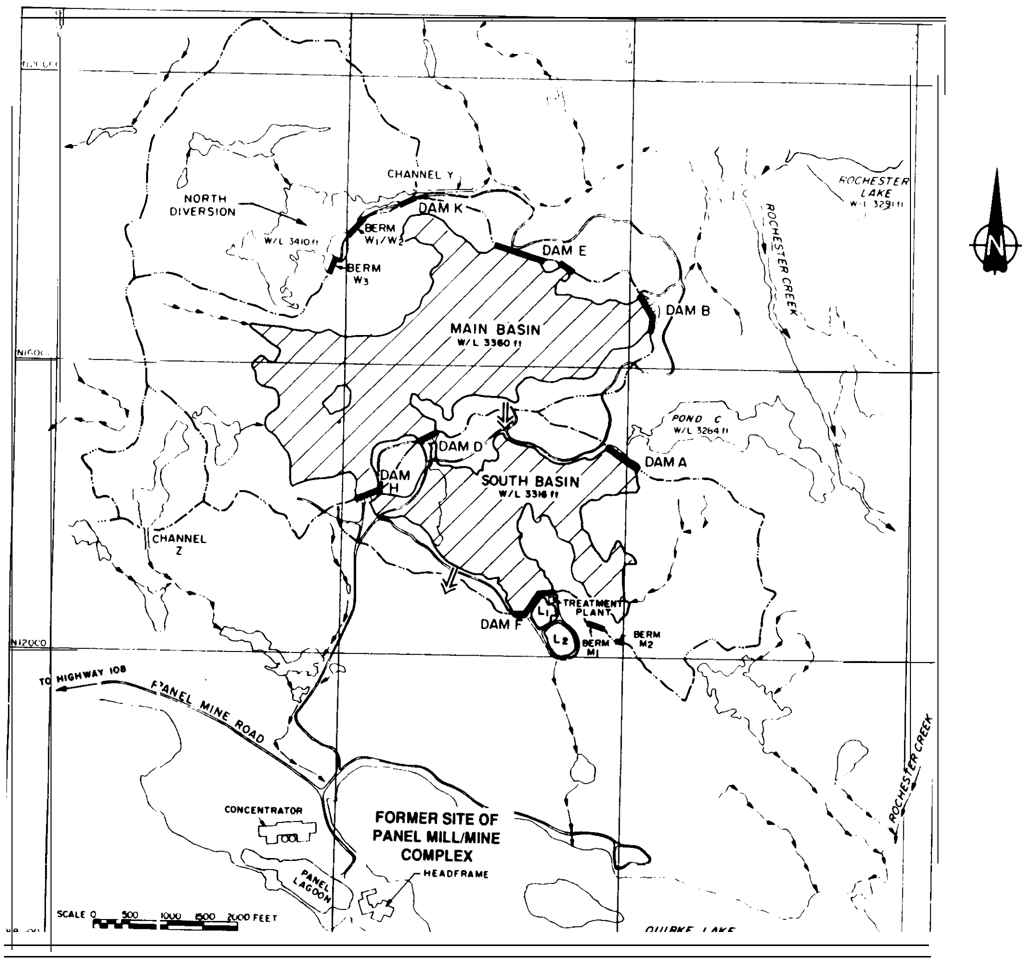
Denison Mines Limited has proposed two different approaches to decommissioning their TMAs. However, both approaches are based on the same underlying principle of maintaining long-term saturation of the acid generating tailings.

The proposal to decommission the Denison TMA, consisting of TMA-1 and TMA-2, suggests using a water cover to keep the tailings saturated. The plan to decommission the Stanrock TMA proposes using a dry cover of acid depleted tailings overlying saturated virgin tailings.

5.3.2 Denison TMA

As noted in Section 2.2, the Denison TMA is divided into two areas: TMA-1 and TMA-2. It is estimated that TMA-1 contains

FIGURE 5: PANEL WMA SITE PLAN



LEGEND:

- WATERSHED BOUNDARY
- ROAD
- SURFACE WATER FLOW
- DAM CREST
- INTERNAL DYKE CREST
- SPILLWAY
- TAILINGS STORAGE AREA

NOTE:

1. ALL ELEVATIONS IN FEET. REFERENCED TO PANEL MINE DATUM.
2. WATER LEVELS SHOWN FOR SOUTH BASIN (ELEV. 1316 FT.) APPLIES TO THE TRANSITIONAL PHASE OF DECOMMISSIONING. THE FINAL WATER LEVEL WILL BE RAISED TO ELEV. 1318 FT.

SOURCE: GOLDER ASSOCIATES LTD., 1992

59.7 million tonnes of tailings, while TMA-2 originally contained approximately 3.3 million tonnes of tailings. In their decommissioned state, TMA-1 and TMA-2 will essentially function as one unit. Their combined volume of 63 million tonnes of tailings, along with their area of 258 ha, establishes them as the largest WMA in the Elliot Lake mining complex.

The area now known as TMA-2 is contained by a northwest trending valley which is closed at the northwest end by Dam 1 (Figure 6). As part of the decommissioning program, the height of Dam 1 has been increased sufficiently to ensure that the water cover on the tailings will be maintained and that the drainage from the area will flow southeasterly toward TMA-1. In addition, 40 per cent of the tailings have been relocated into former underground workings or into TMA-1. The surface areas, from which the tailings have been hydraulically removed, will be revegetated. The excess pond water from TMA-2 will flow to TMA-1 via a spillway in the southeast end of the area. The elevation of the spillway invert has been designed to maintain a water-cover depth of 0.9 m over the tailings under overflow conditions.

To establish the perimeter of TMA-1, five low-permeability dams have been constructed to fill in the low areas between the surrounding rock hills. The east end of the TMA-1 basin terminates in a broad northwesterly ridge adjacent to Quirke Lake, where Dams 9 and 17 were constructed to contain the tailings. Dam 10 was constructed to close the western end of the basin. To the north and south the tailings are generally enclosed by the natural rock ridges. However, at low points dams 16 and 18 were constructed.

Denison proposes to modify the existing dams and to construct new spillways to ensure water covers are maintained and that severe storm flows can be accommodated. In TMA-1, the crests of the eastern dams, dams 9 and 17 will be lowered and erosion protection will be placed on their slopes. Dam 10, at the west end, will be modified to improve its stability in the long term under postulated severe earthquake conditions and to reduce seepage losses (Section 6.2.1.4).

In 1992, a new spillway was constructed to handle the overflow discharge water from TMA-1. The spillway consists of two concrete weirs set at different elevations. The lower level maintains the water level in TMA-1 at a depth of 0.9 m under overflow conditions. The second weir (0.15 m higher **in elevation)** is designed to discharge storm flows. The water discharged through the lower weir passes through a water-treatment plant to a polishing pond and thence via Stollery Lake to the Serpent River. Denison Mines estimates the treatment period to be no more **than** five years, by which time acidity of the surface water would be eliminated.

5.3.3 Stanrock TMA

As noted in Section 2.2, the Stanrock TMA covers an area of approximately 52 ha and contains 5.7 million tonnes of tailings. The unique characteristics of this tailings area have led Denison Mines to propose a decommissioning plan that is different from those proposed for the other TMAs under consideration in this review.

Denison cited three main reasons why the water-cover option proposed to decommission the other sites in the area was not practical for the Stanrock TMA. First, the Stanrock tailings have already developed an acid inventory that would require treatment for a period at least 25 years, even if water cover were provided. Second, Denison is not certain that the water cover could be maintained in times of drought because Stanrock has too small a water catchment area. Third, to establish a water cover would cost an additional $30 million, while bringing Denison no guarantee of better results than the in-situ management approach that Denison has proposed as its preferred option.

With these considerations in mind, Denison originally considered the possibility of moving the Stanrock tailings from their present location to Moose Lake, where it would be easier to create a level containment basin with water cover, similar to the arrangement proposed for the Quirke, Panel and Denison tailings. Denison set this concept aside, however, because of the substantial costs involved. While the panel does not dispute this decision, it does not give undue weight to the cost factor - although, other things being equal, that is a relevant consideration. In the panel's view, a more important concern is the risk of environmental damage that would probably arise in the process of re-excavating and transporting some six million tonnes of currently stable tailings. This course, however, would remain available should the alternative now preferred by Denison, as described below, be approved but subsequently be found to be unsatisfactory as a long-term arrangement.

A further consideration, in the panel's view, would be the potential benefits of proceeding with Denison's preferred option as an essentially experimental approach. This approach would offer an opportunity to gain valuable experience, on a large scale and over a long period, in the use of a dry vegetated cover to maintain underlying saturated tailings under the climatic and ecological conditions of the Elliot Lake area. This experience will not be available at the other sites. Denison expects to maintain active treatment of the Stanrock tailings for some 50 years; should developments during this relatively long period raise concerns about the long-term suitability of this approach, other options (such as removal to Moose Lake) would remain available.

Nine containment structures have been constructed since 1957 to control the tailings and surface run-off. (Figure 7) Eight of these structures are still operative. Of the eight, only four - dams A, B, C and D - currently retain the tailings in the TMA. These dams are built with tailings and are not considered to be engineered, low-permeability structures. The remaining four dams were constructed to facilitate the collection, management and treatment of run-off and seepage from the TMA.

Currently, seepage from Dam A and run-off from the TMA enters Stanrock Creek and flows to a water treatment plant **located** approximately 180 m upstream of Moose Lake. After **treatment,** the water flows into Moose Lake. Seepage from dams B and C, which are along the western perimeter, flows into **a containment** pond created by Dam G. The water is then pumped to Beaver

FIGURE 6: DENISON TMA SITE PLAN

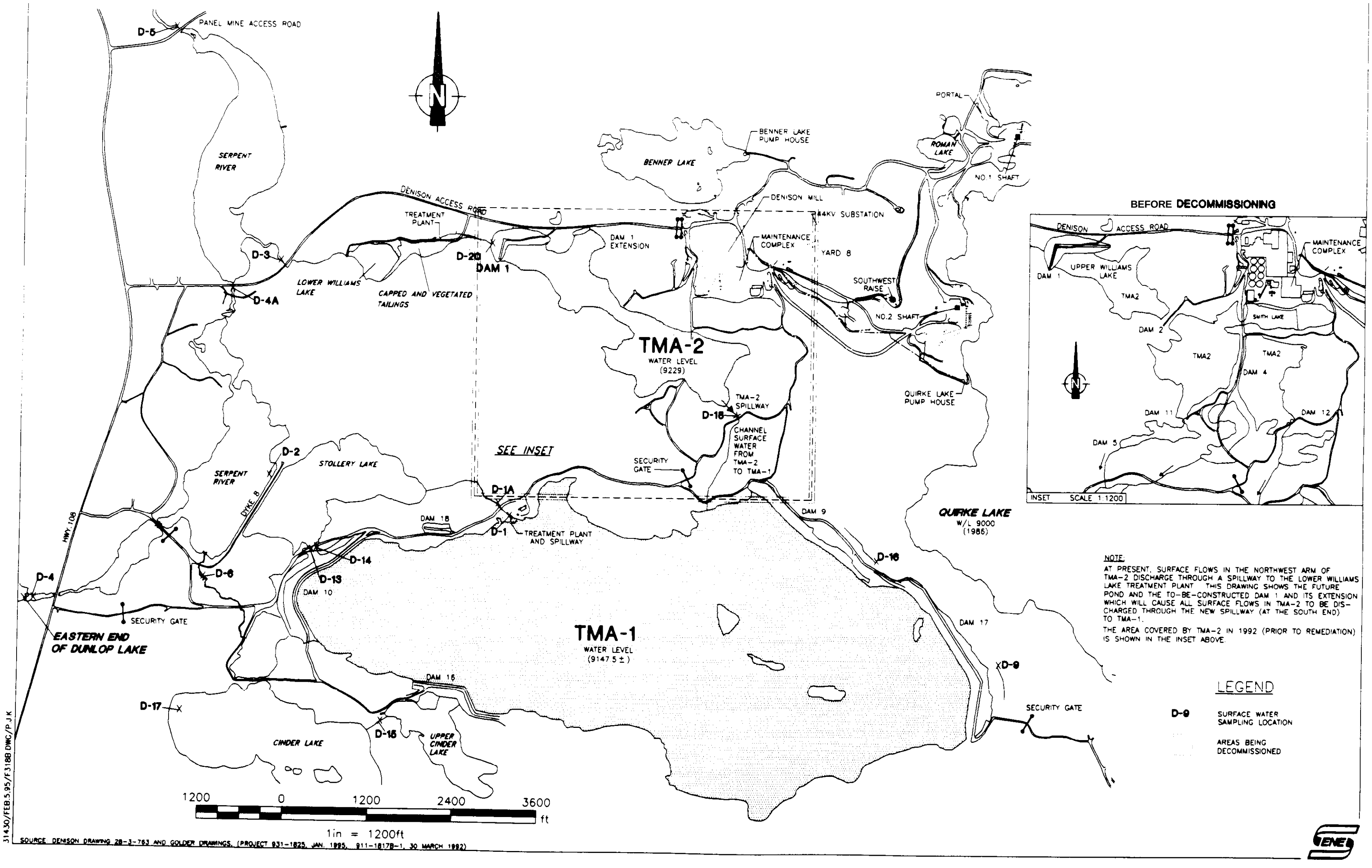
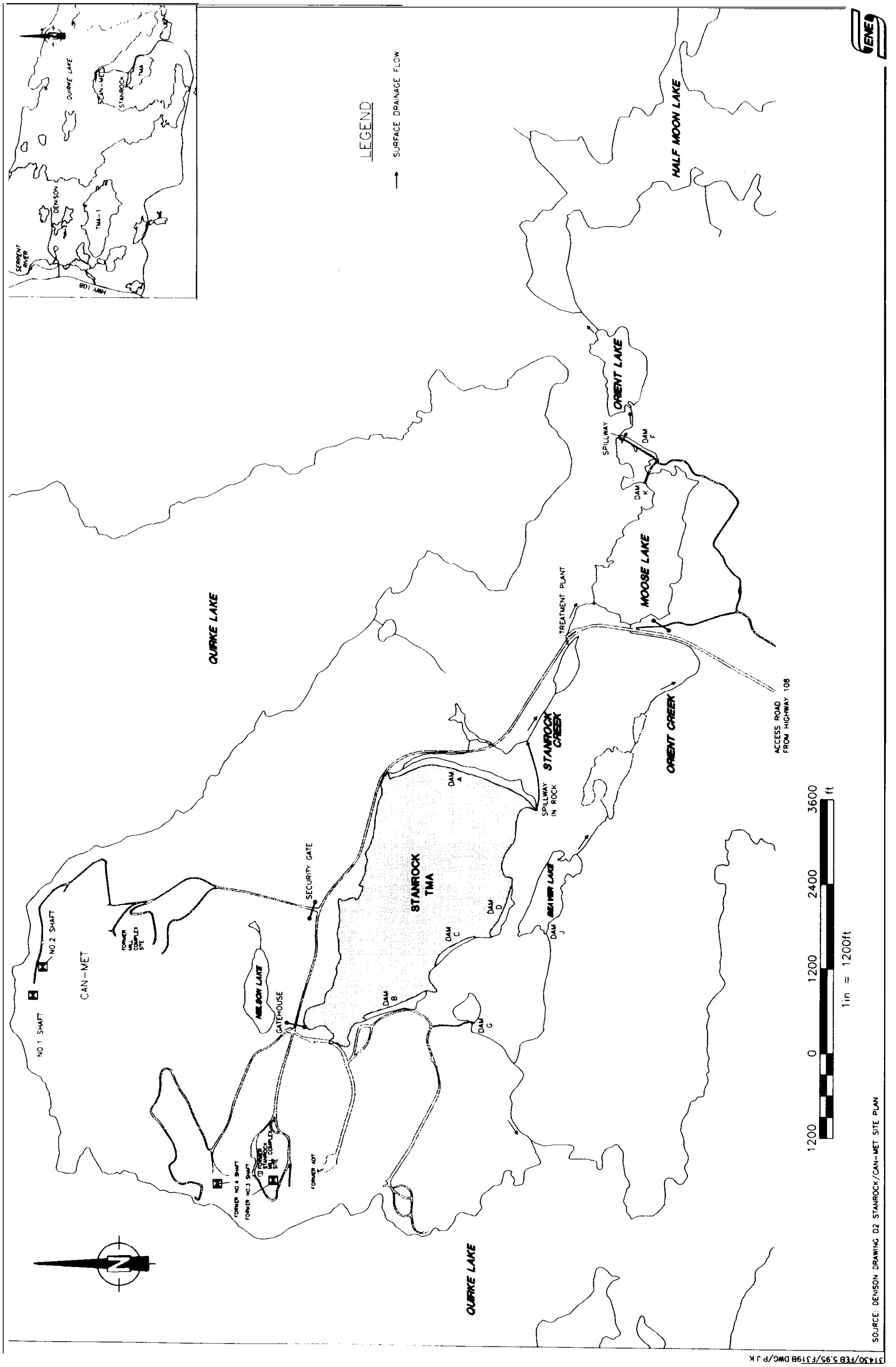


FIGURE 7: STANROCK TMA SITE PLAN



Lake. Seepage from Dam D also feeds into Beaver Lake. This water, combined with run-off from the watershed, flows into Orient Creek and is treated prior to entering Moose Lake.

Dam F, at the outlet of Moose Lake, was built to raise the level of Moose Lake to flood the tailings deposited there in the spill of 1964. Dam K, a rock-fill berm constructed across Moose Lake, was built in the early 1980s to further improve treatment in the western portion of the lake. The treated water discharges over a concrete weir in Dam F and flows into Orient Lake.

The in-situ management plan proposed by Denison Mines involves saturating a large portion of the tailings by raising the water table so that it lies below the ground surface but above the surface of active (i.e. potentially acid-generating) tailings. Four new perimeter dams on the downstream side of the existing dams A, B, C and D will be constructed. The replacement dams will be engineered, low-permeability structures constructed on grouted foundations. Essentially, these new structures will replace the original dams A, B, C and D.

The original pyrite inventory of the Stanrock tailings has been estimated to have been 108,850 tonnes. Over the years, this was reduced through natural, acid-producing oxidation processes. Based on a tailings analysis in 1990, the pyrite inventory was then estimated to be 70,200 tonnes. The proposed in-situ decommissioning plan, with its elevated water table, will flood 90 per cent of this inventory. An estimated 7,739 tonnes of pyrite (approximately 10 per cent) will still be able to react.

Denison believes that the current requirement for a separate seepage collection system along the southwest side of the Stanrock site will be eliminated by building the new dams and grouting the bedrock at the dam foundations. Surface drainage from the TMA will discharge through the existing spillway to the treatment plant, and treatment sludge will then be deposited in the Moose Lake basin. Water treatment will continue for as long as required: Denison expects this period to last for approximately 50 years. Denison plans to upgrade the existing treatment plant.

Denison also proposes that Dam F, at the outlet of Moose Lake, be raised and that the Moose Lake spillway be modified so as to provide for severe storm water flows. In the case of prolonged drought, make-up water for this TMA will have to be pumped in from an outside source. The surface of the tailings will be tilled with an alkaline material, fertilized and then revegetated. The method and the species to be used in establishing the vegetative cover have not been determined.

6.0 ANALYSIS OF DECOMMISSIONING PROPOSALS

6.1 DECOMMISSIONING PHASES

6.1.1 General

The two proponents have proposed similar approaches with regard to the timeline for the decommissioning process. Essentially, they expect to complete the construction work involved as soon as possible after approval for a decommissioning program is given. A transition period would follow, during which operation of the system would be allowed to stabilize. This transitional period would conclude when the satisfactory operation of the system had been demonstrated and effluent quality had reached an acceptable standard - that is, when contaminant levels were at or below those permitted by the terms of the decommissioning licence and reflected in the design standards of the system. At that point the long-term phase would begin, with subsequent operations limited to the program of monitoring, maintenance and repair needed to keep the system operating satisfactorily.

While the panel understands and accepts the desirability of moving as expeditiously as prudently feasible to a long-term care and maintenance regime, it is not satisfied that the approach outlined above gives adequate weight to several important considerations. Essentially, these factors relate to concerns about robustness and flexibility, and the limited extent of our present knowledge about the long-term behaviour of ecosystems involving saturated uranium mine tailings.

6.1.2 Short- and Long-term Phases

The panel accepts, for planning purposes, the proponents' concepts of an early, short-term decommissioning phase and a later long-term phase, although it has reservations, discussed in Section 7.1, with regard to the funding arrangements proposed for these two phases. The panel also accepts the concept of a transitional phase, but believes it should reflect a significantly different approach.

6.1.3 Transitional Phase

The panel envisages a short-term phase in the decommissioning process, during which the containment systems will be put in place and their initial effective operation will be demonstrated to the satisfaction of the AECB, but over a relatively short time period. What the panel sees as the short term includes both the short and transitional phases of the approach outlined in the proponents' EISs. It sees a need, however, for a subsequent period, that could turn out to be relatively extended, in which the robustness of the systems can be tested and verified.

This phase, which the panel regards as transitional, will permit the stability, effectiveness and reliability of the physical and institutional systems to be demonstrated in response to fluctuations in operating and environmental conditions, and will allow time to identify and implement any adjustments that may be desirable in the light of experience gained. The transitional period must be long enough to permit adequate validation of model-based predictions of performance. The panel believes that the proponents should remain fully responsible for all aspects of tailings management and funding throughout this transitional period.

The panel is not in a position to determine how long the transitional phase should be; that will be for the AECB to decide, taking into account experience gained in the short-term phase. The transitional phase will end when long-term performance criteria have been met; the challenge for the AECB will be to define appropriate verification criteria. The duration of the transitional phase will no doubt vary from one site to another. Rio Algom has suggested that the time needed to have its containment systems in place and operating satisfactorily may range from 5 to 10 years. If that proves to be the case, the panel would contemplate a transitional phase of at least as long again to expose the systems to the test of significant climatic or other variations. On the other hand, Denison estimates that perhaps 50 years will be required to flush out the present acid inventory at the Stanrock TMA. During such a relatively extended period, it should be possible to acquire a reasonable understanding of system behaviour under a range of operating conditions. This would reduce substantially the additional transitional time needed to demonstrate stability and robustness.

In summary, the panel recommends that the final or long-term phase at each site should not begin until such time as the containment systems have met their design objectives for a sufficiently long time, and under sufficiently varied conditions, to provide convincing evidence that they are as effective and durable as predicted. Only then should the proponents be authorized to negotiate the transfer to government of their responsibilities relating to these tailings sites.

6.2 TECHNICAL MATTERS

6.2.1 Stability and Longevity of Containment Structures

6.2.1.1 General

As noted in Section 3.2.3, maintaining physical integrity of the waste-impoundment facilities is clearly an important aspect of long-term care. As further noted in Section 3.3.3.1, the characteristics of a satisfactory contain-and-manage system should include both robustness (the ability to perform well under a range of conditions) and flexibility (the ability to respond, adapt or be modified to meet new conditions). Engineering issues to be addressed must include both structural and hydraulic design conditions that are appropriate for the long-term operation of the WMAs.

For the WMAs at Elliot Lake, it is proposed that perpetual containment of the impounded wastes will be achieved by a series of perimeter dams and dykes, with associated spillways. In the case of Quirke, additional internal dykes provide separation between various cells of the WMA (Section 6.2.1.2). In reviewing the material presented to the panel, the following questions have guided our thinking with respect to the adequacy of the proposed approaches.

- Stability of structures. Has design and construction of structures been based on the best available engineering technology with respect to short- and long-term stability?

- Longevity of material. Are materials used in structures likely to display long-term chemical and physical stability?

- Robustness under extreme events. Have analyses shown that structures are likely to perform adequately under postulated extreme events? Are postulated extreme events reasonable, and sufficiently inclusive?

- Consequences of failure. Have analyses been done to determine that the consequences of failures under extreme conditions are limited and acceptable with respect to environmental risk?

- Flexibility of design. Are structures such that reasonable actions can be taken if necessary to adapt the structures to new conditions, or to allow for reasonable repair and refurbishment in the event that failure occurs?

- Monitoring, care and maintenance. Are the structures such that they do not require unreasonable monitoring, care and maintenance, and can the necessary surveillance be conducted easily and reliably over the long term?

With the exception of the existing dams at Stanrock, most of the perimeter containment structures at the Elliot Lake WMAs comprise zoned embankment dams, generally seated on grouted rock foundations. Spillways capable of handling the postulated flood events are incorporated either into the dam structures, or are constructed as separate structures.

Extensive reviews of issues related to the stability and longevity of containment structures were undertaken by several agencies during the review process, resulting in written submissions to the panel that incorporated requests for clarification or provision of additional information regarding various aspects of these issues. In addition to the numerous documents dealing with containment structures which the proponents supplied in support of their EISs, answers to the specific queries raised were provided in two Joint Response documents submitted to the panel in September and October 1995. The panel has found all of the review and proponent documents to be most helpful in forming its opinions concerning containment structure stability and longevity.

The panel is satisfied that the approach proposed by the proponents, based on the use of carefully engineered zoned embankment dams, reflects the best available technology with which to address the problem of perpetual containment of surface-impounded wastes. Well-engineered embankment dams have exhibited remarkable durability - that is, the ability to last and to be maintained over long periods of time. Some ancient dams have lasted for thousands of years. The ability of such structures to absorb significant movements without failure, and of the natural materials of which they are made to resist chemical and physical disintegration, are among the reasons for the robustness of these ancient structures. Significant advances have been made in the understanding, design and construction of embankment dams over the last 50 years or so, and it is not unreasonable in the panel's opinion to place a high degree of confidence in the ability of modern embankment dam structures to endure over time periods measured in millennia, provided some degree of surveillance and maintenance exists.

Dam failures have certainly occurred, sometimes with devastating loss of life, and the study of past failures has contributed much toward an understanding of the behaviour of these structures. In this regard, it is important to emphasize that it is the uncontrolled release of the potential energy of the water stored behind a dam that is the real danger from a dam failure, not the earthwork failure itself. However, field evidence from past failures at the Stanrock site at Elliot Lake, plus associated studies, have shown that the volume and run-out distance of materials released in the event of a perimeter-dam failure at one of the WMAs will be limited by the shallow depth of the water that is stored, and by the relatively poor flow properties of the wastes.

Historically, by far the most common causes of dam failures have been overtopping due to flood waters which were not safely discharged through a spillway system, foundation failure beneath the dam or internal erosion leading to piping failure. It is worth noting that failures due to earthquakes are very rare. The panel is not aware of any recorded failures of embankments that have been specifically designed for service under seismic conditions, although some degree of damage or distress may be caused by a seismic event. The three main causes of historical dam failures are ones that can be addressed through prudent and well-developed design approaches, and for which effective and robust defensive measures can be incorporated into the embankment structures.

Confidence in the performance of the retaining structures rests on confidence in the use of "best available knowledge" for the design, construction, analysis of consequences due to extreme events, and monitoring. The panel accepts that the proponents have utilized "best available knowledge" for the containment structures by retaining highly reputable engineering companies that are recognized as world leaders in this field. Based on the full and continuous involvement of these companies, the panel is confident that the containment design, implementation and monitoring have been undertaken in a manner that reflects the current state of practice for embankment dams. Further, the panel is of the opinion that the current state of practice is adequate to provide a firm foundation of confidence in the perpetual performance of these structures, provided that the appropriate surveillance and maintenance activities are undertaken in perpetuity.

Finally, the panel emphasizes that while predictions of future conditions under which the structures must operate are an important part of prudent design, particularly with respect to extreme conditions, uncertainty will remain. In this regard, we have reviewed with care the long-term containment structure performance assessments undertaken by the proponents, particularly with regard to flood events, seismic events, maintenance deficiencies including blockages and vandalism, and drought effects. The panel was informed, on the last day of the public hearings, that the AECB is conducting continuing studies of the dynamic stability of the dams under seismic loading. While the panel fully supports the diligence of the AECB in this regard, it does not consider it likely that these ongoing studies will indicate any critical deficiency in the design of the structures. The panel has also reviewed with care the proponents' assessments of dam failure (breach) probabilities and the consequences resulting from postulated failure events.

From our review of the information presented, the panel concludes that the overall proposal of the proponents to provide for the perpetual containment of the WMAs using embankment dams is acceptable. We recommend that the proponents' proposals form the basis for developing the details of a decommissioning licence.

Comments on certain specific aspects of each of the four WMAs within the panel's mandate are included in the following sections.

6.2.1.2 Quirke WMA

As discussed in Section 5.2.2, Quirke WMA comprises a series of five internal "cells" separated by dykes between 3 m and 4.5 m in height, with eight embankment dams around the periphery to provide containment. Of these dams, six are founded on grouted bedrock (G1, I, J, K1, K2, L), and two on dense overburden deposits (G2 and Main Dam). The maximum dam height is 26 m (Main Dam), and all perimeter structures have been designed and constructed as water-retaining structures, that meet or exceed the normal standards of modern practice. To prevent overtopping, spillways have been designed to handle floods resulting from the PMP design event of 424 mm precipitation in a 12-hour period. Internal drains and filters are provided to protect against internal erosion ("piping"). All dams are built of and founded on materials that are expected to remain physically and chemically stable. Monitoring to date has confirmed that the dams are performing as designed. Studies of the effects of changing conditions - including increased seepage, climate change, poor maintenance, etc. - have indicated that the structures are robust and capable of performing adequately despite such changes. Credible studies have concluded that the risk of having unplanned discharges of water or wastes from the Quirke WMA is in the order of one in one million, annually, and that the hazards resulting from an extreme event would be minor and readily mitigated. The panel concurs with these conclusions.

There is, however, one element of the Quirke WMA that is less "secure" than the engineered perimeter dams, and that is the presence of the dykes that separate the internal cells. These dykes are relatively pervious structures built of mine waste rock, founded on previously deposited tailings, with an upstream barrier of compacted glacial till to reduce seepage quantities. A dyke section may be more likely to fail than a perimeter dam as a result of earthquake, flooding, seepage and erosion, or other factors. In such a case, water would be released progressively from one cell to another. This scenario was included in the probabilistic assessment of long-term performance submitted by the proponent. The environmental impacts of a dyke failure were predicted to be minimal, and the costs of remediation have been included in the proponent's projections of financial obligations. The panel was informed that this scenario is under continuing review by the AECB. That may result in some modification, although this is not expected to seriously jeopardize the security of the impoundment system as proposed.

Details of an approved program of scheduled and contingency monitoring and maintenance must be worked out during the short-term and transition phases of operation, and should be based initially on meeting all recommendations of the proponent's consultants, as a minimum requirement. In particular, the panel would draw attention to the importance of ensuring that adequate monitoring instrumentation is installed in the containment structures, maintained in good working order and regularly monitored, and that a comprehensive plan of continual surveillance and maintenance is put into place. Some minor additional monitoring of the dyke structures is recommended by the panel, to confirm the proponent's expectation that there is no ongoing settlement of the dykes.

6.2.1.3 Panel WMA

As noted in Section 5.2.3, the Panel WMA comprises two rock-rimmed basins, the Main Basin and the smaller South Basin, with a series of six perimeter containment dams (dams B, E, H and D in the Main Basin; dams A and F in the South Basin). All dams are founded on grouted bedrock except Dam B, which has a partial soil foundation. These structures have been designed and built as water-retaining structures that meet modern requirements. Four of the dams incorporate a synthetic membrane seepage barrier (Hypalon), in addition to other seepage barriers. In response to concerns that were raised that the longevity of Hypalon membranes was short in relation to the life of the WMA, the proponent has clarified that these membranes will not be relied upon for long-term seepage control. The spillway from the Main Basin to the South Basin, and an overflow spillway from the South Basin, are designed to handle floods resulting from the PMP design event.

As of 1993, no monitoring instrumentation had been installed in the containment structures. The panel supports the recommendations made by the proponent's consultants for the installation of essential instrumentation and the implementation of associated monitoring procedures as a minimum standard.

6.2.1.4 Denison TMA-1 and TMA-2

Relocation of approximately 1.5 million tonnes of tailings from the north part of the Denison TMA, called TMA-2, has been completed. The final configuration of TMA-1 and TMA-2 includes a series of five containment dams around TMA-1 (dams 9, 10, 16, 17 and 18), and one main containment dam for TMA-2 (Dam 1). Of these, dams 9, 16, 17, and 18 are fully engineered zoned earthfill dams, and appropriate analyses show them to be stable under postulated static and earthquake operating conditions. Dam 1 (TMA-2) and Dam 10 (TMA-1) both incorporate Hypalon membranes as a seepage barrier.

As part of the decommissioning proposal for TMA-2, Dam 1 must be raised approximately 4 m and extended by approximately 80 m. Analyses of the reconfigured dam indicate that it will perform adequately under both static and earthquake conditions. For the reconfigured dam, seepage control by the Hypalon membrane will no longer be necessary, as the estimated seepage quantities will be too small (approximately 0.3 L/s) to affect downstream water quality adversely. This estimate of seepage should be confirmed by long-term observations.

Within TMA-2, a new spillway will be required to ensure that Dam 1 is not overtopped by floods from the PMP design event. The new TMA-2 spillway and drainage channel will be constructed on bedrock at the south end of TMA-2 and will discharge into TMA-1. The location and sizing of the spillway has not been finally determined, and this issue must receive careful attention as part of the decommissioning licence review process.

Dam 10, within TMA-1, **has** been the subject of particular scrutiny. This dam does not contain an earth-core seepage barrier, and has relied on a Hypalon membrane for seepage control. In addition, while the dam is calculated to be fully stable under static conditions, the computed factor of safety under earthquake conditions is somewhat below normal standards of acceptance. This situation, for both static and dynamic conditions, would be made worse if the Hypalon liner became ineffective in the future. For these reasons, a series of modifications to the dam have been proposed, including construction of an upstream seepage-reduction berm and a downstream stability berm, and sealing of the existing decant tunnel beneath the dam. **These proposals would result in estimated worst-case seepage quantities of about 6** L/s, and would also result **in factors of safety that are acceptable by current standards of practice.**

The panel concludes that the proposed modifications to Dam 10 are acceptable in concept. However, the long-term performance of Dam 10, which is of critical importance to the satisfactory decommissioning of TMA-1, will depend on the satisfactory implementation and longevity of these modifications. The panel recommends that particular care be paid to ensuring that fully adequate monitoring instrumentation and surveillance programs for Dam 10 are put into place. In particular, the panel notes that, historically, the permanent and secure sealing of tunnels passing through dams is difficult, and vigilant monitoring of seal efficiency will be essential.

At TMA-1, **the** dams were built to elevations that were greater than those now needed to contain the wastes, resulting in significant freeboard. Hydrologic modelling indicates that no additional spillway capacity is required for TMA-1 to handle flows from the Regional Storm, because there is sufficient freeboard to impound the full flows safely. A new spillway has been constructed in TMA-1 to handle flows from the PMP design event.

6.2.1.5 Stanrock TMA

Currently, impervious containment structures are not in place around the Stanrock TMA. The proponent's proposed in-situ management plan requires that all of the existing pervious perimeter dams be replaced with engineered low-permeability zoned embankment dams, placed immediately downstream of the four existing dams (A, B, C and D). Such dams must, of course, be designed and constructed to meet rigorous seepage and stability standards, under both static and dynamic conditions. The panel recommends that the AECB arrange for timely reviews of design plans and construction procedures to ensure that these conditions are met. In particular, the panel emphasizes the importance of minimizing seepage losses from the Stanrock site, in order to maintain a high phreatic surface within the wastes and to ensure that potentially acid-generating materials are kept in a saturated condition (Section 6.2.4).

6.2.2 Stability and Longevity of Water Cover

In assessing the stability and longevity of the water cover, the panel assumes that the integrity of the necessary physical structures that contain the water (e.g. dams, berms, spillways, etc.) will be maintained in perpetuity.

Water possesses many of the characteristics that are sought in creating an engineered cover. Water is flexible; it can deform and remain intact. In cases of flood or drought, the surplus can be removed or the shortfall compensated for by additional input, with minimal physical disruption of the site. On the other hand, there is little record of human-created solid or engineered covers that remain intact over long periods and that can resist the deformation and movement of the underlying wastes as well as all the disruptive forces of nature, including northern winters.

In the Elliot Lake area, as throughout northern Ontario, lakes and swamps are a natural and very long-term part of the environment and are likely to remain so. In fact, the sites of some of the WMAs under review were formerly occupied by lakes and wetlands. Under existing climatic conditions in the area, precipitation exceeds the water loss caused by evapotranspiration. Under "normal" conditions, this ensures that more water will be replenished than will be lost due to

natural processes. However, concern was expressed in several presentations about the impact of a possible long-term climate change on the proposed water-cover decommissioning program. The two potential problems most frequently mentioned were either flooding caused by excessive precipitation events, or the evaporation and subsequent loss of water cover during prolonged periods of drought.

The capability of the various WMA structures to accommodate the impact of a Regional Storm and the PMP design event was a basic criterion used in their design. Both Rio Algom and Denison have designed their water-flooded WMAs with sufficient capacity to store and treat Regional Storm events during operations. The spillways in these WMAs have been designed to handle the peak flow from a PMP design event and to safely convey the precipitation out of the basin, without treatment, to a natural watercourse while preserving the integrity of the structure. These guidelines have been included as criteria in the design for the Stanrock TMA.

The problem associated with maintenance of the water cover under prolonged drought conditions was mentioned several times during the hearings. Drought occurs when the loss of water due to evaporation exceeds input of water from precipitation. Drought periods are usually associated with the weather conditions during the growing season, which is the late spring, summer and early fall in the District of Algoma. The length of the drought period can vary and the severity of the drought can be intensified by high temperatures and winds, which increase the rate of evaporation. In some instances, unusual local winter weather can initiate conditions that enhance the possibility of the development of summer droughts. A winter with below-normal temperatures permits deeper frost penetration. Coupled with lower than normal levels of precipitation, this results in a smaller snow melt run-off, which frozen substrates prevent from recharging the soil water reservoirs.

In the case of prolonged drought, make-up water may have to be used to replace or supplement the normal amounts of water supplied by precipitation. In the case of the Quirke WMA, the necessary water can be decanted from Gravel Pit Lake directly into Cell 14. If the other water-covered basins - Panel, Denison TMA-1 and TMA-2 - require additional water to maintain the prescribed depth of the water cover, it will have to be pumped from nearby lakes.

Health Canada expressed concern that water augmentation would not take place until the water cover had dropped to 5 cm. This would indicate that some of the beaches in the basins and possibly other areas would become exposed. This exposure to atmospheric oxygen would lead to acid generation and subsequent release of resident minerals, including the general radionuclide group. Evaporation-induced capillary action would bring these materials to the surface, whence they could become airborne or be flushed out in the effluent when the water levels became sufficiently elevated again.

It is the panel's opinion that the water cover level in the three water-covered WMAs should be kept at or very close to the designed depth and, in the Stanrock TMA, at the designed level for tailings saturation at all times.

The proposed use of a vegetative cover on the Stanrock tailings basin, along with the saturation of the bottom portion of the tailings, will introduce an increased demand for water under drought stress. Whereas the stress on the water covered WMAs under drought conditions is caused by the loss of water solely through evaporation, the Stanrock basin, with its vegetative cover, will lose water due to transpiration as well as evaporation. During the growing season, transpiration loss will be greater than evaporation loss. To offset the combined evapotranspiration loss and to provide replacement water, this TMA may require supplementary water to irrigate the vegetative cover and to bring the elevated water table back to its optimum operating level.

The flooding and drought episodes may be preliminary events in a progressive long-term climate change. The impact of a climate change on the longevity and stability of the water cover will be influenced by the direction of the change. Increasing or decreasing temperatures, increasing or decreasing amounts of precipitation, or any combination of these with other variants, will affect the water cover in different ways.

While acknowledging the difficulty in accurately forecasting climate change, Environment Canada indicated that the trend for the next 50 years for the Great Lakes area is likely to be a warming one, with a possible increase in evaporation rates. The predicted range of the possible increases in evaporation rates is wide, from 1 to 20 per cent. Moreover, this warming trend could also reduce the snowpack accumulation in the winter, and increase the direct snow loss by sublimation, resulting in less run-off in the spring to recharge the reservoirs. However, even with the aforementioned possible change, the Elliot Lake area will remain within a temperate eco-climatic region. An extensive modelling program by Environment Canada indicated that there are adequate water resources available to maintain the water cover under foreseeable drought conditions.

The potential climate change makes it necessary to have the ability to keep local weather records in Elliot Lake. This will allow observers to spot whether or not a trend is developing. With this capability in place, planning can be done for any ameliorating procedures needed to modify the impact of developing climate trends or short-term events on the decommissioned sites. With plans in place, remedial action, if necessary, can be implemented as soon as required.

Climatic variations represent just one factor of many which, when combined, contribute to a slow but constant change of natural ecosystems. It must be expected and accepted that the various natural processes of change will occur in the decommissioned WMAs as time goes by. The development of active ecological systems is discussed in more detail in Section 6.2.5.

One factor that may affect the stability of the tailings ponds' water chemistry is the pH of the local precipitation. In the Elliot Lake area (as throughout central Ontario), the average precipitation pH is 4.5. It is thought that once the tailings basin system is in equilibrium, precipitation water will have only limited contact with unoxidized sulphides, will normally have a short period of residence in the WMAs and will be affected by the alkaline buffering elements released by the natural weathering processes. Thus the precipitation pH is not expected to have an adverse impact.

6.2.3 Effluent Treatment and Quality

Water, particularly drinking water, is a primary pathway for exposure to radioactivity and other contaminants released due to low pH in tailings. The need to control the quality of water emanating from the WMAs is of the utmost importance. The ingestion of fish, game and local produce is an additional, but less important, pathway of exposure. The importance of the quality of the water that a user is returning to a natural environment is clearly indicated by the large number of acts and regulations enacted by federal and provincial governments that establish and enforce standards to protect the quality of such water. These standards of quality are clearly stated in various federal acts and regulations, such as the Fisheries Act, the Metal Effluent Regulations and Guidelines, the Canadian Environmental Protection Act, the Navigable Waters Act, and Environment Canada's Guidelines for Canadian Water Quality.

There are some 15 Ontario acts and regulations that apply, in some way, to effluent quality from mining operations within the province. The principal ones are the Mining Act, the Environmental Protection Act, the Ontario Water Resources Act, the Municipal Strategy for Abatement Act, and the Effluent Guidelines and Receiving Water Quality Objectives for the Mining Industry in Ontario. All of the above affect the decommissioning proposals of the WMAs under consideration in the Elliot Lake area.

In the proposed water-covered WMAs (Quirke, Panel, Denison's TMA-1 and TMA-2) and to a lesser extent, in the proposed decommissioning program at the Stanrock TMA, the principal effluent source will be excess surface water cover. This excess is due to the imbalance of precipitation and evaporation rates. Under present climatic conditions, the amount of water gained from precipitation exceeds the water loss due to evaporation by about 60 per cent. The resultant surplus water acts as a surcharge on the tailings basins. Once the operating level of water cover is achieved, this excess is discharged as an overflow. This overflow water is the major component of the total effluent discharge under normal operating conditions. The two other effluent routes, seepage and groundwater, whose effluent normally has a longer residence time than surface overflow effluent, are discussed in section 6.2.4.

Analyses of the tailings in the different basins under review reveal that there are at least 40 different elements present. Although there is a slight variation in the total number and variety of metals and trace elements present in the different WMAs, the majority of those found are common to, and at roughly similar levels in, all the WMAs. The presence of metals and other trace elements is only a problem if these elements are mobile, can be leached and can enter downstream water sources Their availability is generally a factor of pH. By saturating the tailings with water and thereby excluding the atmospheric oxygen, the oxidation of the sulphide minerals present and the subsequent acid production is substantially reduced. By maintaining the pH of the in-situ tailings in a neutral to alkaline range, the availability of the resident mineral and trace elements, including the general radionuclide group, is substantially reduced.

The effluent treatment system is reasonably simple to operate and to maintain. The chemical compounds needed to adjust the pH and to precipitate the radium-226 to the required levels for the effluent to be acceptable for discharge to a natural watercourse are added just prior to the overflow discharge. The effluent flows to a settling pond where the precipitated elements settle as a sludge. The pH of the effluent leaving the settling pond is alkaline and, if the system works as predicted, the outflow water quality will meet the required government standards.

Sludge in the settling ponds will accumulate during the treatment period. When the quality of the effluent has reached the prescribed standards, the treatment will stop. At this time, the settling ponds will be cleaned. The sludge will be transferred to and stored in the WMA. The radium will be present in a barium-radium-sulphate complex which, under these storage conditions, will release only low concentrations of radium to the water. Both proponents state in their EISs that the radium inventory in this sludge will be less than one per cent of the total radium inventory in the tailings. The panel recommends that the issue of the final disposal of the sludge be carefully reviewed and controlled by the AECB.

The receptors of the effluent from the Quirke and Panel WMAs are Evans Lake, Dunlop Lake, Serpent River, Quirke Lake and Rochester Creek. The results of the modelling reported in Rio Algom's EIS indicate that the Provincial Water Quality Standards will not be exceeded in any of these receptors. The modelling shows that after the closure treatment, the radium-226 level in the pond water (the major effluent source) of the Quirke WMA will peak at 0.5 Bq/L and range from 0.5 Bq/L in 50 years to 0.2 Bq/L in 500 years. The results of the pond water modelling for the Panel WMA parallel those of the Quirke WMA at 0.2, 0.4, and 0.1 Bq/L at the peak 50 year, peak and 500 year points respectively. The provincial water quality standard is 1 .O Bq/L.

Similar conditions are forecast for the receptors of the Denison and Stanrock TMA discharges: Upper Cinder Lake, Half Moon Lake, Quirke Lake and the Serpent River. The modelling results as reported in Denison's EIS indicate that the Provincial Water Quality Standards will not be exceeded. The radium-226 level reduction in the Denison and Stanrock TMAs' effluent are forecast to roughly parallel those of the Quirke and Panel WMAs. The modelling shows that after the closure treatment, the radium-226 levels in the pond water of Denison's TMA-1 and TMA-2 will be 0.2 Bq/L 50 years after closure, 0.3 Bq/L in 100 years, 0.5 Bq/L in 500 years and 0.2 Bq/L in 1000 years.

The decommissioning plan for the Stanrock TMA does not include a pond. The surface will be vegetated. Therefore, the precipitation and melt run-off water will flow across the tailings surface and, after a short residence period, will exit through a spillway to Moose Lake. From there the discharge will flow via Orient Lake to Half Moon Lake. The modelling calculates the incremental levels of radium-226 in Half Moon Lake will be 0.02 Bq/L in 50 years, 0.03 Bq/L in 100 years, 0.08 Bq/L in 500 years and 0.06 Bq/L in 1000 years after closure. The 1994 level of radium-226 in Half Moon Lake was 0.17 Bq/L, which is substantially below the provincial water standard of 1 Bq/L.

Since the present calculations and accumulated data indicate that trace metal and radionuclide levels are not presently affecting receiving water quality, their future impact on receiving waters will not be a factor if the decommissioned WMAs perform as expected. Monitoring will be required.

All of the WMAs under review by this panel have been designed to contain and treat the precipitation from a regional storm prior to the effluents' release to a natural watercourse. However, in the case of a PMP design event, the overflow would be discharged through spillways that have been designed to handle discharges of this quantity safely while maintaining integrity of the structure. In this latter case, the residence time of this floodwater in the basin would be very short and, of necessity, would be discharged directly to a natural watercourse.

The panel recommends, when the effluent water quality meets the required standards and effluent treatment is discontinued, that the treatment plants be "mothballed" on site in case of future need.

6.2.4 Seepage and Groundwater

6.2.4.1 General

Off-site movement of water from the WMAs has the potential to carry contaminants into the surrounding environment. The primary source of off-site water movement will be the flow of excess surface water from the three water covered WMAs. The control of potential contaminant loadings from these surface-water effluent flows is discussed in Section 6.2.3.

In addition to surface-water effluent flows, water will also escape the WMA areas due to seepage and, possibly, groundwater. Although the off-site flow quantities from surface-water effluent are anticipated to be generally much greater than those due to seepage and groundwater, seepage flows do give rise to three specific issues of potential concern of which the panel has been cognizant. These issues are

- the likely effects of seepage and groundwater flows on the quality of downstream receiving waters;
- the likely effects of seepage flows on the ability to maintain the design water-cover depths or design saturation depths in the WMAs; and
- possible effects of seepage flows on the longevity and stability of the containment-dam structures.

There are important distinctions between seepage flows and groundwater flows. "Seepage" generally refers to water that moves through, or directly beneath, the surrounding containment structures (embankment dams). "Groundwater" refers to the broader issue of potential contamination of the natural (or altered) subsurface groundwaters that exist within the geologic materials lying beneath the sites. Concern has been raised that these subsurface waters might then flow off-site, causing unacceptable contamination.

Regarding groundwater, the situation with respect to potential contamination and off-site movement is generally favourable at the WMAs. Each of the WMAs has been developed within natural topographic lows, which represent groundwater discharge (as opposed to recharge) areas in a hydrogeological sense. In other words, local groundwater tends to flow toward and into these sites, rather than out of and away from them. In addition, these sites are underlain by bedrock formations that display low overall hydraulic conductivity (permeability), such that the overall flow quantities that move through the subsurface are small. However, while there are sound scientific principles that suggest that the situation as outlined above is broadly valid and generally supported by monitoring data from the sites, each of the sites can be expected to have not only groundwater inflows from regional up-gradient directions, but also outflows in one or more down-gradient directions. In addition, some localized cross-site or off-site flows may be possible due to the complexity of local subsurface flow regimes.

Indeed, in presentations to the panel, concern was expressed that some evidence of off-site groundwater contamination was present in at least two sites (Denison and Stanrock), and data that support this view were presented by Denison Mines in its EIS. On review of the data, the panel has concluded that there is no evidence that environmental harm is currently associated with groundwater contamination. In terms of the future, the panel is aware that complete, or even statistically significant, monitoring of the complex groundwater regimes within the bedrock beneath and around the WMA sites would be extremely difficult to achieve. Nevertheless, the panel recommends that existing groundwater monitoring stations should continue to be analyzed throughout the short-term phase and the transitional phase of decommissioning. In addition, the panel recommends that the information available concerning off-site groundwater movements at each WMA be carefully reviewed to determine if any additional monitoring is justified.

Generally, seepage flows are directly associated with the containment structures and, in the panel's opinion, some amount of seepage flow is inevitable. The panel concludes that they can be considered as an acceptable part of the long-term operation of the WMAs, provided that seepage flows remain sufficiently minor (or are treated) such that they do not adversely affect quality of the receiving waters; do not affect the maintenance of water cover (or saturation elevation) in the tailings; do not affect dam stability; and remain stable (or decrease) over the long term.

The potential deleterious impact of seepage flows on receiving water quality stems from the combined effects of seepage quantity and seepage water quality. Although the quantities are generally fairly small, the quality of seepage water is often much worse than that of surface water effluent due to the long residence time of seepage flows that emanate from pore water within tailings that have been generating acid during development of the WMA. With time, this effect will diminish as the acid inventory is flushed from the tailings. Maintenance of acceptable quality in the receiving waters will depend on adequate dilution, treatment of the seepage, or a combination of both.

Seepage may also have an impact on dam stability, through several mechanisms. If the seepage water begins to carry out some of the fine materials that are part of the dam, this could lead to internal erosion or "piping" which could, over time, jeopardize dam stability. This phenomenon is well recognized, and would be preceded by the appearance of dirty seepage water (i.e. due to carrying soil particles). Thus, vigilant visual inspection of all seeps will be a perpetual care requirement. Second, seepage that appears on the downstream face of a dam structure could lead to surface erosion which is undesirable. This problem is easily remediated, but also requires a continuing program of inspection. Finally, seepage may indicate that the water pressures inside the dam structure (pore pressures) are elevated, which is also undesirable. Monitoring instrumentation placed within the dams (piezometers) must be monitored to ensure that pore pressures remain within design limits, as noted in Section 6.2.1.

Finally, the panel concludes that the nature of the earthfill containment structures is such that there are a number of options available for remedial work to correct seepage problems, should these arise in the future. Such problems are not likely to occur suddenly, and provided that proper vigilance is maintained, remedial action can be taken. In particular, the panel draws attention to the need for vigilance with respect to any seepage that develops in association with "sealed" structures (pipes, tunnels, etc.) that pass through the dams.

In all cases, the panel concludes that seepage observation and monitoring must be a key part of the program of perpetual care at all four WMAs.

6.2.4.2 Quirke WMA

Primary areas of seepage water loss from the Quirke WMA are associated with the eight perimeter dams, and are predicted to reach a steady-state total of approximately 10 L/s with the largest single contribution coming from dam K1 (4.2 L/s) and reporting to Dunlop Lake. Various portions of the seepage flows will report to Evans Lake (1.6 L/s), Dunlop Lake (5.6 L/s) and the Serpent River (2.6 L/s). Measurements to date indicate that current seepage flows to one of these areas (Evans Lake) are actually about one-tenth of the predicted amount, giving some confidence that the predicted quantities have been based on reasonably conservative assumptions. Seepage flows appear to be stable. The predicted seepage-flow quantities are not anticipated to adversely affect the quality of receiving waters, and this is supported by the monitoring evidence to date.

Water balance calculations show that the maintenance of water cover at Quirke will not be significantly affected by the predicted seepage rates. However, one situation that is unique to Quirke is the presence of the internal dykes separating the cells of the WMA. In particular, for Cell 14 (the most upstream cell), seepage from this cell beneath the dyke will reduce the water available for maintenance of the cover. Analyses by Rio Algom indicate that the system will still perform satisfactorily. However, in the event that these predictions are in error, there are a number of viable remedial actions that can be implemented. Make-up water from Gravel Pit Lake could be added as a temporary measure. More permanent measures could include construction of an upstream seepage control blanket, or of a cut-off wall beneath the dyke. The panel recommends that careful analysis of seepage losses from Cell 14 be undertaken during the short-term and transitional phases of decommissioning to determine if remedial actions are necessary.

The panel concludes that current seepage conditions at Quirke WMA are within acceptable limits and recommends that monitoring be maintained as a key part of the perpetual care program.

6.2.4.3 Panel WMA

Total seepage flows from Panel WMA are predicted to be 8 L/s, most of which will flow into the Rochester Creek system to the northeast of the WMA. Because of the fairly large watershed of Rochester Creek, dilution of about 90:1 has been generally effective in maintaining Provincial Water Quality Standards in the creek. The possible exception is cobalt. As the acid inventory is flushed from the WMA, this situation should further improve, and no long-term deleterious effects to water quality are predicted. The panel agrees that this conclusion is reasonable.

Currently, there is no evidence that the seepage flows are adversely affecting any containment structures. However, as noted in Section 6.2.1, monitoring instrumentation that has been placed in the six dam structures at Panel is currently inadequate, and additional monitoring piezometers are to be installed in Dams A, B, D and H, as a result of discussion with AECB. The panel strongly supports this approach, and emphasizes that seepage observations and monitoring must be an inherent part of the long-term program of care and maintenance at Panel.

6.2.4.4 Denison TMA

In general, subsurface water flows into the low-lying TMA-1 and TMA-2 basins, which represent groundwater discharge zones. Seepage that flows out of the basins is usually associated with the topographic lows across which the containment structures have been built. However, at Denison there is some evidence that dissolved tailings constituents have migrated downwards and laterally through the bedrock ridges between dam sites, moving towards Quirke Lake, Stollery Lake and the Serpent River. The panel recommends that AECB review these areas, to determine if additional monitoring requirements are justified to delineate the extent of the contaminated plume(s), and to determine if any future actions may be required to mitigate potential harm.

In relation to seepage, the most important structure at the Denison TMAs is Dam 10. As noted in Section 6.2.1.4, the panel has scrutinized this structure with particular care, as it does not currently contain an earth-core seepage barrier, and it is penetrated by a (sealed) decant tunnel. Seepage of about 21 L/s is occurring downstream of Dam 10, of which about 4 L/s is contributed from Cinder Lake. The primary concern is that seepage control currently relies on an embedded Hypalon membrane, of questionable longevity. If the membrane fails, seepage rates could rise to more than 75 L/s, jeopardizing maintenance of the water cover over TMA-1, and pore-pressure increases within the dam could jeopardize its stability.

Denison Mines Limited propose to modify Dam 10 in order to reduce seepage to an acceptable level, primarily through the construction of a 20 m-long upstream blanket. This technique is widely used and well understood, and it is predicted to result in reduction of seepage quantities to 6 L/s. In addition, a downstream stabilizing berm 14 m-wide is proposed, to maintain acceptable stability conditions in the event that the Hypalon membrane fails. The panel concludes that the proposed measures are appropriate in concept. Clearly, demonstration of adequate performance of the proposed remedial works must be a requirement for licensing. The panel recommends that the proponent and the AECB pay particular attention to the observation and monitoring of seepage conditions at Dam 10.

Presuming that seepage control at Dam 10 is achieved, total seepage flows from Denison's TMA-1 and TMA-2 are estimated at about 12 L/s, a figure that must be confirmed. For these seepage flows, water-cover maintenance is not predicted to be a problem. Some treatment of seepage water will be required until it can be demonstrated that the quality of receiving waters is not deleteriously affected by direct discharge.

6.2.4.5 Stanrock TMA

The long-term seepage conditions at Stanrock TMA will differ significantly from those currently experienced, due to the addition of "impervious" perimeter dams downstream of the existing permeable structures. The proponent estimates long-term stable seepage flows of 2.3 to 4.5 L/s, once dam construction and foundation treatment are completed. Seepage flows through the structures are currently augmented by flows through the bedrock beneath the structures, and elevated contaminant levels are present in the bedrock downstream of both Dam A and Dam B.

Clearly, control of seepage at Stanrock is of critical importance from several perspectives. Maintenance of saturation within the TMA at the design level, above the acid-generating tailings, is a key goal and will depend strongly on seepage control. Adequate control of seepage quantities, both at surface and in the bedrock of the subsurface, will be necessary to allow for an eventual cessation of treatment and for confidence in predictions that acceptable environmental dose limits have been achieved. The situation at the Stanrock TMA is far from its final form, and the panel is particularly concerned that careful, detailed and continuing scrutiny be applied to this area by the AECB. Within this general concern, the issue of seepage control and monitoring at Stanrock must be viewed as a high-priority item.

6.2.5 Development of Active Ecological Systems

In the opinion of the panel, it is not practically feasible to isolate the mining wastes at Elliot Lake from the environment. As discussed in Section 3, methods of achieving "complete" isolation, through entombment or deep-mine burial, are not realistic for the conditions at Elliot Lake. Rather, approaches based on managed containment have been proposed, and the panel accepts these as appropriate bases for the development of the final decommissioning plans. However, the proposed decommissioning approaches, whether using water cover or dry cover, have important consequences in terms of the development of active ecological systems associated with the areas. Clearly, colonization of the areas by both macro and micro flora and fauna is already occurring, and this process will continue and evolve with time. The fundamental question that arises is whether the development of active ecological systems associated with the WMAs will be beneficial or detrimental to their containment performance.

During the hearings, concern was expressed that the presence of active ecological systems could lead to biological uptake of contaminants, particularly radionuclides, leading to effects such as bio-magnification and off-site transport of contaminants. At the same time, the panel is aware that there is a strong body of scientific evidence and opinion that the presence of a diverse and active ecological system can play an important beneficial role in helping to control acid generation (and hence contaminant mobility in sulphide tailings), control erosion and improve effluent water quality. This sense of apparent contradiction regarding the impact of biotic processes on the containment of uranium-mine wastes is well expressed in some of the material submitted to the panel, such as the work by Hakonson et al titled ***Biotic and Abiotic Processes,*** which states that:

> ***Bio ta can have very beneficial or de trimen tal effects on the performance of a site in isolating waste.***

The panel accepts that there are differences of opinion on this issue. However, the material available to the panel indicates that there is broad scientific agreement that an active ecological system will be beneficial in achieving the goal of minimizing acid generation and its consequences. As organic matter builds up, and as colonization by plants and micro-organisms proceeds, complex chemical and biological processes develop that affect the oxidizing-reducing environment near the surface of the tailings, and the immobilization or breakdown of contaminants, particularly the heavy metals. The organisms' relationships to one another and to their surroundings (i.e. the ecology) that develops, will reflect the unique situation at each WMA. Experience to date at Elliot Lake, while limited, indicates that the development of active ecological systems has been beneficial in helping to improve the quality of effluent water from water-covered WMAs.

Signs of change and development can clearly be observed by the invasion of aquatic plants, which is already beginning in some of the tailings basins. The speed of this voluntary invasion will accelerate as water quality improves, allowing for a greater diversification of species and providing more favourable growing conditions. In the long run, the aquatic plant invasion will initiate a developing ecosystem of its own, which will evolve into the climax cover that the combination of the many variants imposes on each site. In its early stages of development, this ecosystem will parallel the observed changes in beaver ponds as they develop and mature over the years. A dam built by beavers creates a pond in a moving flow of water. As the plant species invade and increase along with the accompanying accumulation of plant detritus, the pond becomes a swamp. Gradually as decomposing plant material accumulates, the area changes into a meadow. These same changes will not occur as rapidly in the tailings basins due to their size, and to the slow accumulation of erosion sediment from spring run-off and major precipitation events from the limited surface drainage areas. For the proposed dry-cover approach at Stanrock, benefits of an active ecological system may be associated with dust control and the formation of an oxidation barrier.

The panel has concluded that, from the viewpoints of control of acid generation, effluent water treatment and dust control, the presence of active ecological systems associated with the WMAs is likely to have positive effects, and that these systems will be capable of providing these positive effects with a minimum of human intervention in the long-term as the systems evolve to fit the specific conditions at each WMA. However, the panel also emphasizes the need to provide not only for monitoring and management of these ecological development processes, particularly during their initial stages, but also for the study, interpretation and understanding of these processes. It is these latter activities that will provide a basis of confidence in the health of the ecological systems and the longevity of their anticipated benefits to the WMAs.

The situation regarding containment of radioactive contaminants is more complex. The tailings at Elliot Lake contain a substantial inventory of radionuclides, and it is primarily the presence of these materials that gives rise to public concern regarding the effects of biota on the containment performance of the WMAs. Studies of disposal methods with uranium mill tailings, such as the well-known UMTRAP (Uranium Mill Tailings Remediation Activity Program) studies in the United States, have concluded that while revegetation of mine sites is commonly required, there is relatively little information regarding revegetation of uranium mill tailings. Based in part on this paucity of information, Waggitt (19941 states:

> ***UMTRAP staff do not generally favour revegetation at sites, citing concerns that tree and shrub roots might penetrate the layers of the cover s truc ture and cause premature failure; they are equally concerned that the vegetation itself might encourage colonization by fauna, both macro and micro, whose burrowing might again breach the integrity of the cover layers and so reduce the life of the containment.***

These concerns of UMTRAP regarding the impact of biota on the integrity of containment are apparently directed primarily at sites where the approach taken has been to contain the tailings in a way that attempts to fully isolate them from the biosphere. Thus, these concerns would seem to relate primarily to "dry" sites with engineered covers that may be at risk of being breached. While it is not clear to the panel that identical concerns will exist for the proposed decommissioning approaches at the Elliot Lake WMAs, neither is it clear that biological uptake of radiological contaminants can be disregarded as a potential problem.

Several presentations to the panel emphasized the importance of thorough monitoring and analysis of the impacts of contaminant uptake, particularly radionuclides, on non-human biota. A number of issues associated with various facets of the ecological systems that will develop were brought to the panel's attention, including waterfowl colonization of the water-covered WMAs, blueberry proliferation in the vicinity of the Stanrock TMA, and the potential for deep root penetration leading to contaminant uptake from active tailings, Although monitoring data to date are limited, it appears that there is no current evidence of measurable environmental harm due to biotic uptake of contaminants. However, the panel recommends strongly that the issue of potential biological uptake of contaminants must receive more extensive and more careful attention, through adequate programs of sampling, analysis and interpretation, than has been suggested in the proponents' EIS submissions. It is imperative not only that public concerns in this regard are addressed, but also that invaluable information that will become available through this "very long-term experiment" is gathered and disseminated.

Finally, the panel wishes to emphasize that the WMAs at Elliot Lake represent a series of different environments with respect to ecological system development. This situation provides both unique challenges and unique opportunities. Manipulation of such factors as nutrient supply, species introduction, pH adjustment, and contouring and drainage of various cover materials may determine the speed, diversity and robustness of ecosystem development. Comprehensive monitoring and analysis of the nature, extent and consequences of biological uptake of contaminants will add to public confidence in the performance of the WMAs, while contributing new knowledge to the Canadian and international scientific community.

6.2.6 **Land-use Controls**

During the public hearings, several issues relative to land-use controls associated with the WMAs were raised. One constant thread through these issues was the strong desire of the Serpent River communities to be intimately involved in the process of determining what land-use controls were necessary and in the best long-term interests of the public, and how such controls would be implemented. For instance, while it was widely accepted that restrictions on development would be necessary and appropriate within the WMA areas, there was also concern that the best long-term interests of the community might not be served by taking too narrow a view of this issue. Compatibility between sustainable development initiatives in the community and prudent land-use restrictions at the WMAs will require cooperation and balance on issues such as appropriate signage, liability of the legal owners of the WMA sites, development of tourism and availability of the lands for research purposes. The panel recommends that members of the Serpent River watershed communities be directly involved in projects undertaken to improve the environment of the Serpent River Basin.

The panel recommends that multi-party agreement be sought on all issues associated with long-term land-use controls and that parties to the discussions include provincial authorities (who will become eventual owners of the lands), federal regulatory authorities, the mining companies, and representatives of the Serpent River watershed communities.

6.3 SOCIO-ECONOMIC CONSIDERATIONS

6.3.1 City of Elliot Lake

Residents of Elliot Lake, like members of other communities in the area, have personal concerns about environmental risks relating to the tailings, and possible long-term effects on human health or on wildlife, vegetation and water quality. In addition, however, they are concerned about the economic future of their community, which was severely threatened by the loss of employment resulting from the shut-down of active mining. They have undertaken a vigorous program of economic diversification, which has had considerable success to date, but they expect that continuing economic development of the community will be greatly influenced by decisions relating to the proposals for decommissioning the tailings sites.

Two aspects of the process that are seen as important by the city and its inhabitants will serve to illustrate their concerns. An important component of their diversification strategy is further development of the region's tourism industry, with particular attention to outdoor recreation; this will depend upon safe access to the waterways and woodlands of the Serpent River Basin. A second important component is the plan for Elliot Lake to become a widely recognized centre of expertise in the rehabilitation and management of former mine sites, thereby generating both well-paying local employment opportunities and a potential technology-exporting industry.

The city therefore wishes to be actively involved in the future management of the tailings sites. For example, it wants to participate in decisions on future use of lands and facilities still held by the mining companies; on measures to control access to the mine, mill and tailings sites; on signage at site access points; and so on. It also wishes to participate in the planning and development of monitoring programs and research activities associated with them.

The panel recognizes the city's concerns as legitimate and supports its desire for an active role in the future management of the mine properties as well as in the planning of future monitoring and research activities. The panel proposes the creation of an organization along lines suggested later in this report, which should carry out these and related functions and on which the community of Elliot Lake should be represented.

6.3.2 Serpent River First Nation

Like the City of Elliot Lake, the Serpent River First Nation wants the natural environment of the drainage basin to be preserved and enhanced, and has particular concerns about possible residual effects of mining activity in the lower stretch of the river passing through its reserve. For this reason, it has a vital interest in the research and monitoring programs to be established.

However, its interest in the future use of mining lands differs somewhat from that of Elliot Lake, in that it wants these lands to revert to traditional uses. In the view of the First Nation, these lands were its aboriginal heritage and the economic hinterland of its subsistence economy. At least some forms of recreational tourism development involve potential conflict with this concept.

More broadly, the First Nation requests "economic compensation... for past, current and future loss of traditional lands," a request spelled out in greater detail in the presentation made to the panel on behalf of the First Nation by Chief Earl Commanda. Chief Commanda followed with a number of more detailed recommendations dealing with such matters as transfers of land ownership to the First Nation, the condition of the lower river basin and the river estuary, and research on the environmental status of the area prior to the opening of the uranium mines in the 1950s.

Apart from actual requests or recommendations, the First Nation representatives enunciated a philosophy that, in their view, should govern humanity's relationship with the natural world. In brief, this philosophy rests on the "Mother Earth" concept, a recognition that our lives and our happiness depend on the well-being of the environment and that consequently it is in our vital interest, as well as a compelling moral obligation, to nurture and protect that environment as opposed to short-sightedly exploiting it. The panel is highly sympathetic to this outlook, which encourages conservation and restraint in the use of natural resources, use of sustainable practices and reliance on renewable rather than non-renewable resources.

The panel also endorses many of the First Nation's specific concerns. For example, it supports the proposal that more study of environmental conditions in the lower Serpent River and its estuary should be undertaken, and that corrective action should be initiated if that part of the drainage basin is found to suffer from continuing contamination. While not persuaded that efforts to obtain an accurate assessment of the basin's environmental status prior to the beginning of uranium mining would be very productive, since technical data from that period are probably both sparse and lacking in precision, the panel agrees that more extensive data should be sought from neighbouring uncontaminated areas to provide a more complete baseline than is currently available. The panel also recognizes the validity of the First Nation's wish to have a substantial voice in decisions on future land uses in the Serpent River Basin. With considerations of this kind in mind, the panel proposes that the First Nation should be a member of the management organization the panel is recommending.

While the panel understands the reasons why the First Nation gave priority to its claim for compensation, this issue does not relate to the proposals for decommissioning the tailings sites and thus falls outside the panel's mandate.

6.3.3 North Shore Community

The interests of the North Shore Community, for the most part, closely parallel those of the City of Elliot Lake, but reflect the fact that its population is small and widely scattered. Its particular concern is to avoid having its economic interests, which are not necessarily identical to those of Elliot Lake, overlooked.

7.0 FACILITY OPERATIONS AND MANAGEMENT

7.1 MAJOR ELEMENTS

As discussed in Section 3.4 in relation to the in-perpetuity problem, the panel believes that there are three major elements that must be securely in place to provide a satisfactory basis for the safe operation and perpetual care of the waste management facilities. The first element required is a comprehensive, agreed-on and fully funded plan for both scheduled and contingency facility operations, monitoring and maintenance. The second element is the support of a program of curiosity-driven research, focused on issues associated with the waste facilities, supported by a research endowment fund, and managed by a community-based organization. A third element must be measures to ensure that response to emergencies, unforeseen events or Acts of God will be timely and that access to the resources necessary for effective response will be available. Although these three elements are related, the panel has concluded that they should be considered separately in order to ensure that each one is fully and adequately addressed.

7.1.1 Operations, Monitoring and Maintenance

Once the short-term phase is complete for each facility (i.e. the facility construction is completed and short-term performance is verified), a program of scheduled operations, monitoring and maintenance will be followed. In addition, this program must make allowances for appropriate and reasonable contingency activities. During the transition period, prior to entering the long-term phase of operations, execution of this program will remain the responsibility of the proponents, who must meet the obligations of the decommissioning licence during this phase. As previously noted (Section 6.1), the panel considers that the transitional phase will likely extend for a longer period than currently indicated by the proponents.

While modifications to the program may be made on the basis of experience, it is important that the initially agreed-on scope of activities be sufficiently comprehensive to ensure that adequate financial and manpower resources are committed in support of the program. Comments regarding the proponents' proposed "Environmental Monitoring Program(s)" are noted below. The issue of financial assurances is discussed in Section 7.2.

- The panel is not in a position to provide explicit comments on all aspects of the proposed monitoring programs, and this will be a matter for detailed negotiation between the proponents and the relevant authorities. However, the panel wishes to draw attention to several issues that require resolution.

- The panel notes that there are a number of inconsistencies between the EIS submissions and the recommendations made by the proponents' consultants regarding type and frequency of monitoring activities. In all cases, the panel views the recommendations of the consultants as minimum requirements to be met.

- The panel has concluded that the scope and frequency of monitoring activities as put forward by the proponents are deficient in a number of areas. As noted by a number of reviewers and presenters, there is insufficient focus on bio-monitoring activities, in terms of both data accumulation and evaluation. Given the fact that these tailings areas will be part of an evolving ecosystem, the potentially toxic materials will have access to the biosphere. Public concerns were clear in this regard, and as there is no current scientific consensus on issues such as the definition of harmful levels of bio-accumulated toxins, the panel recommends that a more comprehensive program of bio-monitoring be agreed on as part of the licensing process. For example, current proposals contain no allowances for "special surveys" of biota once the transition period is complete. Unless the transitional period is extended considerably beyond the period currently proposed by the proponents, this is not acceptable in the view of the panel.

- As one example of the panel's concern, we note that on-site meteorological data are indicated as being "not required" in the long term. The panel does not agree with this stance, and recommends that a meteorological station suitable for the collection of basic climatic data be set up at Elliot Lake.

- Various reviewers of the EIS documents, both government and private, have made comments and suggestions regarding operating, monitoring and maintenance needs. While none these comments demonstrate a "fatal flaw" in the proponents' plans, the panel strongly urges the AECB to consider explicitly each comment with a view to determining whether it should be incorporated in the approved licensing procedures and plans.

- In the opinion of the panel, it is essential for the results of annual operations at the facilities to be transparent to the Serpent River Basin communities. In the proponents' Joint Response to the panel's request for additional information, the suggestion was made to form an Elliot Lake Uranium Tailings Monitoring Committee, which would be a vehicle through which the proponents may communicate the results of the operating, monitoring and maintenance programs. While the panel supports the principle underlying this suggestion, it recommends that this role be filled by a somewhat different organization, as noted in Section 7.3.

7.1.2 Knowledge Acquisition and Research

As discussed in Section 3.4, it is the panel's opinion that curiosity-driven research is an essential monitoring tool, given the longevity of the hazard and the inevitable uncertainties involved in predicting the long-term behaviour of the facilities. Such research is also important in gaining new knowledge and distilling this knowledge for future use and benefit in the management of tailings areas. In terms of the precise content of this element of the facility management package (i.e.

defining what research projects should be supported, the panel urges that this matter be brought under the guidance and control of a newly formed community based non-profit organization, created for this primary purpose, as discussed in Section 7.3. The provision of financial assurance to support appropriate research is discussed in Section 7.2.

As a general comment, the panel notes that the value of future research may be seriously jeopardized if inadequate attention is paid to the collection of baseline data during the short-term phase of these tailings management projects. As one example, several presentations to the panel stressed the need to collect additional baseline data on the current distribution of contaminants in the bottom sediments of downstream waters, particularly near the mouth of the Serpent River. Similar comments were made on other topics. The panel recommends that the organization referred to above, once formed, should take on the task of defining important baseline data research needs as a matter of high priority, and that funding for the initial stages of approved research work be put into place immediately.

7.1.3 Unforeseen Circumstances

One continuing and critical element of the facilities' management must be the ability to respond, effectively, to unforeseen events that may have serious consequences. Effective response will require prompt access to sufficient resources, both financial and physical. Unforeseen events leading to loss of containment, loss of water cover, contaminant dispersion or other unacceptable consequences will require immediate response in order to maintain environmental security and public confidence. In the panel's opinion, the owners of the WMAs must be required to submit a comprehensive emergency preparedness plan on an annual basis. This plan would detail the conditions under which an emergency response would be triggered, the mechanisms by which such triggering would be decided, the nature of the response, and the resources available to mount such a response. The arrangements for funding the costs of monitoring, maintenance and repair, which can be forecast with some certainty, must also include provision for the costs of such contingencies, which are of course far more difficult to quantify.

7.2 FINANCIAL ASSURANCES

7.2.1 General

All participants in the review, including the proponents, agree that the two proponents must provide assurance that funds will be available indefinitely to meet the costs of environmental protection measures for which they become responsible under the provisions of an eventual decommissioning licence. Such measures will include the completion of the approved decommissioning program itself (short-term phase), as well as such active monitoring, testing and adjustment as may be needed to satisfy the AECB that the containment systems are operating effectively and reliably, in accordance with their design criteria and under a range of conditions (transitional phase). Measures will be required thereafter to provide the monitoring, maintenance and repair needed to ensure that potential environmental hazards associated with the tailings continue to be effectively controlled (long-term phase). The monitoring program will have to be sufficiently diversified to detect promptly any problems not foreseen in the design of the system, and special measures may be required to address any such problems. Provision must be made for the prompt repair of any failure of the containment systems resulting from some unusual or unforeseen occurrence. Finally, the panel has recommended that curiosity-driven research associated with the WMAs be supported throughout all phases of operation.

The cost of measures of the kind indicated in the preceding paragraph will in principle be the financial responsibility of the proponents. However, the panel was informed late in the public hearings of the conclusion of an agreement between the governments of Canada and Ontario that would apparently qualify this principle in exceptional circumstances (Appendix D). Specifically, the agreement provides for a Management Committee composed of representatives of the two governments, and states that "in accordance with a plan agreed to" by that Committee "to remedy the damage at a uranium mine caused by an extraordinary event, Canada and Ontario agree to equally pay costs incurred for remedial activities." An extraordinary event is defined as "any acute natural event (so-called "Act of God") which would significantly diminish the effectiveness of the engineered barriers constructed prior to or during the decommissioning of the uranium mine site." Presumably, such a decision of the two governments would rest on a judgment that the amounts involved were beyond the capacity of the proponents to cover.

In support of their decommissioning licence applications, the proponents are required to provide financial assurances that will guarantee that necessary funds will be available in perpetuity to finance the fulfillment of their obligations as outlined above. The methods by which they propose to meet this responsibility are very different, as a result of major differences in their present financial situations.

7.2.2 Hard versus Soft Assurances

Rio Algom's financial assurance proposal has two components. The first reflects Rio Algom's current stable and prosperous financial position, and applies to what Rio Algom terms the "transitional period." This is the time during which the decommissioning program is being implemented (i.e. the approved containment systems are completed and tested long enough to establish that they operate effectively, the tailings become stabilized, and the effluents cease to require treatment). Rio Algom estimates this period to be 5 to 10 years, during which time it would expect, without difficulty, to cover all costs as part of its normal operations. It proposes to negotiate arrangements with the provincial government under which, following the transition period, Rio Algom would surrender its mines to the government and would establish a "site specific fund . . . to provide for the long-term care and maintenance of the properties." Rio Algom proposes that "the detailed costs of residual liabilities, the nature of the fund, and the mechanisms for paying out from the fund" be negotiated at the time that the land surrender is requested.

The panel does not find this proposal fully satisfactory. While it does not question Rio Algom's present ability, or its commitment, to meet the costs of measures that may be required during the short-term phase (Section 6.1), the panel has recorded its view that the reclamation and rehabilitation programs for these Elliot Lake mines should be considered as a large- scale and long-term experiment (Section 3). It accepts the concept that at some stage, after a suitable transitional period, title to the properties should revert to the province, with the residual obligations of the proponents being covered through some appropriate mechanism such as a trust fund. But the panel, as explained in section 6.1.3, foresees a transitional period probably longer, perhaps considerably longer, than proposed by Rio Algom. It also regards as premature an assumption that no significant modifications of the containment programs may, during that period, be found necessary or desirable. Accordingly, the panel would wish to see considerably more specific funding arrangements for the transitional period, such as a formal obligation to make specified annual payments into a trust account from which costs incurred during that period would be met. This would protect against the uncertainties to which a significant extension of the transition period would give rise, and against possible unforeseen changes in Rio Algom's situation or in the programs in question.

The second component of Rio Algom's proposal refers to the long-term (in-perpetuity) phase. The panel considers it unsatisfactory to leave to an indeterminate date in the future the negotiation of firm and precise arrangements to provide perpetual funding of the care and maintenance costs. Furthermore, as the federal government has the regulatory responsibility for approval of the long-term care and maintenance program, it should participate in the negotiation of the detailed arrangements for the funding of that program and should be in a position to approve the arrangements before issuing a decommissioning licence. The terms of the licence should spell out the details of the long-term funding mechanism, with provision for updating of the cost estimates in the light of experience during the transitional period. The amount of Rio Algom's payment into the funding mechanism should be determined on the basis of such revised cost estimates, and the arrangements that the AECB incorporates as conditions in an approved decommissioning licence should carry the prior endorsement of the Ontario government.

Denison Mines, which has been facing severe financial problems, has been forced to adopt a very different approach from that proposed by Rio Algom. As a result of its difficulties, Denison found it necessary to enter into an assets distribution agreement with its creditors and the federal and provincial governments. This agreement requires Denison to contribute 90 per cent of its net cash flow into a reclamation trust account. This obligation, which takes precedence over all other claims against Denison's earnings, is to ensure that Denison meets its financial responsibilities with regard to the decommissioning of its Elliot Lake properties.

Denison has produced estimates of the costs associated with the decommissioning of the Denison and Stanrock mines, including amounts for the estimated net present value of its prospective perpetual-care obligations, which total $64.1 million. Of that total, it is reported that $17.3 million was spent prior to July 1, 1994, leaving $46.8 million to be funded thereafter. Denison's revenue projections forecast annual contributions to the reclamation trust account after that date to reach this total of $46.8 million by the year 2000.

Denison's proposed financial assurances package reflects two major assumptions. First, it assumes that Denison's estimates of the costs associated with its plan, including perpetual-care costs, are sound. Secondly, it assumes that Denison's revenue forecasts are realistic. However, the obligation to contribute to the trust is open ended and continues until such time as the costs associated with a plan approved by the AECB- are covered. Denison acknowledges that these cost estimates will be a matter for negotiation with the AECB. As for Denison's revenue projections, their accuracy will depend on what happens to the price of uranium, among other factors.

Subject to the stability of the uranium market, Denison's proposal thus offers reasonable short-term assurance. Denison has not, however, been in a position to specify how and by whom the funds to cover the perpetual-care component of the costs will be administered after Denison's presumed withdrawal and after responsibility for the site reverts to the government. It will be important to resolve this question before a decommissioning licence is issued.

The preceding paragraphs set out the panel's views on the nature of the financial assurances that should be required of the proponents as conditions governing decommissioning licences. The panel believes such "hard" assurances are necessary to ensure, as far as it is possible to do so, that the primary requirement for continuing care and maintenance will be met effectively and reliably, and to provide public confidence in the security of the funds for these purposes.

Both proponents recognize, and the panel agrees, that for the longer term, funding mechanisms such as a trust fund will be necessary. The panel has emphasized the importance of defining precisely the management regimes to govern those mechanisms, and of doing this in conjunction with the issuance of decommissioning licences and not at some later date. This will be a responsibility of the two governments rather than of the proponents. Failure to do this at the right time will leave serious uncertainty about the long-term reliability of the decommissioning arrangements, by far the most major concern of all interested parties.

7.2.3 Dedicated Funding

The panel has emphasized the importance it attaches to arrangements that will ensure, and be seen by the public to ensure, the availability of adequate funds to cover the long-term care and maintenance costs of the tailings that are the subject of this review. But **it is not** sufficient to ensure that adequate funds are provided by the proponents. It is also critically important that such funds remain available indefinitely to finance the requirements of these particular tailings, and are not diverted to other purposes, however desirable the latter may be. It is therefore necessary that the long-term arrangements for the administration of the funds be so structured as to ensure their dedication to the requirements of these particular tailings and to prevent any possible diversion to other purposes (e.g. funds should not be diverted to cover costs related to the rehabilitation of mine and mill sites).

7.2.4 Three Funding Requirements

7.2.4. 1 General

Provision of financial assurances and management systems for each of the major elements in Section 7.1 will be the subject of negotiations, presumably with formal representation from the proponents, from the AECB as the licensing authority, and from the Canadian and Ontario governments as eventual partners in sharing the long-term liability relating to risks associated with the facilities. The panel cannot pre-empt those negotiations, nor is it possible at present to foresee their content in detail, but it has views on the broad issues involved, which it would wish to have carefully and seriously considered. In particular, the panel recommends that funds for operations, monitoring and maintenance activities be held and administered separately from those intended to support research activities.

7.2.4.2 Operations, Monitoring and Maintenance

During the short-term phase of decommissioning (Section 6.1.2), funding for all site operations, including monitoring and maintenance, will be provided directly by the proponents, although under somewhat differing arrangements as outlined in Section 7.2.2. By the time the long-term phase is entered (Section 6.1.2), following completion of a transition phase (Section 6.1.3), the panel recommends that dedicated hard financial arrangements be in place to cover, indefinitely, the costs of implementing the agreed long-term monitoring and maintenance plan, including reasonable contingencies. In the words of one presentation made to the panel, the assurances should be “in cash, **in the bank,** in perpetuity.” These funds, perhaps in the form of a trust fund or appropriate equivalent, should be accumulated during the short-term and transitional periods, which are designed to demonstrate satisfactory performance of the facilities and to confirm the adequacy of the proposed long-term monitoring plan and the projected levels of funding required to implement the plans.

Further negotiations are necessary to define the details of an acceptable long-term monitoring and maintenance plan for each site (Section 7.3). In arriving at agreed on long-term plans for scheduled and contingency monitoring and maintenance, the panel recommends that representatives from the Serpent River-area communities be invited to be a party to the negotiations.

Authority for expenditure of these funds must remain in the hands of the owner of the facilities, who will be responsible to the regulatory authority for meeting performance standards. In exercising this responsibility, the owner must of course be free to select the manner in which the funds are used. Nevertheless, the panel recommends that every reasonable effort should be made to utilize the surrounding community in undertaking the required monitoring and maintenance tasks, thus drawing on as well as building up expertise in these matters within the community. This recommendation stems not only from the panel’s mandate to be cognizant of sustainable development possibilities, but also from the conviction that an involved local community provides the best basis for an alert and vigilant monitoring system.

The panel has suggested that the proponents set up trust funds or other similar mechanisms to provide assured funds to cover the costs of their responsibilities for operating, monitoring and maintaining the containment systems. These mechanisms will presumably be administered on behalf of the proponents, during the short-term and transitional phases of decommissioning, by a trust company or other such financial institution. It will be important, in terms of assuring the public that adequate funds will be permanently available, that the operation of the mechanisms be subject to an independent audit, to verify publicly that deposits are made into them on schedule and that withdrawals are applied only to care and maintenance programs specified in the decommissioning licences.

Following the transitional phase, when ownership of the sites presumably will revert to the Crown, the panel proposes that responsibility for the operating, monitoring and maintenance programs should be assumed by the Management Committee of the federal and provincial governments, which might decide to delegate the operating responsibility to an appropriate provincial agency. This would seem logical, in light of the contingent liability that the two governments have accepted with regard to these programs. It would also appear sensible for the same Management Committee to take over, at that time, the administration of the funding mechanisms.

7.2.4.3 Knowledge Acquisition and Research

As discussed in Section 3.4.2.2, the panel considers support of curiosity-driven research to be an essential part of an acceptable approach to ensuring long-term vigilance with regard to the waste facilities. The fundamental nature of research is such that it will take the twists and turns necessary to follow and interpret what is actually happening, rather than what is expected to happen. This provides a powerful monitoring tool. In addition, the panel considers there to be an obligation on all parties to ensure that the important knowledge which can be gained from this large-scale, long-term experiment, which has been costly in various terms, is obtained, interpreted and used as widely as possible.

Thus, the panel recommends that the creation of an endowment fund for the support of research associated with the Elliot Lake mine waste facilities be required as a condition of granting a decommissioning licence. This research endowment fund should be created and financially seeded by the proponents, Rio Algom and Denison Mines, as soon as possible during the short-term phase of the decommissioning, to avoid loss of opportunities for researchers to collect crucial baseline data. The initial fund should be of sufficient size to allow for annual expenditures that support a meaningful level of research activity. Definition of the annual cash flow necessary to support a meaningful level of research activity should be undertaken immediately by a committee that includes appropriate representation from the scientific community, the proponents, the Serpent River community and the government.

After creation of the initial research endowment fund, other partners should be sought for contributions, including other mineral resource companies, various levels of government, and international agencies. The panel views this as a unique opportunity. Monitoring and vigilance of the potential uranium waste hazard will be enhanced through curiosity-driven research. The unusual fact that the waste facilities are associated with an existing community, a research centre and an active business community means that the knowledge gained can be used for the development goals of the community and for export to many areas where similar problems are being faced.

7.2.4.4 Emergencies and Acts of God

As noted in Section 7.2.1 above, the panel was informed that an agreement had been signed between the governments of Canada and Ontario, covering certain aspects of financial assurance in the event of "Acts of God" occurring at the waste facility sites. The panel assumes that the two governments, in entering into this agreement, recognized the possibility of emergencies, costs of which would exceed the amounts available for contingencies in the funding mechanisms required of the proponents by the terms of their decommissioning licences. It is reasonable, should that occur, that the government be prepared to cover the costs.

This means, however, that the criteria on which such government intervention would be decided will become a factor in the negotiation, between the proponents and the AECB, on the amounts of the trust funds. The cost of providing, in those funds, for coverage of contingencies can only be estimated if some indication is available of the cost level at which the proponents' responsibility will cease and governmental funding will become available.

It is important that action be taken promptly in the event of a contingency, and not be delayed by confusion about how the costs will be met. In Section 7.1.3, the panel has proposed that the owners of the WMAs, who during the transitional period will be the proponents, should be required to submit a comprehensive emergency preparedness plan. In the panel's view, the two governments should make available sufficient information on how they plan to deal, if necessary, with "Acts of God" so that the proponents can prepare emergency response plans that will effectively ensure prompt injection of government funding in contingency situations, where that is appropriate. For the longer term, when title to the WMAs will have passed to government, the governments will have to have in place a procedure for determining when the contingency costs can be covered from the trust funds established by the proponents and when injection of additional funds from the government is needed.

7.3 MANAGEMENT OF FUNDS

As stated above, the federal and provincial governments have agreed to share equally the costs of remediating the damage if they agree that this requirement has resulted from "an extraordinary event." This decision, it is foreseen, would be taken by the Management Committee which the governments have agreed to establish. It appears reasonable and desirable to the panel that the governments are prepared to assume this contingent liability. The panel assumes that the two governments will make their own arrangements to ensure that they are in a position to fund such costs as they may incur under the agreement referred to above, and it does not propose to explore this point further.

The panel has concluded that curiosity-driven research, associated with the long-term management of the tailings, is essential to the long-term success of the program. As stated in Section 7.2.4.3 above, the panel is recommending the creation of a research endowment fund to finance a program to meet this need. That program would be designed to exploit the opportunity, offered by the decommissioning of these Elliot Lake tailings sites, to gain new knowledge and understanding of the long-term behaviour of tailings such as these. Some potential contributors to such a fund, considered likely to benefit from the results of the research program, were suggested. The panel has recommended that the surrounding community should be used as much as possible in the long-term care and maintenance activities. The panel believes that the case is equally strong for involving the community in the development of the associated research program that the panel proposes.

The panel therefore recommends that an organization be created, which might be called the Serpent River Basin Conservation Council. Its governing board would include representatives of the two proponents, the City of Elliot Lake, the Serpent River First Nation, the research community, and, possibly, other communities in the area. The AECB, because of its responsibility for monitoring the observance of the requirements of the decommissioning licence, would have a non-voting representative.

The Council would be responsible for managing the research endowment fund, and for financing, using earnings from the fund, projects proposed by a research program committee. In addition, the Council would review annual reports on the operation, monitoring, maintenance and repair of the WMA facilities, thereby providing a mechanism for keeping the local communities informed. The Council could also provide a forum for consultation and advice on a range of matters, including the security of the tailings sites, the use of company lands, the relationship between traditional aboriginal land uses and tourist and recreational development, and other important issues.

8.0 CONCLUSIONS AND RECOMMENDATIONS

Set out below are the panel's main conclusions on the issues brought to its attention in the course of the review. Following those conclusions, the panel has summarized its main recommendations.

CONCLUSIONS

C1. The tailings of the Elliot Lake uranium mines contain sulphide ore, which will generate acid if exposed to joint action by air and water. The mines also contain various heavy metals, including, in particular, radioactive isotopes of thorium and radium. Collectively, these contaminants represent a permanent and significant environmental hazard.

C2. The radioactive contaminants constitute, in the view of the public, a very important - perhaps the most important - cause for concern. The possible generation of large quantities of acid is, however, a major concern as well, not only because of the potential impact on the environment of the acid itself but because acidification will increase the solubility, and hence the risk of dispersion, of the radioactive and other metals at rates and levels that are toxic in natural systems.

C3. It is not feasible to extract these contaminants from the vast bulk of the tailings in order to isolate them for disposition elsewhere.

C4. Proposals to deposit the tailings underground, or in a deep lake, while theoretically possible, do not offer a practical solution.

C5. Effective protection against the hazards posed by the contaminants in these tailings requires that the tailings be permanently contained in such a way as to prevent their dispersion into the environment while insulating them from exposure to the joint action of air and water.

C6. The tailings are now mainly or entirely water-saturated. Under the climatic conditions of the Elliot Lake area, it is not possible to dry them nor, if it were, would it be possible to keep them dry.

C7. Effective protection therefore requires that the tailings be insulated against exposure to gaseous oxygen in the atmosphere. This can best be done by keeping them permanently water-saturated.

C8. Tailings can, with suitable arrangements, be kept permanently saturated either under a water cover or under a dry cover, provided a sufficient, reliable supply of water is permanently available.

C.9 The most satisfactory containment system, in the light of current technology and under the climatic and other conditions of the Elliot Lake area, consists of a stable bedrock basin, augmented as required by well-engineered zoned embankment dams to close off low spots in the basin perimeter.

C10. Properly designed and constructed, such a system is both robust and flexible. It is capable of operating effectively over a considerable range of climatic and other conditions, and can be modified to adapt to changing conditions or requirements.

Cl 1. No containment system can totally preclude some release of contaminants, but a system of the kind suggested can hold the rate of release within acceptable limits, (i.e. below or comparable to the level of fluctuations in the natural background levels of the same contaminants).

C1 2. To operate reliably and permanently, as the nature of these contaminants requires, the system must be supported virtually in perpetuity by effective care and maintenance programs; no "walk-away" system is acceptable. Such programs must include vigilant monitoring, maintenance, repair, research and, as necessary, system modification in the light of experience and technological advances. Such support must include the capability to repair promptly major failures caused by exceptional unforeseen events.

c13. Specific and binding financial and institutional arrangements will be necessary to ensure, as far as possible, that these essential support programs will be effectively maintained in perpetuity. The financial assurances proposed, while partially acceptable, are not fully satisfactory.

c14. To minimize long-term requirements for human intervention, the containment system should be designed to work with, and not against, the evolving ecology of the local environment. Hence water cover or a natural dry cover - such as soil and vegetation - is preferable to, and more cost effective than, an engineered hard cover.

Cl 5. Surface containment systems are inevitably subject to biological intrusion. Biological uptake of radiological or other contaminants is an important monitoring consideration in active ecological systems.

C16. Land-use and other access controls will be necessary.

Cl 7. The necessary support programs, and in particular the monitoring, surveillance and research activities, as well as the necessary land-use and access controls, should involve the active participation of communities in the area.

Cl 8. The contribution of the four designated mines is the major component of the cumulative environmental impact of uranium mining in the Serpent River Basin. However, the contribution of other mines in the area, including two that are perhaps adjacent to, rather than actually within, the basin, is also substantial.

Cl 9. It is satisfactory that the proponents are applying for Prescribed Substance licences for these other mines. This will lead the AECB to review the environmental impacts associated with their WMAs and other facilities, and in light of the results of that review, to decide what regulatory requirements may be appropriate.

C20. While the panel's mandate does not extend to consideration of the claim of the Serpent River First Nation for compensation to offset the adverse impacts of uranium mining on their traditional uses of lands in and near the Serpent River Basin, the panel supports the First Nation's wish to have protected access to certain sacred and other traditional sites in this area.

C21. The panel endorses the view, eloquently expressed by the Serpent River First Nation, that humanity should seek to live in harmony with the natural environment, using as few renewable resources as possible and making an effort to minimize the environmental impact of any necessary exploitation of non-renewable resources.

B. RECOMMENDATIONS

Dispersed throughout the previous sections of this report there are expressed, explicitly or implicitly, a large number of recommendations. The more important of these are formally set out below, not necessarily in the order in which they appear in the earlier passages. Interested parties - in particular the AECB, because of its regulatory function - should take the earlier references into account, as well as the recommendations below, for a full understanding of the panel's views.

R1. The proponents' proposals should form the basis for developing the details of decommissioning licences for the WMAs. The panel has recommended a number of conditions as set out below and within this report, which should be incorporated into the licensing process.

R2. The decommissioning licences should recognize three separate phases in the process. The length of each phase will vary for the different WMAs. In the short-term phase, the containment systems will be completed and their initial stable performance must be verified by comparison to design standards and regulatory requirements. The transitional phase that will follow must be long enough to permit the effectiveness of each system to be verified over a range of climatic and other operating conditions, and to permit any desirable adjustments to be implemented. This phase must be utilized to update the estimates of long-term costs. Only then will the long-term phase begin, and only then will the proponents be permitted to seek the transfer to government of their management responsibilities.

R3. Denison's selection of the in-situ management plan for Stanrock mine should be accepted provisionally, but its performance must be closely monitored. During the short-term and transitional phases, no actions should be taken that would eliminate potential alternative approaches, such as the removal of the tailings to Moose Lake, until such time as satisfactory performance of the TMA has been demonstrated.

R4. A more extensive and varied program of bio-monitoring and analysis than was suggested by the proponents is recommended. Appropriate biota must be monitored both on and off site to ensure prompt detection and evaluation of any significant biotic uptake, migration and accumulation of various contaminants from the tailings.

R5. The containment systems must be so designed and managed that the results of research or the advent of new technology can be promptly applied, if necessary, to ensure effective and economical operation of those systems.

R6. Because of the impact that climatic change may have on the performance of the containment systems, it will be important to monitor climatic behaviour closely with a view to early identification of possible trends. Current arrangements for acquiring timely, accurate and site-specific weather data are inadequate. An appropriate weather recording capability should be permanently established in Elliot Lake.

R7. Water-cover depths - or in the case of Stanrock the water table level - must be regularly monitored, so that prompt remedial action can be taken in the event of a threatened loss of saturation. For Stanrock, this program should be intensified during the summer because transpiration losses are likely to increase during the growing season. Explicit guidelines are required concerning minimum allowable water levels. These should detail the remedial measures to be taken if necessary.

R8. For the Quirke WMA, monitoring is required to verify that settlement of the internal dykes has ceased or is negligible.

R9. The issue of returning settling pond sludges to the WMAs should be explicitly reviewed by the AECB to determine the acceptability of this approach. Monitoring will be required to verify that no adverse impact on effluent quality occurs.

R10. Once effluent treatment facilities are no longer required as part of the ongoing operations of the WMAs, the proponents should ensure that adequate treatment facilities are "mothballed" - that is stored and maintained on site and intact in such a way that they can be rapidly brought into service if necessary.

R11. The AECB should ensure that more detailed information is obtained with regard to the cumulative deposit of contaminants in the bottom sediments of various waters downstream from the tailings areas, especially in several lakes that received substantial quantities in earlier years and in the lower reaches and the estuary of the Serpent River.

R12. More extensive sampling should be undertaken of the background ("natural") levels of the more important contaminants in neighbouring waters, to provide more precise and detailed baseline data than are currently available. To be reliable, such investigations must be undertaken at a number of sites carefully selected to be representative of conditions in the Serpent River Basin but, at the same time, located as to be free, as far as can be determined, from contaminants released by the uranium mining activities of the past four decades.

R13. Expert monitoring and review of piezometric levels in the dams, the occurrence and variation of any seepage, modifications or damage to any containment or spillway structures, and off-site movement of contaminated groundwater are essential to provide assurance of containment performance and stability. The panel recommends that the AECB should direct particular care to their review of the adequacy with which these items are handled during all phases of facility operation.

R14. Material prepared by the proponents' consultants, and several of the submissions made to the panel, contained additional specific comments and suggestions regarding monitoring and maintenance of the containment systems. These should be fully considered by the AECB in establishing the conditions of decommissioning licences. In particular, the recommendations made by the consultants regarding instrumentation and monitoring procedures are considered by the panel to be minimum requirements.

RI 5. In addition to ongoing monitoring and maintenance activities, there must also be provision for an effective, long-term program of curiosity-driven research. These facilities represent very long-term experiments, providing both an opportunity and a responsibility to gain better understanding of the physical, chemical and biological processes, as well as the innovative procedures required to initiate the desired results involved in the long-term evolution of the different sites. As one example, in the case of the Stanrock TMA, the opportunity should not be missed to conduct research on the many aspects of vegetative cover, including its impact on acid generation, species selection and nutrient management.

R16. The success of the proposed measures to establish, monitor and maintain the containment systems will require effective and reliable financial and institutional arrangements. Approval of those measures should not be given until satisfactory arrangements have been defined and provision made for their timely implementation. The financial and institutional arrangements contemplated by the panel, and their appropriate time phasing, are illustrated schematically in Figure 8.

R17. The arrangements now in effect under Denison's assets distribution agreement are satisfactory for the short-term and transitional phases (as defined in Recommendation R2), but precise arrangements are necessary to provide for the management of the trust fund for the long term. These arrangements should be incorporated in the provisions of the decommissioning licence.

RI 8. Rio Algom should be required to provide "hard" financial assurance by setting up, during the short-term phase, a trust fund into which it will make regular scheduled payments and from which funds will be drawn, as needed, to meet the costs of establishing, testing and operating the containment systems. Provision should be made for Rio Algom to give up responsibility for management of this fund at the end of the transitional phase; that responsibility should then be transferred, as in the case of Denison, to government.

R19. The schedules of payments into the proposed trust funds should be negotiated on the basis of the estimated costs of permanently operating, monitoring and maintaining the containment systems, plus an appropriate amount to cover the costs of contingencies. The calculation of this latter amount should take into account information on the intentions of the federal and provincial governments with regard to the funding of costs resulting from "Acts of God."

R20. The owners of the WMAs (for the short-term and transitional phases the proponents, thereafter presumably an appropriate governmental agency) should prepare comprehensive emergency preparedness plans to be updated annually. These plans should spell out procedures to be followed to ensure that the necessary decisions are taken promptly, so that timely action can be taken in response to the problem.

R21. In addition to the direct funding requirements relating to the establishment, operation, monitoring and maintenance of the containment systems, there is the need to fund an adequate program of curiosity-driven research not necessarily directed to specific operational questions. To meet this need the panel recommends that the proponents be directed to set up - at the earliest possible moment so as not to lose data that will lapse with time - a research endowment fund. In so doing, they should provide seed money from which the initial earnings will support a meaningful research program, and should canvass additional capital donations from other corporate and other entities likely to benefit from the acquisition of a better understanding of the long-term behaviour of mine waste management areas.

R22. During the short-term and transitional phases of decommissioning, responsibility for the operational management of the WMAs and of the associated monitoring and maintenance programs should remain with the proponents, subject to the responsibility of the AECB to oversee their observance of the conditions of the licences and of an independent audit of the operation of the trust funds.

R23. To provide for the management of the research program, and to perform a number of other functions indicated below, the panel recommends that the proponents be required to take the lead in bringing about the creation of a not-for-profit corporation, which might be named the Serpent River Basin Conservation Council.

R24. The board of this Council should include representatives of the proponents, the City of Elliot Lake, the Serpent River First Nation, the research community and, possibly, other communities in the area. The AECB should be represented by a non-voting member, as voting membership could involve a conflict of interest with its regulatory responsibilities; the federal and provincial governments might wish to be represented by observers.

R25. The Council should manage the research endowment fund, and it should appoint a scientific committee to propose, for approval by the Council, an annual research program to be financed by earnings from the fund together with any directed donations that may be forthcoming.

R26. Other functions of the Council should include:

(a) participating in the development, implementation, evolution and review of the monitoring and maintenance programs;

(b) developing land-use proposals, including proposals for future uses of lands (and perhaps roads, buildings and other facilities) currently controlled by the proponents;

(c) providing a forum for resolving any differences of view with regard to the access controls at the various WMAs; and

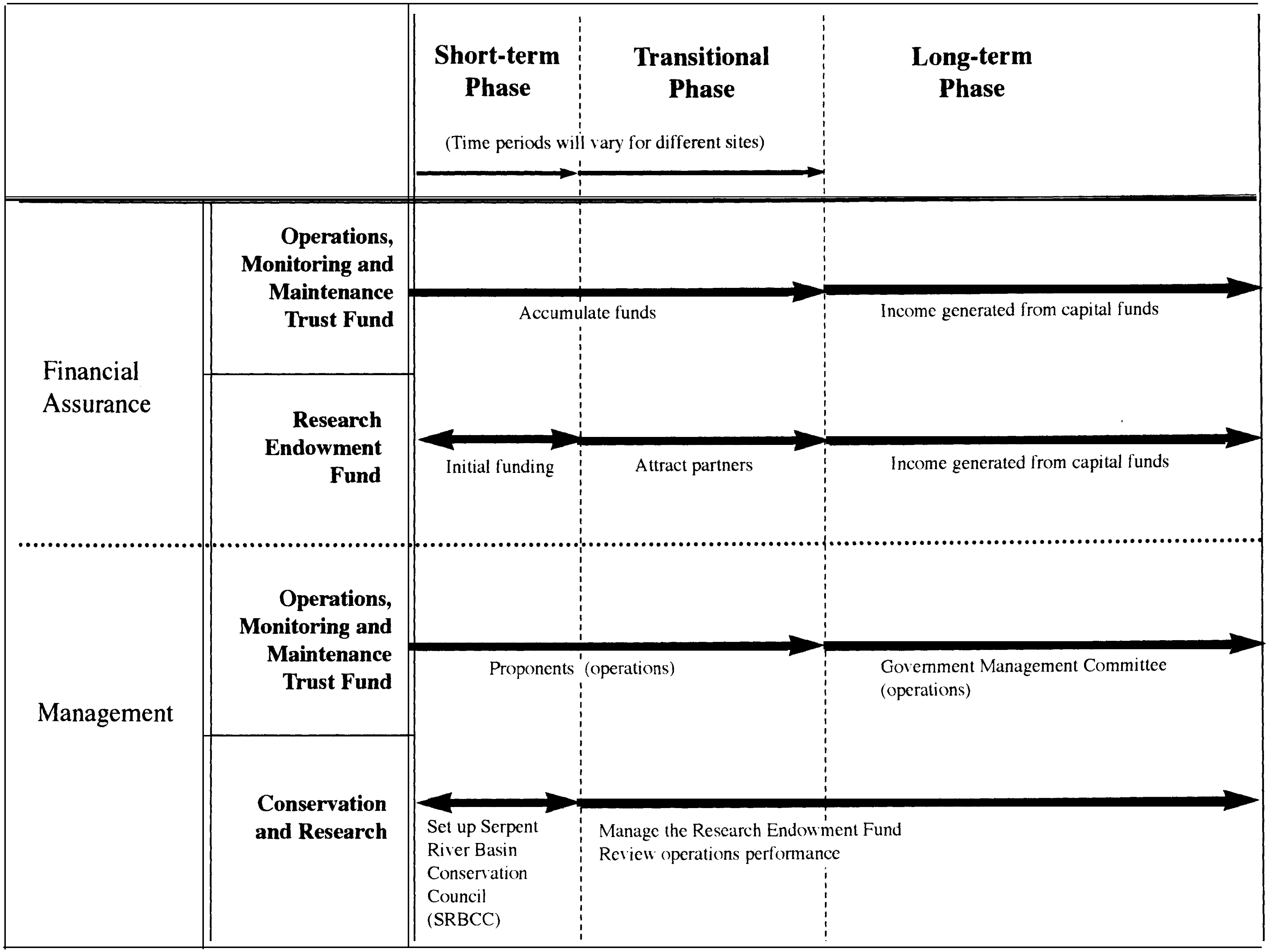
(d) advising the federal and provincial governments on conservation issues that relate to the Serpent River area.

R27. The panel endorses the decision of the federal and provincial governments to provide, through their agreement referred to in Section 7.2.1, for the cost of repairs required as a result of exceptional events that may exceed the resources that the proponents are able, and are required by their licences, to commit. The panel recommends that the Management Committee mentioned in that agreement be charged with administration of the trust funds following the end of the transitional phase.

R28. The panel recommends that, at the end of the transitional period, when title to the mine properties will presumably be transferred to the Crown, the operational management of the long-term monitoring and maintenance programs also be assigned to the Management Committee. The Committee might decide to delegate this responsibility to a suitable operating component of the provincial government.

R29. The measures recommended in this report are designed to protect the environment of the Serpent River Basin and surrounding areas from potential damage that could be caused by the tailings of the four designated uranium mines, It is important that this objective should not be frustrated as a result of the release of contaminants originating at the sites of the other mines in the area. The AECB should therefore ensure that the steps intended to lead to a review of the situation at those sites are vigorously carried through.

FIGURE 8: DECOMMISSIONING PHASES AND OPERATIONS



FEDERAL ENVIRONMENTAL ASSESSMENT PANEL REVIEW ON THE DECOMMISSIONING OF URANIUM MINE TAILINGS AREAS NEAR ELLIOT LAKE ONTARIO

David Kirkwood
Chairman

Thomas Peters

Dougal McCreath

APPENDIX A - PANEL BIOGRAPHIES

Mr. David Kirkwood (Chairperson) is a former Deputy Minister of Health and Welfare Canada and past Chairman of the Anti-Dumping Tribunal. After receiving his M.A. from the University of Toronto, Mr. Kirkwood held several positions in Ottawa and overseas with the Department of External Affairs from 1950 to 1969. He was then appointed Assistant Secretary to the Cabinet. From 1972 until 1986, Mr. Kirkwood served as a senior public servant in various government departments and finally as Deputy Minister of Health and Welfare. Mr. Kirkwood also served as Chair of the Environmental Assessment Panel for Air Traffic Management for Southern Ontario which recently released its report concerning the proposal to construct three new runways at Lester B. Pearson International Airport.

Dr. Dougal R. McCreath is currently a Professor in the School of Engineering at Laurentian University in Sudbury. He has a Ph D. in Civil Engineering from the University of London, a M.Eng. of Geotechnical Engineering from the University of Alberta and a B.Sc. in Civil Engineering from the University of Manitoba. Dr. McCreath worked as a consulting engineer for 20 years before joining the academic community. He has over 25 years of world-wide experience in the practical solution of geotechnical engineering problems in civil and mining projects.

Mr. Thomas H. Peters, a resident of Copper Cliff, Ontario, retired from INCO Limited after 37 years. His last position was as Agriculturist (Manager, Agricultural Department). Mr. Peters' area of expertise is land reclamation for which he has received several awards. He holds a Bachelor of Scientific Agriculture from the University of Toronto and an Honourary Doctorate of Science from Laurentian University for his contribution to land reclamation. He is also active in a variety of community organizations.

APPENDIX B - TERMS OF REFERENCE

REVISED TERMS OF REFERENCE FOR THE REVIEW OF PROPOSED DECOMMISSIONING OF URANIUM MINE TAILINGS MANAGEMENT AREAS IN THE ELLIOT LAKE AREA

Introduction

The environmental assessment panel is to undertake a public review of Rio Algom's proposals for decommissioning of the tailings management areas at the Quirke and Panel uranium mines and of Denison's proposals for decommissioning the tailings management areas at the Denison and Stanrock mines. These proposals were referred for public review in accordance with section 12(d) of the Environmental Assessment and Review Process (EARP) Guidelines Order by the Atomic Energy Control Board (AECB) and the scope of the review agreed to by the former Minister of Energy, Mines and Resources.

As a result of this review the panel will produce a report containing recommendations to the federal Minister of the Environment and the Minister designate for Natural Resources and to the AECB. The AECB is the federal authority responsible for licensing the decommissioning of the tailings management areas. If the panel concludes that one or more proposals are acceptable, it may recommend terms and conditions including mitigation and monitoring measures to be implemented in relation to these proposals. If the panel concludes that one or more proposals are unacceptable, it shall provide reasons for this conclusion.

The panel's report will be a key factor in the decision to be taken by the AECB on whether to issue a licence to the proponents and if so, the nature of the conditions attached to the licence.

Background on Project Proposals

Four uranium mining facilities licenced by the AECB have ceased operations in Elliot Lake, Ontario. Two of these, the Quirke and Panel mines owned by Rio Algom Limited, shut down in August 1990. The two others, the Stanrock Mine and the Denison Mine owned by Denison Mines Limited, ceased operations in 1964 and 1992, respectively.

The proposals referred for public review consist of the decommissioning of the tailings management areas at all four mines.

Scope of the Review

- In order to assess the acceptability of the proposed options the panel will take into consideration the following:

- the short- and long-term environmental effects and social effects directly related to the environmental effects, including human health and safety, of the decommissioning proposals concerning the four mines named above;

- the contribution of these four mines, in light of the aforementioned proposals concerning them, to the cumulative environmental impact resulting from several decades of uranium mining in the Serpent River watershed;

- such information as may be obtained without undue difficulty or delay, with regard to the contribution of other uranium mines in the Elliot Lake area to this cumulative environmental impact;

- the relevant technical experience during the past fifteen years in temperate climates with decommissioning tailings management areas, focusing particularly on radioactive and/or acid-generating tailings;

- the adequacy of short- and long-term measures proposed by the proponents to mitigate any significant adverse environmental effects, including monitoring and maintenance for the protection of the environment and for safeguarding health and safety;

- the environmental effects of malfunctions or accidents that may occur in connection with the project;

- the potential environmental interactions of the proposals of the two proponents and whether the panel's acceptance of one proposal could preclude any panel recommendations with respect to the other proposals;

- the technical feasibility and comparative costs of the proposed options and any alternatives considered by the proponents, including the costs of any federal institutional controls if warranted; and,

- the proponent's rationale for rejecting any alternative options.

The panel's recommendations will be based on the options put forward by the proponent.

Issues Outside the Scope of the Review

Issues associated with the uses of nuclear energy, governments' policies on uranium mining and uranium exports, military application of nuclear technology, and salvage and demolition of surface structures and underground workings are outside the panel's terms of reference.

Review Process

The panel review will be conducted pursuant to the federal Environmental Assessment and Review Process Guidelines Order. The panel should conduct its public review in the area immediately affected by the proposals.

Given that the two proponents are at different stages in their preparation of decommissioning plans, the panel should ensure, to the extent possible, that the review of one proponent's proposals is not delayed unreasonably while the other proponent is preparing its documentation. Since a considerable amount of technical information, including an environmental impact statement (EIS) prepared by Rio Algom, has already been developed, this will be made public and the panel will take this information into consideration at an early stage of the review process. The review shall be carried out as expeditiously as possible and within a budgetary framework.

The main components of the process are:

- preparation and issuance of operating procedures for the review; (within 1 month of appointment of the panel)
- preparation and public release of draft guidelines for the finalization of an EIS in advance of public scoping meetings; (within 1 month of appointment)
- public scoping meetings for the purpose of receiving input on the draft guidelines for the EIS to be prepared by Denison and receipt of comments on the EIS prepared by Rio Algom; (within 3 months of appointment)
- finalization of guidelines for the preparation of Denison's EIS and request for additional information from Rio Algom, if necessary, for the completion of its EIS; (within 5 months of appointment)
-
- completion of EISs by proponents in conformity with the panel's guidelines or additional information request and submission of them to the panel;
- review of the EIS and/or response to a request for additional information by the public, government agencies, and the panel; (within 2 months of receipt of the EIS)
- public hearings to obtain participants' views on the proposals once the panel has determined that the information provided by the proponents adequately responds to the EIS guidelines and/or a request for additional information;
- preparation and submission of the panel's final report, in both official languages, to the Minister of the Environment and to the Minister designate for Natural Resources and the AECB, who make the report public; (within 4 months of the completion of hearings).

The panel may adjust the schedule as appropriate if:

- public hearings do not occur at the same time for the two proponents and in such an event, the panel may release an interim report; and/or
- Rio Algom does not submit its EIS in sufficient time to be considered at the scoping meetings.

APPENDIX C - PUBLIC HEARING PARTICIPANTS

November 14, 1995 (Elliot Lake)

Mr. John Nightingale and Mr. Roger Payne (Rio Algom Limited)
Mr. Andy Rickaby, Mr. Steve Januszewski and Mr Bill James (Denison Mines Limited)
Mr. Bernie Zgola (Atomic Energy Control Board)
Mr. Dan Hutchinson (United Steelworkers of America)
Mr. Lloyd Greenspoon (Algoma-Manitoulin Nuclear Awareness)
Ms. Brennain Lloyd (Northwatch)

November 15, 1995 (Elliot Lake)

Mr. John Nightingale and Mr. Roger Payne (Rio Algom Limited)
Ms. Judy Smith (on behalf of Northwatch)
Mr. Steve Januszewski (Denison Mines Limited)
Mr. Juris Balins (on behalf of Denison Mines Limited)

November 16, 1995 (Elliot Lake)

Mr. Roger Payne (Rio Algom Limited)
Mr. Dave Grogan (Health Canada)
Dr. Martin Resnikoff (on behalf of Northwatch)
Dr. Robert Morris (Laurentian University)
Mr. Andy Rickaby and Mr. Doug Chambers (Denison Mines Limited)
Mr. Dan Hutchinson (United Steelworkers of America)

November 17. 1995 (Elliot Lake)

Mr. John Nightingale and Mr. Roger Payne (Rio Algom Limited)
Mr. Ron Edwards and Mr. Grant Feasby (Natural Resources Canada)
Mr. Ron Shimizu and Mr. Robert Krauel (Environment Canada)
Mr. Dick Cowan (Province of Ontario)
Mr. Andy Rickaby and Steve Januszewski (Denison Mines Limited)
Mr. Bruce Fallis (Department of Fisheries and Oceans)
Mr. Paul Robinson (on behalf of Northwatch)
Mr. Dan Hutchinson (United Steelworkers of America)

November 18, 1995 (Elliot Lake)

Mr. John Nightingale (Rio Algom Limited)
Mr. Andy Rickaby (Denison Mines Limited)
Mr. Lorne Johnson (Northwatch)
Mr. Charles Spencer
Mr. Hubert Fischer

November 27, 1995 (Sudbury)

Mr. John Nightingale (Rio Algom Limited)
Mr. Andy Rickaby (Denison Mines Limited)
Mr. Phillip Penna (Inter-Church Uranium Committee)
Mr. Lloyd Greenspoon (Algoma-Manitoulin Nuclear Awareness)
Mr. Paul McKay (on behalf of Northwatch)
Mr. John Jackson (Great Lakes United)
Mr. Ed Burt

January 23, 1996 (Serpent River First Nation)

Chief Earl Commanda
Mr. Keith Lewis
Mr. John Nightingale (Rio Algom Limited)
Mr. Roger Payne (Rio Algom Limited)
Mr. Andy Rickaby (Denison Mines Limited)
Mr. Steve Januszewski (Denison Mines Limited)
Mr. Bill James (Denison Mines Limited)
Serpent River First Nation presentation by:

- Chief Earl Commanda
- lsadore Peltier
- Angela Lewis
- Lynsey Sago
- Rachel Lewis
- Murphy Rickard
- Gertrude Lewis
- Helen Zavits
- Elaine Johnston

Mr. Charles Meawasige
Mr. Don Francis

Januarv 26, 1996 (Elliot Lake)

Mayor George Farkouh (City of Elliot Lake)
Mr. Bernie Zgola (Atomic Energy Control Board)
Mr. Ron Edwards and Mr. Grant Feasby (Natural Resources Canada)
Mr. Paul Robinson (on behalf of Northwatch)
Ms. Sharon Gow
Ms. Barb MacLeod
Ms. Julie Lance
Mr. Phillip Penna (Inter-Church Uranium Committee)
Dr. Gordon Edwards (Canadian Coalition for Nuclear Responsibility)
Mr. Robert del Terdeci
Ms. Brennain Lloyd (Northwatch)
Mr. Lloyd Greenspoon (Algoma-Manitoulin Nuclear Awareness
Mr. Ed Burt
Mr. Hubert Fischer
Dr. Randy Knapp (Rio Algom Limited and Denison Mines Limited)
Mr. John Nightingale (Rio Algom Limited)
Mr. Andy Rickaby (Denison Mines Limited)

APPENDIX D - MEMORANDUM OF AGREEMENT BETWEEN CANADA AND ONTARIO

Memorandum of Agreement

This Memorandum of Agreement is made, in duplicate, this 23rd day of January, 1996

Between

Her Majesty the Queen in Right of Canada (hereinafter referred to as "Canada"), represented by the Minister of Natural Resources,

of the FIRST PART

and

Her Majesty the Queen in Right of Ontario (hereinafter referred to as "Ontario"), represented by the Minister of Northern Development and Mines,

of the SECOND PART.

WHEREAS Canada and Ontario recognize, in principle, that present and past producers of uranium are responsible for all financial aspects of the decommissioning and perpetual care of uranium mine sites, including the uranium tailings;

AND WHEREAS Ontario Hydro by its uranium delivery contract with Rio Algom, is contractually obligated to assume all costs of the decommissioning activities and perpetual care activities for the Stanleigh uranium mine site as acceptable to the relevant governmental authorities;

AND WHEREAS Canada and Ontario recognize that the decommissioning and perpetual care of uranium mine sites in the Province of Ontario are of concern to the public;

AND WHEREAS Canada and Ontario recognize that decommissioning and perpetual care of uranium mine sites may become a residual responsibility of governments when a uranium producer or property owner is unable to provide the necessary funds;

AND WHEREAS Canada and Ontario recognize that they should cooperate in the decommissioning of uranium mine sites without prejudice to the division of the relevant constitutional responsibilities between Canada and Ontario;

AND WHEREAS Canada and Ontario recognize that any agreement reached between them on cost-sharing arrangements for the decommissioning and perpetual care of uranium mine sites should not impede the regulatory authority of appropriate bodies;

NOW THEREFORE in consideration of the mutual agreements and covenants contained herein, Canada and Ontario agree as follows:

1. INTERPRETATION

For purposes of this Memorandum of Agreement, the following definitions are provided.

Uranium Producer: A private entity which operates or has operated a uranium mine or mill facility on a uranium mine site.

Uranium Mine Site: A delimited site used by a uranium producer to mine or mill

Uranium Mine Site: A delimited site used by a uranium producer to mine or mill uranium. It includes mine structures and workings, mill facilities, tailings on the site whether or not contained in tailings waste management areas, tailings containment structures and administration infrastructure and buildings.

Decommissioning Activities: Activities (including those related to environmental assessment and review processes) necessary to transfer the uranium mine site from an operational or inactive state to an acceptable long-term state as determined by:

a) in the case of a site licensed by the Atomic Energy Control Board (AECB), regulatory requirements which take into consideration the results of the AECB cooperative regulatory process with Ontario;

b) in the case of a site not licensed by the AECB, the requirements agreed to by the parties, subject to any requirement of the appropriate regulatory authority.

Monitoring: Field data collection and surveillance activities.

Perpetual Care Activities: Activities carried out after all decommissioning activities are completed, to monitor the uranium mine site and its environmental impacts and to conduct remedial measures pursuant to Article 6.2.

Extraordinary event: Any acute natural event (so-called "Act of God") which would significantly diminish the effectiveness of the engineered barriers constructed prior to or during the decommissioning of the uranium mine site.

2. SCOPE OF APPLICATION

2.1 This Agreement shall apply to all uranium mine sites located in the Province of Ontario, including sites licensed by the AECB.

3. DECOMMISSIONING ACTIVITIES

3.1 Subject to Articles 3.3 and 3.4, where a uranium producer or property owner is bankrupt or insolvent, defaults on its obligations for decommissioning activities, or in emergency circumstances where Canada and Ontario agree, Canada shall pay 50% and Ontario shall pay 50% of the costs incurred in carrying out any decommissioning activities as agreed to by the parties in a decommissioning plan pursuant to Article 6.2(a).

3.2 Subject to Articles 3.3 and 3.4, where the Crown is the owner of a uranium mine site, and the uranium producer is bankrupt or insolvent, defaults on its obligations for decommissioning activities, or in emergency circumstances where Canada and Ontario agree, Canada shall pay 50% and Ontario shall pay 50% of the costs incurred in carrying out any decommissioning activities as agreed to by the parties in a decommissioning plan pursuant to Article 6.2(a).

3.3 Recognizing that Ontario Hydro is financially obligated to pay costs of all decommissioning activities for the Rio Algom Stanleigh uranium mine site, Canada agrees to pay, for the uranium mine sites owned, leased or held under licensed occupation at the date of this Agreement by Denison Mines Ltd., 70% of the costs incurred in carrying out decommissioning activities as approved by the Atomic Energy Control Board. Ontario agrees to pay the remaining 30% of costs incurred in carrying out decommissioning activities as approved by the Atomic Energy Control Board.

3.4 In the event Ontario Hydro does not pay all costs related to decommissioning activities for perpetual care activities for the Rio Algom Stanleigh mine site, and the uranium producer is unable to provide the necessary funds, Ontario agrees to assume the costs of all decommissioning activities and perpetual care activities for the Rio Algom Stanleigh uranium mine site.

4. PERPETUAL CARE ACTIVITIES

4.1 Subject to Articles 3.3 and 3.4, where a uranium producer or property owner is bankrupt or insolvent, defaults on its obligations for perpetual care activities, or in emergency circumstances where Canada and Ontario agree, Canada shall pay 50% and Ontario shall pay 50% of the costs, excluding labour for monitoring activities, incurred in carrying out any monitoring activities and remedial activities as agreed to by the parties pursuant to Article 6.2.

4.2 Ontario agrees to assume all labour costs for monitoring activities, as agreed to by the parties pursuant to Article 6.2.

5. EXTRAORDINARY EVENTS

In accordance with a plan agreed to by the parties pursuant to Article 6.2(c) to remedy the damage at a uranium mine site caused by an extraordinary event, Canada and Ontario agree to equally pay costs incurred for remedial activities.

6. ADMINISTRATION

6.1 Canada and Ontario agree to establish a Management Committee, reporting to the Deputy Minister (or delegate) of the federal Department of Natural Resources or successor agency and to the Deputy Minister (or delegate) of the Ontario Ministry of Northern Development and Mines or successor agency. The Management Committee shall have equal federal and provincial representation. The function of the Committee is to oversee the management and implementation of this Agreement. The administrative structure of the Management Committee is to be determined by the parties.

6.2 The Management Committee is a forum for the parties to cooperate and shall:

a) Ensure that a competent organization carries out activities in accordance with deconunissioning and perpetual care plans agreed to by the parties, subject to any requirement of the appropriate regulatory authorities;

b) monitor perpetual care activities and agree to remedial plans which may be necessary:

c) agree to plans for remedial activities due to an extraordinary event;

d) ensure that a mechanism is in place to resolve disputes that may arise between parties pursuant to this Agreement;

e) address any other matter that may arise pertaining to this Agreement

7. COOPERATION

7.1 Canada and Ontario agree to cooperate in good faith with respect to their obligations under this Agreement and to enter into any further agreements or provide any further documentation as may be necessary to carry out any activities pursuant to this Agreement

8. TERM OF AGREEMENT

8.1 This Agreement shall come into force when duly signed and dated by each of the parties and shall remain in force for fifty (50) years, unless terminated by the written agreement of both parties. On the written agreement of both parties, it may be renewed for a further fifty (50) years.

8.2 This Agreement should be reviewed every 7 years and, if need be, modified upon the written agreement of both parties.

9. ENTIRE AGREEMENT

9.1 This Agreement constitutes the entire agreement between the parties with respect to the subject matter of this agreement and supersedes all previous relevant negotiations, communications and other agreements, whether written or oral, between the parties.

This Agreement has been executed on behalf of Her Majesty in Right of Canada by the Minister of Natural Resources and on behalf of Her Majesty in Right of Ontario by the Minister of Northern Development and Mines.

HER MAJESTY THE QUEEN
IN RIGHT OF CANADA

JAN 2 3 1996

Date

Minister of Natural Resources

HER MAJESTY THE QUEEN
IN RIGHT OF ONTARIO

Date

Minister of Northern Development and Mines

APPENDIX E - SUMMARY OF THE REGULATORY ENVIRONMENT

Uranium mines in Canada are regulated by the federal Atomic Energy Control Act and a number of regulations administered by the Atomic Energy Control Board (AECB). The AECB issues Mining Facility Operating Licences and Mining Facility Decommissioning Licences. The Uranium and Thorium Mining Regulations, established in 1988, outline the requirements for various licensing stages including aspects of uranium mine operations, waste management, decommissioning, inspection by the AECB, reporting, and planning for financial assurance.

The prime AECB regulatory documents on the AECB's policy on decommissioning nuclear facilities are the ***Policy on the Decommissioning of Nuclear Facilities, Regulatory Document R-90 and Regulatory Objec tives,*** which became effective in August 198 8, and ***Requirements and Guidelines for the Disposal of Radioactive Wastes -Long- Term Aspects, Regulatory Document R-704,*** which became effective in June 1987.

Regulatory Document R-90 describes the policy of the AECB for the decommissioning of nuclear facilities including uranium mines and mills. The document states the AECB's requirement that all nuclear facilities be decommissioned "satisfactorily in the interests of health, safety, security and the protection of the environment according to plans approved by the AECB". The AECB further requires that the decommissioning actions be assured by adequate financial planning. Document R-90 also states that reliance on institutional control mechanisms which involve active ongoing human intervention to control impacts from decommissioned facilities is generally not acceptable to the AECB.

Regulatory Document R-104 presents the regulatory basis for judging the long-term acceptability of radioactive waste disposal. The basic objective of radioactive waste disposal as stated in the Document are "to minimize any burden placed on future generations, protect the environment, and protect human health, taking into account social and economic factors." Future burdens should be minimized by selecting disposal options which do not rely on long-term institutional controls as a necessary safety feature and ensuring that there are no future radiological risks to human health that would not be currently accepted.

While the only licence or permit necessary and in force with respect to the WMAs is the AECB Mine Facility Decommissioning Licence, decommissioning and abandonment activities may be subject to other federal and provincial legislation. For example, the provincial environmental concerns associated with decommissioning and site clean-up in Ontario which are taken into account by the AECB are contained in the Environmental Protection Act, Environmental Assessment Act, the Ontario Water Resources Act, and the Mining Act - Part VII. In addition, the Ontario Ministry of the Environment and Energy (MOEE) guidelines for the clean-up of industrial sites are also considered.

Steps have been taken by the AECB to ensure that all possession of radioactive waste arising from historic mining and milling activities in Canada complies with the regulatory requirements of the Atomic Energy Control Regulations. These materials are "prescribed substances" as defined in section 2 of the Atomic Energy Control Act and subsection 2(2) of the Atomic Energy Control Regulations. Possession of these substances is therefore subject to a licensing requirement under section 3 of the Regulations.

APPENDIX F - KEY REVIEW DOCUMENTS AND REFERENCES

Environmental Impact Statement for the Decommissioning of the Quirke and Panel Waste Management Areas and supporting documents, submitted by Rio Algom Limited, August 1993.

Written comments submitted from the public and government agencies to the Federal Environmental Assessment Review Panel Examining the Decommissioning of Uranium Mine Tailings Management Areas near Elliot Lake, comments on the draft Guidelines Document, December 1993.

Transcript of Scoping Meetings held in Elliot Lake December 9 through to December I I, 1994; Sudbury December 7, 1993 and Serpent River First Nation Reserve December 15, 1993.

Final Guidelines Document issued by the Federal Environmental Assessment Review Panel Examining the Decommissioning of Uranium Mine Tailings Management Areas near Elliot Lake, August 1994.

Written comments submitted from the public and government agencies to the Federal Environmental Assessment Review Panel Examining the Decommissioning of Uranium Mine Tailings near Elliot Lake, comments on the adequacy of the Rio Algom Limited and Denison Mines Limited Environmental Impact Statements, October 1995.

Public hearing submissions to the Federal Environmental Assessment Review Panel Examining the Decommissioning of Uranium Mine Tailings Management Areas near Elliot Lake, January 1996.

Transcript of Public Hearings held in Elliot Lake, November I4 through to November 18, 1995 and January 26, 1996; Sudbury, November 27, Serpent River First Nation Reserve January 23, 1996.

Joint Response to Elliot Lake Assessment Board Request of 28 August 1995 for Additional Information, Prepared by Rio Algom Limited and Denison Mines Limited, September 1995.

Joint Response to Comments Raised by Various Ministries, Agencies and Reviewers of the Quirke and Panel, and Denison and Stanrock EIS Documents, prepared by Rio Algom Limited and Denison Mines Limited, October 1995.

R.P. Benson, W.P. Harland and L. Pinkerton, "The Ancient Madura Oya Sluiceway." Water Power and Dam Construction, Vol. 35, pp.26-31, December 1983.

N. Dave, and A.J. Vivyurka, "Water Cover on Acid Generating Uranium Tailings - Laboratory and Field Studies", Paper presented at the International Land Reclamation and Mine Drainage Conference, Pittsburgh, PA. April 24 to 29, 1994.

E.J. Klohn, "A Lesson Behind Every Failure", Keynote Address, Canadian Dam Safety Association Conference, Whistler, B.C., September 1991.

A.D.M. Penman and V. Milligan, "Longevity of Embankment Dams - A Critical Review", Workshop on Dam Safety Evaluation. Grindelwald, Switzerland, April 28, 1993.

A.M. Robertson, "The Stability of Control Structures for Uranium Mill Tailings", Report 58902, prepared for the National Uranium Tailings Program, March 1996.

J. Todd and N.J. Todd, "From Eco-Cities to Living Machines: Principles of Ecological Design", North Atlantic Books, Berkeley, California, United States, 1994.

P. Wagitt, "A Review of Worldwide Practices for the Disposal of Uranium Mill Tailings," Technical memorandum 48, Australian Government Public Service, 1994.

APPENDIX G - ABBREVIATIONS

AECB - Atomic Energy Control Board
AMD - Acid Mine Drainage
ARD - Acid Rock Drainage
Bq/s - bequerel per second
CANMET - Canada Centre for Mineral and Energy Technology (Natural Resources Canada)
CEAA - Canadian Environmental Assessment Agency
cm - centimetres
EARP - Environmental Assessment Review Process
EIS - environmental impact statement
ha - hectares
IAEA - International Atomic Energy Agency
km - kilometres
L - litres (L/s - litres per second)
LSA - Low Specific Activity
m - metres
MEND - Mine Environmental Neutral Drainage
MOEE - Ontario Ministry of the Environment and Energy
mm - millimetres
NRCan - Natural Resources Canada
pH - hydrogen ion concentration
PMP - Probable Maximum Precipitation
TMA - tailings management area
tpd - tonnes per day
UMTRAP- Uranium Mill Tailings Remediation Activity Program
WMA - waste management area

APPENDIX H - ACKNOWLEDGMENTS

The panel wishes to express its gratitude to all those who participated in the review, particularly members of the public who spent considerable time and effort in reviewing the material and preparing briefs and presenting them to the panel. Thanks also go to representatives of federal, provincial and local government agencies for their participation.

The panel extends a special thanks to the people of the Serpent River First Nation for their participation and significant contribution to this review process.

The panel appreciated the co-operation and work done by Rio Algom Limited, Denison Mines Limited and their consultants.

Finally, the panel would like to thank the members of the Canadian Environmental Assessment Agency who assisted the panel in the review and in the completion of this report.

If you would like additional copies of this report please contact the Canadian Environmental Assessment Agency at the address listed below.

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