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PAPER

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URANIUM TAILINGS IN CANADA - REGULATION AND MANAGEMENT

by

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ABSTRACT

The last few years have produced significant changes in the way uranium tailings are managed in Canada. This is due both to the development of new technology and to changes in regulatory approach. The interrelationships between these two areas are examined with particular attention paid to the long term and the development of close-out criteria. New technological initiatives are examined including dry placement techniques, pit disposal and deep lake disposal.

RÉSUMÉ

Les dernières années ont donné lieu à d'importants changements dans le domaine de la gestion des résidus de traitement d'uranium au Canada. Ceci est dû au développement d'une nouvelle technologie et aux changements dans l'approche de la réglementation. L'interdépendance de ces deux secteurs fait l'objet du présent article qui porte en outre une attention particulière à la gestion à long terme et au développement des critères de déclassement. De nouvelles initiatives technologiques sont également examinées, entreautres les techniques de mise en place à sec, ainsi que l'évacuation dans les tranchées et dans les lacs profonds.

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INTRODUCTION

Uranium mining and milling are generally referred to as the front end of the nuclear fuel cycle. Since the extraction process removes only about one kilogram of uranium oxide from each tonne of ore, a uranium mill produces large quantities of slurry-type wastes called tailings. These tailings contain relatively low, yet still significant concentrations of a number of long-lived radionuclides, notably radium and thorium.

The last two to three years have produced rapid changes in the way uranium tailings are managed in Canada. This is due both to the development of new technology and to changes in regulatory approach. The thrust of this paper is to clarify the interrelationships between these two areas with a particular focus on long-term management.

To better understand the changes taking place in uranium tailings management, it is useful to look first at the period prior to the late 1970's. During this time, approximately one hundred million tonnes of tailings were deposited in various areas of Canada, mainly in the Elliot Lake area of Ontario and to a lesser extent in northern Saskatchewan and near Bancroft in southeastern Ontario. All of these tailings were placed into conventional surface containment structures although a small amount was used for back-filling to the underground mine at some operations. The tailings were placed as a slurry of approximately thirty to forty per cent solids. For older systems, that is for tailings deposited during the 1950's and the 1960's, the confinement structures were predominantly natural topographic basins in combination with relatively permeable embankments. Some of these embankments were constructed of cycloned tailings and were not particularly well controlled in the engineering sense. During the expansion of the 1970's improved containment structures were built with an emphasis on impermeability and overall improved engineering control. As a result of these improvements, there is a high degree of confidence in our ability to physically contain tailings within storage areas. Effluents which used to flow freely to the environment are now subject to control and treatment, giving us further confidence in our ability to manage uranium tailings during operational phases.

Because of these innovations and the resultant confidence in tailings management during the operational or short-term phase, the primary focus has shifted towards a consideration of the long-term or close-out aspects of tailings management. A great deal of research is still needed to better evaluate various options and their impacts. It is expected that the Federal/Provincial Uranium Tailings Research Program being coordinated by the Canada Centre for Mineral and Energy Technology (CANMET) of the Federal Department of Energy, Mines and Resources will take on the lion's share of this work. The Atomic Energy Control Board (AECB), with a somewhat modest research budget, has supported several initiatives related to the long-term, notably the individual dosimetry and collective dose calculations which formed the Canadian contribution to a working group of the Nuclear Energy Agency (NEA). This work, in looking at critical pathways and radiation exposure of populations has provided us with a number of good indicators, such as:

(1) most exposures of individuals occur at very low (trivial) levels,

(2) releases of contaminants over the long term are not necessarily constant in time.

The relevance of these points will become clearer in my discussion of "close-out criteria".

CLOSE-OUT CRITERIA

The overall regulatory approach to waste management is based on trying to achieve the goal of "disposal".* This is in contrast to a number of present waste management schemes which are considered "storage" and in which the need for surveillance and control is accepted and later retrieval a possibility and/or likelihood. At the present time "disposal" as it relates to uranium mill tailings, is a rather uncertain concept and it is not yet clear how or whether in the pure sense, it may be attained. The key problem areas in the long-term would appear to be the potential future misuse (removal) of tailings material along with a more permanent need to prevent access to a site which has been "closed-out". These problems would appear to indicate that some form of institutional control may always be required. Efforts are, however, being aimed at achieving as pure a sense of "disposal" as is reasonable given the present technological state of the art and keeping economic and social considerations in mind.

Close-out, as it is currently envisaged by the AECB, is a state reached after a facility has been decommissioned (shut down and dismantled) and the surrounding environment returned to a condition meeting relevant criteria and any related standards. In order to better understand this concept, it is useful to examine how a tailings management facility might behave in time. In Figure 1, three phases are indicated, an operating phase, a transition phase and the long-term. During the active operating phase the release rate of various radioactive and non-radioactive contaminants will usually be at some fairly constant rate and will be less than an appropriately set control level. During this operational phase, one of the primary means of reducing release rates to less than control levels is the use of active or mechanical systems, for example barium chloride treatment for removal of radium-226. To effectively "close-out" a site, reliance on these active or mechanical systems will have to be phased out. A transition phase will occur while the system adjusts to these natural systems and an equilibrium is established. The figure shows three possible variations that might occur but purely for illustrative purposes, not predictive. Curve A for example, might apply if no active attempt was made to restrict release. In this case the release rate may gradually rise to a level above the current control level and at some point in the future would presumably stabilize at a new but unacceptable level. Curve B, on the other hand, illustrates the case in which the release rate increases somewhat during the time in which mechanical systems are being replaced by natural systems but in time a new acceptable and stable equilibrium is achieved. The final Curve C illustrates the somewhat idealistic view that the release rate decreases in time and eventually reaches a stable equilibrium at a level which is less than the background level. The present line of thinking in the AECB is that once release rates have reached a state

* Disposal may be simply defined as a method of dealing with wastes for which there is no intention of retrieval with the added requirement that the method used should not rely for its integrity on continued human involvement.

of equilibrium at acceptable levels, "close-out" will have been achieved.

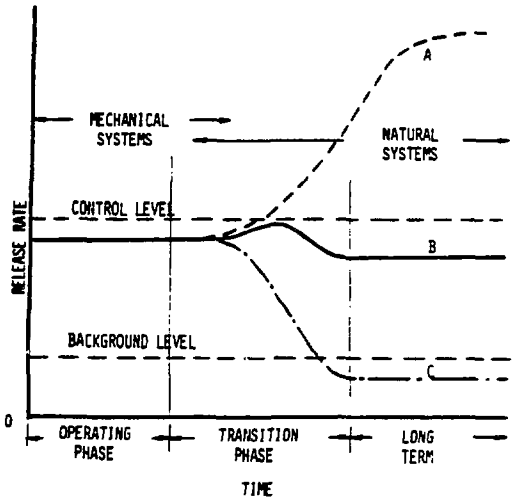

Figure 1: TIME LINE FOR TAILINGS RELEASE RATES

In January of 1981 the AECB issued a draft document referred to as Consultative Document No. 1 which set out some criteria for the close-out of uranium mine tailings areas. Since that time various meetings and public consultations have taken place and as a result a major rewrite of the criteria is being undertaken. Industry, in particular, felt that the first draft lacked sufficient site specificity and expressed concern over the choice of performance objectives for radon emanation and gamma fields originating from the tailings. Concern was also raised about the potentially high costs required to meet these objectives compared to the benefits to be gained. Comments received from the public at large were very limited, ranging from recommendations to cease future developments to general support for the initiative to develop criteria.

While details of the redraft of the close-out document are not as yet available for public distribution, some general statements can be made with respect to the new directions. The thrust of the second draft will allow for more site specificity through somewhat less rigid wording. Fewer performance oriented numbers will be included and these will be replaced by dose considerations in accordance with radiation protection principles for waste management which are currently under development. First and foremost will be the familiar principle that the dose limits specified in the Atomic Energy Control Regulations must be observed. Secondly, the collective dose arising from radioactive waste management practices shall be kept as low as reasonably achievable, economic and social factors being taken into account (ALARA). Thirdly, there is a principle being developed which will be the subject of a later presentation at this conference, that some doses arising from radioactive waste management practices are so small that, for practical purposes, they may be neglected, the so-called "trivial" dose. The definition of this dose is based on considerations of risks that members of the public generally accept as being insignificant. Figure 2 shows in a simple fashion where the optimization zone would occur.

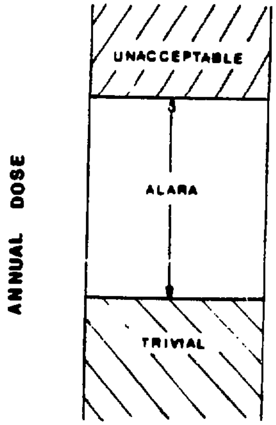

Figure 2: ALARA (OPTIMIZATION) ZONE

The AECB feels there are two purposes for defining the trivial dose criteria previously mentioned. These are:

(1) to identify the need to conduct an optimization analysis; if it can be shown that no individual will be exposed to more than the trivial dose now or in the future, then further optimization of radiation protection is unnecessary and the need to conduct a further analysis is obviated;

(2) to truncate collective dose commitment calculations needed for optimization analyses since no individual doses smaller than the trivial dose need to be included in the calculations.

It must be emphasized that optimization as it is being developed is simply one method of addressing the ALARA principle. A proponent wishing to know how much spending is required to, for example, close-out his tailings area, must look at the costs of various measures and relate them to the benefit they would achieve through a reduction of collective detriment. When the cost of protection roughly matches the benefit, one has reached the optimal point. It is noted that this methodology still requires considerable refinement.

In addition to the three radiation protection principles discussed earlier, facilities will also be controlled in terms of their allowable releases of contaminants. Total annual loadings of contaminants released to the environment in a state of close-out should not exceed operational releases based on good operational practice. A further limitation will be that where practical, local water quality objectives will have to be met at designated points. In looking specifically at the present water quality objectives in Saskatchewan and in Ontario, it is believed that this requirement may be the most stringent of those addressed in the criteria.

With respect to containment principles, the basics of the first draft of the close-out criteria are relatively intact. Passive barriers, either natural or engineered, are encouraged to contain or control radioactive and non-radioactive releases. Emphasis is placed on the need for containment systems which degrade only gradually over time and the need for routine maintenance of containment systems is discouraged.

The application of these close-out criteria is more clearly delineated in the new version. Conceptual close-out plans will be required from each licensed facility within eighteen months of the coming into force of the close-out criteria, including a detailed analysis of the various radiation exposure pathways in the short and long-term (operational and close-out phases). New facilities, that is any facility which is granted its first operating license in that period beyond twelve months of the coming into force of the close-out criteria, will have to meet these requirements prior to receiving its first license.

As a final point of discussion related to the close-out criteria, the AECB is currently engaged in reviewing various financial guarantee mechanisms. The close-out criteria now focus on an initial five year period in part to facilitate the definition of financial guarantees. Efforts are being made to develop a mechanism such as a performance bond whereby assurance is provided that an operator completes his initial close-out work to a standard which is compatible with the close-out criteria, irrespective of his financial circumstances at the time of close-out.

The new draft of the close-out criteria is presently being reviewed by other relevant regulatory agencies across the country. Another meeting with industry will follow (late 1982 or early 1983), and after a further round of public consultation, it is hoped to be able to issue the criteria by mid 1983.

TAILINGS MANAGEMENT SCHEMES

In addressing the refinement of tailings management schemes and the need to develop techniques which best approach the objectives for the longer term, a number of alternative approaches are being evaluated. In Canada, these new placement technologies can best be placed into three main groups; dry placement techniques, pit disposal and deep lake disposal.

DRY PLACEMENT

The term "dry placement" usually refers to methods which result in tailings which are either unsaturated after they have been placed or to tailings which do not segregate into a sands and slimes fraction. The two principal methods currently being evaluated in Canada are coning or stacking techniques and the so-called sub-aerial placement technique. Coning involves increasing the percentage of solids in the tailings to about fifty to sixty percent and then depositing them at a central point which causes a gentle slope to form out to the edges. Vertical permeability is reduced and thus the opportunity for the redissolution of contaminants is also minimized. Stacking involves the use of thickened tailings and/or waste rock to construct internal dams within a waste management system to increase capacity. Both of these approaches seek to develop a topographic high or a continuous slope suited to shedding surface water. In the sub-aerial placement technique, the tailings are placed in thin layers approximately ten centimetres thick. This results in a laminar structure with some vertical segregation of slimes and sands across each layer giving a system with very low overall vertical permeability and fairly high lateral permeability. Since each layer is allowed to dry out before placement of another layer, the tailings are not saturated with water, are incapable of liquifaction and have a very high structural capability. Although the system appears favourable, there is one area of concern. Due to Canada's severe winter climate, there appears to be a period of approximately five months when the conventional laminar approach is not practical due to freezing of the system. This means that relatively thick layers of tailings must be placed during the winter causing some discontinuity in the system. Coning and stacking techniques are mainly being pursued in Ontario while the new Key Lake Uranium Mining operation in Saskatchewan will be the first to utilize the sub-aerial method.

PIT DISPOSAL

This method involves the placement of tailings in a mined out pit. The first major facility to propose such a system is the Gulf Minerals operation in northern Saskatchewan which is currently evaluating a new ore body referred to as the Collins B Zone. The tailings from this new open pit mine would be placed into the old Rabbit Lake pit which will have been fully mined out by that time. The principal feature of this method involves achieving confinement of the tailings and associated contaminants within the pit and surrounding groundwater system by engineering an extremely low hydraulic gradient across the tailings deposit. This gradient is created by incorporating a pervious "envelope" around the tailings mass through which all water flows will occur preferentially. This, in turn, reduces the seepage through the tailings to practically zero. Once a final equilibrium state has been reached, it is visualized that there will be very little interaction between the groundwater regime within the tailings themselves and the surrounding groundwater aquifer. Advantages of this method from a "disposal" point of view are that the tailings are placed in a more inaccessible situation and that there is less need for land use limitations to prevent misuse of material. Furthermore, it is expected that any releases of radionuclides to the environment will be at a very low level since the tailings will be placed within a water environment which tends to inhibit radon and gamma emanation.

DEEP LAKE DISPOSAL

During the last few years a considerable amount of work has been undertaken to evaluate the concept of deep lake disposal. For example, Quirke Lake in the Elliot Lake region of Ontario has been evaluated as a potential site for uranium mine tailings. The lake is quite large with several sub-basins, the deepest of which is approximately one hundred and forty metres. Current estimates would allow approximately five hundred million tonnes of tailings to be deposited into Quirke Lake while maintaining thirty metres of overlying water. The main perceived advantage of using such a system is that lakes are a depositional environment whereby the tailings would ultimately be covered with lake sediments. This would slowly decrease any possible interchange of contaminants between the tailings mass and the overlying water. Perhaps offsetting this benefit are considerable technical uncertainties mainly because there has never been in Canada nor in any other country a practice which is totally analogous to this situation. Although we now have some indications, it is not clear what the interaction of various contaminants will be in the short-term or the long-term after deposition of tailings has ceased. Some of the current research being pursued has compared this option with conventional on-land tailings management in terms of pathways and predictive radiation exposures. The results, although far from conclusive, do suggest that deep lake disposal is certainly worth a serious look. All current information on this disposal option is being summarized in preparation for a public meeting to be held early in 1983. One of the main difficulties being faced is that the time necessary for evaluation and approval is considerable while mining companies in the Elliot Lake area must make decisions on their future tailings management plans in the very near future.

CONCLUSIONS

Although we are continuing to refine our requirements and criteria for uranium mill tailings management and, in particular, expect there will be changes made to the close-out criteria as a direct result of the CANMET program, interim criteria must be set in place without delay. It has not been the policy of the AECB to universally retrofit its newly developed requirements on existing facilities. Neither is it the AECB's intention to retrofit future changes in close-out criteria on already closed-out facilities. Thus any facility which closes-out in the near future according to the criteria that then exist will not be asked to "back-fit" at a later date when new methodologies and requirements are developed. This, however, should not be confused with a facility's responsibility to ensure the integrity of the system that they put in place originally.

In all activities related to licenses and approvals of uranium mine tailings facilities, including the development of criteria such as those discussed in this paper, the AECB utilizes a joint regulatory approach whereby consultation with other agencies, industry and the public is integral. To maintain the necessary balance in a regulatory system often presenting conflicting requirements and priorities, the AECB must strongly resist the urge to allow the process to become dominated by any one approach or by any one group. In this way, the Board feels that it can best regulate the industry with concern for both the short and long-term with the objective being achievement of the greatest collective benefit for all of the people of Canada.