Management of uranium tailings

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This article was first published in The AusIMM Bulletin, June 2013, pp57-58.

Introduction

Uranium tailings are differentiated from other types of tailings due to the radioactive nature of the material. Radioactive tailings facilities pose long term hazards relating to both exposure and dam failure, with the principal concern being the potential harm to both operator and public health.

Primary pathways in which exposure can occur include:

- ingestion of dust
- inhalation of radon gas
- acid rock drainage and metal leaching
- seepage impact / contamination of surface and ground water sources.

Generally, the causes of dam failure at uranium facilities are no different from those at other mill tailings dams. However, the consequences of failure may be more significant than non-hazardous facilities, depending on the radioactivity of the material and the sensitivity of the receiving environment.

The long half-lives of the radioactive constituents require effective facilities to be designed for a minimum of 200- 1000 years or longer, and closure design is a far more important consideration. Therefore, radioactive storage facilities are subject to stricter design and operating standards than non-hazardous facilities and are equipped with more extensive controls, especially regarding seepage and dispersion of dust.

Uranium tailings and heap leach case studies

The design of tailings and heap leach facilities for low grade uranium mines focuses on implementing both active operational practices as well as passive design measures to isolate the stored waste from the environment and limit human exposure. Design controls have included:

- composite liner systems utilising both natural and synthetic materials
- in-pit spent leach disposal above the water table
- closure cover designs with internal radiation barriers
- surface water diversions and management structures, 'pervious surround' groundwater controls
- seepage collection systems
- innovative dewatering plans to assist in closure preparation.

All of these design controls are focused on planning for the long closure life of the facility, managing radon emissions and protecting surface and groundwater.

Composite liners

Environmental protection was identified as a key requirement for the design of a dedicated heap leach pad (HLP) and associated ponds for a lower-grade uranium project in Niger. In order to prevent groundwater egress and tails pore water egress, the leach pad and ponds were equipped with a composite lining system consisting of a 300 mm-thick, low-permeability clay layer overlain by a 2 mm-high density polyethylene (HDPE) liner.

Groundwater protection

An additional study looked into the modification of the current HLP from a permanent pad with five remaining lifts to an ON/OFF dynamic pad in combination with pit backfilling. An economic evaluation and risk assessment was used to compare the two options. It was found that the ON/OFF pad would be more cost effective, despite increased haulage requirements and would have a lower consequence of failure than the permanent pad. The risk assessment also identified potential impact to groundwater and therefore in-pit spent leach disposal was implemented above the water table.

Closure covers

A further project in Niger proposed two different radioactive material management strategies, either a tailings storage facility (TSF) or a HLP. As water is a scarce commodity in the project area, the proposed TSF has been designed as a dry stack tailings facility. The conceptual closure plan for the TSF proposes a two-layer cover design: an inner mixed layer to prevent oxygen ingress, radon emissions and to act as a general barrier to radiation; and an outer coarse rock layer to prevent wind and water erosion of the underlying finer material. The closure plan for the HLP will include capping all exposed contamination sources with suitable waste rock. The final slopes will be graded to promote surface water runoff as opposed to percolation and surrounding surface flows will be diverted around the storage facilities.

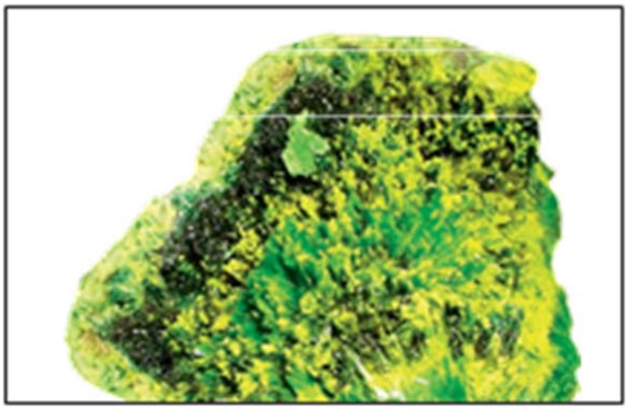
Placement of the clay liner during leach pad construction in Niger

Zero-discharge

A uranium heap leach project in central Botswana was designed as a zero-discharge facility to prevent water contamination. Water balance modelling was used to ensure the zero-discharge requirement would be achieved. The design prevents egress of water through the incorporation of a clay layer and HDPE synthetic liner at the base of the pad and containment berms constructed around the facility ensure leach solutions and stormwater runoff are retained within the leach pad footprint.

Pervious surround protection

A recent project in Namibia involving in-pit uranium tailings disposal, identified the groundwater system coming into contact with the uranium tailings as the key risk. From international experience, it was proposed to use a ‘pervious surround’ to provide a preferential flow path for groundwater to flow under or around the backfilled pits. The pervious surround is constructed along the edges of the backfilled pit, consisting of high permeability sand, with drainage collected in a seepage collection system at the base of the pit. The pervious surround method was first introduced by Matich and Tao (1984 and 1986) in the 1980s to manage the disposal of uranium tailings in the Canadian mining industry.



Secondary copper uranium minerals

Innovative dewatering systems

A dewatering plan was developed for a historic uranium tailings impoundment in Utah preparing for closure. Dewatering was necessary to minimise the amount of water entering the groundwater through the base of the impoundment during cover placement. Geotechnical and hydrogeological investigations of the tailings were conducted to develop options and vertical wick drains were selected as the best option for dewatering. The wick drains were corrugated strips of plastic covered with a mesh to filter sediment. Under the pressure of the soil cover, water is forced up the wicks and onto the surface where it can evaporate. The effectiveness of the wicks was observed immediately after installation.

Conclusion

The design considerations for uranium tailings facilities are fundamentally the same as those for non-hazardous facilities, namely to prevent the migration of tailings and contaminants beyond the facility. Due to the exposure hazards associated with uranium tailings, the degree of impact resulting from a failure may be more significant for facilities storing radioactive material, depending on the nature of the material released and the sensitivity of the receiving environment. However, implementation of best practice design and management standards to stabilise and contain the radioactive materials in such a way that it is isolated from environment can greatly reduce, or even eliminate, the risks they pose.