

**Analysis of long-term
groundwater dispersal
of contaminants from
proposed Jabiluka
Mine tailings
repositories**



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Foreword

At the twenty-second meeting of the World Heritage Committee, held in Paris from 22 to 27 June 1998, a decision was reached that the Chair of the Committee should lead a mission to Australia and Kakadu National Park to assess any ascertained or potential threats to the World Heritage values of Kakadu National Park that might arise from the proposal to mine uranium at Jabiluka. The visit of the Mission took place from 26 October 1998 to 1 November 1998.

The report of the Mission was submitted to the Bureau of the World Heritage Committee at its meeting held in Kyoto, Japan, on 27–28 November 1998. Following consideration of the report, the Bureau made recommendations that were considered by the World Heritage Committee at its meeting from 30 November 1998 to 5 December 1998.

The report noted ‘severe ascertained and potential dangers to the cultural and natural values of Kakadu National Park posed primarily by the proposal for uranium mining and milling at Jabiluka’ and recommended that the mining and milling of uranium should not proceed. In the case of threats to the natural values of the Park, the mission placed very significant weight on ‘the serious concerns expressed by some of Australia’s most eminent scientists as to the degree of scientific uncertainties relating to the Jabiluka mine design, tailings disposal and possible impact on catchment processes’. The concerns cited were made in a submission by Wasson, White, Mackey and Fleming (Wasson et al 1998, Appendix 2).

Because the Australian authorities had not had sufficient time to respond to the report, the World Heritage Committee made no firm decision of the future status of Kakadu at the November 1998 meeting. In its decision, the Committee requested that the Supervising Scientist conduct a full review of the areas of scientific uncertainty. The issues specified were hydrological modelling, prediction and impact of severe weather events, storage of uranium ore on the surface and the long-term storage of mine tailings.

The Supervising Scientist’s response to that request has been published as a Supervising Scientist Series report:

Johnston A & Prendergast JB 1999. *Assessment of the Jabiluka Project: Report of the Supervising Scientist to the World Heritage Committee*. Supervising Scientist Report 138, Supervising Scientist, Canberra.

In preparing this report, the Supervising Scientist has drawn on the broad range of expertise available within his own organisation. In addition, given the intense interest in the World Heritage issue and the need for absolute transparency, he has sought independent expert advice from a number of scientific institutes within Australia. Scientists from the Bureau of Meteorology, the University of Melbourne, the Commonwealth Scientific and Industrial Research Organisation and the University of New South Wales prepared reports on specific topics at the request of the Supervising Scientist. These reports have been published as separate Supervising Scientist reports:

Bureau of Meteorology 1999. *Hydrometeorological analyses relevant to Jabiluka*. Supervising Scientist Report 140, Supervising Scientist, Canberra.

Jones RN, Abbs DJ & Hennessy KJ 1999. *Climate change analysis relevant to Jabiluka*. Supervising Scientist Report 141, Supervising Scientist, Canberra.

Chiew FHS & Wang QJ 1999. *Hydrological analysis relevant to surface water storage at Jabiluka*. Supervising Scientist Report 142, Supervising Scientist, Canberra.

Kalf FRP & Dudgeon CR 1999. *Analysis of long-term groundwater dispersal of contaminants from proposed Jabiluka Mine tailings repositories*. Supervising Scientist Report 143, Supervising Scientist, Canberra.

Included in the series is *Protection of the environment near the Ranger uranium mine* (Johnston & Needham 1999, Supervising Scientist Report 139), which summarises the extent to which the environment of the region has been protected throughout the period of operations at the Ranger uranium mine. This report was presented to the Mission when it visited Kakadu and subsequently to the World Heritage Committee as part of the Supervising Scientist's report.

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Executive summary

The Jabiluka project area lies within a 73 km² mining lease near the edge of Kakadu National Park, a World Heritage area of approximately 19 800 km². Existing approvals require all tailings to be disposed of underground. The current proposal is to add cement to the partially dewatered tailings to form a paste which would be deposited and allowed to set in the underground mine voids and specially excavated underground silos.

Fears have been expressed that the park will suffer long term adverse effects as a result of the mining operation. Contamination of groundwater is one possibility to be considered.

This report describes and gives the results of an investigation into the movement of the potential contaminants, magnesium sulphate, manganese, radium and uranium from mine tailings by groundwater flow towards the park after disposal of tailings underground in the mine voids and silos. The proposed silos would be constructed to hold the balance of the tailings which could not be accommodated in the mine workings. The tops of the silos would be approximately 100 m below ground surface. Tailings stored in mine voids would have an even greater average cover, with a minimum of approximately 90 m.

Groundwater flow in the vicinity of the mine is topographically controlled. A relatively high mean annual rainfall of about 1500 mm, which occurs mainly in the annual Wet seasons, and relatively low permeability of the sandstone hills surrounding the mine site maintain, high water table levels in the hills. Both surface water and groundwater drainage is from the hills towards the major valleys which run approximately east and west from the surface water divide which is located near the mine site. Groundwater flow in both of these directions eventually reaches the Magela floodplain in Kakadu National Park. The westward flow towards the floodplain follows the general line of Mine Valley. The eastward flow must turn north to follow the course of Swift Creek and flow further before it can reach the floodplain.

Groundwater flow and consequent contaminant transport from the mine site towards the Magela floodplain has been modelled to predict the concentrations of contaminants to be expected along the flow paths. The availability of data on aquifer properties and the nature of the drainage pattern led to the use of a two dimensional finite element numerical model of flow along the paths described above. A three dimensional numerical solute transport model applied in a single layer was used to predict relative concentrations along the flow paths of contaminants leached from the tailings repositories. An analytical contaminant transport model was used in conjunction with a numerical model to determine the effects of advection, dispersion and retardation on contaminant movement away from the tailings storages. Monte Carlo simulations were used to determine concentration profiles over a range of relevant variables. The hybrid model was run for the equivalent of 1000 years in the case of radium and uranium and 200 years for other contaminants.

Predicted median relative contaminant concentration versus distance curves for flow east from the tailings silos can be seen in figure 9d for non-reactive contaminants, figure 10b for uranium and figure 11b and 11d for radium 226. Corresponding results for flow west from the mine voids repository can be seen in figures 12b, 13b, 14b and 14d. The distances to negligible concentration are greater to the west than to the east because of higher permeability west of the mine and consequent higher velocity groundwater flow in that direction. However, it will be seen that even after 1000 years the median predicted concentration of uranium 200 m west of the source is negligible. The range of concentration versus distance curves resulting from the Monte Carlo simulations can be seen in figures 9a, 10a, 11a and 11c for movement of non-reactive contaminants, uranium and radium 226 respectively for movement

east from the silos. Corresponding figures for movement west of the mine voids storage are 12a, 13a, 14a and 14c.

Extreme curves of very low probability show that east of the mine no significant concentration of any contaminant is likely beyond a few hundred metres for radioactive contaminants and one kilometre for non-reactive contaminants.

The results indicate that west of the mine it is possible, although improbable, that significant concentrations of uranium and radium could occur in groundwater about one kilometre from the mine. For non-reactive contaminants such as magnesium sulphate, the distance could be several kilometres. However, in this case the contaminated groundwater would be entering an area of known poor water quality and could not be considered to have a significant adverse effect on the water quality.

Weak upward components of groundwater flow are indicated both east and west of the mine. It is considered that any such flow which reaches the shallow alluvial or weathered rock zone will be diluted and flushed away by the annual surficial Wet season flows.

The overall conclusion is that underground storage of tailings will not have any significant adverse effect on Kakadu National Park as a result of leaching by groundwater of contaminants from the tailings provided a permeability of 10^{-4} m/day of the set tailings paste is achieved. A target of 10^{-5} m/day would be preferable.