Summary of the report on 'Assessment of the radiological exposure pathways at Rum Jungle Creek South (Rum Jungle Lake Reserve) – Batchelor'

The Rum Jungle Lake Reserve, located near the township of Batchelor, is a recreation area that lies on the footprint of the rehabilitated Rum Jungle Creek South uranium mine. Uranium ore was mined at the site from 1961–63. The site was rehabilitated in 1990–91 to reduce potential hazards from residual mining wastes and to repair damage from erosion that had occurred over the years since the cessation of mining. A study conducted in 1991–92 concluded that total annual radiation doses to the public accessing the site were less than 50% higher than typical background doses received in Batchelor. In 2010 it was considered timely to reassess the site to determine whether there had been any changes in radiation levels over the past ~20 years and, in particular, to demonstrate that any exposure to radiation of members of the public accessing the site for recreational activities was acceptable in the context of current international recommendations for radiation protection.

Some of the features of the old Rum Jungle Creek South mine can still be seen at the site today. The pit from where the ore was mined has been allowed to fill with water to form the lake. The overburden heap where waste rock and below ore grade material was placed forms the large hill to the southwest of the lake. Most other residual features of the old mine were removed or reshaped as part of the 1990–91 rehabilitation works.

The present assessment of the Rum Jungle Lake Reserve was conducted by the Environmental Research Institute of the Supervising Scientist (***eriss***), part of the Australian Government's Supervising Scientist Division (http://www.environment.gov.au/ssd). The assessment considered the most important pathways through which the public could potentially be exposed to radiation, with environmental sampling and measurements conducted to collect radioactivity information specific to each pathway. The exposure pathways that were investigated are summarised below.

- **External gamma radiation** – Gamma radiation is similar to x-rays and comes primarily from the decay of naturally occurring radioactive elements ('radionuclides') in soil and rocks. In areas of elevated soil uranium concentration the amount of naturally occurring radionuclides is higher than at typical background sites and so is the level of gamma radiation. A radiation dose is delivered to a person from gamma radiation when standing, sitting or lying on the soil. A site-wide survey of gamma radiation levels was conducted, with more than 800 individual measurements made.
- **Radon and radon decay products** – Radon is formed naturally in the soil as part of the radioactive decay of uranium. In areas where the level of uranium in the soil is high the amount of radon produced is also relatively high. Radon is a radioactive gas and it permeates from the soil into the air where it decays further to form radioactive decay products. The inhalation of these decay products delivers a radiation dose to the lung. Radon and radon decay products in air were measured so that their concentrations at different locations across the site at different times of the day could be determined.
- **Radionuclides in dust** – Radionuclides in dust may be inhaled and subsequently incorporated into the body, delivering a radiation dose to a person. Dust samples were collected at the site over a three month period in the 2011 dry season, including samples collected for conditions mimicking overnight camping at the site, with radioactivity concentrations in the dust samples measured.

- **Radionuclides in lake and creek water** – Radionuclides in water may be ingested through drinking or accidental swallowing. Some of the ingested radionuclides will be incorporated into the body delivering a radiation dose to a person. Consequently, water samples from the lake and from Meneling Creek were collected and analysed for their concentrations of radionuclides.
- **Radionuclides in bushfoods** – Plants and animals can take up radionuclides from the soil or water in which they live and these radionuclides can, when eaten, deliver a radiation dose to a person. Samples of various bushfood items growing at the site (fruits, yams and mussels) were collected and their radionuclide activity concentrations measured. The radionuclide activity concentrations in bushfoods that were not collected on site (fish, wallaby and pig) were estimated from previous studies conducted elsewhere in the Top End.

To estimate radiation doses which the public may potentially receive when accessing the site, the assessment considered different access scenarios and compared the results with typical background doses. The scenarios considered were:

- **Short-term visits** – It was assumed that a person (adults and children) accessed the site 14 times in a single year for daytime picnics between midday and 6:00 pm. No bushfoods or water from the site were consumed for this scenario.
- **Long-term visits** – It was assumed that a person (adults and children) camped at the site for 14 days per year and collected and consumed bushfoods and water from the site.
- **Visits by instructors and students of the Batchelor Outdoor Education Unit (BOEU)** – It was assumed that participating children accessed the site once a year as part of the program, whereas instructors accessed the site up to 40 times a year. These access scenarios were developed following consultation with the BOEU.

For short-term visits the total yearly radiation dose (ie the sum of the dose received from being at the site during the afternoon for 14 times in a year and the dose received from natural background when offsite) to a person was only 1.5% higher on average than the background yearly dose received by a person living in Batchelor and not accessing the site. Most of the above background dose was from external gamma radiation. There was no above background contribution from inhalation of radon decay products. This is because between midday and 6:00 pm the air is well mixed so that the concentration of radon decay products at the site is no different to that at Batchelor.

For a person camping at the site for 14 days in a year the total yearly radiation dose (ie the sum of the dose received from being at the site and the dose received from natural background when offsite) via the gamma radiation and inhalation pathways was around 20% higher on average than the background yearly dose received by a person living in Batchelor and not accessing the site. If it was assumed that all food during those 14 days is hunted and collected on site, rather than shop bought, the total yearly radiation dose was around 50% higher than background. The main contributors, in order of highest to lowest, to the above background dose were ingestion of bushfoods, inhalation of radon decay products and external gamma radiation.

Potential radiation doses to instructors and students of the BOEU were also estimated for the scenario given above. The total yearly radiation dose (ie the sum of the dose received from being at the site and the dose received from natural background when offsite) to a student attending a single day BOEU activity on site would be only 0.2% (that is 1 in 500) higher on

average than the background yearly radiation dose received by a child living in Batchelor and not participating in BOEU activities. The total yearly radiation dose received by an instructor who accesses the site 40 times in a single year would be around 7% higher on average than the background yearly radiation dose to an adult living at Batchelor and not accessing the site. The main exposure pathway contributing to the above background yearly dose was external gamma radiation, as it was conservatively assumed that the entire time was spent on the banks of the lake. In this context it should be noted that in practice some time would be spent in or on the water where the exposure to gamma radiation would be much lower.

For the considered scenarios, the above background yearly radiation doses received by the public are low and generally within the natural variation of typical yearly background doses across Australia. Importantly, the above background yearly doses for the recreational uses of the site considered in the assessment are less than internationally recommended reference levels for guiding decision making on whether or not to restrict individual doses through intervening actions, such as further site rehabilitation or restrictions on access. It is concluded that for the current recreational uses of the site there is presently no unacceptable radiation risk to the public.