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A soil radiological quality guideline value for wildlife-based protection in uranium mine rehabilitation

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ABSTRACT

A soil guideline value for radiological protection of the environment was determined for the impending rehabilitation of Ranger uranium mine in the wet-dry tropics of northern Australia. The guideline value was 1000 Bq kg^{-1} of ^{226}Ra in the proposed waste rock substrate of the rehabilitated landform and corresponded to an above-baseline dose rate of 100 μGy h^{-1} to the most highly exposed individuals of the limiting organism. The limiting organism was reptile based on an assessment using site-specific concentration ratio data.

1. Introduction

The concept of 'environmental exposures' in radiological protection refers to above-background radiation exposures of wildlife in the natural environment resulting from human activities (ICRP, 2014). The need to consider such exposures and their potential impacts has been recognised by the International Commission on Radiological Protection (ICRP) in their revised recommendations (ICRP, 2007) and has lead to the development of a framework for radiological protection of the environment (ICRP, 2008, 2009, 2014).

Environmental exposures are typically quantified as the above-background dose rate to wildlife from a radionuclide contaminated environment and can be placed in a risk context by comparing to a benchmark dose rate. The benchmark dose rate is a dose rate value that is considered to provide an acceptable level of protection to the environment; generally the prevention of deleterious impacts to wildlife populations and ecosystem biodiversity (ICRP, 2007, 2008). The risk context for environmental exposures can also be established by comparing the measured or predicted above-background soil radionuclide activity concentrations in the contaminated environment to those that would result in a dose rate to wildlife equal to that of the benchmark dose rate. This equivalent soil activity concentration can be back-calculated from the benchmark dose rate as:

$$\textit{Equivalent soil activity concentration}\left(\text{Bq kg}^{-1}\right) = \frac{BDR}{F}$$

where:

BDR (μGy h^{-1}) is the benchmark dose rate; and
F (μGy h^{-1} per Bq kg^{-1}) is the dose rate to the organism per unit activity concentration of the radionuclide(s) in the soil of the contaminated environment.

This study aims to derive a soil radiological quality guideline value for wildlife-based protection for the impending rehabilitation of Ranger uranium mine that can be considered at the landform design stage of rehabilitation planning. This is the first known study of its kind assessing soil guideline values for radiological protection of the environment in the context of naturally occurring radioactive material (NORM) relevant to mine site rehabilitation.

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2. Regional context

Ranger uranium mine is located in the Alligator Rivers Region in the wet-dry tropics of northern Australia (Fig. 1). The mine is surrounded by, though technically separate from, the world heritage listed Kakadu National Park. Mining at Ranger began in 1980 and has included the extraction of uranium mineralised material through open-cut methods and onsite ore processing. The

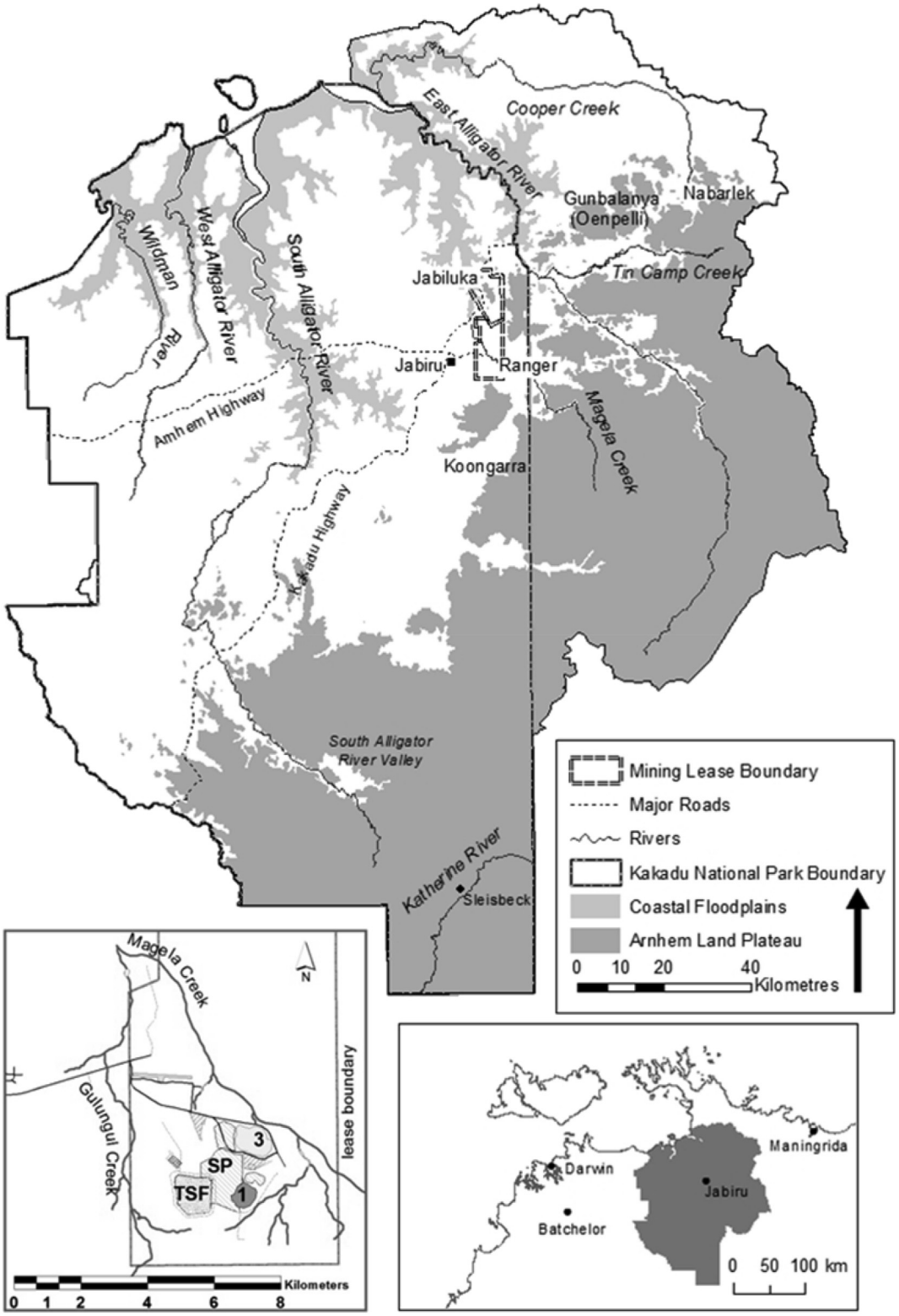

Fig. 1. Alligator Rivers Region map showing Kakadu National Park and the location of Ranger uranium mine. The inset at the bottom left shows an expanded view of the mine (TSF = tailings storage facility, SP = stockpiles, 1 = pit 1, 3 = pit 3). The inset at the bottom right shows the location of the Alligator Rivers Region in the broader geographical context of Australia's 'Top End'.

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