



Uranium in Sediments — Rehabilitation Standard for the Ranger uranium mine

Water and sediment theme

Preface

The Supervising Scientist developed this Rehabilitation Standard to describe the requirements to protect aquatic ecosystems outside of the Ranger Project Area in the Alligator Rivers Region of the Northern Territory from the effects of uranium in sediments.

This document is part of a series of Rehabilitation Standards for the Ranger uranium mine. It may be updated as additional relevant knowledge becomes available.

This Standard should be cited as follows:

Supervising Scientist 2021. Uranium in Sediments — Rehabilitation Standard for the Ranger uranium mine (version 1). Supervising Scientist Branch, Darwin, NT. <http://www.environment.gov.au/science/supervising-scientist/publications/ss-rehabilitation-standards>. Cited [Date].

1. General elements

Scope

1.1 The Rehabilitation Standards for the Ranger uranium mine have been developed in accordance with section 5c of the *Environment Protection (Alligator Rivers Region) Act 1978* and are advisory only.

1.2 The *Environmental requirements of the Commonwealth of Australia for the operation of the Ranger uranium mine* (Environmental Requirements) (Australian Government 1999) specify the environmental objectives for the rehabilitation of the Ranger uranium mine.

1.3 The Supervising Scientist's Rehabilitation Standards quantify the rehabilitation objectives and recommend specific values based on the best available science that will ensure a high level of environmental protection. These values can be used to

assess the achievement of, or progress towards, the rehabilitation objectives, some of which may not be reached for a significant period of time.

1.4 Until it can be determined that the rehabilitation objectives have or will be reached, there will be an ongoing need to ensure environmental protection during and after rehabilitation, through continued sediment quality monitoring and verification of the water-sediment uranium partitioning model (section 4.7).

Objective

1.5 There is currently no agreed acceptable level of effect to the environment surrounding the Ranger Project Area. In the absence of agreement, the Rehabilitation Standard for uranium in sediment aims to protect the biodiversity and health of aquatic ecosystems outside of the Ranger Project Area. If an acceptable level of effect is agreed, this standard will be updated accordingly.

Application

1.6 This Rehabilitation Standard should be applied in the billabongs outside the boundary of the Ranger Project Area, downstream from the Ranger uranium mine.

1.7 Given the potentially long time frame between the completion of rehabilitation and the peak delivery of contaminants to surface water and sediments, this Rehabilitation Standard will most likely be used to assess predicted uranium concentrations from modelled scenarios. Ongoing sediment monitoring will be required after rehabilitation to continue to ensure the environment is being protected, and to validate and assess confidence in the models.

2. Relevant requirements

Environmental Requirements

2.1 The primary environmental objectives in the Environmental Requirements require that surface waters or groundwater arising from the Ranger uranium mine do not result in any detrimental change to biodiversity or impairment of ecosystem health outside of the Ranger Project Area, including during or following rehabilitation. This Rehabilitation Standard is relevant to the Environmental Requirements listed in Box 1.

2.2 This sediment Rehabilitation Standard is related to the Environmental Requirements for water quality because changes in water quality can affect the sediment quality.

Aspirations of Traditional Owners

2.3 The Mirarr Traditional Owners desire that operations at the Ranger uranium mine should not result in any change to the natural water quality of surface waters outside of the Ranger Project Area (Iles 2004). Specifically, as stated in Garde (2013):

...the waters contained within all riparian corridors, (i.e. rivers and billabongs), must be of a quality that is commensurate with non-affected riverine systems and health standards. The principle of 'as low as reasonably achievable' should not apply to these areas. Instead, the standard of rehabilitation must be as high as is technically possible and level of contamination must be as low as technically possible.

Box 1: Ranger Environmental Requirements relevant to the Uranium in Sediments Rehabilitation Standard

1 Environmental protection

- 1.1 The company must ensure that operations at Ranger are undertaken in such a way as to be consistent with the following primary environmental objectives:
- (a) maintain the attributes for which Kakadu National Park was inscribed on the World Heritage list
 - (b) maintain the ecosystem health of the wetlands listed under the Ramsar Convention on Wetlands (i.e. the wetlands within Stages I and II of Kakadu National Park)
 - (d) maintain the natural biological diversity of aquatic and terrestrial ecosystems of the Alligator Rivers Region, including ecological processes.
- 1.2 In particular, the company must ensure that operations at Ranger do not result in:
- (a) damage to the attributes for which Kakadu National Park was inscribed on the World Heritage list
 - (b) damage to the ecosystem health of the wetlands listed under the Ramsar Convention on Wetlands (i.e. the wetlands within Stages I and II of Kakadu National Park)
 - (d) change to biodiversity, or impairment of ecosystem health, outside of the Ranger Project Area. Such change is to be different and detrimental from that expected from natural biophysical or biological processes operating in the Alligator Rivers Region.

3 Water quality

- 3.1 The company must not allow either surface or ground waters arising or discharged from the Ranger Project Area during its operation, or during or following rehabilitation, to compromise the achievement of the primary environmental objectives.

3. Recommended values for uranium in sediments

3.1 To protect the aquatic ecosystems outside the Ranger Project Area in accordance with the rehabilitation objectives, predicted sediment quality in the billabongs outside the boundary of the Ranger Project area should not exceed the recommended values for the parameter shown in Table 1.

Table 1 Rehabilitation standards for uranium and manganese in surface water

Parameter	Location	Rehabilitation standard
Weak-acid extractable uranium (in whole sediment)	In the billabongs outside boundary of the Ranger Project Area, downstream of the Ranger uranium mine	100 mg/kg

3.2 Work undertaken by the Supervising Scientist has demonstrated that uranium in sediments at values of less than 100 mg/kg will protect sediment-dwelling organisms (Sections 4.4 – 4.6).

4. Scientific basis

Guidelines and standards used to develop the recommended values

4.1 The rehabilitation standard for uranium in sediment is based on the site-specific guideline values derived from field effects data, using procedures recommended in the

4.4.2 The portion of TR-U extractable as AE-U was similar at the start and end of the 4.5-month field-deployment. Comparing the data with environmental monitoring data from sediment in the vicinity Ranger mine indicated that the sediments were representative of sediments on the mine-site in terms of physico-chemistry, i.e. they had U with similar lability and potential bioavailability. This confirmed the suitability of the spiking procedure for preparing sediments suitable for deriving a sediment quality guideline value for uranium.

4.4.3 Changes to microbial communities were characterised through the use of amplicon (16S gene) and shotgun metagenomic next generation sequencing (NGS) (Sutcliffe et al. 2017). Statistically significant changes in microbial community assemblages were detected at >400 mg/kg U. However, changes to functional community assemblages were most apparent at a concentration of 1500 mg/kg sediment and above.

4.4.4 Changes to the eukaryotes were characterised through the use of amplicons (18S and COI). For the COI, no changes in the richness and community composition across the treatments were evident. However, using the 18S there was a statistically significant difference detected using multivariate analysis methods between the 100 mg/kg and the 200 mg/kg treatment, with 100 mg/kg representing a No Observed Effect Concentration (NOEC). Independent Threshold Indicator Taxa Analyses (TITAN) (Baker and King 2010) also detected a community composition change above 100 mg/kg.

4.5 Another line of evidence contributing to guideline derivation for U in sediment was provided in a multi-year study of macroinvertebrate communities sampled from reference and mine-water-exposed waterbodies and billabongs associated with Ranger. Sampling of sediment habitat in 2011 showed that the U-contaminated sediments of Ranger Retention Pond 1 (RP1) contained benthic macroinvertebrate communities statistically similar in structure, abundances and taxa number to those from reference billabongs (Humphrey and Chandler 2018). Total Recoverable (TRM) U in the sediments of the three most contaminated (out of 5) RP1 replicate samples had measured U concentrations of 102, 134 and 149 mg/kg (TRM U). The geometric mean of these was 127 mg/kg, indicating that the NOEC derived from eukaryote analysis from Section 4.4.4 (100 mg/kg U) is protective of sediment-dwelling macrobenthos communities.

4.6 Based on the results of the experimental field exposures (Section 4.4) and field macroinvertebrate study (Section 4.5), a sediment quality guideline value of 100 mg U/kg (whole sediment, dry weight) is an appropriate Standard where no ecological impacts would be expected.

Supporting evidence

4.7 Internationally (Canada), Thompson et al. (2005) recommended a sediment quality guideline value of 100 mg/kg uranium, which was based on a “screening level approach” that analysed benthic community data from uranium mine sites in northern

Saskatchewan and northern Ontario. These sites were also contaminated with other metals but the study provides support for the site-specific guideline value.

5. Future knowledge needs

5.1 Rehabilitation planning can only be based on the best available information at a given time, but this should not preclude the continual improvement of the knowledge base and its subsequent application where directly relevant and possible.

5.2 The Supervising Scientist, through its Key Knowledge Needs, has identified the knowledge required to ensure appropriate management of the key risks to the environment from the rehabilitation of the Ranger uranium mine. For uranium and manganese, these knowledge needs are shown in Table 3.

5.3 The value(s) based on field toxicity testing in this Standard were derived using the methodology prescribed in ANZG (2018). In keeping with best practice, the current Standard will be reviewed in due course in line with further updated guidance from ANZG (2018).

Table 3 Key Knowledge Needs for uranium and manganese in surface waters

ER Link	KKN Title	Questions
Biodiversity and human health	WS7. Determining the impact of chemical contaminants on aquatic biodiversity and ecosystem health	WS7D. How do acidification events impact upon, or influence the toxicity of contaminants to, aquatic biota?

6. References

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