



Environmental Radiation — Rehabilitation Standard for the Ranger uranium mine

Radiation protection theme

Preface

The Supervising Scientist developed this Rehabilitation Standard to describe the radiation protection requirements for aquatic and terrestrial ecosystems within and outside of the Ranger Project Area in the Alligator Rivers Region of the Northern Territory.

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

This Standard should be cited as follows:

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<http://www.environment.gov.au/science/supervising-scientist/publications/ss-rehabilitation-standards>. Cited [Date].

1. General elements

Scope

1.1 The Rehabilitation Standards for 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 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 The rehabilitation of the Ranger uranium mine is a planned exposure situation (ARPANSA 2016). Until it can be determined that the rehabilitation objectives have or will be reached, there will be an ongoing need to ensure the protection of the environment, including the need for continued radiation monitoring and associated comparison of dose estimates with relevant environmental reference levels.

Objective

1.5 The Rehabilitation Standard for environmental radiation protection aims to protect the environment in and outside of the Ranger Project Area from the harmful effects of radiation resulting from uranium mining operations.

Application

1.6 This Rehabilitation Standard should be assessed against the absorbed dose rates to representative organisms (defined in 4.3 to 4.6).

1.7 Radiation dose rates from natural background sources are not subject to this Rehabilitation Standard and are not to be included in the calculation of absorbed dose rates.

2. Relevant requirements

Environmental Requirements

2.1 The primary environmental objectives in the Environmental Requirements require that operations at Ranger uranium mine do not result in any detrimental changes to biodiversity, or impairment of ecosystem health, outside of the Ranger Project Area, including during and following rehabilitation. The objectives also require that, after rehabilitation, any effects within the Ranger Project Area are as low as reasonably achievable and conform with Australian law. This Rehabilitation Standard is relevant to the Environmental Requirements listed in Box 1.

Aspirations of Traditional Owners

2.2 The Mirrar Traditional Owners desire that animal and plant populations will persist within off-site ecosystems and recolonise on-site ecosystems of the Ranger Project Area after rehabilitation. It is implicit that radiation should not impact on the achievement of these aspirations. More explicitly, the traditional owners desire that, after rehabilitation of the Ranger Project Area, the cover design for the mined-out pits and the construction of the final landform will achieve a level of radiation no higher than the pre-mining level.

Box 1: Ranger Environmental Requirements relevant to the Environmental Radiation Protection 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
 - (e) environmental impacts within the Ranger Project Area which are not as low as reasonably achievable, during mining excavation, mineral processing, and subsequently during and after rehabilitation

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.

11 Management of tailings

- 11.3 Final disposal of tailings must be undertaken, to the satisfaction of the Minister with the advice of the Supervising Scientist on the basis of best available modelling, in such a way as to ensure that:
- (ii) any contaminants arising from the tailings will not result in any detrimental environmental impacts for at least 10,000 years.

3. Recommended values for environmental radiation protection

3.1 To protect aquatic and terrestrial ecosystems outside and within the Ranger Project Area in accordance with the rehabilitation objectives, radiation dose rates to aquatic and terrestrial organisms should not exceed the recommended values shown in Table 1.

Table 1 Rehabilitation standard for environmental radiation protection for Ranger uranium mine

Rehabilitation standard	Measure of success
Environmental reference level of 400 $\mu\text{Gy h}^{-1}$ for aquatic organisms	Absorbed dose rates to the most highly exposed individuals are as low as reasonably achievable below the environmental reference level
Environmental reference level of 100 $\mu\text{Gy h}^{-1}$ for terrestrial organisms	Absorbed dose rates to the most highly exposed individuals are as low as reasonably achievable below the environmental reference level

4. Scientific basis

Guidelines and standards used to develop the recommended values

4.1 This Rehabilitation Standard has been developed from the approach outlined in the most recent and relevant national guidance for radiation protection of the environment (ARPANSA 2015).

4.2 The environmental reference levels reflect the conclusions of the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) with regard to radiation exposures and effects on organisms (UNSCEAR 1996, 2008).

4.3 Representative organisms are organisms from the local environment exposed to radiation after rehabilitation. They should cover a range of organism types to enable adequate assessment of potential radiation exposures and effects across the different species present in the local environment.

4.4 Absorbed dose rates to representative organisms are the sum of the dose rates obtained from assessment of radionuclides internal and external to the organism. Appropriate radiation weighting factors must be applied in the assessment to account for the relative biological effectiveness of different radiation types.

4.5 The most highly exposed individuals within each representative organism population are those with an absorbed dose rate no lower than the 95th percentile level.

4.6 Absorbed dose rates to the most highly exposed organisms are as low as reasonably achievable if the best option to reduce radiation exposures of organisms has been selected and implemented from the options available, after considering economic and societal factors.

Scientific evidence summary

4.7 The scientific evidence underpinning the environmental reference levels in this Rehabilitation Standard is summarised in UNSCEAR (1996, 2008).

4.8 The International Commission on Radiological Protection (ICRP) has proposed dose rate criteria for radiation protection of the environment (ICRP 2008) that differ from the UNSCEAR (1996, 2008) criteria. Table 2 compares the relevant criteria.

Table 2 Comparison of the dose rate criteria of UNSCEAR and ICRP

UNSCEAR (1996, 2008) criteria	ICRP (2008) criteria
'... chronic dose rates of less than 100 $\mu\text{Gy h}^{-1}$ to the most highly exposed individuals would be unlikely to have significant effects on most terrestrial animal communities and that maximum dose rates of 400 $\mu\text{Gy h}^{-1}$ to a small proportion of the individuals in aquatic populations of organisms would not have any detrimental effect at the population level.'	'... a band of dose rate within which there is likely to be some chance of deleterious effects of ionising radiation occurring to individuals of that type of reference animal or plant ... that, when considered together with other relevant information, can be used as a point of reference to optimise the level of effort expended on environmental protection, dependent upon the overall management objectives and the relevant exposure situation.'
	4–40 $\mu\text{Gy h}^{-1}$ Reference deer Reference duck Reference pine tree Reference rat
	40–400 $\mu\text{Gy h}^{-1}$ Reference flatfish Reference frog Reference wild grass Reference trout
	400–4000 $\mu\text{Gy h}^{-1}$ Reference bee Reference crab Reference earthworm Reference brown seaweed

ICRP = International Commission on Radiological Protection; UNSCEAR = United Nations Scientific Committee on the Effects of Atomic Radiation.

4.9 The ICRP criteria are taxa-dependent order of magnitude bands of dose rate within which there is likely to be some chance of deleterious effects to individuals of that type. The bands are intended to be used as points of reference to help with the optimisation of environmental protection in different exposure situations. In planned exposure situations, such as rehabilitation of the Ranger uranium mine, the ICRP recommends the environmental reference level be set at or below the lower bound of the relevant band (ICRP 2014).

4.10 A limitation of the ICRP criteria is that they do not cover all species types. The criteria are considered by ICRP to be 'preliminary' and 'a first step' towards the derivation of reference levels in its framework for radiation protection of the environment (ICRP 2008).

4.11 By contrast, the UNSCEAR criteria are all-of-ecosystem values that inherently cover all species types. The criteria and review on which they are based are intended to assist national and international bodies to select appropriate criteria for radiation protection of the environment. A follow-up review of the UNSCEAR (1996) criteria (UNSCEAR 2008) concluded that:

'data developed since its 1996 report do not support changes to its previous conclusions of the values of nominal chronic dose-rates below which direct effects on non-human species are unlikely at the population level'.

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 environmental radiation protection, these knowledge needs are shown in Table 3.

Table 3 Key Knowledge Needs for Environmental Radiation Protection

ER Link	KKN Title	Questions
Human Health and Ecosystem Protection	RAD6. Radiation dose to wildlife	RAD6D. What are the dose-effect relationships for wildlife represented by the representative organism groups?

6. References

ARPANSA 2015. *Guide for radiation protection of the environment*. Radiation Protection Series G-1, ARPANSA, Commonwealth of Australia.

ARPANSA 2016. *Code for radiation protection in planned exposure situations*. Radiation Protection Series Publication C-1, ARPANSA, Commonwealth of Australia.

Australian Government 1999. *Environmental requirements of the Commonwealth of Australia for the operation of the Ranger uranium mine*. Australian Government Department of the Environment and Heritage, Canberra.

ICRP 2008. *Environmental protection: the concept and use of reference animals and plants*. ICRP Publication 108, *Annals of the ICRP* 38(4–6).

ICRP 2014. *Protection of the environment under different exposure situations*. ICRP Publication 124, *Annals of the ICRP* 43(1).

UNSCEAR 1996. *Sources and Effects of Ionizing Radiation*. Report to the General Assembly with Scientific Annex, Annex: Effects of Radiation on the Environment, United Nations, New York.

UNSCEAR 2008. *Sources and Effects of Ionizing Radiation*. Report to the General Assembly with Scientific Annexes, Annex E: Effects of Ionizing Radiation on Non-Human Biota, United Nations, New York.