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What enables regulatory capacity building in the closure of Ranger uranium mine in northern Australia?

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Abstract

This paper outlines the Australian Government Supervising Scientist's unique role that enables regulatory capacity building in mine closure.

The position of the Supervising Scientist was established under the Environment Protection (Alligator Rivers Region) Act 1978 to ensure the protection of the Alligator Rivers Region (ARR) in northern Australia from the impacts of uranium mining. This includes Ranger uranium mine, which is surrounded by Kakadu National Park and is in the process of rehabilitation and closure. Under the Act, the Supervising Scientist is set up as an independent expert advisor to the Australian and Northern Territory ministers for Resources and their regulatory agencies. In addition, Ranger's mining licence requires that the regulator and the ministers seek advice from the Supervising Scientist before making a decision.

To provide expert advice, the Supervising Scientist is supported by staff at the Office of the Supervising Scientist (OSS), which consists of subject matter experts relevant to uranium mining, regulation, rehabilitation and mine closure. The research arm of the OSS undertakes independent environmental monitoring and research and develops standards and practices for environmental protection. The supervision arm executes a regulatory oversight program in collaboration with the Northern Territory regulator and representatives of the First Nations people (i.e. the Traditional Owners of the land).

To ensure the best science is delivered, the legislation establishes an independent committee of national experts (Alligator Rivers Region Technical Committee) that guides the OSS's and Ranger mine operator's research. The legislation also establishes a forum for community liaison and engagement (Alligator Rivers Region Advisory Committee). The forum drives the OSS's accountability to the public, ensures public disclosure of the environmental performance of mines in the ARR and provides transparency in the regulatory process.

For over 40 years the work of the Supervising Scientist has helped to ensure that the environment, including Kakadu National Park and the land of the First Nations people, has been protected from the impacts of uranium mining.

Keywords: *regulation, capacity building, uranium mining, rehabilitation, mine closure, environmental protection*

1 Introduction

Rehabilitating a mine is often very complex. Technical challenges across a large range of environmental and engineering disciplines, as well as social and cultural demands, need to be addressed to achieve a successful outcome: mine closure.

A problem for regulators is how to make informed decisions amongst these complexities. It takes interdisciplinary oversight and long-term knowledge of the site and its environments, but also a good understanding of the significance of each technical issue in the bigger picture. While advice from subject matter experts is essential, it is generally only focused on specific technical challenges. In addition, mining

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companies are at risk of losing valuable corporate knowledge during rehabilitation and closure. Different skill sets are required during the various closure phases from those needed during operations. Often there are also changes to how the work is undertaken; for example, adopting a contractor model to undertake the rehabilitation.

This paper outlines the Australian Government Supervising Scientist's unique position and set up that enables capacity building and ultimately informed decisions by the regulator in the rehabilitation and closure of uranium mines in northern Australia.

2 Background

The unique position of the Supervising Scientist has its origin in the history of uranium policies in Australia. Initial uranium mining in the Northern Territory (NT) in the 1950s and 1960s generated little public controversy (O'Faircheallaigh et al. 1989). However, opposition from the public and local First Nations people grew in the 1970s (Graetz 2014; O'Brien 2003), prompting Australian governments keen to develop the resource to commission an environmental inquiry into the development of the Ranger uranium deposits (Commonwealth of Australia 1977).

The inquiry found that many of Australia's richest uranium bodies were in the Alligator Rivers Region (ARR) in northern Australia (Figure 1), on land owned and occupied by Aboriginal people regarded as being among the most 'traditional' in Australia. The inquiry also identified the area's biodiversity and archaeological values as significant for Australia (Commonwealth of Australia 1977).

Based on the outcomes of this environmental inquiry, Ranger uranium mine (Ranger) was approved with a range of safeguards implemented to minimise risks to the environment. These included the establishment of Kakadu National Park in the area surrounding Ranger and a legislative framework including the *Environment Protection (Alligator Rivers Region) Act 1978* (Commonwealth of Australia 1978), which established the Supervising Scientist (see Sections 3 and 4). Shortly afterwards, the entire Kakadu National Park was listed as a Ramsar wetland in 1980 (Ramsar 2011) and became a UNESCO World Heritage Site in 1981 (UNESCO World Heritage Convention n.d.), recognising its exceptional natural and cultural values.

Ranger operated as an open cut mine from 1980 to 2021, producing more than 132,000 tonnes of uranium oxide (Environmental Resources of Australia [ERA] 2024). Rehabilitation planning and revegetation trials started in the 1990s. Since 2018 the mine operator is required to outline all closure and rehabilitation activities in the Ranger Mine closure plan (RMCP), which is updated annually. According to the 2024 RMCP (ERA 2024), rehabilitation works are expected to be completed by 2035. This would be followed by a 25-year monitoring and maintenance phase with progressive relinquishment (close-out) achieved by 2060.

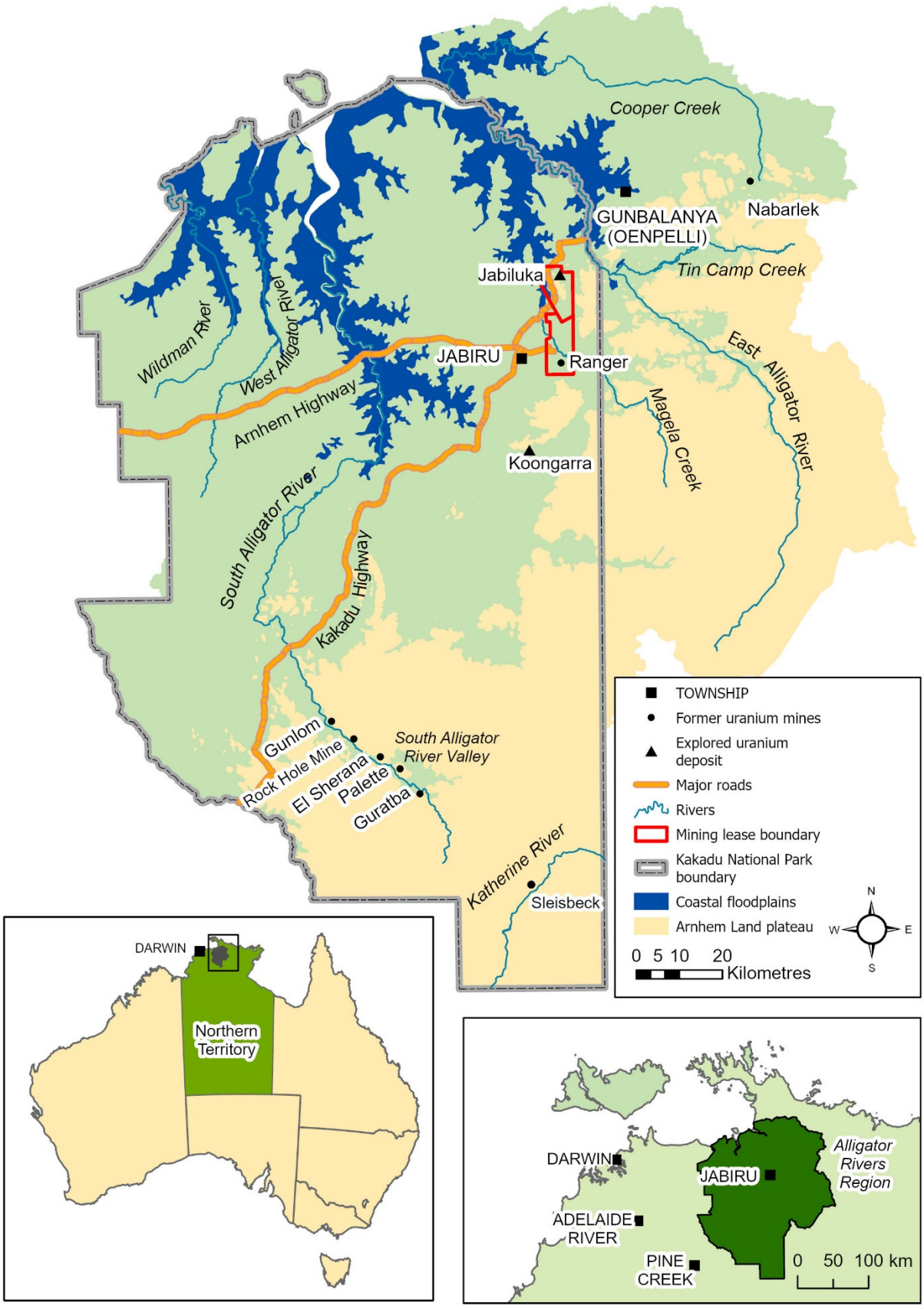

Figure 1 **The Alligator Rivers Region in northern Australia showing all current and former uranium mines, and the explored uranium deposits Jabiluka and Koongarra which have/had mineral titles but were not mined**

3 Legislative framework

In the early years of the Cold War, the Commonwealth of Australia (Australia's name in the constitution) established the *Atomic Energy Act 1953* (AE Act) (Commonwealth of Australia 1953) to ensure the proper regulation and management of all things related to atomic energy in the NT, which did not have its own government at the time and is still not a fully recognised state in Australia.

Under the AE Act, the Commonwealth of Australia owns all "prescribed substances capable of being used for the production of atomic energy" (e.g. uranium deposits) in Australian territories (but not the Australian states) and grants authorities for companies to mine them. Specific 'environmental requirements' are attached to these authorities, which set the environmental standards for operation, rehabilitation and closure of the mine. For example, Ranger's environmental requirements stipulate that the uranium mine be rehabilitated to a standard that, in the opinion of the Australian minister for Resources and with the advice of the Supervising Scientist, enables it to be incorporated into the surrounding World Heritage listed Kakadu National Park.

In addition to the AE Act, the Commonwealth of Australia established the *Environment Protection (Alligator Rivers Region) Act 1978* (EPARR Act) (Commonwealth of Australia 1978). This Act established the position of the Supervising Scientist in 1978 to provide independent oversight of uranium mining activities in the ARR of the NT. The EPARR Act also established the Environmental Research Institute of the Supervising Scientist (ERISS), the Alligator Rivers Region Technical Committee (ARRTC) and the Alligator Rivers Region Advisory Committee (ARRAC) (see Section 4 for further details).

The Australian Government entered into agreements with the NT Government which define the principles in relation to the regulation of uranium mining in the NT and each party's roles and responsibilities in this regard. Under the agreements, the day-to-day regulatory powers over environmental aspects of uranium mining are delegated to the NT Government and given effect under the NT's *Environment Protection Act 2019* (Government of the Northern Territory 2019). However, the NT minister for Resources must seek and act in accordance with the advice of the Supervising Scientist. Should the NT minister wish to act against this advice, the NT minister must notify the Supervising Scientist, who may elect to refer the matter to the Australian minister for Resources. In that case, the NT minister must wait for, and act in accordance with, the advice received from the Australian minister.

In the NT, access to land owned by First Nations people (Traditional Owners), and permissions to explore and mine that land, are managed by Aboriginal Land Councils and are regulated through the Australian *Aboriginal Land Rights (Northern Territory) Act 1976* (Commonwealth of Australia 1976). For Ranger, the Northern Land Council works closely with the Gundjeihmi Aboriginal Corporation, a representative body of the Mirarr Traditional Owners of the land on which Ranger is located.

An overview of the regulatory framework of the rehabilitation and closure of Ranger uranium mine is provided in Figure 2.

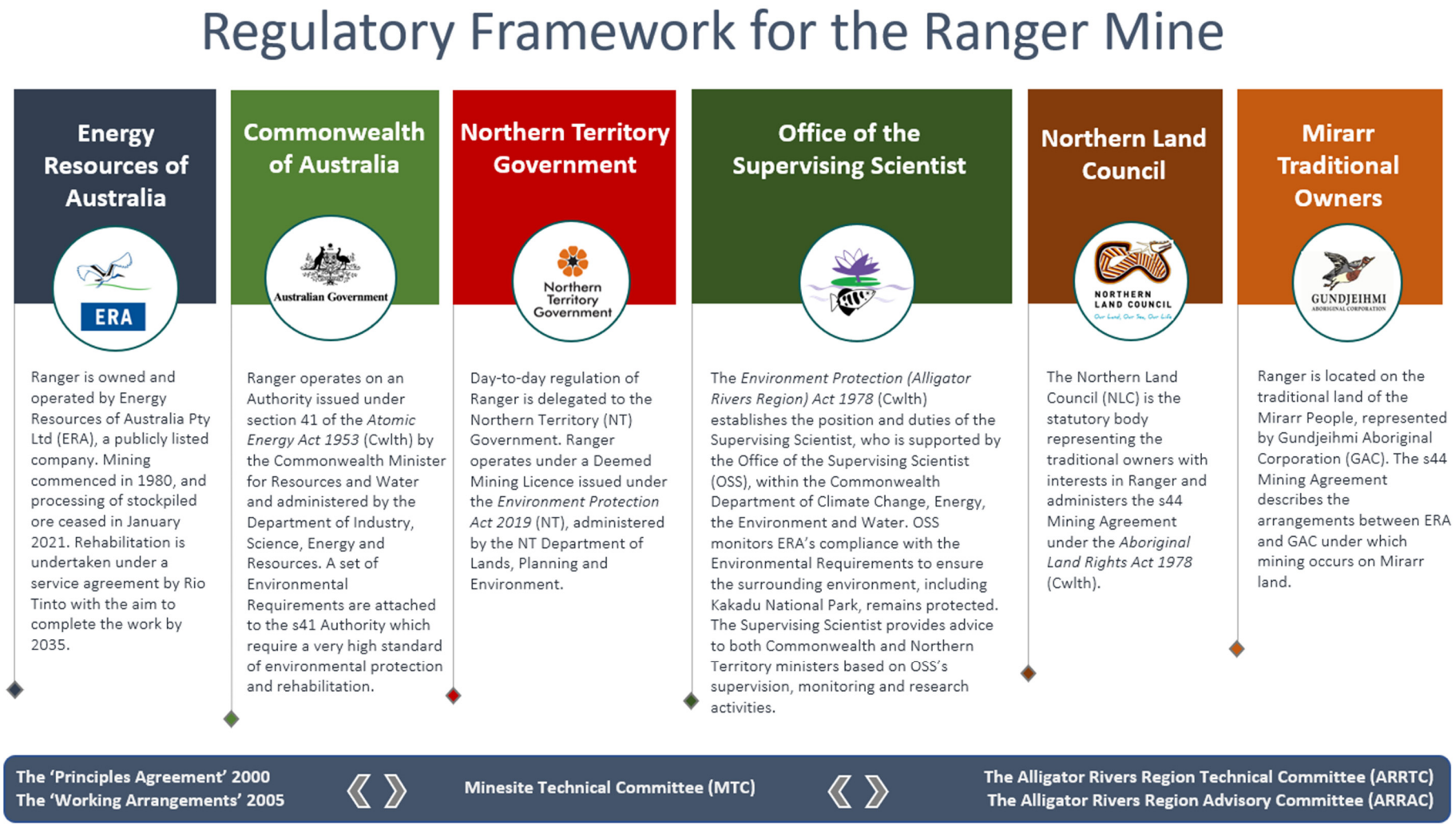

Figure 2 The regulatory framework of the rehabilitation and closure of Ranger uranium mine

4 The Supervising Scientist

As outlined in Section 3, the position of the Supervising Scientist was established under the EPARR Act in 1978 in response to a recommendation of the Ranger Uranium Environmental Inquiry final report (Commonwealth of Australia 1977) to ensure the protection and the restoration of the environment of the ARR in northern Australia from the impacts of uranium mining. This includes the Ranger uranium mine, which is surrounded by Kakadu National Park and is in the process of rehabilitation and closure (Figure 1).

Under the EPARR Act, the Supervising Scientist is set up as an independent expert advisor to the Australian and NT ministers for Resources and their regulatory agencies. In addition, Ranger's mining licence requires the regulator and the ministers to seek advice from the Supervising Scientist before making a decision.

The Supervising Scientist is supported by the Office of the Supervising Scientist (OSS) which sits within the Australian Department of Climate Change, Energy, the Environment and Water (Figure 3). The OSS consists of the ERISS and the Supervision and Assessment arms (Department of Climate Change, Energy, the Environment and Water [DCCEEW] 2025). The OSS's key functions are supervision, research, monitoring, public assurance and regulatory advice. Staff at the OSS are subject matter experts relevant to uranium mining, and mine regulation, rehabilitation and closure.

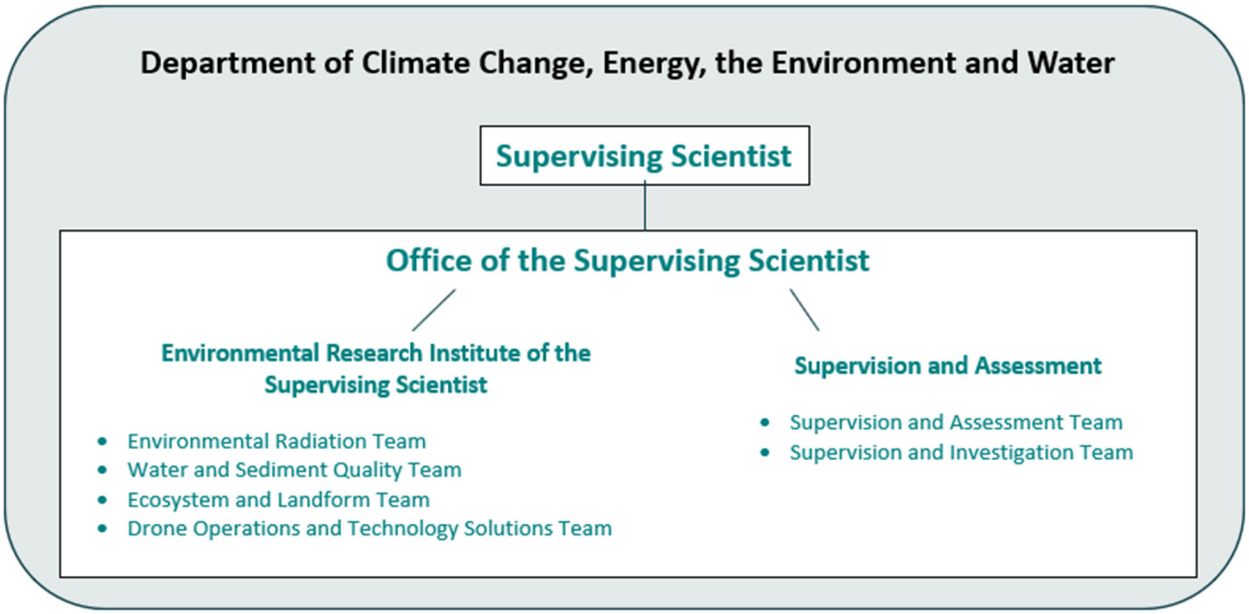

Figure 3 Organisational structure supporting the Supervising Scientist

4.1 Environmental Research Institute of the Supervising Scientist

The ERISS, the OSS's research arm, is a statutory research institute under the EPARR Act. It is tasked with providing scientific evidence and advice to inform and improve mine site rehabilitation and closure. ERISS undertakes independent environmental monitoring and research and develops standards and practices for the protection of the environment and ARR people from the effects of uranium mining.

Environmental research programs are managed by nationally and internationally recognised experts at the forefront of scientific research in the wet-dry tropics. Areas of expertise include radioecology, aquatic ecology, ecotoxicology, ecological risk assessment, ecosystem restoration, geomorphology, landform modelling and spatial sciences.

Research programs include:

- laboratory ecotoxicology and field-based bio-assessments to establish site-specific water and sediment quality guideline values

- development of effective monitoring methods to measure rehabilitation and ecosystem restoration success, ranging from eDNA and artificial intelligence to remote sensing using satellite imagery and aerial/aquatic drones
- monitoring of radioactivity in Aboriginal bush foods, surface water and in the atmosphere (dust, radon) using specialist radiochemistry, and alpha and gamma spectrometry measurement methods developed in-house.

Potential environmental impacts from mining and rehabilitation are assessed through early detection monitoring and long-term ecosystem-level response monitoring. For aquatic ecosystem monitoring, methods range from water quality analysis and bioaccumulation measurements in freshwater mussels to monitoring of long-term responses in benthic macroinvertebrates and fish communities.

ERISS's scientific experts regularly attend conferences and webinars and are active members of professional affiliations intended to build capacities in the scientific fields required to close Ranger mine. The ERISS radiation experts also participate in technical programs coordinated by the International Atomic Energy Agency to maintain proficiency with world's best practice standards in radiation management and radiation dose assessment methodologies.

4.2 Supervision and assessment

The Supervision and Assessment arm of the OSS supports the Supervising Scientist in the oversight of the regulation of uranium mining and exploration activities in the ARR. This includes:

- assessment of mine rehabilitation/closure plans, reports and applications made under the NT EP Act
- monthly site inspections and an annual environmental audit of Ranger's rehabilitation activities
- site inspections and environmental audits of active and rehabilitated mining and exploration sites throughout the ARR
- investigation of environmental incidents
- verification that major rehabilitation activities have been completed in accordance with approval conditions
- participation in stakeholder consultative forums.

All site inspections and audits are undertaken in collaboration with the NT regulator and representatives of the Traditional Owners of the land. Relevant ERISS subject matter experts also accompany the inspections and audits.

The Supervision and Assessment team plays a key role in integrating the scientific outcomes of ERISS into the regulation of mine closure. To be able to do so, recruitment of team members focuses on those with tertiary qualifications in relevant science disciplines such as aquatic ecology, environmental chemistry, hydrogeology and ecosystem restoration. All team members must have capabilities in regulatory skills such as auditing, radiation safety, incident investigations and environmental impact assessment, with respective training supported by the OSS. Supervision and Assessment team members are also supported to further develop their respective scientific expertise; for example, through conferences, courses and additional tertiary studies.

4.3 Accountability to deliver best science

The ERISS's research is peer reviewed biannually by the ARRTC, an independent scientific advisory panel. The ARRTC consists of leading experts in fields relevant to the ERISS's current research and who report directly to the Australian Minister for the Environment.

The ARRTC is a statutory technical committee under the EPARR Act. Its membership, structure and functions were revised in 2001 in response to recommendations from an Independent Science Panel established by the World Heritage Committee.

In addition to the ARRTC's peer review, research findings are regularly published in peer-reviewed scientific journals (e.g. Doering et al. 2017; Hancock et al. 2017) and as reports to stakeholders (DCCEEW 2025), and presented at conferences (e.g. Humphrey et al. 2012)

4.4 Accountability to the public

The ARRAC is established under the EPARR Act to provide a forum for community liaison and engagement on uranium mining activities in the ARR. ARRAC members include representatives of government and regulatory bodies, First Nations people, Kakadu National Park, relevant community stakeholders such as environment organisations, and mining companies involved in uranium mining and exploration in the ARR.

Public disclosure of environmental performance through the ARRAC is an important means of ensuring transparency in the regulatory process. The ARRAC also assists in providing assurance to the broader community that the ARR environment (including the World Heritage listed Kakadu National Park) remains protected from uranium mining impacts.

At each meeting, members including the Supervising Scientist provide reports and presentations such as operational updates from uranium exploration, mining and rehabilitation/closure activities, reviews of monitoring, audit and assessment programs, and any other topics of relevance to the committee.

Outcomes of the OSS's work are made publicly available on the Supervising Scientist's webpage (DCCEEW n.d.), including monitoring data, assessment reports, rehabilitation standards and annual reports.

4.5 Examples of the Supervising Scientist's and the Office of the Supervising Scientist's activities in the closure of Ranger uranium mine

The statutory roles of the Supervising Scientist and the OSS (see Sections 4.1 and 4.2), combined with the statutory scientific and public committees ARRAC and ARRTC (see Sections 4.3 and 4.4), provide a holistic framework for oversight of the Ranger mine closure. Examples of how this framework applies in the closure of this mine are outlined in this Section.

4.5.1 Key knowledge needs

Key knowledge needs (KKNs) for the closure of Ranger mine were identified and developed in 2014–15 in consultation with stakeholders (including the ARRTC and mine operator) via an ecological risk assessment process. The KKNs span a range of environmental aspects (e.g. water quality, radiation, ecosystem restoration, landform stability) and represent the information gaps needing to be addressed to inform scientifically robust assessments against closure criteria and the environmental requirements. The KKNs underpin the ERISS's and operator's research programs. Research outcomes against the KKNs are presented to, and reviewed by, the ARRTC biannually.

4.5.2 Rehabilitation standards

The OSS developed rehabilitation standards for Ranger mine in 2018 as a precursor to the development of closure criteria by the mine operator. The standards drew upon 40 years of research by the ERISS and international best practice to provide quantitative benchmarks that reflected the protection objectives of the environmental requirements. While non-binding, the benchmarks provided in the rehabilitation standards are now largely incorporated into the closure criteria of the mine operator, which are given regulatory effect through ministerial approval of the Ranger mine closure plan.

4.5.3 Assessment of closure activities

The Supervision and Assessment arm of OSS facilitates the assessment of Ranger's closure activities, which are outlined in the annual Ranger Mine closure plans and in separate applications for larger and more complex activities (i.e. backfilling of Pit 3). Respective subject matter experts within OSS are highly involved in the assessment and external subject matter experts are consulted as required. Assessment outcomes are

compiled in a publicly available report (DCCEEW 2025) and presented to ARRAC. Significant gaps and inadequacies are identified in recommendations to the Australian and NT Government ministers for consideration in their approvals. The recommendations and associated activities are discussed with the operator via technical working groups and tracked to completion by the OSS through various pathways such as monthly periodic inspections, regulatory and technical forums, verification programs (e.g. for the backfilling of Pit 3) and annual environmental audits by stakeholders. Stakeholders have the opportunity to be involved in these activities and are kept up to date via the biannual ARRAC meetings.

5 Conclusion

As outlined in this paper, the primary driver for regulatory capacity building is the Supervising Scientist's unique statutory role and functions as embedded in legislation and agreements. As an independent expert advisor to the respective Australian and Northern Territory ministers for Resources and their regulatory agencies, the Office of the Supervising Scientist (OSS) conducts environmental monitoring, research, assessment and supervision of the Ranger uranium mine closure.

Other drivers for capacity building are two statutory committees which hold the Supervising Scientist and staff at the OSS accountable for delivering best science and to ensure transparency of the OSS's work to stakeholders such as First Nations people and the community.

The legislative framework was designed to ensure the regulatory system continues to assure the protection of the Alligator Rivers Region environment during the rehabilitation phase and provide confidence that long-term predictions of environmental risks (such as water quality) are reliable in informing regulatory decision-making.

For over 40 years, the work of the Supervising Scientist has helped ensure that the environment, including Kakadu National Park and the land of First Nations people, has been protected from the impacts of uranium mining.

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