ERA Energy Resources of Australia Ltd

Executive summary

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Cover photograph: Yellow Oriole (*Oriolus flavocinctus*) on Trial Landform

EXECUTIVE SUMMARY

The following Executive Summary is a brief overview of the content of the main body of the 2020 Ranger Mine Closure Plan. For further detail, please refer to the appropriate sections of the main document.

1 SCOPE AND PURPOSE

This Mine Closure Plan (MCP) is prepared by Energy Resources of Australia Ltd (ERA) to meet its Northern Territory (NT) and Commonwealth regulatory obligations and conditions, as described below. The MCP is prepared for the Commonwealth Minister for Resources, Water and Northern Australia and the Northern Territory Minister for Mining and Industry to meet Annex B.2 of the Ranger Authority. This MCP is an update to the 2019 MCP, issued on 1 October 2019.

The MCP represents the updated Ranger Mine closure strategy following further studies and on-the-ground experience in the past 12 months. The 2019 MCP was prepared after the finalisation of the closure Feasibility Study for the rehabilitation of the Ranger Project Area (RPA) (Feasibility Study) in 2018. ERA, supported by an experienced engineering service provider, undertook the Feasibility Study to further refine scheduled rehabilitation activities and plans. This Feasibility Study, which developed the technical, costing and scheduling aspects of Ranger Mine closure to a very high level of detail, was subject to scrutiny during multiple internal and external reviews.

The 2020 MCP is an update of the studies and closure planning from the 12 month period from 1 July 2019 to 30 June 2020. As well as providing a concise description of the closure strategy, this MCP includes an overview of the rationale and knowledge base used for the development of the document. It must be acknowledged that further studies and works are ongoing, and that these will be utilised to further develop the annual updates of the plan.

A result of a variation to the Authorisation (0108), issued on 22 June 2018, is the requirement for the MCP to be reviewed and updated annually with submission to the Commonwealth Minister and the NT Minister due on or before 1 October each year. The variation details the process for submission and assessment of the MCP (also referred to as a ‘rehabilitation plan’) in accordance with section 34 of the *Mining Management Act*.

The 2019 MCP was subject to stakeholder review and the detailed feedback has been considered for the preparation of this document. ERA has prepared a detailed response to stakeholder feedback on the 2019 Ranger MCP (Appendix A). In reviewing this 2020 MCP submission, stakeholders are requested to use the form provided in Appendix 1.1 for feedback for consideration in the next annual review process.

This MCP has been prepared with reference to the Western Australian Guidelines for Preparing Mine Closure Plans (the WA Guidelines) (DMIRS 2020)[2]. The WA Guidelines outline a general mine closure planning process and document structure for the MCP. ERA has followed this mine closure planning process throughout its operation and addresses each component of this process in detail throughout this MCP. The structure of the 2020 MCP was modified to align with the updated WA Guidelines and improve narrative flow.

The changes of content that have occurred in the 2020 MCP, compared to the 2019 version, are outlined in the table at the front of this document. The changes are either due to:

- provision of new information obtained through findings over the past 12 months (1 July 2019 to 30 June 2020)
- improvement in narrative flow of the document
- updated figures
- alignment with the 2020 WA Guidelines

It is intended that the 2021 update will follow the same format as 2020, but with updates to sections where new information has been obtained.

Figure ES- 1: Ranger Mine site (August 2020)

[2] Clause B6 of the Ranger Authorisation 0108-18 requires that the MCP must be prepared in accordance with mine closure guidelines accepted by the Commonwealth Minister. The currently adopted guidelines are the Western Australian (WA) mine closure guidelines.

2 PROJECT OVERVIEW

The Ranger uranium mine (Ranger Mine) is located within the Ranger Project Area (RPA) adjacent to Jabiru, approximately 260 km east of Darwin in the Alligator Rivers Region of the NT (Figure ES- 2). The RPA is surrounded by Kakadu National Park (NP) and is bounded on the east and north by Magela Creek and its tributaries, and on the west by Gulungul Creek and its tributaries. Access to the mine is via the Arnhem Highway (Figure ES- 3).

ERA has operated the Ranger Mine since the commencement of operations in 1980. ERA has provided international customers with reliable supply of uranium oxide in the 38 years since production at Ranger Mine began. Ranger Mine has produced in excess of 130,000 tonnes of uranium (ERA 2020) to meet the world uranium demand for fuelling nuclear power plants. ERA production is supplied to power utilities in Asia, Europe and North America in accordance with strict international and Australian safeguards. The ERA shares are publicly held and traded on the Australian Securities Exchange, with Rio Tinto, a diversified resources group, currently holding 86.3 per cent of ERA shares.

The initial discovery of the Ranger Mine deposits was made in October 1969 by an exploration joint venture between Peko-Wallsend Operations Limited (Peko) and Electrolytic Zinc Company of Australasia Ltd through aerial radiometric survey. ERA was established in February 1980 as the operator of the Ranger Mine.

The Commonwealth Government announced approval of the project under the, now repealed, Commonwealth *Environmental Protection (Impact of Proposal) Act 1974* (*EPIP Act*) in August 1977, following submission of an Environmental Impact Statement (EIS) and associated supplements under this Act. Construction of the Ranger Mine began in January 1979 and the mine came into full production in October 1981.

During the same period, much of the Alligator Rivers Region was declared a National Park and Aboriginal people were given a major role in the Kakadu NP management. The Commonwealth Government introduced laws covering the Alligator Rivers Region (*Commonwealth Environment Protection (Alligator Rivers Region) Act 1978*) and established several research bodies and committees to overview the environmental regulation of mining in the region. These included the Supervising Scientist and the Environmental Research Institute of the Supervising Scientist (ERISS), the Alligator Rivers Region Advisory Committee (ARRAC) and the Alligator Rivers Region Technical Committee (ARRTC).[3] In 1978, title to the RPA was granted to the Kakadu Aboriginal Land Trust, in accordance with the Commonwealth *Aboriginal Land Rights (Northern Territory) Act 1976* (*Aboriginal Land Rights Act*) and the Commonwealth Government entered an agreement with the Northern Land Council to permit mining to proceed.

[3] The functions of these committees and research bodies are described further in Section 4.

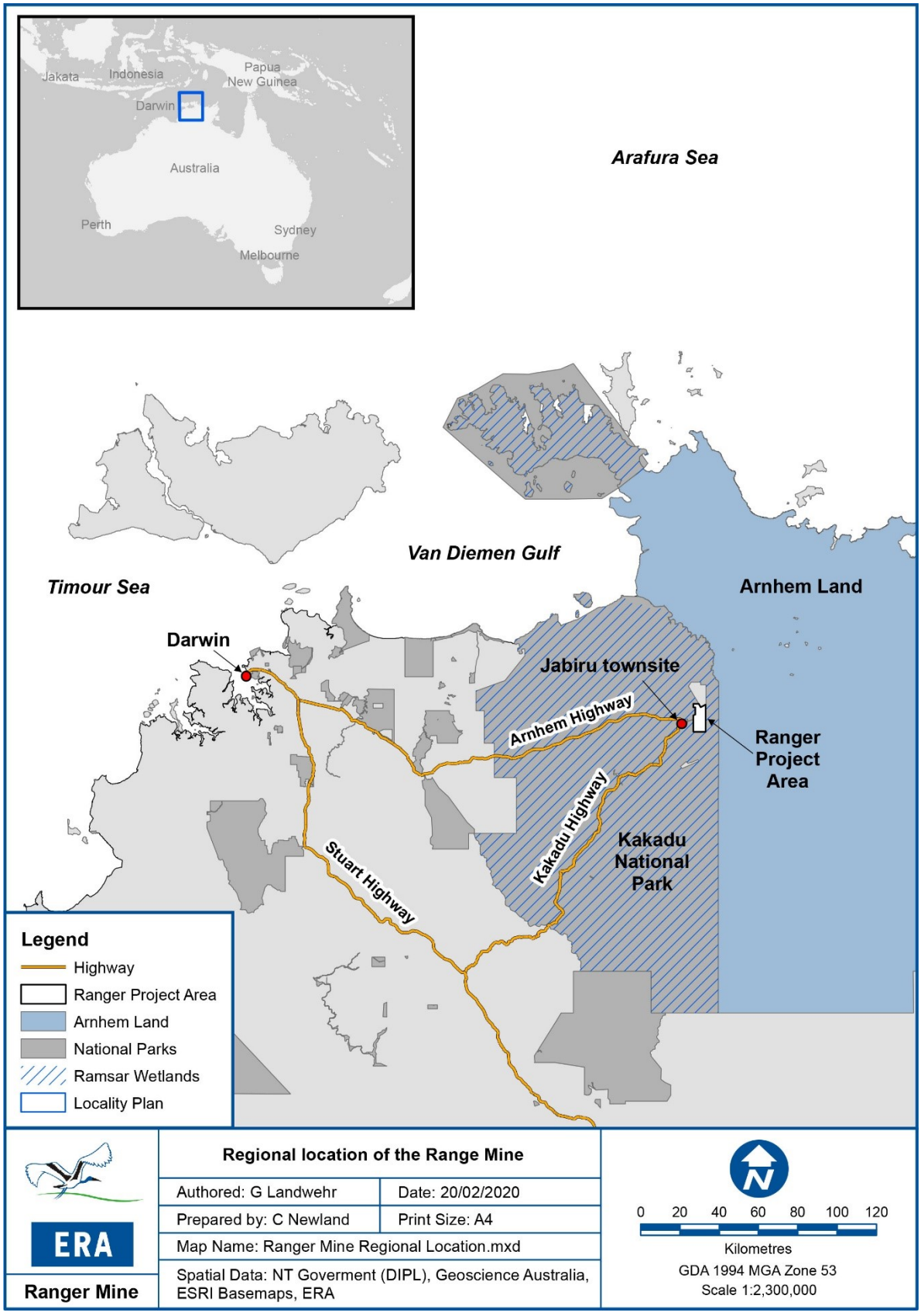

Figure ES- 2: Regional location of Ranger Project Area

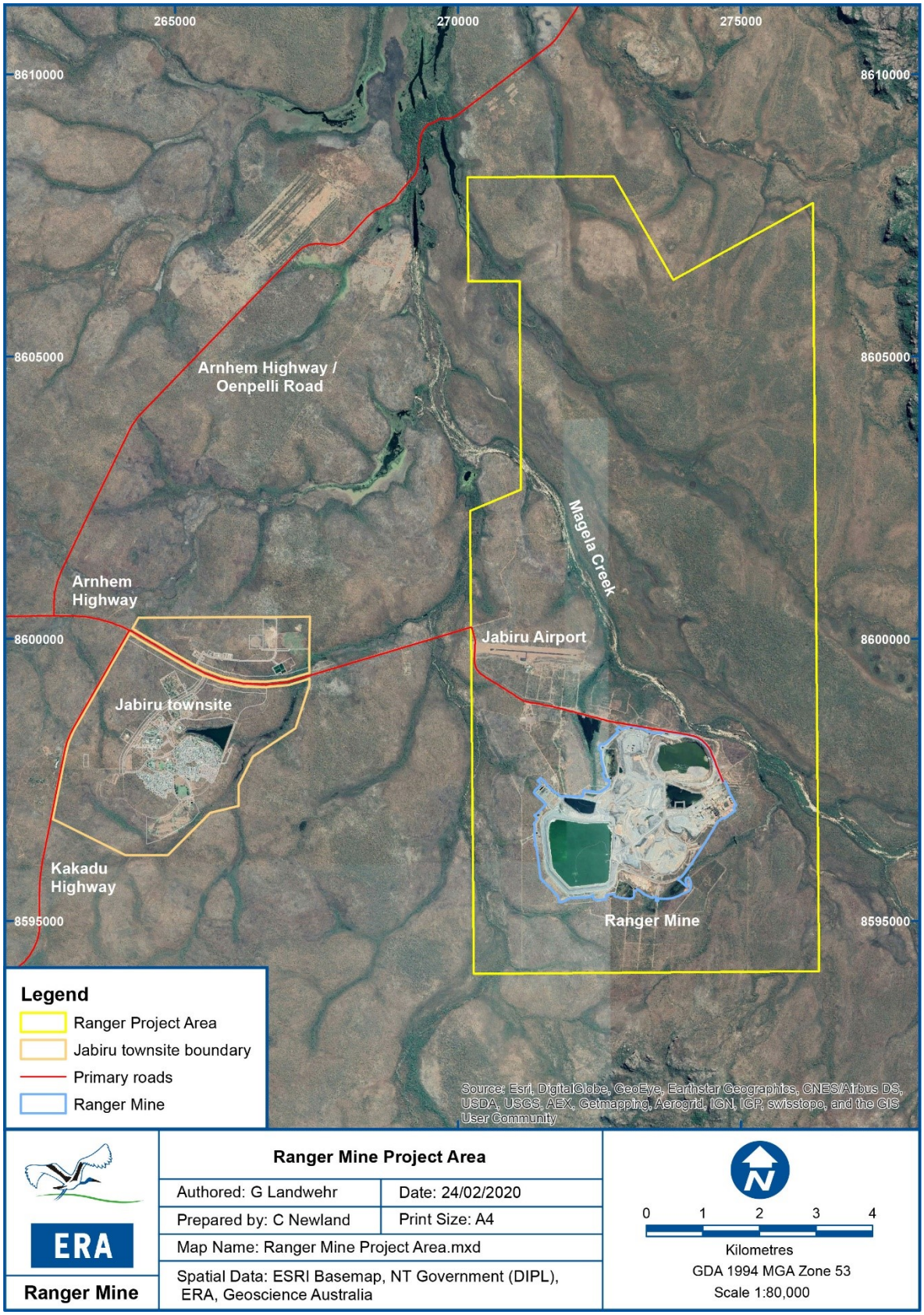

Figure ES- 3: Ranger Mine Project Area

Mining of Pit 1 finished in December 1994. During that time, 19.78 million tonnes of uranium ore was mined. Mining from Pit 3 commenced in July 1997 and concluded in November 2012. Since mining finished in Pit 3, ERA has produced uranium oxide from stockpiled ore.

The processing of stockpiled ore will continue during the operations phase through the Ranger Mine processing plant, where uranium is leached from the ore using sulfuric acid. The uranium is then purified, concentrated, precipitated, calcined (dried), placed into drums and exported. Components of the mining and processing operations include:

- processing area including a power station (which also provides power to the town of Jabiru), administration and maintenance facilities
- Ranger 3 Deeps (R3D) exploration decline
- a tailings storage facility (TSF) (historically referred to as the 'tailings dam')
- two mined-out pits – Pit 1 and Pit 3
- ore and waste rock stockpiles
- several water retention ponds, water storage structures and constructed wetland filters
- water treatment plants (WTPs)
- irrigation areas for the disposal of managed release water
- an access road and service tracks
- Jabiru Airport, Jabiru East and associated infrastructure.

Water management is the most significant environmental and operational aspect of the Ranger Mine and is an integral part of the ERA Health, Safety and Environment Management System. It encompasses all aspects of water capture, storage, supply, distribution, use and disposal. The water management facilities within the RPA include:

- retention ponds
- water treatment ponds
- wetland filters
- Land Application Areas
- High Density Sludge plant
- Brine Concentrator (BC)
- Brine Squeezer.

Water is managed according to the Ranger Water Management Plan (RWMP), which describes the method used to control water on site. The RWMP fulfils the requirements of the Ranger Authorisation (0108-18) and is approved annually by regulators.

Water management and closure planning at the Ranger Mine has been supported since 2006 by a dynamic water and solute balance model. The model considers the characteristics, connectivity and operational rules associated with the material elements of the process and pond water circuits at the Ranger Mine, and the planned changes to the nature of those elements through to 2026.

3 CLOSURE OBLIGATIONS AND COMMITMENTS

Closure of the Ranger Mine is governed by both Commonwealth and NT legislation and regulations. The key instrument that governs operations at the Ranger Mine on a day-to-day basis is the Ranger Authorisation, issued under the NT *Mining Management Act 2018* (*Mining Management Act*). The main Commonwealth authority issued under section 41 of the *Atomic Energy Act 1953* (Cth) (*Atomic Energy Act*), provides the key tenure and land access approval required for the operations (the section 41 Authority).

Title to the RPA was granted to the Kakadu Aboriginal Land Trust in 1978, in accordance with the Commonwealth *Aboriginal Land Rights (Northern Territory) Act 1976* (*Aboriginal Land Rights Act*). Prior to the Commonwealth Minister approving the Ranger Mine, the Commonwealth Government entered the section 44 Agreement with the NLC under the *Aboriginal Land Rights Act*. The section 41 Authority (described above) was granted on 9 January 1979.

The Ranger Environmental Requirements (ERs) are appended to the section 41 Authority and set out environmental objectives which establish the principles by which the Ranger Mine operation is to be conducted, closed and rehabilitated and the standards that are to be achieved. The *Mining Management Act* also requires the Ranger Authorisation to incorporate, by reference, the ERs. The ERs were revised in 1999 to be inclusive of conditions relating to rehabilitation.

It is implicit that ERA will comply with all necessary legal obligations and uphold internal standards during closure to ensure the ongoing protection of the environmental values surrounding Kakadu NP; the health and safety of the community and preservation of cultural values. ERA is committed to protecting these values by implementing the required management controls.

The transition into closure will involve applying for regulatory approvals to authorise new requests or to modify the currently authorised activities that have the potential to result in an environmental impact to either intact or undisturbed areas of the RPA; or downstream and/or offsite. It is planned that no areas outside of the existing footprint will be disturbed during closure and, as such, no additional permits or approvals relating to land disturbance will be required. Permits for decommissioning works, post-closure and access approvals will be submitted to the relevant authority, as needed.

4 STAKEHOLDER ENGAGEMENT

ERA has a diverse and complex range of stakeholders. (The generic term “stakeholder” is used in this MCP to cover all interested and affected external parties, including Traditional Owners and regulatory agencies. It is noted that in other contexts Traditional Owners and regulators may be differentiated from the broader stakeholder groups). These stakeholders have interests in specific areas of the closure process or outcomes and/or in the more general closure objectives and successful achievement of the planned post-mining land use. The ERA approach to stakeholder engagement is focused on building enduring relationships based on mutual respect, active partnership, transparency and long-term commitment.

ERA representatives are in frequent, regular contact with the Gundjeihmi Aboriginal Corporation (GAC), NLC, Northern Territory Department of Industry, Tourism and Trade (DITT), Commonwealth Department of Industry, Science, Energy and Resources (DISER) and the Supervising Scientist Branch (SSB), both informally and formally through various stakeholder committees, including the Minesite Technical Committee (MTC). There are documented communications via forums including the Alligator River Regions Technical Committee (ARRTC) and the Alligator River Regions Advisory Committee (ARRAC), which date back to 2001. Public communication on aspects of mine rehabilitation and closure can be traced back to the first ERA annual report in 1981.

Throughout the life of the Ranger Mine, ERA has engaged, communicated and consulted with multiple stakeholder groups through various engagement activities and range from formal, often regulatory based, processes to informal consultative processes. This stakeholder consultation aims to both provide information and to seek feedback on closure plans.

5 KNOWLEDGE BASE AND SUPPORTING STUDIES

The baseline information provides an overview of the physical, environmental and social setting of the Ranger Mine, and provides the context to planning mine closure. The substantial dataset has been accumulated by ERA and regulators over more than 30 years of environmental, safety and health monitoring and research investigations of the site and surrounding environment.

The RPA is surrounded by Kakadu NP (Figure ES- 2). The Kakadu region has had at least 65,000 years of indigenous occupation, with increasing contact between the region's Aboriginal people and other cultures from around the 17th century and a more permanent non-indigenous presence evident from the late 1800s. Historical land use within the Alligator Rivers Region has included indigenous occupation, buffalo hunting, missions, pastoral grazing, agriculture, mining exploration, uranium mining and tourism. The RPA is within the Magela catchment, within the Alligator Rivers Region, and currently contains several land use types, including Kakadu NP, mining and native title lands. Kakadu NP is a World Heritage listed area and within a Ramsar wetland site (Figure ES- 2). Section 5.1 describes the social setting.

The description of the physical environment (Section 5.2) includes an overview of the RPA climate, land systems, surface water resources, groundwater and radiation. The description of the biological environment (Section 5.3) includes an overview of the bioregions, NPs and protected areas, terrestrial ecology and aquatic ecosystems which the RPA is sited within.

The climate of the Alligator Rivers Region, within which the Ranger Mine is located, is dominated by a seasonal wet-dry monsoon cycle with the large inter-annual and intra-seasonal variability largely associated with the effects of the El Niño Southern Oscillation, the Madden-Julian Oscillation and tropical cyclone activity. The wet season generally extends from late October to early April with predominantly westerly winds, whilst the dry season is dominated by easterly to south-easterly winds and extends from May to September.

Surface water management will be a key focus of rehabilitation and closure, as it is one of the pathways for constituents of potential concern (COPC) to enter the environment. The Ranger Mine is located within the 1,600 km^2 of the Magela catchment and adjacent to Magela Creek (Figure E- 4). Two tributaries of Magela Creek are also located in close proximity to the mine: Gulungul Creek to the west and Corridor Creek to the south. Magela Creek is a seasonally flowing tributary of the East Alligator River, with a catchment originating from headwaters on the Arnhem Land Plateau.

The tropical, monsoon climate of the NT creates seasonal changes that drive groundwater flow into and out of the Ranger Mine area (Section 5.2.7). Groundwater occurrence and flow through the RPA consists of a shallow groundwater flow system, within the relatively permeable alluvium and weathered rock, and a deeper bedrock groundwater flow system with relatively low permeability, in which groundwater is encountered within faulted, sheared, cracked and brecciated rocks[4]. Groundwater also occurs in intermediate layers of weathered bedrock between the shallow and deeper groundwater flow systems. The natural background hydrochemistry of groundwater of the RPA typically exhibits relatively low concentrations of total dissolved constituents.

There has been a substantial survey and monitoring of the terrestrial flora across the RPA over the past 15 years. In a 2013 survey of lowland riparian and woodland areas within the RPA, 292 flora species from 30 families were identified. These species are common in surrounding Kakadu NP and did not include any threatened or rare species. Approximately 1,600 terrestrial and aquatic flora species have been recorded in Kakadu, including 15 species considered rare or threatened. These conservation significant species have not been recorded within the RPA.

The RPA has been surveyed by ERA annually for weeds since 2003, and approximately 80 species have been recorded during this time. Weeds of National Significance (WoNS) are categorised under the Federal *EPBC Act.* Gamba Grass (*Andropogon gayanus*) is the only WoNS previously recorded in the RPA with the recorded presence restricted to isolated plants on roadsides or in the vicinity of the Jabiru Airport. With successful weed control, there has been no plants or viable seeds of this species detected for a number of years. A new weed to Australia, Indian Pinkroot (*Spigelia anthelmia*) was discovered onsite in April 2019 and an eradication program has been implemented.

[4] Brecciated means rock that has been mechanically broken by faulting and shearing, resulting in angular fragments

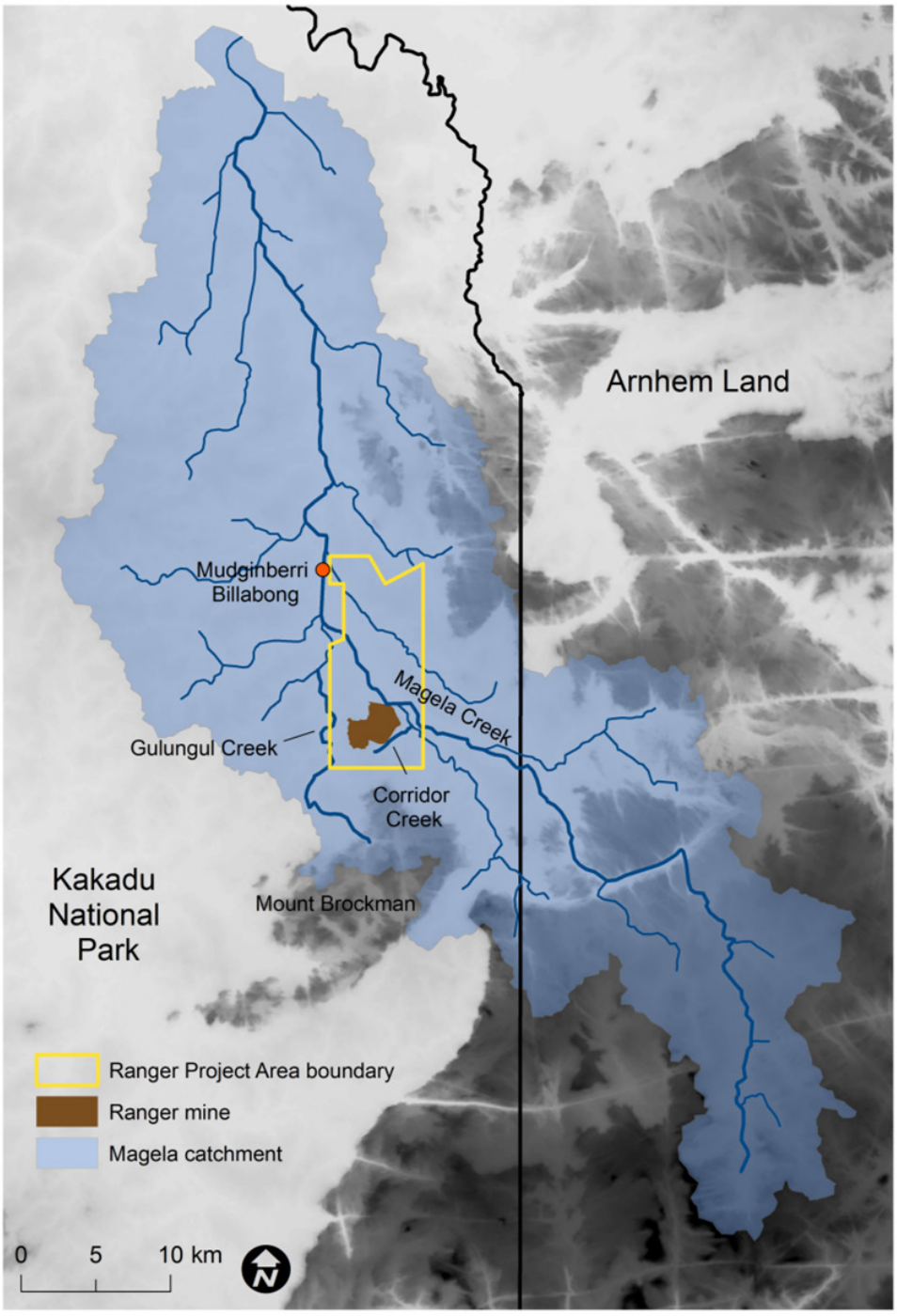

Figure E- 1 Regional extent of Magela catchment

A number of conservation significant fauna species (including a large number of mostly bird species listed under various migratory agreements) have been recorded on the RPA during previous surveys 4.3. The identified species include the conservation listed Northern Quoll *Dasyurus hallucatus* (Endangered; Critically Endangered) and the Partridge Pigeon *Geophaps*

smithii smithii (Vulnerable; Vulnerable) (the *EPBC Act* and *Territory Parks and Wildlife Conservation Act)*.

Fire within the RPA is managed by ERA for asset protection and weed control, and includes fuel reduction burns, excluding fire from certain areas and maintaining a network of graded firebreaks.

Studies and monitoring programs within the RPA have been conducted since before mining commenced. The outcomes of this substantive body of work have:

- informed the overarching closure strategy and approach
- informed the development of closure criteria
- informed strategies for closure implementation aligned to best environmental practice and the ERs
- informed identification and rank of closure risks to ensure the ongoing management of potentially high risks and an iterative approach to mine closure risk assessment
- informed the construction of a final landform
- provided baseline data against which to measure closure performance
- highlighted knowledge gaps and/or alternative options to previous elements of the closure strategy.

It is recognised that some projects have been finalised whilst others are ongoing. Further updates of the ongoing studies are provided in Section 5.5, Appendix 5.1 and in subsequent MCPs. The Key Knowledge Needs (KKNs) have been identified, by stakeholders and ERA, as the information gaps that are required to be addressed for the effective closure of the Ranger Mine. Both ERA and the SSB will implement KKN projects, either independently or cooperatively, depending upon the project.

A summary of the ERA closure-related technical and scientific studies are provided below (Table ES- 1).

Table ES- 1: Summary of supporting studies

Area of study	Summary of studies
Tailings	Comprehensive test work and characterisation of tailings has been undertaken on the Ranger Mine tailings, including *in situ* testing in both Pit 1 and Pit 3 since 2003. This large body of work has underpinned the development of a tailings consolidation model for Pit 1 and Pit 3. The Pit 1 model has been continually validated throughout the backfill of Pit 1 through a series of settlement plates installed at the commencement of backfill activities and provided a high level of confidence in the model. The consolidation model enables the prediction of final tailings elevations and expected process water volumes in Pit 1 and Pit 3. The model output includes density, permeability, void ratio and effective stress profiles at user defined times and cumulative consolidation flows to the surface and base.

Area of study	Summary of studies
	Validation and verification of the consolidation model using monthly tailings settlement readings in Pit 1 and *in situ* test data in Pit 3 demonstrates that the model is still valid. The validated model suggests that the target process water removal from the tailings in Pit 1 and Pit 3 will occur by January 2026. Another geotechnical investigation will be conducted in Pit 3 from September to November 2020, to verify the consolidation model and provide tailings parameters for the capping design. The investigation will comprise cone penetration tests with pore pressure measurements, pore pressure dissipation test, vane shear test, and ailings sampling and laboratory testing. After completion of tailings deposition into Pit 3, the tailings consolidation model will be updated then utilised for the settlement monitoring during the Pit 3 capping and bulk backfill period.
Groundwater	The 2016 Ranger Mine conceptual and numerical models for groundwater were updated in 2018 for use in assessment of potential impacts from post-closure conditions. The updated conceptual model describes the most important hydrogeologic elements governing groundwater flow and transport at the Ranger Mine. The calibrated groundwater flow model incorporates the major stresses applied to the Ranger groundwater flow system at Pit 1, Pit 3 and the TSF. All available spatial and temporal data was used to build and calibrate the flow model constrains the values of the model parameters and provides confidence gained through the calibration process. Development of the post-closure groundwater flow model consisted of modifying the calibrated groundwater flow model to represent backfill, landform conditions and the time scale of post-closure hydrogeologic conditions. The groundwater calibrated model will meet all indicators for a high confidence level after the planned peer review by an independent hydrogeologist with modelling experience is completed. The Ranger Mine conceptual modelling has been undertaken in part to support Key Knowledge Needs projects for groundwater and surface water. Updates to the post-closure solute transport modelling have commenced and include a number of supporting studies including an updated to the site source term model and the groundwater surface water interaction model. Updates to predictions of post-closure solute transport modelling will be provided in subsequent submissions of the MCP. *The Ranger Conceptual Model and solute transport areas of interest/concern* The Ranger Conceptual Model is an important tool for understanding groundwater and surface water flow and solute migration within and out from the Ranger Mine. Conceptual models were developed for the regional scale, sitewide scale, and the scale of individual areas of interest where the COPC sources are located. The Ranger Mine Conceptual Model provides an evidence based framework by which ERA can measure and implement decommissioning and closure activities to meet its environmental rehabilitation obligations. There are specific areas that are of interest/concern for COPC sources and migration within and from the Ranger Mine site, and smaller-scale conceptual models have been developed for each of these areas: • Pit 3 • Pit 1 • TSF • Processing plant area • LAAs • Ranger 3 Deeps • Landform waste rock.

Area of study	Summary of studies
	Pit 1 Solute Egress Modelling The Pit 1 solute egress model, updated in 2014, demonstrates that no detrimental impact to the surrounding environment will occur for at least 10,000 years due to tailings storage within the pit, as required under the Ranger Authorisation. Pit 3 Solute Transport Modelling Pit 3 solute transport modelling, both conceptual and numerical, was developed to assess the ability of the proposed Pit 3 backfill options to meet the ERs outlined in the Ranger Authorisation. Much of the data has been incorporated into the Ranger Mine Conceptual Model. The overall objective was to quantify the amounts and rates of groundwater COPCs transported from Pit 3 to Magela Creek over a 10,000-year period for closure scenarios, with and without mitigation features. The mitigation features evaluated include a low-permeability cap at the top of the shallow waste rock backfill, a low-permeability cap over the tailings, and a cut-off wall between Pit 3 and Magela Creek. The modelling identified that mitigation through the use of low-permeability caps was preferred over a cut-off wall. When reviewing the effectiveness of these caps in reducing solute loads to Magela Creek in the context of the overall site, the modelling predicted the caps only have a marginal impact on loads. The conceptual model demonstrates that these low-permeability caps will not be required. Other closure-related groundwater studies that have informed the Ranger Mine Conceptual Model include: • magnesium loading to Magela Creek from Pit 3 tailings – post-closure • extent and hydraulic properties of the MBL hydrolithologic zone near Pit 1 • effect of tailings deposition on flow from Pit 3 • hydrological conditions after halt of pumping in the Ranger 3 Deeps decline • predicting post-closure groundwater solute loading to creeks using uncertainty analysis • assessment of groundwater levels and quality in Sed2B bores • groundwater assessment in waste rock stockpiles • background COPCs in groundwater • aquatic ecosystem assessment & framework development
Surface water	The purpose of the surface water modelling is to refine the closure strategy and support the approvals required to rehabilitate the minesite by providing estimates of the concentrations of nominated COPCs in receiving surface waters over a period of 10,000 years following the rehabilitation of the mine. The area of interest is the Magela Creek catchment, from the rehabilitated minesite down to Mudginberri Billabong. An updated surface water model was developed in 2020 and included the following elements: • flow configuration and calibration • water quality configuration and calibration • derivation of site loadings and time series • preliminary simulations Five scenarios were simulated using the configured and calibrated model. The first modelled scenario is the case used for model calibration, referred to as the ‘No Mine’

Area of study	Summary of studies
	case as it represents just the loads from natural catchment sources, that is, no loads are included from the minesite. (This scenario has been included in the results to assist in understanding the results for the other four scenarios.) The other four scenarios are the selected four time horizons Year 1, 20, 270 and 10000. The groundwater loads input into this model were derived from the initial groundwater modelling described above. The results of these preliminary simulations are provided in Section 5.4.4. The model is currently undergoing further updates to address key stakeholder feedback, improvements identified through development of the model, and included updated post closure solute transport loadings predictions and the surface water to groundwater interaction model outcomes. Following completion of the update in late 2020, multiple projects, including assessments of sediment accumulation, human diet and health, ecosystem vulnerability, release water pathways and cumulative aquatic risks can be conducted to assess if water quality closure criteria/objectives will be met. This will include additional studies such as assessing the traditional diet, risks associated with the predicted water quality, and predictions of accumulation of uranium into sediments. This will also inform decisions on what is as low as reasonably achievable (ALARA) on the RPA.
Landform	The shape of the current final landform is largely determined by the requirement to maintain pre-mining drainage and catchment areas and to ensure stability in either current or the predicted climate/rainfall regime that will result from climate change. Initial landform development was based on landform design criteria developed by ERA through studies of a nearby natural analogue area. Topography of the final landform is similar to the pre-mining landform; maximum elevation after consolidation increases from 38 m pre-mining to a final landform maximum of 44 m Australian height datum (AHD). Slopes of the landform range in grade from approximately 2 percent to 5 percent. Analysis showed slopes vary from about 1 in 30 (3 %) to 1 in 200 (0.5 %), with the larger catchments tending to have lower slopes, although this is not always the case. The current version of the final landform is version 6 (FLv6). Each version of the landform has been subjected to landform evolution modelling by the SSB to assess the performance of the landform. The SSB uses a modified version of the CAESAR-Lisflood landform evaluation model to assess the stability of the final RPA landform over time frames ranging from decades to millennia. The model predicts both the locations of gully formation and the broad scale erosion and deposition across the landform with long-term denudation rates being calculated. The results show most of the deposition occurs in the first 100 years with erosion ongoing throughout the model. Denudation rates decrease over time and are found to approach the published background denudation rate for the region. Modelled denudation rates after 10,000 years provided by the SSB on FLv5 are: • Coonjimba: 0.05 mm per year • Corridor Creek: 0.03 mm per year • Djalkmara Creek: 0.02 mm per year, and • natural background: 0.01 – 0.04 mm per year. Modelling of FLv6 is ongoing, to date the SSB landform model simulations for extreme wet and extreme dry rainfall scenarios over the Corridor Creek catchment predict that gullies, which could potentially expose tailings, will not form across the surface of Pit 1 within a simulated period of up to 1,000 years. In mid-2019 ERA engaged a Rio Tinto hydrologist to build capacity in the assessment of closure landforms using the CAESER-Lisflood landform evolution

Area of study	Summary of studies
	modelling software. ERA is currently evaluating closure landforms and completing sensitivity testing of key model parameters including climate sequences, rainfall losses, particle size distribution and vegetation cover. This project has allowed for faster evaluation of landforms, and a better understanding of the modelling process and the implications for erosion outcomes dependent upon both landform design and parameter choice. Landform design is an iterative process; design of drainage channels and other erosion mitigations is ongoing to minimise the potential impact on landform stability and revegetation success. ERA's ongoing engagement with a Rio Tinto hydrologist will assist ERA in understanding whether incremental changes in landform design are achievable and/or beneficial, and to better provide input into the final evaluation of landform stability at closure (denudation and the formation of gullies).
Water & Sediment	*Background and operational surface water quality* Surface water and sediment quality monitoring at the Ranger Mine and surrounding environment has occurred for several decades, providing significant information on surface water and sediment quality within the creeks and billabongs. Several studies describe the background conditions in billabongs and creeks in the Magela Creek catchment. Surface water monitoring over 30 years indicates that at the end of the wet season, upstream of Ranger Mine, waters have elevated magnesium and EC levels which are not related to mining. Downstream of the Ranger Mine there is a general trend of relatively constant magnesium concentration and salinity. The SSB's integrated monitoring programs have been developed over nearly 30 years and are leading practice. The 30 years of multiple lines of evidence show that during the operational phase, the mine derived COPCs (including magnesium, uranium, manganese and radium-226) have not adversely affected the abundance or diversity of aquatic organisms downstream of Ranger Mine. Background COPCs in groundwater require characterisation in order to identify the natural range in concentrations in different HLUs across the site. The background COPCs in groundwater project was completed in June 2020. This included the development of interactive html dashboards allowing for full interrogation of the dataset and statistical analysis undertaken to develop the background threshold values. This data will inform the modelling of post-closure solute transport, solute source Area / Concentration conceptual model and the modelling of surface water. *Aquatic sediments* Aquatic sediment sampling is required to understand any potential ecological impacts related to mine contaminated sediments. This will inform ALARA-BPT assessments which in turn inform the decommissioning requirements for onsite waterbodies. A sampling and analyses program based on leading practice and a review of historical data from earlier investigations of billabong sediments was trialled in 2015 and implemented and refined in 2016. These results demonstrated that there has been no sediment contamination in off-site billabongs as a result of mining. Given the improved water quality leaving the minesite in recent years the risk of sediment contamination off the RPA occurring now is negligible. Metal contamination of onsite billabongs has not increased in recent years and the formation of acid sulfate soils (ASS) is now the recognised priority hazard to sediments in water bodies on the RPA. Therefore, the focus has now shifted away from routine monitoring of on and off-site sediments to a targeted program to understand the ASS issues. A preliminary site wide ASS conceptual model has been developed, based on a collation and review of historical topography, groundwater and surface water data,

Area of study	Summary of studies
	and existing soil and sediment sampling result. The objective of the model is to further understand: • source dynamics of ASS formation at the site • mechanisms of potential ASS exposure and oxidation to form AASS • potential pathways for acidification products (dissolved metals, acid and sulfate) from ASS sources areas • surface water and groundwater receptors that may receive such acidification products • potentially complete source-pathway-receptor linkages ERA has now commenced investigating the risk associated with each conceptualised potential ASS source location. Targeted sediment sampling during the next 12-18 months, along with the development of a location specific risk-ranking, are proposed to evaluate potential ASS formation in the sources areas identified. The risk-ranking for each identified sources area will be based on location specific concentrations in surface water and groundwater, likelihood of hydrodynamic changes associated with closure, and the sensitivity of the potential receptor to acidification products. The risk assessment can then be used as a tool for monitoring regime development. An ASS model for closure conditions will also be developed to inform closure risks and management strategies. *Contaminated sites* ERA maintains a register of potentially contaminated sites, identified on the basis of site activities including use and storage of chemicals. Targeted assessments have been undertaken at some known contaminated sites to assess the type and extent of contamination and inform remediation requirements, if necessary. ERA plans to undertake a whole of site contaminated sites assessment. The assessment will then trigger the development of remediation plans, if required, and update the contaminated sites register. Other contamination related studies conducted to date include potential contamination in the Land Application Areas (LAAs) and effective radiation dose estimates for members of the public from the LAAs. These works indicate the dose contribution from the all LAAs to be very low and, with the exception of Magela A and B, are below the exemption levels. These results indicate that no remediation for radiological contamination will be required in the LAAs. Work to assess soil contamination from metals in the LAAs is ongoing. As part of the feasibility study undertaken in 2018, a review of the contaminated sites register was undertaken. The review involved ensuring all areas of potential contamination were captured as well as aligning historical investigations undertaken to date, thereby developing a current knowledge based of site contamination. Sites were also classified according to risk. Following this review, a *Plume and contaminated site management plan* was developed. The plan describes future site assessments and BPT assessments, post remediation validation assessments and post-closure monitoring. Site assessments, in the form of a drilling program, were executed between November 2019 and January 2020 to sample soils, install groundwater monitoring wells and re-develop existing monitoring wells (Section 5.5.2.5). The results of this work are currently being analysed. Results will further inform the *Plume and contaminated site management plan.*

Area of study	Summary of studies
Health impacts of radiation and contaminants	In order to determine the achievement of closure criteria for both human health and environmental protection, ERA and the SSB have developed a pre-mining radiation baseline. All assessments against radiation closure criteria will be made based on the above-background mine-sourced radiation dose. A radiation dose assessment for the post-closure phase is currently in progress. The dose assessment includes two phases of modelling and will consider potential radiation exposure to members of the public as well as terrestrial and aquatic biota. The radiation dose assessments will be completed once the surface water modelling results provide the required data inputs.
Ecosystem rehabilitation	*Long-term flora and fauna baseline monitoring* In 2011, ERA implemented a long-term fauna and flora monitoring program on the RPA and in adjacent areas of Kakadu NP (in agreement with Mirarr Traditional Owners and Kakadu NP Management). The primary objective of the program is to study the natural woodland ecosystem for the development of fit for purpose closure criteria, and to inform the development of the rehabilitation strategy. Historical flora and fauna surveys, including targeted studies, and extensive ecological research on the Ranger Mine site and surrounds, have also contributed to development of closure criteria and measurement, and rehabilitation approaches. The program development, site selection and monitoring has been undertaken in collaboration with the SSB/ERISS. Soil, vegetation and ecohydrological studies undertaken have included: • plant responses to water stress in the wet-dry tropics • whole-tree sap flow • stand transpiration • stand evapotranspiration • canopy cover dynamics • seed provenance • total water requirements of the vegetation • shallow groundwater table and soil water dynamics Flora species composition and community structure studies include: • species selection • species establishment via seeding vs tubestock • emergent vegetative features in constructed waterbodies Ongoing monitoring of both the final landform and the analogue sites will continue to provide data to determine trends in the composition and abundance of flora and fauna, and any natural variability resulting from seasonal changes and fire. *Trial landform (TLF)* The eight hectare (ha) TLF, constructed in 2008/2009, was designed based on ERA and the ERISS studies of analogue sites and previous revegetation work conducted at the Ranger Mine. The TLF is four to seven metres above the original natural ground surface and is comprised of 800 k tonnes of primary and weathered waste rock. The design allowed for the performance testing of different types of substrates, different depths of mixed materials over the waste rock only layer, different planting methods and different irrigation regimes. Runoff and catchment management features and monitoring systems provide water quality data to inform decision-making on future water management strategies and landform design. The monitoring includes 66 soil moisture probes, a weather station and four erosion plots.

Area of study	Summary of studies
	The TLF was first planted with tubestock in 2009 and monitoring of revegetation performance and ecosystem development has been ongoing. Flora monitoring includes the growth, performance and survival of plants and vegetation communities under different conditions. Ten years of studies have assessed aspects critical to the successful closure and revegetation of the landform, including: • infiltration, runoff, soil erosion and solute loss • radon exhalation • plant available water • revegetation trials • establishment • performance • root distribution. Discussion on ecosystem establishment, including revegetation trials and seed provenance is provided in Appendix 5.1. This also includes a fine scale assessment, including plant species composition and relative abundance in the RPA, and surrounding natural analogue sites.
Climate change	A stakeholder workshop was held in March 2020 to undertake a first pass assessment of climate change risk to the closure of Ranger. The assessment was undertaken by subject matter experts from within and outside of ERA. A further on-line workshop was conducted with bushfire experts to gather additional expert input into this critical aspect. The process included delivery of a briefing on climate projections for the target area, based on available information obtained from reliable resources including the Commonwealth Scientific and Industrial Research Organisation (CSIRO), the Bureau of Meteorology (BoM) and the National Climate Change Adaptation Research Facility (NCCARF). Additional information was drawn from published peer reviewed literature. In assessing risk, the current management plans and activities relating to the mine closure were discussed. Their role in addressing relevant climate change risks was assessed to enable any residual risk to be identified. Thirty-seven potential risks were discussed and assessed. Risks were classified into four key areas • onsite activities (management and monitoring) • vegetation • onsite and receiving water quantity, quality and ecology • erosion and sediment In general, the relatively short period (compared to climate change timeframes) of active onsite management and monitoring, expected before the site stabilises and meets close-out conditions, meant that the risk profile for the mine closure was fairly low. The outcomes of the risk assessment will be included in the 2021 MCP once the report has been finalised.

6 BEST PRACTICABLE TECHNOLOGY

The identification and use of Best Practicable Technologies (BPTs) are a key component of the ERs (described above). The ERs specify that:

> *12.1 All aspects of the Ranger Environmental Requirements must be implemented in accordance with BPT*
>
> *12.2 Where there is … agreement … that the primary environmental objectives can be best achieved by … (an) action which is contrary to the Environmental Requirements … and which has been determined in accordance with BPT, that proposed action should be adopted*
>
> *12.3 All environmental matters not covered by these Environmental Requirements must be dealt with by the application of BPT.*

A BPT is defined in the ERs (Annex A – 12.4) as *that technology from time to time relevant to the Ranger Project Area which produces the maximum environmental benefit that can be reasonably achieved having regard to all relevant matters*. The definition of BPT in the ERs establishes a framework for assessment of currently available technology at any point during the operational and rehabilitation phases of mine life, rather than the ERs specifying particular technologies which may become obsolete.

A summary of each closure-related BPT submitted to regulators to date is provided within Section 6.2. Further BPT assessments will accompany each future closure application submitted to the MTC for assessment, as per the provisions outlined in the Ranger Authorisation.

Several ERs require environmental impacts to be as low as reasonably achievable (ALARA). ERA has researched and documented a process for the application of ALARA with respect to non-radiological hazards to demonstrate that environmental impacts on the RPA and exposure to chemical pollutants are ALARA. The process is described in Section 6.3 and Appendix 6.2 and adopts recommendations from the international literature to implement an holistic framework that combines options and risk assessments to derive and demonstrate an ALARA outcome. The process can also consider options that would result in levels of contamination in the riparian zones that are as low as technically possible, as requested by the Traditional owners.

7 RISK ASSESSMENT AND MANAGEMENT

The approach ERA has taken to risk assessment has been developed to identify hazards, aspects and opportunities in advance of project or activity implementation. The resulting risks and impacts to the business, people, property, assets and the environment are recorded and evaluated, and strategies are developed to manage them. The framework is consistent with recognised Australian standards and corporate management standards and practices including AS ISO 31000:2018 Risk Management – Principles and guidelines, AS/NZS ISO 14001 Environmental Management Systems and internal Rio Tinto and ERA standards and commitments. Risk management forms part of ERA's Health, Safety and Environmental

Management System, which has been certified to meet the requirements of the AS/NZ ISO14001:2015.

During the Ranger Mine Closure Feasibility Study, a series of risk assessment workshops were completed to further develop the Ranger closure risk register. In June 2019 the environmental risk assessment published in the 2018 MCP was updated with the outcomes of the feasibility study risk assessment and to consider the comments received from the Supervising Scientist on the 2018 MCP risk section. During 2020 the register has undergone several reviews including quarterly and annual risk reviews to ensure that the information remains current, risk trend update, control effectiveness, overall control effectiveness, action status and overall action status.

The current risk profile for Ranger Mine closure is provided in Section 7.4. There are 46 open risks as of June 2020. Of these, three are Class IV (Critical) risks:

- failure to contain and/or eradicate Spigelia weed from the operations area causing infestation in Kakadu NP.
- rainfall is greater than planned in the water model (P50) increasing the process water inventory. Additional water management, leads to a later completion of process water treatment than planned
- unable to inject brine into the underfill of Pit 3

The causes, impacts, existing controls, evaluation rationale and planned actions for each of the threats above are detailed within Appendix 7.1.

Seventeen risks were identified as Class III (high) with the majority of these related to impacts on project schedules and ERA's licence to operate. In each case, controls to mitigate the risks have been identified. All Class III (High) risks require ongoing management.

There are a total twenty one Class II (Moderate) risks and five Class I (Low) risks open as at June 2020 in the Ranger Mine closure risks register.

The Class IV risk detailed in the 2019 MCP, insufficient volume or quality of viable seed stock available for whole of site revegetation, was actively managed throughout 2019 and 2020 and has be re-evaluated to a Class III risk. Some of the actions completed during the past 12 months include the upgrade of the Ranger Nursery to increase security and fire protection, the evaluation of the viability of historical seed, the development of a seed tracking metric and the commencement of routine seed collection on the RPA. The current open actions for this risk are detailed within Appendix 7.1.

8 POST-MINING LAND USE, CLOSURE OBJECTIVES AND CLOSURE CRITERIA

The post-mining land use for the RPA is determined by the Environmental Requirements (ERs), which are conditions of the section 41 Authority issued under the *Atomic Energy Act 1953* and appended to the Ranger Authorisation (as Annex A) issued under the *Mining Management Act 2018 (NT)*

The pre-determined post-mining land use of the rehabilitated RPA includes the "potential incorporation into the Kakadu NP". It should be noted that any decision on the actual incorporation of the RPA to Kakadu NP will be made by the relevant authority in consultation with Traditional Owners and may not eventuate until sometime after closure.

Consultation has indicated that the Mirarr are likely to return to the area for:

- customary harvesting of bush foods and medicine
- recreation
- land management activities, and
- cultural site visitation and ritual responsibilities.

To meet these post-mining land uses, the closure of the Ranger Mine is required to fulfil a number of closure objectives. The ERs provide specific regulated closure objectives, which align to the post-closure land uses. These objectives were developed at the time of mining authorisation with the post-mining land use in mind. The objectives have been reviewed with stakeholders throughout the project and have been agreed as being appropriate for the project impacts and proposed land uses.

A key component of closure planning for the Ranger Mine is the development of closure criteria. The closure criteria represent performance metrics which will be used to measure the achievement of the rehabilitation closure objectives. These criteria represent direct measurable and quantifiable values, or tiered assessment processes based on industry best practice frameworks. Close-out certificates will be issued by the relevant authority upon the successful fulfilment of these closure criteria.

The closure criteria have been developed to align with the requirements of the ERs and Ranger Authorisation to achieve the overarching closure objectives. Development of the criteria has involved continuous consultation with stakeholders and input by the Closure Criteria Working Group with the support of various studies and reports. Section 8 provides justification for criteria development; identifies measurable parameters and provides a formal description for the individual closure criteria that have been assigned to each of the relevant closure themes. The closure criteria will be subject to further refinement, improvement and validation to ensure finalised criteria reflect acceptable standards and achieve desired outcomes.

In consultation with key stakeholders ERA developed a set of closure criteria themes, which are: landform, radiation, water and sediment, ecosystem (previously flora and fauna), soils, and cultural. For each theme the following have been identified, against the relevant ERs:

- Objectives
- Outcomes
- Parameters
- Draft or Final criteria.

The closure criteria presented in this MCP have been divided into two categories; proposed criteria for approval by the minister, and draft criteria for further review. These have been divided into separate tables in order to clearly identify the two categories. The draft closure criteria will continue to undergo review and refinement, based on studies and consultation with MTC members with a plan to finalise all criteria for the 2021 MCP.

9 CLOSURE IMPLEMENTATION

The primary goal of closure at the Ranger Mine is to rehabilitate the disturbed areas of the RPA, establishing an environment similar to the adjacent areas of Kakadu NP. The total area of disturbance in the RPA to be rehabilitated is approximately 1062.5 ha. The closure domains for Ranger are provided in Figure ES- 4 with a summary of closure activities to be completed for each domain provided in Table ES- 2.

ERA has undertaken significant progressive rehabilitation works since 2012, with more than AUD$600 Million spent on rehabilitation activities including tailings transfer, process water treatment and the backfill of Pit 1. Opportunities for the final revegetation of disturbed areas have so far been limited, in part due to efforts to maintain a minimum footprint and concentrate operational activities within the existing disturbed area. Despite this, over 12 ha of successful native revegetation has been completed

The closure implementation plan for Ranger Mine has been designed to mitigate the identified risks detailed in Section 7. The plan has been developed through the combination of the application of Best Practicable Technology (Section 6), business requirements and the outcomes of engineering, solute modelling and consolidation modelling.

The closure implementation plan includes the completion of the following key activities before January 2026:

- place all tailings into mined-out pits (transfer tailings in the TSF to Pit 3)
- following tailings deposition, backfill Pit 1 and Pit 3 with low-grade mineralised and waste rock
- eliminate the process water inventory
- manage salt and store brine in mined-out Pit 3

- demolish plant and associated infrastructure and for disposal within Pit 3
- deconstruct and rehabilitate the TSF and surrounds
- create a final landform that blends in with the surrounding environment
- revegetate disturbed areas to develop a self-sustaining ecosystem similar to the Kakadu NP
- demonstrate, with appropriate modelling, no detrimental impact from tailings for 10,000 years.

Closure planning is subject to continual revision as results of closure studies become available, and from continual assessment of implementation activities to ensure feasibility and a best practice approach to all closure activities. A schedule of all closure tasks is presented for each domain/activity within Section 9 and in Appendix 9.1.

The closure implementation plan factors in a number of contingency options for implementation in the event that the preferred option cannot be implemented or fails to achieve the desired outcome. The majority of these options are discussed in Section 6 as part of the best practical technology assessment with some specific contingencies further outlined in Section 9.

The proposed closure strategy is subject to ongoing review based on the outcomes of closure studies and assessment of implementation activities to ensure feasibility and a best practice approach.

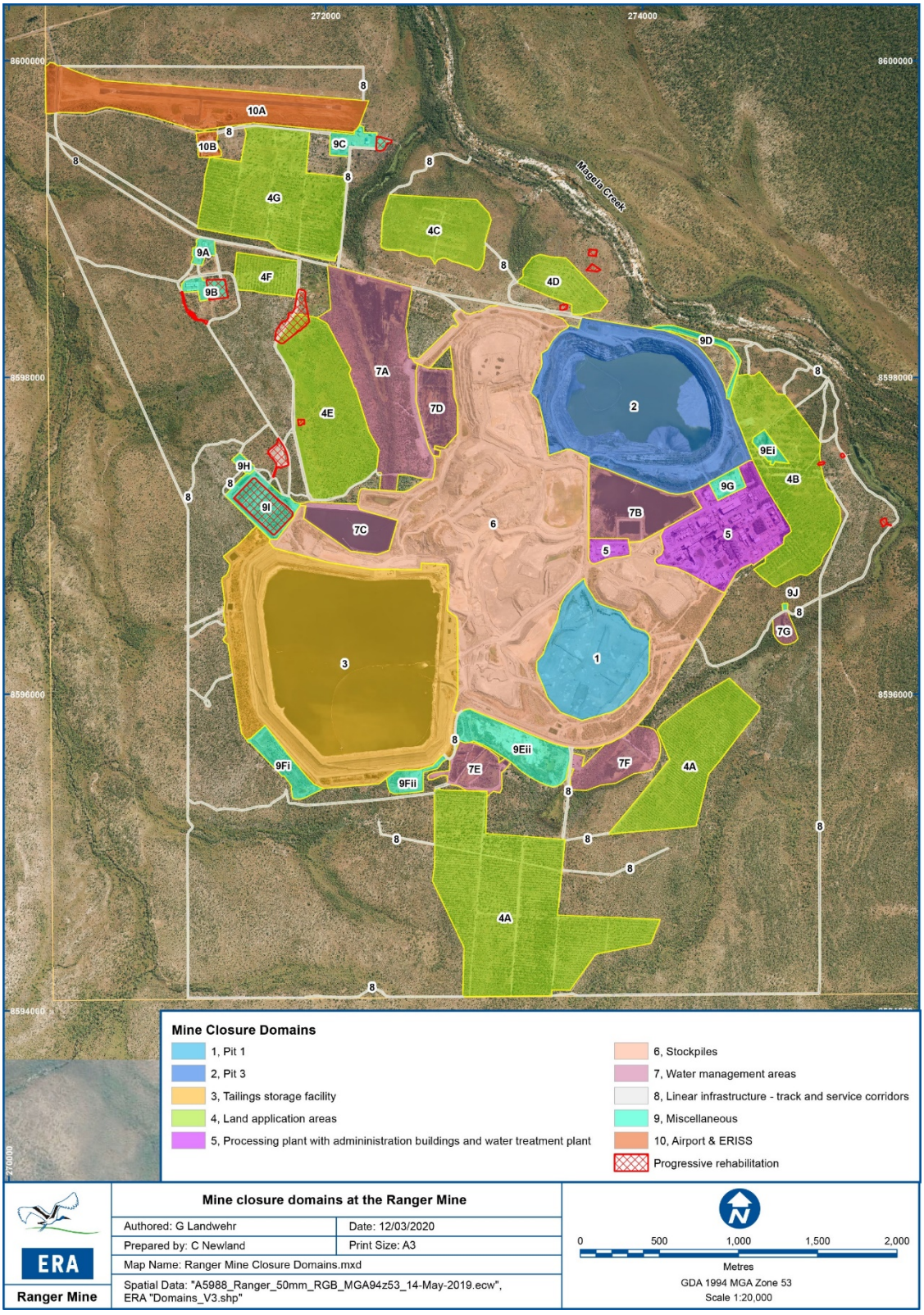

Figure ES- 4: Ranger Mine closure domain map

Table ES- 2: Closure implementation work program summaries

Area	Summary of closure implementation
Pit 1	ERA commenced deposition of neutralised tailings into Pit 1 in 1996 following an application to the MTC, approved by the NT Minister in 1995. Following the installation of prefabricated vertical drains (wicks) to promote consolidation in 2012, Pit 1 backfill activities commenced. Placement of waste rock to cap the tailings has now been completed with the final landform contouring and ripping scheduled to be completed by later in 2020. Revegetation activities will commence, with initial planting to occur during the 2020/2021 wet season. Water is removed from Pit 1 via the decant wells. Based on the results of the settlement monitoring it is expected that pumping from the wells will cease in late 2020.
Pit 3	Open-cut mining in Pit 3 commenced in July 1997 and ended in November 2012. Tailings deposition into Pit 3 commenced in 2015 and is estimated to end by December 2020, this will be followed by activities to facilitate tailings consolidation, as in Pit 1. Tailings deposition methods have been trialled and modified to improve consolidation and increase the likelihood of achieving the target closure date. Levels are managed so as to maintain the pit as a hydraulic sink and prevent outflows of solutes to groundwater. Decant wells will be installed during backfill options for tailings dewatering/consolidation. Prior to the placement of tailings in Pit 3, 33 Mt of waste rock was backfilled into the base of the pit to provide a flat surface for tailings deposition. This waste rock underfill was also designed to be a reservoir for long-term brine disposal. Brine is produced during process water treatment in the Brine Concentrator. Brine injection wells are installed to allow for placement of the brine into Pit 3 underfill and were operated for a short period in 2016 before being turned off due to issues with the underdrain bore. The underdrain bore has now been refurbished and brine injection is expected to re-commence later in 2020. Following completion of tailings deposition, pit capping will commence with works similar to Pit 1; including installation of prefabricated vertical drains (wicks), geofabric and an initial cap. Once sufficient geotechnical strength is obtained in the initial cap, bulk backfill will commence, followed by surface contouring to the final landform shape and revegetation. The bulk backfill of Pit 3 is scheduled to commence in 2023 with revegetation completed in November 2025.
TSF	To enable ERA to complete closure as planned, the TSF dredged tailings transfer to Pit 3 started in 2015 and will continue through 2020. After completion of tailings reclamation and transfer, the TSF will be cleaned of all visible tailings, infrastructure and foreign objects, prior to use as a process water storage dam. At the cessation of process water storage, the TSF will be deconstructed. The TSF will serve as an important storage facility for water, during Pit 3 closure works and then for disposed infrastructure (dredges) following appropriate decontamination and decommissioning processes. During closure, the TSF will act as a catchment to prevent the outflow of impacted rainwater. The TSF will then be deconstructed and converted to a release catchment. Final landform contouring and revegetation for the TSF site is planned for 2025.

Area	Summary of closure implementation
Water management	Process water, contained within the TSF, is fed to the Brine Concentrator (BC) plant for treatment via induced thermal evaporation. Distillate from the BC is released to the wetland filter system and brine is injected into the Pit 3 for disposal or recirculated to the TSF as required. A High Density Sludge (HDS) plant is available to support the BC and treat additional process water using a two-step process involving the application of lime and soda ash to promote precipitation. HDS permeate is suitable for further treatment within the pond water circuit and sludge disposal within Pit 3. Pond water is currently treated with a series of pond water treatment plants (WTPs), which involve ultrafiltration and reverse osmosis. Pond water treatment plant permeate is distributed to either the wetland systems or to Retention Pond 1 (RP1) for release onto the LAAs. Pond water treatment brine is fed to the Brine Squeezer (BS) for further treatment (reverse osmosis) with waste brine being directed to the TSF and permeate being released to the wetland systems. Modifications to the current water treatment system are being considered to increase the treatment capacity and capability in order to minimise the site water inventory post-closure. The water inventories relevant to closure are those associated with pond water and process water. To enable the successful closure of the Ranger Mine, both the pond and process water inventory on site must reduce to a zero balance, in time to allow for deconstruction of the water storage facilities prior to the closure of the RPA. The process water inventory is actively tracked, and additional water treatment facilities may need to be installed if expected water treatment and inventory targets are not met. The capacity of existing site infrastructure for treating process water is critical to meeting closure target dates and is being reviewed for suitability as closure processes and material volumes become clearer. Rainfall is a variable with the potential to impact closure water management and schedules. Should a number of higher than predicted wet seasons occur, in particular late in the closure project, additional water treatment capacity may be required in order to meet the final closure date in January 2026. Throughout closure, site water flows and facilities will be required for use and need to be managed. However, by January 2026 all water management areas will need to have been rehabilitated and require no active management. These areas include pond water storage, release water storage, wetland filters, water management sumps, land application areas and onsite billabongs that receive release discharge water. The exact timing and methods for rehabilitation of the various water management areas will depend largely on rainfall and the need for their continued use. Currently it is assumed within the closure schedule that all are to undergo rehabilitation toward the end of the closure period, commencing from 2023.
Plant and administration buildings	A decommissioning sequence has been determined for the areas of the plant, based on the interaction of the plant decommissioning with other activities in the overall RPA closure project. Decontamination of assets in the demolition area will be undertaken to allow safe and efficient demolition and disposal. Plant, equipment, buildings and other structures will be removed unless approval of the Traditional Owners and Commonwealth Minister is given for infrastructure to remain on the RPA. Demolished materials will need to be disposed of onsite at 6 m level deep below final landform if disposed amidst waste rock.
Ranger 3 Deeps	The proposed R3D underground mine project was not progressed and the decline was in care and maintenance since June 2015. ERA has now commenced transition

Area	Summary of closure implementation
exploration decline	to final closure. The ventilation shaft, portal and decline will be decommissioned in a staged closure approach with consideration given to geological and hydrological conditions. The first stages of closure of the decline commenced in 2019 with the removal of all infrastructure, the plugging of the base of the vent shaft and the flooding of the underground workings. Final decommissioning is planned for 2021.
Stockpiles	The bulk material movement of all waste rock to final destination and the construction of the final landform has been considered within the Ranger Mine closure Feasibility Study. A dynamic mine model, including haulage simulations, has been created to assist in producing the closure strategy. This confirmed a complex sequence of material movements to ensure all mineralised material ended up in the right part of Pit 3 and that access is not constrained. In 2008 an extensive stockpile block model was developed. The block model has been maintained, tracking locations of sources and destinations of materials since that time. Mineralised material stockpiled for processing will be processed prior to commencement of closure. All mineralised material not processed at the completion of milling in January 2021 will be placed well below final landform surfaces. Low 1s (non-mineralised material) has been scheduled to be used for final landform surface.
Other areas	Other areas subject to closure implementation and addressed in this MCP include: • waste material management • linear infrastructure • miscellaneous non-plant buildings • nursery and core-yard • Magela levee Under current legislation, ERA is obliged to rehabilitate the airport precinct. ERA is in consultation with key stakeholders regarding the ongoing operation of the airport. The ERISS offices and external services (Telstra) facilities are excluded from the Ranger Mine Closure Plan.
Contaminated sites	Soil remediation across the RPA will occur prior to decommissioning and will be based on the *Plume and Contaminated Site Management Plan*, refer section 5 above and Section 5 within the body of the MCP. Works have been undertaken to identify and risk rank potential contaminated sites. Remediation strategies have been broadly developed, including identification of further works to further define requirements. Remediation activities will be considered in relation to other closure activities for efficiencies and to avoid double handling of potentially contaminated sites. A schedule of rehabilitation of contaminated sites will be prepared at a later date based on the outcomes of ongoing work and further refinement of the closure schedule.
Final landform	A number of landform studies have been undertaken to address key closure issues and risks to inform the design parameters of the final landform and to validate design attributes such as landform stability, erosion, topography and visual amenity; and inform the current landform model predictions. The outcomes of these studies have

Area	Summary of closure implementation
	resulted in a final landform topography that incorporates low elevation and slopes to enhance landform stability and visual aesthetics to blend with the surrounding landscape. The final landform design continues to mirror the original topography as much as possible. The model addresses: • total material available for closure works • flood modelling for erosion • control of infiltration • control of sediment movement • outcomes from land evolution modelling conducted by the SSB. The surface layer to form the final landform will be constructed as 1s waste rock (non-mineralised) to ensure that radiation doses from the final landform are ALARA and to facilitate successful rehabilitation. To achieve the revegetation objectives, plant available water, depth and heterogeneity of the waste rock surface layer, material chemical characteristics, and surface treatments to optimise nutrient cycling have been considered when developing the design and construction of the surface layer. The final landform construction of Pit 1 has been completed. The remainder of the final landform construction will not commence until March 2023 and will be ongoing to enable areas to be released progressively for revegetation. This will enable revegetation works to be completed by the completion of closure milestone (8 January 2026).

Revegetation strategy	There is approximately 1062 ha of land to rehabilitate and revegetate for the successful closure of the Ranger Mine, including 795 ha of waste rock covered area.
	Revegetation will be guided by the ERA revegetation strategy (Appendix 5.1) that was developed utilising knowledge from over 30 years of revegetation trials, analogue vegetation studies and particularly the findings from the trial landform. Ongoing monitoring of the trial landform will continue to inform the final approach to revegetation of the RPA.
	A key consideration of the closure strategy was to provide progressive handover of final landforms to facilitate achievable revegetation production rates for contractors. A maximum rate of 1.5 ha/day revegetation day was set as a target, with the schedule commencing in April 2023.
	Initial revegetation activities commence after site preparation is complete for an entire revegetation area. However, revegetation planning and preparation begins several years earlier; for example, with seed collection and tubestock production. The initial revegetation process broadly includes:
	• planting design (planting density and distribution according to domain).
	• seed collection and plant production.
	• revegetation activities:
	  ○ site preparation (herbicide application, irrigation installation, planting site cultivation)
	  ○ tubestock planting (hole digging, fertiliser application, planting, watering in and/or irrigation).

Area	Summary of closure implementation
	Revegetation domains will be developed to reflect any physical and/or chemical constraints that may impact the type of revegetated ecosystem that is able to be re-established. These 'revegetation domains' will each have a suitable 'agreed conceptual reference ecosystem' identified, which will form the basis of the species list and target densities for revegetation planning and implementation. Whilst the conceptual reference ecosystems are yet to be finalised, the intention is to revegetate the majority of the landform post mining with open eucalypt-dominated woodlands that have similarities to the native vegetation typical of the surrounding areas near Ranger and within Kakadu National Park. In the meantime, a list of agreed tree and shrub species has been developed based on reference site monitoring, revegetation trials, and cultural consultation with Traditional Owners and forms the basis of current revegetation planning Over 60 species are currently being considered for initially establishment as tubestock, with a nominal planting density of 1,000 stems per hectare to allow for attrition during plant establishment and subsequent ecosystem development.

10 CLOSURE MONITORING AND MAINTENANCE

The monitoring programs developed for the Ranger Mine have been detailed in Section 10 and are designed to assess performance against the closure criteria.

The Ranger closure monitoring programs align with six closure criteria themes. The closure monitoring programs proposed build upon the existing, extensive monitoring regimes established during mining operations at the Ranger Mine. The closure monitoring program is required to assess rehabilitation success, including determination of the protection of potentially impacted ecosystems and environmental values.

Monitoring has already commenced as part of the progressive rehabilitation activities during operations and will continue into closure. The closure monitoring program will enable an adaptive management approach to site rehabilitation to inform performance strategy. The monitoring program will provide ongoing feedback of the site rehabilitation performance allowing for the refinement of the closure plan as required.

Monitoring programs associated with closure studies will also continue throughout the operation and closure phases.

The monitoring and maintenance program is initiated following the successful completion of closure (decommissioning and rehabilitation). This monitoring phase will occur after January 2026 when the site is progressing towards the development of a long-term stable landform and self-sustaining ecosystem that meets the closure objectives.

The focus of landform monitoring and maintenance program will be erosion control, and design of the program will utilise information derived from the TLF studies. Surface water monitoring in the post-closure period is required to assess rehabilitation success including identifying any unexpected events or COPC concentrations (compared to model predicted results), and

assessing the protection of ecosystems, human health and environmental values by comparison of water quality against closure criteria (when agreed).

The aims of the post-closure surface water monitoring program are to:

- assess whether closure criteria are met, or if water quality is transitioning toward meeting criteria
- provide assurance that the environment is being protected
- validate and assess confidence in, the solute transport predictive models

The proposed surface water monitoring program details include the location, parameters, relevant closure criteria and frequency of sampling, and is applicable to both the closure and monitoring and maintenance phases.

The primary objective of the closure groundwater monitoring program will be to confirm that measured time series changes to water quality are consistent with the hydrogeological model predictions and the regional groundwater environment remains protected. Monitoring 'envelopes' in the four sub-catchments; Gulungul, Coonjimba, Djalkmarra and Corridor creeks, will be progressively refined during decommissioning. The ‘envelopes’ will comprise new and/or existing monitoring bores.

The proposed groundwater monitoring will comprise monthly measurements of standing water level and quarterly sampling and chemical analysis. The aim of groundwater monitoring is to demonstrate that solute transport velocities and concentrations are consistent with modelling predictions and that the receiving environment will remain protected from defined COPCs. A representative sample of bores will remain for the groundwater monitoring program post-closure. As the groundwater environment stabilises, it is proposed that monitoring frequency requirements will decrease over time if no risks are identified.

Radiation monitoring, undertaken for the purposes of assessment of closure criteria, will be limited during the closure phase. The proposed monitoring for radiological performance has been structured around the exposure pathways for radiation due to the potential access to and final land use of the area. These pathways are:

- inhalation of Long Lived Alpha Activity (e.g. radioactive dust)
- inhalation of radon progeny (Potential Alpha Energy Concentration)
- ingestion of radioactive material in (or with) food or water, and
- external irradiation from gamma rays (and beta particles).

Soil remediation at contaminated sites within the RPA will be monitored to confirm successful achievement of closure criteria.

Revegetation and fauna monitoring and maintenance will begin following initial planting. The majority of the infill planting and understorey planting activities will occur during the monitoring and maintenance phase. Initial annual monitoring may involve recording every planted stem,

or belt transects, point centred quarter or other techniques to sample a subset of the stems. Some permanent plots will be established and repeatedly measured to gather information on rates of change of various attributes over time. Fixed photo points will be used to provide a visual representation of revegetation progress. For the initial monitoring attributes, consistent methods will be used each year, to enable comparisons over time and between sites, and into the long-term monitoring program.

As the vegetation matures, monitoring of species composition and density will remain essential, whilst other aspects related to ecosystem structure and function will become increasingly important. Attributes to be measured as part of this long-term monitoring program may include occurrence of flowering and fruiting, presence of understorey (including weeds) and leaf litter, canopy cover, tree height and diameter at breast height. Monitoring will also include aspects other than vegetation, such as surveys for fauna, pests, weeds and erosion.

Monitoring of established, maturing ecosystems will focus on comparison with closure completion criteria attributes, and will gradually provide a developmental trajectory including predictive trends towards achieving the criteria.

The fauna criteria is in draft and will require further studies and stakeholder consultation. Once closure criteria is finalised, appropriate monitoring plans will be developed. Monitoring of fauna recolonisation may be more suitable on a campaign (e.g. five-year) basis in the mature revegetation (along with similar surveys of the reference sites).

Alongside the development of the cultural closure criteria, consultant linguist Murray Garde proposed a number of indicators that could be used to reflect the Traditional Owner attitudes towards rehabilitation progress and by extension the satisfication of the cultural closure criteria during the closure and post-closure phases. A number of these indicators are largely based on visual and aesthetic values, as viewed through the lens of Mirarr culture. These indicators represent the overall cultural health of the ecosystem, which needs to be assessed by Mirarr Traditional Owners.

The GAC and the NLC have provided feedback that the MCP is to include a compliance and monitoring process for meeting the cultural closure criteria and that they would propose a process for ERA consideration that included direct involvement of Traditional Owners with technical support. The GAC and the NLC have been working with Traditional Owners and Murray Garde to build on previous work completed. Once GAC and NLC have finalised the proposed process, it will be reviewed by ERA and incorporated into future revisions of the MCP.

11 FINANCIAL PROVISION FOR CLOSURE

The ERA rehabilitation provision as at 30 June 2020 was $744 million.[5] The calculation of the rehabilitation provision relies on estimates of costs and their timing to rehabilitate and restore disturbed land to original condition.

The costs are estimated on the basis of this MCP and the closure model, taking into account considerations of the technical closure options available to meet the obligations of ERA. The provision for rehabilitation represents the net present cost at 30 June 2020 of the preferred plan within the requirements of the Ranger Authority.

The closure model is based on the closure feasibility study, completed in February 2019, which expanded on the previous prefeasibility study (PFS) completed in 2011. Key packages of work completed since 2012 include preliminary Pit 3 backfill, Pit 1 capping and design, construction and commissioning of the tailings dredging system. The Feasibility Study has increased the level of certainty regarding forecast rehabilitation expenditure.

Major activities for the execution of the rehabilitation plan include: material movements, water treatment, tailings transfer, demolition and revegetation. Major cost sensitivities include material movements, water treatment and tailings transfer costs.

The ultimate cost of rehabilitation is uncertain and can vary in response to many factors such as technological change, weather events and market conditions. It is reasonably possible that outcomes from within the next financial year that are different from the current cost estimate could require material adjustment to the rehabilitation provision for the RPA.

Separate to this MCP, each year ERA prepares and submits an Annual Plan of Rehabilitation (APR) to the responsible Commonwealth Minister for assessment and approval in accordance with the Ranger Uranium Project Agreement between ERA and the Commonwealth Government (Government Agreement). The specific purpose of the APR is to determine the securities amount to be held by the Commonwealth Government for rehabilitation obligations; these funds are held in the Ranger Rehabilitation Trust Fund. Once the APR is accepted by the Commonwealth Government, the APR is independently assessed and costed and the amount to be provided by ERA into the Ranger Rehabilitation Trust Fund is determined.

12 MANAGEMENT OF INFORMATION AND DATA

This section provides an overview of the information management systems used by ERA to manage closure-related data.

To support closure activities and provide confidence in the strategy, ERA has identified three key components for closure knowledge to be retained:

- validation of site conceptual/numerical models

[5] The 30 June 2020 provision discounted at 2 per cent and presented in real terms ($785 million undiscounted in real terms).

- landform design and construction
- progressive rehabilitation.

The retention and management of this information is important to demonstrate the appropriateness of and adherence to the closure strategy, drive change where required and provide a history with which to inform any future issues.

New/expanded data sets will continue to inform and/or validate the various conceptual and numerical models on which the closure strategy and design criteria are developed, as well as other aspects of the overall design and construction of the final landform. ERA maintains these datasets within its various document management systems.

13 REFERENCES

Department of Mines, Industry Regulation and Safety (2020) Mine closure plan guidance – how to prepare in accordance with the Statutory Guidelines – March 2020.

http://www.dmp.wa.gov.au/Documents/Environment/REC-EC-112D.pdf