Chapter 9 Risk Assessment and Management
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Appendix

APPENDIX 9.1 RANGER CLOSURE RISK ASSESSMENT
9 RISK ASSESSMENT AND MANAGEMENT

ERA’s overarching approach to potential health, safety and environmental risks is embedded in its Hazard Identification and Risk Management Standard (ERA 2014). ERA has undertaken risk assessments throughout the life of operations at the Ranger mine. These risk assessments incorporated representation from internal ERA and Rio Tinto stakeholders, ecological, social, engineering and radiation specialists, and leading government science bodies (i.e. CSIRO, ERISS). The outcomes of the risk assessments are maintained in a risk register.

A risk assessment for specific closure related matters was undertaken by ERA on 15 and 16 August 2016, which incorporated all other risk assessments undertaken over the life of Ranger. As part of the scoping and in addition to incorporating previous risk assessment outcomes, the best practicable technology options described in Chapter 8 were then taken forward into the risk assessment.

An overview of the risk assessment methods and process from ERAs Hazard Identification and Risk Management Standard is provided in Section 9.1. Section 9.2 provides a summary of previous risk assessments, and Section 9.3 summarises the closure risk assessment process and outcomes with full results provided in Appendix 9.1. Section 9.5 provides further evaluation of the Class III (high) risks, which require active management.

9.1 Risk Assessment Methodology Overview

The Hazard Identification and Risk Management Standard was developed to ensure that hazards, aspects and opportunities for a particular project or major activity are identified in advance. 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. ERA’s Hazard Identification and Risk Management Standard is adopted in element 3 of ERA’s Health, Safety and Environmental Management System which has been certified to meet the requirements of the standard AS/NZ ISO14001:2004 and AS4801. The framework is presented in Figure 9-1, and is consistent with the intent of the following Australian standards, and corporate management standards and practices:

- AS/NZS ISO 14001 Environmental management systems – specification with guidance for use.
- AS4801 Occupational health and safety management systems – specification with guidance for use.
- Rio Tinto Risk policy and standard.
- Rio Tinto HSEQ management system - Element 3 hazard identification and risk assessment.
- Rio Tinto HSE performance standards.
- ERA Ranger Environmental Requirements, which require risk controls to safeguard:
  - The protection of attributes for which the Kakadu National Park was inscribed on the World Heritage list.
• Protection of ecosystem health of wetlands listed under Ramsar Convention on Wetlands.
• Protection of health of the members of the regional community.
• Maintenance of the nature and biological diversity of aquatic and terrestrial ecosystems of the Alligator Rivers Region, including ecological processes.

Importantly, risk assessments undertaken by ERA are for setting priorities and management strategies, not for calculating the risk exposure,

Figure 9-1: The ERA HSEQ risk framework (adapted from: AS/NZS ISO 31000:2009)

9.2 Previous Risk Assessments

The risk assessment process implemented by ERA has been used to identify all potential environmental closure risks. Several risk assessments have been undertaken to date on components or aspects of the proposed closure strategy. A review of the respective risk assessments was completed with an emphasis on incorporating relevant risks from these earlier registers into the 2016 risk assessment, therefore reflecting the current status of the Ranger closure strategy. The risk assessments reviewed, include:

• Pit 1 Interim Tailings, Water and Closure Prefeasibility (ITWC PFS) risk register, 2008: The purpose of this risk analysis was to identify and evaluate threats and opportunities associated with the options being considered for Pit 1 closure to PFS level. The output of this risk analysis has been used to help determine the appropriate closure method to be advanced to feasibility level.

• ITWC PFS risk register, 2011: The purpose of this risk analysis was to identify and evaluate threats and opportunities associated with all aspects of closure across a 14 year schedule (2012 to 2026) and 10,000 year tailings containment period.
• Tailings transfer risk register, 2012: The purpose of this risk analysis was to identify and evaluate threats and opportunities associated with elements of the tailings transfer process from the tailings dam to Pit 3, including dredging, Pit 3 pumping system, power requirements and procurement.

• PFS brine injection prefeasibility operational risk register, 2012: The purpose of this risk analysis was to identify and evaluate the risks associated with the brine injection aspect of the Ranger closure project.

• FS tailings and brine management closure risk register, 2013: The purpose of this risk analysis was to identify and evaluate the risks associated with the tailings and brine management aspect of the Ranger closure project. Elements assessed during this risk assessment included: Brine injection; tailings transfer and implications for both Pit 3 and the tailings dam during the activity; dredging; Pit 3 pumping system; and, operational readiness.

• Ranger Pit 1 closure risk environmental register, 2016: The purpose of this risk analysis was to identify and evaluate the consequences and significance of the opportunities and threats on the surrounding environment, associated with the closure of Pit 1, and the final average tailings deposition level in the pit of 7 mRL. This risk analysis takes into consideration existing controls.

In addition to reviewing previous ERA closure risk registers, consideration was also given to the sources, stressors, pathways and endpoints described in the Alligator Rivers Region Technical Committee (ARRTC) ecological risk assessment (Pollino et al., 2013) that underpin the Key Knowledge Needs (KKNs) reported in Supervising Scientist (2016a). This was a collaborative project between the Supervising Scientist and ERA, and incorporates input from ARRTC members and key stakeholders. Where practicable, parameters from the ARRTC ecological risk assessment have been incorporated into the ERA closure risk assessments, either as risk breakdown categories and subcategories, threats, causes or consequences, depending on the application.

9.3 Closure Risk Assessment

A risk assessment for specific closure related matters was undertaken by ERA on 15 and 16 August 2016, to identify and assess potential impacts arising from key aspects of the final landform rehabilitation and construction relevant to the closure of Ranger. The following sections describe the process of the closure risk assessment in accordance with AS/NZS ISO 31000:2009 (Figure 9-1).

Outcomes from this risk assessment will continue to be reviewed and additional risks identified during internal or external workshops (e.g. the cumulative risk assessment currently being run by SSB) will be considered in future iterations of the Ranger MCP.
9.3.1 Establishing the Context and Scope

The purpose, scope, objectives, and assumptions of the closure risk assessment are described below.

9.3.2 Scope of the Closure Risk Assessment

The scope of the closure risk assessment was evaluated based on three defined phases of closure:

- **Decommissioning** - commences at the completion of processing, currently scheduled to end in 2020, and will continue to 2026; however it is already well advanced in Pit 1. Decommission is the general works associated with rehabilitating the site to an agreed standard of environmental protection and the re-contouring and re-vegetation of the final landform.

- **Stabilisation and monitoring** - is the period post decommission where the site is settling down and has commenced the slow progression towards the development of a long-term viable ecosystem and achievement of closure criteria. This phase may require initial management as the landform settles down, subsidence and soil forming processes occur and the vegetation establishes. There will also be a number of sumps installed as silt and contaminant traps to manage water quality during the initial settling of the landform, these may require removal once they are no longer required.

- **Post closure** - is the period after monitoring has demonstrated that the closure criteria have been achieved and a close-out certificate has been issued. It is in this period that the site will be returned to the traditional owners who may or may not elect to have it incorporated back into Kakadu National Park. This period continues indefinitely from the time of issue of the close-out certificate.

Each phase is identified as it applies to the individual risks, as shown in Appendix 9.1 under the columns "applicable to".

The closure risk assessment took into consideration existing and proposed controls and results of monitoring and modelling work undertaken to date.

9.3.3 Purpose and Objectives of the Closure Risk Assessment

The purpose of the closure risk analysis was to identify and evaluate the consequences and significance of the threats on the surrounding environment associated with the closure of Ranger. The key strategic objectives are that ERA meets its requirements under the Ranger Authorisation to: a) return and securely store tailings to the mined out pits for at least 10,000 years; b) establish an environment with habitats and erosion characteristics similar to the adjacent areas of Kakadu National Park; c) establish stable radiological conditions with doses that are in-line with national requirements and as low as reasonably achievable; and d) ensure all Environmental Requirements are met. Implicit in these key strategic objectives are the primary and secondary Environmental Requirements associated with onsite (ALARA) and offsite mine water management to ensure the protection of human health and biodiversity in the Alligator Rivers Region.
9.3.4 Assumptions of the Closure Risk Assessment

The following assumptions were made in considering the analysis and outcomes of the closure risk assessment:

- Technical advice generated from both internal and external sources (e.g. contractors, consultants, associates, government agencies and research partners) was assumed to be appropriate.
- All existing ERA controls will continue to be applied where applicable.
- All standard Rio Tinto risk controls will be applied.

The following topics were excluded from the closure risk assessment:

- There is no consideration of socio-economic related risks, as this will be a separate body of work.
- There is no consideration for the closure and rehabilitation of a) the infrastructure immediately south of the Jabiru Airport, identified as the Jabiru field station currently occupied by the Supervising Scientist Branch, and b) Jabiru township, as the final use of the township facilities is part of ongoing negotiations.

9.3.5 Risk Identification and Analysis

As required, ERA risk assessments are conducted by teams with relevant qualifications and experience relating to the activity of concern and area of risk. The potential impacts from hazards are classified using risk matrices based on the consequence (impact) and likelihood classifications of each potential impact. The risk rankings were determined for each risk using a severity matrix. The matrix is a tabular portrayal of risk as the combination of the probability of occurrence (likelihood) and consequence severity.

During the identification of the closure risks, consideration was given to results and issues raised in past and recent risk assessments and modelling studies (solute transport, tailings consolidation, etc). As previously stated the sources, stressors, pathways and endpoints agreed on by stakeholders in the joint ERA and SSB led Ranger closure ecological risk assessment (Bartolo et al., 2013) were also considered.

The aim of risk identification is to generate a comprehensive list of credible risks over the life of the project, based on the previous operational and current and planned closure activities. The hazards were analysed to identify any significant risk to human health, safety, or the natural environment with all current and proposed mitigation measures in place. Risk is measured in terms of consequence and likelihood of the adverse impact occurring. Both hazards and risks are an element or action giving rise to a condition that may cause harm, whereas potential impacts (consequences) are the effect or result triggered by the risk being realised.
The likelihood (Table 9-1) and severity of consequences (Table 9-2) were defined for each environmental aspect and factor (receptor) relevant to the closure of Ranger. Likelihood classifications provide a consistent scale or measure of a potential impact applied across a broad range of risks; the scale allows for consistent assessment by the individual assessors. The consequence definitions are based on ERA’s risk scheme and were customised to align with the particular environmental, radiation and cultural aspects of Ranger (Table 9-3).

Table 9-1: Likelihood classification

<table>
<thead>
<tr>
<th>Likelihood</th>
<th>Rare</th>
<th>Unlikely</th>
<th>Possible</th>
<th>Likely</th>
<th>Almost certain</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency interval</td>
<td>Less than once per 100 years</td>
<td>Once in ten to once in 100 years</td>
<td>Once per year to once in ten years</td>
<td>Twice per year to once per year</td>
<td>More than twice per year</td>
</tr>
<tr>
<td>Probability (single events)</td>
<td>&lt;0.1%</td>
<td>0.1% – 1%</td>
<td>1% – 10%</td>
<td>10% – 25%</td>
<td>&gt;25%</td>
</tr>
</tbody>
</table>

The risk rankings are determined for each risk using the risk matrix shown in Table 9-2. The matrix is a tabular portrayal of risk as the combination of the probability of occurrence and consequence severity.

Table 9-2: Risk assessment matrix

<table>
<thead>
<tr>
<th>Severity</th>
<th>Very low</th>
<th>Low</th>
<th>Moderate</th>
<th>High</th>
<th>Very high</th>
</tr>
</thead>
<tbody>
<tr>
<td>Almost certain</td>
<td>Class II</td>
<td>Class III</td>
<td>Class IV</td>
<td>Class IV</td>
<td>Class IV</td>
</tr>
<tr>
<td>Likely</td>
<td>Class II</td>
<td>Class III</td>
<td>Class III</td>
<td>Class IV</td>
<td>Class IV</td>
</tr>
<tr>
<td>Possible</td>
<td>Class I</td>
<td>Class II</td>
<td>Class III</td>
<td>Class IV</td>
<td>Class IV</td>
</tr>
<tr>
<td>Unlikely</td>
<td>Class I</td>
<td>Class I</td>
<td>Class II</td>
<td>Class III</td>
<td>Class IV</td>
</tr>
<tr>
<td>Rare</td>
<td>Class I</td>
<td>Class I</td>
<td>Class II</td>
<td>Class III</td>
<td>Class III</td>
</tr>
</tbody>
</table>

Risk scenarios that result in the highest ranked potential impacts (Class III and Class IV) were identified for consideration of additional risk reduction treatments (Section 9.4). The consequences assessed included both impacts to the natural environment and to the health and safety of the workforce and the public based on the definitions provided in Table 9-3.

While risks with lower ranked potential impacts are predominantly subject to normal operational controls and ongoing improvement processes, the risk assessment also identified additional treatments for some Class I and Class II risks (refer Appendix 9.1).
### Table 9-3: Consequence classes

<table>
<thead>
<tr>
<th>Consequence Type</th>
<th>Very Low</th>
<th>Low</th>
<th>Moderate</th>
<th>High</th>
<th>Very High</th>
</tr>
</thead>
<tbody>
<tr>
<td>Health</td>
<td>Reversible health effects of little concern. First aid treatment.</td>
<td>Reversible health effects of concern. Medical treatment.</td>
<td>Severe reversible health effects of concern. Lost time illness.</td>
<td>Single fatality or irreversible health effects or disabling illness.</td>
<td>Multiple fatalities or serious disabling illness to multiple people.</td>
</tr>
<tr>
<td>Safety</td>
<td>Low level short-term subjective inconvenience or symptoms. First aid treatment.</td>
<td>Reversible injuries requiring treatment, but does not lead to restricted duties. Medical treatment.</td>
<td>Reversible injury or moderate irreversible damage or impairment to one or more persons. Lost time injury.</td>
<td>Single fatality and/or severe irreversible damage or severe impairment to one or more persons.</td>
<td>Multiple fatalities or permanent damage to multiple people.</td>
</tr>
<tr>
<td>On-site environment</td>
<td>Near-source confined and promptly reversible impact. (Typically a shift).</td>
<td>Near-source confined and short-term reversible impact. (Typically a week).</td>
<td>Near-source confined and medium-term recovery impact. (Typically a month).</td>
<td>Impact that is unconfined and requiring long-term recovery, leaving residual damage. (Typically years).</td>
<td>Impact that is widespread unconfined and requiring long-term recovery, leaving major residual damage. (Typically years).</td>
</tr>
<tr>
<td>Community trust</td>
<td>Tangible expressions of trust / mistrust amongst a handful of community members with no influence on public opinion and decision-makers.</td>
<td>Tangible expressions of trust / mistrust amongst a few community members with some influence on public opinion and decision-makers.</td>
<td>Tangible expressions of trust / mistrust amongst some community members with moderate influence on public opinion and decision-makers.</td>
<td>Tangible expressions of trust / mistrust amongst most community members with significant influence on decision-makers.</td>
<td>Widespread loss / gain of trust across the community setting the agenda for decision-makers and key stakeholders.</td>
</tr>
<tr>
<td>Consequence Type</td>
<td>Very Low</td>
<td>Low</td>
<td>Moderate</td>
<td>High</td>
<td>Very High</td>
</tr>
<tr>
<td>------------------</td>
<td>----------</td>
<td>-----</td>
<td>----------</td>
<td>------</td>
<td>-----------</td>
</tr>
<tr>
<td>Compliance</td>
<td>Non-conformance with internal requirement with very low potential for impact. Non-compliance with community commitment goes unnoticed by external party/parties, requiring minimal effort to correct.</td>
<td>Non-compliance with external or internal requirement with low potential for impact. Formal censure. Non-compliance with community commitment, requiring limited effort to correct.</td>
<td>Non-compliance with internal or external requirement with moderate impact. Moderate penalties for breach of legislation, contract, permit or licence. Non-compliance with community commitment reported formally, with significant effort to correct.</td>
<td>Breach of licence(s), legislation, regulation-high potential for prosecution. Contract breach-significant penalty. Systemic internal standards breach-high impact. Community commitment breach-high potential business impact-significant effort to fix.</td>
<td>Suspended or severely reduced operations imposed by regulators. Breach of community commitment results in direct loss of established consents with widespread secondary effects.</td>
</tr>
<tr>
<td>Cultural heritage</td>
<td>Reparable damage to site or item of low cultural significance.</td>
<td>Irreparable damage to site or item of low cultural significance.</td>
<td>Repairable damage to site or item of cultural significance.</td>
<td>Irreparable damage to site or item of cultural significance.</td>
<td>Irreparable damage to site or item of international cultural significance.</td>
</tr>
<tr>
<td>Radiation (employees, contractors or public)</td>
<td>Measurable increase in radiation dose with outcomes remaining below dose constraints.</td>
<td>Increase in radiation dose above the dose constraints but still below international limits.</td>
<td>Increase in radiation dose to above international limits.</td>
<td>Radiation doses above 100 mSv to an individual and likely to significantly increase the risk of cancer to that individual.</td>
<td>Radiation doses to multiple individuals above 100 mSv or acute radiation syndrome to an individual.</td>
</tr>
</tbody>
</table>
Risks were also assessed qualitatively for "control effectiveness", based on existing controls or proposed controls and current site knowledge in relation to managing the risk. These scores provide additional information to ERA on the need for additional risk management needs. The matrix describing these parameters is provided in Tables 9-4. The ranking of these parameters is based on expert opinion of the members of the risk assessment group at the time of undertaking the risk assessment. This group has knowledge of the standard operating procedures and controls that currently control risks at Ranger mine and the proposed mitigations (e.g.; process water treatment systems, management procedures, closure strategy, etc).

In some cases, ranking this parameter can assist to ensure the appropriateness of the final risk ranking for each threat. For example, if the control effectiveness is C4, it is highly unlikely that a class I risk ranking would be appropriate for a given threat.

Table 9-4: Control effectiveness

<table>
<thead>
<tr>
<th>Control Rank</th>
<th>Description</th>
<th>Guidance</th>
</tr>
</thead>
<tbody>
<tr>
<td>C1</td>
<td>Substantially effective/adequate design</td>
<td>Controls are considered adequately designed and are operating effectively on almost all occasions</td>
</tr>
<tr>
<td>C2</td>
<td>Mostly effective/adequate design</td>
<td>Controls are considered adequately designed and are operating effectively on most occasions</td>
</tr>
<tr>
<td>C3</td>
<td>Inadequate design/partially effective</td>
<td>Controls are considered inadequately designed or are only operating to partial effectiveness on most occasions</td>
</tr>
<tr>
<td>C4</td>
<td>No controls/ineffective</td>
<td>There are no controls designed or the existing controls are operating ineffectively on all occasions</td>
</tr>
</tbody>
</table>

Potential credible risks were identified by considering the activities and phases associated with the closure of the Ranger mine. For each risk (threat), one or more possible causes (triggers/indicators) were identified and together these were used to define the potential impacts (consequences) of each risk scenario.

Each risk scenario was assigned a unique identification number, and assessed by using the risk matrix and applying a consequence and likelihood rating to the potential impact. This step of the assessment process took into account existing and/or proposed operational controls; to generate a risk ranking established for the area of the environment (aspect) anticipated as having the highest potential impact, e.g., onsite environmental impacts, offsite environmental impacts, compliance, etc.

Ranger mine has been in operation for over 35 years and has an extensive suite of existing environmental management controls. Such controls (e.g. bunds and water diversion controls) will continue to operate during the decommissioning phase; and possibly through the stabilisation and monitoring phase. As outlined previously, existing controls are taken into account when determining the risk ranking, thus it is the "residual" rather than the "inherent" (simple) risk that is ranked (as per ISO 31000).
A risk breakdown structure was established from the key areas of risk identified in previous risk assessments and to form the basis of the closure risk assessment Table 9-5. The risk breakdown structure underpins the process of risk identification and subsequent processes of risk analysis, risk evaluation and risk treatment. It focuses the risk assessment process on mine closure to ensure that risk identification is undertaken at a sufficient level of detail.

Table 9-5: Risk breakdown structure

<table>
<thead>
<tr>
<th>Category (risk code)</th>
<th>Sub-category</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aquatic ecosystem (TA)</td>
<td>Onsite water bodies (TA1)</td>
</tr>
<tr>
<td></td>
<td>Offsite water bodies (TA2)</td>
</tr>
<tr>
<td></td>
<td>Onsite water and waste management (TA3)</td>
</tr>
<tr>
<td>Terrestrial ecosystem (TB)</td>
<td>Landform (TB1)</td>
</tr>
<tr>
<td></td>
<td>Revegetation (TB2)</td>
</tr>
<tr>
<td></td>
<td>Fauna (TB3)</td>
</tr>
<tr>
<td></td>
<td>Weeds (TB4)</td>
</tr>
<tr>
<td></td>
<td>Fire (TB5)</td>
</tr>
<tr>
<td>People (TC)</td>
<td>Radiation (TC1)</td>
</tr>
<tr>
<td></td>
<td>Diet (TC2)</td>
</tr>
<tr>
<td></td>
<td>Cultural heritage (TC3)</td>
</tr>
<tr>
<td></td>
<td>Stakeholder and legal expectations (includes agreements, commitments, etc) (TC4)</td>
</tr>
<tr>
<td></td>
<td>Community (includes workforce) (TC5)</td>
</tr>
</tbody>
</table>

NB: Categories and most sub-categories align with the themes of the ecological risk assessment

9.4 Risk Assessment Results

The risk assessment identified a total of 45 risks. Of the 45 risks identified, 15 were related to the Aquatic ecosystem; 18 were related to the Terrestrial ecosystem; and, 12 were related to People. Of these 45 risks, 23 were identified as Class III (high) risks, requiring active management. There were no Class IV (critical) risks identified during the risk assessment. Figures 9-3 to 9-5, show the breakdown of all risks over category, subcategory, consequence area, and control effectiveness, respectively.

Of the 45 risks identified, 15 were related to the aquatic ecosystem; 18 to the terrestrial ecosystem; and, 12 to people. Of these, 23 were identified as Class III (high) risks, requiring active management. There were no Class IV (critical) risks identified during the risk assessment. Figures 9-3 to 9-5, show the breakdown of all risks over category, subcategory, consequence area, and control effectiveness, respectively. There were no Class III risks identified for subcategories diet, fire or fauna.

All risks and risk controls are provided in Appendix 9.1. Table 9-6 provides a summary of Class III (managed) risks. Included in the table is an assessment of the control effectiveness of each risk. The controls are discussed in Section 9.5.
Figure 9-2: Distribution of risks across category (see Table 9-5)

Figure 9-3: Distribution of risks across subcategory (see Table 9-5)
Figure 9-4: Threat risk profile by consequence area

Figure 9-5: Control effectiveness by category
Table 9-6: Summary of Class III risks across subcategories

<table>
<thead>
<tr>
<th>Threat title</th>
<th>Causes (triggers/indicators)</th>
<th>Potential impacts (consequences)</th>
<th>Class III risks and consequence</th>
<th>Control effectiveness</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Aquatic ecosystem (TA)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>RPA water bodies (TA1)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Offsite water bodies (TA2)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TA2-02: Poor quality water from Pit 3 enters offsite water bodies (e.g. downstream Magela Ck).</td>
<td>Seepage rates from Pit 3 tailings/waste rock are much higher than predicted. Volumes of process water expressed during consolidation are not recovered and treated, as predicted. Poor quality water shedding from waste rock is released offsite. Source material exposed through landform instability (e.g. gullying).</td>
<td>Non-compliance with ER 3.1 and ER 11.3(ii) (e.g. KNP values are compromised; Ramsar status is compromised, aquatic biodiversity of ARR is compromised). Water quality closure criteria not met. Potential toxicity to downstream aquatic biota. Bioaccumulation in bush tucker rendering it unfit for consumption.</td>
<td>Onsite environment Community trust</td>
<td>C1</td>
</tr>
<tr>
<td>TA2-03: Poor quality water from cumulative sources (e.g. landform, legacy sites, etc) enters off-site water bodies.</td>
<td>Seepage rates from pit tailings/waste rock are higher than predicted. Volumes of process water expressed during consolidation are not recovered and treated, as predicted. Poor quality water shedding from waste rock is released offsite. Source material exposed through landform instability (e.g. gullying).</td>
<td>Non-compliance with ER 3.1 and 11.3 (i) (e.g. KNP values are compromised; Ramsar status is compromised, aquatic biodiversity of ARR is compromised). Water quality closure criteria not met.</td>
<td>Onsite environment</td>
<td>C2</td>
</tr>
<tr>
<td>Threat title</td>
<td>Causes (triggers/indicators)</td>
<td>Potential impacts (consequences)</td>
<td>Class III risks and consequence</td>
<td>Control effectiveness</td>
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</tr>
<tr>
<td>Ongoing water and waste management (TA3)</td>
<td>Water management structures undersized and/or unable to cope with extreme events. Ineffective decommissioning of legacy sites. Active water treatment ceases too early.</td>
<td>Potential toxicity to downstream aquatic biota. Bioaccumulation in bush tucker rendering it unfit for consumption.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TA3-01: Uncontrolled release of contaminated material into the onsite environment during tailings transfer to Pit 3</td>
<td>Failure or damage is incurred to tailings transfer pipeline.</td>
<td>Onsite water is contaminated. Non-compliance with Ranger Authorisation and ERs.</td>
<td>Onsite environment Community trust C2</td>
<td></td>
</tr>
<tr>
<td>TA3-02: Uncontrolled release of process water stored in tailings dam to the environment.</td>
<td>Wall failure occurs from operating the tailings dam outside the original design parameters. Seepage of process water through the dam floor in the absence of tailings.</td>
<td>Contamination of groundwater and/or surface water.</td>
<td>Onsite environment Offsite environment C3</td>
<td></td>
</tr>
<tr>
<td>TA3-04: Potential migration of hydrocarbons into groundwater from buried blackjack.</td>
<td>Insufficient storage and containment options. Current management options ineffective.</td>
<td>Contamination of groundwater and/or surface water.</td>
<td>Onsite environment C1</td>
<td></td>
</tr>
<tr>
<td>TA3-05: Potential migration of contaminants from tailings dam plumes.</td>
<td>Elevated solute loadings from the tailings dam plumes.</td>
<td>Contamination of groundwater and/or surface water.</td>
<td>Offsite environment C4</td>
<td></td>
</tr>
<tr>
<td>Terrestrial ecosystem (TB)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Landform (TB1)</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>TB1-02: Erosion and gully formation across landform surface exposes contained tailings in Pit 1.</td>
<td>Landform evolution, including erosion in locality of Pit 1 is very different and higher than the prediction. Failure of proposed erosion controls. Bulk backfill and final landform designs are not implemented across the pit.</td>
<td>Non-compliance with ER 2.1, ER 5 and ER 11.3(i). Potentially increases solute transport on/off site. Potentially increases radiation dose to members of the public. Limits access by traditional owners to post decommissioning site.</td>
<td>Onsite environment C2</td>
<td></td>
</tr>
<tr>
<td>Threat title</td>
<td>Causes (triggers/indicators)</td>
<td>Potential impacts (consequences)</td>
<td>Class III risks and consequence</td>
<td>Control effectiveness</td>
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<tr>
<td>TB1-03: Consolidation settlement is significantly greater than predicted in Pit 3.</td>
<td>Consolidation modelling incorrect. Inadequate characterisation of tailings properties. Delays to tailings transfer from the tailings dam. Sub aqueous deposition causes increased segregation of fine material and irregular consolidation of the tailings. Divergence from the bulk backfill strategy during implementation.</td>
<td>Landform subsidence causes delays and impacts to the success of revegetation. Process water expressed post 2026; more solute seepage post closure. Differential settlement of final landform surface not as expected.</td>
<td>Onsite environment Offsite environment Community trust</td>
<td>C1</td>
</tr>
<tr>
<td>TB1-04: Consolidation settlement is significantly greater than predicted in Pit 1.</td>
<td>Landform evolution, including erosion in locality of Pit 1 is very different and higher than the prediction. Failure of proposed erosion controls. Bulk backfill and final landform designs are not implemented across the pit.</td>
<td>Landform subsidence causes delays and impacts to the success of revegetation. Increased pit tailings flux post 2026; more solute seepage post closure. Landform instability. Differential settlement of final landform surface not as expected.</td>
<td>Onsite environment</td>
<td>C2</td>
</tr>
<tr>
<td>TB1-06: Excessive erosion impacts landform stability and revegetation success.</td>
<td>Landform design is inadequate. Rainfall patterns vary significantly outside of the statistical range applied in modelling. Particle size distribution at the surface may be difficult to control. Weeds and fire. Revegetation fails. Erosion controls are inadequate.</td>
<td>Revegetation is unsuccessful. Extensive cracking and subsidence occurs over the landform leading to an increased maintenance regime. Stability issues occur along the developing gullies.</td>
<td>Onsite environment</td>
<td>C2</td>
</tr>
</tbody>
</table>

Revegetation (TB2)

<table>
<thead>
<tr>
<th>Threat title</th>
<th>Causes (triggers/indicators)</th>
<th>Potential impacts (consequences)</th>
<th>Class III risks and consequence</th>
<th>Control effectiveness</th>
</tr>
</thead>
<tbody>
<tr>
<td>TB2-04: Low plant propagation success in nursery stage.</td>
<td>Under skilled propagators. Lack of viable seed. Technical issues in the nursery - e.g. disease, procedures, equipment failures.</td>
<td>Reduction in floristic diversity and density. Delay in revegetation schedule.</td>
<td>Compliance</td>
<td>C2</td>
</tr>
<tr>
<td>Threat title</td>
<td>Causes (triggers/indicators)</td>
<td>Potential impacts (consequences)</td>
<td>Class III risks and consequence</td>
<td>Control effectiveness</td>
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</tr>
<tr>
<td>TB2:05: Low plant survival rates in the field during establishment and vegetation decline at mature stage.</td>
<td>Sole provider.</td>
<td>Revegetation does not support fauna diversity. Unable to meet cultural criteria for a sustainable food and medicinal source.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Weeds (TB4)</td>
<td>Insufficient staff or mechanical planting techniques available. Competing closure activities. Seasonal availability of landform is not optimum for planting. Low propagation success in nursery stage.</td>
<td>May not meet closure timeframe (e.g. s.41 agreement 8 Jan 2026).</td>
<td>Onsite environment Community trust</td>
<td>C2</td>
</tr>
<tr>
<td>TB4-01: Exposed land surface contributes to increased weed recruitment.</td>
<td>Unsuitable growth medium to sustain framework species. Weed recruitment from surrounding KNP. Seedbank in landform medium.</td>
<td>Reduction in floristic diversity and density. Reduction in faunal diversity and density. Unable to meet cultural criteria for a sustainable food and medicinal source.</td>
<td>Onsite environment</td>
<td>C1</td>
</tr>
<tr>
<td>Threat title</td>
<td>Causes (triggers/indicators)</td>
<td>Potential impacts (consequences)</td>
<td>Class III risks and consequence</td>
<td>Control effectiveness</td>
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<tr>
<td>TB4-02: Weeds from RPA impact KNP weed density and diversity.</td>
<td>Vectors leaving site - e.g. machinery, vehicles, animals, or wind or water-borne.</td>
<td>Increase in KNP weed density and species diversity. Introduction of new weed species into KNP.</td>
<td>Offsite environment</td>
<td>C1</td>
</tr>
</tbody>
</table>

### People (TC)

#### Radiation (TC1)

| TC1-01: Radiation doses from the final landform are not ALARA. | Mineralised material left on surface (gamma, dust and radon). Exposed tailings - see risk TB1-01. Solutes expressed to surface water and mobilised. | Non-compliance with ER 5. Increased dose to public (e.g. not ALARA). | Compliance | C1 |

#### Cultural heritage (TC3)

| TC3-01: Damage occurs to cultural heritage site. | Vehicle movement in restricted areas. Non-conformance with the land disturbance permit process. Breach to the cultural heritage management system. Not all sites identified. | Breach of Northern Territory Heritage Protection Act. | Compliance | C1 |
| TC3-02: Surface water runoff and groundwater transport from the landform affects sacred site. | Suspended sediments binding to vegetation. Elevated major ions in shallow groundwater. | Damage to a sacred site. | Community trust Cultural heritage | C2 |

#### Stakeholder and legal expectations (includes agreements, commitments, etc) (TC4)

<p>| TC4-01: Rehabilitated site fails to meet stakeholder and/or community expectations. | Assessed closure elements viewed as not meeting “Best Practicable Technology” (BPT). Poor environment performance onsite. Closure studies and the outcomes presented in reports, undertaken by relevant experts, are complex and difficult to communicate to stakeholders. Significant changes to pre-communicated/approved closure strategy. | Traditional owners do not return to country. Community dissatisfied with final landform. Inability to obtain final close-out. | Community trust | C2 |</p>
<table>
<thead>
<tr>
<th>Threat title</th>
<th>Causes (triggers/indicators)</th>
<th>Potential impacts (consequences)</th>
<th>Class III risks and consequence</th>
<th>Control effectiveness</th>
</tr>
</thead>
<tbody>
<tr>
<td>TC4-02: Mine closure impacts the economic sustainability of the region.</td>
<td>The community may be concerned about what infrastructure is retained or lost as a result of the closure. Community expectations for the retained infrastructure are different to that remaining. Misunderstanding of the Authorisation by the community. Lack of community consultation. Failure to maintain the external commitments register. Conflict between Federal and Territory statutes. Lack of rigour in Management of Change (MoC) system to address material changes to closure elements. Failure to address perceived or unknown commitments. Landform does not achieve visual amenity for stakeholder expectations. RPA perceived to be contaminated.</td>
<td>Businesses become unviable. Social dislocation. Loss of leasehold to operate businesses.</td>
<td>Community trust</td>
<td>C3</td>
</tr>
<tr>
<td>TC4-03: Delays to rehabilitation and/or closure activities extending beyond 2026.</td>
<td>Process water treatment / management strategy not achieved. May not meet the closure requirements by the required date. Closure strategy implementation delays (e.g. water treatment, tailings and/or ground consolidation, revegetation).</td>
<td>Non-government organisations and community members are dissatisfied that closure has been extended. Ongoing mine legacy issues.</td>
<td>Compliance</td>
<td>C2</td>
</tr>
<tr>
<td>Threat title</td>
<td>Causes (triggers/indicators)</td>
<td>Potential impacts (consequences)</td>
<td>Class III risks and consequence</td>
<td>Control effectiveness</td>
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<tr>
<td></td>
<td>Ongoing rehabilitation and/or maintenance requirements. Extreme weather events disrupt closure activities. Significant changes to pre-communicated/approved closure strategy. Delays in approvals (e.g. approvals for final in-pit tailings levels delays pit backfilling and final landform shaping). Closure strategy/implementation is incorrect. Parallel closure processes cause conflict.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Community (includes workforce) (TC5)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TC5-01: Closure activities may introduce new health and safety risks to workforce.</td>
<td>New hazards and risks associated with activities that are different from current operations.</td>
<td>Health and safety incidents.</td>
<td></td>
<td>C2</td>
</tr>
</tbody>
</table>
9.5 Discussion of Class III Risks

9.5.1 RPA Waterbodies (TA1)

The risk assessment identified one Class III risk (TA1-02) relating to high erosion from the final landform potentially causing waterbodies such as Georgetown Billabong and/or Coonjimba Billabong to infill, or for increased sedimentation in creek beds to occur, smothering aquatic biota.

The Supervising Scientist Branch has assessed the geomorphic stability of the Djalkmarra, Corridor, Gulungul and Coonjimba Creek catchments of final landform version 5 for a simulated period of 10,000 years using the CAESAR-Lisflood landform evolution model (Supervising Scientist, 2016b). The model is conservative in nature, having only minimal vegetation on the surface for the entire 10,000 year period and excludes any planned, orthodox storm water and erosion control structures to reduce bedload yields. The catchment areas used for assessing the Ranger conceptual landform are shown in Figure 9-6.

![Figure 9-6: Catchment areas – Ranger conceptual landform (Supervising Scientist, 2016c)](image-url)
As described in Chapter 7, Section 7.3.2, Erskine & Saynor (2000) reported that early bedload yields from the trial landform were less than non-rehabilitated mine waste rock stockpiles but exceeded yields from the natural surface. The mean annual bedload yields underwent an exponential decline, similar to that reported previously in the region (Lowry & Saynor, 2015).

Lowry & Saynor (2015) report that bedload yields are more influenced by time since construction than by rainfall intensity; and that vegetation cover and depth of contour rip lines, are also important drivers of annual bedload yield.

Ultimately, the final landform will be constructed and revegetated to control erosion using predominantly 1s waste rock in the upper layer of the landform. The landform will incorporate a number of engineered mitigations/controls, such as:

- Design, implementation and management of a number of orthodox storm water and erosion control structures on the final landform to reduce bedload yield – (e.g. sumps installed as silt and contaminant traps as passive water management techniques for the initial settling of the landform); the use of existing retention ponds, such as RP1 post closure.

- Implementation of an active water management strategy and inventory control during the decommissioning and stabilisation phases of closure, based on similar practices currently implemented at Ranger.

- Iterative landform design informed by the landform evolution modelling predictions; this includes locating and sizing of proposed stormwater and erosion control structures.

For further discussion on the outcome of previous studies relating to the development of the final landform, refer Chapter 7.

9.5.2 Offsite Waterbodies (TA2)

The risk assessment identified two Class III risks associated with poor water quality from on-site sources entering offsite water bodies.

**TA2-02**: Poor quality water from Pit 3 enters offsite water bodies (e.g. downstream Magela Creek). This risk relates to the potential for poor quality water from Pit 3 tailings, brines and waste rock backfill entering offsite water bodies (e.g. Magela Creek, Mudginberri, Ramsar wetlands, etc), via groundwater and/or surface water pathways. Pit 3 sources that may release constituents of potential concern (COPC) (Chapter 7, Section 7.7.1.7) to Magela Creek are brine, tailings and shallow waste rock placed above the tailings (INTERA 2016, Sigda et al., 2016).

**TA2-03**: Poor water quality from cumulative sources (e.g. landform, legacy sites, etc) enters off-site water bodies. This risk relates to the potential for poor quality water from cumulative sources (e.g. the final landform, legacy sites, pits etc), to enter offsite water bodies via groundwater and/or surface water pathways. The risks associated with pit 1, as an isolated source, were ranked Class II but it is one of the sources included in the "cumulative source". Pit 1 sources that may release COPC to Corridor Creek are tailings and overlying waste rock and expressed process water (or pit-tailings flux, PTF). Waste rock from the landform is the other large contributor of COPC for these risks. (Contaminated groundwater associated with the tailing dam is discussed under TA3-05.)
The Ranger site conceptual model estimates peak annual Mg from all waste rock and in-pit tailings, brine and PTF to be under 150,000 kilograms per year, compared to annual average loading from operations which is in the order of 180,000 kilograms per year, and natural loads of 135,000 (refer Figure 9-7). The main source of loading is from the waste rock cover, with tailings and brine representing much smaller sources.

![Graph showing estimated post-closure Mg loading](image)

Figure 9-7: Comparison of estimated post-closure Mg loading from all waste rock, all tailings, Pit 1 pit tailings flux, Pit 3 brine, and Ranger 3 Deeps backfill to historical mine-derived and natural Magela Creek Mg loadings

Loads of reactive COPC emanating from Pit 1 and Pit 3 sources were estimated and reported in (INTERA 2014a, b, 2016, Sigda et al., 2016). Operational criteria exist for Mg and some additional COPC, i.e., manganese (Mn), uranium (U), calcium (Ca) (as a Mg:Ca ratio), radium-226 ($^{226}\text{Ra}$), polonium-210 ($^{210}\text{Po}$), phosphate ($\text{PO}_4$-$\text{P}$), nitrate-$\text{N}$ ($\text{NO}_3$-$\text{N}$), and total ammonia-$\text{N}$ ($\text{NH}_3$-$\text{N}$). As discussed in Chapter 7, Section 7.4.3.3, a number of additional agreed COPC relevant to waste rock, and tailings/process water were identified. These additional COPC have undergone a first tier assessment, comparing loads and concentrations to available guidelines. The assessment shows that the risk from all sources is low (Chapter 7, Section 7.4.3.3). A comparison of the predicted loads to the current and previous limits (
Table 9-7) shows that loads of metals and nutrients from the combined Pit 1 and Pit 3 waste rock and tailings sources present a low risk following closure.
Table 9-7: Loads of COPC emanating from the combined sources (waste rock, tailings and brine/PTF) from Pits 1 and 3 for the years when each of these sources peaks

<table>
<thead>
<tr>
<th>Years when</th>
<th>12 when</th>
<th>270 when</th>
<th>10,000 when</th>
<th>Annual Additional Load Limits</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>PTF peaks</td>
<td>waste rock peaks</td>
<td>tailings peaks</td>
<td>current and rescinded</td>
</tr>
<tr>
<td>Uranium</td>
<td>3.30E+01</td>
<td>1.40E+02</td>
<td>8.10E+01</td>
<td>3.50E+03</td>
</tr>
<tr>
<td>Manganese</td>
<td>2.50E+03</td>
<td>1.56E+03</td>
<td>1.89E+03</td>
<td>6.00E+03</td>
</tr>
<tr>
<td>NO₃-N</td>
<td>3.90E+01</td>
<td>1.88E+02</td>
<td>1.88E+02</td>
<td>4.40E+03</td>
</tr>
<tr>
<td>Total-P</td>
<td>5.10E+00</td>
<td>2.39E+01</td>
<td>2.39E+01</td>
<td>2.80E+03*</td>
</tr>
<tr>
<td>Radium-226</td>
<td>2.10E-06</td>
<td>7.20E-06</td>
<td>4.30E-06</td>
<td>3.55E+04</td>
</tr>
<tr>
<td>Po-210</td>
<td>1.20E-10</td>
<td>9.60E-11</td>
<td>1.39E-10</td>
<td>4.22E-08</td>
</tr>
<tr>
<td>Copper</td>
<td>1.60E-01</td>
<td>1.24E-01</td>
<td>1.84E-01</td>
<td>9.00E+04</td>
</tr>
<tr>
<td>Lead</td>
<td>1.40E+00</td>
<td>4.74E-01</td>
<td>5.97E-01</td>
<td>8.00E+03</td>
</tr>
<tr>
<td>Cadmium</td>
<td>1.30E-02</td>
<td>9.90E-03</td>
<td>1.45E-02</td>
<td>1.30E+03</td>
</tr>
<tr>
<td>Zinc</td>
<td>4.50E+00</td>
<td>1.88E+00</td>
<td>2.41E+00</td>
<td>2.00E+05</td>
</tr>
</tbody>
</table>

* AALL is for PO₄-P

To assess the impact of these loads, and those from the final landform, to the surface water environment it is also necessary to assess resulting surface water concentrations.

Data from INTERA 2016 (groundwater seepage from surface waste rock, Pit 3 tailings and Pit 1 tailings) and water quality data from the trial landform were input to a surface water model based on that developed by the Australian Institute of Marine Science (AIMS) and the Water Research Laboratory at the University of NSW and run in PCSWIMM (Esslemont, 2016 refer Chapter 7, Section 7.8 for more details).

Annual loads (kilograms per year) and concentration (milligrams per litre) terms associated with groundwater seepage (INTERA 2014a, b, 2016), were converted into suitable input format for the surface water model (discharge m³/s, concentration mg/L). The model was run for both peak and long-term loads at 5 percent and 10 percent recharge. Rainfall, evaporation and river flow conditions observed in Magela Creek between 1/1/2000 and 31/12/2016 were used. COPC in downstream Magela Creek on the RPA were similar for each of these scenarios. (Refer to figures in Chapter 7, Section 7.8.)

Surface water modelling predictions indicate that magnesium, manganese, uranium and total ammonium nitrogen (TAN) concentrations reporting below the confluence of Magela Creek and Gulungul Creek were below the current site specific guideline values for protection of 99 percent of species. Furthermore the magnesium calcium ratio remained below 9 (the relevant ratio for the laboratory derived toxicity guideline value) (Chapter 7, Section 7.8).
Creek concentrations resulting from the loads of additional metals and nutrients originating from the tailings sources were calculated by normalising to ammonium nitrogen loads (another tailings origin COPC) and its resulting concentration. This approach is conservative as these reactive parameters are treated as non-reactive. The resulting concentrations were all much lower than national default guidelines for 99 percent species protection (refer to Chapter 7, Section 7.8).

Based on a comparison of load limits and guideline values to the predicted loads, downstream solute concentrations, and the magnesium calcium ratios, the major cumulative sources in the post closure final landform do not pose a risk to the downstream environment.

Natural controls that reduce the concentrations further than predicted include natural attenuation of reactive COPC in groundwater and surface water. Existing active operational water management controls will remain in place during decommissioning including: Segregation, treatment and release of water in accordance with the Ranger water management plan; and ongoing recovery of pit tailings flux via the decant towers.

Future controls include the design and construction of passive sediment and water management structures as required, across the whole of site post closure landform to manage solutes from waste rock sources. The existing and future controls provide a high level of confidence in the control effectiveness (C1) of the risk.

9.5.3 Onsite Water and Waste Management (TA3)

Four risks were identified for this subcategory. Three risks (TA3-01, TA3-02 and TA3-05) relate to the threats from contaminated materials and plumes associated with the existing tailings dam. The other risk (TA3-04) related to the potential migration of hydrocarbons into groundwater from buried blackjack on site.

TA3-01: The risk of uncontrolled release of contaminated material (e.g. process liquor or slurry) into the onsite environment during the transfer of tailings to Pit 3 has previously been identified as a risk in ERA's process safety management framework. As such, this risk has undergone an extensive bow-tie analysis to identify critical risk controls in order to gain a better understanding of the extent and quality of barriers and mitigation measures that exist for its management. It is a risk that is only relevant to current closure activities. As outlined in ERA's Process Safety Standard, it is ERA's intention to "...manage process safety at Ranger by ensuring that controls are both functional and effective at preventing and mitigating the impacts of high consequence low probability process safety events." Figure 9-8 shows the extensive bowtie analysis that also covers potential uncontrolled release of contaminants between the tailings dam and Pit 3, during tailings transfer.

The controls identified by process safety and shown in the bow-tie provide a high level of confidence of the control effectiveness of the risk and containment on site.
Figure 9-8: Bowtie analysis for loss of containment of process liquor (all activities); key areas of importance to risk TA3-01 are highlighted orange.
TA3-02: Uncontrolled release of process water stored in the tailings dam. During decommissioning it may be necessary to convert the tailings dam to a process water storage facility from 2022 - 2024, for temporary storage. This risk relates to the uncontrolled release of process water stored in the tailings dam to the onsite and/or offsite environment during this two year timeframe.

Several controls are proposed to manage this risk, including:

- Active management of the sequencing of process water treatment and tailings transfer to minimise storage volumes.
- Engineering assessment of suitability of the tailings dam for process water storage
- Tailings dam operations manual.
- Compliance with Rio Tinto D5 standard.
- Hydrogeological assessment of potential for seepage and implementation of mitigations if required.

Preliminary hydrogeological modelling and assessment to assess the adequacy of the tailings dam to store process water has been completed by INTERA. The modelling was also used to estimate the water seepage rate during the operational period from 1981 to 2016, using an average level for tailings and process water in the tailings dam. These results were then compared to the seepage rate estimated from an evaluation of observed sulfate and magnesium concentrations in monitoring bores. A key finding of this work is that the estimated seepage rate based on observed concentration data is 42 cubic metres per day, compared to the average simulated seepage rate of 150 cubic metres per day.

As a process water storage facility, the average seepage rate over the 5 year period is estimated to be 28 cubic metres per day. Over the 5 year period, the total seepage is 50,000 cubic metres. This represents an incremental increase in seepage volume from the tailings dam of 9 percent relative to the total seepage volume (550,000 cubic metres) during the entire operational period. In the likely event that the tailings dam will be converted to a temporary process water/brine storage facility, further studies will be required to investigate its suitability. However based on the outcomes of preliminary modelling the control effectiveness is currently C3.

TA3-04: Potential migration of hydrocarbons into groundwater from buried blackjack. Uranium ore processing at the Ranger mine uses Blackjack (gear oil), a hydrocarbon lubricant injected onto the spindle of the ball mill. Radiation concerns limit options for off-site disposal, and used oil needs to be disposed of in line with Rio Tinto and ERA policies and standards, and the Ranger Environmental Requirements prescribed by the s.41.

Three options were evaluated for disposing of Blackjack:

1 Data were presented at the Minesite Technical Committee meeting in November 2017.
Option 1: High temperature incineration has been proposed to burn off the blackjack hydrocarbon. The high temperature would ensure a "clean burn" to completely decompose Blackjack without releasing soot.

Option 2: Burial of the Blackjack within the Pit 3 tailings. This option provides a hydrogeologically "tight" environment in which to contain blackjack but could potentially lead of hydrocarbons leaching into the groundwater table during tailings emplacement and consolidation, and compromise the underdrain system.

A conceptual design containment structure has been proposed based on solidification and stabilisation of Blackjack, encapsulated in multiple strain compatible barriers. Solidification and stabilisation involves the addition of cementitious and surface adsorption reagents to bind the Blackjack medium. The multi-layer design includes several layers of geofabric barriers containing low permeability media (e.g. tailings or soil), which would allow for redundancy in a corrosive, dynamic environment during tailings emplacement and settling. This would provide high protection against migration of contaminants during tailings consolidation.

Option 3: The separation of light hydrocarbons from Blackjack would allow for the radioactive solid materials to be buried in Pit 3 without risk of light hydrocarbons leaching into the groundwater table, while recovering the light hydrocarbons for recycling as a fuel additive.

This option proposes dissolving Blackjack into a high flash point solvent in a custom designed tank. This mixture would be filtered to remove radioactive solids (without light fuel oil) for disposal in Pit 3. The non-radioactive filtered blackjack distillate would be removed from site.

Currently option 1 is preferred as it is low risk proven technology which has been used in the past at Ranger, with capital already allocated for a new incinerator to be built. If constructed, the incinerator would continue to operate until six months after milling ceases at Ranger.

The level of options assessment that has occurred provides a high level of confidence of the control effectiveness proposed to manage this risk.

TA3-05: Potential migration of contaminants from tailings dam plumes. This risk relates to the seepage of impacted groundwater from the tailings dam plumes and the potential transport of elevated concentrations of COPC to surface water.

The location and pathways for the transport of elevated concentrations of COPC from the tailings dam plumes have been the subject of numerous studies; the outcomes of which inform the Ranger conceptual site model and are comprehensively discussed in INTERA (2016). The conceptual site model (INTERA 2016), identifies several key decommissioning activities and events that will lead to a reduction in the localised hydraulic heads and migration of COPC from the tailings dam to down-gradient creeks and tributaries; these include:

- A gradual lowering of the hydraulic head that is currently driving the transfer of tailings COPC migration away from the tailings dam, as tailings are transferred to Pit 3.
- Reclamation and reshaping of the walls of the tailings dam leading to a change in the recharge rates in local hydraulic heads and the gradient around the tailings dam resulting in much lower rates of groundwater flow.
• Evapotranspiration from revegetation of the final landform leading to a decrease in the rate of groundwater recharge and subsequent flow of groundwater from the tailings dam footprint towards down-gradient creeks and tributaries.

Due to the uncertainty that still exists with regard to solute concentrations and transport from the tailings dam, the number and type of mitigations that will be required is unknown. As a result the control effectiveness for this risk is C4. Additional groundwater studies are underway to gain a better understanding of the system and improve the confidence.

9.5.4 Landform (TB1)

Four Class III risks were identified for landform, pertaining to erosion and gully formation and consolidation. Two of these risks (TB1-02 and TB1-04) were brought across from the Pit 1 notification (Pugh et al., 2016).

TB1-02: Erosion and gully formation across landform surface exposes contained tailings in Pit 1.

Based on the analysis of the final landform version 5 by the Supervising Scientist, the erosion surface predicted two gullies forming in the southern parts of Pit 1, refer Chapter 7, Section 7.5. ERA has compared the predicted gullying to the corresponding depth of the consolidated tailings surface at the same location in the pit. The comparison indicates that a distance of approximately 5 vertical metres separates buried tailings and the proposed gullies, refer Figure 9.9 (Pugh et al., 2016). Even though this conservative analysis confirms that tailings will not be exposed (Supervising Scientist, 2017), ERA will make minor adjustments to the final constructed landform, such that any drainage channels or significant gully formation will occur outside the shell of the pit.

Existing and proposed controls to mitigate this risk include:

• Iterative/adaptive landform design and landform stability modelling.
• Establishment of vegetative surfaces to reduce erosion.
• Incorporation of erosion structures into the landform design - e.g. ripping and armouring where required.
• Ongoing maintenance of erosion structures and mitigation of gully formation.
• Implementation of a quality assurance program for landform construction and erosion controls.
TB1-03: Consolidation settlement is significantly greater than predicted in Pit 3.

The potential consequences of this risk occurring include a delay in the success of the revegetation and/or a delay in the completion of process water treatment by 2026 are high, resulting in this risk being ranked Class III. Existing and proposed controls to mitigate this risk include:

- Placement of the underfill to reduce the rate of rise of tailings during deposition and decrease the maximum tailings thickness, both of which will decrease consolidation time.
- Placement of the underfill eliminated modelled differential settlement of tailings.
- Operation of an underdrain pump to keep the underdrain at atmospheric pressure, maximising the downwards consolidation flow.
- Pit 3 design has been informed by the learnings of Pit 1.
- Installation of prefabricated vertical drains (wicks) to maximise consolidation rate.
- Placement of bulk backfill according to schedule to activate the wicks and lead to timely completion of consolidation.
- Active management post 2026 of landform surface (e.g. repairs to minor subsidence).

Given that a substantial portion of the consolidation will occur during the decommissioning, when the landform will be actively managed, and the high level of confidence in success demonstrated through Pit 1, this risk has a control effectiveness of C1.

TB1-04: Consolidation settlement is significantly greater than predicted in Pit 1.

While the risk of the consolidation settlement being significantly greater than predicted in Pit 1 is unlikely, the potential implications particularly to the success of the revegetation are high, resulting in this risk being ranked Class III.
Nevertheless, the activities associated with the bulk backfill strategy have been developed to expedite the steady consolidation of the tailings and removal of the pit tailings flux, further details are provided Chapter 7, Section 7.1.2.

The majority of the consolidation in Pit 1 will occur during current operations, then there will be significant opportunities to correct and/or rectify any settlement issues during and immediately after the bulk backfill, scheduled to commenced in quarter 4 2016.

Existing and proposed controls to manage this risk include:

- In situ material testing and laboratory testing.
- Ongoing validation of the tailings consolidation model. The 28 settlement plates in Pit 1 are surveyed on a monthly basis, weather conditions permitting, and the measured settlement volumes subsequently compared against the model. Bulk backfilling will be complete in late 2019 and at the current rate of consolidation, it is expected that Pit 1 will reach 95% consolidation sometime in 2020.
- Work has been reviewed by experienced geotechnical engineers.
- Monitoring of the rate of settlement and modification to landform if required.

**TB1-06: Excessive erosion impacts landform stability and revegetation success.**

As outlined previously the Supervising Scientist, in collaboration with research partners at the University of Hull (Professor T Coulthard) and the University of Newcastle (Associate Professor G Hancock), have carried out an initial assessment of the geomorphic stability of final landform version 5 for a simulated period of up to 10,000 years using the CAESAR-LisFlood landscape evolution model (LEM). Details of these studies have been provided in Chapter 7, Section 7.5. These show that erosion rates are higher in the first 100 years then decrease over time, approaching background denudation rate for the region in 10,000 years.

Gully erosion is shown to form across the landform; these areas have been selected as the locations requiring the design of drainage channels and other erosion mitigations to minimise the potential impact on landform stability and revegetation success.

The final landform has been designed with very moderate slopes, negating the risk to landform stability from mass failure (refer Chapter 7, Section 7.5).

The proposed controls to minimise erosion and landform stability risks include, for example:

- **Surface treatments**: Measures on the hillslopes to reduce erosion and sediment discharge, including:
  - Ripping 0.5 metres deep along the contour at 4 metre intervals.
  - Applying a concave slope approach that gradually reduces as the catchment area uphill/upstream increase.
  - Using the limited available woody/vegetative debris/rocks to create selected small areas of habitat, and also slow runoff and encourage infiltration.
• **Drainage channel treatment**: Measures along the more defined drainage lines to reduce erosion and sediment discharge.

• **Edge sediment basins**: The design of sediment basins around the edge of the final landform to capture sediment discharging from the landform.

• **Second layer sediment basins**: Where the terrain permits, a second sediment basin has been positioned further downstream from the final landform, providing a second layer of protection to limit sediment discharge from the site.

  Further information on these and additional surface treatments are discussed in Chapter 10, Section 10.7.8.

• Implementation of a revegetation strategy that is tailored to landform elements (e.g. slopes, gullies, etc) (Chapter 10, Section 10.8).

• Construction of access (service) tracks designed to minimise erosion and/or not cause erosion (Chapter 10, Section 10.8).

Based on the detailed modelling and understanding of erosion mitigations, which are described in Chapter 10, this risk has a control effectiveness ranking of C2.

9.5.5 **Revegetation (TB2)**

Three Class III risks were identified associated with revegetation on the final landform and affecting low propagation success in the plant nursery (TB2-04), low survival rate in the field post planting (TB2-05) and the inability to plant out the landform within the closure timeframe. (For a comprehensive discussion on the proposed revegetation strategy for the final landform, refer Chapter 7, Section 7.6.)

**TB2-04: Low plant propagation success in nursery stage.**

ERA has been working extensively with Kakadu Native Plants Pty Ltd, a locally owned and run indigenous supplier, to provide seedlings for much for the revegetation projects that have occurred both at Ranger and on Jabiluka over the past 10 to 12 years. This supplier has extensive expert propagation and plant knowledge; however propagation success can be affected by a number of variables, which are outside the control of the supplier, including but not limited to: access to a lack of viable seed, technical issues such as disease or equipment failure, fire and/or fauna (birds, possums) destroying potential seed sources, high fire frequency limiting access during seed collection, etc. Given the potential impacts that this risk would have to the overall planting schedule (compliance), this risk is ranked Class III.

The existing/proposed controls include the following:

• Expert propagation knowledge and implementation provided by existing contractor.

• Supply of contractor prequalification process in place at ERA to ensure suppliers/contractors can meet project obligations.

• Multiple plant nurseries required to deliver plant volumes in later years. Continued collection of seeds every year till 2016, and cool temperature storage of seeds to alleviate the seasonal and yearly fluctuation in seed availability (some species only fruit once several years).
ERA establishes a new nursery with capacity of producing up to 200,000 plants in 2017-18. Based on the level of existing propagation expertise and supply history to date and other mitigation measures, this risk has a control effectiveness ranking of C2.

**TB2-05: Low plant survival rates in the field during establishment and vegetation decline at mature stage.**

This is a Class III risk as there remains several outstanding aspects of the landform’s (water) store-and-release cover design and revegetation strategy that are currently being reviewed, including assessment of infiltration rates as a function of the landform slope and surface preparation; and the assessment of the effects of ripping/spot cultivation on water storage, erosion rates, nutrient recycling, etc. The ongoing work to address these aspects of the revegetation strategy is reflected in the control effectiveness ranking of C3.

To date, ERA has undertaken extensive revegetation studies to inform the proposed revegetation strategy and to support long term plant survival. The outcome of these studies is provided in Chapter 7, Sections 7.3 and 7.6. In summary, revegetation trials at Ranger have focused on establishing native trees and shrubs on a waste rock substrate. The aim in all these trials has been to establish species that occur locally in eucalypt dominated woodland communities. Planting of nursery-grown tubestock and direct-seeding techniques have been used. Results from the various revegetation trials have indicated that:

- Waste rock (mine soils) can sustain the growth of local native tree species, at least until the age of 17 years old, the age of the oldest trial data.
- Planting nursery-grown tubestock results in a more reliable and rapid establishment than direct seeding.
- Initial irrigation has enhanced plant establishment and permits year round planting.

Topsoil has not been stockpiled for use at closure at Ranger due to its 30 years operation on a relatively small disturbance footprint. Early studies and investigations on the trial landform at Ranger using topsoil in revegetation has identified challenges with weed contamination in topsoil and water logging issues.

Mine soils have been found to develop rapidly on the waste rock stockpiles with rapid weathering of surface materials of some types of rocks (Figure 9-11). In addition, mine soils sampled from waste rock dumps have been described as more fertile than undisturbed soils in the area and they have been assessed as capable of supporting plant establishment and growth (Reddell & Milnes, 1992), with some active management required to minimise potential nutrient and mycorrhizal deficiencies to achieve vegetation success. This view has been supported by various revegetation trials including the established trial landform (Figure 9-12).
Figure 9-10: A kapok tree naturally recruited from seeds produced by the 4 – 5 year old revegetation plants at the Ranger trial landform. Note that the seedling has actually grown on a weathered rock (waste rock only tubestock section, trial landform, 12 Oct 2016).

Existing and proposed controls include:

- Irrigation during plant establishment, but also allow plants to experience annual dry-wet cycles to develop deep root system.
- Infill planting during stabilisation phase as required.
- Adjustment to planting density of individual species based on their observed performance on waste rock substrates on the trial landform, e.g., *E. tetrodonta* are more adapted to the waste rock substrates than the *E. miniata*.
- Weed control and fire exclusion for 5 to 7 years.
- Integration of fire into the revegetation management after 5 to 7 years.
- Revegetation strategy informed by trial landform studies and other onsite revegetation trials.
- Subsurface compaction layers to enhance water holding capacity.
- Initial fertilisation and inoculation of tubestock.
- Partial, selective contour ripping.
- Surface pitting resulting from a mechanical cultivator used to make planting holes, which increases surface roughness, infiltration and local accumulation of the litters and fines.
- Natural weathering of waste rock resulting in the development of increased fines.
• Plant species selection will consider topography and predicted edaphic conditions.

• Modelling predicts that waste rock cover of 4 – 7 metres thick as built, will provide sufficient plant available water for a mature eucalypt woodland (see Chapter 7, Section 7.3.5 and Chapter 10, Section 10.8).

• Landform store-and-release waste rock cover is thicker than 7 metres over the rock base – e.g., over the pits. Where the waste rock cover is thinner over natural ground surfaces, roots will develop into the natural ground (soil); reducing the chance of limited plant available water (refer Chapter 7, Section 7.3.5 and Chapter 10, Section 10.7 and 10.8).

Figure 9-11: Ranger trial landform revegetation (7 year old, waste rock and tubestock section, 16/06/2016). Note the relative size of a caravan parked next to the revegetation and *E. phoenicea* in full bloom.

**TB2-06: Inability to plant-out landform within timeframe.**

A key driver of this Class III risk is the closure schedule and potential for other closure activities and/or climatic events to impede access to optimum seasonal planting times. The consequence of this risk occurring is to ERA's compliance obligations and community trust. In order to achieve initial revegetation by 2026, ERA may be required to employ an additional labour force to complete the task.
Existing/proposed controls to mitigate this risk include:

- Implementation of the revegetation strategy informed by trial landform studies and other onsite revegetation trials.
- Expert propagation knowledge and implementation provided by existing contractor.
- Supply of contractor prequalification process in place.
- Implementation of closure schedule to meet the timeframe.
- Supporting the development of GAC’s ranger program to assist with the revegetation activities.

9.5.6 Weeds (TB4)

Two Class III weed risks were identified relating to increased weed recruitment (TB4-01) and the potential impact for weeds from the RPA to impact weed density and diversity in KNP (TB4-02). Existing effective weed management practices occur on the RPA for both these risks, resulting in a control effectiveness of C1.

**TB4-01: Exposed land surface contributes to increased weed recruitment.**

During the initial planting and establishment of vegetation on the final landform there is potential for the exposed land surface to contribute to increased weed recruitment. During the decommissioning, there will be ongoing weed management, including maintaining a buffer zone around the rehabilitated site to reduce the likelihood for increased weed recruitment on the final landform.

The existing/proposed controls to mitigate this risk are the same as for risk TB4-02, below and include:

- Spraying of the final landform surface prior to planting to reduce weed recruitment.
- Ongoing weed management (including research and trialling of various herbicides to identify those that will have minimal impact on the survival of planned revegetation).
- Ongoing liaison with KNP regarding fire, weed and feral animal management strategies.
- Material selection for surface cover - e.g. limited laterite at the surface and use of weeds-free material.
- Weed and seed inspections during decommissioning and stabilisation.
- Implementation of post decommissioning access tracks for ongoing weed and fire management.
- Maintaining a weed free buffer zone around the rehabilitated site.

**TB4-02: Weeds from RPA impact KNP weed density and diversity.**

Weed management within KNP is mainly focussed on weed species that impact upon wetlands (e.g. *Mimosa pigra*, para grass, salvinia, etc.), which is not too much of a concern for the RPA during the decommissioning, stabilisation/monitoring phases.
During decommissioning a key concern would be the introduction of gamba grass on the RPA, which is already present in KNP mainly along roadsides, but under control by Parks. Large infestations exist outside of the Park in the south and west; these are seen to present a high risk. Therefore to become a source of gamba grass in our location in relation to the Park boundaries would be quite significant. The distribution of mission grass is already increasing within KNP (from other sources), and ERA is currently demonstrating success in managing mission grass.

The likelihood is a factor of multiple events occurring, for example:

1. Gamba grass introduced to the RPA
2. Gamba grass infestation undetected and/or not controlled
   Gamba grass infestation spreads into KNP

The first event, whilst there are existing controls in place, the presence of gamba grass has been recorded at the Jabiru Airport and immediately removed. ERA has considerably more control over events 2 and 3, not least of which is an efficient and effective weed management team. However, while the likelihood of ERA impacting on weed density and diversity outside of the RPA is extremely low, weed management resourcing and the ability to maintain the current standard of weed hygiene during multiple work programs remains an unknown.

Overall, there is no hard barrier (engineering control) that could be implemented to reduce the consequence, however existing/proposed controls to mitigate this risk include:

- Spraying of the final landform surface prior to planting to reduce weed recruitment.
- Ongoing weed management (including research and trialling of various herbicides to identify those that will have minimal impact on the survival of planned revegetation).
- Ongoing liaison with KNP regarding fire, weed and feral animal management strategies.
- Material selection for surface cover - e.g. limited laterite at the surface and use of weeds-free material.
- Weed and seed inspections during decommissioning and stabilisation.
- Implementation of post decommissioning access tracks for ongoing weed and fire management.
- Maintaining a weed free buffer zone around the rehabilitated site.
9.5.7 Radiation (TC1)

TC1-01: A risk was identified relating to the radiation doses from the final landform not meeting as low as reasonably achievable (ALARA)\(^2\) during the stabilisation and post closure phases.

The pathways for exposure of members of the public to radiation from the rehabilitated landform are shown in Figure 9-12 and include:

Major pathways:

- External gamma radiation from landform waste rock.
- Inhalation of radon emanating from the landform waste rock.

Minor pathways:

- Ingestion of terrestrial bush foods growing on the landform waste rock and accumulated radionuclides.
- Ingestion of surface water containing radionuclides from the rehabilitated site.
- Ingestion of aquatic bush foods that have accumulated radionuclides entering local surface waters from the rehabilitated site.

Negligible pathway:

- Inhalation of dusts re-suspended from the waste rock landform.

\(^2\) ALARA - As low as reasonably achievable, with economic and social factors being taken into account.
Figure 9-12: Pathways for exposure of members of the public post closure
The major pathways (inhalation of radon and external gamma radiation) and therefore majority of the radiation exposure will be directly related to the radionuclide content in the final landform waste rock surface material. Optimisation of radiation doses to ALARA will therefore focus on the waste rock material. ERA has a high level of understanding of the uranium content in each of its waste rock stockpiles via the following mechanisms:

- Previous testing of each truck load prior to placement with the discriminator (a radiation detector used to measure the uranium ore grade of each load).
- Undertaking a detailed stockpile drilling campaign in 2008.
- Sampling and analysis of pit material post 2008.
- Development of a detailed stockpile uranium grade block model.

This information will be used to plan rehabilitation so the waste rock with the lowest uranium content (1's waste rock) will be placed on the surface, with other higher content material being placed in the mined out pits.

The uranium content of 1's waste rock is less than 0.02 percent U\textsubscript{3}O\textsubscript{8} (0.017 percent or 170 parts per million U). Therefore the final average uranium content across the landform is expected to be less than 80 parts per million U or 1 Becquerel per gram, which is lower than the level for exemption published in the ARPANSA National Directory for Radiation Protection (ARPANSA, 2014). Based on these assumptions, the radiation doses to the public are optimised to ALARA.

The existing and proposed controls identified during the risk assessment to mitigate this risk include:

- Material movement planning and stockpile resource model to identify location of 1s and 2s rock for placement across the final landform.
- Dust control during decommissioning.
- Final landform thickness reduces the likelihood of exposing tailings and radon emanation from tailings.
- Potentially applying access restrictions to particular areas of the RPA post closure to keep doses below dose constraint.
- Implementation of the engineering dose constraint of 300 micro Sieverts per year across the landform.
- Storm water and erosion control, design and management structures.
- Iterative landform design informed by LEM.
- Data from trial landform studies has informed the landform design and LEM.
- Active water management strategy and inventory control.

The level of control effectiveness ranking of C1 reflects ERA's long term experience with managing radiation and exposures on site.
9.5.8 Cultural heritage (TC3)

Two Class III risks were identified relating to potential damage/impacts to a cultural heritage site (TC3-01: Damage occurs to cultural heritage site) or sacred site (TC3-02: Surface water runoff and groundwater transport from the landform affects sacred site).

Risk TC3-01 has a high level of control effectiveness (C1) based on long standing and effective cultural heritage risk management on site during operations which will be carried forward to the closure activities. However, the new registration of a sacred heritage site to the north of the outer bounds of the proposed final landform, potentially introduces a level of complexity and uncertainty to the existing cultural heritage management system and therefore risk TC3-02 has been given a control effectiveness ranking of C2.

The risk of damage occurring to a cultural heritage site on the RPA carries a high compliance consequence but low likelihood, compared to the risk of damage to a sacred site via surface water runoff and groundwater transport which carries a high community trust and cultural heritage consequence but low likelihood. The controls to manage both these risks are the same, and are therefore addressed together.

ERA has a comprehensive cultural heritage management system that protects the cultural heritage values within the RPA. The ERA cultural heritage management system is informed by the requirements of the ERA GAC Interim Cultural Heritage Protocol (agreed with Traditional Owners of the RPA in 2006), Northern Territory and Commonwealth heritage legislation and Rio Tinto cultural heritage management standards.

The protocol provides for an agreed process, which ensures that cultural heritage surveys are conducted on the RPA prior to any land disturbance on undisturbed land or land that has already been disturbed with authorisation. This process must include Mirarr traditional owners. As previously discussed, ERA has conducted cultural heritage surveys across approximately 73% of the RPA under this agreement.

The system is designed to achieve a number of key outcomes in relation to cultural heritage management. Essentially, these outcomes are to:

- Ensure that all identified areas of significance and cultural sites on the RPA remain undisturbed.
- Provide ERA employees and contractors with the necessary cultural heritage training and awareness of their cultural heritage responsibilities.
- Provide ERA employees and contractors with the necessary cultural heritage operational procedures, process and work instructions to ensure the protection of all cultural sites.
- Ensure regulatory compliance by mitigating the potential risk of disturbance or damage to cultural heritage sites by operational, construction, and rehabilitation activity.

The system comprises two key heritage protection mechanisms being:

1. Standard operational procedures are embedded in the ERA health, safety and environment management system. These procedures and associated work instructions detail a particular procedure and process with specific accountabilities. They are updated regularly to ensure that
they are appropriate to the current potential risk that ERA operations may pose to significant areas and cultural sites, and that ERA remains compliant with Northern Territory and Commonwealth heritage legislation.

2. A number of physical controls, also exist including: cultural heritage surveys prior to land disturbance; the boundary of archaeological sites marked with red star pickets; the boundary of significant sites enclosed with permanent steel posts and rail fence; generic cultural heritage awareness signage placed across the RPA; all cultural sites marked with cultural heritage signage; bunds or other environmental protection near sites; cultural site vibration monitoring; site marked out with flagging tape with project supervisors prior to land disturbance; feral animal control program for pigs; and periodic audits of all cultural sites by an external cultural heritage specialist and Mirarr.

Physical controls may be added subject to conditions as a particular works site warrants. For example, a physical control imposed around the R34 archaeological site is a galvanised steel posted rail fence with signage at seven points.

In addition to the above physical controls, the cultural heritage management system also contains a number of administrative elements, including: dedicated cultural heritage geographic information system (GIS); site-wide cross cultural training and awareness (classroom); site-wide community induction; cultural heritage management training (web based); Rio Tinto cultural heritage standards; Rio Tinto health safety environment and quality management system; Rio Tinto cultural heritage management system business conformance audits; Rio Tinto social risk analysis; site managed assessments; ERA GAC Interim Cultural Heritage Protocol; and Northern Territory and Commonwealth heritage acts and regulations.

The cultural heritage management system is subject to Rio Tinto business conformance audits, risk reviews, ERA site managed assessments and ongoing improvements. Elements may vary due to changes in the working environment of ERA operations, changes to Northern Territory or Commonwealth heritage legislation, or cultural criteria as requested by traditional owners.

9.5.9 Stakeholder and legal expectations (TC4)

Three Class III risks were identified for this subcategory relating to rehabilitated site failing to meet stakeholder and/or community expectations (TC4-01); the impact to the economic sustainability of Jabiru from the closure of the Ranger mine (TC4-02); and delays in rehabilitation and/or closure activities extending past 2026 (TC4-03).

TC4-01: Rehabilitated site fails to meet stakeholder and/or community expectations.

The risk that the rehabilitated site does not meet stakeholder/community expectations has a high community trust consequence, low likelihood and will be managed predominantly through ERA's existing stakeholder engagement protocols. Comprehensive site specific research has been undertaken to ascertain optimal environmental protection design and management protocols to prefeasibility level. Further work to inform the construction of the final landform will occur in 2017 during the feasibility study which will focus on the methodology for deconstructing the plant, tailings dam, etc and subsequently informs the overall costs of closure. The feasibility study is a corporate
activity that identifies and defines the work streams that will fit into the sequence of closure activities required. It is estimated to take approximately 6 months to complete.

The existing and proposed controls identified during the risk assessment to mitigate this risk include:

- Early engagement with stakeholders.
- Application of BPT process.
- Completion of management of change processes for all significant changes.
- Engagement via communication fora (e.g. ARRTC, ARRAC, MTC, stakeholder workshops, etc).
- Complex information presented in various forms.
- External commitments register.
- GAC board endorsement of cultural criteria and overall closure strategy.
- Socio-economic impact assessment.
- Stakeholder engagement has occurred to understand their needs and the ability to meet these needs.
- GIS study undertaken to model the potential view lines, which has been approved by stakeholders.

The control effectiveness for this risk is C2. This ranking is based on the number of active stakeholder engagement fora currently in place, and technical working groups and programs that have taken place over recent years (e.g. the Independent Surface Water Working Group).

For further information on ERA’s approach to stakeholder engagement, refer to Chapter 5.

**TC4-02: Mine closure impacts the economic sustainability of the region.**

The high dependency of the local economy (Jabiru) and wider West Arnhem Region on direct and indirect contributions from the Ranger mine were recently assessed and described in (ERA 2014). In summary, the Jabiru economy is underpinned by a narrow commercial base, with mining being the town's principal provider of jobs and the main driver of its economic development. While other sectors such as tourism, services and education are significant they are also highly dependent on economic activity generated by the Ranger mine. For the period 2010 to 2011, Ranger mine contributed 1.3 percent to the Northern Territory's gross value added of $16.17 billion, 43 percent to the West Arnhem Region and 67 percent to Jabiru.

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3 The socio-economic impact assessment (SIA) was commissioned to assess the impacts of the proposed Ranger 3 Deeps project on the wider West Arnhem Region community. Included in the SIA as an economic assessment that assessed the benefits of ERA's operations on the region (refer Ranger 3 Deeps draft EIS, Chapter 11).
As the mine continues to move toward closure, contributions from all sources (direct and indirect) will decline, and have a significant impact on the local and regional economies. ERA engaged consultants to undertake a socio-economic impact assessment, which concluded in May 2017, aimed at assessing the impacts associated with ERA’s rehabilitation obligations under the current Jabiru head lease that potentially extend to the removal of town assets and rehabilitation of the land, and develop potential mitigation options for the identified impacts. Based on the outcomes of the assessment and the fact that the impact is, to some extent inevitable, this risk has a control effectiveness of C3.

**TC4-03: Delays to rehabilitation and/or closure activities extending beyond 2026.**

The risk that delays to rehabilitation and/or closure activities extending beyond 2026 is a high compliance consequence, low likelihood. As a condition of ERA’s environmental authority to comply with closure and rehabilitation requirements, ERA is committed to apply all necessary resources to achieve closure by the statutory data and achieve an environment that can be integrated into Kakadu National Park.

ERA will commit to ensuring compliance with Commonwealth environmental requirements and closure criteria as required under the Ranger Authorisation. Regulators will determine if ERA has appropriately closed and rehabilitated the site in accordance with established criteria.

Based on scenario changes being fully modelled and communicated to interested parties via the numerous stakeholder engagement fora currently in place, this risk has a control effectiveness of C2.

**9.5.10 Community (TC5)**

One Class III risk was identified (TC5-01) relating to the potential introduction of new health and safety risks to the Ranger closure workforce.

**TC5-01: Closure activities may introduce new health and safety risks to workforce.**

ERA maintains a Health, Safety and Environment management system, which aligns with the standards to which we are certified (ISO 14001:2004 Environmental management systems and AS 4801:2001 Occupational health and safety management systems), and is designed along the principles of the “Plan, Do, Check and Review” continual improvement cycle.

Beneath this broader management system are a number of health and safety performance standards, which are consistent with the health and safety management systems and standards of major shareholder Rio Tinto.

The management of safety at ERA is structured and formal with the implementation of the ERA performance standards. At a practical level, safety at ERA revolves around leadership. All leaders undergo general leadership training with specific attention placed on responsibilities, necessary skills (such as auditing, risk management and hazard identification) and leadership competencies (such as communication and consultation) for effective management of health and safety.

Engagement, consultation and communication between leaders, employees and contractors means that safety and health issues in the workplace are identified and rectified in the most effective and efficient manner, with issues best resolved by those who have identified them.
ERA also regularly conducts targeted safety and health programs to complement the health and safety management system. For example, recent programs include traffic safety and heat stress management. Key messages about the particular topics are communicated through team meetings and training sessions. The programs consider additional controls to reduce accidents, incidents or near misses.

This risk will be managed via the continued application of the Rio Tinto and ERA Safety Management Systems, including specific hazard and operability studies (HAZOP) and risk analysis of new activities.
9.6 References


Sigda, J, Jones, T & Pickens, J. 2016. COPC Source Concentrations and Creek Loadings for Sources in Pit 3 and Pit 1. Technical memorandum from INTERA Incorporated to Energy Resources of Australia Ltd. 15 August 2016.


APPENDIX 9.1 RANGER CLOSURE RISK ASSESSMENT
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<th>Causes (Triggers / Indicators)</th>
<th>Risk Description</th>
<th>Impacts (Consequences)</th>
<th>Existing / Proposed Controls</th>
<th>Control Effectiveness</th>
<th>Likelihood</th>
<th>Onsite Environment</th>
<th>Offsite Environment</th>
<th>Community Trust</th>
<th>Cultural Heritage</th>
<th>Risk Evaluation</th>
<th>Risk Management Class</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Aquatic ecosystem</td>
<td>RPA water bodies</td>
<td>A 1 01</td>
<td>2 3</td>
<td>Water quality in billabongs and creeks on the RPA is not ALARA.</td>
<td>Increase in major ions/metals to the billabongs from tailings, legacy groundwater plumes or waste rock sources. Failure to extract or pump and treat tailings flux. Flow path for collection of pit tailings flux is compromised during bulk backfill. Mineralised (e.g. 2s) rock is placed on surface or too high in pits during bulk backfill. Source material exposed through landform instability (e.g. gullying). Poor quality water is unable to be actively treated post closure. Potential contamination of groundwater from brine injection.</td>
<td>Decrease in aquatic biodiversity / habitat.</td>
<td>Interception and treatment of expressed process water from tailings (e.g. pit tailings flux) during mine operations. Material movement planning and stockpile resource model to identify location of 1s and 2s rock for placement during pit backfill.</td>
<td>CI</td>
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<tr>
<td>A</td>
<td>Aquatic ecosystem</td>
<td>RPA water bodies</td>
<td>A 1 02</td>
<td>2 3</td>
<td>Sedimentation of RPA waterbodies.</td>
<td>Erosion (bedload sediment) from final landform. Infill of onsite billabongs. Creased aggradation / sedimentation smothering aquatic biota.</td>
<td>Storm water and erosion control, design and management structures.</td>
<td>CI</td>
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<tr>
<td>A</td>
<td>Aquatic ecosystem</td>
<td>RPA water bodies</td>
<td>A 1 03</td>
<td>2 3</td>
<td>Increased weed establishment in RPA billabongs.</td>
<td>Transfer from surrounding environment, vehicles, transient fauna. Transport of weeds from surrounding KNPs.</td>
<td>Decrease in aquatic biodiversity / habitat. Weeds will be managed in accordance with existing operational management plans and strategies.</td>
<td>Early warning monitoring and subsequent adaptive management.</td>
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<tr>
<td>A</td>
<td>Offsite water bodies</td>
<td>Poor quality water from Pit 1 enters offsite water bodies (e.g. downstream Mapela Creek).</td>
<td>A 2 01</td>
<td>3</td>
<td>Seepage rates from Pit 1 tailings/waste rock are much higher than predicted. Volumes of process water expressed during consolidation are not recovered and treated, as predicted. Poor quality water shedding from waste rock is released offsite. Source material exposed through landform instability (e.g. gullying).</td>
<td>Non-compliance with ER 3.1 &amp; ER 11.3(ii) (e.g. KNP values are compromised; Ramsar status is compromised, aquatic biodiversity of ARR is compromised). Water quality closure criteria not met. Potential toxicity to downstream aquatic biota. Bioaccumulation in bush Tucker rendering it unfit for consumption.</td>
<td>A natural control is the dilution factor associated with backflow into Georgetown Billabong and flows into Mapela Creek. Natural attenuation of reactive COPCs in groundwater and surface water.</td>
<td>CI</td>
<td>R</td>
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<tr>
<td>A</td>
<td>Offsite water bodies</td>
<td>Poor quality water from Pit 3 enters offsite water bodies (e.g. downstream Mapela Creek).</td>
<td>A 2 02</td>
<td>3</td>
<td>Seepage rates from Pit 3 tailings/waste rock are much higher than predicted. Volumes of process water expressed during consolidation are not recovered and treated, as predicted. Poor quality water shedding from waste rock is released offsite. Source material exposed through landform instability (e.g. gullying).</td>
<td>Non-compliance with ER 3.1 &amp; ER 11.3(ii) (e.g. KNP values are compromised; Ramsar status is compromised, aquatic biodiversity of ARR is compromised). Water quality closure criteria not met. Potential toxicity to downstream aquatic biota. Bioaccumulation in bush Tucker rendering it unfit for consumption.</td>
<td>A natural control is the dilution factor associated with backflow into Georgetown Billabong and flows into Mapela Creek. Natural attenuation of reactive COPCs in groundwater and surface water.</td>
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<tr>
<td>A</td>
<td>Offsite water bodies</td>
<td>Poor quality water from cumulative sources (e.g. landform, legacy sites, etc) enters offsite water bodies.</td>
<td>A 2 03</td>
<td>3</td>
<td>Seepage rates from pit tailings/waste rock are higher than predicted. Volumes of process water and pit tailings flux are not recovered and treated, as predicted. Poor quality water shedding from waste rock is released offsite. Source material exposed through landform instability (e.g. gullying). Water management structures undermined and/or unable to cope with extreme events.</td>
<td>Non-compliance with ER 3.1 &amp; 11.3 (ii) (e.g. KNP values are compromised; Ramsar status is compromised, aquatic biodiversity of ARR is compromised). Water quality closure criteria isn’t met. Potential toxicity to downstream aquatic biota. Bioaccumulation in bush Tucker rendering it unfit for consumption.</td>
<td>Characterisation of legacy sites. Whole of site closure strategy and landform design are based on solute transport modelling predictions.</td>
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<tr>
<td>A</td>
<td>Offsite water bodies</td>
<td>Suspended sediments from the final landform enter offsite waterbodies.</td>
<td>A 2 04</td>
<td>3</td>
<td>Erosion from final landform.</td>
<td>Poor water quality. Creased aggradation / sedimentation smothering aquatic biota.</td>
<td>Storm water and erosion control, design and management structures on the edges of rock fill. Iterative landform design informed by LEM. Data from trial landform studies informs LEM and subsequent landform design.</td>
<td>CI</td>
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<td>Onsite water and waste management</td>
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<tr>
<td><strong>A.3.03</strong></td>
<td>Uncontrolled release of contaminated material into the onsite environment during tailings transfer to Pit 3.</td>
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<td><strong>A.3.03</strong></td>
<td>Uncontrolled release of process water stored in tailings dam to the environment.</td>
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<td><strong>A.3.03</strong></td>
<td>Potential migration of contaminants from legacy landfill sites.</td>
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<td><strong>A.3.04</strong></td>
<td>Potential migration of hydrocarbons into groundwater from buried blackpad.</td>
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<td><strong>A.3.06</strong></td>
<td>Potential migration of contaminants from tailings dam plumes.</td>
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<tr>
<td><strong>A.3.06</strong></td>
<td>Potential migration of contaminants from other legacy plumes (e.g. processing plant).</td>
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<tr>
<td><strong>A.3.07</strong></td>
<td>Potential migration of contaminants from legacy sites (e.g. land application areas, wetland filters).</td>
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### Risk Evaluation

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<thead>
<tr>
<th>Risk Type (Threat)</th>
<th>On-site Environment</th>
<th>Off-site Environment</th>
<th>Community Trust</th>
<th>Compliance</th>
<th>Cultural Heritage</th>
<th>Risk Management Class</th>
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<td>A</td>
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### Risk Description

- **Onsite water and waste management**
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- **Onsite water and waste management**
- **Onsite water and waste management**

### Existing/Proposed Controls

- **Onsite water and waste management**
- **Onsite water and waste management**
- **Onsite water and waste management**
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- **Onsite water and waste management**
- **Onsite water and waste management**
- **Onsite water and waste management**
- **Onsite water and waste management**

### Risk Type (Threat)

- **A**
  - **A.3.03**
  - **A.3.04**
  - **A.3.06**
  - **A.3.07**

### Onsite Environment

- **U**

### On-off site Environment

- **L**

### Community Trust

- **H**

### Compliance

- **A**

### Cultural Heritage

- **M**

### Risk Management Class

- **I**

### Contingency

- **U**

### Conceptual site model predicts that due to reduction in hydraulic gradient once the tailings dam is removed: a) the rate of migration will decrease; b) vertical gradient will reduce significantly; c) concentrations in the plume will decrease over time; and d) solute loading in the vicinity of Gulungul Creek will be greatly reduced.

### Treatment

- **R**

### Prevention

- **R**

### Mitigation

- **R**

### Current management options ineffective.

### Implementation of a QA program for landform construction and erosion controls.

### Remediation plan for wetland filters and LAA to be developed during FS. This will be based on the ongoing investigations into the level of soil remediation.

### Natural drainage of groundwater basalt to surface water results in negligible changes to surface water concentrations from impact pathways.

### Waste rock cover and revegetation of RPA wetland filters.

### Erosion and gully formation across landform surface exposes contaminated tailings in Pit 3.

### Landform evolution, including erosion in locality of Pit 3 is very different and higher than the prediction.

### Failure of proposed erosion controls.

### Bulk backfill and final landform designs are not implemented across the pit.

### Establishment of vegetative surfaces to reduce erosion.

### Erosion structures are incorporated into landform design - e.g. rippling and armouring where required.

### Ongoing maintenance of erosion structures and mitigation of gully formation, post decommissioning.

### Implementation of a QA program for landform construction and erosion controls.

### Gully predicted over Pit 3 is minimal.

### Construction control: Predicted consolidated tailings level in Pit 3 will be approximately -30 mRL.

### Release of process water treatment and tailings transfer to minimise storage volumes.

### Engineering assessment of suitability of the tailings dam for water storage.

### Tailings dam operations manual.

### Compliance with Rio Tinto D5 standard.

### Hydrogeological assessment of potential for seepage and implementation of mitigations if required (e.g. clay liner).

### Landform surface exposes application areas, wetland filters).

### From legacy sites (e.g. land processing plant).

### From tailings dam plumes.

### From buried blackjack.

### Hydrocarbons into groundwater and/or surface water.

### Contamination of groundwater and/or surface water.

### Transfer from RPA to surrounding environment via surface water pathways.

### Migration of COPC via shallow groundwater and/or surface water.

### Possible migration of COPC from soil to surface water via erosion and runoff.

### Contamination of soils, groundwater and/or surface water.

### Remediation plan for wetland filters and LAA to be developed during FS. This will be based on the ongoing investigations into the level of soil remediation.

### Conceptual site model predicts that for all LAAs, groundwater chemistry is expected to show very limited to no impacts from land application at the time of site closure.

### Natural drainage of groundwater basalt to surface water results in negligible changes to surface water concentrations from impact pathways.

### Waste rock cover and revegetation of RPA wetland filters.

### Failure of proposed erosion controls.

### Non-compliance with Ranger Authorisation and ERs.

### Bulk backfill and final landform designs are not implemented across the pit.

### Iterative/adaptive landform design and landform stability modeling.

### Establishment of vegetative surfaces to reduce erosion.

### Erosion structures are incorporated into landform design - e.g. ripping and armouring where required.

### Ongoing maintenance of erosion structures and mitigation of gully formation, post decommissioning.

### Implementation of a QA program for landform construction and erosion controls.

### Gully predicted over Pit 3 is minimal.

### Construction control: Predicted consolidated tailings level in Pit 3 will be approximately -30 mRL.
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<thead>
<tr>
<th>Ref</th>
<th>Risk Type</th>
<th>Threat Title</th>
<th>Causes (Triggers / Indicators)</th>
<th>Impacts (Consequences)</th>
<th>Existing/Proposed Controls</th>
</tr>
</thead>
<tbody>
<tr>
<td>B 1</td>
<td>02</td>
<td>Erosion and gully formation across landform surface exposes contained tailings in Pit 1.</td>
<td>Non-compliance with ER 2.1, ER 5 and ER 11.3(i). Potentially increases solute transport on/off site. Potentially increases radiation dose to members of the public. Limits access by traditional owners to post-decommissioning site.</td>
<td>Iterative adaptive landform design and landform stability modelling. Establishment of vegetative surfaces to reduce erosion.</td>
<td>C2</td>
</tr>
<tr>
<td>B 1</td>
<td>03</td>
<td>Consolidation settlement is significantly greater than predicted in Pit 3.</td>
<td>Landform subsidence causes delays and impacts to the success of revegetation. Process water expressed post 2026; more solute seepage post closure. Landform instability. Differential settlement of final landform surface not as expected.</td>
<td>Placement of the underfill to reduce the rate of rise of tailings during deposition, maximising potential consolidation.</td>
<td>C3</td>
</tr>
<tr>
<td>B 1</td>
<td>04</td>
<td>Consolidation settlement is significantly greater than predicted in Pit 1.</td>
<td>Landform subsidence causes delays and impacts to the success of revegetation. Increased pit tailings flux post 2026; more solute seepage post closure. Landform instability. Differential settlement of final landform surface not as expected.</td>
<td>In situ material testing and laboratory testing. Wick drains and pumping infrastructure installed. Experienced geotechnical engineers have reviewed the work. Monitoring of the rate of settlement via the settlement plates and modification to landform if required. Implement backfill design recommendations to protect pit tailings flux collection system (Fitton).</td>
<td>C2</td>
</tr>
<tr>
<td>B 1</td>
<td>05</td>
<td>Landform does not meet the values (e.g. land uses) that are expected from the stakeholders.</td>
<td>Broad definition in the legislation interpreted differently by authorities. Ongoing changing expectations of stakeholders. Insufficient consultation with traditional owners.</td>
<td>Traditional owners do not return to the land and/or end use until for cultural purposes. ERA will not be released from the legal responsibilities.</td>
<td>C2</td>
</tr>
<tr>
<td>B 1</td>
<td>06</td>
<td>Excessive erosion impacts landform stability and revegetation success.</td>
<td>Landform evolution, including erosion in locality of Pit 1 is very different and higher than the prediction. Failure of proposed erosion controls. Bulk backfill and final landform designs are not implemented across the pit. Inadequate controls are implemented during the mine's operational phase.</td>
<td>Vegetation is unsuccessful. Extensive cracking and subsidence occurs over the landform leading to increased maintenance regime. Stability issues occur along the developing gullies.</td>
<td>C2</td>
</tr>
<tr>
<td>B 1</td>
<td>07</td>
<td>Legacy erosion areas persist post 2026.</td>
<td>Ongoing erosion and deposition in downstream drainage lines.</td>
<td>Implementation of stabilisation works.</td>
<td>C2</td>
</tr>
<tr>
<td>B 2</td>
<td>01</td>
<td>Consolidated tailings level impacts revegetation success in Pit 3.</td>
<td>Water deficit causes root system to infiltrate tailings. Inappropriate species choice and composition across the pit.</td>
<td>The thickness of the waste rock cover over the pit is greater than typical root penetration zone/depth. Revegetation strategy is informed by trial landform studies and other onsite revegetation trials. Plant species selection will consider topography and predicted edaphic conditions. Thickness of waste rock supports adequate plant available water.</td>
<td>C1</td>
</tr>
<tr>
<td>B 2</td>
<td>02</td>
<td>Consolidated tailings level impacts revegetation success in Pit 1.</td>
<td>Water deficit causes root system to infiltrate tailings. Inappropriate species choice and composition across the pit.</td>
<td>Thickness of waste rock cover greater than root penetration zone/depth. Revegetation strategy informed by trial landform studies and other onsite revegetation trials. Plant species selection will consider topography and predicted edaphic conditions. Thickness of waste rock supports adequate plant available water.</td>
<td>C1</td>
</tr>
<tr>
<td>Risk Type</td>
<td>Threat Title</td>
<td>Causes (Triggers / Indicators)</td>
<td>Impacts (Consequences)</td>
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<tr>
<td>Fauna</td>
<td>Inability to plant-out landform within timeframe.</td>
<td>Insufficient staff or mechanical planting techniques available. Competing close-up activities. Seasonal availability of landform is not optimum for planting. Low propagation success in nursery stage.</td>
<td>May not meet closure timeframe (e.g. s.41 agreement 8 Jan 2026).</td>
<td>Revegetation strategy informed by trial landform studies and other onsite revegetation trials. Expert propagation knowledge and implementation provided by existing contractor. Supply of contractor prequalification process in place. Implementation of closure schedule to meet the timeframe.</td>
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<tr>
<td>Fauna</td>
<td>Low plant survival rates in the field during establishment and vegetation decline at mature stage.</td>
<td>Low plant available water in waste rock substrate. Late seasonal fires. Competition from weedy species. Seasonal availability of landform is not optimum for planting. Plant disease. Lack of nutrient cycling. Lack of local accumulation of litters and fines (sediments). Fauna grazing on tubestock/seedlings. Elevated magnesium sulfate concentrations in groundwater.</td>
<td>Reduction in floristic diversity and density. Delay in revegetation schedule. Revegetation does not support fauna diversity. Unable to meet cultural criteria for a sustainable food and medicinal source.</td>
<td>Ongoing weed management (including research and trialling). Active weed and fire management, including treatments and monitoring. Implementation of rocky habitat areas.</td>
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<tr>
<td>Fauna</td>
<td>Feral animals occur at higher densities than in surrounding KNP.</td>
<td>Lack of management. Open disturbed area. Weed infestation. RPA becomes a source of feral animals to KNP. Impacts natural recruitment of fauna. Impacts revegetation success. Spreads weeds.</td>
<td>Active feral animal management aligned with current operational practices. Ongoing liaison with KNP regarding feral animal management strategies.</td>
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<tr>
<td>Fauna</td>
<td>Low plant propagation success in nursery stage.</td>
<td>Under skilled propagators. Lack of viable seed. Technical issues in the nursery - e.g. disease, procedures, equipment failures. Sole provider.</td>
<td>Reduction in floristic diversity and density. Delay in revegetation schedule. Revegetation does not support fauna diversity. Unable to meet cultural criteria for a sustainable food and medicinal source.</td>
<td>Expert propagation knowledge and implementation provided by existing contractor. Supply of contractor prequalification process in place. Multiple plant nurseries required to deliver plant volumes in later years.</td>
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<tr>
<td>Fauna</td>
<td>Insufficient volume or quality of viable seed stock available for whole of site revegetation.</td>
<td>Changes in seasonality - e.g. dryer wet season leads to less flowering and fruiting. Size of areas to be revegetated concurrently, exceed stock capacity. Late seasonal fires. Local provenance area may still be too restrictive. Availability of contractor/labour force to meet demand. Limited seed harvesting capacity.</td>
<td>Reduction in floristic diversity and density. Delay in revegetation schedule. Revegetation does not support fauna diversity. Unable to meet cultural criteria for a sustainable food and medicinal source.</td>
<td>Contract in place with seed and plant provider. Early collection and storage of seed stock. Implementation of revegetation schedule/plan. Further review of extent of local provenance area if necessary.</td>
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<tr>
<td>Fauna</td>
<td>Weeds from RPA impact KNP weed density and diversity.</td>
<td>Vectors leaving site - e.g. machinery, vehicles, animals, or wind or water-borne.</td>
<td>Increase in KNP weed density and species diversity. Introduction of new weed species into KNP.</td>
<td>Spray final landform surface prior to planting to reduce weed recruitment. Ongoing weed management (including research and trialling). Ongoing liaison with KNP regarding weed, and feral animal management strategies. Material selection for surface cover - e.g. limited treatall at the surface and use of weeds-free material. Weed and seed inspections. Implementation of post decommissioning access tracks for ongoing weed and fire management.</td>
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<tr>
<td>Fauna</td>
<td>Fire damage to habitat.</td>
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<tr>
<td>Fauna</td>
<td>Unsuitable growth medium to sustain framework species. Weed recruitment for surrounding KNP. Seedbank in landform medium.</td>
<td>Reduction in floristic diversity and density. Reduction in faunal diversity and density. Unable to meet cultural criteria for a sustainable food and medicinal source.</td>
<td>Spray final landform surface prior to planting to reduce weed recruitment. Ongoing weed management (including research and trialling). Ongoing liaison with KNP regarding weed, and feral animal management strategies. Material selection for surface cover - e.g. limited treatall at the surface and use of weeds-free material. Weed and seed inspections. Implementation of post decommissioning access tracks for ongoing weed and fire management.</td>
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</tr>
<tr>
<td>Fauna</td>
<td>Changes in seasonality - e.g. dryer wet season leads to less flowering and fruiting. Size of areas to be revegetated concurrently, exceed stock capacity. Late seasonal fires. Local provenance area may still be too restrictive. Availability of contractor/labour force to meet demand. Limited seed harvesting capacity.</td>
<td>Reduction in floristic diversity and density. Delay in revegetation schedule. Revegetation does not support fauna diversity. Unable to meet cultural criteria for a sustainable food and medicinal source.</td>
<td>Contract in place with seed and plant provider. Early collection and storage of seed stock. Implementation of revegetation schedule/plan. Further review of extent of local provenance area if necessary.</td>
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<tr>
<td>Fauna</td>
<td>Competition from feral animals and weeds. Fire damage to habitat. Compost from feral animals and weeds. Acutely toxic onsite waterbodies.</td>
<td>Reduction in floristic diversity and density. Delay in revegetation schedule. Revegetation does not support fauna diversity. Unable to meet cultural criteria for a sustainable food and medicinal source.</td>
<td>Expert propagation knowledge and implementation provided by existing contractor. Supply of contractor prequalification process in place. Multiple plant nurseries required to deliver plant volumes in later years.</td>
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<tr>
<td>Fauna</td>
<td>Insufficient volume or quality of viable seed stock available for whole of site revegetation.</td>
<td>Changes in seasonality - e.g. dryer wet season leads to less flowering and fruiting. Size of areas to be revegetated concurrently, exceed stock capacity. Late seasonal fires. Local provenance area may still be too restrictive. Availability of contractor/labour force to meet demand. Limited seed harvesting capacity.</td>
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</tr>
<tr>
<td>Risk Type</td>
<td>Risk Title</td>
<td>Causes (Triggers / Indicators)</td>
<td>Impacts (Consequences)</td>
<td>Existing/Proposed Controls</td>
<td></td>
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<td></td>
<td>Radiation doses from the final landform are not ALARA.</td>
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<td>Radiation levels from final landform exceed annual dose limits.</td>
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<td>Total above baseline radiation dose to plants and animals exceed UNSCEAR values.</td>
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<td>Elevated levels of contaminants (metals) in bush tucker.</td>
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<td>Levels of contamination in offsite drinking water exceed health guidelines.</td>
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<tr>
<td>Ref</td>
<td>Risk Type (T=Threat)</td>
<td>Category</td>
<td>Subcategory</td>
<td>Item</td>
<td>Risk Description</td>
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<tr>
<td>R4</td>
<td>Cultural heritage</td>
<td>C3</td>
<td></td>
<td></td>
<td>Damage occurs to cultural heritage site.</td>
</tr>
<tr>
<td>R4</td>
<td>Cultural heritage</td>
<td>C3</td>
<td></td>
<td></td>
<td>Surface water runoff and groundwater transport from the landform affects sacred site.</td>
</tr>
<tr>
<td>R4</td>
<td>Stakeholder &amp; legal expectations (includes agreements, commitments, etc)</td>
<td>C4</td>
<td></td>
<td></td>
<td>Rehabilitated site fails to meet stakeholder and/or community expectations.</td>
</tr>
<tr>
<td>R4</td>
<td>Cultural heritage</td>
<td>C4</td>
<td></td>
<td></td>
<td>Delays to rehabilitation and/or closure activities extending beyond 2008.</td>
</tr>
<tr>
<td>Ref</td>
<td>Category</td>
<td>Subcategory</td>
<td>Item</td>
<td>Applicable to</td>
<td>Risk Description</td>
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<tr>
<td>1</td>
<td>C 5 01</td>
<td>1</td>
<td>Closure activities may introduce new health and safety risks to workforce.</td>
<td>New hazards and risks associated with activities that are different from current operations.</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>C 5 02</td>
<td>2</td>
<td>Public may be injured on the rehabilitated site.</td>
<td>Uncapped bores. Uneven waste rock surface and trip hazards.</td>
<td></td>
</tr>
</tbody>
</table>