Chapter 5
Risk assessment method

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5 RISK ASSESSMENT FRAMEWORK

5.1 INTRODUCTION

This chapter describes the process for identifying, assessing and managing environmental risks associated with the Project. The environmental risk assessment was independently facilitated by RMI Pty Ltd. To assist with the environmental risk assessment scoping, the best practicable technology assessment was completed on the range of available project options and is provided in **Chapter 4**. The options that represent best practicable technology were then taken forward into the risk assessment.

The environmental risk assessment identified a total of 80 Project risks. Key environmental Project risks, i.e., risks identified as Class III and Class IV risks,[1] and new treatments (controls) identified during the risk assessment are discussed in detail in **Chapters 6** to **10, 13** and **14** and supporting **Appendix 5**.

Specifically this chapter includes:

- ERA's approach to risk management (**Section 5.2**)
- EIS guideline requirements (**Section 5.3**)
- Environmental risk assessment method (**Section 5.4**)
- Conclusion (**Section 5.5**)

In addition to the environmental risk assessment, there were two, dedicated, independent impact assessments undertaken: a) a social impact assessment by Banarra; and b) a traffic impact assessment by GHD Pty Ltd. Social risks identified during the environmental risk assessment workshops were subsequently incorporated into the social impact assessment to minimise duplication. Similarly, traffic risks were not considered during the environmental risk assessment due to the comprehensiveness of the traffic impact assessment. Full discussion on the outcomes of these two assessments including the assessment method for each study is presented in **Chapter 11** and **Chapter 12**, respectively.

5.2 ERA'S APPROACH TO RISK MANAGEMENT

ERA's overarching approach to determining potential health, safety and environmental risks is embedded in the company's hazard[2] identification and risk management standard. The hazards are analysed to identify any significant residual risks to human health, safety or the natural environment following the implementation of proposed mitigation measures. It 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,

[1] Class III risks are defined as requiring proactive management. Class IV risk are defined as needing urgent and immediate attention.

[2] A hazard is a source of potential harm, or a situation with the potential to cause loss or adverse impacts, i.e., a fuel storage tank; whereas a risk is the effect of uncertainty on objects, i.e., the chance of something happening that will have an impact on objects.

whereas potential impacts (consequences) are the "felt" consequence of event(s) triggered by the risk being realised.

This hazard identification and risk management standard has been 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 accordingly recorded and evaluated, and strategies are developed to manage them.

ERA's hazard identification and risk management standard is presented in **Figure 5-1**, 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.
- AS/NZS ISO 31000:2009 Risk management – principles and guidelines.
- 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 specify stringent standards to safeguard that risk controls ensure:
    - 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.

A risk register, containing health, safety and environmental risks, is maintained and reviewed for Ranger mine.

ERA's primary goal of hazard and risk identification is to eliminate operational hazards as far as reasonably practicable and, if not reasonably practicable, to minimise the likelihood and/ or consequences as far as is reasonably practicable. ERA maintains a risk management framework to meet the requirements of its Health and Safety Policy and Environment Policy. These policies can be found on the ERA website at:

http://www.energyres.com.au/index_ourapproach.asp.

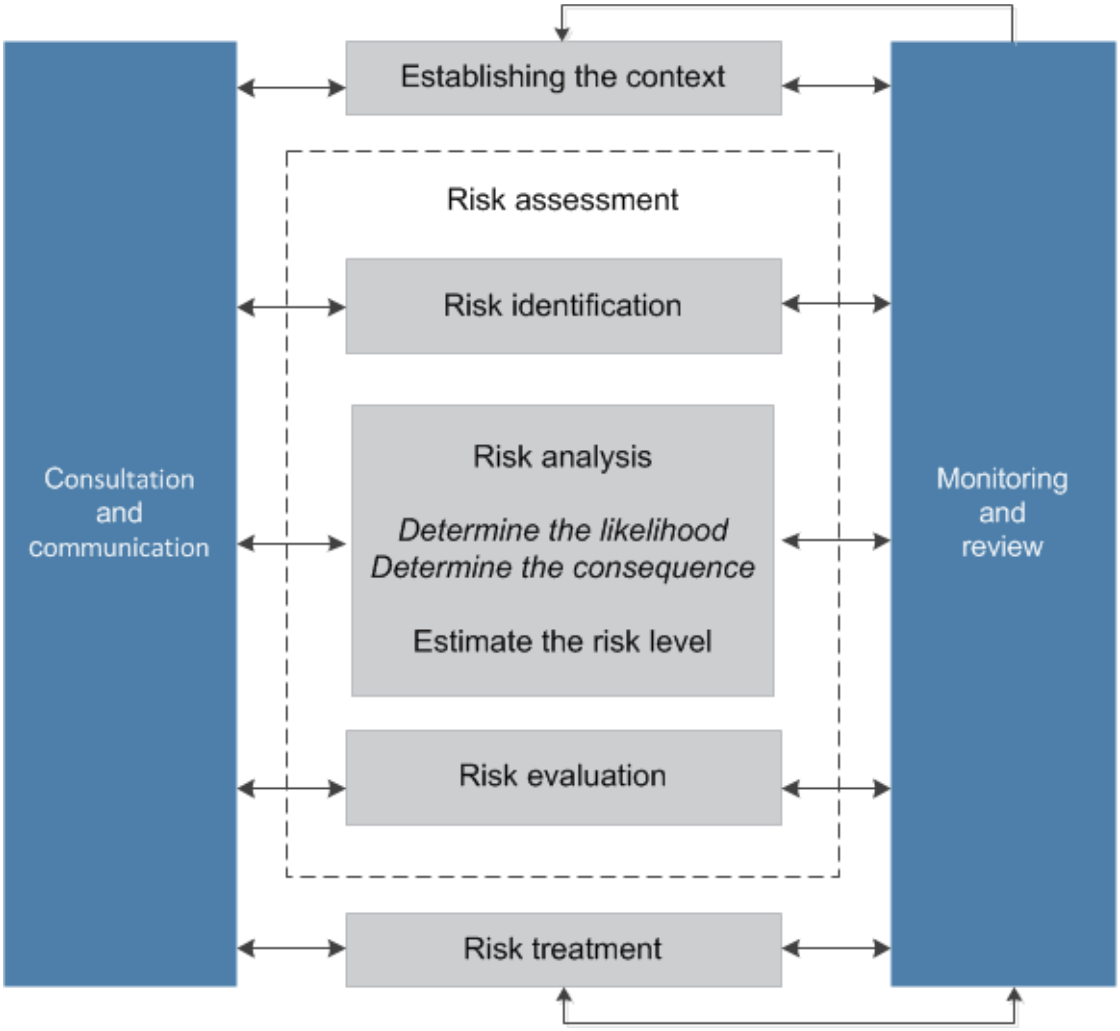

Figure 5-1: Risk management process (source: AS/NZS ISO 31000:2009)

5.2.1 Levels of Risk Assessment

The level of risk assessment depends on the nature of the hazard and the extent of rigor required. Three levels of risk assessment are routinely applied at ERA's operations:

- Level 1 assessment such as Take 5 and Job Hazard Analysis are the most common.
- Level 2 assessments occur in circumstances where a more rigorous approach is required and use a matrix to assess the extent of risk, based on likelihood and severity of consequence. Level 2 assessments are detailed in ERA's risk registers, which are maintained and reviewed periodically.
- Level 3 assessments are the most rigorous and use quantitative or semi-quantitative techniques for significant or complex risks. ERA undertakes a comprehensive review of its most significant risks every two years using a semi-quantitative risk assessment process.

Hazards and risks identified during level 2 and level 3 assessments are recorded in the risk register. ERA's risk management framework is monitored and reviewed in accordance with

the assurance practices shown in **Figure 5-2** and outlined in SA/SNZ HB 436:2013 (Guidelines to AS/NZS ISO 31000:2009). As the most rigorous assessment the level 3 process has been applied to the risk assessment of the Project.

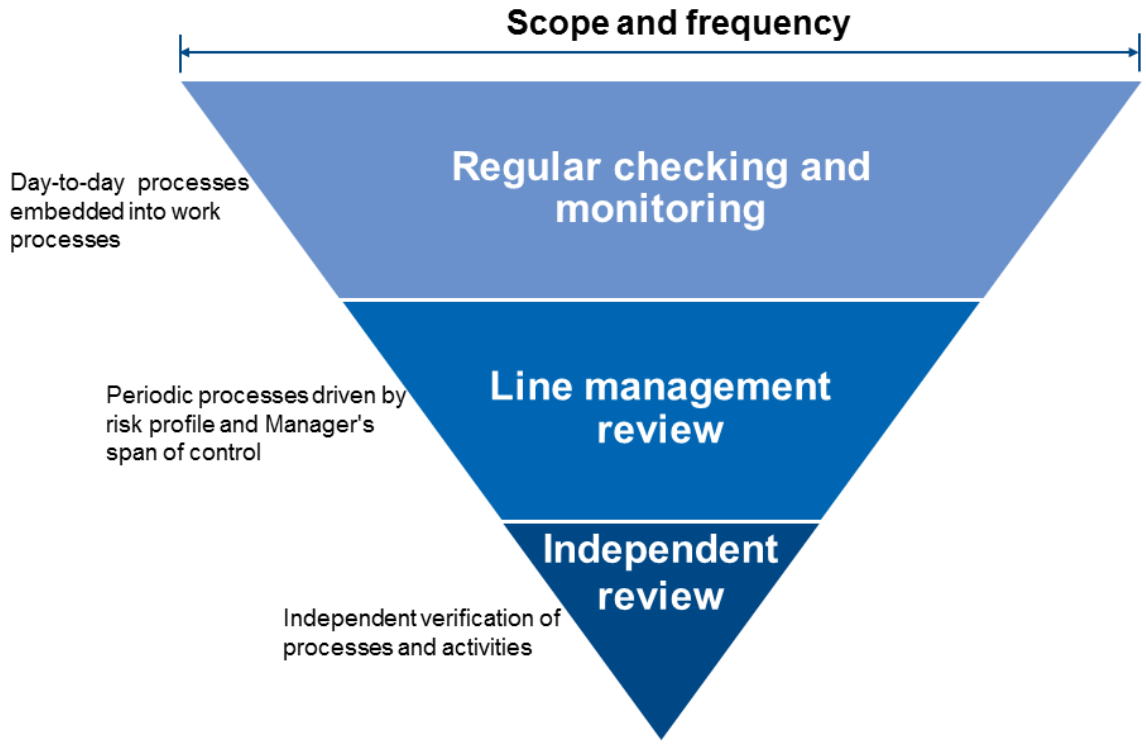

Figure 5-2: Hierarchy of monitor and review activities (source: SA/SNZ HB436:2013)

5.3 EIS GUIDELINE REQUIREMENTS

Section 4 of the EIS guidelines[3] requires a risk assessment approach that:

- *"Identifies and discusses the full range of risks presented by the project, including those of special concern to the public; identifies relevant impacts; quantifies and ranks risks so that the reasons for proposed management responses are clear; and identifies levels of any uncertainty about estimates of risk and the effectiveness of risk controls in mitigating risk."* (NT EPA & SEWPAC 2013; p 12.)

The EIS guidelines also highlight a number of potential environmental areas of risk associated with the Project. These include:

- Uncertainty around the scope of the project in relation to the scale, operational factors, timeframes, and complexity of all components with respect to the current operations, including closure activities, at the Ranger mine.
- Regional water resources, and dependent ecosystems, from the development, operation and closure of the underground mine.

[3] The EIS guidelines are provided as Appendix 2.

- Creation of new radiation risks with the potential to increase exposure and associated health risks to employees, the public, and the environment.
- The environment and public safety from the transportation of uranium, explosives (bulk emulsion), and consumables, including dangerous goods, on public road.
- Localised impacts from the ventilation and fan exhausts with respect to noise, amenity, and areas of deposition and accumulation of dusts and contaminants from the underground operations on surface soils and vegetation, including bush foods.
- Uncertainties associated with processing the Ranger 3 Deeps ore and associated management of water, tailings and waste streams.

5.4 ENVIRONMENTAL RISK ASSESSMENT METHOD

5.4.1 Overview

To address the concerns identified in the EIS guidelines, the environmental risk assessment was undertaken to determine and assess potential impacts arising from key aspects of the Project, including but not limited to: emissions, human health and safety, water, flora and fauna, cultural heritage, Commonwealth matters of national environmental significance (MNES), and closure and rehabilitation.

Potential risks were identified by considering; a) facilities present during all Project phases (e.g., construction operation and closure); and b) the activities associated with the facilities and phases. For each risk, 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 threat[4] identification number and initially assessed by using a risk matrix and applying a consequence and likelihood rating to the potential impact. This step of the assessment process took into account any existing operational controls, to generate an "inherent" risk ranking established for the area of the environment (aspect) anticipated to have the highest potential impact, e.g., flora and fauna, human health and safety, cultural heritage.

Where possible, a number of new treatments[5] were identified to minimise the severity of potential impacts or decrease its likelihood of occurrence, thereby increasing certainty around protecting the surrounding environment. The risk scenario was reassessed across all environmental aspects and relevant Project phases to give a residual risk ranking. The new treatments will be incorporated into the Project design, ERA's existing management systems and associated management plans. The new treatments derived from the risk assessment are described and discussed in **Chapter 15** and **Appendix 17**, which should be read in conjunction with this chapter.

[4] Where the term "threat" is used interchangeably with the term "risk".

[5] "Treatments" is terminology consistent with risk analysis standards. Treatments might more generically be termed "controls" or "mitigation measures".

5.4.2 Method

The environmental risk assessment identified potential risks and impacts to, for example, human health and safety; water, air quality, biodiversity; and, the surrounding Kakadu National Park.

The risk identification process is dynamic and requires ongoing monitoring of tasks, controls and human elements of risk management, to ensure that changes in the operation, or the environment of the operation, trigger a review of the adequacy of controls. An analysis of the risks was carried out by ERA based on experience at the existing Ranger mine and other similar construction and operational projects nationally and internationally. The analysis outlines the implications for, and the potential impacts on, surrounding land uses and includes:

- Relevant health, safety, environment, and cultural heritage hazards.
- The possible frequency of occurrence of hazards, accidents, spillages, and abnormal events occurring during all stages of the Project;
- Cumulative risks to surrounding land uses and users (**Section 5.4.5**).
- Evaluation of the environmental and social risks associated with the construction, operation, closure and post-closure of the Project on the surrounding and downstream environments.

As outlined previously in **Section 5.3**, the EIS guidelines highlighted six potential areas of risk relating to such matters as: uncertainty of the scale and complexity of the Project; impacts to regional water resources; radiation risks; transportation; localised amenity issues such as noise and air quality; and onsite water management.

Potential risk scenarios were identified by considering the range of:

- Activities carried out and facilities present during all phases of the Project; and,
- Potentially hazardous events (incidents) that might be associated with each of the activities or facilities.

5.4.3 Hazard Identification and Analysis

The aim of hazard identification is to generate a comprehensive list of risks over the life of the Project, based on the Project activities that may result in an environmental impact. This process was undertaken in a series of independently facilitated workshops held in Darwin on 9 – 13 December 2013. The workshops were attended by a cross-section of internal stakeholders and specialist ecological, social and radiation consultants. A full list of participants is provided in **Appendix 5**.

As a first step, a risk breakdown structure was established from the key areas of risk identified in the EIS guidelines and is provided in **Table 5-1**. 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 particular areas/elements of the Project to ensure that risk identification is undertaken at a sufficient level of detail.

Table 5-1: Risk breakdown structure

Surface infrastructure • Surface preparation • Ventilation raise construction • Surface ventilation infrastructure operation • Power supply • Backfill plant • Fuels facilities • Potable water supply	Mining operations • General operations • Dill and blast • Ground support installation • Load, haul and dump • Paste backfill • Water management • Ventilation
Processing • Beneficiation • Material movement • Water management • Consumables	Waste management • Waste rock • Tailings • Radioactive waste • Non-radioactive waste • Hazardous waste • General waste • Emissions
Rehabilitation and closure • Grouting of surface drillholes • Infrastructure removal • Decline and ventilation raise backfill • Neutralisation of acid waste • Soil remediation • Revegetation • Earthworks	Health and safety • Surface activities • Underground activities • Radiation exposure

The likelihood (**Table 5-2**) and severity of consequences (**Table 5-3**) were defined for each environmental aspect and factor (receptor) relevant to the Project. The consequence definitions are based on the Rio Tinto risk scheme and were customised to align with the particular environmental, radiation and cultural sensitivities of Ranger mine's location. For example, the consequence definitions encapsulate those environmental aspects that may lead to a significant impact to the world heritage values upon which Kakadu National Park is inscribed, and therefore address aspects of MNES which are relevant to the Project.

Table 5-2: Likelihood classification

	Likelihood				
	Rare	**Unlikely**	**Possible**	**Likely**	**Almost certain**
Frequency Interval (multiple events)	<1/100 years	1/10 – 1/100 years	1 year – 1/10 years	2/year – 1/year	>2/year
Probability (single events)	<0.1%	0.1% – 1%	1% – 10%	10% – 25%	>25%

The risk rankings were determined for each risk using the risk matrix shown in **Figure 5-3**. The matrix is a tabular portrayal of risk as the combination of the probability of occurrence and consequence severity.

	Severity				
	Very low	**Low**	**Moderate**	**High**	**Very high**
Almost certain	Class II	Class III	Class IV	Class IV	Class IV
Likely	Class II	Class III	Class III	Class IV	Class IV
Possible	Class I	Class II	Class III	Class IV	Class IV
Unlikely	Class I	Class I	Class II	Class III	Class IV
Rare	Class I	Class I	Class II	Class III	Class III

Figure 5-3: Risk assessment matrix

Risk scenarios that result in the highest ranked potential impacts (Class III and Class IV) are judged to have the highest priority for consideration of additional risk reduction treatments. However, 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 5**). All new treatments identified during the risk assessment are discussed in the ensuing chapters and will be incorporated into ERA's existing environmental management plans.

The consequences assessed included both threats to the natural environment and to the health and safety of the workforce and the public based on definitions provided in **Table 5-3**.

In addition to assigning the risk rankings, the assessment also applied a certainty level to each overall risk ranking based on the quality of data and information available (**Table 5-4**). The certainty assessment applied to each risk therefore incorporates the effectiveness of the treatments in mitigating the risk.

Ranking each risk was based on the following:

- Risks were initially assessed and ranked with existing operational controls (current ranking). The initial ranking is also known as the inherent risk ranking. Where appropriate new treatments were identified in addition to the existing operational treatments, the risk was reassessed with existing and new treatments in place to give a final or residual risk ranking. Where a risk impacts several environmental aspects, each potential outcome was assessed in turn.
- The severity of the consequence of each event, should it occur, takes into consideration the maximum reasonable outcome with the proposed mitigation measures (treatments) in place.[6]
- Cumulative impacts associated with the Project have been implicitly considered in the overall approach to the environmental risk assessment. The outcome of the environmental risk assessment and associated risk rankings is also informed by the results of technical (specialist) studies that have assessed the cumulative impacts, of both the existing operation and the Project, in terms of, for example: emissions (**Chapter 6**), radiation (**Chapter 7** and **Chapter 9**) and solute transport modelling (**Chapter 13**).
- Potential impacts on sensitive receptors were considered when evaluating and ranking each risk scenario. Such receptors include Kakadu National Park, contractor and fly-in fly-out employee camps, the 009 transient camp, the Jabiru airport precinct, Jabiru township, Mount Brockman, and cultural heritage site R34. (For a detailed description and map of the locations of sensitive receptors, refer **Section 6.2**.)

As outlined above, all new treatments identified during the risk assessment (for high and low risks) are aggregated in **Chapter 15** and its associated **Appendix 17**, where the overall management strategies associated with each environmental aspect and factor of the Project are discussed. In addition, **Chapter 15** identifies the relevant environmental management plan within which the treatments will be incorporated, and **Appendix 17** details the action plans against each environmental aspect.

[6] The maximum reasonable consequence is the largest realistic or credible consequence from an event, considering the credible failure of controls. It is generally a higher consequence than the most likely consequence and less severe than the worst case consequence which considers the failure of all controls.

Table 5-3: Consequence classes for hazardous events

Consequence type	Consequences				
	Very low	**Low**	**Moderate**	**High**	**Very high**
Health	Reversible health effects of little concern, requiring first aid treatment at most. Can include minor irritations of eyes, throat, nose and/ or skin, or minor unaccustomed muscular discomfort.	Reversible health effects of concern that would typically result in medical treatment. Can include temperature effects; travel effects; stress; and sunburn.	Severe, reversible health effects of concern that would typically result in a lost time incident. Can include acute/medium-term effects associated with extreme temperature effects or musculo-skeletal effects; vibration effects; nervous system effects; some infectious diseases; and non-falciparum malaria.	Single fatality or irreversible health effects or disabling illness. Can include effects of suspected carcinogens, mutogens, teratogens and reproductive toxicants, progressive chronic conditions and/or acute/medium-term high risk effects.	Multiple fatalities or serious disabling illness to multiple people. Can include effects of known human carcinogens, mutogens teratogens and reproductive toxicants, and life threatening respiratory sensitisation and falciparum malaria.
Safety	Low level short term subjective inconvenience or symptoms. Typically a first aid and no medical treatment.	Reversible injuries requiring treatment, but does not lead to restricted duties. Typically a medical treatment.	Reversible injury or moderate irreversible damage or impairment to one or more persons. Typically a lost time injury.	Single fatality and/or severe irreversible damage or severe impairment to one or more persons.	Multiple fatalities or permanent damage to multiple people.
General flora and fauna	Insignificant effect	Local short-term decrease in abundance of some species with no lasting effects on local population.	Local long-term decrease in abundance of some species resulting in some change to community structure.	Regional decrease in abundance of some species resulting in some changes to community structure.	Regional loss of numerous species resulting in the dominance of only a few species.
Species of conservation significance	Minor local habitat modification and/or lifecycle disruption for a listed species. No loss of individuals of listed fauna species.	Moderate local habitat modification and/or lifecycle disruption for a listed species. Minor local decrease in size of population(s) of listed fauna species.	Substantial local habitat modification and/or lifecycle disruption for a listed species. Moderate local decrease in size of population(s) of listed fauna species.	Moderate regional habitat modification and/ or lifecycle disruption for a listed species. Substantial local decrease in size of population(s) of listed fauna species.	Substantial regional habitat modification and/or lifecycle disruption for a listed species. Moderate or substantial regional decrease in size of population(s) of listed

Consequence type	Consequences				
	Very low	Low	Moderate	High	Very high
					fauna species.
Community trust	Tangible expressions of trust/ mistrust amongst a handful of community members with no influence on public opinion and decision-makers.	Tangible expressions of trust/ mistrust amongst a few community members with some influence on public opinion and decision-makers.	Tangible expressions of trust/ mistrust amongst some community members with moderate influence on public opinion and decision-makers.	Tangible expressions of trust/ mistrust amongst most community members with significant influence on decision-makers.	Widespread loss/gain of trust across the community setting the agenda for decision-makers and key stakeholders.
Compliance	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.	Non-compliance with external or internal requirement with low potential for impact. Formal censure. Non-compliance with community commitment, requiring limited effort to correct.	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.	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.	Suspended or severely reduced operations imposed by regulators. Breach of community commitment results in direct loss of established consents with widespread secondary effects.
Reputation	Community complaint resolved via existing site procedures Impact on reputation of several work areas within an operation. One off public exposure in local media, word of mouth or local mythologies.	Impact on reputation of Business Unit. Significant public exposure in local media.	Impact on reputation of Product Group. Comment from national non-government organisation(s) which impacts credibility with neighbours/regional government. Public exposure in national media.	Impact on reputation of Rio Tinto Group. Comment from international non-government organisation(s). Public exposure in international media	Severe impact on reputation of Rio Tinto Group. Severe prolonged comment from international non-government organisation(s). Greater than three years public exposure in

Consequence type	Consequences				
	Very low	Low	Moderate	High	Very high
					international media.
Aboriginal and cultural heritage	Insignificant effect. Encroachment on non-archaeologically surveyed area.	Repairable damage to site or item of low cultural significance. Non-conformance with ERA internal land disturbance permit procedures.	Irreparable damage to site or item of low cultural significance. Relocation of archaeological findings in agreement with heritage regulation.	Repairable damage to site or item of cultural significance. Infringement of heritage regulation, as a result of ignoring the current cultural GIS, likely to tarnish ERA's image.	Irreparable damage to site or item of cultural significance. Damage to Aboriginal Areas Protection Authority listed site(s) leading to tension with Traditional Owners and NT Government. Negative effect on Rio Tinto's image of an environmentally conscious company supportive of indigenous cultures.
Amenity	Visual: No noticeable change to vista as viewed from sensitive premises. Noise: Negligible noise level increase at closest affected receiver <1dBA (not noticeable by all people).	Visual: Near-source and short-term change to vista as viewed from sensitive premises. Noise: Marginal noise level increase at closest affected receiver 1 dBA to 2 dBA (not noticeable by most people).	Visual: Near-source and medium-term, or local and short-term change to vista as viewed from sensitive premises. Noise: Moderate noise level increase at closest affected receiver 3 dBA to 5 dBA (not noticeable by some people but may be noticeable by others).	Visual: Near-source and long-term, or local and medium-term change to vista as viewed from sensitive premises. Noise: Appreciable noise level increase at closest affected receiver 5 dBA to 10 dBA (noticeable by most people).	Visual: Local and long-term change to vista as viewed from sensitive premises. Noise: Significant noise level increase at closest affected receiver > 10 dBA (noticeable by nearly everyone).

Consequence type	Consequences				
	Very low	**Low**	**Moderate**	**High**	**Very high**
Soils	Near surface soils are confined and short-term impact. Promptly reversible.	Near-surface soils confined and medium-term reversible impact. May take <1 year to remediation.	Near-surface soils confined and long-term recovery impact. May take >1 year for full remediation.	Impact most likely affecting deep soil profiles and requiring long-term recovery, leaving residual damage. May take years for full remediation.	Impact most likely affecting deep soil profiles and requiring long-term recovery, leaving major residual damage. May take decades for full remediation.
Surface water	Minimal contamination or change with no significant loss of quality.	Near-source medium-term contamination or change in water quality.	Local short-term contamination or change in water quality.	Local medium-term contamination or change in water quality.	Regional long-term contamination or change in water quality.
Groundwater	Quality: Near-source contaminants confined and promptly reversible impact. Promptly reversible. Drawdown: Insignificant effect.	Quality: Near-source contaminants confined and medium-term reversible impact. May take <1 year to remediate. Drawdown: Near-source minor change in recharge patterns within sub-catchments.	Quality: Near-source contaminants confined and medium-term impact. May take >1 year to remediate. Drawdown: Near-source major change in recharge patterns within sub-catchments.	Quality: Large volumes of, or deep-seated contaminants requiring long-term recovery. May take years for full remediation. Drawdown: Local major changes in recharge patterns within sub-catchments.	Quality: Large volumes of, or deep-seated contaminants requiring long-term recovery. May take decades for full remediation. Drawdown: Regional major changes in recharge patterns.
Air quality	No measureable air quality impacts.	Local medium-term and minor exceedance(s) of standards.	Local long-term change in air quality.	Regional medium-term change in air quality.	Regional long-term change in air quality.
Radiation	Measurable increase in radiation dose with outcomes remaining below dose constraints.	Increase in radiation dose above the dose constraints but still below international limits	Increase in radiation dose to above international limits	Radiation doses above 100 mSv to an individual and likely to significantly increase the risk of cancer to that individual.	Radiation doses to multiple individuals above 100 mSv or acute radiation syndrome to an individual.

Table 5-4: Certainty descriptors

Control rank	Description	Guidance
C1	Low	Risk ranking is based on subjective opinion or relevant past experiences
C2	Moderate	Risk ranking is based on similar conditions being observed previously and/ or qualitative analysis. Analysis is based on unverified models and/ or data.
C3	High	Risk ranking is based on testing, high fidelity modelling or simulation, use of prototype or experiments. Analysis is based on verified models and/ or data. Assessment is based on an historical basis.

5.4.4 Bow Tie Analysis

A selected number of risks were subject to a Bow Tie analysis to gain a better understanding of the extent and quality of mitigation measures that might exist for the management of those risks. The criteria used to identify those risks that were subject to a Bow Tie analysis were the current risk rankings, where the risk was determined to be:

- Class IV (most severe level of risk).
- A higher consequence/lower likelihood Class III risk.

There are five main steps in developing a basic Bow Tie diagram, including:

- Clarification of the event of interest: typically for a Bow Tie diagram it is the event of interest (the risk) that ties the threat to the consequence.
- Causal analysis to identify the possible causes of the event of interest.
- Identification of a) different types of consequences within the same broad areas of impact, e.g., safety; and b) identification of consequences in different areas of impact.
- The steps above provide the basic structure of the Bow Tie diagram, i.e., the event of interest (the risk), possible causes (threats) and possible consequences (**Figure 5-4**).
- The final two steps in developing a basic Bow Tie diagram include:
- Identification of preventative controls that seek to prevent the event of interest occurring and therefore are located on the left hand side of the Bow Tie diagram. For example, controls 1.1, 1.2 and 2.1 are preventative controls (see **Figure 5-5**).
- As well as preventative controls, there may also be recovery or mitigation controls that seek to prevent the escalation of consequences. These are identified and included on the right hand side of the Bow Tie diagram (**Figure 5-5**).

In undertaking the Bow Tie analysis, three broad topic areas were considered that involved aggregating several common risks into the same topic area, namely:

- Project interaction with radiation exposure at elevated levels;
- cultural heritage site, place or object; and
- excessive mobilisation of solutes[7] to Magela Creek from tailings or waste rock; contained within either the underground void backfill material or Pit 3.

The results of these analyses are discussed in **Chapters 7**, **10** and **13**, respectively.

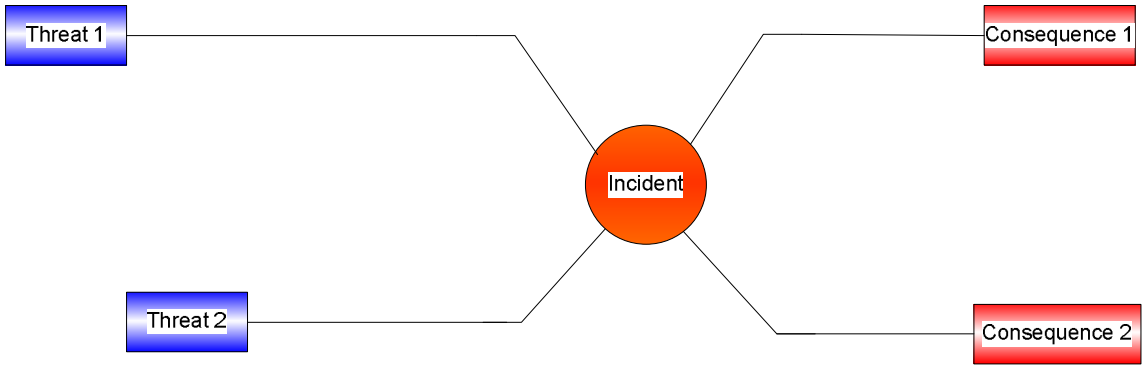

Figure 5-4: Basic structure of the Bow Tie diagram

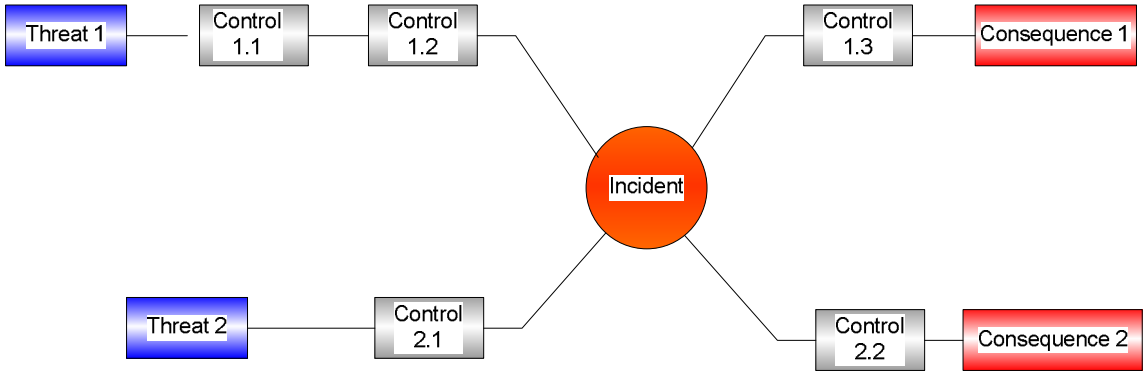

Figure 5-5: Final structure of the Bow Tie diagram

5.4.5 Cumulative Impacts

Cumulative impacts associated with the Project have been implicitly considered in the overall approach to the environmental risk assessment and impact assessments. As an established operation, ERA has a comprehensive understanding of the existing operational risk profile. This is part of the company's ongoing approach to risk management. The identification and

[7] A solute is a dissolved chemical constituent, typically a "salt". A range of solutes originating from the Project may have the potential to cause harm to the environment if they were to reach the Magela Creek in sufficiently high concentration.

assessment of Project aspects and associated risks have been considered in combination with current risks where they have potential to interact with the environment. The outcome of the environmental risk assessment and associated risk rankings is further informed by the results of technical (specialist) studies that have assessed the cumulative impacts of both the existing operation and the Project, in terms of, for example: solute transport modelling, air emissions, noise and vibration), and radiation. Cumulative impacts are discussed in the relevant chapter.

5.4.6 Monitoring and Review

As outlined in **Section 5.2.1**, significant risks identified during Level 3 assessments undergo a comprehensive review every two years using a semi-quantitative risk assessment process and are detailed in ERA's risk registers. Level 2 assessments are also detailed in ERA's risk registers, which are maintained and reviewed periodically.

In addition to the review of significant risks and risk registers, ERA's risk management framework is monitored and reviewed in accordance with the assurance practices outlined in SA/SNZ HB 436:2013.

5.4.7 Risk Assessment Outcomes and Management

A total of 80 risks were identified for the Project (**Appendix 5**). Of these 80 risks, 34 risks were identified as having an inherent risk ranking of Class III (32) or Class IV (2) (refer **Figure 5-6**). **Figure 5-7** shows the overall residual risk profile, which takes into account existing controls and new treatments or controls that have been firmly committed as part of the project scope. The overall residual risk profile indicates 19 Class III risks and no Class IV risks and the remainder of the residual risk rankings being either Class I or Class II.

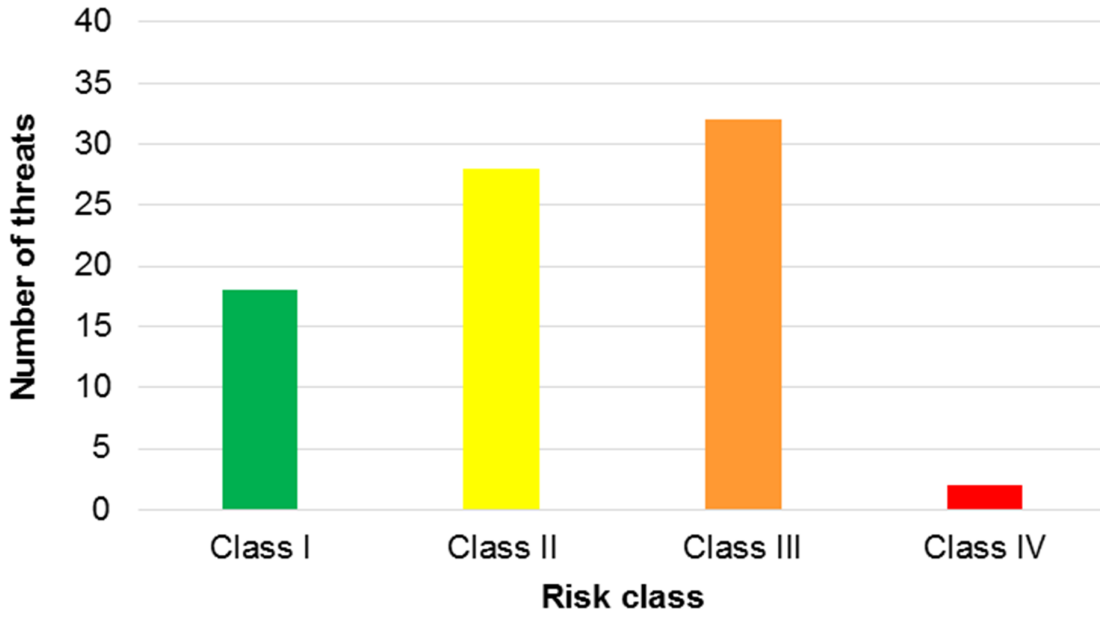

Figure 5-6: Current (inherent) risk profile

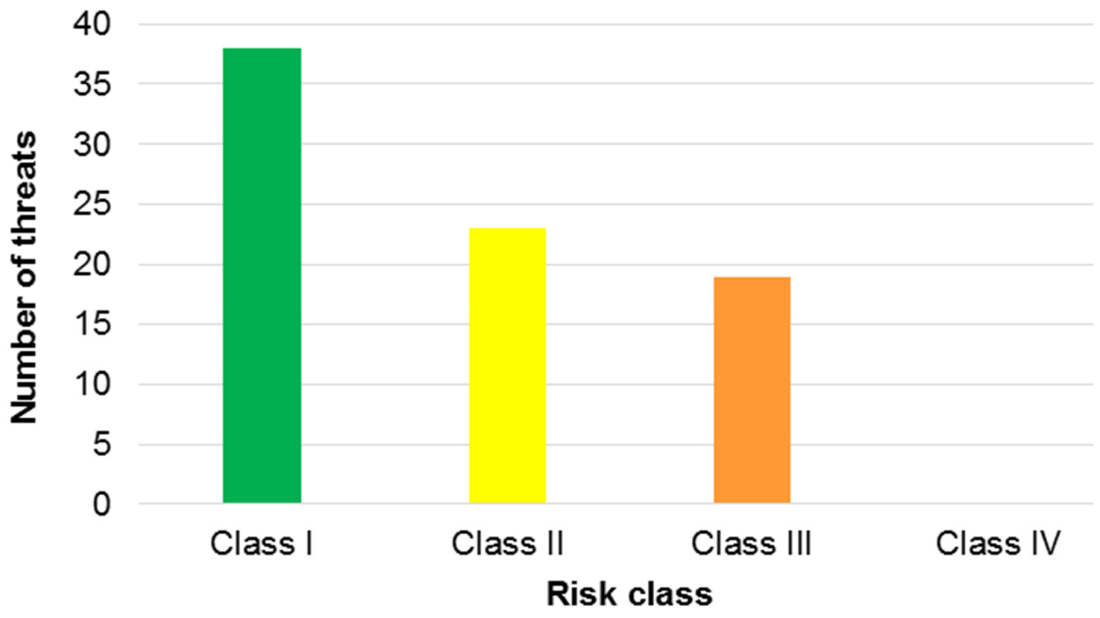

Figure 5-7: Residual risk profile

The distribution of the residual Class III and Class IV risks based on the main risk breakdown structure elements is provided in **Figure 5-8** and shows the large number of Class III health and safety risks, compared to the distribution across the remaining breakdown structure elements. As highlighted in **Appendix 5**, significant health and safety risks are those with high consequences and low likelihood and therefore are automatically classified as Class III risks. A full discussion on the Class III health and safety risks is provided in **Chapter 7**.

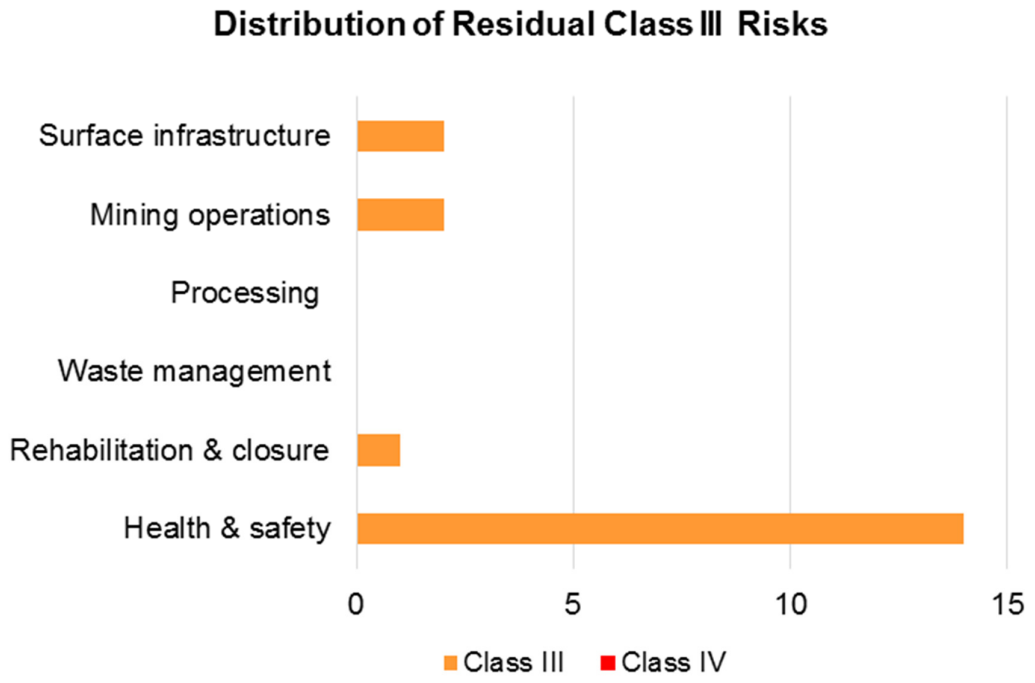

Figure 5-8: Distribution of residual Class III risks

While the primary focus of discussion in the ensuing chapters is the Class III and Class IV risks and additional treatments identified during the risk assessment process, the chapters will also include discussion of any lower ranked risks known to be of particular interest to stakeholders.

Some potential impacts that were categorised as Class III or IV at the time of the risk workshop remain listed within the register as residual Class III after the consideration of new treatments. However, a consequence of this iterative interaction between risk analysis and studies is that in a number of cases finalisation of the studies has demonstrated the potential impact or its likelihood of occurrence is less than that recorded in the register and thus a lower risk ranking in now appropriate. Rather than adjust the register, these particular risks are also discussed in the relevant chapters.

As highlighted above, risk assessment is an ongoing process, which is formally revisited at various stages of project planning and execution. The risk workshop that culminated in the risk register and the risk report provided as **Appendix 5** was conducted in December 2013. Numerous technical and environmental impact studies have been undertaken through various stages of the project development, including specifically for this EIS. Earlier studies contributed to the information available at the time of the December risk analysis workshop, and the workshop informed the scope for subsequent environmental studies.

5.5 CONCLUSION

The environmental risk assessment identified a total of 80 risks (**Appendix 5**). Where there are multiple outcomes for a risk, the highest risk ranking (based on the assessment of multiple consequence categories) is recorded in the risk register. Risk rankings reflect the appropriate controls, management strategies, and mitigation measures that will be implemented to manage each risk.

Of all the environmental risks that were assessed, 34 were identified as having an inherent risk ranking of Class III or Class IV. The final residual risk profile indicates 19 Class III risks and no Class IV risks. The remainder of the residual risk rankings were either Class I or Class II. The primary focus of discussion in **Chapters 6** to **10**, **13** and **14** will be potential impacts associated with the Class III and Class IV risks, and any additional treatments identified during the risk assessment process. However, these chapters will also include discussion of any lower ranked risks known to be of particular interest to stakeholders.

5.6 REFERENCES

NT Environment Protection Authority & Department of Sustainability Environment Water Population and Communities (2013) Guidelines for the Preparation of an Environmental Impact Statement: Ranger 3 Deeps Underground Mine, Energy Resources of Australia Ltd, Issued by the NT EPA, Darwin, Northern Territory, p 44.

Standards Australia (2009) AS/NZS ISO 31000:2009: Risk management - Principles and Guidelines, p 37.