RioTinto

Environmental Review Document - Appendices

West Angelas Revised Proposal

Robe River Mining Co. Pty. Ltd.

Assessment Number: 2290

December 2023

Robe River Mining Co. Pty. Ltd.

152-158 St Georges Terrace, Perth WA 6000

GPO Box A42, Perth WA 6837

RTIO-0997696

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ENVIRONMENTAL SCOPING DOCUMENT

WEST ANGELAS REVISED PROPOSAL

1. INTRODUCTION

The Environmental Protection Authority (EPA) has determined that the above Proposal is to be assessed under Part IV of the *Environmental Protection Act 1986* (EP Act).

The purpose of the Environmental Scoping Document (ESD) is to define the form, content, indicative timing and procedure of the environmental review, required by s. 40(3) of the Act.

Robe River Mining Co. Pty Ltd (the Proponent) has prepared this draft ESD according to the procedures in the EPA's *Procedures Manual*.

The EPA requires the Proponent to undertake the environmental review according to the procedures in the EPA's *Administrative Procedures* and *Procedures Manual*, and the *Instructions and Template: How to prepare an Environmental Review Document*.

Table 1 General Proposal and Proponent Information

Proposal name:	West Angelas Revised Proposal
Proponent:	Robe River Mining Co. Pty. Ltd.
Assessment number:	2290
Location:	The West Angelas Revised Proposal is located approximately 130 km northwest of Newman in the east Pilbara region of Western Australia.
Local Government Area:	Shire of East Pilbara and Shire of Ashburton
Public review period:	Environmental Review Document – Public Environmental Review; 8 weeks
EPBC Reference Number:	2021/8923

1.1. INDICATIVE TIMING OF THE ENVIRONMENTAL REVIEW

Table 2 sets out the indicative outline of the timing of the environmental review (indicative timeline) agreed between the EPA and the Proponent.

Table 2: Indicative outline of the timing of the environmental review (indicative timeline)

Key Assessment Milestones	Completion Date
EPA approves ESD	February 2023
Proponent submits first draft Environmental Review Document (ERD)	March 2023
EPA provides comment on draft ERD (including Department of Climate Change, Energy, the Environment and Water (DCCEEW) comments) *(6 weeks from receipt of ERD)*	April 2023
Proponent submits revised draft ERD	July 2023
EPA authorises release of ERD for public review *(2 weeks from EPA approval of ERD)*	September 2023
Proponent releases ERD for public review for 8 weeks	October 2023

Close of public review period	December 2023
EPA provides Summary of Submissions *(3 weeks from close of public review period)*	December 2023
Proponent provides Response to Submissions	May 2024
EPA reviews the Response to Submissions (includes DCCEEW review) *(4 weeks from receipt of Response to Submissions)*	June 2024
Proponent submits revised final Response to Submissions	July 2024
EPA finalises Assessment Report (including two-week consultation on draft conditions) and gives report to Minister. Assessment Report (which includes draft Ministerial Statement) to be provided to DCCEEW. *(6 weeks from completion of assessment)*	December 2024

1.2. COMMONWEALTH GOVERNMENT APPROVALS

The Proposal has been referred and determined to be a 'Controlled Action' under the *Environment Protection and Biodiversity Conservation Act 1999* (Cth) on 1 June 2021 (EPBC 2021/8923). The Proposal is being assessed an accredited process under section 87 of that Act. Further information regarding Commonwealth Government approvals can be found in Attachment 1.

2. FORM AND CONTENT (REQUIRED WORK)

The EPA requires that the form of the report on the environmental review required under section 40 of the EP Act is in accordance with the *Instructions and Template: How to prepare an Environmental Review Document*. The EPA requires that the content of the Environmental Review Document (ERD) is in accordance with the *Instructions and Template: How to prepare an Environmental Review Document.*

Work required to inform the ERD will be conducted in accordance with the requirements of EPA Environmental Factor Guidelines and Technical Guidance for each preliminary key environmental factor and that a consolidated report of the surveys and/or investigations undertaken is provided for each factor. Where previous investigations or surveys are relied upon, justification will be provided to demonstrate that they are relevant and consistent with EPA guidance.

As the Proposal is a significant amendment to Ministerial Statement 1113, the ERD will also include the following required information:

- The approved proposal, such that the environmental impacts may be considered in the context with the significant amendment.
- The combined effects that implementation of the significant amendment with the approved proposal might have on the environment.
- The existing implementation conditions and whether the Proponent considers these should be inquired into or proposes amendments.
- Consideration of existing implementation conditions are adequate to ensure the Proposal's ongoing elements are consistent with the EPA's environmental objectives.
- Consideration of whether outcome conditions and associated monitoring can replace existing management plan conditions.
- Where existing management plan conditions are proposed to continue, include updated plans to address combined impacts and to ensure amended proposal meets current EPA objectives.
- Consideration of Section 3.2.1 of the *Environmental Impact Assessment (Part IV Divisions 1 and 2) Procedures Manual.*

The EPA also requires that the environmental review includes the Proposal specific additional content outlined in Section 2.

The Proponent will also undertake a review of the ERD to ensure the requirements of the relevant EPA instructions, templates and guidance have been met. The ERD will include a scoping checklist that identifies the section(s) and page number of the ERD indicating where both all the dot points in the scoping checklist on page 5 of the ERD Template (2021) and the requirements of this ESD can be found,

2.1. Preliminary Key Environmental Factors

The preliminary key environmental factors to be addressed in the ERD are:

1. Inland waters
2. Flora and vegetation
3. Terrestrial fauna
4. Subterranean fauna
5. Greenhouse gas emissions
6. Social surroundings.

2.2. Specific additional work required for assessment of Proposal

The form and content of the ERD will be in accordance with the *Instructions and Template: How to prepare an Environmental Review Document*.

A Mine Closure Plan will be submitted with the ERD, which includes the consideration for rehabilitation and closure of final landforms, consistent with the *Statutory guideline for mine closure plans* (DMIRS, March 2020) and *Mine Closure Plan Guidance – How to Prepare in Accordance with Part 1 of the Statutory Guidelines* (DMIRS, March 2020).

A Proposal Content Document (PCD) will be completed and submitted with the ERD to the requirements of current EPA guidance: *Instructions and Template – How to identify the content of a Proposal* (EPA Western Australia, October 2021).

Table 3 outlines the Proposal specific additional work required.

Table 3 Proposal specific additional work required

Inland waters	
Required work	1. Conduct peer review of hydrogeological modelling (undertaken to determine the EPA objective for Inland Waters, as it relates to groundwater, can be met) associated with additional deposits of the West Angelas Revised Proposal where below water table mining is proposed and at Western Hill Deposit due to the proximity to Karijini National Park.
Terrestrial fauna	
Required work	1. Update the existing West Angelas Environmental Management Plan (EMP), in accordance with the requirements of *EPA Instructions on how to prepare Environmental Protection Act 1986 Part IV Environmental Management Plans* (2020 or any subsequent revisions), that describes any proposed management and/or monitoring plans that will be implemented to ensure residual impacts (direct and indirect) are not greater than predicted as a result of the Significant Amendment. 2. Where significant residual impacts to MNES remain and contributions to the Pilbara Environmental Offsets Fund are not proposed, include a discussion of the consideration of the *EPBC Act Environmental Offsets Policy*.
Subterranean Fauna	
Required work	1. Determine and quantify any significant residual impacts by applying the Residual Impact Significance Model in the WA Environmental Offsets Guidelines (2014, or any subsequent revisions) and include reference to the Commonwealth Offsets Assessment Guide for any MNES. Where significant residual impacts remain, propose an appropriate offsets package that is consistent with the WA Environmental Offsets Policy and Guidelines (or any subsequent revisions). 2. If offsets are proposed for subterranean fauna, a thorough assessment of the outcome of the proposed offset will be provided which demonstrates that EPA's objective can be met.
Greenhouse gas emissions	
Required work	1. Prepare and implement a Greenhouse Gas Management Plan in accordance with the most recent 'final' published guidance which will demonstrate, but not limited to, the following: a. The Proponents' contribution towards the State's aspiration of net zero emissions by 2050, in relation to Scope 1 GHG emissions as outlined in the State GHG Policy and Guideline b. The intended reduction in Scope 1 emissions, via interim targets c. That all reasonable and practicable measures have been applied to avoid, reduce and offset the Scope 1 emissions from the Proposal.

Social surroundings	
Required work	1. Provide evidence of consultation with relevant stakeholders, demonstrate how issues raised through consultation have been addressed, and specify how the Proponent will minimise impacts to social surroundings values within the Development Envelope. 2. Provide a detailed description and assessment of the potential impacts (direct, indirect and cumulative) to visitors to Karijini National Park. 3. Conduct and undertake meaningful investigations, consultation and engagement with relevant Traditional Owner groups to identify tangible and intangible cultural heritage values within and outside the Development Envelope that could be directly or indirectly impacted by the Proposal (to the extent that they are impacted upon by the physical or biological environment): a. Provide evidence of meaningful investigations, engagement and consultation undertaken with Traditional Owner groups such as survey reports and documented consultation outcomes. b. Provide details of the methodology used for the investigations and engagement, including (but not limited to) the timing, scope, activities undertaken and stakeholders involved, and a description of how the methodology adequately identifies tangible and intangible cultural heritage values for consideration in the assessment of impacts to social surroundings. 4. Prepare a Social, Cultural and Heritage Management Plan for each Traditional Owner group, in consultation with each group, that describes the social, cultural and heritage values within the relevant country and specifies how the Proponent will avoid (where possible) and minimise impacts to social, cultural and heritage values within and directly adjacent to the Development Envelope.
Environmental offsets	
	1. Where offsets are proposed for any environmental factor, the content for offsets detailed in the ERD instructions will be provided, including sufficient evidence about whether and how an offset is likely to counter-balance a significant residual impact. 2. Where current offsets exist for the approved proposal, current offsets practice applies in accordance with relevance guidance including: • Biodiversity factors: WA Environmental Offsets Policy and the WA Environmental Offsets Guidelines, and complete the WA Environmental Offsets template and the WA Residual Impacts Significance Model table template. • Greenhouse gas emissions factor: Government of Western Australia's Greenhouse gas emissions policy for major projects and EPA's Environmental Factor Guideline – Greenhouse Gas Emissions. 3. Where a contribution to the Pilbara Environmental Offsets Fund is proposed to offset significant residual impacts for any environmental factor, provide an impact reconciliation procedure prepared in accordance with Instructions on how to prepare Environmental Protection Act 1986 Part IV Impact Reconciliation Procedures and Impact Reconciliation Reports (2018, or any subsequent revisions) and the Template for Environmental Protection Act 1986 Part IV Reconciliation Procedures (2018, or any subsequent revisions). Where a contribution to the Pilbara Environmental Offsets Fund is not appropriate (i.e. it's not related to native vegetation or fauna habitat that is not native vegetation) other appropriate offsets will be proposed with due consideration of the WA Environmental Offsets Policy and Guidelines (or any subsequent revisions).

2.3. Cumulative impact assessment – scoping of activities, boundaries and environmental values for relevant environmental factors

For all preliminary environmental factors, a summary of the activities associated with the Proposal, boundaries (of the cumulative impact assessment) and environmental values that will be considered for the cumulative impact assessment will be provided in relation to each preliminary key environmental factor.

The ERD will include cumulative impact assessment to assess the following:

- Inland waters: Assess and quantify cumulative impacts on ground and surface water from the Proposal.
- Flora and vegetation: Assess cumulative impacts of the implementation of the Proposal on identified environmental values including any significant vegetation types, listed ecological communities, potential groundwater dependent ecosystems, and Priority flora. Include a quantitative assessment of the cumulative impact of the Proposal on significant vegetation units, listed ecological communities, potential groundwater dependent ecosystems and Priority flora. Describe and assess cumulative impacts within local, regional and State contexts, as appropriate.
- Terrestrial fauna:
    - Assess and quantify the extent of direct and indirect cumulative impacts of implementation of the Proposal to fauna, including SRE and the following MNES species: Northern Quoll (*Dasyurus hallucatus*), Ghost Bat (*Macroderma gigas*), Pilbara Leaf-nosed Bat (*Rhinonicteris aurantia* [Pilbara Form]), Pilbara Olive Python (*Liasis olivaceus barroni*), Grey Falcon (*Falco hypoleucos*), Night Parrot (*Pezoporus occidentalis*) and Fork-tailed Swift (*Apus pacificus*).
- Subterranean fauna:
    - Describe and assess the extent of direct, indirect and cumulative impacts to subterranean fauna as a result of implementation of the Proposal, taking into consideration the significance of fauna and fauna habitat values.
    - Quantify the extent of direct and indirect cumulative impacts, including where feasible, percentages of habitat types to be disturbed or otherwise impacted
- Greenhouse Gas: the West Angelas Greenhous Gas (GHG) Management Plan, required by condition 9 of Ministerial Statement 1113 (approval of the GHG Management Plan is pending), will be updated to include the Proposal subject to this assessment. The GHG Management Plan will provide context and, where relevant, information on the entire existing approved West Angelas operations and the Proposal subject to this assessment. The plan will also include updates of estimates of peak, annual average and total GHG emissions from existing approved West Angelas operations and the Proposal subject to this assessment.
- Social surroundings:
    - Provide a detailed description and assessment of the potential direct and indirect cumulative impacts to social surroundings as a result of changes to the environment from the Proposal with specific consideration given to Traditional Owners, pastoralists and visitors to Karijini National Park and their activities on the land including areas adjacent to and surrounding the Proposal which have the potential to be impacted.

3. STATE DECISION-MAKING AUTHORITIES

The Proponent has identified the State decision-making authorities listed in Table 4 for this Proposal. Additional decision-making authorities may be identified during the course of the assessment. Information about how DMAs processes can meet expected outcomes and EPA objectives will be provided in the ERD on a per impact basis.

Table 4 State decision-making authorities and processes

State Decision making authority	Legislation or Agreement regulating the activity	Approval required (and specify which Proposal element the approval is related to)	Whether and how statutory decision-making process can mitigate impacts on the environment? (Yes/No and summary of reasons Include a separate line item for each relevant impact, and discuss how the EPA's factor objective will be met)
Minister for Aboriginal Affairs	*Aboriginal Heritage Act 1972* (AH Act)	Disturbance of sites of Aboriginal heritage significance: • Section 16 authorisation to enter, excavate, examine or remove anything on an Aboriginal site. • Section 18 consent where the impact on an Aboriginal site is unavoidable. Relates to the potential for the Proposal to impact on the Social Surroundings environmental factor.	Yes - this process is for assessing and authorising impacts on sites of Aboriginal heritage significance.
Minister for State Development	*Iron Ore (Robe River) Agreement Act 1964*	State Agreement Proposal for approval under the *Iron Ore (Robe River) Agreement Act 1964.*	No – not a process that manages environmental impacts.
Minister for Environment	*Biodiversity Conservation Act 2016* (BC Act)	Impacts to threatened flora and fauna species are managed through DBCA: • Authorisations to take threatened flora species • Authorisations to take or disturb threatened fauna species	Yes - this process is for assessing impacts to threatened flora and fauna species and provides authorisations to take threatened flora and fauna species.
Minister for Water	*Rights in Water and Irrigation Act 1914* (RiWI Act)	Section 5C licence to take water: • Operation of dewatering and water supply borefields	Yes - this process is for assessing the abstraction of groundwater associated with the Proposal. Licences manage the location and volume of groundwater abstracted for water supply. Requires monitoring and reporting against licence requirements.
		Section 26D licence to construct or alter a well • Construction or dewatering and water supply bores	Yes - this process is for assessing the construction of a bore to access and/or monitor water within the aquifer.

State Decision making authority	Legislation or Agreement regulating the activity	Approval required (and specify which Proposal element the approval is related to)	Whether and how statutory decision-making process can mitigate impacts on the environment? (Yes/No and summary of reasons Include a separate line item for each relevant impact, and discuss how the EPA's factor objective will be met)
		Permit to interfere with bed or banks	Yes - this process is for assessing the interference with bed and banks of a watercourse from the Proposal.
		Groundwater Operating Strategy • Manage significant volumes of water proposed to be taken from several sources and multiple bores	Yes - the groundwater operating strategy supplements a section 5C licence, detailing how the licensee will manage its operations given broader management issues associated with taking and using water.
Chief Executive Officer, Department of Water and Environmental Regulation	*Environmental Protection Act 1986* - Part V	Licence • Operating licence • Licence amendments	Yes – licences manage emissions to air, land and water, including water quality and volume, emissions released to the environment. Requires monitoring and reporting against licence requirements.
Minister for Mines and Petroleum	*Mining Act 1978*	Mine Closure Plan (MCP) • Mine closure and rehabilitation	Yes - responsibility for assessing Mine Closure Plans (MCP) which specify closure and rehabilitation actions and outcomes. A MCP will be submitted with the ERD.

Attachment 1

Commonwealth Government Approvals

The controlling provisions are listed threatened species (sections 18 and 18a) and migratory species (sections 20 and 20a):

- Northern Quoll (*Dasyurus hallucatus*);
- Night Parrot (*Pezoporus occidentalis*);
- Ghost Bat (*Macroderma gigas*);
- Pilbara Leaf-nosed Bat (*Rhinonicteris aurantia* [Pilbara Form]);
- Pilbara Olive Python (*Liasis olivaceus barroni*); and
- Grey Falcon (*Falco hypoleucos*).
- Fork-tailed Swift (*Apus pacificus*)

This draft ESD includes work required to be carried out and reported on in the Environmental Review Document in relation to MNES. The Environmental Review Document will also address the matters in Schedule 4 of the *Environmental Protection and Biodiversity Conservation Regulations 2000*. MNES that may be impacted by the Proposal will be identified and the potential impacts on these matters addressed in a separate MNES chapter, in relation to preliminary environmental factor identified in Section 2.1 of this ESD. Proposed offsets to address significant residual impacts on MNES will also be discussed in the Environmental Review Document. The Environmental Review Document will provide sufficient information to allow the Minister for the Environment to make an informed decision on whether to approve, under Part 9 of the EPBC Act, the taking of the Action for each controlling provision. All relevant standards, policies and other guidance material published by DCCEEW will be referred to and followed, or justification will be provided.

A.2: Other Matters Required by Schedule 4 of the EPBC Regulations

OTHER MATTERS REQUIRED BY SCHEDULE 4 OF THE EPBC REGULATIONS

Matters to be addressed by the draft public environment report and environmental impact statement as set out in Schedule 4 of the *Environment Protection and Biodiversity Conservation Regulations 2000* are detailed in Table 1.

Table 1: Matters to be addressed by the ERD

Regulation Reference	Description	Report Section/Information
1 General information	1.01 The background of the action including:	
	(a) the title of the action.	Table 2-1
	(b) the full name and postal address of the designated Proponent.	Table 1-1
	(c) a clear outline of the objective of the action.	Table 2-1
	(d) the location of the action.	Table 2-1; Figure 2-1
	(e) the background to the development of the action.	Section 2.1
	(f) how the action relates to any other actions (of which the Proponent should reasonably be aware) that have been, or are being, taken or that have been approved in the region affected by the action.	Section 3.2
	(g) the current status of the action.	Section 3.1
	(h) the consequences of not proceeding with the action.	The consequence of not proceeding with the Proposed Action would be Rio Tinto's inability to maintain the current iron ore production level from Greater Hope Downs mining hub and fully use existing infrastructure and processing facilities. The Proposed Action would extend the life of mine at Greater Hope Downs operations and is critical to the Proponent's business activities in the Pilbara region.
2 Description	2.01 A description of the action, including:	
	(a) all the components of the action.	Table 2-2 and Section 2.1
	(b) the precise location of any works to be undertaken, structures to be built or elements of the action that may have relevant impacts.	Table 2-2; Figure 2-2; Figure 2 3; Figure 2-4
	(c) how the works are to be undertaken and design parameters for those aspects of the structures or elements of the action that may have relevant impacts.	Section 2.1
	(d) relevant impacts of the action.	Sections 13.6.7, 13.7.7, 13.8.7 and 13.9.7, supported by Section 7.6
	(e) proposed safeguards and mitigation measures to deal with relevant impacts of the action.	Section 13.5 supported by Section 7.5

Regulation Reference	Description	Report Section/Information
	(f) any other requirements for approval or conditions that apply, or that the Proponent reasonably believes are likely to apply, to the proposed action.	Sections 13.2, 13.6.9, 13.7.9, 13.8.9 and 13.9.9
	(g) to the extent reasonably practicable, any feasible alternatives to the action, including: (i) if relevant, the alternative of taking no action (ii) a comparative description of the impacts of each alternative on the matters protected by the controlling provisions for the action (iii) sufficient detail to make clear why any alternative is preferred to another	Section 2.2
	(h) any consultation about the action, including: (i) any consultation that has already taken place (ii) proposed consultation about relevant impacts of the action (iii) if there has been consultation about the proposed action—any documented response to, or result of, the consultation	Section 4
	(i) identification of affected parties, including a statement mentioning any communities that may be affected and describing their views	Section 4
3 Relevant impacts		
	(a) a description of the relevant impacts of the action	Sections 13.4, supported by Section 7.4
	(b) a detailed assessment of the nature and extent of the likely short term and long term relevant impacts	Sections 13.6.7, 13.7.7, 13.8.7 and 13.9.7, supported by Section 7.6
	(c) a statement whether any relevant impacts are likely to be unknown, unpredictable or irreversible.	Relevant impacts to EPBC-listed matters are addressed in Section 13. Impacts are generally well understood from previous similar projects in the Pilbara. Clearing has been assessed as an irreversible impact, and offsets are proposed where there is a loss of critical (high significance and moderate significance) habitat for MNES. Monitoring is proposed to confirm that the outcomes are as predicted.
	(d) analysis of the significance of the relevant impacts.	Sections 13.6.8, 13.7.8, 13.8.8 and 13.9.8, supported by Section 7.6
	(e) any technical data and other information used or needed to make a detailed assessment of the relevant impacts.	Appendix C.1 to C.6
4 Proposed safeguards and mitigation measures	4.01 Information given under paragraph 2.01(e) must include:	
	(a) a description, and an assessment of the expected or predicted effectiveness of, the mitigation measures.	Section 13.5

Regulation Reference	Description	Report Section/Information
	(b) any statutory or policy basis for the mitigation measures.	Sections 13.2, 13.6.9, 13.7.9, 13.8.9 and 13.9.9
	(c) the cost of the mitigation measures.	The cost of mitigation measures is part of the Proposal's overall cost.
	(d) an outline of an environmental management plan that sets out the framework for continuing management, mitigation and monitoring programs for the relevant impacts of the action, including any provisions for independent environmental auditing.	Appendix A.9
	(e) the name of the agency responsible for endorsing or approving each mitigation measure or monitoring program.	DWER is responsible for approving mitigation measures and monitoring programs relating to protected fauna. However, DWER may seek technical advice and/or endorsement from other agencies, e.g. DBCA and DCCEEW. DWER is responsible for compliance with conditions that prescribe monitoring and mitigation requirements as part of approvals given under the EP Act.
	(f) a consolidated list of mitigation measures proposed to be undertaken to prevent, minimise or compensate for the relevant impacts of the action, including mitigation measures proposed to be taken by State governments, local governments or the Proponent.	A consolidated list of mitigation measures has been included in the Executive Summary. Mitigation measures will be the responsibility of the Proponent.
5 Other approvals and conditions	5.01 Information given under paragraph 2.01(f) must include:	
	(a) details of any local or State government planning scheme, or plan or policy under any local or State government planning system that deals with the proposed action, including: (i) what environmental assessment of the proposed action has been, or is being, carried out under the scheme, plan or policy (ii) how the scheme provides for the prevention, minimisation and management of any relevant impacts	Not applicable
	(b) a description of any approval that has been obtained from a State, Territory or Commonwealth agency or authority (other than an approval under the Act), including any conditions that apply to the action	Section 3.2
	(c) a statement identifying any additional approval that is required	Section 3.2
	(d) a description of the monitoring, enforcement and review procedures that apply, or are proposed to apply, to the action.	Appendix A.9

Regulation Reference	Description	Report Section/Information
6 Environmental record of person proposing to take the action	6.01 Details of any proceedings under a Commonwealth, State or Territory law for the protection of the environment or the conservation and sustainable use of natural resources against:	
	(a) the person proposing to take the action	Not applicable
	(b) for an action for which a person has applied for a permit, the person making the application.	Not applicable
	6.02 If the person proposing to take the action is a corporation—details of the corporation's environmental policy and planning framework	Appendix A.9
7 Information sources	7.01 For information given in a draft public environment report or environmental impact statement, the draft must state:	
	(a) the source of the information	Sections 7.3 and 13.3
	(b) how recent the information is	Sections 7.3 and 13.3
	(c) how the reliability of the information was tested	Tables 7-2 and 13-3
	(d) what uncertainties (if any) are in the information	Sections 7.3 and 13.3

A.3: Ministerial Statement 1113

THIS DOCUMENT
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Published on: 2 September 2019 Statement No. 1113

STATEMENT THAT A REVISED PROPOSAL MAY BE IMPLEMENTED (*Environmental Protection Act 1986*)

WEST ANGELAS IRON ORE PROJECT – REVISED PROPOSAL

Proposal: Proposal: The development of additional or expanded iron ore deposits, waste dumps, ore processing operation and associated infrastructure at West Angelas, 130 kilometres west of Newman, and rail infrastructure, as documented in Schedule 1 of this Ministerial Statement.

Revised proposal: The revised proposal includes the existing West Angelas Iron Ore Project and the revisions in the Proposal.

Proponent: Robe River Mining Co. Pty. Ltd.
Australian Company Number 008 694 246

Proponent Address: Central Park, 152-158 St Georges Terrace
PERTH WA 6000

Assessment Number: 2132

Report of the Environmental Protection Authority: 1636

Previous Assessment Numbers: 2046, 1914

Previous Reports of the Environmental Protection Authority: 1551, 1508

Previous Statement Numbers: 1015, 970

Pursuant to section 45, read with section 45B of the *Environmental Protection Act 1986,* it has been agreed that:

1. the proposal described and documented in Table 1 of Schedule 1 may be implemented; and

2. the implementation of the revised proposal to which the above reports of the Environmental Protection Authority relate is subject to the following conditions and procedures, which replace and supersede all previous conditions and procedures of Statements 970 and 1015.

1 Proposal Implementation

1-1 When implementing the revised proposal, the proponent shall not exceed the authorised extent of the revised proposal as defined in Table 2 of Schedule 1, unless amendments to the revised proposal and the authorised extent of the revised proposal have been approved under the EP Act.

2 Contact Details

2-1 The proponent shall notify the CEO of any change of its name, physical address or postal address for the serving of notices or other correspondence within twenty-eight (28) days of such change. Where the proponent is a corporation or an association of persons, whether incorporated or not, the postal address is that of the principal place of business or of the principal office in the State.

3 Compliance Reporting

3-1 The proponent shall prepare, and maintain a Compliance Assessment Plan which is submitted to the CEO at least six (6) months prior to the first Compliance Assessment Report required by condition 3-6, or within six (6) months of this Statement being issued, whichever is sooner.

3-2 The Compliance Assessment Plan shall indicate:

(1) the frequency of compliance reporting;

(2) the approach and timing of compliance assessments;

(3) the retention of compliance assessments;

(4) the method of reporting of potential non-compliances and corrective actions taken;

(5) the table of contents of Compliance Assessment Reports; and

(6) public availability of Compliance Assessment Reports.

3-3 After receiving notice in writing from the CEO that the Compliance Assessment Plan satisfies the requirements of condition 3-2 the proponent shall assess compliance with conditions in accordance with the Compliance Assessment Plan required by condition 3-1.

3-4 The proponent shall retain reports of all compliance assessments described in the Compliance Assessment Plan required by condition 3-1 and shall make those reports available when requested by the CEO.

3-5 The proponent shall advise the CEO of any potential non-compliance within seven (7) days of that non-compliance being known.

3-6 The proponent shall submit to the CEO the first Compliance Assessment Report by 30 April 2020 addressing the previous calendar year period and then annually from the date of submission of the first Compliance Assessment Report, or as otherwise agreed in writing by the CEO.

The Compliance Assessment Report shall:

(1) be endorsed by the proponent's CEO or a person delegated to sign on the CEO's behalf;

(2) include a statement as to whether the proponent has complied with the conditions;

(3) identify all potential non-compliances and describe corrective and preventative actions taken;

(4) be made publicly available in accordance with the approved Compliance Assessment Plan; and

(5) indicate any proposed changes to the Compliance Assessment Plan required by condition 3-1.

4 Public Availability of Data

4-1 Subject to condition 4-2, within a reasonable time period approved by the CEO of the issue of this Statement and for the remainder of the life of the proposal the proponent shall make publicly available, in a manner approved by the CEO, all validated environmental data (including sampling design, sampling methodologies, empirical data and derived information products (e.g. maps)), management plans and reports relevant to the assessment of this proposal and implementation of this Statement.

4-2 If any data, plans and reports referred to in condition 4-1 contain particulars of:

(1) a secret formula or process; or

(2) confidential commercially sensitive information;

the proponent may submit a request for approval from the CEO to not make these data publicly available. In making such a request the proponent shall provide the CEO with an explanation and reasons why the data should not be made publicly available.

5 Environmental Management Plan

5-1 The proponent shall implement the revised proposal to meet the following environmental objectives:

(1) the proponent shall ensure there is no irreversible impact, as a result of the discharge of surplus water from the revised proposal, to the health of riparian vegetation of Turee Creek East (Figure 3 in Schedule 1);

(2) the proponent shall ensure that there is no direct or indirect disturbance to the West Angelas Cracking Clay Priority Ecological Community (PEC-2015-5, Figure 3 in Schedule 1), due to the revised proposal that results in an irreversible impact;

(3) the proponent shall ensure no more than 20 ha of direct or indirect disturbance due to the revised proposal to other representations of the West Angelas Cracking Clay Priority Ecological Community (Figure 3 in Schedule 1);

(4) the proponent shall ensure that there is no disturbance due to the revised proposal to the potential maternity Ghost Bat roosts (Caves AA1, WA13, WA-21 and WA-23) (Figure 4 in Schedule 1);

(5) the proponent shall minimise disturbance due to the revised proposal to other Ghost Bat roosts (Caves A1, A2, L1, L2, L3, WA-9, WA-10, WA-11, WA-12, WA-17, WA-20 and WA-22) (Figure 4 in Schedule 1); and

(6) the proponent shall avoid where possible, or otherwise minimise the introduction to and spread of weeds due to the revised proposal within the West Angelas rail corridor (Figure 5 in Schedule 1).

5-2 In order to meet the objectives of condition 5-1, the proponent shall prepare and submit the Environmental Management Plan within three (3) months of this Statement.

5-3 The Environmental Management Plan shall:

(1) specify trigger criteria that must provide an early warning that the threshold criteria identified in condition 5-3 may not be met;

(2) specify threshold criteria to demonstrate compliance with the environmental objectives specified in condition 5-1. Exceedance of the threshold criteria represents non-compliance with these conditions;

(3) specify monitoring to determine if trigger criteria and threshold criteria are exceeded;

(4) specify trigger level actions to be implemented in the event that trigger criteria have been exceeded;

(5) specify threshold contingency actions to be implemented in the event that threshold criteria are exceeded; and

(6) provide the format and timing for the reporting of monitoring results against trigger criteria and threshold criteria to demonstrate that condition 5-1 has been met over the reporting period in the Compliance Assessment Report required by condition 3-1.

5-4 After receiving notice in writing from the CEO in consultation with the Department of Biodiversity, Conservation and Attractions that the Environmental Management Plan satisfies the requirements of condition 5-3, the proponent shall:

(1) implement the provisions of the Environmental Management Plan; and

(2) continue to implement the Environmental Management Plan until the CEO has confirmed by notice in writing that the proponent has demonstrated the objectives specified in condition 5-1 have been met.

5-5 In the event that monitoring, tests, surveys or investigations indicates exceedance of threshold criteria specified in the Environmental Management Plan, the proponent shall:

(1) report the exceedance in writing to the CEO within seven (7) days of the exceedance being identified;

(2) implement the threshold contingency actions specified in the Environmental Management Plan within twenty-four (24) hours and continue implementation of those actions until the CEO has confirmed by notice in writing that it has been demonstrated that the threshold criteria are being met and the implementation of the threshold contingency actions is no longer required;

(3) investigate to determine the cause of the threshold criteria being exceeded;

(4) investigate to provide information for the CEO to determine potential environmental harm or alteration of the environment that occurred due to threshold criteria being exceeded; and

(5) provide a report to the CEO within twenty-one (21) days of the exceedance being reported as required by condition 5-5(1). The report shall include:

(a) details of threshold contingency actions implemented;

(b) the effectiveness of the threshold contingency actions implemented against the threshold criteria;

(c) the findings of the investigations required by conditions 5-5(3) and 5-5(4);

(d) measures to prevent the threshold criteria being exceeded in the future;

(e) measures to prevent, control or abate the environmental harm which may have occurred; and

(f) justification of the threshold remaining, or being adjusted based on better understanding, demonstrating that objectives will continue to be met.

5-6 The proponent:

(1) may review and revise the Environmental Management Plan, or

(2) shall review and revise the Environmental Management Plan as and when directed by the CEO.

5-7 The proponent shall implement the latest revision of the Environmental Management Plan, which the CEO has confirmed by notice in writing, satisfies the requirements of condition 5-3.

5-8 The proponent shall implement the *West Angelas Operations Environmental Management Program* (RTIO-HSE-0210871) dated November 2013 until the CEO has confirmed by notice in writing the Environmental Management Plan required by condition 5-2 satisfies the requirements of condition 5-3.

6 Groundwater Management

6-1 Prior to dewatering of Deposit C or D, the proponent shall prepare and submit a Condition Environmental Management Plan to meet the following outcome:

(1) ensure that there is no drawdown of groundwater associated with the proposal at the boundary of, or within, Karijini National Park.

6-2 The Condition Environmental Management Plan shall:

(1) specify trigger criteria that must provide an early warning that the threshold criteria identified in condition 6-2 may not be met;

(2) specify threshold criteria to demonstrate compliance with the environmental outcomes specified in condition 6-1. Exceedance of the threshold criteria represents non-compliance with these conditions;

(3) specify monitoring to determine if trigger criteria and threshold criteria are exceeded;

(4) specify trigger level actions to be implemented in the event that trigger criteria have been exceeded;

(5) specify threshold contingency actions to be implemented in the event that threshold criteria are exceeded; and

(6) provide the format and timing for the reporting of monitoring results against trigger criteria and threshold criteria to demonstrate that condition 6-1 has been met over the reporting period in the Compliance Assessment Report required by condition 3-1.

6-3 After receiving notice in writing from the CEO in consultation with the Department of Biodiversity, Conservation and Attractions that the Condition Environmental Management Plan satisfies the requirements of condition 6-2, the proponent shall:

(1) implement the provisions of the Condition Environmental Management Plan; and

(2) continue to implement the Condition Environmental Management Plan until the CEO has confirmed by notice in writing that the proponent has demonstrated the outcome specified in condition 6-1 have been met.

6-4 In the event that monitoring, tests, surveys or investigations indicates exceedance of threshold criteria specified in the Condition Environmental Management Plan, the proponent shall:

(1) report the exceedance in writing to the CEO within seven (7) days of the exceedance being identified;

(2) implement the threshold contingency actions specified in the Condition Environmental Management Plan within twenty-four (24) hours and continue implementation of those actions until the CEO has confirmed by notice in writing that it has been demonstrated that the threshold criteria are being met and the implementation of the threshold contingency actions is no longer required;

(3) investigate to determine the cause of the threshold criteria being exceeded;

(4) investigate to provide information for the CEO to determine potential environmental harm or alteration of the environment that occurred due to threshold criteria being exceeded; and

(5) provide a report to the CEO within twenty-one (21) days of the exceedance being reported as required by condition 6-4(1). The report shall include:

(a) details of threshold contingency actions implemented;

(b) the effectiveness of the threshold contingency actions implemented, against the threshold criteria;

(c) the findings of the investigations required by conditions 6-4(3) and 6-4(4);

(d) measures to prevent the threshold criteria being exceeded in the future;

(e) measures to prevent, control or abate the environmental harm which may have occurred; and

(f) justification of the threshold remaining, or being adjusted based on better understanding, demonstrating that outcomes will continue to be met.

6-5 The proponent:

(1) may review and revise the Condition Environmental Management Plan, or

(2) shall review and revise the Condition Environmental Management Plan as and when directed by the CEO.

6-6 The proponent shall implement the latest revision of the Condition Environmental Management Plan, which the CEO has confirmed by notice in writing, satisfies the requirements of condition 6-2.

6-7 The proponent shall implement the *Groundwater Management Plan* component of the *West Angelas Operations Environmental Management Program* (RTIO-HSE-0210871) dated November 2013 until the CEO has confirmed by notice in writing the Condition Environmental Management Plan required by condition 6-1 satisfies the requirements of condition 6-2.

7 Rehabilitation and Decommissioning

7-1 The proponent shall manage the implementation of the revised proposal to meet the following environmental objectives:

(1) the proponent shall ensure that the revised proposal is rehabilitated and decommissioned in an ecologically sustainable manner; and

(2) ensure that closure planning and rehabilitation are undertaken in a progressive manner.

7-2 Within twelve (12) months of the issue of this Statement the proponent shall prepare and submit a Mine Closure Plan in accordance with the *Guidelines for Preparing Mine Closure Plans*, May 2015, (or any subsequent revisions of the guidelines), to the requirements of the CEO, on advice of the Department of Mines, Industry Regulation and Safety, and the Department of Water and Environmental Regulation.

7-3 The proponent shall review and revise the Mine Closure Plan required by condition 7-2 at intervals not exceeding three (3) years, or as otherwise specified by the CEO, and submit the plan to the CEO at the agreed interval.

7-4 The proponent shall implement the latest revision of the Mine Closure Plan, which the CEO has confirmed by notice in writing, satisfies the requirements of condition 7-2.

7-5 The proponent shall implement the *West Angelas Closure Plan* (RTIO-HSE-0228290) dated April 2018 until the CEO has confirmed by notice in writing the Mine Closure Plan required by condition 7-2 satisfies the requirements of the CEO on advice of the Department of Mines, Industry Regulation and Safety, and the Department of Water and Environmental Regulation.

8 Offsets

8-1 In view of the significant residual impacts and risks as a result of the implementation of the revised proposal, the proponent shall contribute funds to the Pilbara Environmental Offsets Fund calculated pursuant to condition 8-2, subject to any reduction approved by the CEO under condition 8-9.

8-2 The proponent's contribution to the Pilbara Environmental Offsets Fund shall be paid biennially, with the amount to be contributed calculated based on the clearing undertaken in each year of the biennial reporting period in accordance with the rates in condition 8-3. The first biennial reporting period shall commence from vegetation clearing activities for the environmental values identified in condition 8-3.

8-3 Calculated on the 2018 calendar year, the contribution rates are:

(1) $821 AUD (excluding GST) per hectare of 'Good' to 'Excellent' condition native vegetation cleared within the development envelope (delineated in Figure 2 and defined by the geographic coordinates in Schedule 2) within the Hamersley IBRA subregion.

(2) $1,642 AUD (excluding GST) per hectare of the West Angelas Cracking Clay Priority Ecological Community cleared within the development envelope (delineated in Figure 3 and defined by the geographic coordinates in Schedule 2) within the Hamersley IBRA subregion.

(3) $1,642 AUD (excluding GST) per hectare of riparian vegetation communities within Turee Creek East affected by discharge within the development envelope (delineated in Figure 3 and defined by the geographic coordinates in Schedule 2) within the Hamersley IBRA subregion.

(4) $1,642 AUD (excluding GST) per hectare of foraging and roosting habitat for the Ghost Bat ('major gorge or gully'; 'hilltop, hillside, ridge or cliff'; and 'major drainage' habitat), including removal of one night roost (WA-16), cleared within the development envelope (delineated in Figure 4 and defined by the geographic coordinates in Schedule 2) within the Hamersley IBRA subregion.

8-4 From the commencement of the 2019 calendar year, the rates in condition 8-3 will be adjusted annually each subsequent calendar year in accordance with the percentage change in the CPI applicable to that calendar year.

8-5 Within three (3) months of the issue of this Statement, the proponent shall prepare and submit an Impact Reconciliation Procedure to the CEO, for the CEO to provide written confirmation that the Impact Reconciliation Procedure satisfies the requirements of condition 8-6.

8-6 The Impact Reconciliation Procedure required pursuant to condition 8-5 shall:

(1) state that clearing calculations for the first biennial reporting period will commence from vegetation clearing activities for the environmental values identified in condition 8-3 in accordance with condition 8-2 and end on the second 31 December following this date;

(2) state that clearing calculations for each subsequent biennial reporting period will commence on 1 January of the required reporting period, unless otherwise agreed by the CEO;

(3) include a methodology to calculate the amount of clearing undertaken during each year of the biennial reporting period for each of the environmental values identified in condition 8-3;

(4) indicate the timing and content of the Impact Reconciliation Reports; and

(5) include the clearing previously approved and undertaken under Ministerial Statement 1015 subject to the rate of $750 AUD (excluding GST) per hectare of 'good to excellent' condition native vegetation, adjusted in accordance with the percentage change in the CPI applicable to that calendar year.

8-7 The proponent shall submit an Impact Reconciliation Report in accordance with the Impact Reconciliation Procedure approved in condition 8-5.

8-8 The Impact Reconciliation Report required pursuant to condition 8-7 shall provide the location and spatial extent of the clearing undertaken within the development envelope during each biennial reporting period.

8-9 The proponent may apply in writing and seek the written approval of the CEO to reduce all or part of the contribution payable under condition 8-2 where:

(1) a payment has been made to satisfy a condition of an approval under the *Environment Protection and Biodiversity Conservation Act 1999* in relation to the revised proposal;

(2) the payment is made for the purpose of counterbalancing impacts of the proposal on matters of national environmental significance; or

(3) the payment is made for the purpose of counterbalancing the significant residual impacts to the environmental value identified in condition 8-3(4).

8-10 The 4,667 ha of clearing of native vegetation previously approved under Ministerial Statement 970 is exempt from the requirement to offset under condition 8-1.

8-11 Where clearing coincides with more than one category of habitat under conditions 8-3(1) to 8-3(4) the higher contribution rate applies.

9 Greenhouse Gas Reporting

9-1 The proponent shall manage the implementation of the proposal to meet the following environmental objective:

(1) avoid, where possible, and minimise greenhouse gas emissions as far as practicable.

9-2 Within three (3) months of the issue of this Statement, the proponent shall prepare and submit a Greenhouse Gas Management Plan to meet the objective required by condition 9-1.

9-3 The Greenhouse Gas Management Plan shall address the following matters:

(1) benchmarking against applicable standards for iron ore processing;

(2) design of the proposal to minimise greenhouse gas emissions as far as practicable;

(3) monitoring and public reporting; and

(4) opportunities for continuous improvement and minimising net emissions in the future within the existing design of the proposal.

9-4 After receiving notice in writing from the CEO that the Greenhouse Gas Management Plan satisfies the requirements of conditions 9-2 and 9-3, the proponent must implement the Greenhouse Gas Management Plan.

9-5 The proponent may review and revise the Greenhouse Gas Management Plan.

9-6 The proponent shall review and revise the Greenhouse Gas Management Plan as and when directed by the CEO.

9-7 The proponent shall continue to implement the version of the Greenhouse Gas Management Plan most recently approved by the CEO until the CEO has confirmed by notice in writing that the plan meets the objective specified in condition 9-1.

10 Aboriginal Heritage

10-1 Prior to the commencement of ground disturbing activities, the proponent shall consult with the relevant Traditional Owners group(s) and ensure that the proponent complies with its obligations under the *Aboriginal Heritage Act 1972.*

10-2 That any contractors are made aware of their obligations under the *Aboriginal Heritage Act 1972*.

[signed on 2 September 2019]

Hon Stephen Dawson MLC
MINISTER FOR ENVIRONMENT

Schedule 1

Table 1: Summary of the Proposal

Proposal title	West Angelas Iron Ore Project – Revised Proposal
Short description	This proposal is a revision of the existing West Angelas Iron Ore Project and includes the above and below water table, open-cut iron ore mining from additional deposits and the construction and operation of associated infrastructure including but not limited to the following: dewatering and surplus water management infrastructure, Managed Aquifer Recharge scheme, surface water management infrastructure, linear infrastructure, processing and support facilities. Mine dewatering, which dewaters the ore bodies to allow below water table mining, supplies water for local operational purposes. Surplus dewatering water, exceeding the local operational water requirement, is transferred to the existing operations to supply operational water demand, the Managed Aquifer Recharge Scheme and / or discharged to the Turee Creek East tributary. This proposal will be contained within the revised West Angelas Mine Development Envelope.

Table 2: Location and authorised extent of physical and operational elements of the revised proposal

Element	Location	Authorised Extent
Mine and associated infrastructure	Figure 1, Figure 2, Figure 3, Figure 4	Clearing of no more than 12,205 hectares (ha) within a 26,700 ha Mine Development Envelope, including: • No clearing within the Ghost Bat Cave AA1, WA-13, WA-21 and WA-23 Exclusion Zones. • No clearing within the West Angelas Cracking Clay Priority Ecological Community, PEC-2015-5. • No more than 20 ha of clearing of other representations of the West Angelas Cracking Clay Priority Ecological Community. • No more than 25 ha of clearing of riparian vegetation. Below water table pits are to be backfilled to a level to prevent the formation of permanent pit lakes.
Linear infrastructure	Figure 5	A 413 km rail network transports processed ore from West Angelas to port facilities located at Cape Lambert. Clearing no more than 1,500 ha within a 19,400 ha Linear Infrastructure Development Envelope, including: • Five existing sidings; Spoonbill, Bellbird, Rosella, Brockman Refuge and Emu and potential additional sidings to support the rail network. • Turee Creek B Borefield, pipeline, powerline, access roads and other associated infrastructure
Surplus water management	Figure 3	Dewatering water will be used onsite in the first instance to supply water for operational purposes. Surplus dewatering water, exceeding the operational requirement is discharged to a local ephemeral tributary of Turee Creek East. The surface discharge extent will not extend within 2 km of the boundary of Karijini National Park under natural no-flow conditions.

Table 3: Abbreviations and Definitions

Acronym or Abbreviation	Definition or Term
CEO	The Chief Executive Officer of the Department of the Public Service of the State responsible for the administration of section 48 of the *Environmental Protection Act 1986*, or his delegate.
CPI	The All Groups Consumer Price Index numbers for Perth compiled and published by the Australian Bureau of Statistics.
EP Act	*Environmental Protection Act 1986*
ha	hectare
IBRA	Interim Biogeographic Regionalisation for Australia
Pilbara E nvironmental Offsets Fund	The special purpose account that has been created pursuant to section 16(1)(d) of the *Financial Management Act 2006* by the Department of Water and Environmental Regulation.
Ground disturbing activities	Activities that are associated with the substantial implementation of a proposal including but not limited to, digging (with mechanised equipment), blasting, earthmoving, vegetation clearance, grading, gravel extraction, construction of new or widening of existing roads and tracks.

Figures (attached)

Figure 1 Conceptual mine layout and revised development envelope
Figure 2 Native vegetation condition mapping within the revised development envelope
Figure 3 West Angelas Cracking Clay PECs and riparian vegetation with surplus water discharge in Turee Creek East
Figure 4 Ghost Bat cave locations and fauna habitat within the West Angelas project area
Figure 5 Linear infrastructure development envelope

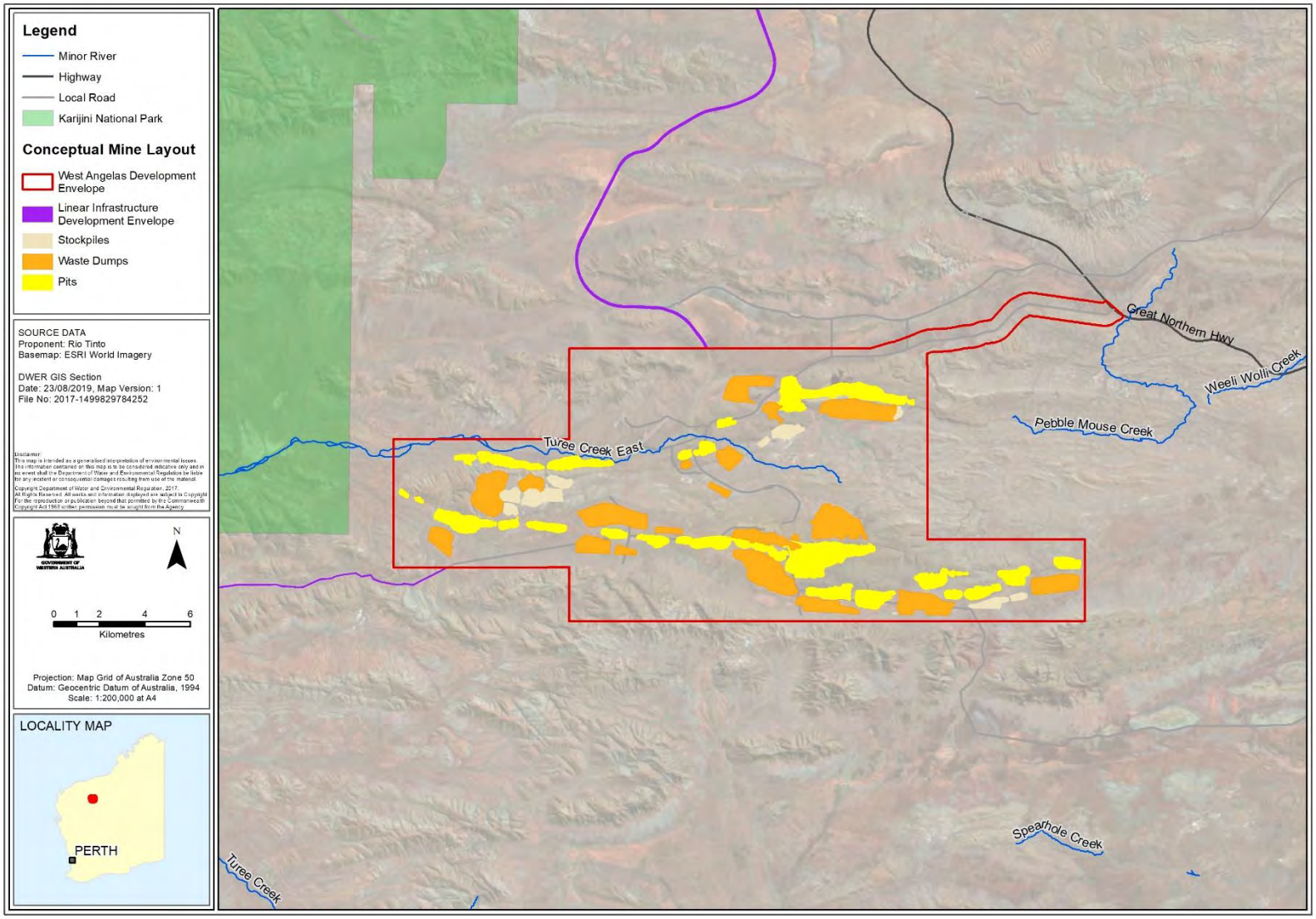

Figure 1. Conceptual mine layout and revised development envelope

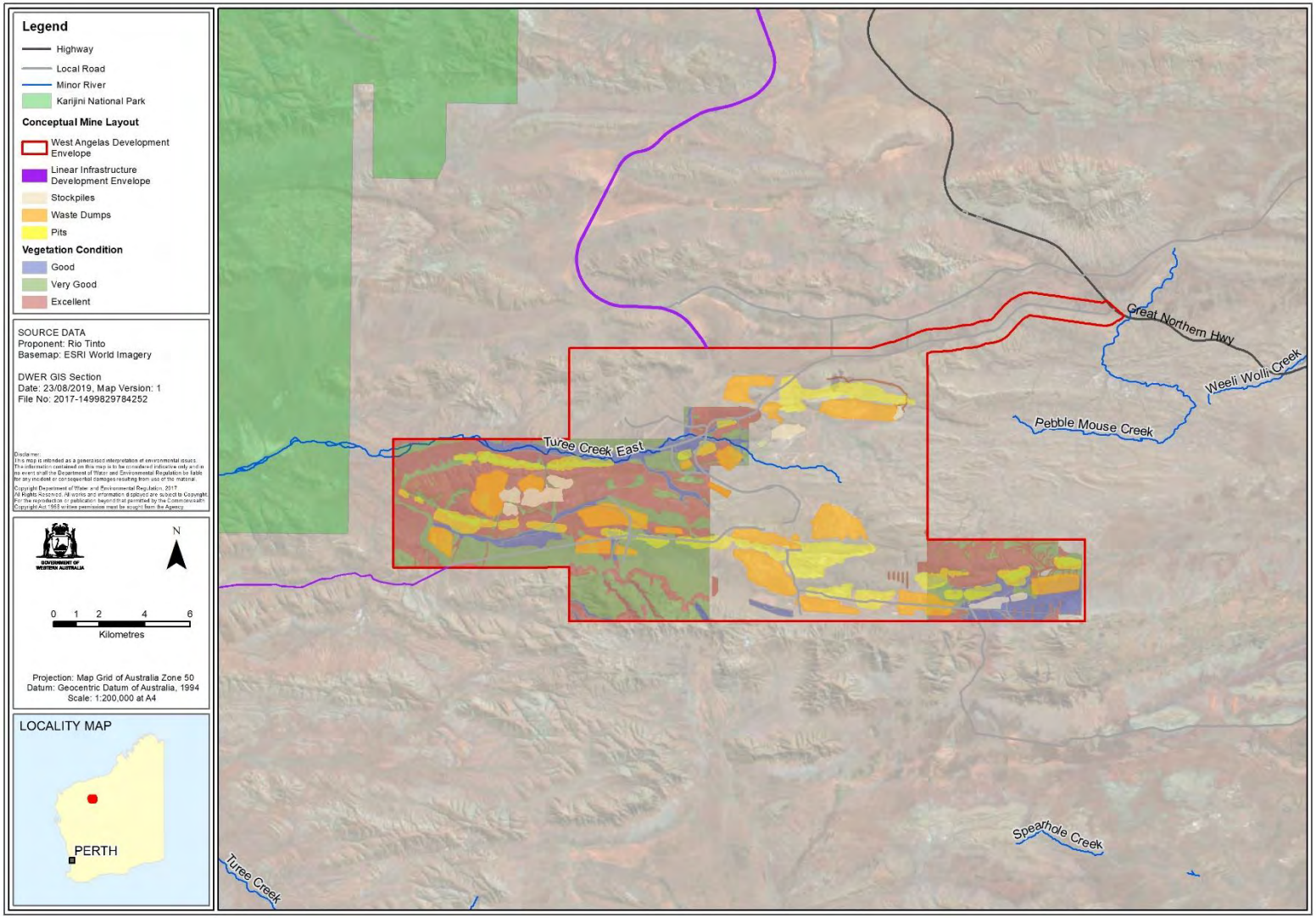

Figure 2. Native vegetation condition mapping within the revised development envelope

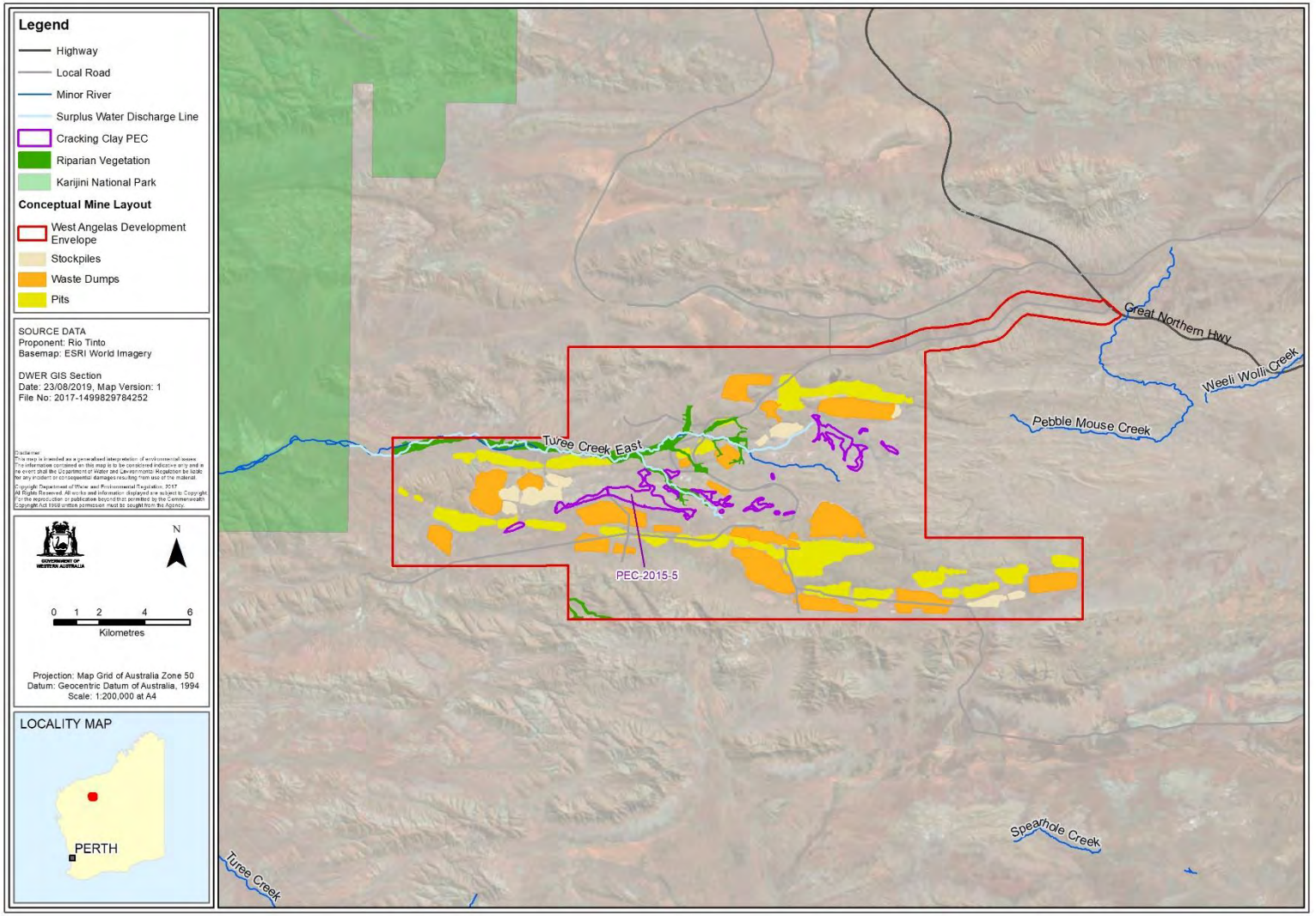

Figure 3. West Angelas Cracking Clay PECs and riparian vegetation with surplus water discharge in Turee Creek East

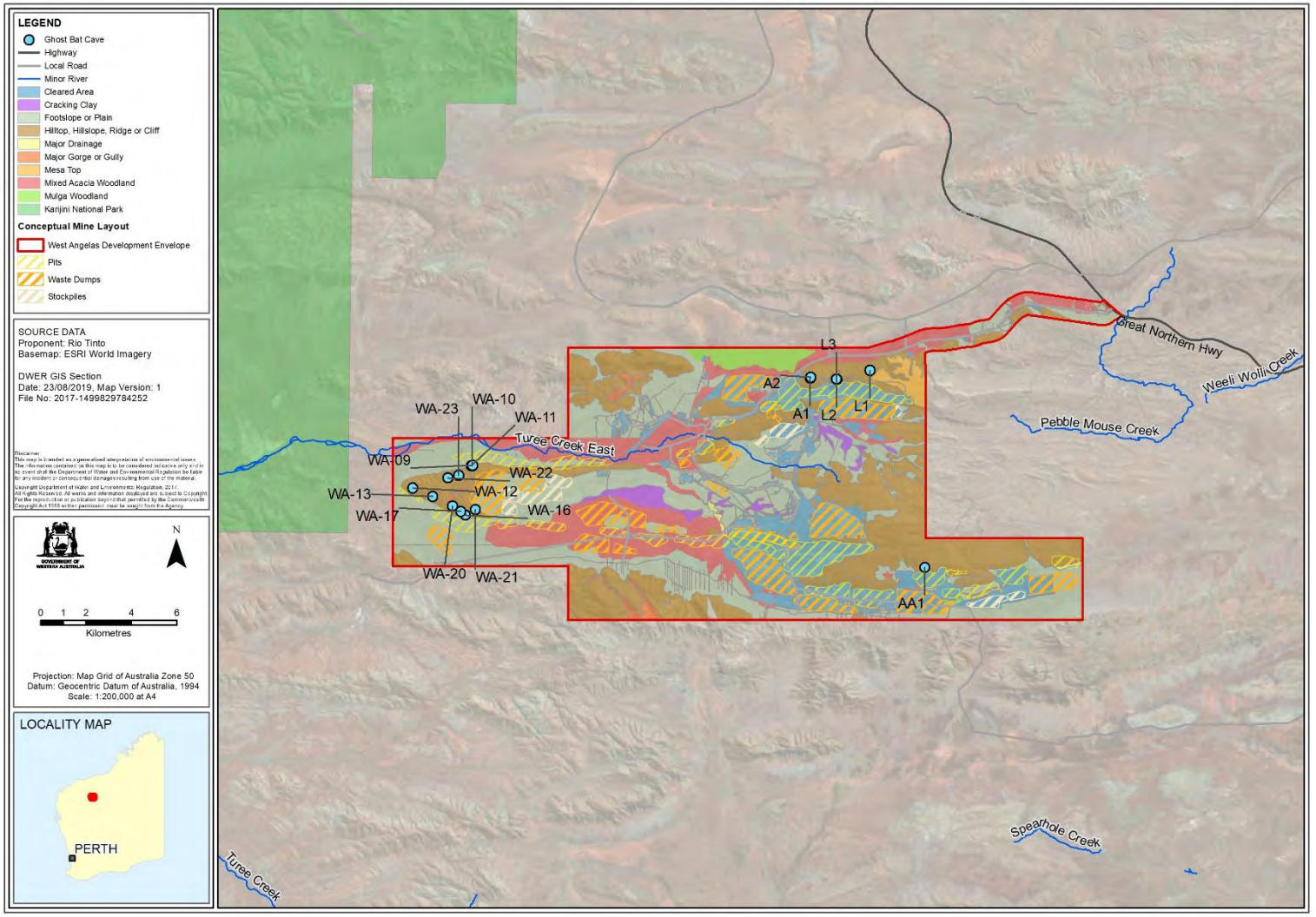

Figure 4. Ghost Bat cave locations and fauna habitat within the West Angelas project area

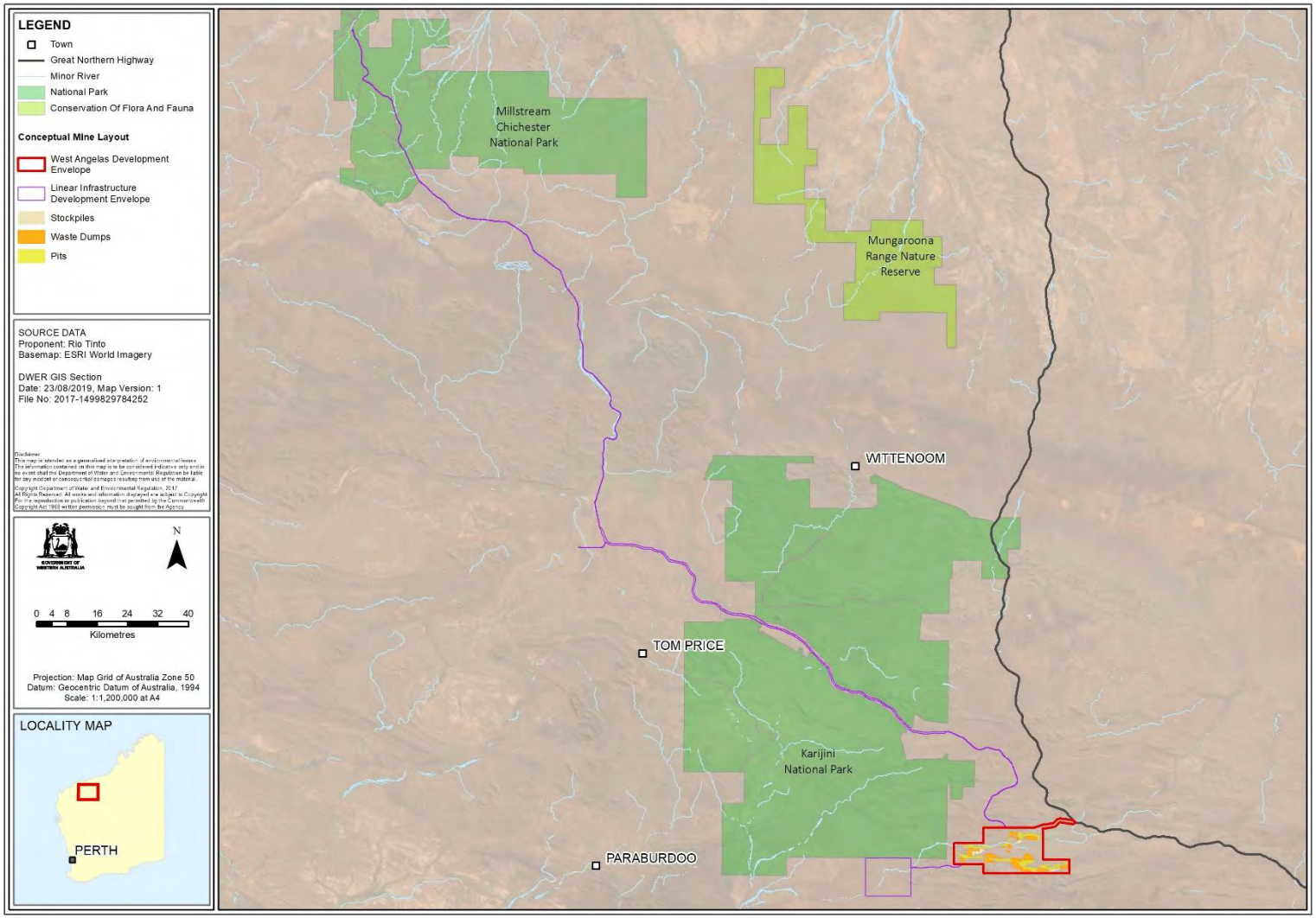

Figure 5. Linear infrastructure development envelope

Schedule 2

Coordinates defining the areas shown in Figures 1–5 are held by the Department of Water and Environmental Regulation under the following reference numbers:

- West Angelas Revised Development Envelope – 2019-1554965602236
- West Angelas Cracking Clay PEC – 2019-1554965601463
- Ghost Bat cave locations – 2019-1555313120739
- Riparian vegetation – 2019-1555313123266
- Surface water discharge – 2019-1555313124263
- Linear infrastructure development envelope – 2019-1554965598647.

All coordinates are in metres, listed in Map Grid of Australia Zone 50 (MGA Zone 50), datum of Geocentric Datum of Australia 1994 (GDA94).

Minister for Environment; Disability Services; Electoral Affairs
Deputy Leader of the Legislative Council

ATTACHMENT 1 TO STATEMENT 1113

Notices of changes to implementation conditions

(section 46C of the *Environmental Protection Act 1986*)

WEST ANGELAS IRON ORE PROJECT – REVISED PROPOSAL

Pursuant to section 46C(1)(b)(i) of the *Environmental Protection Act 1986*, the implementation conditions applying to the above proposal are changed in accordance with this Notice. I consider these changes to be of a minor nature and necessary in order to correct an unintentional error.

Hon Stephen Dawson MLC
MINISTER FOR ENVIRONMENT

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1. Change to Condition 5-3(6)

Condition 5-3 (6) is deleted, and replaced with:

5-3 (6) provide the format and timing for the reporting of monitoring results against trigger criteria and threshold criteria to demonstrate that condition 5-1 has been met over the reporting period in the Compliance Assessment Report required by condition 3-6.

2. Change to Condition 8-3(3)

Condition 8-3 (3) is deleted, and replaced with:

8-3 (3) $1,642 AUD (excluding GST) per hectare of riparian vegetation communities within Turee Creek East cleared within the development envelope (delineated in Figure 3 and defined by the geographic coordinates in Schedule 2) within the Hamersley IBRA subregion

Level 12, Dumas House, 2 Havelock Street, West Perth, Western Australia, 6005.
Telephone +61 8 6552 5800 Facsimile +61 8 6552 5801 Email: Minister.Dawson@dpc.wa.gov.au

Minister for Environment; Disability Services; Electoral Affairs
Deputy Leader of the Legislative Council

Our Ref: 62-24519

ATTACHMENT 2 TO STATEMENT 1113

NOTICE OF CHANGES TO IMPLEMENTATION CONDITIONS

(section 46C of the *Environmental Protection Act 1986*)

WEST ANGELAS IRON ORE PROJECT – REVISED PROPOSAL

Pursuant to section 46C(1)(b)(i) of the *Environmental Protection Act 1986,* the implementation conditions applying to the above proposal are changed in accordance with this Notice. I consider the change to be of a minor nature and necessary in order to standardise and correct implementation conditions.

[signed 4 January 2021]

Hon Stephen Dawson MLC
MINISTER FOR ENVIRONMENT

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1. Condition 8-4 is deleted, and replaced with:

8-4 From the commencement of the 2018 calendar year, the rates in condition 8-3 will be adjusted annually each subsequent calendar year in accordance with the percentage change in the CPI applicable to that calendar year.

Level 12, Dumas House, 2 Havelock Street, West Perth, Western Australia, 6005.
Telephone +61 8 6552 5800 Email: Minister.Dawson@dpc.wa.gov.au

Attachment 3 to Ministerial Statement 1113

Change to proposal approved under section 45C of the
Environmental Protection Act 1986

This Attachment replaces Schedule 1 and Schedule 2 of Ministerial Statement 1113.

Proposal: West Angelas Iron Ore Project – Revised Proposal

Proponent: Robe River Mining Co. Pty. Ltd.

Changes:

The change is to amend the Mine Development Envelope prescribed in Ministerial Statement 1113 which requires the following:

- Moving the western-most boundary of the Mine Development Envelope approximately 2 km to the west and moving a small section of the adjoining northern boundary approximately 1.8 km to the north to incorporate the managed aquifer recharge scheme.
- Increasing the area of the Mine Development Envelope from 26,700 hectares (ha) to 28,322 ha (increase of 1,622 ha).

Figures 1 to 5 have been updated to reflect the change to the Mine Development Envelope. Furthermore, Figure 4 which depicts the location of ghost bat cave locations has been updated to remove night roost (WA-16) as this roost was proposed to be cleared for the existing proposal subject of Ministerial Statement 1113 published on 2 September 2019. The GPS location of ghost bat caves WA-11 and WA-21 have been updated to accurately reflect the locations of these caves. The location of caves and water features within the Mine Development Envelope extension area have been included in Figure 4. Figure 4 now also depicts additional ghost bat caves (CMAR-01 to CMAR-04) and water features (WMAR-01 and WMAR-02) identified in a targeted fauna survey undertaken in February 2021.

The reference numbers for the spatial data defining the areas shown in Figures 1–5 have been updated because of this change.

Table 1: Summary of the Proposal

Proposal Title	West Angelas Iron Ore Project – Revised Proposal
Short Description	This proposal is a revision of the existing West Angelas Iron Ore Project and includes the above and below water table, open-cut iron ore mining from additional deposits and the construction and operation of associated infrastructure including but not limited to the following: dewatering and surplus water management infrastructure, Managed Aquifer Recharge scheme, surface water management infrastructure, linear infrastructure, processing and support facilities. Mine dewatering, which dewaters the ore bodies to allow below water table mining, supplies water for local operational purposes. Surplus dewatering water, exceeding the local operational water requirement, is transferred to the existing operations to supply operational water demand, the Managed Aquifer Recharge Scheme and / or discharged to the Turee

	Creek East tributary. This proposal will be contained within the revised West Angelas Mine Development Envelope.

Table 2: Location and authorised extent of physical and operational elements of the revised proposal

Element	Location	Previously Authorised Extent	Authorised Extent
Mine and associated infrastructure	Figure 1, Figure 2, Figure 3, Figure 4	Clearing of no more than 12,205 hectares (ha) within a 26,700 ha Mine Development Envelope, including: • No clearing within the Ghost Bat Cave AA1, WA-13, WA-21 and WA-23 Exclusion Zones. • No clearing within the West Angelas Cracking Clay Priority Ecological Community, PEC-2015-5. • No more than 20 ha of clearing of other representations of the West Angelas Cracking Clay Priority Ecological Community. • No more than 25 ha of clearing of riparian vegetation. Below water table pits are to be backfilled to a level to prevent the formation of permanent pit lakes.	Clearing of no more than 12,205 ha within a **28,322** ha Mine Development Envelope, including: • No clearing within the Ghost Bat Cave AA1, WA-13, WA-21 and WA-23 Exclusion Zones. • No clearing within the West Angelas Cracking Clay Priority Ecological Community, PEC-2015-5. • No more than 20 ha of clearing of other representations of the West Angelas Cracking Clay Priority Ecological Community. • No more than 25 ha of clearing of riparian vegetation. • **No clearing of Hilltop, Hillslope, Ridge or Cliff habitat for the Managed Aquifer Recharge scheme infrastructure.** • **No clearing of:** o **Water features (WMAR-01 and WMAR-03).** o **Caves (CMAR-01, CMAR-02, CMAR-03 and CMAR-04).** • **Clearing of no more than 0.6 ha of Major Drainage habitat for the Managed Aquifer**

Element	Location	Previously Authorised Extent	Authorised Extent
			Recharge scheme infrastructure. Below water table pits are to be backfilled to a level to prevent the formation of permanent pit lakes.
Linear infrastructure	Figure 5	A 413 km rail network transports processed ore from West Angelas to port facilities located at Cape Lambert. Clearing no more than 1,500 ha within a 19,400 ha Linear Infrastructure Development Envelope, including: • Five existing sidings; Spoonbill, Bellbird, Rosella, Brockman Refuge and Emu and potential additional sidings to support the rail network. • Turee Creek B Borefield, pipeline, powerline, access roads and other associated infrastructure.	A 413 km rail network transports processed ore from West Angelas to port facilities located at Cape Lambert. Clearing no more than 1,500 ha within a 19,400 ha Linear Infrastructure Development Envelope, including: • Five existing sidings; Spoonbill, Bellbird, Rosella, Brockman Refuge and Emu and potential additional sidings to support the rail network. • Turee Creek B Borefield, pipeline, powerline, access roads and other associated infrastructure
Surplus water management	Figure 3	Dewatering water will be used onsite in the first instance to supply water for operational purposes. Surplus dewatering water, exceeding the operational requirement is discharged to a local ephemeral tributary of Turee Creek East. The surface discharge extent will not extend within 2 km of the boundary of Karijini National Park under natural no-flow conditions.	Dewatering water will be used onsite in the first instance to supply water for operational purposes. Surplus dewatering water, exceeding the operational requirement is discharged to a local ephemeral tributary of Turee Creek East. The surface discharge extent will not extend within 2 km of the boundary of Karijini National Park under natural no-flow conditions.

Note: Text in **bold** in Table 2 indicates a change to the proposal.

Table 3: Abbreviations and Definitions

Acronym or Abbreviation	Definition or Term
CEO	The Chief Executive Officer of the Department of the Public Service of the State responsible for the administration of section 48 of the Environmental Protection Act 1986, or his delegate.
Conservation Significant Flora	Specially protected (threatened) flora under the Biodiversity Conservation Act 2016 and Department of Biodiversity, Conservation and Attractions listed priority flora and its habitat.
CPI	The All Groups Consumer Price Index numbers for Perth compiled and published by the Australian Bureau of Statistics.
EP Act	*Environmental Protection Act 1986*
ha	hectare
IBRA	Interim Biogeographic Regionalisation for Australia
Km	Kilometre
Pilbara Environmental Offsets Fund	The special purpose account that has been created pursuant to section 16(1)(d) of the *Financial Management Act 2006* by the Department of Water and Environmental Regulation
Ground disturbing activities	Activities that are associated with the substantial implementation of a proposal including but not limited to, digging (with mechanised equipment), blasting, earthmoving, vegetation clearance, grading, gravel extraction, construction of new or widening of existing roads and tracks.

Figures (attached)

Figure 1 Conceptual mine layout and revised development envelope.
Figure 2 Native vegetation condition mapping within the revised development envelope.
Figure 3 West Angelas Cracking Clay PECs and riparian vegetation with surplus water discharge in Turee Creek East.
Figure 4 Ghost bat cave locations, water features and fauna habitat within the West Angelas project area.
Figure 5 Linear infrastructure development envelope.

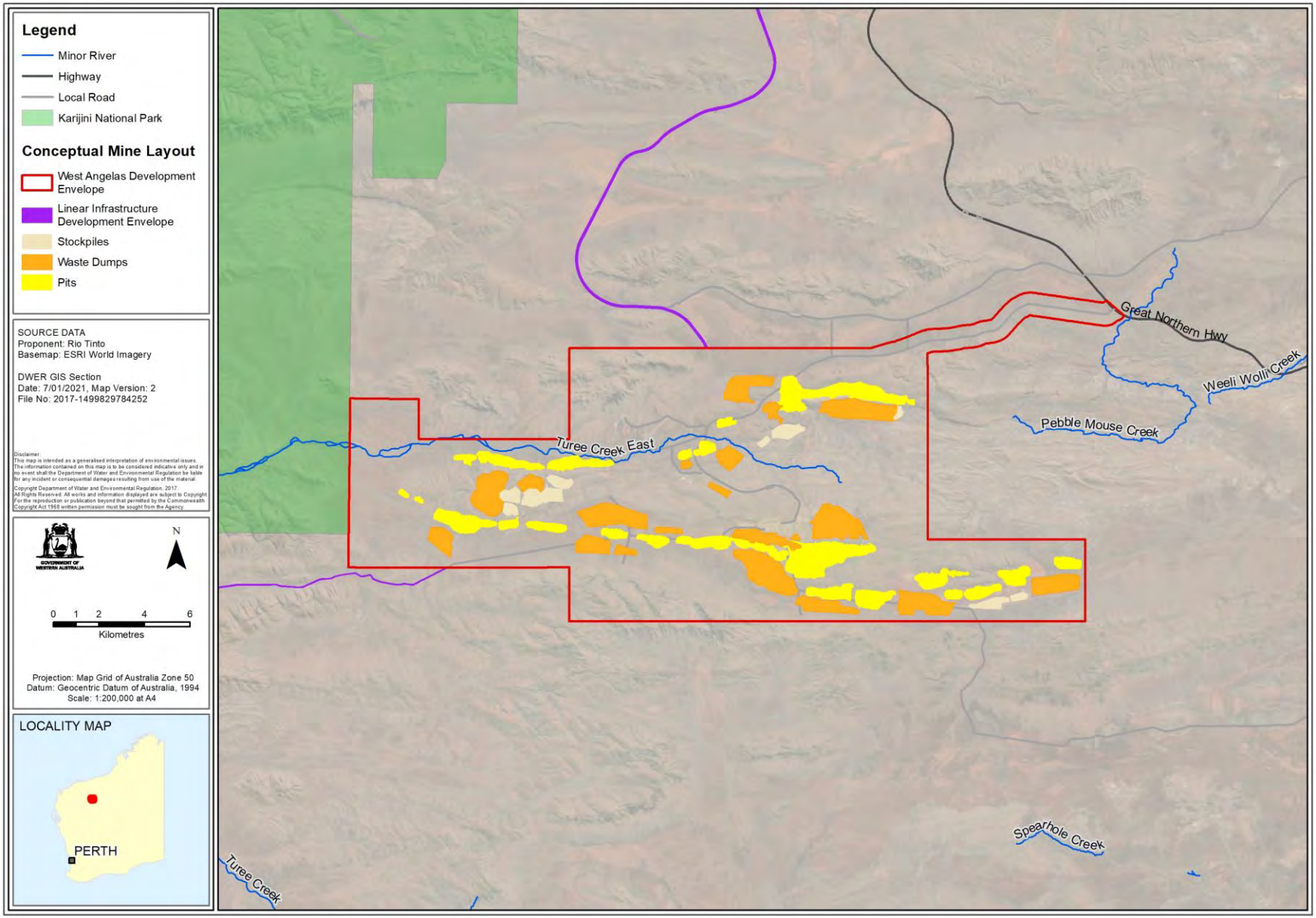

Figure 1. Conceptual mine layout and revised development envelope.

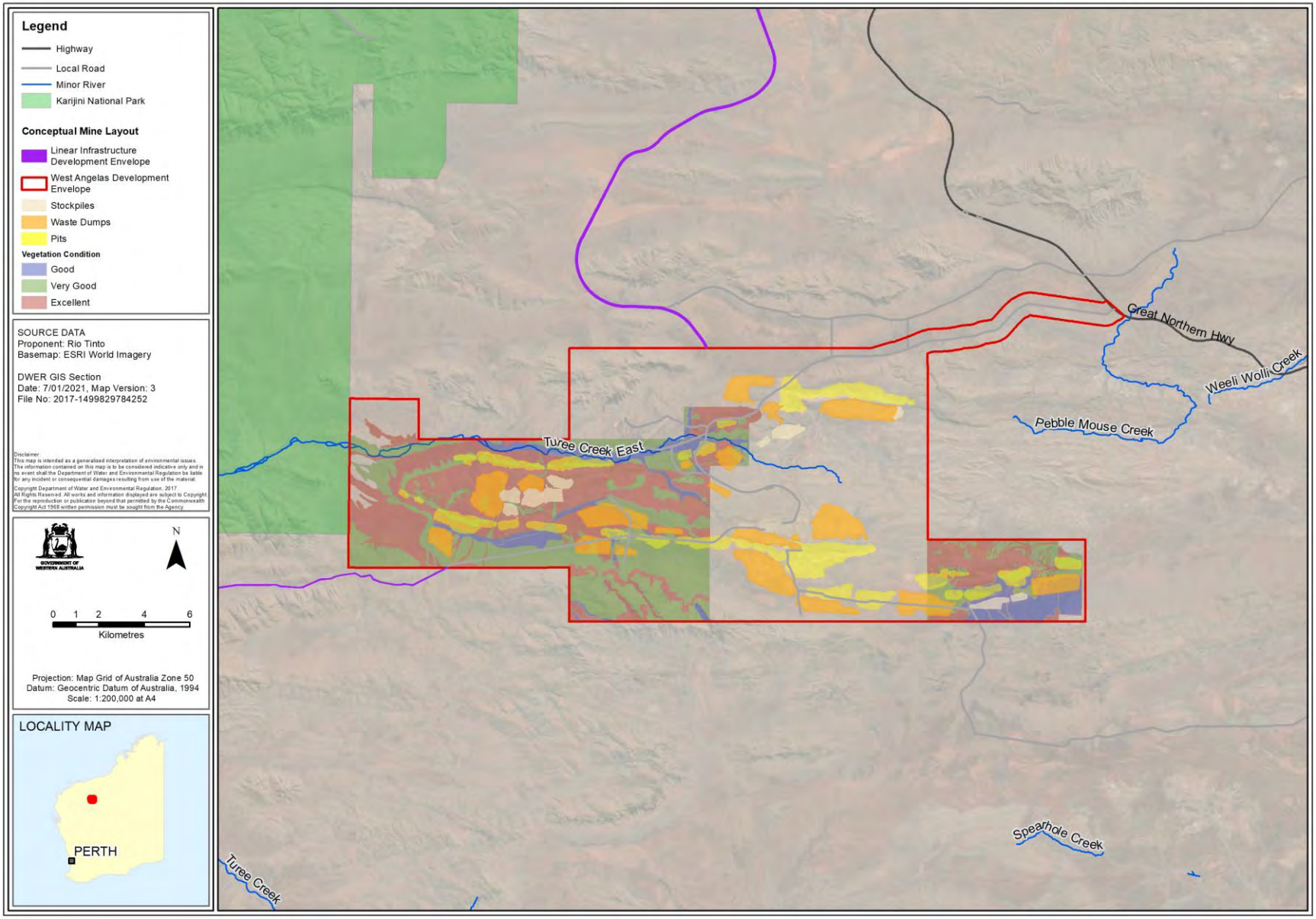

Figure 2. Native vegetation condition mapping within the revised development envelope.

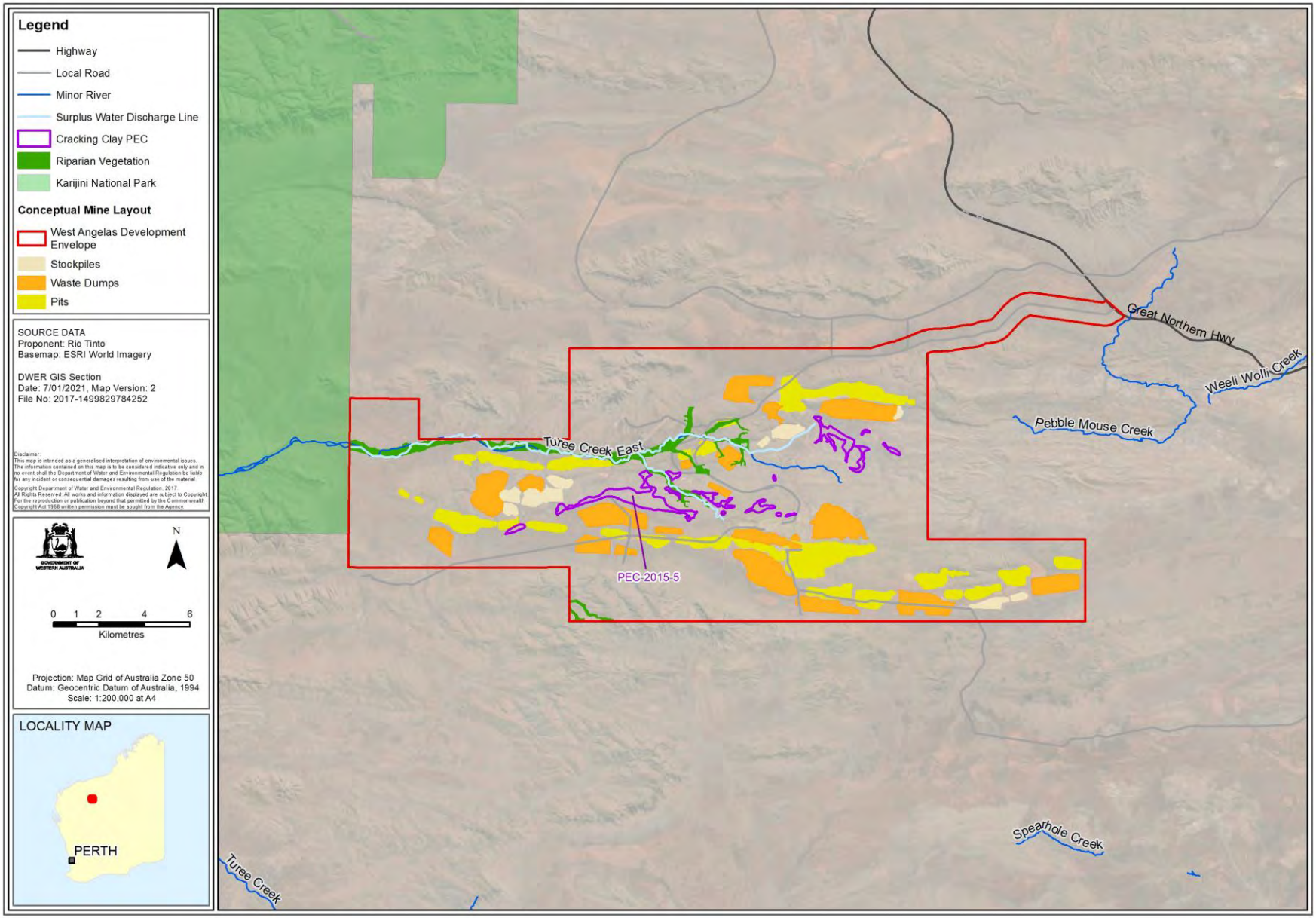

Figure 3. West Angelas Cracking Clay PECs and riparian vegetation with surplus water discharge in Turee Creek East.

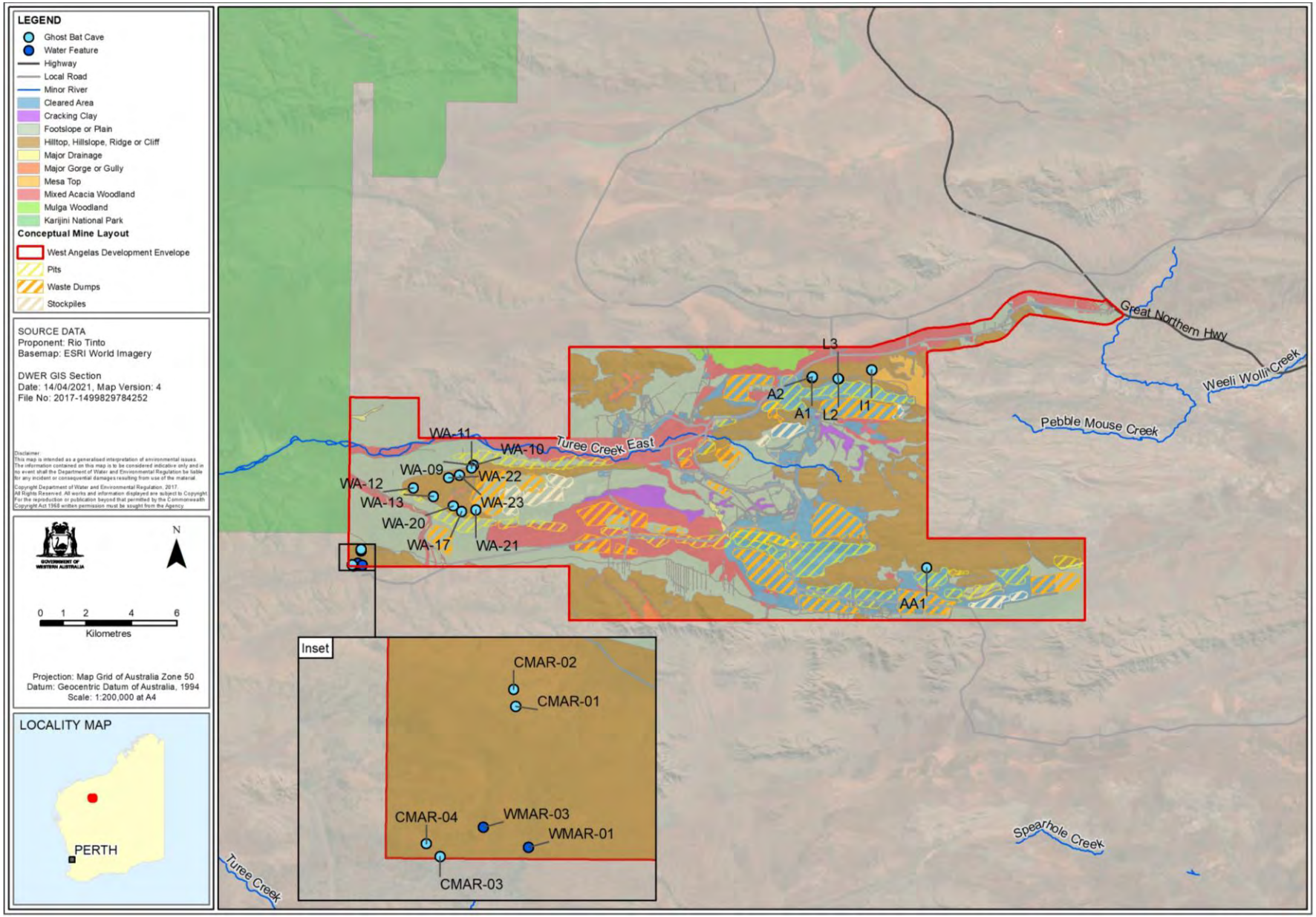

Figure 4. Ghost bat cave locations, water features and fauna habitat within the West Angelas project area.

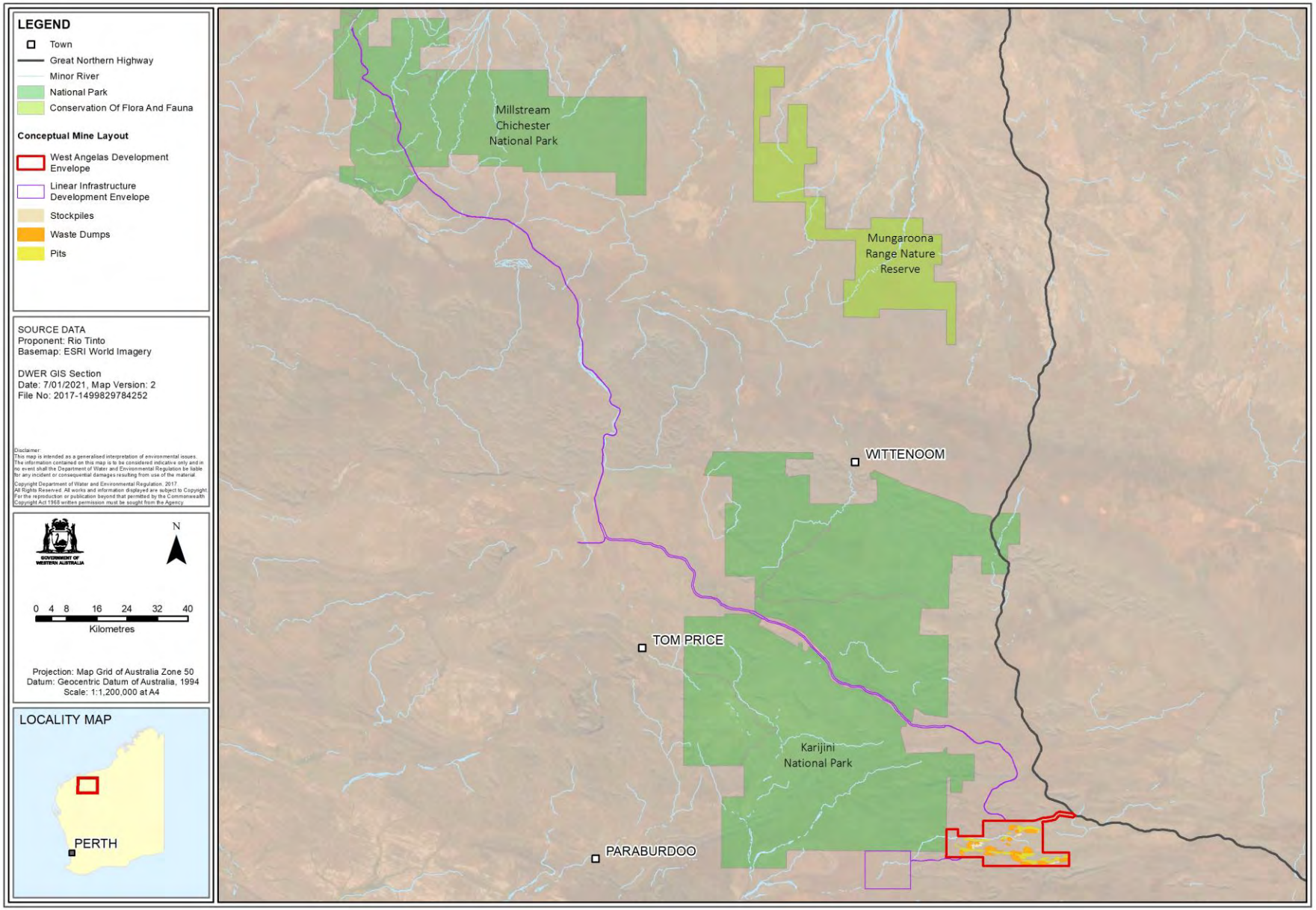

Figure 5. Linear infrastructure development envelope

Spatial data defining the areas shown in Figures 1–5 is held by the Department of Water and Environmental Regulation under the following reference numbers:

- West Angelas Revised Development Envelope – DWERDT321097
- West Angelas Cracking Clay PEC – DWERDT323025
- Ghost Bat cave locations – DWERDT323025
- Caves and water features in the Mine Development Envelope extension area – A1996199
- Riparian vegetation – DWERDT323025
- Surface water discharge – 2019-1555313124263
- Linear infrastructure development envelope – DWERDT321097
- Fauna habitat – DWERDT382303
- Native vegetation condition - DWERDT398856.

All coordinates are in metres, listed in Map Grid of Australia Zone 50 (MGA Zone 50), datum of Geocentric Datum of Australia 1994 (GDA94).

[Signed 16 April 2021]

Professor Matthew Tonts
CHAIR
Environmental Protection Authority
under delegated authority

A.4: Proposal Content Document

Proposal Content Document

West Angelas Revised Proposal

Robe River Mining Co Pty Ltd

Assessment Number: 2290

February 2023

Robe River Iron Associates

152-158 St Georges Terrace, Perth WA 6000

GPO Box A42, Perth WA 6837

RTIO-0980960

RioTinto

Disclaimer and Limitation

This document has been prepared by Rio Tinto's Iron Ore Group (Rio Tinto), on behalf of Robe River Mining Company (ACN 008694246), specifically for the West Angelas Revised Proposal. Neither the report nor its contents may be referred to without the express approval of Rio Tinto, unless the report has been released for referral and assessment of proposals.

Document Status					
Rev	Author	Reviewer/s	Date	Approved for Issue	
				To Whom	Date
1	E. Mason	C. Baxter	21/12/2022	EPAS	10/02/2023

1. CONTENT OF A PROPOSAL

1.1 General Proposal Description

Table 1 provides a consolidated updated general proposal description for the Proposal.

Table 1: General Proposal Content Description

Proposal Title	West Angelas Revised Proposal	No change
Proponent Name	Robe River Mining Co Pty Ltd	Robe River Mining Co Pty Ltd (ACN 008694246)

Short Description	The Proposal is located approximately 130 km northwest of Newman in the East Pilbara region of Western Australia. The Proposal is located within Yinhawangka and Ngarlawangga Peoples Native Title Determination Areas. The Proposal includes the development of AWT and BWT iron ore deposits and associated infrastructure including:
	• Development of above and below water table mine pits;
	• Activities required to facilitate the development of mine pits which may include as relevant, but are not limited to, the following:
	  • Mineral waste management: including waste rock landforms, land bridges, low grade ore dumps, topsoil and sub-soil stockpiles, in-pit waste rock landforms and storage of waste fines;
	  • Ore processing (including crushing) infrastructure;
	  • Other facilities including workshops, hydrocarbon and Ammonium Nitrate Fuel Oil (ANFO) storage and laydown areas;
		The Proposal is located approximately 130 km northwest of Newman in the East Pilbara region of Western Australia. The Proposal is located within Yinhawangka and Ngarlawangga Peoples Native Title Determination Areas. The Proposal includes the development of AWT and BWT iron deposits and associated infrastructure including:
		• Development of above and below water table mine pits;
		• Associated activities which may include as relevant, but are not limited to, the following:
		  • Mineral waste management: including waste rock landforms, land bridges, low grade ore dumps, topsoil and sub-soil stockpiles, in-pit waste rock landforms and storage of waste fines;
		  • Ore processing (including crushing) infrastructure;
		  • Other facilities including workshops, hydrocarbon and Ammonium Nitrate Fuel Oil (ANFO) storage and laydown areas;
		  • Linear infrastructure including heavy and light vehicle access roads, rail and associated infrastructure, conveyors, utilities corridors, pipelines and power (including sub-stations) and communications distribution networks;

	• Linear infrastructure including but not limited to heavy and light vehicle access roads, rail and associated infrastructure, conveyors, utilities corridors, pipelines and power (including sub-stations) and communications distribution networks; • Infrastructure for surface water management including crossings, diversion drains, levees and culverts; • Groundwater abstraction and utilisation, and associated infrastructure; • Dewatering to enable below water table mining and associated infrastructure (including bores and pipelines); • Infrastructure for management and use of water from dewatering • Offices and accommodation villages	• Infrastructure for surface water management including crossings, diversion drains, levees and culverts; • Groundwater abstraction and utilisation, and associated infrastructure; • Dewatering to enable below water table mining and associated infrastructure (including bores and pipelines); • Infrastructure for management and use of water from dewatering; • Offices and accommodation villages; • Renewable energy including renewable energy generation, energy storage and associated ancillary infrastructure.

2.1 General Proposal Description

Table 2 details the changes to Proposal elements for the West Angelas Revised Proposal which have been identified as those elements which have the potential to have a significant effect on the environment.

Table 2: Proposal Content Elements

Proposal Element	Location/Description	Revised Proposal Extent (as referred)	Proposed Amendment	Revised Proposal Extent (as amended)
Physical Elements				
Mine and associated infrastructure	Figure 1	Clearing of up to an additional 19,405 ha of native vegetation within a mine development envelope of 41,484 ha No clearing within Ghost Bat Cave AA1, WA-13, WA-21 and WA-23 Exclusion Zones No clearing within the West Angelas Cracking Clay Priority Ecological Community (PEC-2015-5) No more than 20 ha of clearing to other representations of the West Angelas Cracking Clay Priority Ecological Community No more than 25 ha of clearing of riparian vegetation No clearing of Hilltop, Hillslope, Ridge or Cliff habitat for the Managed Aquifer Recharge Scheme infrastructure No clearing of: Water features - WMAR-01 and WMAR-03 Caves - CMAR-02, CMAR-03 and CMAR-04 Clearing of no more than 0.6 ha of Major Drainage habitat for the Managed Aquifer Recharge scheme infrastructure Below water table pits are to be backfilled to a level to prevent the formation of permanent pit lakes.	Reduction by 4,705 ha to the Development Envelope and reduction in the clearing of 1,850 ha	Clearing no more than **17,555 ha** within a **36,779 ha** Development Envelope. No clearing within Ghost Bat Cave AA1, WA-13, WA-21 and WA-23 Exclusion Zones No clearing within the West Angelas Cracking Clay Priority Ecological Community (PEC-2015-5) No more than 20 ha of clearing to other representations of the West Angelas Cracking Clay Priority Ecological Community No more than 25 ha of clearing of riparian vegetation No clearing of Hilltop, Hillslope, Ridge or Cliff habitat for the Managed Aquifer Recharge Scheme infrastructure No clearing of: Water features - WMAR-01 and WMAR-03 Caves - CMAR-02, CMAR-03 and CMAR-04 Clearing of no more than 0.6 ha of Major Drainage habitat for the Managed Aquifer Recharge scheme infrastructure Below water table pits are to be backfilled to a level to prevent the formation of permanent pit lakes.

Rail Infrastructure	NA	A 413 km rail network transports processed ore from West Angelas to port facilities located at Cape Lambert Clearing no more than 1,500 ha within a 19,400 ha Linear Infrastructure Development Envelope, including: Five existing sidings (Spoonbill, Bellbird, Rosella, Brockman Refuge and Emu) and potential additional sidings to support the rail network Turee Creek B Borefield, pipeline, powerline, access roads and other associated infrastructure	No change	A 413 km rail network transports processed ore from West Angelas to port facilities located at Cape Lambert Clearing no more than 1,500 ha within a 19,400 ha Linear Infrastructure Development Envelope, including: Five existing sidings (Spoonbill, Bellbird, Rosella, Brockman Refuge and Emu) and potential additional sidings to support the rail network Turee Creek B Borefield, pipeline, powerline, access roads and other associated infrastructure
Operational Elements				
Surplus water management	Figure 1	Management of surplus water via water management options including, but not limited to: • Use and storage onsite, • Discharge to disused mine pits, • Controlled discharge to the environment: Turee Creek East (not to extend within 2 km of the boundary of Karijini National Park) and other unnamed ephemeral creeks.	Amended to more clearly identify water use hierarchy and proposed use of surface water Addition of use in Managed Aquifer Recharge Project and Provision to other users	Dewatering water will be used on-site in the first instance to supply water for operational purposes. Use of surplus water may include: • Use in processing • On-site other use • Options for temporary storage in disused mine pits • Infiltration to the aquifer • Use in Managed Aquifer Recharge Project • Provision to other users Surplus dewatering water exceeding the operational requirement is discharged to a local ephemeral tributary of Turee Creek East. The surface discharge extent will not extend within 2 km of the boundary of Karijini National Park under natural no-flow conditions
Proposal Elements with Greenhouse Gas Emissions				
Peak Annual				
Scope 1		Diesel and land clearing –approximately 193,388 t CO_2-e pa.		

Scope 2	Electricity – approximately 25,335 t CO_2-e pa.	
Scope 3	Annual average approximately 17.4 Mt CO_2-e pa.	
Rehabilitation		
The key closure outcome is to rehabilitate the site to create a safe, stable, non-polluting landscape consistent with the post-mining land use and maintain environmental and cultural heritage values. Rehabilitation and closure activities will be carried out in accordance with the approved Mine Closure Plan (MCP).		
Other Elements that Affect the Extent of Effects on the Environment		
Proposal Time	Maximum project life	Operational phase estimated to be ~ 15 years (not including construction and closure implementation phases).

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Figure 1
Development Envelope and Indicative Location of Proposal Elements

Drawn: GIS Team
Plan: RTIO-0976827v1
Date: December 2022

Proj: GDA 1994 MGA Zone 50
Scale: 1:120,000 @A3
GIS.Team@riotinto.com

660,000 670,000 680,000 690,000

7,450,000 7,440,000 7,430,000

Karijini National Park

Great Northern Highway

Western Hill

Deposit C

Deposit D

Deposit A West

Deposit G

Deposit B

Deposit A

Deposit E

Deposit H

Deposit F North

Deposit F

Mt Ella East

Turee Creek East Branch

Spearhole Creek

Millstream-Chichester National Park

Karijini National Park

Tom Price

Paraburdoo

0 40 80
Kilometres

Legend

- Revised Development Envelope
- Ministerial Statement Boundary 1113

Conceptual Layout

- Infrastructure
- Pit
- Waste Dump
- Stockpile
- National Park
- Rio Tinto Railway
- Highway
- Major Creek

N

0 1 2 3 4 5
Kilometres

Map units in metres

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A.5: Mine Closure Plan

West Angelas Mine Closure Plan

29 November 2023 Version 1.1

IMS #	RTIO-0983209
Environmental Group Name	West Angelas Environmental Group
Environmental Group Site	S0231516
Mineral Field(s)	47 – West Pilbara, 52 – Peak Hill
Proponent	Robe River Mining Co. Pty. Ltd.
ABN	71 008 694 246

Tenement	Tenement Holder
Iron Ore (Robe River) Agreement Act 1964, ML248SA Sections	
G47/1235, G47/1236; L47/41; L47/50; L47/52; L47/53; L47/54; L47/60; L47/61; L47/62; L47/63; L47/409; L47/769; L47/842; L47/853; L47/884; L47/885; L47/910; L47/1027; L47/1028; L52/72; L52/75 L52/153	Joint tenement holders: North Mining Limited; Robe River Mining Co. Pty Ltd; Mitsui Iron Ore Development Pty Ltd; Pannawonica Iron Associates; Cape Lambert Iron Associates

RioTinto

Disclaimer and Limitation

This Mine Closure Plan has been prepared by Rio Tinto's Iron Ore Group (Rio Tinto), on behalf of Robe River Mining Co. Pty Ltd (the Proponent) as manager and agent for the participants in the Robe River Iron Associates joint venture, in relation to West Angelas.

Date	Agency	Purpose	Status
2014-2016	DWER	Compliance with MS 970	V1 regulatory review V2 regulatory review V3 regulatory review V4 regulatory review Superseded
2017-2018	DWER	Compliance with MS 1015	Regulatory review V1 Regulatory review V2 Superseded
Jan 2020	DMIRS	To support a Mining Proposal	NA
Sep 2020	DWER	Compliance with MS 1113 condition 7-2	V1 regulatory review V2 regulatory review (submitted March 2021)
Mar 2023	DWER (EPA) YAC,NAC	Submitted with Environmental Review Document	Submitted March 2023
Nov 2023	DWER	Submitted the West Angelas Revised Proposal ERD for public comment	Submitted November 2023

EXECUTIVE SUMMARY

The West Angelas iron ore mine is in the Pilbara region of Western Australia, approximately 100 km west of Newman in the Shire of East Pilbara and the Shire of Ashburton (Turee B Borefield) and is within the traditional lands of the Yinhawangka and Ngarlawangga people.

The deposits at West Angelas are held by the participants in the Robe River Iron Associates (Robe), an unincorporated joint venture (JV) comprising Robe River Mining Co. Pty. Ltd (RRMC), Mitsui Iron Ore Development Pty Ltd, North Mining Limited, Pannawonica Iron Associates, and Cape Lambert Iron Associates. These deposits are managed by RRMC, being a member of the Rio Tinto group, as manager and agent for Robe, pursuant to the *Iron Ore (Robe River) Agreement Act 1964* (WA) (the **State Agreement**).

West Angelas commenced operations in 2001 and comprises open cut operations utilising conventional drill-and-blast and load-and-haul mining methods. Ore is processed on-site before being transported via rail to either Dampier or Cape Lambert ports for shipping. The Project has a remaining operational life of approximately 16 years with completion of mining of approved deposits scheduled for approximately 2039.

Scope

The West Angelas mine closure plan (MCP) incorporates above and below water table mining operation, accommodation camps and associated infrastructure as approved under Part IV of the *Environmental Protection Act 1986* (WA) (EP Act) via Ministerial Statement 1113 (MS 1113). This MCP also includes proposed deposits Western Hill, Deposit F North, Deposit H and Mount Ella East.

Closure outcomes

The following closure outcomes in the last approved MCP for West Angelas were:

- public health and safety hazards have been appropriately managed;
- contamination risks have been appropriately managed;
- final landform is stable and considers ecological and hydrological factors;
- vegetation on rehabilitated land consists of self-sustaining native species and is compatible with the final land use;
- infrastructure is appropriately managed;
- Cultural heritage values have been preserved where possible; and
- the closure strategy ensures that no drawdown of groundwater or impact to quality occurs as a result of the West Angelas operation at the boundary of, or within, Karijini National Park.

Small modifications have been made to some of the outcomes in this MCP to better reflect current Rio Tinto nomenclature, as presented below:

- The final landform is stable, and its design considers hydrological and ecological factors.
- Contamination risk has been appropriately managed and does not preclude the agreed post-mining land users(s).
- Vegetation on rehabilitated land is self-sustaining and compatible with the post-mining land use.
- Public health and safety hazards have been appropriately managed.
- Infrastructure has been appropriately managed.
- Cultural heritage values have been preserved where possible, in consultation with stakeholders.

- The closure strategy ensures that no drawdown of groundwater or impact to quality occurs as a result of the West Angelas operation at the boundary of or within Karijini National Park.

Due to the extended operation timelines, these closure outcomes have yet to be agreed with key stakeholders and are likely to evolve in future versions of this plan as knowledge of closure issues progress and detailed closure discussions commence.

Risk assessment and management of key issues

The current risk profile for closure of West Angelas is provided in Section 7 of this MCP. There are 14 open risks as of 12/2022: A total of two Class IV risks were identified following the review of the closure risk register in March 2022. The threats assigned to this risk classification include:

- Risk 515550 - Implementation of the closure strategy does not result in the agreed environmental outcome.
- Risk 515545 - Pit wall stability at West Angelas compromises closure outcomes.

A total of seven Class III risks were identified following the review of the closure risk register in March 2022. The threats assigned this risk classification include:

- Risk 804079 - Insufficient material for backfill/capping increases closure liability and complexity.
- Risk 722921 – Inadequate management of surface water results in increased closure complexity and costs.
- Risk 707951 – Consultation fails to identify and/or address stakeholder concerns.
- Risk 515552 – Implementation of the closure strategy does not achieve the required cultural heritage outcomes.
- Risk 515549 – The safety risk for people entering West Angelas after it has been rehabilitated has not been effectively mitigated.
- Risk 515547 – Rehabilitation outcomes at West Angelas do not meet closure objectives.
- Risk 515546 – Waste dumps and land-bridges are subject to excessive erosion.

The risk profile for West Angelas has changed since the last Closure Plan submission with an increase in the number of Class IV risks (0 to 2) and an increase in Class III risks (4 to 7)

The causes, impacts, existing controls, evaluation rationale off all risks associated with closure of West Angelas are captured in the West Angelas Closure Risk Register (Appendix 3) and the current open actions associated with key risks are detailed in the West Angelas Action Register (Appendix 4).

Post-mining land use

The proposed final land uses assumes that the site will be rehabilitated to create a safe, stable and non-polluting landscape revegetated with native species, to maintain environmental and cultural heritage values and ensure the site does not adversely impact on the current surrounding land use. The final land use will be determined prior to closure during final planning phases and in consultation with relevant stakeholders.

Anticipated closure outcome

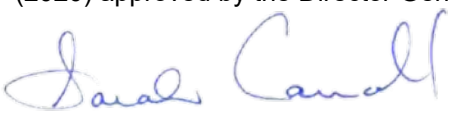
Mine voids will be backfilled to prevent the formation of permanent pit lakes, although water may temporarily pool at the base of the voids following heavy rainfall. Groundwater is not predicted to recover to pre-mining levels in all areas. Waste dumps will be reshaped to be stable based on their material characteristics. Potential Acid Forming (PAF) and fibrous waste will be encapsulated, with a store and release cover included on PAF waste dumps. It is assumed that all above ground infrastructure and buried services <1 m from surface will be removed, but this will be subject to negotiation with the

Western Australian State Government in accordance with the State Agreement and Traditional Owners. All other disturbed areas, except pit walls and floors (unless within 10 m of the pit crest) will be rehabilitated. General rehabilitation practices include spreading of topsoil or another growth medium where available and spreading native seed with the aim of creating self-sustaining ecosystems.

The area around pit voids may be unstable as pit walls are expected to collapse over time, and inadvertent access will be restricted using physical barriers (e.g., abandonment bunds). Strategies for managing safety risks will be developed as the site approaches closure but will need to consider the potential for ongoing public access resulting from access requirements of local Traditional Owner Groups.

Corporate endorsement:

I hereby certify that to the best of my knowledge, the information within this Mine Closure Plan is true and correct and addresses the relevant requirements of the *Statutory Guidelines for Mine Closure Plans* (2020) approved by the Director General of Mines, Industry Regulation and Safety.



Sarah Carroll

General Manager – Integrated Planning

Date: 29 November 2023

NB: The corporate endorsement section must be given by tenement holder(s) or a senior representative authorised by the tenement holder(s), such as a Registered Manager or Company Director.

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GLOSSARY AND ABBREVIATIONS

AEP	Annual Exceedance Probability
ALUM	Australian Land Use Management
AMD	Acid and Metalliferous Drainage
AWT	Above Water Table
BIF	Banded Iron Formation
BWT	Below Water Table
CHMP	Cultural Heritage Management Plan
CMIP6	Coupled Modelled Intercomparison Project Phase 6
DAWE	Department of Agriculture, Water and the Environment
DBCA	Department of Biodiversity Conservation and Attractions
DMIRS	Department of Mine, Industry Regulation and Safety
DOH	Department of Health
DPIRD	Department of Primary Industries and Regional Development
DPLH	Department of Planning, Lands and Heritage
DWER	Department of Water and Environmental Regulation (including EPA Services, Water and Environmental Regulation)
EPA	Environmental Protection Authority
ERD	Environmental Review Document
ESP	Exchangeable Sodium Percentage
FS	Feasibility Study
GDE	Groundwater Dependent Ecosystem
ha	Hectare
IBRA	Interim Biogeographic Regionalisation for Australia
ILUA	Indigenous Land Use Agreements
IMS	Information Management System
IPCC	Intergovernmental Panel on Climate Change
JTSI	Department of Jobs, Tourism, Science and Innovation
LoMP	Life of Mine Planning
mRL	Metres above relative level
MS	Ministerial Statement
NVCP	Native Vegetation Clearing Permits
OoM	Order of Magnitude
PAF	Potentially Acid Forming
PCO	Present Closure Obligation
PFS	Pre-feasibility Study
PUPEZ	Potentially Unstable Pit Edge Zone
Rio Tinto	Rio Tinto Iron Ore

SCARD	Spontaneous Combustion and Acid Rock Drainage
SCHMP	Social Cultural Heritage Management Plan
TDS	Total dissolved solids
TPC	Total Projected Closure
WD	Waste dump
WEPP	Water Erosion Prediction Program
WFSF	Waste fines storage facility
WRL	Waste Rock Landform

1. PURPOSE AND SCOPE

1.1. Purpose of the Mine Closure Plan

This Mine Closure Plan (MCP) has been developed to describe the strategies to be adopted by Robe River Mining Co Pty Ltd (Rio Tinto) as manager and agent for the participants of the Robe River Iron Associates Joint Venture to manage the closure of the West Angelas mining operations.

Specifically, this MCP has been prepared in support of the amended West Angelas Revised Proposal (Proposal) submission to the Environmental Protection Authority (EPA) for assessment under s38 of the *Environmental Protection Act 1986* (WA) (EP Act). Approval for the Proposal to be amended under s43a has been sought.

The purpose of this MCP is to:

- Achieve compliance with condition 7-3 of Ministerial Statement 1113
- Assist Rio Tinto in the planning for and management of West Angelas rehabilitation and closure requirements by informing life of mine planning, operational activities and the development of closure provisions.
- Meet the internal requirements of the Rio Tinto Closure Standard (2021) mandated for all Rio Tinto Assets.
- Consult with key stakeholders on how Rio Tinto plans to meet its mine rehabilitation and closure requirements for West Angelas.
- Reflect the current knowledge and requirements for closure of the West Angelas operations and identify the knowledge gaps and inform the closure task register to continue to reduce risk and progress towards a planned and managed closure of the site.
- Meet the requirements in the Department of Mines, Industry Regulation and Safety (DMIRS) *Statutory Guidelines for Mine Closure Plans* (2020) and *Mine Closure Plan Guidance - How to prepare in accordance with Part 1 of the Statutory Guidelines for Mine Closure Plans* (2020).
- Address progress on comments (dated 23rd June 2021) from DMIRS, Department of Biodiversity, Conservation and Attractions (DBCA) and the Department of Water and Environmental Regulation (DWER) on the West Angelas MCP (Version 2, March 2021).

This MCP, or future iterations of this MCP, will be used by Rio Tinto and its contractors in the implementation of appropriate rehabilitation and mine closure strategies at West Angelas.

1.2. Scope of this Mine Closure Plan

This MCP covers the current mining operations at West Angelas and the proposed development of new above and below water table iron ore mine pits and associated infrastructure (subject to the Proposal), to sustain the existing West Angelas operations and is applicable to areas and mine development features within the following tenements (Table 1-1)[1]:

[1] Note that the scope of the closure plan has been aligned to tenure boundaries, which may differ from the Development Envelope approved under Part IV of the *Environmental Protection Act 1986* and includes disturbance approved under Native Vegetation Clearing Permits (NVCPs) which are outside the MS 1113 development envelope.

Table 1-1: Tenements covered by this MCP

Tenement	Detail	Holder
ML248SA	Sections that fall within the Part IV development envelope including 068 to 086, 112 (mining leases issued pursuant to the *Iron Ore (Robe River) Agreement Act 1964.*	Robe River Limited
G47/01235	GPL West Angelas 1	Joint tenement holders: North Mining Limited; Robe River Mining Co. Pty. Ltd; Mitsui Iron Ore Development Pty Ltd; Pannawonica Iron Associates; Cape Lambert Iron Associates.
G47/01236	GPL West Angelas 2	Joint tenement holders: North Mining Limited; Robe River Mining Co. Pty. Ltd; Mitsui Iron Ore Development Pty Ltd; Pannawonica Iron Associates; Cape Lambert Iron Associates.
L47/00041	Turee B (Water)	Joint tenement holders: North Mining Limited; Robe River Mining Co. Pty. Ltd; Mitsui Iron Ore Development Pty Ltd; Pannawonica Iron Associates; Cape Lambert Iron Associates.
L47/00050	Railway 4 (limited to the rail loop and spur up until it intersects the mainline);	Joint tenement holders: North Mining Limited; Robe River Mining Co. Pty. Ltd; Mitsui Iron Ore Development Pty Ltd; Pannawonica Iron Associates; Cape Lambert Iron Associates.
L47/00052	Road / Pipe / AC 1	Joint tenement holders: North Mining Limited; Robe River Mining Co. Pty. Ltd; Mitsui Iron Ore Development Pty Ltd; Pannawonica Iron Associates; Cape Lambert Iron Associates.
L47/00053	Road / Pipe / AC 2	Joint tenement holders: North Mining Limited; Robe River Mining Co. Pty. Ltd; Mitsui Iron Ore Development Pty Ltd; Pannawonica Iron Associates; Cape Lambert Iron Associates.
L47/00054	Gas Pipe Road 2	Joint tenement holders: North Mining Limited; Robe River Mining Co. Pty. Ltd; Mitsui Iron Ore Development Pty Ltd; Pannawonica Iron Associates; Cape Lambert Iron Associates.
L47/00060	Repeater Station 2	Joint tenement holders: North Mining Limited; Robe River Mining Co. Pty. Ltd; Mitsui Iron Ore Development Pty Ltd; Pannawonica Iron Associates; Cape Lambert Iron Associates.
L47/00061	Repeater Station 3	Joint tenement holders: North Mining Limited; Robe River Mining Co. Pty. Ltd; Mitsui Iron Ore Development Pty Ltd; Pannawonica Iron Associates; Cape Lambert Iron Associates.
L47/00062	Repeater Station 4	Joint tenement holders: North Mining Limited; Robe River Mining Co. Pty. Ltd; Mitsui Iron Ore Development Pty Ltd; Pannawonica Iron Associates; Cape Lambert Iron Associates.
L47/00063	Railway 6	Joint tenement holders: North Mining Limited; Robe River Mining Co. Pty. Ltd; Mitsui Iron Ore Development Pty Ltd; Pannawonica Iron Associates; Cape Lambert Iron Associates.

Tenement	Detail	Holder
L47/00409	West Angelas Gas Pipeline and Power Station	Joint tenement holders: North Mining Limited; Robe River Mining Co. Pty. Ltd; Mitsui Iron Ore Development Pty Ltd; Pannawonica Iron Associates; Cape Lambert Iron Associates.
L47/00769	Turee B Borefield	Joint tenement holders: North Mining Limited; Robe River Mining Co. Pty. Ltd; Mitsui Iron Ore Development Pty Ltd; Pannawonica Iron Associates; Cape Lambert Iron Associates.
L47/00842	West Angelas Gas Pipeline Realignment	Joint tenement holders: North Mining Limited; Robe River Mining Co. Pty. Ltd; Mitsui Iron Ore Development Pty Ltd; Pannawonica Iron Associates; Cape Lambert Iron Associates.
L47/00853	West Angelas Powerline Tie-in	Joint tenement holders: North Mining Limited; Robe River Mining Co. Pty. Ltd; Mitsui Iron Ore Development Pty Ltd; Pannawonica Iron Associates; Cape Lambert Iron Associates.
L47/00884	West Angelas Camp Water Supply	Joint tenement holders: North Mining Limited; Robe River Mining Co. Pty. Ltd; Mitsui Iron Ore Development Pty Ltd; Pannawonica Iron Associates; Cape Lambert Iron Associates.
L47/00885 (pending)	Turee B Borefield Monitoring Bores	Joint tenement holders: North Mining Limited; Robe River Mining Co. Pty. Ltd; Mitsui Iron Ore Development Pty Ltd; Pannawonica Iron Associates; Cape Lambert Iron Associates.
L47/00910	West Angelas Monitoring Bores	Joint tenement holders: North Mining Limited; Robe River Mining Co. Pty. Ltd; Mitsui Iron Ore Development Pty Ltd; Pannawonica Iron Associates; Cape Lambert Iron Associates.
L47/1027 (pending)	Deposit H Infrastructure Corridor North	Joint tenement holders: North Mining Limited; Robe River Mining Co. Pty. Ltd; Mitsui Iron Ore Development Pty Ltd; Pannawonica Iron Associates; Cape Lambert Iron Associates.
L47/1028 (pending)	Deposit H Infrastructure Corridor North	Joint tenement holders: North Mining Limited; Robe River Mining Co. Pty. Ltd; Mitsui Iron Ore Development Pty Ltd; Pannawonica Iron Associates; Cape Lambert Iron Associates.
L52/00072	Angelo River 2 (Water)	Joint tenement holders: North Mining Limited; Robe River Mining Co. Pty. Ltd; Mitsui Iron Ore Development Pty Ltd; Pannawonica Iron Associates; Cape Lambert Iron Associates.
L52/00075*	Gas Pipeline Road 2	Joint tenement holders: North Mining Limited; Robe River Mining Co. Pty. Ltd; Mitsui Iron Ore Development Pty Ltd; Pannawonica Iron Associates; Cape Lambert Iron Associates.
L52/00153	Indabiddy Gap Gas Pipeline 2	Joint tenement holders: North Mining Limited; Robe River Mining Co. Pty. Ltd; Mitsui Iron Ore Development Pty Ltd; Pannawonica Iron Associates; Cape Lambert Iron Associates.

This MCP excludes the following:

- potential future deposits within the West Angelas operations area that are not approved, or approval is not currently being sought, although these may be subsequently incorporated into future updates of this closure plan subject to relevant regulatory approvals;
- the rail line beyond L47/00050 rail loop and spur, which is subject to a separate closure plan;
- exploration areas and exploration infrastructure; and
- linear infrastructure that is connected to an integrated network (e.g. power, communications), which are subject to a separate closure plan.

1.3. Review and Updates of this Mine Closure Plan

This West Angelas MCP has been updated to include responses on progress related to agency comments raised in assessment of the Version 2, 2021 MCP and to capture the closure strategy for the proposed deposits and waste rock landforms. Details of these comments made previously in the Version 2 2021 MCP Section 15 includes RTIO's responses and 2023 updated/progression comments.

Upon approval, this MCP will supersede all previous closure, decommissioning and rehabilitation plans for the West Angelas operations.

2. PROJECT SUMMARY

2.1. Proponent Information

The deposits at West Angelas are held by the participants in Robe River Iron Associates, an unincorporated joint venture (JV) comprising Robe River Mining Co. Pty. Ltd (RRMC), Mitsui Iron Ore Development Pty Ltd, North Mining Limited, Pannawonica Iron Associates, and Cape Lambert Iron Associates. These deposits are managed by RRMC as manager and agent for the Robe JV. RRMC is a subsidiary[2] of Rio Tinto Limited and a member of the Rio Tinto group of companies.

2.2. Location, History, Tenure and Setting

West Angelas is located in the Pilbara region of Western Australia (Figure 2-1) approximately 100 km north-west of Newman and falls within the local authority of the Shire of East Pilbara and the Shire of Ashburton (Turee B Borefield and the western most portion of Western Hill). The West Angelas operations are located immediately adjacent to Karijini National Park to the west. Tenure associated with current and proposed mining activities and included in the scope of this MCP is presented in Figure 2-2 and detailed in Table 1-1. Mining operations at West Angelas commenced in 2001.

The mine is located predominantly on the traditional lands of the Yinhawangka people, with the eastern portion of Deposit F, F North and Deposit H located on the traditional lands of the Ngarlawangga people. The southern extent of Closure Boundary covering miscellaneous tenure intersects the traditional lands of the Nharnuwanngaa people. Due to the inclusion of pending tenure (L47/1027 and L47/1028) the closure boundary now extends into the land held by Nyiyaparli people. There is currently no disturbance or proposed disturbance on Nharnuwanngaa and Nyiyaparli traditional lands for the West Angelas Operation.

The nearest Aboriginal communities are Bellary Springs and Wakathuni, which are both located on Yinhawangka land and are 80 km and 100 km respectively to the west.

The West Angelas mining lease has been issued on unallocated crown land. There is no pastoral activity in the immediate vicinity of the mine, with the nearest pastoral stations being Turee Creek Pastoral Station. The closure boundary extends over Turee Creek Pastoral Station, other pastoral stations within the vicinity include - Juna Downs (N050471), approximately 20 km from the northern boundary of the closure plan scope, and Rocklea Station (N050372), approximately 75 km to the west. Juna Downs is operated by Hamersley Iron Pty. Limited, which is wholly owned by Rio Tinto.

The West Angelas operations are located in proximity to the West Angelas Cracking Clay Priority Ecological Community (PEC) described further in Section 5.12.2 of this MCP.

[2] 60% of RRMC is ultimately held by Rio Tinto Limited.

Figure 2-1: Regional location of West Angelas

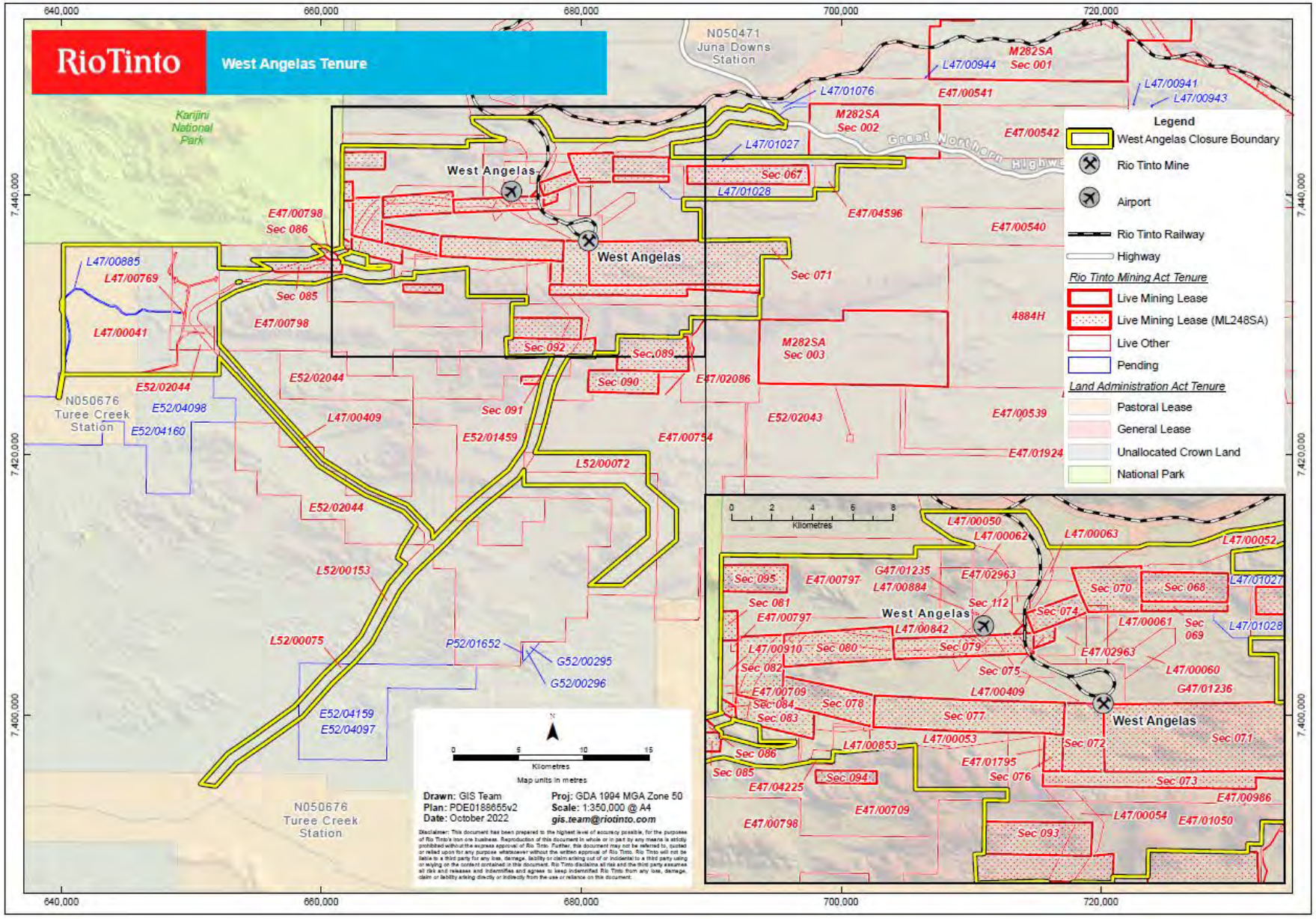


Figure 2-2: Tenure associated with the West Angelas Closure Boundary

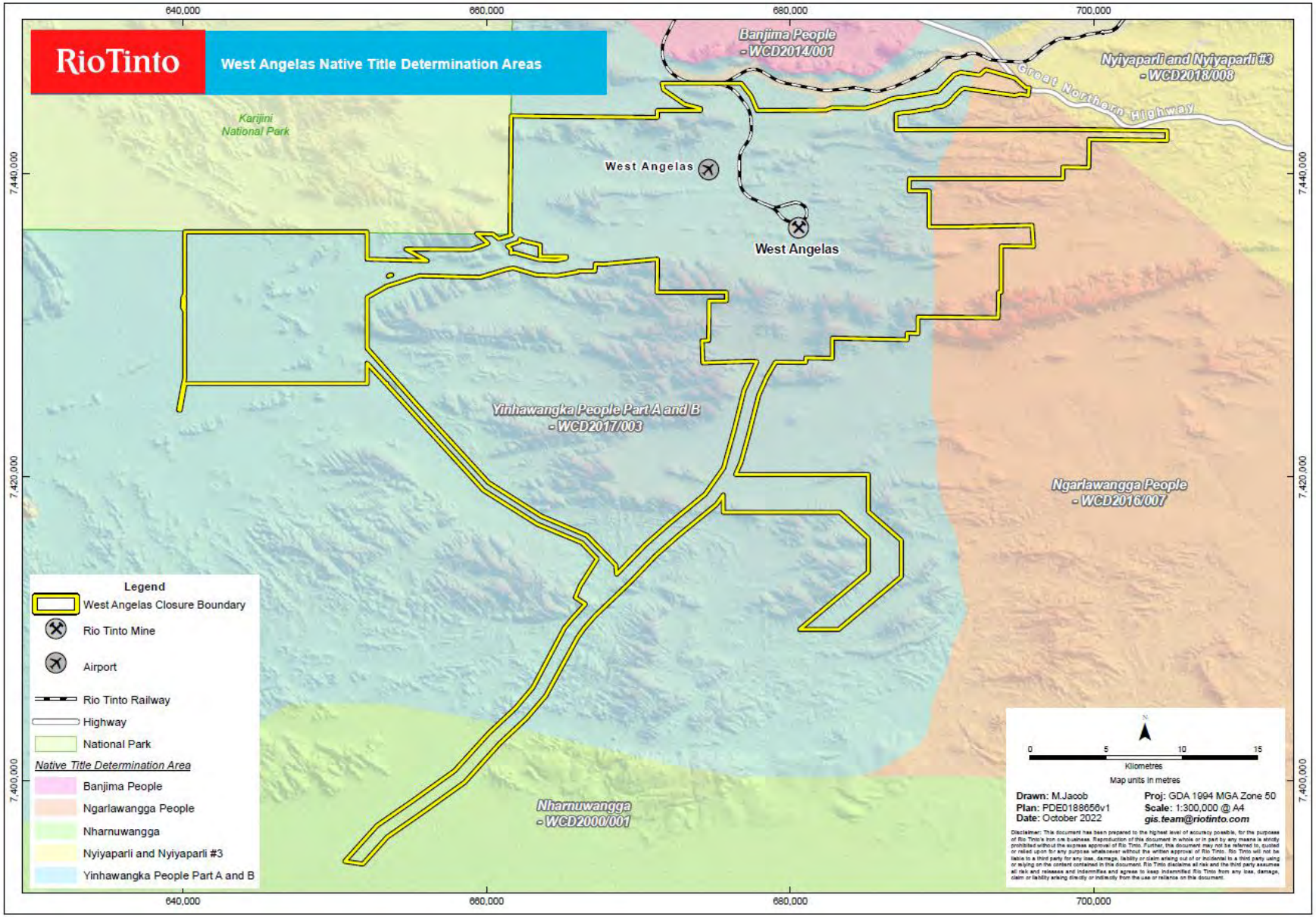


Figure 2-3: Traditional Owner lands within the West Angelas Closure Boundary

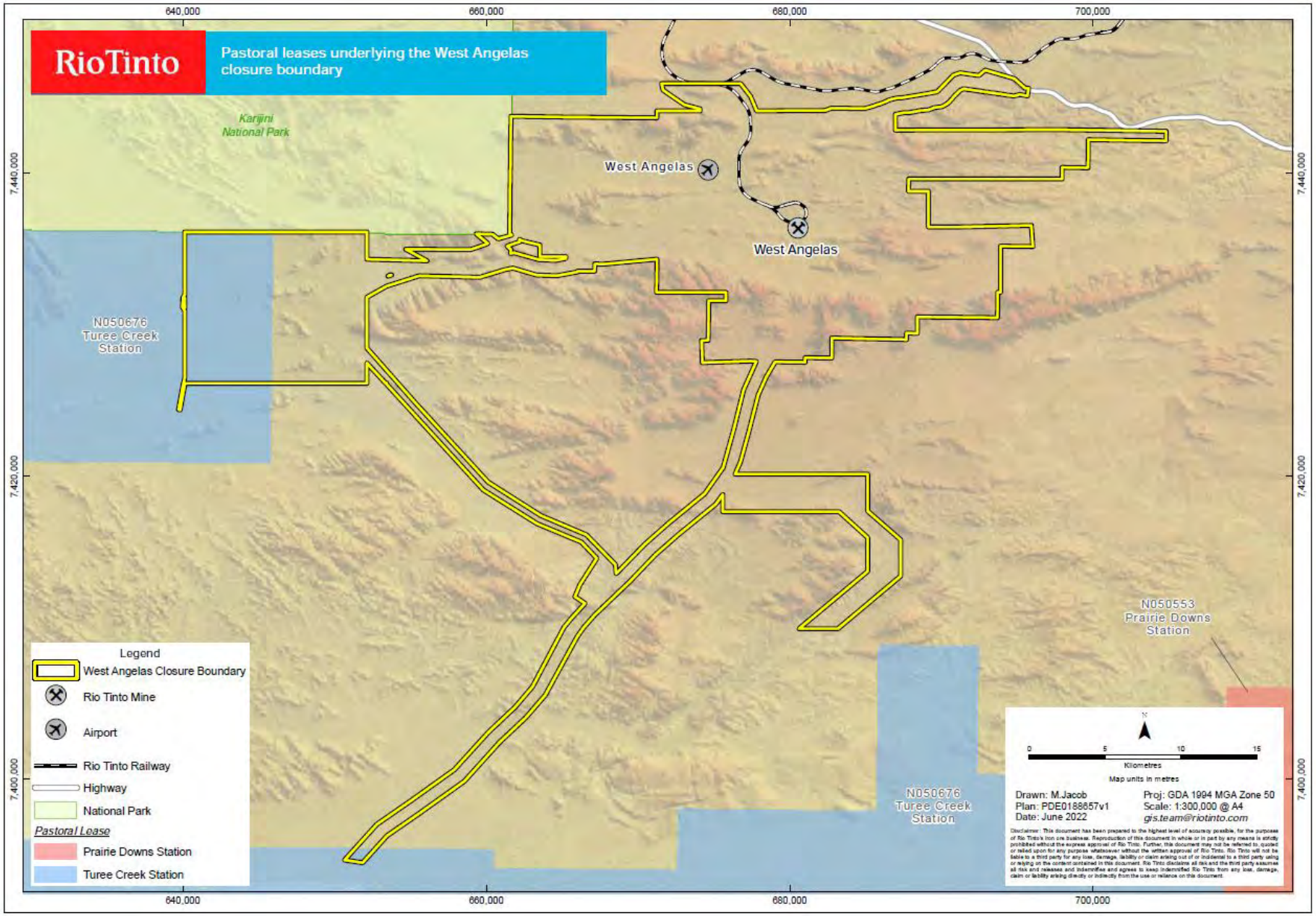


Figure 2-4: Pastoral leases underlying the West Angelas Closure Boundary

2.3. Mine operations

2.3.1. Overview

The West Angelas operation commenced in 2001 and is an open cut operation utilising conventional drill-and-blast and load and haul mining methods. Ore is crushed on-site before being transported via rail to Dampier or Cape Lambert for shipping. Waste is placed in in-pit and ex-pit dumps. The currently approved Life of Mine (LOM) layout is presented in Figure 2-5.

The 2021 life of mine (LoM) layout for the West Angelas operations consists of seven main mining areas, as shown in Figure 2-5. The major components of current mining infrastructure and activities at West Angelas include the following:

- AWT and BWT table mining of seven deposits (Deposit A – Deposit G) by conventional open pit methods;
- external and in pit waste dumps;
- low grade, subsoil, and topsoil stockpiles;
- overland conveyors, primary crushing facilities, ore handling plants and train load-out facilities;
- haul roads and light vehicle access roads to mine areas, waste dumps and other mine infrastructure as required over the life of the mine;
- use of the Turee B borefield to supply water for operational purposes;
- dewatering to allow BWT and discharge of surplus water from dewatering into tributaries of Turee Creek East (under licence);
- Managed Aquifer Recharge (MAR) scheme and associated infrastructure;
- surface water diversion infrastructure;
- administration and support facilities including mine offices; workshop and wash bays; topsoil and subsoil stockpiles;
- explosive stores (i.e. ammonium nitrate); fuelling facilities; water supply and distribution; electricity supply and distribution;
- water treatment plant and waste handling facilities;
- rail loop, rail line, rail access road; and
- utilities including transmission lines, transfer stations, power stations, pipelines, access roads, etc.

The Proposal includes the development of new above and below water table mine pits, associated waste rock landforms and mine infrastructure at:

- Western Hill (above water table only);
- Deposit H;
- Deposit F North; and
- Mt Ella East (above water table only).

2.3.2. Mined landforms

Currently, West Angelas has a remaining operational life of 16 years with completion of mining of approved deposits currently scheduled for 2039. The scheduled completion date for each mining area at West Angelas is indicated in Table 2-1. Mine planning schedules are continuously revised to maximise efficiencies and incorporate approved new deposits. The mine schedules and plans are subject to regular review to ensure optimised performance of the operations and are therefore subject to change.

The Proposal includes the development of new deposits at Western Hill (above water table only), Deposit H, Deposit F North, and Mt Ellla East (above water table only). The proposed development of these deposits will extend the life of West Angelas by two years to 2041. The proposed developments change mining schedules, causing some mining areas to extend beyond the current closure date (summarised in Table 2-1).

Table 2-1: Indicative mining schedule

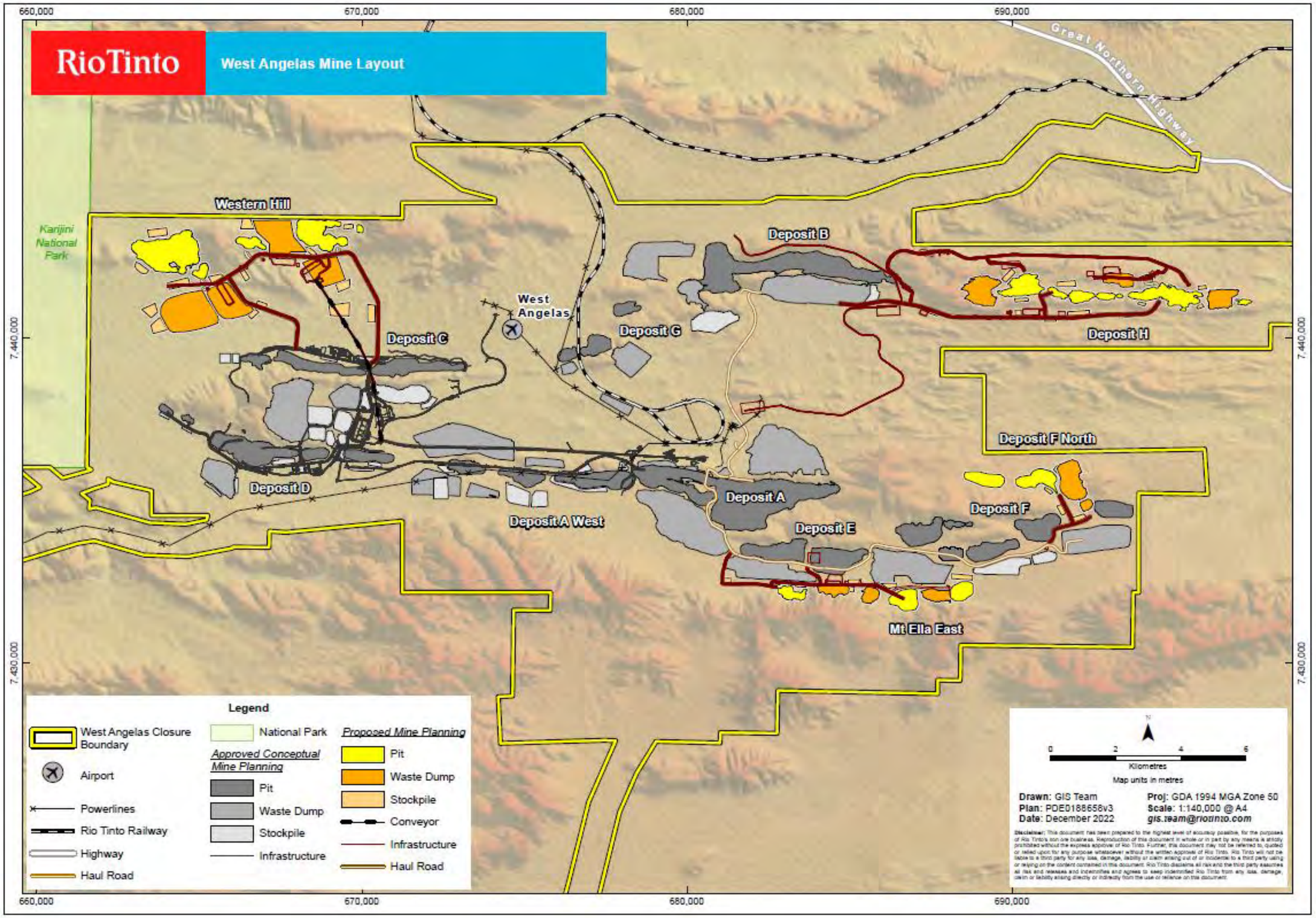
Mining area	Pit	Operational status	Indicative completion date	Description	Regulatory status
Deposit A	WEPN	Complete	2010	AWT	Approved
Deposit A	CEPN	Complete	2016	BWT	Approved
Deposit A	CEPS	Operational	2022	BWT	Approved
Deposit A	WEPS	Planned	2024	BWT	Approved
Deposit A	Gum Leaf	Planned	2023	AWT	Approved
Deposit A	Cake Pit	Operational	2023	AWT	Approved
Deposit A West	AW1	Planned	2036	BWT	Approved
Deposit A West	AW2	Planned	2037	BWT	Approved
Deposit A West	AW3	Planned	2037	BWT	Approved
Deposit B	DBC3	Operational	2023	AWT	Approved
Deposit B	DBC4	Operational	2022	BWT	Approved
Deposit B	DBC5	Operational	2025	BWT	Approved
Deposit C	C1	Operational	2023	AWT	Approved
Deposit C	C2	Operational	2026	BWT	Approved
Deposit C	C3	Planned	2028	BWT	Approved
Deposit D	D1	Operational	2032	BWT	Approved
Deposit D	D2	Operational	2024	BWT	Approved
Deposit D	D3	Operational	2025	BWT	Approved
Deposit D	D4	Planned	2025	AWT	Approved
Deposit D	D5	Planned	2025	AWT	Approved
Deposit E	East	Planned	2036	BWT	Approved
Deposit E	West	Planned	2027	BWT	Approved
Deposit F	DFW	Operational	2022	BWT	Approved
Deposit F	DFN1	Operational	2020	AWT	Approved
Deposit F	DFS1	Operational	2024	BWT	Approved
Deposit F	DFSW	Planned	2026	AWT	Approved
Deposit F	DFE	Operational	2024	BWT	Approved
Deposit F	Marlu	Planned	2039	AWT	Approved
Deposit G	G1	Planned	2027	BWT	Proposed

Mining area	Pit	Operational status	Indicative completion date	Description	Regulatory status
Deposit G	G2	Planned	2026	AWT	Proposed
Deposit G	G3	Operational	2021	AWT	Approved
Deposit G	G4	Planned	2036	BWT	Approved
Mount Ella	Pit 1	Planned	2038	AWT	Proposed
Mount Ella	Pit 2	Planned	2041	AWT	Proposed
Mount Ella	Pit 3	Planned	2033	AWT	Proposed
Western Hill	Pit 1	Planned	2032	AWT	Proposed
Western Hill	Pit 2	Planned	2038	AWT	Proposed
Western Hill	Pit 3	Planned	2032	AWT	Proposed
Western Hill	Pit 4	Planned	2031	AWT	Proposed
Western Hill	Pit 5	Planned	2032	AWT	Proposed
Deposit F	F North	Planned	2031	BWT	Proposed
Deposit H	Central	Planned	2031	AWT	Proposed
Deposit H	East	Planned	2031	BWT	Proposed
Deposit H	West	Planned	2028	AWT	Proposed

7,353 ha of the currently approved 12,205 ha (within a 26,700 ha mine development envelope) has been cleared, this disturbance is presented in Figure 2-5. The proposal seeks approval of clearing up to 5,350 ha of native vegetation for the proposed deposits and expanded mine development envelope over the life of the proposal. As of Q1 2022, a total disturbance area of 617.7 ha at West Angelas has been rehabilitated to date (see Appendix 12).

2.3.3. Mining voids and waste landforms

The mining areas listed in Table 2-1 include multiple pits and associated waste rock landforms (including permanent landbridges and ROM pads). The location of each pit and waste landform are shown on Figure 2-5. Table 2-2 and Table 2-3 provide the pit and waste landform inventories, based on the 2021 LoM plan. This includes those features from the current approved operations as well as those new features included as part of the Proposal.


RioTinto
West Angelas Mine Layout
660,000
670,000
680,000
690,000
7,440,000
7,430,000
Great Northern Highway
Karijini National Park
Western Hill
Deposit B
West Angelas
Deposit C
Deposit G
Deposit H
Deposit F North
Deposit D
Deposit A
Deposit A West
Deposit F
Deposit E
Mt Ella East
Legend
West Angelas Closure Boundary
Airport
Powerlines
Rio Tinto Railway
Highway
Haul Road
National Park
Approved Conceptual Mine Planning
Pit
Waste Dump
Stockpile
Infrastructure
Proposed Mine Planning
Pit
Waste Dump
Stockpile
Conveyor
Infrastructure
Haul Road
N
0 2 4 6
Kilometres
Map units in metres
Drawn: GIS Team
Plan: PDE0188656v3
Date: December 2022
Proj: GDA 1994 MGA Zone 50
Scale: 1:140,000 @ A4
gis.team@riotinto.com
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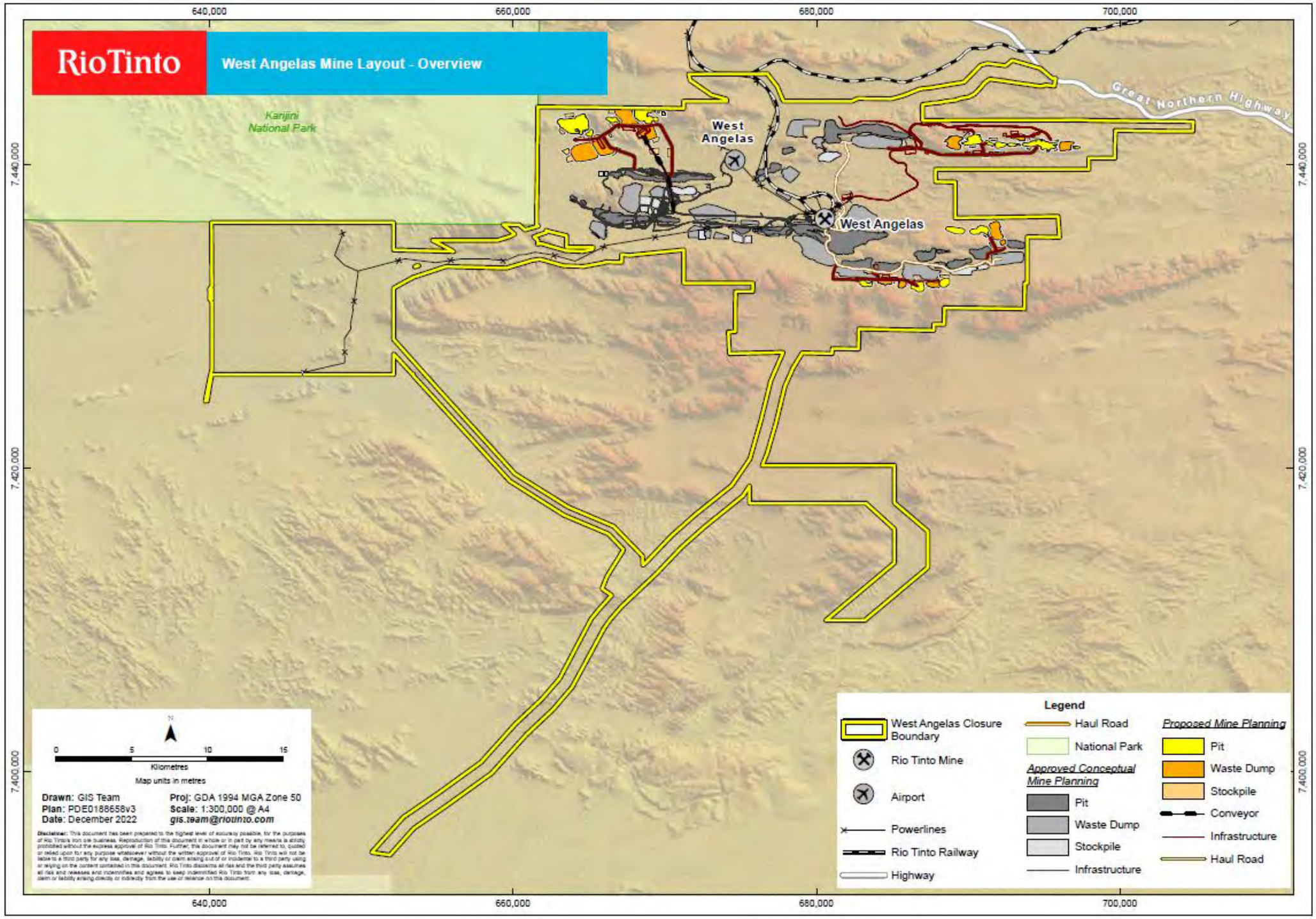


Figure 2-5: West Angelas life of mine layout

Table 2-2: Life of mine pit inventory including indicative pit backfill levels

Deposit	Pit name	Post mining pit crest (mRL)	Post mining pit floor (mRL)	Proposed backfill level if known (mRL)	Pre-mining Water table (mRL)	BWT or AWT	Pit Status
Deposit A	WEPN	750	644	760 (backfill completed)		AWT	Complete
Deposit A	CEPN	840	560	643	641	BWT	Complete
Deposit A	CEPS	798	524	642	640	BWT	Active
Deposit A	WEPS	740	628	642	640	BWT	Active
Deposit A	Gum Leaf	760	716	-	641	AWT	Planned
Deposit A	Cake Pit	830	732	-	637	AWT	Planned
Deposit A West	AW1	720	600	629	627	BWT	Planned
Deposit A West	AW2	712	600	629	627	BWT	Planned
Deposit A West	AW3	720	624	629	627	BWT	Planned
Deposit B	DBC3	800	660	-	633	AWT	Active
Deposit B	DBC4	760	585	632	630	BWT	Active
Deposit B	DBC5	760	585	632	630	BWT	Active
Deposit C	C1	712	635	626	623	AWT	Active
Deposit C	C2	730	576	626	624	BWT	Active
Deposit C	C3	768	576	638	636	BWT	Active
Deposit D	D1	722	624	626	624	BWT	Active
Deposit D	D2	722	584	627	625	BWT	Active
Deposit D	D3	737	632	627	625	AWT	Planned
Deposit D	D4	683	640	-	624	AWT	Planned
Deposit D	D5	672	624	-	624	AWT	Planned
Deposit E	East	790	548	670	668	BWT	Planned
Deposit E	West	830	644	670	668	BWT	Planned
Deposit F	DFW	866	658	688	686	BWT	Complete

Deposit	Pit name	Post mining pit crest (mRL)	Post mining pit floor (mRL)	Proposed backfill level if known (mRL)	Pre-mining Water table (mRL)	BWT or AWT	Pit Status
Deposit F	DFN1	854	782	-	686	AWT	Complete
Deposit F	DFS1	794	658	670	668	BWT	Active
Deposit F	DFSW	784	698	-	668	AWT	Planned
Deposit F	DFE	790	650	672	670	BWT	Active
Deposit F	Marlu	778	670	672	670	AWT	Planned
Deposit G	G2	760	636	-	635	AWT	Active
Deposit G	G3	735	656	-	635	AWT	Complete
Mount Ella	Pit 1	836	692	-	665	AWT	Proposed
Mount Ella	Pit 2	TBA	TBA			AWT	Proposed
Mount Ella	Pit 3	TBA	TBA			AWT	Proposed
WHILL	Pit 1	756	708	-	624	AWT	Proposed
WHILL	Pit 2	828	628	-	624	AWT	Proposed
WHILL	Pit 3	844	732	-	624	AWT	Proposed
WHILL	Pit 4	724	636	-	624	AWT	Proposed
WHILL	Pit 5	796	628	-	624	AWT	Proposed
Deposit F	F North	802	698	724	716 m	BWT	Proposed
Deposit H	Central	838	742	-	735	AWT	Proposed
Deposit H	East	814	702	728	726	BWT	Proposed
Deposit H	West	838	737	-	735	AWT	Proposed

- Planned – Approved but mining not yet commenced
- Proposed – Part of current proposal (not yet approved)
- BWT – Below Water Table / AWT – Above Water Table
- Note Table 2-2 does not include preliminary commitments to backfill where agreed to with stakeholders. As agreements are formalised, the MCP will be updated.

Table 2-3: Life of mine waste landform inventory

Deposit	Landform name	Type	Material classification	In-pit or ex-pit	Status	Notes
Deposit A	South WD	Waste dump	Inert	Ex-pit	Active	
Deposit A	North WD	Waste dump	Fibrous	Ex-pit	Active	Incorporates former East waste dump
Deposit A West	North backfill	Waste dump	Inert	In-pit	Active	
Deposit A	CEPN backfill	Waste Dump	Inert	In-pit	Proposed	Not included in previous closure plan, new feature
Deposit A	Spine Dump	Waste Dump	Inert	Ex-pit	Proposed	Not included in previous closure plan, new feature
Deposit B	East WD	Waste Dump	Fibrous	Ex-pit	Active	-
Deposit B	West WD - Boeing	Waste Dump	Inert	Ex-pit	Active	-
Deposit B	Low Grade	Stockpile	Inert	Ex-pit	Active	-
Deposit B	In-pit Dump	Waste Dump	Inert	In-pit	Active	-
Deposit C	WD1	Waste Dump	Inert/Potential future PAF	Ex-pit	Active	If small amounts of PAF material are encountered at C2 Pit.
Deposit C/D	WD2	Waste Dump	Fibrous/Potential future PAF	Ex-pit	Planned	Approved, but not yet constructed. If small amounts of PAF material are encountered at D1 Pit.
Deposit D	WD3	Waste Dump	Inert	Ex-pit	Planned	Approved, but not yet constructed
Deposit C	LG	Stockpile	Inert	Ex-pit	Planned	Approved, but not yet constructed
Deposit D	LGA	Stockpile	Inert	Ex-pit	Active	-
Deposit D	LGS	Stockpile	Inert	Ex-pit	Planned	Approved, but not yet constructed

Deposit	Landform name	Type	Material classification	In-pit or ex-pit	Status	Notes
Deposit CD	HGA	Stockpile	Inert	Ex-pit	Active	-
Deposit A West	WD1	Waste Dump	Inert	Ex-pit	Planned	Approved, but not yet constructed
Deposit A West	Hydrated Dump 1	Waste Dump	Inert	Ex-pit	Planned	To be used as capping material at closure, will not require rehabilitation.
Deposit A West	Hydrated Dump 2	Waste Dump	Inert	Ex-pit	Planned	To be used as capping material at closure, will not require rehabilitation.
Deposit A West	LG_SP	Stockpile	Inert	Ex-pit	Planned	Approved, but not yet constructed
Deposit A West	WPS Dump	Waste Dump	Inert/Potential future PAF	Ex-pit	Proposed	Not included in previous closure plan, new feature. If small amounts of PAF material are encountered at AW1
Deposit G	South WD1	Waste Dump	Inert	Ex-pit	Planned	Approved, but not yet constructed
Deposit G	South WD2	Waste Dump	Inert	Ex-pit	Planned	Approved, but not yet constructed
Deposit G	South WD3	Waste Dump	Inert	Ex-pit	Planned	Approved, but not yet constructed
Deposit G	South LG	Stockpile	Inert	Ex-pit	Planned	Approved, but not yet constructed
Deposit E	South WD	Waste Dump	Fibrous/Potential future PAF	Ex-pit	Active	If small amounts of PAF material are encountered at Deposit E - East
Deposit E	West WD	Waste Dump	Inert	Ex-pit	Active	-
Deposit F	West WD	Waste Dump	Inert	Ex-pit	Active	-
Deposit F	East WD	Waste Dump	Inert/ Potential future PAF	Ex-pit	Planned	Approved, but not yet constructed. If small amounts of PAF material are encountered at Deposit F- East.
Deposit F	Low Grade	Stockpile	Inert	Ex-pit	Active	-will be reclaimed in new LOM

Deposit	Landform name	Type	Material classification	In-pit or ex-pit	Status	Notes
Deposit F	East in-pit	Waste Dump	Inert	In-pit	Active	Not included in previous closure plan, new feature.
Deposit F	West in-pit	Waste Dump	Inert	In-pit	Active	Not included in previous closure plan, new feature.
Western Hill	-	Waste Dump	Not yet determined/ Potential future PAF	Ex-pit	Proposed	Not included in previous closure plan, new feature included as part of the Proposal. If small amounts of PAF material are encountered at Western Hill Central Pit.
Western Hill	-	Waste Dump	Not yet determined	Ex-pit	Proposed	Not included in previous closure plan, new feature included as part of the Proposal.
Western Hill	-	Stockpile	Not yet determined	Ex-pit	Proposed	Not included in previous closure plan, new feature included as part of the Proposal.
Western Hill	-	Stockpile	Not yet determined	Ex-pit	Proposed	Not included in previous closure plan, new feature included as part of the Proposal.
Deposit H	-	Waste Dump	Not yet determined	Ex-pit	Proposed	Not included in previous closure plan, new feature included as part of the Proposal.
Deposit H	-	Waste Dump	Not yet determined	Ex-pit	Proposed	Not included in previous closure plan, new feature included as part of the Proposal.
Deposit H	-	Stockpile	Not yet determined	Ex-pit	Proposed	Not included in previous closure plan, new feature included as part of the Proposal.
Deposit F North	-	Waste Dump	Not yet determined/ Potential future PAF	Ex-pit	Proposed	Not included in previous closure plan, new feature included as part of the Proposal. If small amounts of PAF material are encountered at Deposit F-North
Deposit F North	-	Stockpile	Not yet determined	Ex-pit	Proposed	Not included in previous closure plan, new feature included as part of the Proposal.
Mt Ella East	-	Waste Dump	Not yet determined	Ex-pit	Proposed	Not included in previous closure plan, new feature included as part of the Proposal.
Mt Ella East	-	Waste Dump	Not yet determined	Ex-pit	Proposed	Not included in previous closure plan, new feature included as part of the Proposal.
Mt Ella East	-	Waste Dump	Not yet determined	Ex-pit	Proposed	Not included in previous closure plan, new feature included as part of the Proposal.
Mt Ella East	-	Stockpile	Not yet determined	Ex-pit	Proposed	Not included in previous closure plan, new feature included as part of the Proposal.

Deposit	Landform name	Type	Material classification	In-pit or ex-pit	Status	Notes
Mt Ella East	-	Stockpile	Not yet determined	Ex-pit	Proposed	Not included in previous closure plan, new feature included as part of the Proposal.

3. IDENTIFICATION OF CLOSURE OBLIGATIONS AND COMMITMENTS

The Australian mining industry has a well-established commitment to ensure that mine operations are closed with safe, stable, non-polluting landforms which are sympathetic to the surrounding landscape and that will require minimal (preferably none) ongoing maintenance post closure.

Australian State and territory Government are mostly responsible for the regulation and management of mine closure requirements for the mining industry (ANZMEC and MCA 2000).

This section details the relevant commonwealth, state and local requirements pertaining to the closure of West Angelas.

3.1. Commonwealth

3.1.1. Primary legislation

The Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (Cth) (EPBC Act) has established a consistent framework for environmental assessment of new proposals and variations to existing projects. Mining proposals that have the potential to significantly impact on matters of national environmental significance (MNES) are assessed for approval under this legislation. Issues related to mine closure are considered during the assessment process. Approved projects that have the potential to impact on MNES are declared a Controlled Action under the EPBC Act and are required to meet conditions of approval are provided in a Decision Notice.

Current operational activities at West Angelas are approved under the EPBC Act by Decision Notice 2018/8299.

3.1.2. Primary guidelines

The Strategic Framework for Mine Closure (ANZMEC and MCA 2000) is intended to promote a nationally consistent approach to mine closure management in all Australian jurisdictions. The Strategic Framework has established principles for mine closure that have been utilised in the development and subsequent revisions of this MCP.

3.2. Western Australia

DMIRS is the lead regulator and decision-making authority for mining projects in Western Australia under the *Mining Act 1978* (WA) (Mining Act). DMIRS also has an advisory role in relation to the environmental management aspects of mines which are regulated under the State Agreement and the EP Act.

The Department of Water and Environmental Regulation (DWER) is the lead regulator and decision-making authority under the EP Act. The Environmental Protection Authority (EPA) is the Government's chief advisor on environmental issues and is responsible for carrying out environmental impact assessment (EIA) of significant proposals under Part IV of the EP Act.

The Department of Biodiversity, Conservation and Attractions (DBCA) protects and conserves the State's natural environment on behalf of the people of Western Australia under the *Biodiversity Conservation Act 2016* (WA) (BC Act).

3.2.1. Primary legislation

State Agreement

A State Agreement is a contract held between a mining company and the Western Australian Government that has been ratified by Parliament to become legislation. A State Agreement sets out the terms, conditions, rights and obligations of the parties in relation to the development and ongoing

operation of a mining project and associated activities. The West Angelas mining operations are carried out in accordance with approved proposals submitted under the State Agreement.

Mining Act 1978

The Mining Act regulates mining leases, licenses, terms and conditions for mines on private and crown land, surrender of tenements, regulations, litigation and administration of justice issues. In 2010, amendments to the Mining Act provided for the requirement of an MCP to be submitted to DMIRS for approval as part of a Mining Proposal and in any other circumstances as outlined in Section 84AA of the Mining Act.

Environmental Protection Act 1986

The EP Act outlines environmental management requirements for mining projects in Western Australia. Under Part IV the EP Act any proposal that may result in a significant impact to the environment must be referred under Section 38 (s38) to DWER for determination to assess and recommend Ministerial approval for implementation. DWER require the provision of an MCP to support the assessment of significant proposals. Following assessment of a proposal under Part IV of the EP Act, the Western Australian Minister for the Environment issues a Ministerial Statement (MS) approving implementation of the proposal subject to implementation conditions prescribed within the MS.

The existing operations at West Angelas have been approved under a number of Ministerial Statements, superseded by the release of MS 1113 in 2019. The West Angelas Revised Proposal was referred to the EPA Under Part IV of the EP Act in March 2021 and a Public Environmental Review (PER) level of assessment was determined on 22 April 2021. Key environmental objectives and closure outcomes relevant to the existing MS will be captured in the new MS or as closure outcomes within this MCP.

Existing conditions outlined in MS 1113 related to closure include:

- 7-1 The proponent shall manage the implementation of the revised proposal to meet the following environmental objectives:
    - the proponent shall ensure that the revised proposal is rehabilitated and decommissioned in an ecologically sustainable manner; and
    - (2) ensure that closure planning and rehabilitation are undertaken in a progressive manner.
- 7-2 Within twelve (12) months of the issue of this Statement the proponent shall prepare and submit a Mine Closure Plan in accordance with the Guidelines for Preparing Mine Closure Plans, May 2015, (or any subsequent revisions of the guidelines), to the requirements of the CEO, on advice of the Department of Mines, Industry Regulation and Safety, and the Department of Water and Environmental Regulation.
- 7-3 The proponent shall review and revise the Mine Closure Plan required by condition 7-2 at intervals not exceeding three (3) years, or as otherwise specified by the CEO, and submit the plan to the CEO at the agreed interval.

3.2.2. Primary guidelines

Guidelines for Preparing Mine Closure Plans

DMIRS developed the industry guidance document *Statutory Guidelines for the Preparation of Mine Closure Plans*. This guideline was originally released in June 2011, was revised in May 2015 and became a statutory guideline in March 2020.

The guideline adopts the objectives and principles of the Strategic Framework (Section 3.1.2), whilst providing further description of how MCPs in Western Australia can meet the objectives and principles. It also outlines a planning process that aims at ensuring that a mine can be closed, decommissioned

and rehabilitated in an ecologically sustainable manner, consistent with agreed post-mining outcomes and land-uses, without unacceptable liability to the State.

All Mining Proposals for new projects need to be accompanied by an MCP.

The EPA and DMIRS undertake parallel assessment of MCPs if the Proposal requires approvals under Part IV of the EP Act and Mining Act.

Other guidelines and industry standards

This MCP has been prepared in consideration of the relevant aspects from the following closure guidelines and industry standards:

- Environmental Objectives Policy for Mining in Western Australia (DMIRS 2020a);
- Guidance – How to prepare a Mine Closure Plan in accordance with Part 1 of Statutory Guidelines for Mine Closure Plans in Western Australia (DMIRS 2020);
- Guidance Note – Environmental Risk Assessment for Mining Proposals and Mine Closure Plans (DMIRS 2019);
- A Framework for Developing Mine-site Completion Criteria in Western Australia (Western Australian Biodiversity Science Institute, (WABSI 2019);
- Mine Closure: Leading Practice Sustainable Development Program for the Mining Industry (DISER 2016);
- Mine Rehabilitation Handbook (Mineral Council of Australia 1998);
- Mine Closure and Completion (DISER 2016a);
- Preventing Acid and Metalliferous Drainage (DISER 2016c);
- Mine Rehabilitation (DISER 2016d);
- Integrated Mine Closure: Good Practice Guide (International Council of Mining and Metals, ICMM 2019); and
- Guideline for safety bund walls around abandoned open pit mines (Department of Industry and Resources, DOIR 1997).

3.3. Approval history

West Angelas is currently approved via MS 1113 pursuant to Part IV of the EP Act. Operations originally commenced in 2001 with the first closure statement submitted for West Angelas in 2003 in accordance with MS 514. Subsequent decommissioning and rehabilitation plans were submitted in 2004, 2009 and 2010.

In July 2014 an MCP was submitted to Office of the Environmental Protection Authority (OEPA) in compliance with condition 9 of MS 970. In February 2015, May 2015 and again in October 2015 the MCP was re-submitted to address OEPA/DMIRS comments. The MCP was conditionally approved by the OEPA on 27th July 2016.

In July 2017 the MCP was revised to support the Part IV assessment for Deposits C, D and G (EPA Assessment 2132). In February and April 2018 the MCP was revised to address DWER comments and also included the scope of MS 1015 (for West Angelas Deposit A West and Deposit F). The April 2018 MCP was approved on 10th December 2018.

MS 1113 was issued on 2nd September 2019 with implementation conditions superseding those of all previous MS's. MS 1113 includes Condition 7-2 which requires submission of an MCP within 12 months of issue of the Statement. Condition 7-5 requires implementation of the April 2018 MCP until DMIRS and DWER approved the revised plan required under Condition 7-2.

In January 2020 the MCP was updated to support a Mining Proposal including relevant tenure and removal of reference to permanent drawdown of the aquifer under (Karijini National Park) KNP. This MCP was submitted to DMIRS only. The Mining Proposal approved the April 2018 version of the MCP.

In September 2020, Version 1 of the West Angelas MCP was submitted to DWER to in line with Condition 7-2 of MS 1113 which requires submission of an MCP within 12 months of issue of the Statement. Comments were received from regulators and Version 2 of the MCP was resubmitted in March 2021 and approved by EPA Services on the 23rd June 2021 and is the current approved version of the MCP.

3.4. Existing legal obligations

A register of legally binding obligations relating to rehabilitation and closure of West Angelas is provided as Appendix 1. The register also identifies legislation, standards and guidelines that may not apply to this site specifically, but that may be relevant to closure of mine sites generally.

This register captures legal obligations from the following instruments:

- State Agreement - *Iron Ore (Robe River) Agreement Act 1964* (WA);
- Controlled Action via Decision Notice 2018/8299 under the Commonwealth EPBC Act due to potential significant impacts to listed threatened species and communities;
- MS 1113 (West Angelas Iron Ore Project) issued under Part IV of the EP Act; and Management Plans developed as conditions of MS 1113;
- relevant Native Vegetation Clearing Permits (NVCP);
- mining leases, general purpose leases and miscellaneous licences issued under the *Mining Act 1978* pursuant to the *Iron Ore (Robe River) Agreement Act 1964*;
- special leases and easements issued under the *Land Administration Act 1997* pursuant to approval under the *Iron Ore (Robe River) Agreement Act 1964*;
- Licence L7774/2000/6 issued under Part V of the EP Act; and
- Licence to Take Water issued under the *Rights in Water and Irrigation Act 1914* (RIWI).

The register also identifies legislation, standards and guidelines that may not apply to this site specifically, but that may be relevant to closure of mine sites in general.

The West Angelas operations closure boundary falls within the boundary of the Yinhawangka Native Title Determination (18 July 2017) and the Ngarlawangga Native Title Determination (7 December 2016). Rio Tinto has a comprehensive land use agreement with both the Yinhawangka and Ngarlawangga Peoples and is committed to ongoing consultation regarding the operation of the Project and its eventual closure.

This MCP has been prepared to support approval for the Proposal and additional obligations will arise through the approval process. Any new obligations and commitments, such as commitments made as part of agreed Social and Cultural Heritage Management Plans (SCHMPs) will be documented in the next update of this MCP.

4. STAKEHOLDER ENGAGEMENT

4.1. Consultation Program

Rio Tinto recognises that regular and ongoing stakeholder engagement is a key part of mine closure planning as it ensures that the views and expectations of stakeholders are understood by the mine operator and are considered and managed during the operational phase and through to planning and implementation phase of closure. The ability to build relationships and to work collaboratively and transparently with our host communities is critical to Rio Tinto's long-term success regarding rehabilitation and closure.

Rio Tinto has an ongoing consultation program relating to West Angelas with government agencies (local, State and Commonwealth), non-government organisations, Traditional Owners, and land users impacted by, or interested in, the implications of the operation of the West Angelas Project and the Proposal and associated closure strategies. The key stakeholders are listed below in Table 4-1.

Table 4-1: Key stakeholder list

Category	Stakeholder
Commonwealth	Department of Climate Change, Energy, the Environment and Water (DCCEEW) Civil Aviation Safety Authority (CASA)
State	Department of Water and Environmental Regulation (DWER) Department of Mines, Industry Regulation and Safety (DMIRS) Department of Jobs, Tourism, Science and Innovation (DJTSI) Department of Biodiversity Conservation and Attractions (DBCA) Department of Planning, Lands and Heritage (DPLH) Department of Primary Industries and Regional Development (DPIRD) Department of Health (DOH)
Local	Shire of Ashburton Shire of East Pilbara WA Police – Pilbara Main Roads Western Power/Horizon Pilbara Development Commission WA Country Health Service-
Non-government	JV partners FMG, BHP, Roy Hill, other surrounding companies Dampier to Bunbury Natural Gas Pipeline Conservation Council, Land Care, other environmental groups Tourism Commission WA Pilbara Aboriginal Businesses
Community	Yinhawangka People Yinhawangka Aboriginal Corporation (YAC) Ngarlawangga People Ngarlawangga Aboriginal Corporation (NAC) Nyiyaparli People Karlka Nyiyaparli Aboriginal Corporation (KNAC) Nharuwangga People Regional communities, including Newman Turee Creek Pastoral Station
Internal	Rio Tinto employees and contractors

Regular consultation is conducted with a wide range of stakeholders via a variety of forums, for example various State and Local Government agency briefing meetings and Traditional Owner consultation forums established under Indigenous Land Use Agreements. Agenda items regarding closure and related activities are included in these meetings as appropriate. Ongoing engagement with both the Ngarlawangga People/NAC and Yinhawangka People/YAC is maintained through formal and informal engagement activities such as a dedicated Closure workshop in September 2021 with the Yinhawangka people and the initiation of a proposed Mine Closure working group with Yinhawangka for dedicated continuation of closure discussions.

Given the stage of the West Angelas operations, the current consultation program typically focuses on life of mine, progressive rehabilitation and technical study updates. The level of closure specific content and detail will increase as closure approaches.

Details of all consultation regarding rehabilitation and closure of the West Angelas operation are captured in the stakeholder consultation register (Appendix 2).

4.2. Closure Stakeholder Engagement Strategy

An overview of the closure stakeholder engagement to be undertaken throughout the life of the Project is presented in Table 4-2. Future stakeholder identification, cadence and focus will change as the operation approaches closure.

The focus of this consultation will be to:

- Provide information to key stakeholders regarding the progress of the operation, progressive rehabilitation, the closure planning process and proposed closure landscape.
- Identify expectations for, and progress towards agreement on post-mining land use(s) and closure outcomes.
- Establish agreed management actions through the Social and Cultural Heritage Management Plans (SCHMPs), currently being co-prepared with Yinhawangka and Ngarlawangga Traditional Owners.
- Identify the key opportunities, recommendations, issues and concerns of key stakeholders regarding the design and management of rehabilitation and closure activities at West Angelas.
- Where practicable, allow for adjustments to the design and/or management of any proposed rehabilitation and closure activities to accommodate opportunities, recommendations, concerns or issues raised by key stakeholders.

Table 4-2: Closure stakeholder engagement strategy for key stakeholders

Stakeholder	Engagement Forum and Timing	Focus
JTSI, DWER, DMIRS	Rio Tinto Closure Regulator Engagement Forum, face to face meetings held three to four times per year. Meetings as required.	Consultation to support three yearly updates to Closure Plans. Agenda may include: • progressive rehabilitation; • technical studies updates; • completion criteria etc.
DBCA, DPLH	DBCA have requested targeted consultation to be held when closure planning impacts their areas of responsibilities. Ad-hoc meetings on an “as needs” basis.	Targeted closure planning engagement to commence during OoM closure studies to support further refine of closure strategies and completion criteria.
Yinhawangka People Ngarlawangga People	Local Implementation Committee (LIC) meetings: face to face meetings between company senior leaders, invited subject matter experts, and Traditional Owner representatives and advisors. At a minimum, two meetings per year. Life of Mine Planning Forum: regular face to face meeting to discuss and provide updates to Traditional Owners on exploration, studies/projects, mining, and closure activities, on a Traditional Owner’s country. Key themes are management of water and environment,	Progressive rehabilitation, ongoing closure planning, life of mine and technical studies updates. Targeted closure planning engagement to commence during OoM closure studies to support & further refine: • Post Mining Land Uses, closure strategies, closure outcomes andcompletion criteria; • closure landscape designs • Consultation for culturally appropriate closure landscape and rehabilitation opportunities

Stakeholder	Engagement Forum and Timing	Focus
	rehabilitation, cultural heritage, and opportunities for Pilbara Aboriginal businesses. Mine Closure Working Group and Forum: face to face meetings between company representative, Yinhawangka People, PBC representatives and invited subject matter experts including consultants. Working Group meetings held annually or as agreed/required. Environment and/or Cultural Heritage Sub-Committee meetings: mutually agreed forum to discuss, in detail, environment and/or cultural heritage matters that have mutual impact and interest to both parties- particularly environmental and heritage applications and approvals. Usually precede or follow an LIC meeting. Ad hoc meetings: to discuss matters of mutual priority and concern. These meetings often take place 'on-country' with support from internal and external SME's, Traditional Owner Elders and Aboriginal Corporation staff	• post-closure land use; • outline potential or identified pipelines of business opportunities linked to rehabilitation/closure works; • opportunities to engage Traditional Owner rangers for rehabilitation, closure and monitoring work. Targeted consultation regarding closure and rehabilitation to support environmental approvals submissions (such as 'social surrounds' impact evaluations)
Local community	Not deemed required due to absence of communities (such as Newman) in proximity to West Angelas.	Targeted closure planning engagement to commence during OOM closure studies to support further refine of closure strategies and completion criteria.
Turee Creek Pastoral station	Meetings as required. Matters of mutual interest and impact are discussed in a timely and productive manner.	

4.3. Targeted Stakeholder Consultation

Rio Tinto has consulted with key stakeholders regarding rehabilitation and closure of the West Angelas Operation, details of which are presented in Appendix 2.

The West Angelas Operation, including proposed deposits, is on land which is the subject of the Ngarlawangga and Yinhawangka Native Title Determinations. Rio Tinto has undertaken dedicated consultation focussed on the Social Surroundings key environmental factor to inform the West Angelas Revised Proposal assessment. Key parties consulted with include:

- Ngarlawangga Traditional Owners
- Ngarlawangga Aboriginal Corporation (NAC)
- Yinhawangka Traditional Owners
- Yinhawangka Aboriginal Corporation (YAC)
- Turee Creek Pastoral Station

Social Cultural Heritage Management Plans (SCHMP) are jointly developed by Rio Tinto and each Traditional Owner Group. The SCHMP applies to the Proposal and has been prepared to meet the Environmental Protection Authority's (EPA) environmental objective for the "Social Surroundings" environmental factor. The SCHMPs are designed to incorporate the ongoing engagement and consultation with Traditional Owners with respect to closure design including final landforms and rehabilitation activities along with describing the agreed engagement framework with each Traditional Owner group in respect of consultation to inform closure planning and involvement with the West Angelas Mine Closure Plan.

The theme of closure and rehabilitation has been an important part of discussion with both Yinhawangka and Ngarlawangga. In initial Social Surroundings in-field consultations, both have expressed their specific desires on mine design planning for closure. Rio Tinto has been working with both groups to explore the complexity and practicality of these. This has coalesced in the planned creation of a Closure working group for Yinhawangka and a specific closure and rehabilitation topic for LoMP consideration for Ngarlawangga.

Key themes arising from Traditional Owner consultation to date are:

- water management, particularly in relation to the protection of ephemeral pools, catchments, groundwater drawdown and surface water quality/protection;
- care for and protection of country, cultural sites/places and cultural heritage management, both during operations and at closure;
- design of closure landscapes including waste rock landforms and associated visual amenity, a strong preference for 'natural looking landforms' has been expressed;
- continued access to Country, which has implications for post-closure access planning;
- management of pit voids at closure, particularly options to backfill these progressively or at closure;
- general employment opportunities associated with closure activities; and
- inclusion of culturally significant flora species in rehabilitation areas to facilitate cultural use, and fauna return.

Some values, concerns, recommendations, requests or details raised by the Traditional Owner groups within the themes raised are not considered directly relevant to EIA in relation to the EP Act (i.e. in relation to physical or biological changes to the environment); however, they often contain elements recognised by Rio Tinto as important to integrate into the SCHMPs with respect to Traditional Owner involvement in Proposal activities and engagement processes over the life of the Proposal, and in the transition from mining to post-closure land use. Some elements may also be more appropriate to be managed in accordance with, or integrated into, other agreements or existing consultation forums between the Traditional Owners and Rio Tinto.

Further details of stakeholder feedback relevant to the Revised Proposal are detailed in Section 10 of the ERD and associated appendices, and Section 5.1.4 of this mine closure plan.

In addition to the targeted stakeholder engagement to support the Revised Proposal, Rio Tinto conducts ongoing engagement with relevant stakeholders throughout the life of its mining operations. Rio Tinto will continue ongoing dialogue with key stakeholders over the lifetime of West Angelas with closure remaining an ongoing point of discussion.

Given the small areas of disturbance occurring or proposed on the Country of Nharnuwangga and Nyiyaparli People, closure consultation has not been undertaken regarding the West Angelas Mine Closure Plan. This will be progressed in the future.

5. BASELINE AND CLOSURE DATA AND ANALYSIS

This section provides a summary of relevant baseline and operational data; identifies any closure implications and knowledge gaps. Key baseline data reports are included as Appendices to this MCP and referenced in relevant sections. Rio Tinto will use this information to assist in the refinement of completion criteria and effective mitigation and management of identified risks leading up to and during the closure implementation phase.

Identified closure knowledge gaps are discussed in each section and summarised in Section 6. The knowledge gaps are aligned with the West Angelas Closure Risk Register (Appendix 3) and associated actions captured in the West Angelas Action Register (Appendix 4).

SOCIAL SETTING

5.1. Aboriginal Culture and Heritage

Rio Tinto recognise and respects the significance of Australia's cultural heritage, and in particular the cultural heritage of Aboriginal people who have traditional ownership of, and/or cultural connections to, the land on which we operate. Consultation with all Traditional Owner groups interested in and affected by the West Angelas Operation will be maintained in established forums throughout the life of the operation to ensure that proposed closure strategies address cultural requirements, and to ensure closure outcomes for the site remain appropriate. Extensive archaeological and ethnographic surveys have been undertaken in the West Angelas region, and these surveys have helped to inform the heritage values of the area.

All reasonable and practicable measures are taken to prevent harm to cultural heritage sites, including during works associated with rehabilitation and closure. Where this is not possible, steps are taken in consultation with Traditional Owner groups to minimise or mitigate impacts or obtain statutory approvals, if required. In these instances, cultural material may be salvaged under Section 18 approval of the *Aboriginal Heritage Act 1972* (WA) (currently operating in conjunction with the *Aboriginal Cultural Heritage Act 2021* (WA)) and placed into storage to facilitate mining activity.

Closure works consider issues such as post closure access requirements to culturally significant sites and appropriate return of any materials salvaged during mining operations. The ongoing consultation with Traditional Owner groups has also informed the mine layout and design to avoid impacts to significant social and cultural values, sites, and places, as well as identify options to reduce and manage impacts through the implementation, operation rehabilitation and closure phases of the West Angelas Operation.

5.1.1. Relevant Aboriginal groups

The Yinhawangka, Ngarlawangga, Nharnuwangga and Nyiyaparli People are the Traditional Owners of the land located within the Closure Boundary of the West Angelas Operation (Figure 2-3). Yinhawangka is represented by Yinhawangka Aboriginal Corporation (YAC) and Ngarlawangga is represented by Ngarlawangga Aboriginal Corporation (NAC) assisted by Ngurra Barna Aboriginal Corporate Services a subsidiary of Yamatji Marlpa Aboriginal Corporation (YMAC) which currently act as Ngarlawangga's representative heritage body.

As of June 2022, the published Yinhawangka member list indicates there are 371 registered Yinhawangka members. Many Yinhawangka People reside within the townships of Paraburdoo and Tom Price and at the Aboriginal Communities of Bellary Springs (approx. 30 kilometres (km) north of Paraburdoo) and Wakathuni (approx. 30km south of Tom Price). As of April 2022, the published Ngarlawangga member list indicates there are 52 registered Ngarlawangga members. Many Ngarlawangga People reside within the townships of Karratha and Port Hedland and at the Aboriginal Communities of Wakathuni (approx. 25km south, south-east of Tom Price). Both Ngarlawangga and Yinhawangka People also reside in Roebourne, Karratha, Onslow, Perth and interstate. Consultation

with regards to closure has been ongoing as part of the preparatory works for the West Angelas Revised Proposal. Topics that were the subject of consultation include the on-going access to cultural heritage sites, post closure access, final landform design, water management, culturally appropriate rehabilitation seed mixes, and the repatriation of any artefacts salvaged.

5.1.2. Native Title determination

The Yinhawangka, Ngarlawangga, Nharnuwangga and Nyiyaparli People hold Native Title rights and interests within the land the subject of their respective determined areas, inclusive of the West Angelas closure boundary. The West Angelas closure boundary is located primarily on land that is subject to the Yinhawangka native title determination (WCD2017/003), with a portion of the eastern extent located on the land subject to the Ngarlawangga and Nyiyaparli native title determinations (WCD2016/007 & WCD2018/008 respectively). The southern portion of the closure boundary extends into land that is subject to the Nharnuwangga native title claim (WCD2000/001) (Figure 2-3).

On 31 January 2013, Rio Tinto Iron Ore executed a Claim Wide Participation Agreement (PA) and an Indigenous Land Use Agreement (ILUA) with the Yinhawangka People (collectively 'the Agreements'), with the latter being registered with the National Native Title Tribunal on 5 July 2013. The PA commits Rio Tinto and the Yinhawangka People to work together to manage and maintain the areas in which Rio Tinto operates. The PA sets clear guidelines for processes such as land access, tenure, heritage and environmental approvals, mining benefit payments and reporting and communication requirements along with other issues relating to Rio Tinto's operations.

The Ngarlawangga People and Rio Tinto Northern Claim Area Participation Agreement was executed on 22 March 2011. It is important to note that the agreement area does not cover the full claim area, only taking in the northern most area within the claim boundary. The PA replaces all previous agreements with Ngarlawangga People. Ngarlawangga People have also Opted-In to the Regional Framework Deed and have been invited to participate in the Regional Implementation Committee.

The Ngarlawangga native title claim (National Native Title Tribunal number: WC2016/007, Federal Court of Australia number: WAD78/2005) covers approximately 6,105 square kilometres of land and waters in the east Pilbara region, covering an area southwest of Karijini National Park, south of Hope Downs operations and down toward Newman. The claim takes in lands covered by the Bulloo Downs and Prairie Downs Stations. The native title consent determination was held on 7 December 2016 in Tom Price.

5.1.3. Ethnographic and archaeological values

Archaeological investigations have shown that Aboriginal occupation of the Hamersley Plateau, on which the West Angelas operation is located, extends back at least 50,000 years. For Traditional Owner groups of the region, this provides physical (tangible) evidence of their long standing and intimate connection to "Country".

Archaeological and ethnographic surveys have been conducted at West Angelas with the participation and involvement of nominated Yinhawangka and Ngarlawangga representatives. As part of these surveys, sites and places of important cultural value to the Yinhawangka and Ngarlawangga People have been identified across West Angelas.

Archaeological places and objects identified at West Angelas include, but are not limited to, artefact scatters, quarries, water holes, modified trees, stone structures, rock art and rock shelters. These places are important physical markers in the landscape and demonstrate cultural heritage values that are relevant to the past presence, persistence and traditional practices of the Yinhawangka and Ngarlawangga People and their ancestors.

Ethnographic surveys have identified further intangible cultural heritage values that have an equally important role in representing the continuous living culture of Yinhawangka and Ngarlawangga People. As well as enhancing the significance of archaeological places and objects, these intangible values are often tied to natural landscape features (such as ranges and water ways) through mythologies, song lines and oral histories

Water systems are of high cultural significance to the Yinhawangka People and the Ngarlawangga People. Water systems not only sustain the landscape, they also form the basis of long and continued understandings of Country and are often key markers of cultural identity.

In many cases intangible and tangible cultural values are merged and overlaid within a landscape, and any impact upon one value may impact another. Heritage sites seemingly separated in the landscape may in fact be connected through intangible links to create cultural heritage precincts or complexes. It is for these reasons that surveys must also be multi-layered and consultations undertaken with the appropriate informants at each level of consultation.

Yinhawangka People

Key ethnographic and archaeological values and significant site for the Yinhawangka people include, but are not limited to:

- *Guburingu* - an ephemeral water site where creeks merge at the base of a hill within Karijini National Park, which is in close proximity to Western Hill.
- *Bibi Thalu* & *Gurrinbiddy* Range – To the south of West Angelas operations, sections of the West Angelas valley range hold strong ethnographic and ceremonial values to the Yinhawangka community.
- The unnamed range to the south of existing West Angelas operations - Important ethnographic feature of the range that is important to Yinhawangka and the neighbouring Traditional Owner groups.
- Western Hill Site Complex made up of archaeological sites such as rockshelters, modified tree and artefact scatters (RTIO database: WAN20-009, WAN20-014, WAN20-012, TBR-18-20, WAN20-007, WARE14-87-SS, WAN20-002, TBR-18-19, WAN20-11, WA-18-05-RS, WAN20-008, WAN20-010, WAN20-013, WAN20-006, WA-16-23-AS, WAN20-005, WAN20-004, WAN20-003, WA-18-02-ST, WA-18-04-RS).
- Mt Ella Site Complex (RTIO database: WA-18-ETH-01 [No DPLH Place ID]).
- Rockshelter with handprint (RTIO database: YINHARR-39 [DPLH Place ID 20444]).
- Rockshelter with engravings (RTIO database: WA-16-45-ENG [No DPLH Place ID]).
- Rockshelter with engravings (RTIO database: WA-16-51-ENG [No DPLH Place ID]).
- The Sinkhole – (Rio Tinto Database: Yinta).

Ngarlawangga People

Key ethnographic and archaeological values and significant sites for the Ngarlawangga people include, but are not limited to:

- Deposit H waterhole site complex; located within the Deposit H area of the proposal conceptual footprint.
- Turtle Pool; located approximately 550m to the east of the Development Envelope.
- ‘Additional place of cultural significance’; located to the east of the approved Deposit F development area.
- ‘The Range’ - Important ethnographic feature that is important to Ngarlawangga and the neighbouring Traditional Owner groups.

At West Angelas, where disturbance of sites has been unavoidable, cultural material from heritage places has been removed (in consultation with the appropriate Traditional Owner group) and placed into storage to facilitate mining activity, and consideration of post-closure management of the objects is required. This cultural material, which has been salvaged in accordance with Section 16 and Section 18 of the *Aboriginal Heritage Act 1972* (WA), is currently stored at the following two areas: Yinhawangka

material is being stored at a permanent facility at West Angelas (with the working name: Yinhawangka West Angelas Archaeological Repository) with the move from a previously temporary facility enabled by members of Yinhawangka in August 2022 with an official Yinhawangka name for the room to be determined; Ngarlawangga material is being temporarily stored at Rio Tinto's Dampier ATAL office, also until a more permanent facility can be agreed upon with Rio Tinto and the Ngarlawangga people and Ngarlawangga Aboriginal Corporation.

5.1.4. Social surroundings

Aboriginal social and cultural heritage can include tangible values embodied in all facets of the environment and the landscape, and specific places and heritage sites, as well as intangible values related to cultural associations Traditional Owners have with an area – which may include, for example, traditional hunting and gathering activities, learning, teaching, ceremony, healing activities and enjoyment of country. Understanding places and cultural associations with the environment and country which are particularly important, helps to prioritise areas to be avoided where possible, and inform the requirement, design and implementation of other mitigation strategies.

Consultations during the development of the West Angelas Revised Proposal have considered social surroundings factors required under the EP Act. These consults included identifying important social and cultural values, work to develop options to avoid, reduce or manage impacts to these values, and closure planning discussions regarding the proposed closure strategy and planning, closure outcomes and the West Angelas MCP.

These consultations were undertaken with representatives of the Ngarlawangga and Yinhawangka Traditional Owner groups considering Rio Tinto's original West Angelas Revised Proposal Development Envelope that was inclusive of a larger Mt Ella East Development Envelope, and an additional mining deposit and access known as Deposit J.

Based on Social Surroundings results and ongoing consultation with both Traditional Owner groups, Deposit J has been entirely removed from this Proposal, and Mt Ella East has been substantially amended and reduced in size post July 2022. The Revised Development Envelope has been amended to reflect changes to the scope also.

Some of the key concerns identified by the Traditional Owner in respect of these values are summarised below:

- The potential physical destruction of sites and places and the loss of cultural knowledge.
- An observed loss of native honeybee species and honey-trees in the region that is thought to be related to cumulative habitat reduction from existing mining operations. As a result, *Eucalyptus leucophloia* has been included in the rehabilitation seed mix.
- The care for and protection of country, cultural sites/places and cultural heritage.
- The protection and management of the Deposit H waterhole site and Turtle Pool and their catchments, and potential impacts to surface water and groundwater and the use of water for dust suppression.
- The impacts of dust, noise and vibration on animal habitats and the visual and general amenity of country.
- The management of water, plants and animals.
- Restrictions on access to country for native title purposes and social and cultural activities. Access by non-Traditional Owners to country, particularly areas of high cultural importance.
- Rehabilitation of completed pits and waste landforms having a homogenised appearance that is not representative of the natural landscape.

- Backfilling of pit voids and minimisation of external waste landforms including mine design, closure and rehabilitation.
- Cumulative impacts of mining operations across each Traditional Owner Country.
- Traditional Owners share their country with plants and animals essential for cultural and economic practices; impacts to this could effect:
    - availability of and access for collecting bush medicines;
    - availability of and access for collecting food – plants and hunting (e.g. goannas, kangaroos, emus, bush turkey etc.);
    - availability of and access for collecting resources;
    - caring for country;
    - culturally appropriate rehabilitation seed mixes; and/or
    - rehabilitation to resemble natural habitat, which will help establish micro-climates for plants and animals.

Broadly speaking, these groups seek to ensure these values are considered during closure, and that their country is returned to them in a way which reinstates social, cultural and environmental values as much as possible. Further consultation and surveys are planned to continue to build understanding and appreciation of social and cultural values for the West Angelas Operation and how to incorporate them into closure planning as detailed in Section 4.

5.1.5. Ethnobotanical surveys

Ethnobotany is the study of traditional plant knowledge usually undertaken as a cross-disciplinary endeavour, involving traditional knowledge holders and botanists, heritage professionals and often social scientists as well. The work draws on traditional knowledge of useful or culturally significant plants and on botanical knowledge for plant identification.

In 2019 Stevens Heritage Services (SHS) botanists and Yinhawangka female elders undertook ethnobotanical research around the West Angelas Deposits C and D. The Yinhawangka ethnobotany study involved an alternative approach, using ethnobotany to understand archaeological sites and artefact distribution, and so involves investigation of the possible relationships between archaeological sites, other cultural features, and contemporaneous plant associations. The field survey took place over 4 days during the end of summer between March and April 2019. 42 locations were sampled around Deposit C and D. The survey team identified 173 species at 41 locations, from 33 plant families. Of these 173 species, 50 were identified by the female Yinhawangka elders as having cultural significance as either food sources or providing another resource (traditional remedies or medicine, fibre, firewood, craftwood, or materials for ceremonies) (Stevens Heritage Services, 2019).

In 2021, Vicki Long and Associates and thirteen Ngarlawangga representatives conducted two separate Traditional Ecological Knowledge (TEK) surveys, one for male and one for female participants. The male survey was carried out over 20 and 21 August and the female survey on the following two days (22 and 23 August 2021).

The Ngarlawangga survey participants collected samples from a total of 36 species, with 31 of the species having relevance to TEK (Vicki Long and Associates, 2021).

A primary purpose of the surveys is to develop a written record of existing knowledge and known language names of plants as provided by Traditional Owners and for use within their community and ranger programme. But also to gain an understanding of plants that are traditionally and culturally important to the past and current lives of Traditional Owners, and how these plants may be impacted by both singular and cumulative mining developments, in order that these may be mitigated to some extent. The content of these reports has been summarised below with taxonomic names and culturally sensitive information redacted, as they are the intellectual property of the Yinhawangka and Ngarlawangga Traditional Owners.

Work is ongoing to understand which of the identified culturally significant species are suitable for inclusion in future rehabilitation seed mixes, and to identify knowledge gaps associated with seed collection and plant establishment.

5.1.6. Closure implementation affecting heritage sites

There are several highly significant heritage sites and important social and cultural values (identified in Section 5.1.3) that will require management during operations and closure implementation, and which will be considered as part of the closure planning process.

As part of closure planning, detailed consultation will occur with Traditional Owners for Rio Tinto to understand their priorities, to inform closure options and align and manage closure expectations. Consultation is intended to include:

- The repatriation of salvaged artefacts.
- Management and protection of heritage sites and culturally important places and values (such as waterways, and ecological niches of culturally important environmental values during closure implementation.
- How to facilitate meaningful and beneficial post-mining land access and use by Traditional Owners, including the proposed placement of pit abandonment bunds.
- Landform rehabilitation practices and processes, including seed mixes and landform design

- How to promote meaningful opportunities to include Traditional Owners, Pilbara Aboriginal People and Pilbara Aboriginal businesses in closure related work.

Ongoing consultation with each Traditional Owner group regarding heritage sites and social and cultural values will inform the design of the West Angelas proposal and inform closure strategies and outcomes.

Consultation and collaboration with the Traditional Owner groups will be maintained in established forums throughout the life of the operation to ensure that proposed closure strategies consider cultural requirements, and that closure outcomes for the site remain appropriate.

Post closure access to culturally significant sites and places and repatriation of any materials salvaged during mining operations need to be considered as part of closure planning. Specific plans for these artefacts post-closure have not been discussed with the Yinhawangka and Ngarlawangga group members to date. These discussions will occur during ongoing consultations.

Whilst this MCP does not include specific strategies for maintaining or restoring cultural values, it does recognise that post-closure access to some sites will be required and that where possible these areas will need to be made safe for this purpose.

Social Cultural Heritage Management Plans (SCHMPs) will be jointly developed with each Traditional Owner group and will include agreed processes and commitments in respect of the management of broader social and cultural values with regular reviews to allow for updates and amendments where required. A Cultural Heritage Management Plan (CHMP) will also be developed with each Traditional Owner group to manage heritage sites and places with each group and in accordance with the relevant legislation.

Although considered during landform design and planning (which includes rehabilitation designs), there is potential for social and cultural significant sites and cultural landscapes to be impacted as a result of closure implementation. This can include footprint encroachment, zones of instability, and lack of access to sites within abandonment bunds. As engineering and rehabilitation design options are refined as the site approaches closure, any potential for sites to be impacted will be identified and managed in consultation with the relevant Traditional Owners and in accordance with appropriate procedures and regulatory frameworks. Heritage surveys, and any future assessments or clearances that are required to facilitate closure implementation will be conducted in collaboration with the Traditional Owner groups in alignment with the appropriate Cultural Heritage Management System, Heritage Protocols, and/or SCHMP/CHMP as required.

Specific engagement with each Traditional Owner group will occur as required to communicate access restrictions to certain areas of the site due to the potential for geotechnical instability associated with pit crests. Site access will be determined in consultation with Traditional Owners and communicated in a post-closure site access plan to ensure that areas of geotechnical instability associated with pit voids are well understood.

Regular consultations will continue as the site progresses through operations towards closure and be further defined in each iteration of the MCP.

5.1.7. Implications for closure and knowledge gaps

Closure implications associated with cultural heritage values at West Angelas include:

- Potential for long-term indirect impacts to cultural heritage sites from changes to geotechnical stability, surface water movement and sediment transport are considered during initial mine design siting and development of closure strategies.
- Heritage sites located within Potential Unstable Pit Edge Zone (PUPEZ) being inaccessible due to abandonment bunds restricting access.
- Heritage site exclusion zones to be maintained through the decommissioning, closure and rehabilitation implementation phases.

- Closure strategies to be developed in consultation with Traditional Owner groups to fully consider the cultural implications.
- Provision of safe access for Yinhawangka and Ngarlawangga People to identified sites of cultural heritage significance post-closure.
- Incorporation of culturally significant species into the rehabilitation seed mix.

Key closure knowledge gaps associated with cultural heritage values, are summarised below and detailed further in Table 6-1.

- The final rehabilitation seed mix; this is to be updated and finalised in consultation with Traditional Owners to ensure inclusion of appropriate species of ethnobotanical significance.
- Safe post-closure access routes to cultural heritage sites and other places of cultural value
- Closure outcomes and completion criteria based on consultation with Traditional Owners.
- Strategy for the safe keeping or return of any artefacts or materials salvaged.
- Potential for long-term indirect impacts to cultural heritage sites from areas of geotechnical instability, surface water movement and sediment transport.

5.2. Socio-Economic Aspects

The West Angelas operation is located across both the Shire of Ashburton - which covers 105,647 km^2 with a population of 7,391 (ABS 2021) and the Shire of East Pilbara – which covers 372,571 km^2 and has a population of 9,760 (ABS 2021). The closest regional centre to West Angelas is Newman, situated approximately 100 km to the south-east.

Approximately 849 people work at the West Angelas mine site of which 76 identify as being of Aboriginal and/or Torres Strait Islander descent. Most staff are flown directly from Perth to West Angelas via the Rio Tinto owned and operated site airstrip, with small numbers also flying directly from Geraldton, Albany and Busselton or driving in and out from local towns. Personnel are housed at West Angelas in fully serviced accommodation facilities that will be decommissioned as part of the closure activities.

Mining activities are anticipated to continue at a similar rate within the wider Pilbara region after the West Angelas mine ceases to operate. Thus, regional employment opportunities and mine related services are not anticipated to be significantly impacted by closure of the mine, however there may be some contraction in the workforce in the local area.

5.2.1. Implications for closure

Closure implications associated with the socio-economic setting include:

- Regional communities may be impacted by closure of West Angelas, particularly regarding cessation of opportunities for employment and business opportunities. However, as West Angelas is a predominantly FIFO operation, these impacts are not expected to be significant due to ongoing activities of operations in the Eastern Pilbara beyond the closure of West Angelas.

There are currently no known closure knowledge gaps associated with socio-economic aspects.

PHYSICAL ENVIRONMENT

5.3. Climate

5.3.1. Local climatic conditions

West Angelas is in the Pilbara region of Western Australia which has an arid climate and experiences regular cyclonic activity during November to March. Characteristic climatic features of the region include seasonally low rainfall with high temperatures, high evaporation rates and high daily temperature range.

The nearest certified meteorological station to West Angelas is located at Newman Aerodrome (BOM Station 007176) approximately 107 km to the east of the operation/mine. Climatic data gathered from Station 007176 is considered representative of that experienced at West Angelas and is utilised in this MCP. In addition to the BOM weather station, Rio Tinto maintains automatic weather stations, including a station at West Angelas.

Maximum average temperatures generally occur from November to March, during the season of peak rainfall, with mean daily maximum temperatures range from 40°C in summer to 23°C in winter (refer to Figure 5-1). The coolest months occur between June and August (refer to Figure 5-1).

Rainfall occurs predominantly in the summer months with the largest events being associated with tropical cyclone events bringing heavy rain to the inland parts of the Pilbara. Frequent summer thunderstorm activity and occasionally protracted rainfall when a low-pressure trough descends into the region are characteristic.

The long-term annual average rainfall for Station 007176 (1971 to 2022) is 315.3 mm/year (Figure 5-1). Rainfall during December to February ranges from 35-72mm per month, whilst the months of September to November range between 4-12mm per month.

The rainfall distribution typically experienced at West Angelas peaks from December to February followed by a declining average monthly trend from May to June, resulting from the influence by two main climatic systems:

- the northern rainfall system of tropical origin; and
- the southern winter rainfall associated with low-pressure frontal systems.

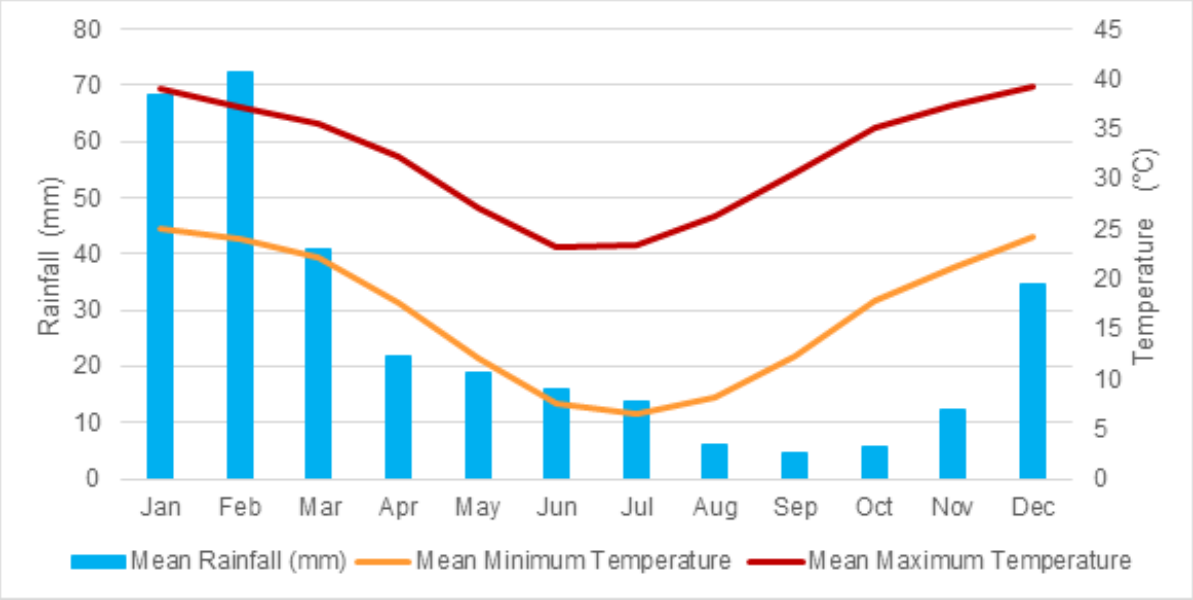


Figure 5-1: Newman Airport Average Monthly Climate Data from 1996 - 2022 (BoM Station 007176) (BoM 2022 [G149])

The annual evaporation rate for the region is 3,400mm (BOM, 2021) vastly exceeding the annual average rainfall (refer to Figure 5-2). Maximum evaporation rates generally occur in January with approximately 400mm anticipated in the seasonal peak. These rates can reduce to approximately 125mm in June.

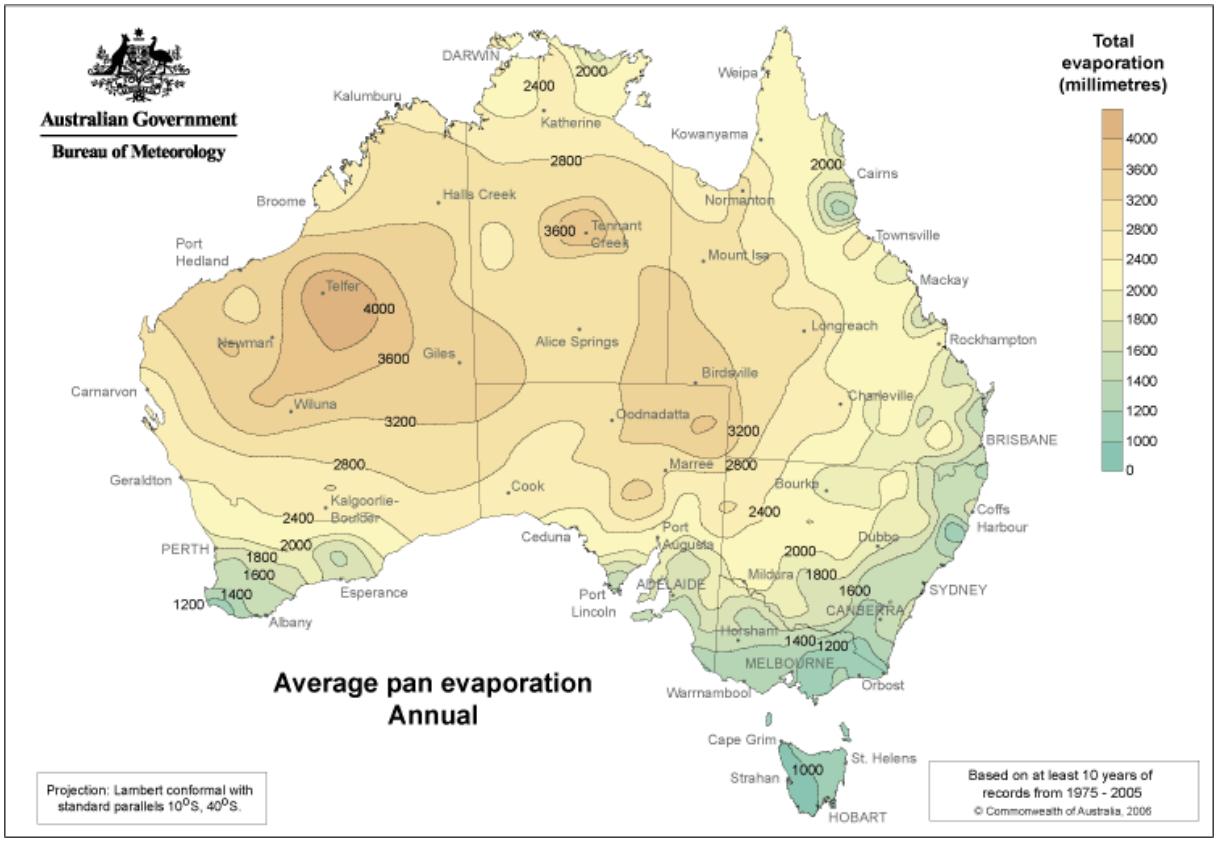


Figure 5-2: Average annual evaporation rates across Australia (BOM 2006)

5.3.2. Climate Change

According to the Commonwealth Scientific and Industrial Research Organisation (CSIRO) and BOM (2021) Climate Change in Australia website and supporting CSIRO report (Watterson et al. 2015), the Pilbara is located within the Rangelands North sub-cluster national resource management region and the predicted impacts associated with climate change include:

- Increase in average and extreme temperatures in all seasons, with forecast warming 0.6°C to 1.5°C for the near future (2030) – predictions for later in the century (up to 2090) depend on the emission scenario;
- changes to rainfall are likely, but the direction of change is unclear, and as such, impact assessment needs to consider both drier and wetter conditions;
- increase in intensity of extreme rainfall events;
- increase in time spent in drought over a 100-year period;
- uncertain change in bushfire risk due to rainfall being critical to vegetative fuel load;
- increase in potential evapotranspiration in all seasons as warming progresses; and
- tropical cyclones may decrease in number but increase in intensity and duration.

The materialisation of these climate projections is likely to make successful rehabilitation in the Pilbara more challenging.

5.3.3. Climate change resilience

Rio Tinto accepts the climate science assessed by the Intergovernmental Panel on Climate Change (IPCC) which unequivocally shows that human influence has warmed the atmosphere, ocean and land and that widespread and rapid changes in the atmosphere, ocean, cryosphere and biosphere have occurred (IPCC 2021). Rio Tinto understands that climate change will amplify existing risks in mining, port and rail operations in the Pilbara region and recognises a responsibility to act by focusing on a reduction in greenhouse gas emissions (particularly with the use of low emissions technology); and increasing resilience to physical climate change impacts.

To address the business, social and environmental risks associated with climate change, Rio Tinto have:

- Established emission reductions targets: 15% reduction by 2025, 50% reduction by 2030 and net zero emissions by 2050;
- Developed a Physical Climate Change Analysis Guidance Note (RTIO 2022) which sets out:
    - The physical climate change risk analysis process for identification and evaluation of material risks from climate change on our assets and communities; and
    - The key requirements to be utilised in all climate modelling for Rio Tinto assets, including: future time horizons; climate scenarios; climate variables; time steps and spatial resolution;
- Engaged a climate data service provider to provide Rio Tinto with high-quality and site-specific climate change projections using the latest generation Coupled Modelled Intercomparison Project Phase 6 (CMIP6) modelling;
- Conducted Pilbara physical risk assessment workshops between June and August 2022 which identified priority risks for evaluation and future inclusion in the relevant mine risk registers, including the closure risk register; and
- As a signatory to the Global Industry Standard for Tailings Management (GISTM), uncertainty and impacts associated with climate change will be considered in all TSF closure designs through the six specific requirements of GISTM relating to climate change.

5.3.4. Implications for closure and knowledge gaps

Closure implications associated with climate and climate change include:

- Consider optimal timing of rehabilitation works to maximise germination following seeding in changing conditions.
- WRL design parameters to consider more intense of rainfall events.

Closure knowledge gaps associated with climate and climate change, as summarised in Table 6-1, include:

- Consideration of climate change at West Angelas on:
    - revegetation success;
    - erosion resistant landforms;
    - the rebounding water table and its implications on backfill levels; and
    - flood modelling and closure surface water controls.

5.4. Bioregions, Land Systems and Topography

5.4.1. Bioregions

Bioregions for the Australian content have been created as part of a national classification of ecosystems called the Interim Biogeographic regionalisation (IBRA). There are currently 89 bioregions and 419 sub-

regions in Australia. Each region is based on similarities in climate, geology, landform, native vegetation and species information.

West Angelas lies within bioregion 68 or the Pilbara (PIL), a bioregion defined by the IBRA. The Pilbara bioregion is characterised by vast coastal plains and inland mountain ranges with cliffs and deep gorges. Vegetation is predominantly mulga low woodlands or snappy gum over bunch and hummock grasses. The Pilbara bioregion covers an area of 17,823,126 ha and is divided into four subregions: Chichester (PIL01), Fortescue Plains (PIL02), Hamersley (PIL03) and Roebourne Plains (PIL04).

West Angelas lies within the Hamersley (PIL03) subregion, occupying an area of 5,634,727 ha with features including:

- mountainous areas of Proterozoic sedimentary ranges and plateaux, dissected by gorges (basalt, shale and dolerite);
- Mulga low woodland over bunch grasses on fine textured soils in valley floors, and *Eucalyptus leucophloia* over *Triodia brizoides* on skeletal soils of the ranges;
- gorges of Hamersley Range, particularly those of Karijini National Park. Deeply incised gorges, up to 100m deep, containing extensive permanent spring fed streams and pools (Duck creek and Palm Springs);
- major land uses such as unoccupied Crown Land, Crown Reserves pastoralism, intensive rural freehold blocks, horticulture, mining and indigenous freehold; and
- major population centres at Tom Price, Paraburdoo and Newman.

5.4.2. Land Systems and topography

Land systems refer to an area or group of areas throughout a region where there is a recurring pattern of topography, soils and vegetation. The Pilbara region has been mapped into 20 broad land types comprised of 102 land systems (Van Vreeswyk et al. 2004).

Thirteen land systems occupy the West Angelas closure boundary (Figure 5-3). Descriptions of these land systems are as follows:

- Newman: Rugged, jaspilite plateaux, ridges and mountains supporting hard spinifex grasslands.
- Platform: Dissected slopes and raised plains supporting hard spinifex grasslands.
- Boolgeeda: Stony lower slopes and plains below hill systems and supporting hard and soft spinifex grasslands or mulga shrublands.
- Egerton: Highly dissected hardpan plains supporting mulga shrublands and hard spinifex hummock grasslands.
- Jamindie: Stony hardpan plains and rises supporting groved mulga shrublands, occasionally with spinifex understorey.
- Rocklea: Basalt hills, plateaux, lower slopes and minor stony plains supporting hard (and occasionally soft spinifex) grasslands.
- Elimunna: Stony plains on basalt supporting sparse acacia and cassia shrublands and patchy tussock grasslands.
- Pindering: Gravelly hardpan plains supporting groved mulga shrublands with hard and soft spinifex.
- River: Active flood plains and major rivers supporting grassy eucalypt woodlands, tussock grasslands and soft spinifex grasslands.
- Robe: Low limonite mesas and buttes supporting soft spinifex (and occasionally hard spinifex) grasslands.

- Spearhole: Gently undulating hardpan plains supporting groved mulga shrublands and hard spinifex.
- Table: Low calcrete plateaux, mesas and lower plains supporting mulga and cassia shrublands and minor spinifex grasslands.
- Wannamunna: Hardpan plains and internal drainage tracts supporting mulga shrublands and woodlands (and occasionally eucalypt woodlands).

Two main landscape features denominate regional topography; the Hamersley Range to the north of the closure boundary and the lower areas of flats and undulating plains. The top of the Hamersley Range plateau is a series of rounded hills and narrower ridges, reaching 1,245 m above sea level at its highest point. The plateau forms the watershed between the Fortescue River to the north and the Ashburton River to the south. Numerous rivers and streams have dissected the plateau, forming gorges and broader scree and rubble-filled valleys (Copp 2005).

The highest peak in the closure boundary is at an elevation 1,240 m, which sits southwest of the Development Envelope and is a dominant landscape feature.

5.4.3. Implications for closure and knowledge gaps

Closure implications associated with Bioregions, land systems and topography include:

- Final closure landscape to consider existing landscape and topography.

There are currently no known closure knowledge gaps associated with Bioregions, land systems and topography.

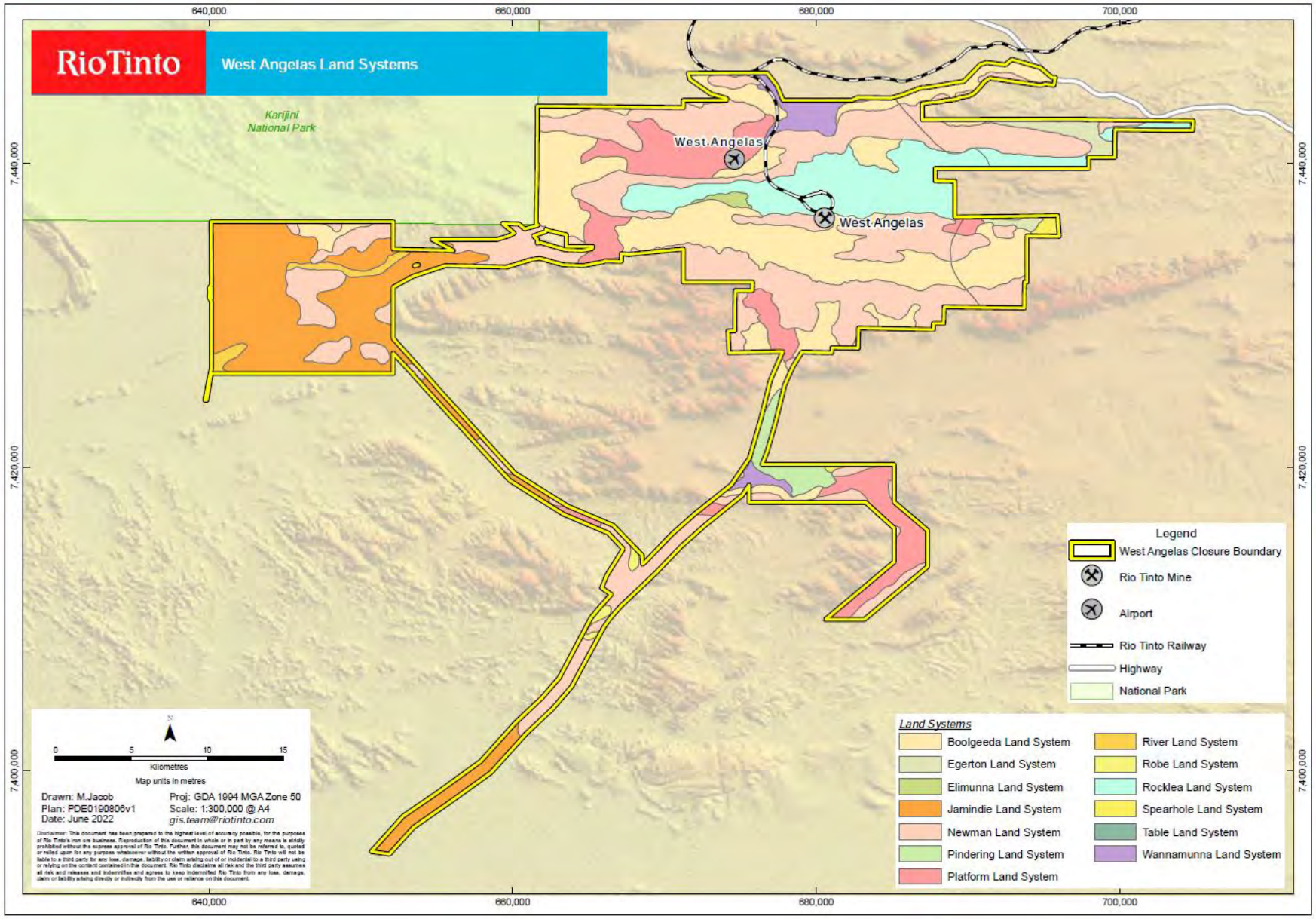


Figure 5-3: Land systems within the West Angelas closure boundary

5.5. Soils

5.5.1. Soil characterisation

Topsoil is recognised as an important factor in achieving high quality, sustainable rehabilitation results. Characterisation of soils provides an indication of soil properties and their potential impacts on vegetation establishment, growth and erosiveness. Appropriate characterisation of soils can also assist when soils with adverse properties are avoided in rehabilitation.

In the Pilbara, hills and rock ridges have extensive areas without soil cover occurring and the soils that do occur, are often shallow and skeletal. Rocks of this formation weather very slowly, and any soil which does form tends to be transported into the surrounding valleys and plains. This results in sparse vegetation cover and erosion force of heavy rains derived from thunderstorms and cyclones. The soils on slopes, although having had more time to develop than the soils of the adjacent ridges, are still influenced by the parent rock and may be shallow and stony sands or loams. These soils are generally unfavourable for plant growth due to low moisture holding capacity and poor nutrient status. On pediments, older pediplains and alluvial plains hard alkaline red loamy soils tend to be dominant and may be considered as the regional mature soil type. The surface of these areas may carry a layer of small gravel, which is derived from the more resistant rocks in the area.

A comparison of physical and some chemical properties of typical Pilbara soils and West Angelas topsoil samples are provided in Table 5-1. Overall, West Angelas soil is consistent with Pilbara soil parameters.

West Angelas topsoil is generally classified as shallow coherent and porous loamy soils, with weak pedologic development (Mattiske Consulting Pty Ltd, 2009). Soil was classed as slightly acidic to neutral (pH 4.6 to 7.2), non-saline and non-sodic (i.e non-dispersive). Organic carbon varies according to landscape position; with the highest levels found in the hilltop landscape.

Subsoil has physical properties suitable for plant growth and generally has chemical properties amenable to plant growth, although it does lack the nutrient content, organic matter, soil microbes and soil seed bank of topsoil. Subsoil characterisation is unknown, future studies will address Action WAN-10 which is included in the closure action register (Appendix 4).

Table 5-1: Comparison between West Angelas soils and typical Pilbara soil parameters[3]

Properties		Pilbara Soils	West Angelas Topsoil[4]	
			0-5cm	10-20cm
Physical	Soil texture (<2 mm soil fraction)	Sand clay loam	Clay loam	Clay loam
	Coarse material content (%)	0 - 93	40	33
Chemical	Soil pH	5.3 – 9.5	5.6	5.7
	Salinity (dS/m)	0.007 – 0.233	0.047	0.045
	Organic Carbon (%)	0.07 – 3.74	2.6	2.2
	Macro-nutrient status[5]	Low	NA	NA
	Micro-nutrient status[5]	Low - moderate	NA	NA
	Effective Cation Exchange Capacity (meq/100g)[5]	1.9 – 16.8	NA	NA

[3] Note that the typical ranges above apply to topsoil and may not be representative of subsoil properties.

[4] Data has been averaged across nine topsoil samples (0 – 5cm) and nine topsoil samples (10-20cm) which were taken over varying topography

[5] Not tested in the baseline assessment (Mattiske 2009).

Properties		Pilbara Soils	West Angelas Topsoil[4]	
			0-5cm	10-20cm
	Exchangeable Sodium Percentage (%)[5]	0.21 – 6.39	NA	NA
	Total metal concentrations[5]	Low	NA	NA

5.5.2. Soil inventory

Topsoil is a limited resource in the Pilbara with topsoil recovery often being restricted due to the nature and terrain of the landscape. The goal of soil management is to maximise the collection of topsoil (and subsoil and detritals, where a deficit of topsoil occurs) to ensure there is sufficient soil for subsequent use in rehabilitation and to store it to maximise its viability and productivity for improved rehabilitation performance.

Where practical, a minimum of 200 mm of topsoil and 600 mm of subsoil is collected when new areas are disturbed. However, this is not practical in all areas such as rocky ridges where soils are shallow or non-existent and/or are unsafe to access. Table 5-2 provides the current and projected soil inventory for the current operations at West Angelas assuming recovery rates remain consistent over time.

Table 5-2: Predicted LOM soil balances for current operations at West Angelas (as of April 2022)

Topsoil parameters	Current balance	Future predicted clearing and recovery (current approval)	Total at Closure
Topsoil volume (m^3)	6,712,838	2,372,760	9,085,598
Subsoil volume (m^3)	6,192,319	7,118,280	13,310,599
Total soil volume (m^3)	12,905,157	9,491,040	22,396,197
Total disturbance area (ha)[6]	7,893	1,186	9,079
Pit areas not rehabilitated (ha)	1,574	552	-
Completed rehabilitation (ha)	712	-	712
Area requiring topsoil (ha)	5,607	635	6,242
Soil volume required 200mm (m^3)	11,213,706	1,269,721	12,483,426
Soil Surplus (m^3)	1,691,451	3,475,800	5,167,251
Soil Surplus (%)	115%	374%	141%

Rehabilitation requirements are calculated based on the closure footprint (excluding pit voids), landform geometry and thickness of topsoil application. There is expected to be a surplus of soil available at closure for rehabilitation requirements at West Angelas for current approved operations. This surplus is likely to be greater than indicated due to the requirement to backfill voids, which will see some waste dump material returned to the pit at closure thereby reducing the ex-pit area requiring rehabilitation.

The proposed new disturbance at West Angelas and associated soil inventory is presented in Table 5-3. As proposed waste landform designs are not complete at the time of writing this MCP, it is not clear if a soil surplus or deficit is present at closure for the combined current and proposed operations. It is noted that a significant surplus is predicted for current operations which can be utilised for rehabilitation of proposed features if soil availability is found to be deficient for proposed operations. Updated soil resource information will be presented in future iterations of this MCP.

[6] Based on the closure footprint with pit voids excluded

Table 5-3: Predicted LOM soil balances for proposed operations at West Angelas (as of April 2022)

Topsoil parameters	Predicted future balance	Future predicted clearing and recovery	Total at Closure
Topsoil volume (m^3)	-	1,090,823	1,090,823
Subsoil volume (m^3)	-	3,272,468	3,272,468
Total soil volume (m^3)	-	4,363,291	4,363,291
Total disturbance area (ha)	482	545	1,027
Pit areas not rehabilitated (ha)	-	545	-
Completed rehabilitation (ha)	113	-	113
Area requiring topsoil (ha)	369	-	369
Soil volume required 200mm (m^3)	738,000	-	738,000
Soil Surplus (m^3)	738,000	4,363,291	3,625,291
Soil Surplus (%)	-	-	-

5.5.3. Alternative growth media

In 2010, Rio Tinto commissioned a study into use of mine waste materials as an alternative rehabilitation growth medium. The study reviewed soil, tailing and mineral waste characteristics from select Pilbara mining operations, to identify material combinations that may be suitable as a topsoil substitute or supplement in cases where topsoil may be insufficient for rehabilitation requirements. In these cases, topsoil would be applied to high priority areas such as waste landforms first and lower priority areas such as laydown areas may receive alternative growth media.

The study showed plant-available nutrients held within the waste materials, although variable, was characteristically low and comparable to natural soils in the region. The majority of the waste materials had macro and micronutrient concentrations within the range or above the levels measured in benchmark Pilbara topsoil and rehabilitated soils. The pH and phosphorus-buffering index of most waste materials were also comparable to that of the benchmark topsoil materials.

In general, Pilbara mineral wastes were non-saline and non-sodic, with no sample presenting above the 15% threshold for exchangeable sodium percentage (ESP), the indicator of high sodicity. The soil structure of waste materials was relatively stable, with only slight or no dispersion upon re-moulding, indicating a relatively stable structure that is not easily degraded, and were not prone to hard setting. However, estimated plant available water content of the waste materials ranged from <3% to >25%.

Whilst rehabilitation areas have generally performed better with topsoil application, absence of topsoil does not necessarily mean that rehabilitation will fail, or that completion criteria will not be achieved. Trials have been conducted on waste dump rehabilitation without topsoil application (for example the Channar 84E5 waste dump trial) and are performing strongly against most success indicators. Further trials using detrital waste material have begun at Tom Price (MMW4 waste dump).

In summary, alternative growth media options are available for consideration in West Angelas rehabilitation, should a shortfall of available topsoil and subsoil be encountered. Options for utilising the alternative growth media will be considered as the site comes closer to closure. However, current soil balance forecasts suggest that the use of alternative growth media will not be required.

5.5.4. Implications for closure and knowledge gaps

Closure implications associated with soils include:

- The predicted soil balance indicates a surplus if all available topsoil and subsoil can be harvested. In the event the predicted volume is not realised, Rio Tinto will need to identify and test alternative growth media to support future rehabilitation efforts.
- The assumed soil recovery rates may not be realised in future clearing. Soil reconciliations are required to be updated annually to track progress toward estimated volumes of soil required for rehabilitation.

Closure knowledge gaps associated with soils, as summarised in Table 6-1, include:

- There is a topsoil surplus for the landforms associated with current operations. However further investigation into topsoil availability for the proposed waste landforms are required once all designs have been completed, and backfill planning refined.

5.6. Geology and Mineralisation

The West Angelas project area includes sixteen discrete areas of mineralisation. These deposits lie on the limbs of the east-west trending, west plunging Wonmunna Anticline located in the eastern part of the Ophthalmia Fold Belt. The West Angelas deposits, comprise mainly Marra Mamba Iron Formation (MMIF) with mineralisation occurring in the Mt Newman Member. Mineralisation is found in limited quantities in the Nammuldi Member, Macleod Member and the lower portion of the West Angelas Member. Tertiary Detrital material derived from both the Marra Mamba and Brockman Iron Formations also accumulates throughout the project area. The main mineralised units being targeted for mining are the MMIF, which are generally low phosphorus deposits.

Mineral waste generated at West Angelas is categorised with respect to the geological origins of the material (refer to examples shown in Figure 5-4 - Figure 5-14):

- detritals;
- hydrated;
- dolerite;
- tertiary alluvials;
- Nammuldi Member;
- MacLeod Member;
- Mt Newman Member;
- Wittenoom dolomite; and
- West Angelas shale.

5.6.1. Deposit A

Deposit A (Figure 5-4) is situated on the Southern Limb of the of the west plunging, east west trending Wonmunna Anticline. Mineralisation occurs within second order synclines, folding appears to have had some control in the localisation of mineralisation, with the highest iron concentrations forming in synclinal keels. It has a strike length of 6.5 km and varies in width from 400 m to 1,500 m.

Most of the iron enrichment occurs in the upper two thirds of the Mt Newman Member of the Marra Mamba Iron Formation, with minor mineralisation in the lower 6 m of the overlying West Angela Member of the Wittenoom Formation. The area has been cut by south-dipping thrust and reverse faults. The faults commonly occur within, or at the margins of, over-tightened anticlines. The direction of tectonic transport on these faults is south block over north.

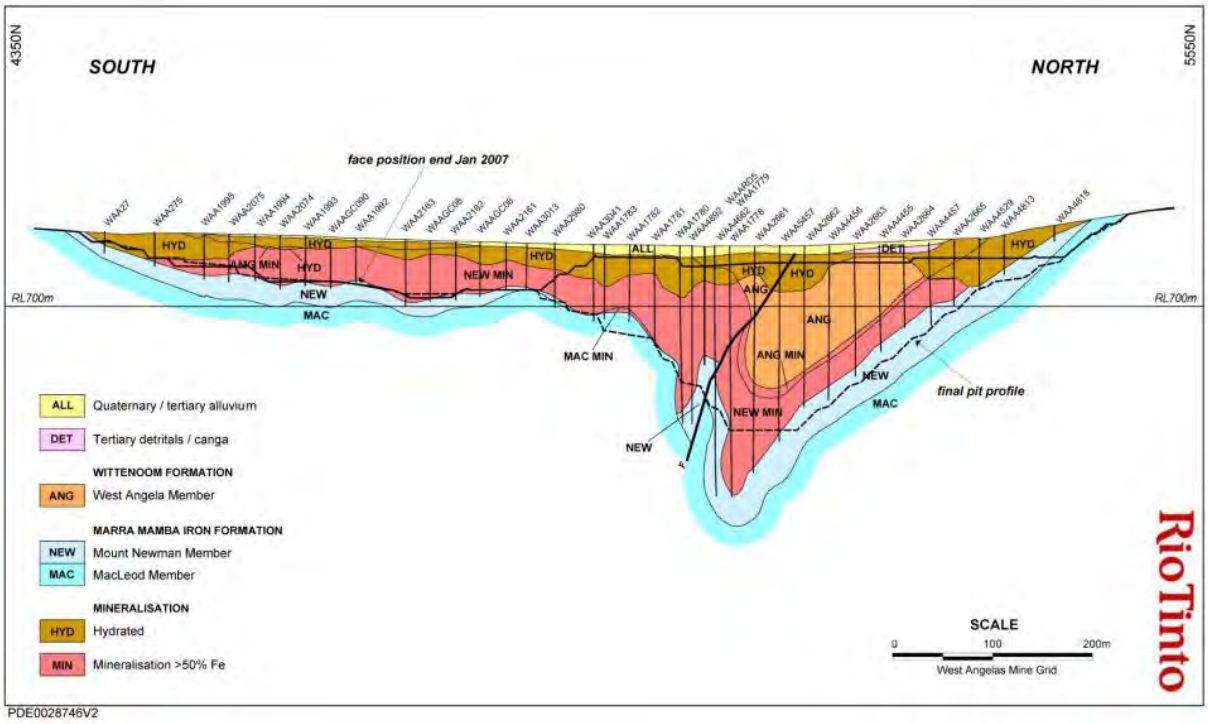


Figure 5-4: Typical geological cross section from Deposit A (looking west)

5.6.2. Deposit A West

Deposit A West (Figure 5-5) is situated on the southern limb of the Wonmunna Anticline. It strikes east-west for approximately 6.4 km from the western extents of Deposit A. Bedding at Deposit A West is typically dipping south at approximately 35 degrees and characterised by minor folding along the strike.

Mineralisation in Deposit A West is predominately contained in the Mt Newman Member, particularly within NE2 and is typically goethite-hematite rich material. Detrital units consist of low grade pisolitic, limonitic and canga material, with thick clay and waste inclusions. High grade Red Ochre Detritals have also been encountered and modelled in the area.

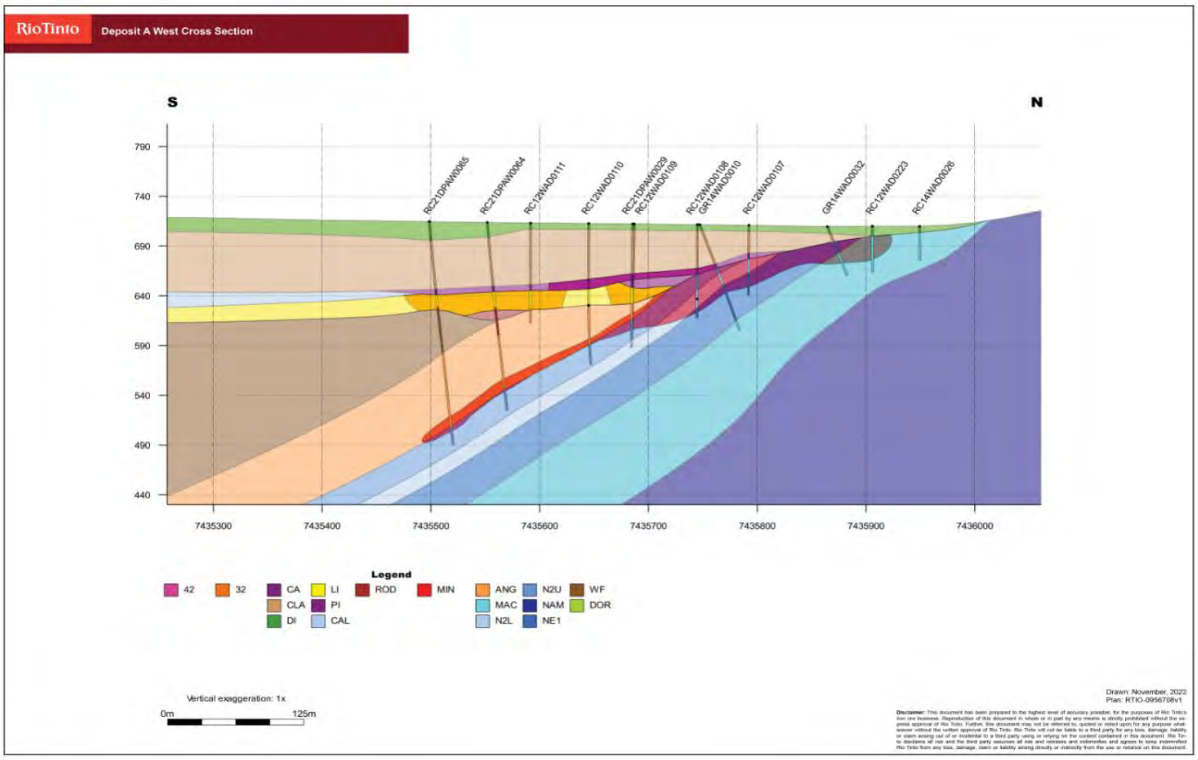


Figure 5-5: Typical geological cross section from Deposit A-West

5.6.3. Deposit B

Deposit B (Figure 5-6) is located on the northern limb of the Wonmunna anticline. The strike length is approximately 7.6 kilometres long and is structurally complex, existing as a doubly plunging syncline that is truncated by two shallow dipping thrust faults to the west, with an additional normal fault located in the eastern extents of the deposit.

High-grade hematite-goethite mineralisation occurs generally in the Mount Newman Member of the Marra Mamba Iron Formation. Lower grade mineralisation occurs occasionally within the lower West Angela Member of the Wittenoom Formation and in the MacLeod Member of the Marra Mamba Formation. Detrital mineralisation is discrete, occurring as pods within paleo-channels.

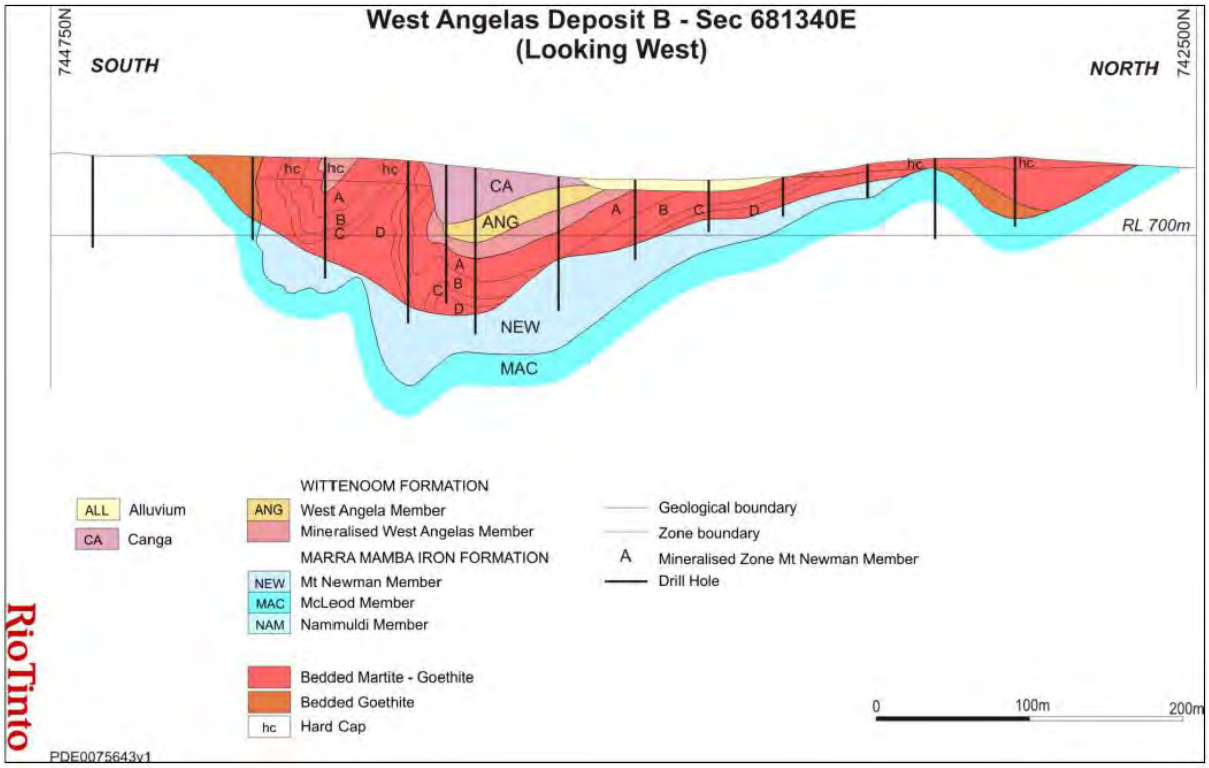


Figure 5-6: Typical geological cross section from Deposit B (looking west)

5.6.4. Deposit C

Deposit C (Figure 5-7) is situated on the western closure of the northern limb of the west plunging, east west trending Wonmunna Anticline. The strike length is approximately 8 km. The deposit has two distinct regions, the east is relatively simple, with bedding typically dipping north at approximately 30-45 degrees and is characterised by minor folding along strike and one minor normal fault structure. In the west, bedding becomes strongly folded, with normal faulting horst-graben and half graben sequences identified.

Bedded mineralisation in the deposit is typical Marra Mamba sequence, with thick Wittenoom Formation shale, into Mount Newman, McLeod and Nammuldi Members. Mineralisation is typically goethite-hematite rich material that is predominately contained in the Mt Newman member, primarily within NE2. Hydrated, bedded mineralisation and detritals cover much of the deposit, with lignite intersections identified in drillholes. The mineralised detrital units intersected are generally of a lower grade and are pisolitic or limonitic in lithology.

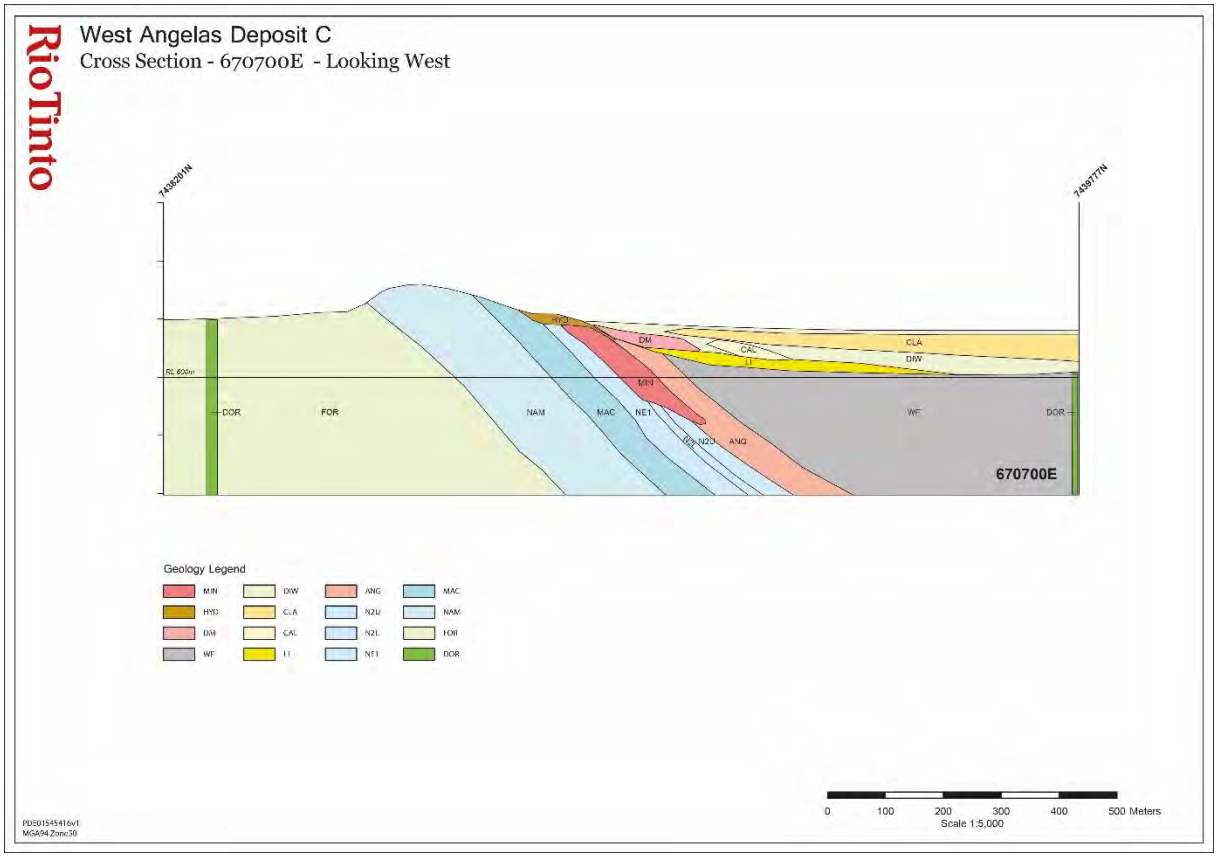


Figure 5-7: Typical geological cross section from Deposit C (looking west)

5.6.5. Deposit D

Deposit D (Figure 5-8) is located on the southern limb of the Wonmunna Anticline, close to the western closure. It has an overall strike length of ~9 km. The deposit geology is dominated by a discontinuous south dipping thrust fault which has been noted in Deposit A to the east of Deposit D.

The overall strike of the deposit changes between approximately E-W to NE-SW towards the hinge of the Wonmunna Anticline. A largely continuous syncline follows parallel to the overall strike of the deposit. This folding becomes more complex in the central area where the deposit strike changes, where there are several additional synclines. Stratigraphy of Deposit D generally dips towards the south, following the overall deposit strike of E-W to NE-SW.

Bedding in the deposit is typical Marra Mamba sequence, with thick Wittenoom Formation shales, into Mt Newman, McLeod and Nammuldi Member. The Mt Newman Member makes up most of the resource material with NE2 preferentially mineralised when compared to the NE1. Newman mineralisation is hematite and goethite rich, with variable amounts of hydrated material recorded close to surface.

An extensive profile of detrital material blankets the bedded stratigraphy in the south and consists of; immature and lesser mature detritals, clay, pisolite, calcrete, canga, limonite, lignite, siderite and Red Ochre Detritals (ROD). Of these, the mature detritals, pisolite, canga, limonite and ROD are mineralised in parts, however this is generally low grade.

The area is intruded by a prominent dolerite dyke swarm which generally strikes on a NW-SE trend.

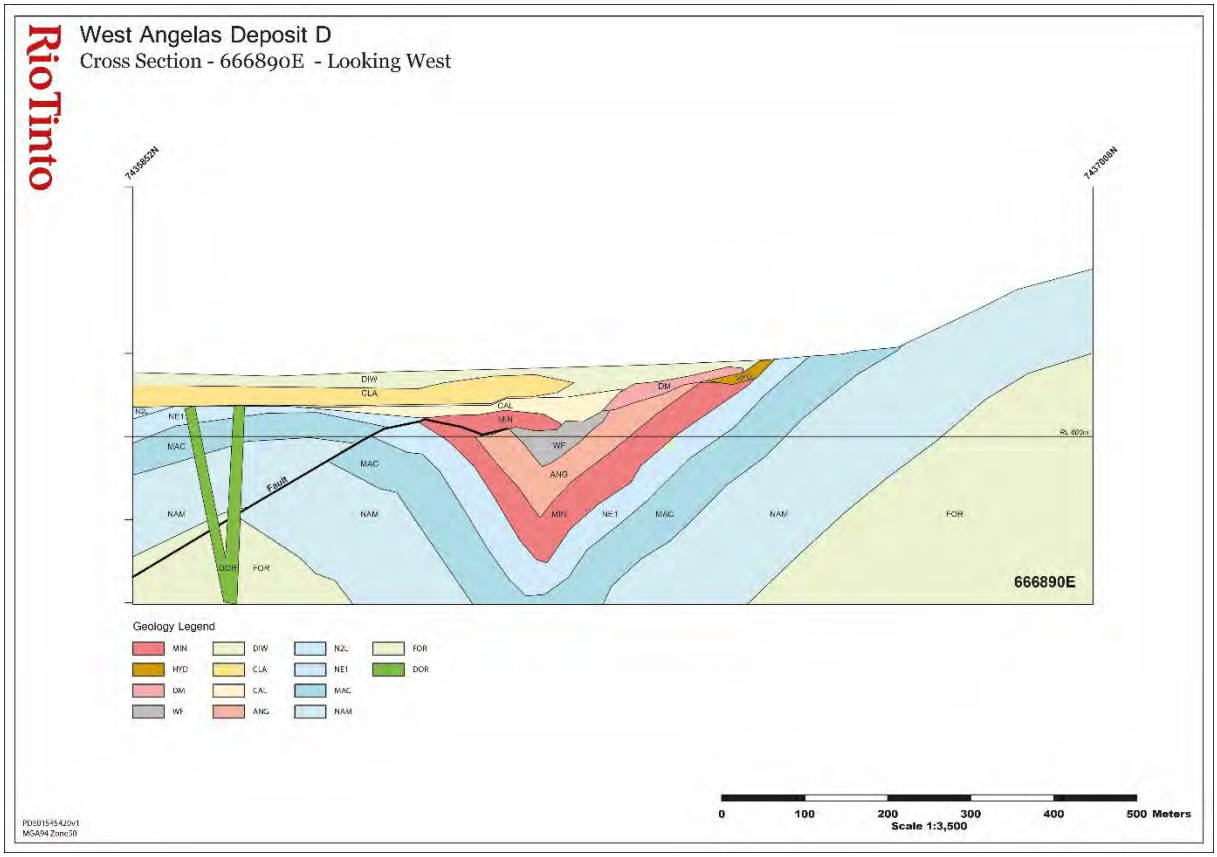


Figure 5-8: Typical geological cross section from Deposit D (looking west)

5.6.6. Deposit E

The West Angelas Deposit E (Figure 5-9) is situated on the southern limb of the west plunging, east-west striking Wonmunna Anticline. The deposit extends approximately 3.5 km in strike, 300 m in width, with varying thickness of 45 m to 60 m. Deposit E is defined by strong folding and faulting of the West Angelas Member and the underlying Marra Mamba Iron Formation.

Most of the bedded mineralisation occurs within the Mt Newman Member of the Marra Mamba Iron Formation. This mineralisation occurs predominantly within the NE2 unit with occasional low-grade enrichment within the NE1 unit. Minor mineralisation occurs within the West Angelas Member.

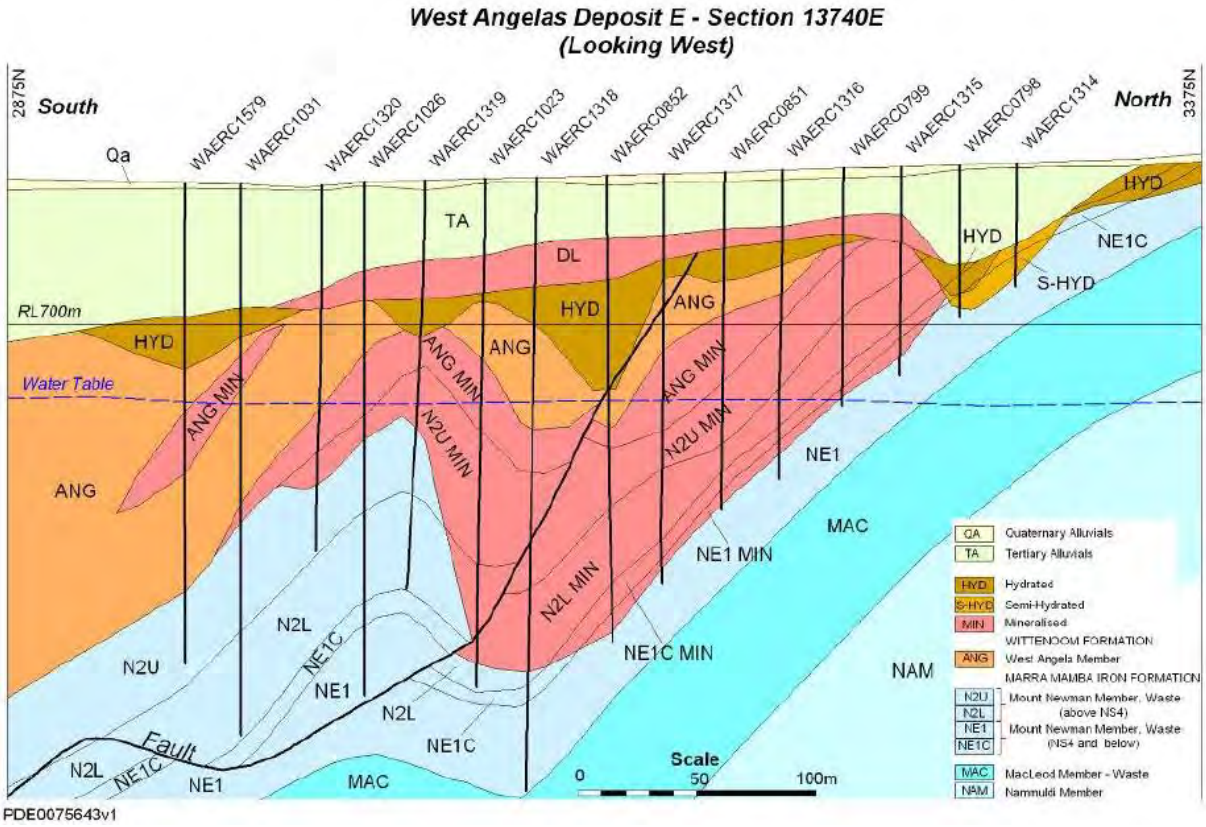


Figure 5-9: Typical geological cross section from Deposit E (looking west)

5.6.7. Deposit F

Deposit F (Figure 5-10) is located on the southern limb of the west plunging, east-west striking Wonmunna anticline, approximately 5 km ESE of Deposit A, east of Deposit E. The orebody is structurally complex, with low angle thrusts and normal faulting interpreted and has an interrupted geometry of approximately 7.5 km in strike length and up to 1 km in width.

Mineralisation is found within the tertiary mature and limonitic detritals that blanket the paleo-topography, as well as the E-W striking folded Marra Mamba Iron Formation, primarily within NE2 of the Mount Newman member. Mature detritals intermittently overlie a hydrated bedded material that transitions into mineralised Mt Newman and less frequently, the Macleod or Nammuldi Members. Immature detrital, clay and quaternary alluvial material overlies the mineralised zone with thicknesses of approximately 2 to 80 metres.

The area is intruded infrequently by dolerite dykes which generally strike on a NW-SE trend.

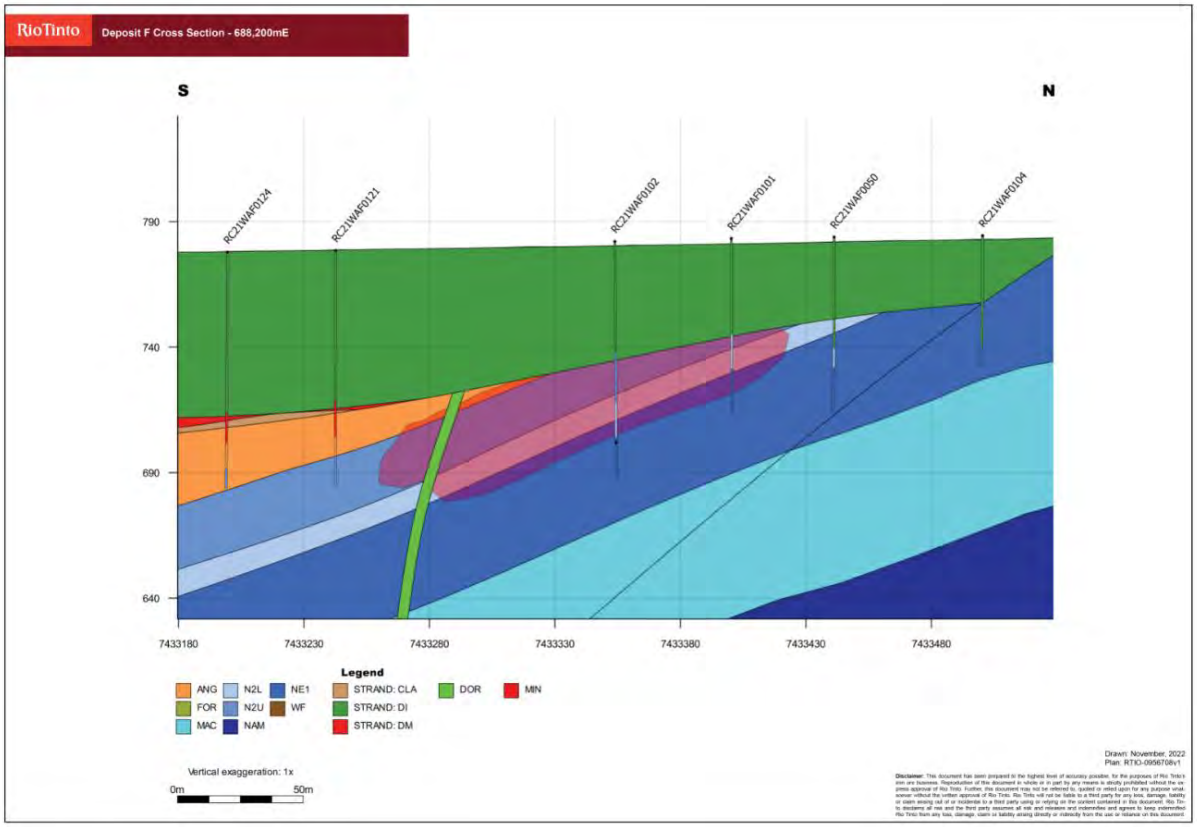


Figure 5-10: Typical geological cross section from Deposit F

5.6.8. Deposit G

Deposit G (Figure 5-11) is located on the northern limb of the Wonmunna Anticline, as the western extension of Deposit B to the east, and the eastern extension of Deposit C to the west. The bedded mineralisation in the deposit is divided into a northern orebody and a southern orebody that is separated by the northern fault. The Northern orebody is present mostly under cover and is constrained by synclinal structure which gently plunges to the west. The Southern orebody is northerly dipping, becoming steeper towards the west. It is localised within a series of antiform and synform structures within an interpreted graben structure which is controlled by two WNW-ESE trending normal faults in the area.

A majority of the bedded mineralisation occurs within the Mount Newman Member of the Marra Mamba Iron Formation. The Mount Newman Member makes up the majority of the resource material with the NE2 preferentially mineralised when compared to NE1. Additionally, there is a significant amount of detrital mineralisation present within the deposit, which has been classified as mature detritals, canga, limonite and pisolite.

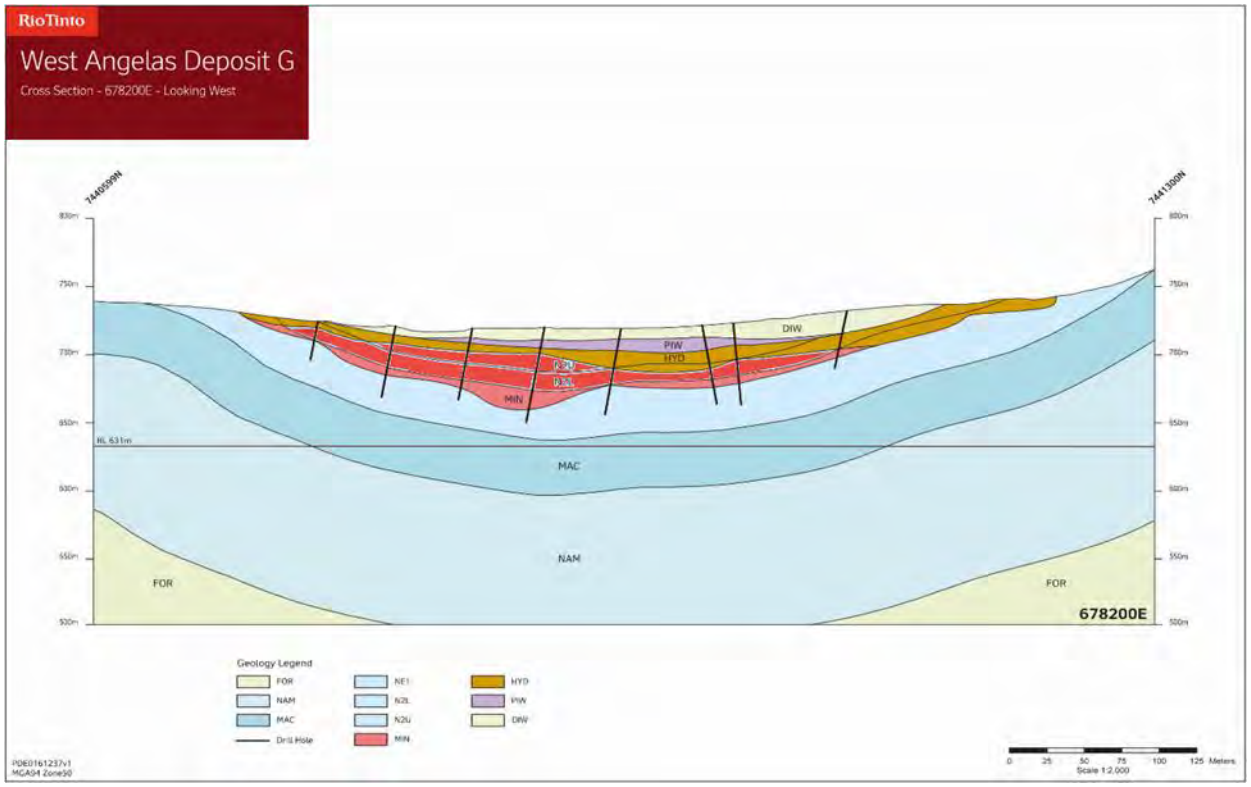


Figure 5-11: Typical geological cross section from Deposit G (looking west)

5.6.9. Deposit H

Deposit H (Figure 5-12) is the eastern most West Angelas deposit situated on the northern limb of the Wonmunna Anticline, and is separated from Deposit B to the west by a north-easterly trending normal fault. The 5.5 km long deposit is approximately 3.5 km east of adjacent Deposit B, and 9 km north-east of infrastructure at West Angelas Mine. It consists of an open doubly plunging synclinal structure, cross-cut with interpreted normal, thrust and reverse faulting. Minor amounts of detrital material sheet the Wittenoom formation in the core and Newman, MacLeod & Nammuldi formation surrounding the deposit.

Mineralisation is not of typical Marra Mamba specifications. It is composed of primarily martite and goethite with high iron grades but has elevated phosphorous (P>0.10) throughout the deposit. The elevated phosphorus is more prominent in the western area. A majority of the bedded mineralisation is hosted within the various sub-members of the Mount Newman Member, with lesser West Angelas Shale, MacLeod and Nammuldi mineralisation. Detritals are primarily unmineralised, with minor volumes of mature detrital present.

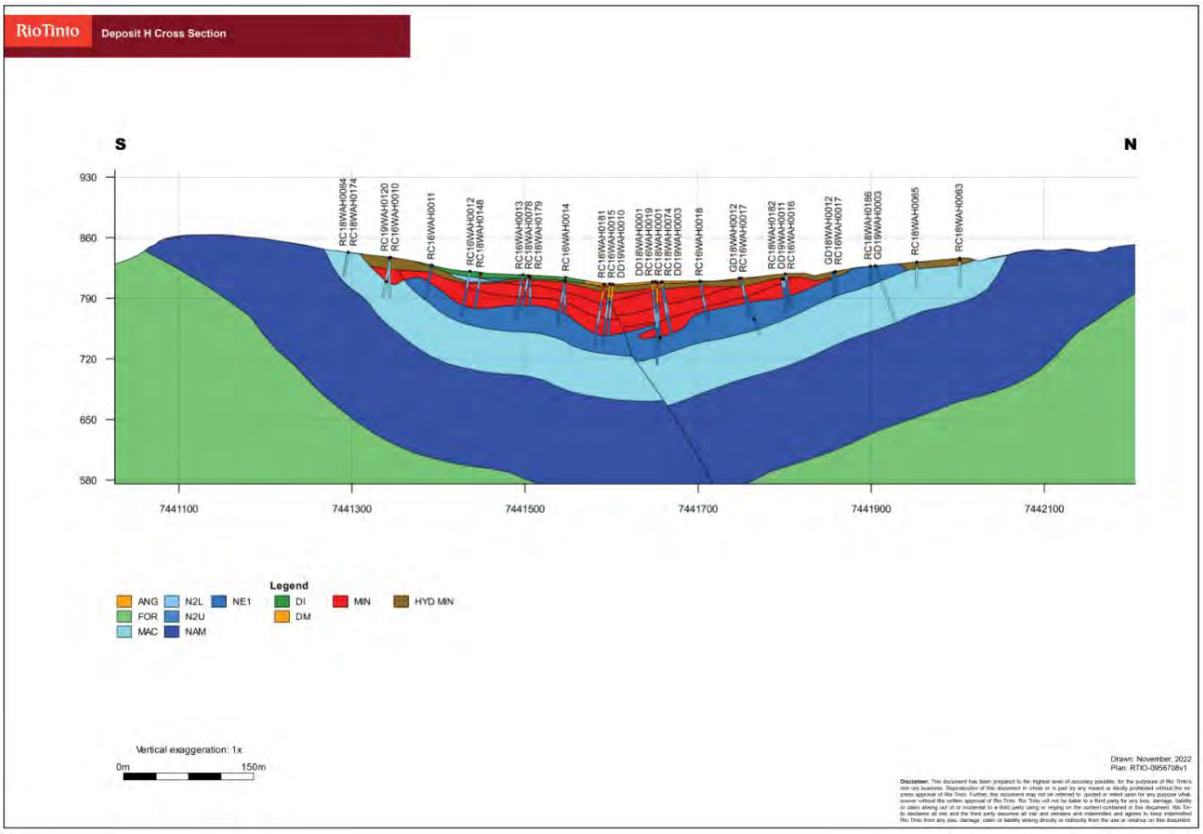


Figure 5-12: Typical geological cross section from Deposit H

5.6.10. Mount Ella East

The Mount Ella East deposit (Figure 5-13) is predominantly a detrital deposit, consisting of mature detritals with some bedded high-phosphorus mineralisation within the Brockman Iron Formation. The deposit is situated to the south of West Angelas deposits E and F, within a syncline formed between the Wonmunna anticline's southern limb and the Northern anticline.

Bedded mineralisation is generally concealed beneath a detrital package, within the Dales Gorge member of the Brockman Iron Formation, and is generally located between intersections of ENE and WNW trending normal faults. Detrital mineralisation occurs as discrete fans against the slope of the hills to the south, with some additional distal pods. Immature detrital cover is underlain by mature detritals consisting of minor pisolites with magnetic detritals in a variably hematite-rich/siliceous clay matrix. In some pockets, the detrital sequence terminates with a distinctly limonitic/goethitic detrital or basal clay.

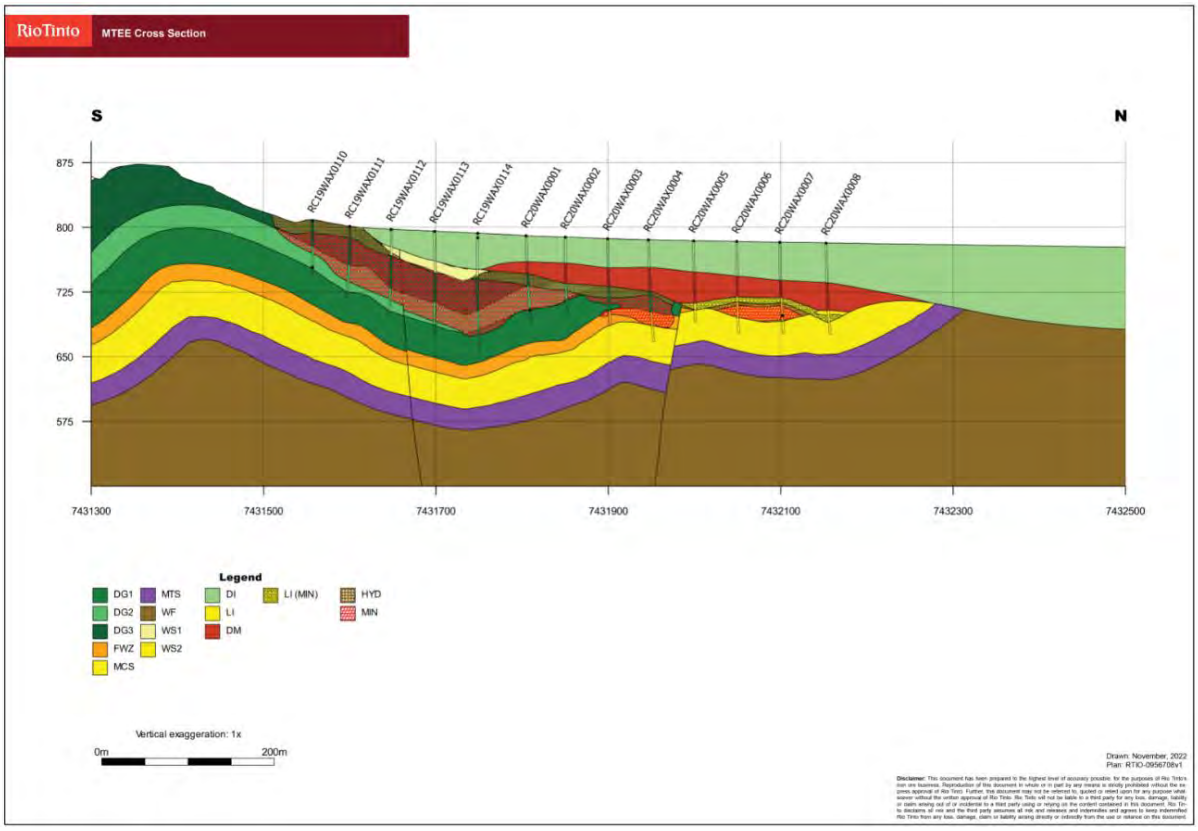


Figure 5-13: Typical geological cross section from Mt Ella East.

5.6.11. Western Hill

Western Hill (Figure 5-14) lies along the Northern limb of the Wonmunna Anticline, and consists predominantly of lower Brockman Iron Formation members, flanked by secondary detrital deposits. The area is structurally complex, with controversial splay faulting and negative flower structures interpreted, most likely better explained through north verging folding and overturning.

The Dales Gorge and Joffre Members host the majority of the mineralisation in the area, although lower grade mineralisation also occurs within the Footwall Zone at the base of Dales Gorge. Accumulations of mature detrital mineralisation have also been intersected throughout the deposit.

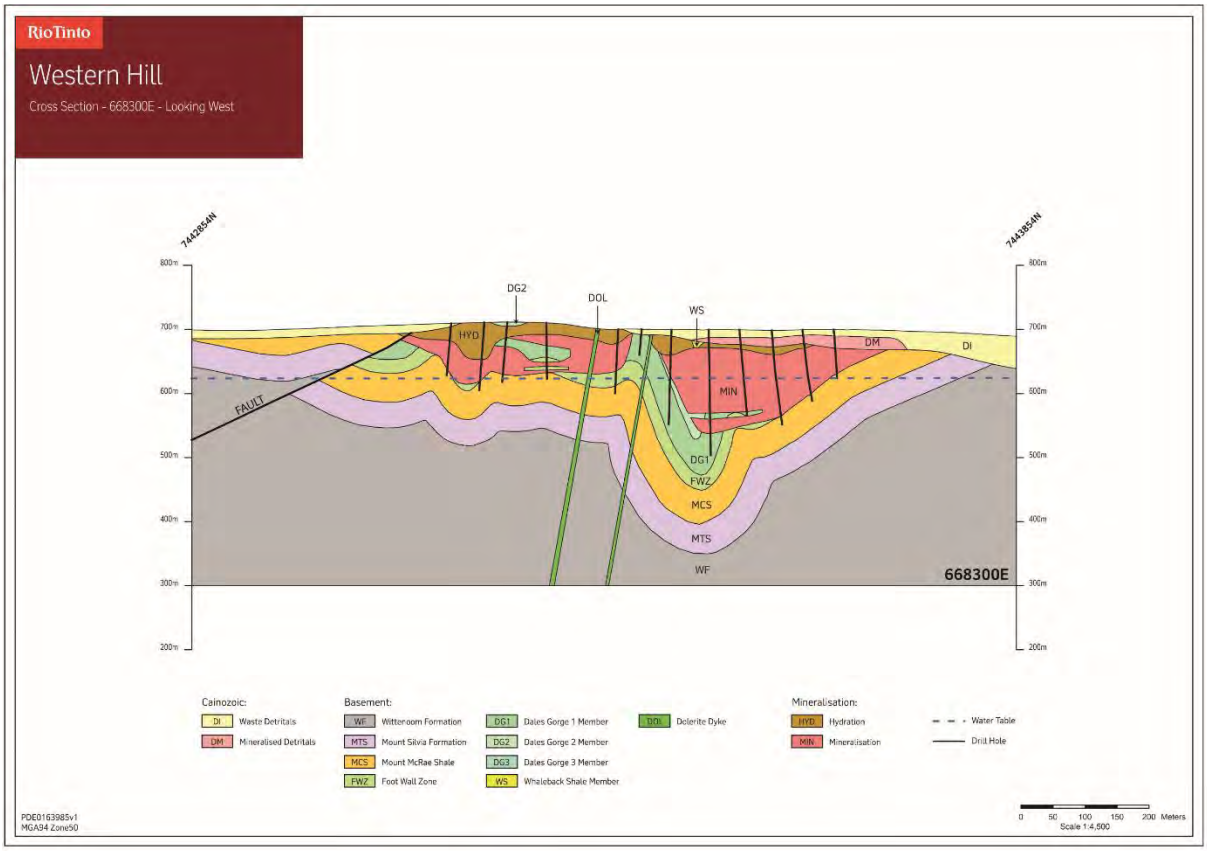


Figure 5-14: Typical geological cross section from Western Hill (looking west)

5.6.12. Implications for closure

The geological knowledge base is used to inform closure planning aspects related to geotechnical stability, mineral waste and hydrogeology which are discussed in the following sections of this MCP. The existing knowledge is considered appropriate to support closure planning for West Angelas.

Additional drilling is planned to further define the West Angelas orebodies and support ongoing refinement of the associated closure date. Future changes in the life of mine plan will be addressed in updates to the MCP.

5.7. Geotechnical stability of pit walls

Preliminary zones of potential geotechnical instability have been identified around pits covered within the scope of this MCP (Figure 5-18). Determining the potentially unstable pit edge zone (PUPEZ) is based on the angle method described in the Department of Industry and Resources (DIR) *Safety Bund Walls Around Abandoned Open Pit Mines* (1997) *guidelines*, using the conservative assumption that all pit walls are embedded into weathered rock (i.e. the polygons are lines drawn at a 25º angle from the base of the pit) (Figure 5-15). The PUPEZ is refined over time with pit design, backfill design and mine plan changes.

The location of pit abandonment bunds will be constructed a minimum of 10 m from the PUPEZ, and locations will be refined as mining nears completion, and to account for pit backfill levels, topography, surface water drainage and closure strategies.

Rio Tinto have committed to backfilling all pit voids at West Angelas to above the groundwater recovery level to avoid the formation of pit lakes, although water may pool temporarily at the base of the voids following heavy rainfall. Aside from pits that will be backfilled close to ground level, there is no intent to reshape or rehabilitate these in-pit areas, and the remaining pit walls will be retained in the same configuration as when mining ceases. It is recognised that there will be some degree of geotechnical instability, and that walls will have the potential to collapse in some areas.

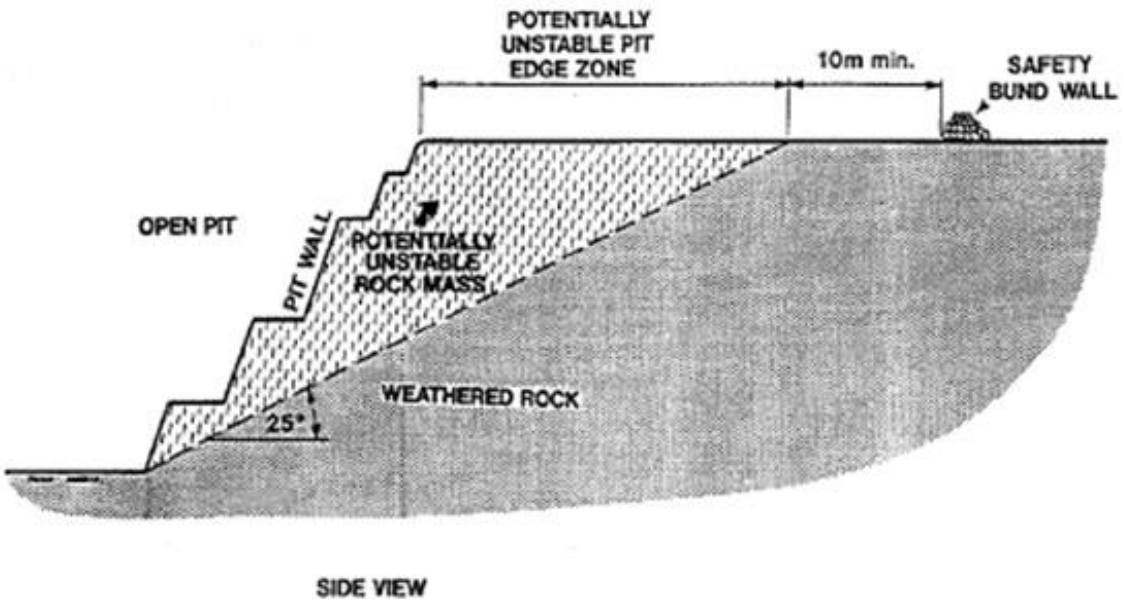


Figure 5-15: Calculation of PUPEZ for pits within weathered rock

In 2022 Rio Tinto commissioned Advisian to undertake landform design work (Appendix 9). As part of this work flood protection levees proposed to be constructed adjacent to Pit C3, Pit D1, Pit D3 and Pit F at closure were assessed for geotechnical stability. Representative geological cross-sections were generated at selected locations, and imported into the geotechnical slope stability modelling software Slope/W. Where calculations indicated an unacceptably low factor of safety (FoS <1.5 under static conditions and <1.2 under seismic conditions) buttressing was recommended.

An outcome of the geotechnical stability assessment for the mine pits has been the determination that buttressing and backfilling requirements are mostly independent of the closure design option. To achieve the design criteria, a minimum level of backfill and buttress is required for each pit assessed. Only where a proposed closure levee is within, or near to, the estimated PUPEZ are additional buttress or backfill requirements identified.

Pit buttressing is a method of partial backfilling along a final pit wall in order to buttress the in-situ potentially unstable rock mass and offset the PUPEZ area. The resulting buttressed pit wall PUPEZ area is therefore reduced in this area, creating additional stable pit edge area capacity, conceptually displayed in Figure 5-16. This is proposed in areas where the current location of abandonment bunds and flood levees encroaches on the PUPEZ.

Buttress designs were developed using representative cross sections and results of geotechnical slope stability modelling. This occurred at Pits C2 and D1, with further buttressing recommended at Pits D2 and D3 to ensure there is adequate separation between the closure levee and the PUPEZ (Figure 5-17).

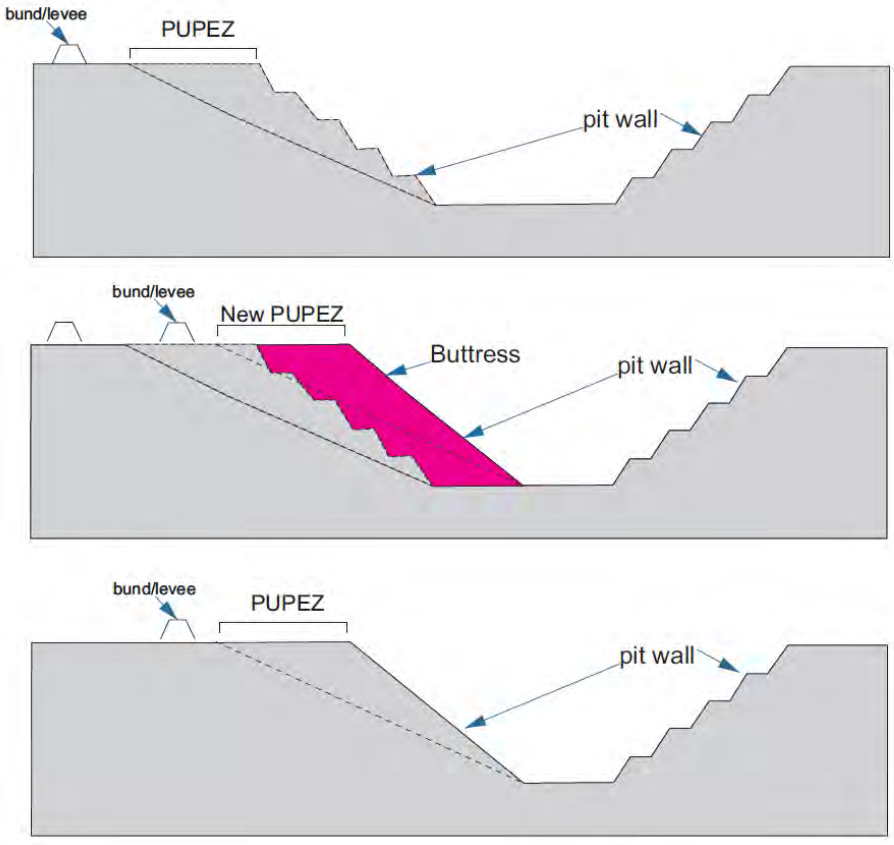


Figure 5-16: Pit buttressing and PUPEZ alteration schematic diagram

5.7.1. Risk of inadvertent public access to pit voids

For most Pilbara operations, the issue of public safety is mainly related to potential for members of the public to inadvertently access pit voids (or areas of potential instability surrounding pits) post closure. Open pits are designed to be stable during the life of the mining operations but may not be stable in the long term as materials weather and erode, leading to instability of sections of the pit walls. These failures would pose significant risks to people if they were to access these areas in vehicles or on foot.

As with waste landforms, designs for restricting public access need to be developed on a case-by-case basis after considering a range of factors such as:

- accessibility of the site (e.g., proximity to towns/major roads/areas of interest);
- nature of the surrounding landscape (e.g., pits abutting steep natural slopes, floodplains, water courses);
- the availability of suitable material to construct structures (e.g., material for abandonment bunds/ rock structures);

- pit geology and geometry (e.g., natural stability of the pit, pit backfill);
- the post closure land use (e.g., pastoral areas may require exclusion of cattle from pit voids); and
- the location of heritage sites (e.g., sites which may require access post closure).

Public access to the West Angelas area is limited due to its remoteness. Traditional Owners will require access to parts of the mining areas post-closure and parts of the area are expected to return to pastoral activities post-closure.

To mitigate the risk of inadvertent public access, the following conceptual measures are proposed:

- rehabilitation of tracks that are not required for monitoring and/or maintenance post-closure;
- rehabilitation of all access roads prior to relinquishment unless agreed with a third party that a road will remain;
- installation of physical barriers (e.g. earthen bunds) where appropriate to prevent access;
- installation of a locked gate on access roads for the duration of the post-closure monitoring and maintenance period; and
- a review of the potential visitors to access the site, and installation of additional control measures, including abandonment bunding around pits, where appropriate.

Abandonment bunds

The *Safety Bund Walls Around Abandoned Open Pit Mines* (DoIR 1997) guidelines require a 5 m wide by 2 m high abandonment bund be placed around a completed pit outside the zone of instability. The purpose of the guidelines is to reduce the likelihood of inadvertently access to pits. Natural topography more than 35 degrees is considered a suitable natural barrier to preclude inadvertent access; hence abandonment bunds will be designed to intersect with such areas. Where bunds could impact heritage sites then bund designs are amended to avoid sites. Local site drainage and the maintenance of surface flows post-closure has also been considered as part of the abandonment bund designs, in conjunction with development of the backfill strategy.

While a PUPEZ has been calculated for all pit designs, at this stage of closure planning, abandonment bund locations are conceptual due to the likelihood of changes to pit design, Waste Rock Landform (WRL) rehabilitation footprint, buttressing requirements, levee placement and backfill heights resulting in a change to the final PUPEZ. A review of the PUPEZ calculated from the current final pit designs and its interaction with WRLs and natural topography has been completed and conceptual abandonment bund locations shown in Figure 5-18. PUPEZ and abandonment bunds have not been mapped for the proposed deposits yet but will be during the Pre-Feasibility and Feasibility study phases.

5.7.2. Implications for closure and knowledge gaps

Closure implications associated with geotechnical stability include:

- Pit designs ensure PUPEZ does not encroach on culturally significant sites and associated post-closure access can be maintained once abandonment bunds have been constructed.
- The levee proposed at Pit D3 is within the PUPEZ and pit buttressing is required at closure
- The abandonment bund is required to be built from competent low erodibility mineral waste which will be stockpiled for construction at closure or constructed during operations where possible.
- The final rehabilitated toe of all permanent WDs will be located outside the final pit crest PUPEZ. A review and strategy will be implemented to determine required closure activities, which may include buttressing, backfill or removal of waste.
- Abandonment bund location and construction will consider creek flood inundation zones and surface water flows to ensure long-term post-closure stability.

- Abandonment bund locations will utilise natural steep topography, where appropriate, to prevent inadvertent access.
- Potential for long-term indirect impacts to cultural heritage sites from areas of geotechnical instability, surface water movement and sediment transport need to be assessed
- Several recommendations were made by Advisian 2022 for further Geotechnical work at West Angelas. In particular, geotechnical assessment of the areas where flood levees are to be constructed (including deposit H) to confirm construction requirements.
- Pit buttressing for deposits C2, D1, D2 and D3
- PUPEZ for proposed pits (Western Hill, Deposit H, Deposit F-North and Mt Ella)

Closure knowledge gaps associated with geotechnical stability, as summarised in Table 6-1, include:

- PUPEZ associated with final pit voids, abandonment bund locations and surface water management implications.

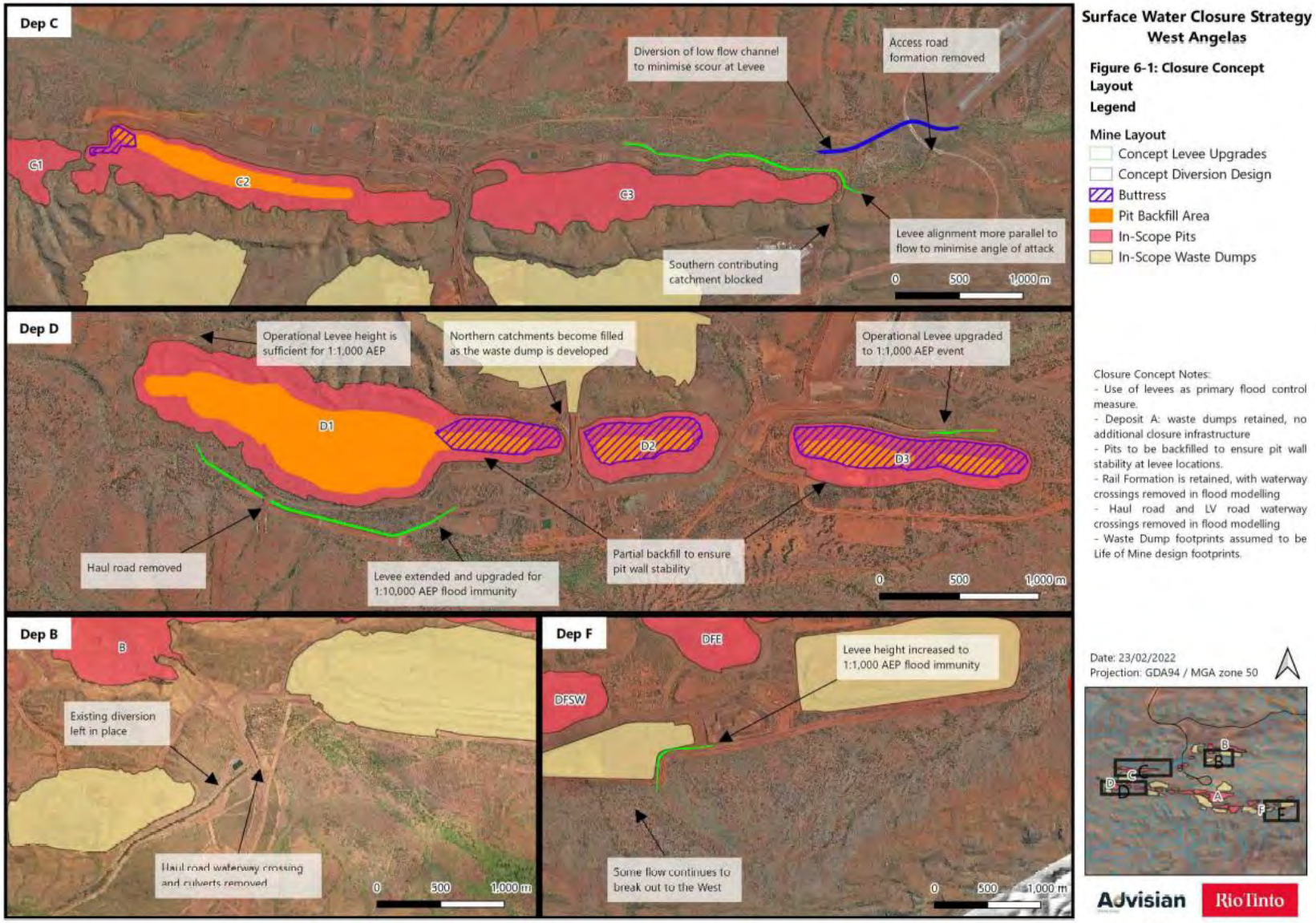


Figure 5-17: Conceptual buttressing across the West Angelas deposits

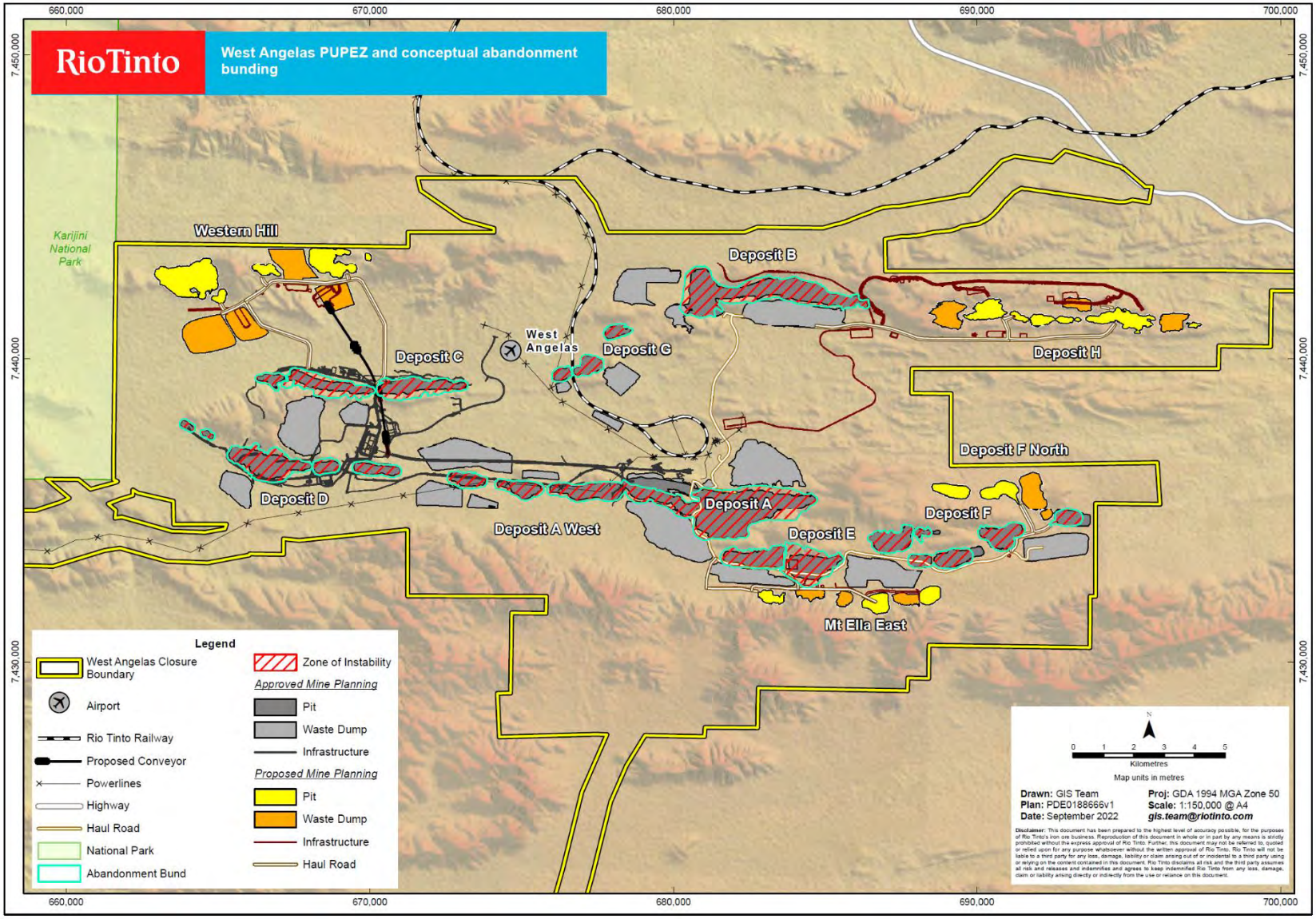


Figure 5-18: West Angelas geotechnical zones of instability (PUPEZ) and conceptual abandonment bunding

5.8. Mineral Waste Characteristics

Developing a comprehensive understanding of the types and volume of mineral waste material that will be generated/exposed during mining is critical for the effective design, construction and rehabilitation of final landforms. Rio Tinto has well-developed processes for the collection and analysis of physical and geochemical characteristic data initiated during early exploration and continuing through the life of the mine, which are used to identify issues to be managed through operations and at closure.

5.8.1. Mineral waste inventory

The total waste material volumes for current West Angelas forecast at cessation of mining, broken down by waste geological units, are summarised in Table 5-4 for currently approved mining operations and in Table 5-5 for the proposed operations. These values are based on the 2021 LoM plan. Much of the mineral waste inventory at West Angelas is represented by the following geologies:

- Detritals (~8%);
- Newman Member (~40%);
- Macleod Member (~15%); and
- West Angela Member (~21%).

These four units account for approximately 84% of the total mineral waste inventory at West Angelas. Of these, Detritals and West Angela Member are known to be highly erodible and require specific consideration during closure planning and implementation.

Table 5-4: Mineral waste inventory (current operations)

Mineral Waste Unit	Abbreviation	Total waste (Mt)	% of total waste
Alluvials	all	27.4	2.7
West Angela Member	ang	211.1	21
Calcrete	cal	0.006	0
Clay Waste	cla	75.4	7.5
Dolerite	dor	2.23	0.2
Immature Detritals	di	84.8	8.4
Mature Detritals	dm	31.4	3.1
Limonite	li	0.58	0.1
MacLeod Member	mac	151.9	15.1
Nammuldi Member	nam	8.75	0.9
Newman Member	n2l	58.6	5.8
Newman Member	n2u	37.2	3.7
Newman Member	ne1	279.9	27.9
Newman Member	ne1c	28.9	2.9
Newman Member	new	0.7	0.1
Null (Default)	null	1.2	0.1
Rock	rock	4.2	0.4
Wittenoom Formation	wf	0.25	0
TOTAL		**1004.6**	**99.9**

Table 5-5: Mineral waste inventory (proposed operations)

Mineral Waste Unit	Abbreviation	Total waste (Mt)	% of total waste
Dales Gorge Member	dg	11.3	3.4
Dolerite	dor	0.1	0
Mature Detritals	dm	0.1	0
Detrital	det	226	67
Hydrated Zone	hyd	7.1	2.1
Limonite	li	0.01	0
MacLeod Member	mac	11.65	3.5
Marra Mamba Formation	mm	6.3	1.9
Newman Member	new	43.4	12.9
Rock	rock	1.9	0.6
Wittenoom Formation	wf	28.3	8.4
Whaleback Shale	ws	1.5	0.4
TOTAL		**337.6**	**100.2**

5.8.2. Waste rock physical characteristics

Rio Tinto has a Pilbara-wide physical waste characterisation programme; the erodibility risk of the major rock units expected to be mined, and conceptual landform designs, can be predicted using the database. The erodibility ranking and erosion modelling results, presented in this MCP draw on this existing data, with implications for West Angelas summarised in the following sections and presented in Appendix 5.

The key physical property of mineral waste material that is applicable to the closure landform design is its susceptibility to erosion. This susceptibility is commonly described as the material's erodibility. Erodibility can be defined in different ways depending on the erosion prediction tool being used.

Erodibility has been considered using two different means. First, erodibility from the Revised Universal Soil Loss Equation (RUSLE) has been used to rank each mineral waste type into groups that help to broadly consider erosion risk. Second, erodibility has been considered within the WEPP (Water Erosion Prediction Project) runoff/erosion model to define material-specific landform designs for each mineral waste type.

The erodibility ranking system, as developed using the RUSLE, seeks to broadly rank mineral waste types into one of three levels of erodibility – low, medium, or high. The RUSLE is an empirical equation that calculates long-term annual erosion rates using five factors that are multiplied together. Two of these factors, erodibility (K-factor) and cover (C-factor), are specifically related to the material. The remaining three describe the rainfall and slope conditions. The K-factor describes the erodibility of the fine fraction (<2mm diameter) excluding the coarse fraction (>2mm). The C-factor describes the impact that different surface conditions have on erosion. For this ranking system, surface rock cover is a surface condition that reduces erosion potential. The Landloch Pty Ltd 2022 report (Appendix 5) summarises the RUSLE process and methodology.

The RUSLE erodibility ranking system was developed by considering the particle size distribution (PSD) of the fine fraction and the rain-armoured rock cover levels for 36 mineral waste samples from across

the Pilbara mine sites. These samples had a wide range of PSD and rock cover levels. The results of this analysis showed that K-factors for the materials assessed are consistent with highly and very highly erodible materials. By themselves, they do not explain the observed differences in erosion potential of the wastes being managed on the sites. However, when the impact of rock cover was included using the C-factor, it was shown that rock cover strongly influenced material erodibility and could explain the observed differences in erosion potential between materials. Mineral wastes that had rock cover levels >70% were ranked as low erodibility and had an erodibility factor (K-factor multiplied by C-factor) of <0.001. Materials with rock cover levels of 30-70% were ranked as medium erodibility and had an erodibility factor ranging from 0.001-0.02. Materials with rock cover levels <30% were ranked as high erodibility and had an erodibility factor >0.02 as summarised in Table 5-6.

Table 5-6: Erodibility classification of mineral waste

Material classification	Rock Cover Level	K factor (fine fraction <2mm erodibility)	Erodibility factor (K factor x C factor)
Low	>70%	High	<0.001
Medium	30-70%	High	0.001-0.02
High	<30%	High	>0.02

The RUSLE ranking system is used to broadly guide rehabilitation planning. For example, materials ranked as low erodibility contain appreciable competent, hard rock suitable for placement on the outer surface of waste landforms to provide long term erosion protection. Wastes ranked as medium erodibility can also be placed on the outer surface. However, there are likely more limitations in terms of the batter shapes (e.g. lower lift heights and/or batter angles) that are needed to ensure acceptable erosion rates are met. High erodibility waste, where present in large proportions, requires the application of conservative rehabilitation design parameters (e.g. low lift heights and/or gradients) or selective placement of more erosion resistant waste to prevent unacceptable erosion.

Although the RUSLE ranking system provides broad guidance, it is not used to define the landform designs that are adopted. This is done through physical measurement of the erodibility parameters that are used in conjunction with site-specific climate data within the WEPP (Water Erosion Prediction Project) runoff/erosion model. The WEPP model describes erodibility via four key and interdependent parameters:

- Interrill erodibility;
- Rill erodibility;
- Critical shear for rill initiation; and
- Effective hydraulic conductivity.

Interrill erodibility describes the rate of detachment of particles by the combined action of raindrops and shallow overland flows. Effective hydraulic conductivity defines the rate of water movement through the surface profile in response to wetting by rainfall. These are measured by applying a simulated rain event with known rainfall intensity to simulation plots, and measurement of runoff and sediment concentrations. Rill erodibility describes the detachment of particles by shear stresses caused by concentrated runoff flows. Critical shear for rill initiation is the shear stress above which particle detachment rapidly increases and rills form. These are measured by applying runoff to simulation flumes, and measurement of sediment concentrations, flow depths within the rill, and rill dimensions.

These erodibility measurements are used within the WEPP runoff/erosion model to develop rehabilitation designs. In this way, the designs are specific to the particular materials and climate of the site. They are derived from measurable materials properties that are directly related to erosion (as opposed to the RUSLE that estimates erosion based on the surrogate measure of PSD). By using WEPP to develop designs, erosion from a range of landform batter designs (slope gradient, length and

profile shape) can be assessed and appropriate designs selected such that the predicted rates of erosion meet acceptable erosion rates.

The WEPP erodibility parameters are interrelated, which makes it very difficult to define acceptable values for a single parameter. For example, when rainfall occurs within the model, the effective hydraulic conductivity is used to assess runoff potential. Only if runoff is predicted to occur will the model then compute erosion potential. In this example, it is possible for a material with a high effective hydraulic conductivity to produce low erosion potential with wide ranging values of the other three key parameters. In another example, for a material that does runoff, rill detachment only occurs when the critical shear for rill initiation is exceeded. In this case, it is possible for materials with similar rill erodibility parameters to have different erosion potential because their critical shear values vary. Results of Rio Tinto's Pilbara-wide WEPP modelling are incorporated into their landform design database to assist in the most appropriate selection of landform designs through the use of the Batter Selector Tool.

WEPP modelling has been completed for waste types at West Angelas using WEPP erodibility parameters. Seven waste samples were specifically sourced from West Angelas: two samples of West Angelas Shale, two samples of Mt Newman Member, one Hydrated Zone and two Detritals/Alluvials samples. These account for 93% of the waste at West Angelas. All samples characterised have been taken from waste dumps and stockpiles. Results for mineral waste present at West Angelas are summarised in Table 5-7.

Table 5-7: Mineral waste physical characteristics used to inform West Angelas designs

Material	Effective Hydraulic Conductivity (mm/h)	Interrill Erodibility (kg.s/m^4)	Rill Erodibility (s/m)	Critical Shear (Pa)
Detritals				
Average value	26	236,317	0.0116	28
West Angelas sample	9	353,752	0.0119	44
Newman Member				
Average value	33	203,540	0.0033	28
West Angelas samples (average of 2)	7	420,311	0.0027	48
Wittenoom Formation (West Angelas member)				
Average value	Not currently included in batter selector tool			
West Angelas samples (average of 3)	25	558,515	0.0028	18
Hydrated Zone				
Average value	103	63,860	0.0030	28
West Angelas sample	34	276,491	0.0022	42

Source: Landloch 2022

The parameters for waste and soil samples derived from West Angelas were consistent with parameters measured from reference soil sites located across other Rio Tinto mine sites. WEPP-predicted erosion for site-specific material was found to be similar to erosion predicted using Pilbara-wide parameter values more commonly used to determine landform designs. Therefore, it is concluded that batter geometries generated using the Pilbara-wide erodibility parameters will be suitable for use at West

Angelas. The recommended batter heights and angles based on the above results are summarised in Table 5-8.

Table 5-8: Recommended batter heights used to inform West Angelas designs

Material	Erodibility ranking	Recommended batter height (m)	Batter angle (degrees)
Detritals			
Average value	High	7	20
West Angelas sample	High	10	20
Newman Member			
Average value	Low	20	20
West Angelas samples (average of 2)	Low	20	20
Wittenoom Formation (West Angelas member)			
Average value	Not currently included in batter selector tool		
West Angelas samples (average of 3)	High	5	20
Hydrated Zone			
Average value	Low	20	20
West Angelas sample	Low	20	20

A large proportion of highly erodible material across the deposits exists at West Angelas, as summarised in Table 5-9 and Table 5-10. Table 5-11 to Table 5-30 list the volume of waste by erodibility class in more detail for each individual waste dump at West Angelas (current or proposed). This information is used to inform the landform design and management strategies during operations and closure. Volumes are based on current mining models and are subject to change. Accordingly, volumes of highly erodible material have been accounted for in final landform design. The proportion of each waste type, within each waste landform, is expected to vary. This accounts for differences in stable rehabilitation parameters across the deposits. Further work is required to refine the closure strategies for waste dumps containing high volumes of erodible waste types. Options for management at closure include adoption of conservative rehabilitation design parameters, preferential backfill of erodible waste and encapsulation with competent rock materials (e.g. hydrated zone material).

Table 5-9: Waste material erodibility summary – current operations

Erodibility	Total waste volume (Mt)	Total waste (%)
High	438.8	44%
Moderate	0.59	0%
Low	565.5	56%
Total	**1,004.9**	**100**

Table 5-10: Indicative waste material erodibility summary – proposed operations

Erodibility	Total waste volume (Mt)	Total waste (%)
High	264.9	78%
Moderate	0	0%

Erodibility	Total waste volume (Mt)	Total waste (%)
Low	72.7	22%
Total	**337.6**	**100**

Table 5-11: Indicative waste material erodibility characterisation by type – Deposit A South WD

Waste material	Erodibility	Total waste (Mt)	Total waste (%)
Alluvials	High	3.6	1%
West Angelas member	High	59.1	23%
Dolerite	High	0.0	0%
MacLeod member	Low	53.9	21%
Newman Member (n2l)	Low	28.0	11%
Newman Member (n2u)	Low	12.7	5%
Newman Member (ne1)	Low	87.7	34%
Newman Member (ne1c)	Low	15.7	6%
Total		**260.7**	**100**

Table 5-12: Indicative waste material erodibility characterisation by type – Deposit A North WD

Waste material	Erodibility	Total waste (Mt)	Total waste (%)
Alluvials	High	1.2	1%
West Angelas member	High	0.0	0%
Dolerite	High	0.0	0%
MacLeod member	Low	65.2	30%
Newman Member (n2l)	Low	11.2	5%
Newman Member (n2u)	Low	0.4	0%
Newman Member (ne1)	Low	126.1	59%
Newman Member (ne1c)	Low	8.8	4%
null	High	1.0	0%
Total		**213.9**	**100**

Table 5-13: Indicative waste material erodibility characterisation by type – Deposit B East WD

Waste material	Erodibility	Total waste (Mt)	Total waste (%)
Alluvials	High	12.06	6%
West Angelas member	High	78.70	40%
Immature Detritals	High	24.96	13%
Mature Detritals	Low	6.07	3%
Dolerite	Low	0.02	0%
MacLeod member	Low	20.07	10%
Newman Member (n2l)	Low	8.88	4%
Newman Member (n2u)	Low	11.29	6%

Waste material	Erodibility	Total waste (Mt)	Total waste (%)
Nammuldi Member	High	6.41	3%
Newman Member (ne1)	High	26.21	13%
Rock	High	2.99	2%
Total		**213.9**	**100**

Table 5-14: Indicative waste material erodibility characterisation by type – Deposit B West WD

Waste material	Erodibility	Total waste (Mt)	Total waste (%)
Alluvials	High	4.37	6%
West Angelas member	High	28.50	40%
Immature Detritals	High	9.04	13%
Mature Detritals	High	2.20	3%
Dolerite	High	0.01	0%
MacLeod member	Low	7.27	10%
Newman Member (n2l)	Low	3.21	4%
Newman Member (n2u)	Low	4.09	6%
Nammuldi Member	Low	2.32	3%
Newman Member (ne1)	Low	9.49	13%
Rock	High	1.08	2%
Total		**71.57**	**100**

Table 5-15: Indicative waste material erodibility characterisation by type – Deposit B LG Stockpile

Waste material	Erodibility	Total waste (Mt)	Total waste (%)
West Angelas member	High	3.14	23%
Mature Detritals	High	0.60	4%
MacLeod member	Low	2.92	22%
Newman Member (n2l)	Low	1.53	11%
Newman Member (n2u)	Low	2.40	18%
Nammuldi Member	Low	0.00	0%
Newman Member (ne1)	Low	2.75	20%
Rock	High	0.11	1%
Total		**13.44**	**100**

Table 5-16: Indicative waste material erodibility characterisation by type – Deposit F West WD (Wombat)

Waste material	Erodibility	Total waste (Mt)	Total waste (%)
West Angelas member	High	12.96	12%
Calcrete	High	34.31	31%
Immature Detritals	High	34.96	31%

Waste material	Erodibility	Total waste (Mt)	Total waste (%)
Mature Detritals	High	13.53	12%
Dolerite	High	1.56	1%
MacLeod member	Low	1.19	1%
Newman Member (n2l)	Low	1.70	2%
Newman Member (n2u)	Low	3.40	3%
Nammuldi Member	Low	0.02	0%
Newman Member (ne1)	Low	8.43	8%
Rock	High	0.01	0%
Total		**112.1**	**100**

Table 5-17: Indicative waste material erodibility characterisation by type – Deposit F East Dump (Emu)

Waste material	Erodibility	Total waste (Mt)	Total waste (%)
West Angelas member	High	4.7	12%
Calcrete	High	12.5	31%
Immature Detritals	High	12.8	31%
Mature Detritals	High	4.9	12%
Dolerite	High	0.6	1%
MacLeod member	Low	0.4	1%
Newman Member (n2l)	Low	0.6	2%
Newman Member (n2u)	Low	1.2	3%
Nammuldi Member	Low	0.0	0%
Newman Member (ne1)	Low	3.1	8%
Total		**41**	**100**

Table 5-18: Indicative waste material erodibility characterisation by type – Deposit F LG Dump

Waste material	Erodibility	Total waste (Mt)	Total waste (%)
West Angelas member	High	0.0008	14%
Mature Detritals	High	0.0029	50%
Dolerite	High	0.0000	0%
MacLeod member	Low	0.0002	4%
Newman Member (n2l)	Low	0.0005	8%
Newman Member (n2u)	Low	0.0010	17%
Newman Member (ne1)	Low	0.0005	8%
Total		**0.0059**	**100**

Table 5-19: Indicative waste material erodibility characterisation by type – Deposit E South WD

Waste material	Erodibility	Total waste (Mt)	Total waste (%)
West Angelas member	High	21.12	36%
Calcrete	High	28.51	49%
Immature Detritals	High	0.59	1%
Mature Detritals	High	2.73	5%
MacLeod member	Low	0.37	1%
Newman Member (n2l)	Low	0.48	1%
Newman Member (n2u)	Low	0.43	1%
Newman Member (ne1)	Low	2.95	5%
Quaternary Alluvium	High	0.72	1%
Rock	High	0.03	0%
Total		**57.94**	**100**

Table 5-20: Indicative waste material erodibility characterisation by type – Deposit CD Hub Waste Dump 1

Waste material	Erodibility	Total waste (Mt)	Total waste (%)
West Angelas member	High	0.902	11%
Calcrete	Low	0.006	0%
Clay Waste	High	0.100	1%
Immature Detritals	High	2.457	30%
Mature Detritals	High	1.360	17%
Dolerite	High	0.036	0%
Limonite	Medium	0.585	7%
MacLeod member	Low	0.372	5%
Newman Member (n2l)	Low	0.223	3%
Newman Member (n2u)	Low	0.220	3%
Nammuldi Member	Low	0.001	0%
Newman Member (ne1)	Low	1.664	20%
Rock	High	0.020	0%
Wittenoom Formation	High	0.252	3%
Total		**8.2**	**100**

Table 5-21: Indicative waste material erodibility characterisation by type – Deposit CD Hub Waste Dump 3

Waste material	Erodibility	Total waste (Mt)	Total waste (%)
Detrital	High	21.1	63%
Dolerite	High	0.009	0%
MacLeod member	Low	3.7	11%
Nammuldi Member	Low	0.2	1%
Newman Member	Low	3.8	11%
Rock	High	0.45	1%
Wittenoom Formation	High	4.1	12%
Total		**33.36**	**100**

Table 5-22: Indicative waste material erodibility characterisation by type – Deposit C LG

Waste material	Erodibility	Total waste (Mt)	Total waste (%)
West Angelas member	High	0.017	19%
Mature Detritals	High	0.037	42%
Limonite	Medium	0.009	10%
MacLeod Member	Low	0.005	6%
Newman Member (n2l)	Low	0.003	3%
Newman Member (n2u)	Low	0.006	7%
Newman Member (ne1)	Low	0.012	13%
Total		**0.089**	**100**

Table 5-23: Indicative waste material erodibility characterisation by type – Deposit D LG stockpile

Waste material	Erodibility	Total waste (Mt)	Total waste (%)
Detrital	High	7.1	53%
Hydrated Zone	Low	1.9	14%
MacLeod Member	Low	0.1	1%
Newman Member	Low	2.4	18%
Rock	High	0.02	0%
Wittenoom Formation	High	1.8	14%
Total		**13.32**	**100**

Table 5-24: Indicative waste material erodibility characterisation by type – HGA Stockpile

Waste material	Erodibility	Total waste (Mt)	Total waste (%)
West Angelas member	High	0.004	7%
Mature Detritals	High	0.046	84%
Limonite	Medium	0.002	4%
Newman Member (n2l)	Low	0.000	1%

Waste material	Erodibility	Total waste (Mt)	Total waste (%)
Newman Member (n2u)	Low	0.001	2%
Newman Member (ne1)	Low	0.001	1%
Total		**0.055**	**100**

Table 5-25: Indicative waste material erodibility characterisation by type – Deposit A West Waste Dumps

Waste material	Erodibility	Total waste (Mt)	Total waste (%)
Detrital	High	80.4	93%
Dolerite	High	0.002	0%
Marra Mamba Formation	High	4.7	5%
Rock	High	0.6	1%
Wittenoom Formation	High	0.74	1%
Total		**86.4**	**100**

Table 5-26: Indicative waste material erodibility characterisation by type – Deposit A West LG Stockpile

Waste material	Erodibility	Total waste (Mt)	Total waste (%)
Detrital	High	5.2	47%
Hydrated Zone	Low	4.2	38%
Marra Mamba Formation	High	1.6	14%
Wittenoom Formation	Low	0.18	2%
Total		**11.18**	**100**

Table 5-27: Indicative waste material erodibility characterisation by type – Deposit G South Waste Dumps

Waste material	Erodibility	Total waste (Mt)	Total waste (%)
Detrital	High	8.9	74%
Hydrated Zone	Low	0.4	3%
MacLeod Member	Low	0.28	2%
Newman Member	Low	2.4	20%
Rock	High	0.075	1%
Total		**11.18**	**100**

Table 5-28: Predicted waste material erodibility characterisation by type – Western Hill Deposit

Waste material	Erodibility	Total waste (Mt)	Total waste (%)
Detrital	High	99.9	58%
MacLeod Member	Low	7.3	4%
Newman Member	Low	33	19%
Rock	High	0.69	0%
Wittenoom Formation	High	19.6	11%
Whaleback Shale	High	1.5	1%

Waste material	Erodibility	Total waste (Mt)	Total waste (%)
Nammuldi Member	Low	0.03	0%
Dales Gorge Member	Low	11.2	6%
Dolerite	High	0.084	0%
Total		**173.3**	**100**

Table 5-29: Predicted waste material erodibility characterisation by type – Mount Ella East Waste Dumps

Waste material	Erodibility	Total waste (Mt)	Total waste (%)
Detrital	High	0.3	28%
Hydrated Zone	Low	0.57	53%
Rock	High	0.08	7%
Dales Gorge Member	Low	0.13	12%
Total		**1.08**	**100**

Table 5-30: Predicted Waste material erodibility characterisation by type –Deposit H Waste Dumps

Waste material	Erodibility	Total waste (Mt)	Total waste (%)
Detrital	High	3.1	39%
MacLeod Member	Low	0.27	3%
Newman Member	Low	1.8	23%
Rock	High	0.76	10%
Wittenoom Formation	High	1.9	24%
Nammuldi Member	Low	0.12	2%
Total		**7.95**	**100**

5.8.3. Waste rock geochemical characteristics

Rio Tinto has undertaken an extensive program of geochemical testing over several years to understand the potential for acid and metalliferous drainage (AMD) to occur as a result of exposing various waste rock types common to mining operations in the Pilbara.

The geochemical characterisation process aims to assess sulfur content as an indicator of acid generation potential, and to undertake static (acid base accounting) and, if appropriate, kinetic testing of materials. This information is applied to the geological block model and subsequent mining model, to ensure materials posing potential geochemical risks are identified prior to mining and managed appropriately. This work is in accordance with the Spontaneous Combustion and Acid Rock Drainage (SCARD) Management Plan V7 (Rio Tinto, 2021c) (Appendix 6).

The most significant geochemical risk in Pilbara iron ore bodies is associated with sulfides, such as pyrite (FeS_2), which can form sulfuric acid when exposed to oxygen and water. Mt McRae Shale, the geological unit most commonly associated with pyrite and acid mine drainage in the Pilbara, is predicted to be encountered during mining at Western Hill deposit only. However, pyrite can also occur in Banded Iron Formations, such as the unmineralised MMIF. Other sulfate minerals present at the site, such as alunite and jarosite, can also pose a geochemical risk, albeit the risk is usually lower due to self-limiting chemical processes. It is noted that Potential Acid Forming (PAF) material is currently predicted to be encountered at Deposit A-West, Deposit A, Deposit C, Deposit D, Deposit E, Deposit F and Western Hill. PAF operational management is detailed in Section 5.8.4.

Rio Tinto operations identify and manage PAF waste under the *SCARD Management Plan for Operations, V9* (Rio Tinto 2023) (Appendix 6). The SCARD Management Plan, which commenced implementation in 2003, outlines operational accountability for PAF management and establishes the following principles:

- identification of PAF distribution;
- minimising the exposure and mining of PAF to the extent possible;
- identification and special handling of PAF where mined;
- encapsulation of PAF inside specially designed WRL to limit water contact and enable revegetation; and
- Where practicable, in-pit disposal is the preferred PAF material management practice over external WDs, particularly where the PAF waste will eventually be covered by the rebounding water table. Pits likely to have PAF exposures in the final pit shell are preferred disposal locations over pits with no expected PAF exposures.

Where the disposal of PAF waste in-pit is not possible, PAF material will be encapsulated in external WDs. When designing new PAF WDs, the following design criteria are considered:

- PAF WDs should be located outside drainage lines with significant upstream catchments so they do not receive increased runoff following rainfall;
- PAF WDs should not be placed over or adjacent to significant regional aquifers if there is a significant risk of AMD impact to the aquifer;
- PAF WDs should not be placed over or adjacent to significant seeps or springs;
- The number of PAF disposal locations and their footprint should be kept to a minimum;
- PAF WDs should be located near sources of NAF waste, or sources of NAF waste for future encapsulation; and
- total sulfur and acid base accounting.

Differing levels of analytical test work aimed at characterising waste material has been undertaken at West Angelas. Sulfur analysis, which is utilised as an indicator of acid generation potential has been extensively analysed across all Deposits, with a total of 475,319 samples (including ore and waste) collected and assayed within the current mine plan pit shells. The Deposits with extensive sulfur analysis include:

- Western Hill;
- Mt Ella East (referred to as Mt Ella East Extension in supporting documents);
- Deposit A and A-West; and
- Deposits B, C, E, F,G and H (data has also been collected for Deposit J and is included in the summary below, although it is noted Deposit J does not form part of this Proposal).

Approximately 3.0% of samples reported a total sulfur value greater than 0.1% (14,372 samples) and only 973 samples had greater than 0.3% total sulfur (Table 5-31). Most elevated sulfur samples were near the surface, suggesting that the sulfur may be present in the form of sulfate minerals within the samples. Both sulfate minerals gypsum and alunite have been recorded in the deposit, with the alunite potentially having a lower capacity of acid release; however, the low solubility of alunite typically results in a low flux of acid (and contaminant) release.

An AMD risk assessment has been conducted for West Angelas in 2021 (MWM, 2021) (Appendix 7) and a subsequent memo was developed in 2022 (Rio Tinto, 2022) (Appendix 8) that addresses changes to the designed pit shells. The AMD risk assessment includes all waste lithologies present at the site, and analyses have been conducted in accordance with the Global Acid Rock Drainage (GARD) Guide,

developed by the International Network for Acid Protection (INAP, 2009). Test-work has included Acid Base Accounting (ABA), total sulfur, multi-element analysis to determine chemical enrichment and liquid extract analysis for metals or metalloids and the plotting of sulfide risk estimates against the final pit designs. The following rock units have been characterised:

- Quaternary Alluvium;
- Detrital material;
- Undifferentiated – BIF;
- Dolerite;
- Whaleback Shale Member;
- Dales Gorge Member;
- Mount McRae Shale;
- Mount Sylvia Formation;
- Wittenoom Formation (including West Angela Shale Member); and
- Marra Mamba Iron Formation (including Mount Newman, MacLeod and Nammuldi Members).

Table 5-31: Total sulphur analysis for West Angelas deposits

Deposit	Count of S samples	Average of S samples	Number of S>0.1	Percentage of Samples with S>0.1%	Average of S Value if >0.1	Number of S>0.3	Percentage of Samples with S>0.3%	Average of S Value if >0.3
DPAW	21,187	0.2	174	0.8%	0.17	14	0.1%	0.39
DEPA	234,933	0.02	5,780	2.5%	0.17	373	0.2%	0.57
DEPB	54,985	0.04	4,142	7.5%	0.15	96	0.2%	0.56
DEPC	18,356	0.03	223	1.2%	0.24	38	0.2%	0.69
DEPD	26,344	0.02	292	1.1%	0.24	63	0.2%	0.56
DEPE	42,203	0.02	602	1.4%	0.19	76	0.2%	0.47
DEPF	32,108	0.03	763	2.4%	0.21	115	0.4%	0.55
DEP G	7,969	0.02	54	0.7%	0.15	3	0.0%	0.34
DEP H	5,873	0.03	236	4.0%	0.15	7	0.1%	0.40
DEP J*	4,253	0.05	379	8.9%	0.20	36	0.8%	0.65
MTEE	2,279	0.05	224	9.8%	0.21	24	1.1%	0.75
WHILL	24,829	0.04	1,503	6.1%	0.19	128	0.5%	0.64
Total	475,319	0.03	14,372	3.0%	0.17	973	0.2%	0.57

**Note: Deposit J has been removed from the proposal, however kept in the table for completeness*

Additional analysis, which includes static acid base accounting (ABA) has been completed on a total of 209 samples (Figure 5-19) from Deposit A, Deposit A-West, Deposit B, Deposit D and Deposit F. The results of the ABA testwork shows that of the 209 samples, 175 are classified as NAF (Non Acid Forming), 15 as UC-NAF and 19 as PAF. The majority of PAF samples are from the Wittenoom Formation (n=13), with other PAF samples are from Dolerite (n=1) and the Marra Mamba Iron Fomration (n=5). ANC ranges between <1 kg H_2SO_4 and 297.5 kg H_2SO_4.

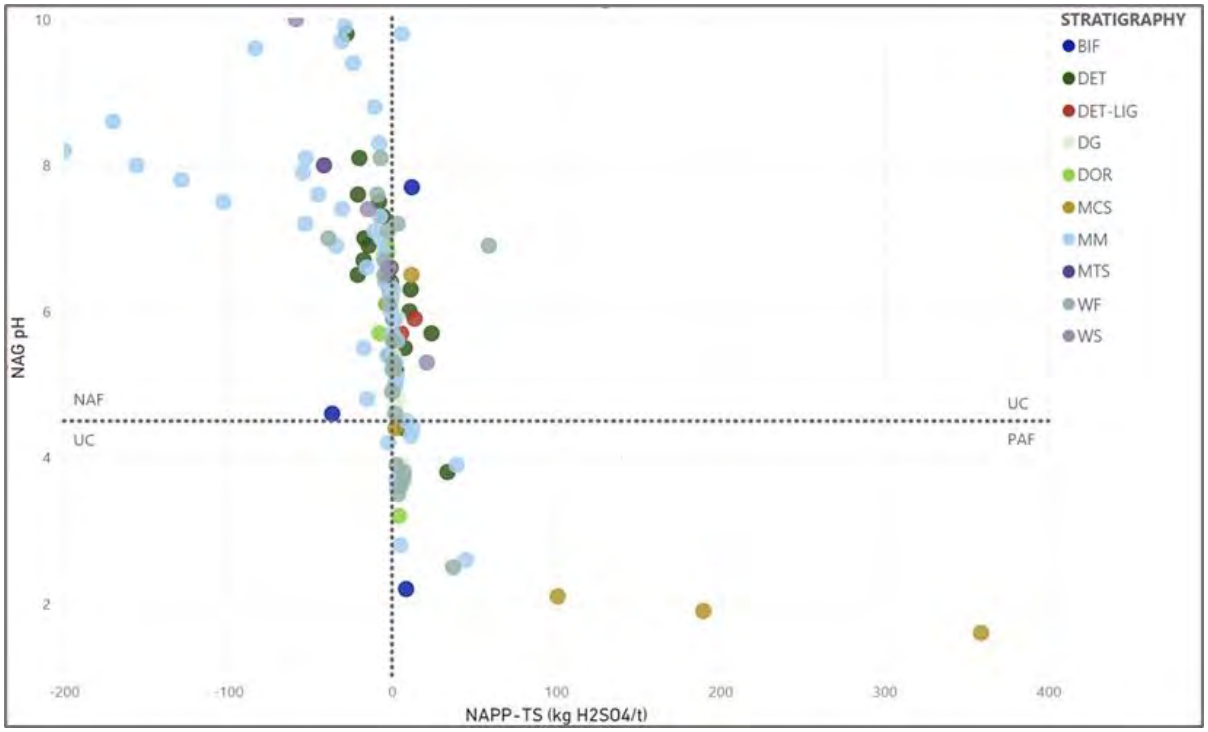


Figure 5-19: NAG pH vs NAPP according to rock unit at West Angelas

The current mining operations are generally predicted to pose a low AMD risk (Table 5-32), with one deposit (Western Hill) posing a moderate risk . Although Western Hill has been assigned a moderate risk score, no below water table mining is planned and any measured sulfur is likely sulfate (Figure 5-20). The risk rankings were developed using Rio Tinto's internal process for assessing AMD source hazard risk, which is detailed in Geochemical Risk Assessment Process for Rio Tinto's Pilbara Iron Ore Mines (Green and Borden, 2011) and in Mineral Waste Management in the Pilbara: A Position Statement (Brown, 2012). A risk-based process is used to identify those rock types which require specific management to mitigate the impacts associated with AMD. The AMD source hazzard risk assessment method is outline in Appendix 7.

Table 5-32: Assessed geochemical risk at West Angelas utilising Rio Tinto ARD hazard score cards

Deposit	Preliminary assessment score	Detailed assessment score	Combined hazard score	AMD Risk
Deposit A	52	15	28	Low
Deposit A West	44	15	26	Low
Deposit B	48	16	28	Low
Deposit C	49	17	29	Low
Deposit D	45	17	28	Low
Deposit E	45	17	28	Low
Deposit F	43	15	26	Low
Deposit G	39	15	25	Low
Deposit H	39	20	30	Low
Mount Ella East	29	21	28	Low
Western Hill	51	22	35	Moderate

These results are based on the exploration and evaluation drill hole information, geological modelling and subsequent pit designs and mine plans. As part of annual life of mine planning process, the AMD risk is reviewed primarily by reviewing the material flagged in geological and mining models and ensuring that it is consistent with outcomes from the more detailed risk assessment.

Element enrichment and mobility

Approximately 950,000 samples from across the West Angelas project have been analysed for routine chemical element suite of Al, Ca, Fe, K, Mg, Mn, Na, P, S and/or Ti, as well as, Ba, Cl, Co, Cr, Cu, Ni, Pb, Si, Sn, Sr, V, Zn and Zr. As part of the ABA suite of tests, and to support the liquid extract analyses, 48 samples have been analysed for an extended elemental suite. To investigate the potential for identified enriched elements to mobilise, static leach testing (liquid extract analysis) has been completed on 38 samples. The 38 West Angelas samples submitted for short-term leach testing were sourced from the following rock units (Appendix 7):

- Detritals (DET) (six samples);
- Dolerite (DOR_ (two samples);
- Wittenoom Formation (WF) (12 samples); and
- Marra Mamba (MM) (18 samples).

Results indicate that the majority of enriched and depleted elements were not readily mobile at significant concentrations during short-term leach testing (Table 5-33). Specifically:

- Generally, mobility of trace elements is low with leachates slightly acidic to alkaline (5.8-8.9) and containing low to moderate salinity (21-889 µS/cm). Fe, Mn, Si, and Zn were the only elements measured above 1 mg/L.
- Sulfate concentrations are generally low (<500 mg/L). The exception is three Deposit A MM samples with sulfate between 555-1,650 mg/L.
- Of the elements identified through GAI analysis as being enriched:
    - As was not mobilised above 0.02 mg/L.
    - Fe was only mobilised from one Deposit A West DOR sample in excess of 1 mg/L (1.5 mg/L).
    - Cr was mobilised above the limit of reporting in two samples at low concentrations (0.003 and 0.009 mg/L).
    - Sb and Se were only measured in one WF sample above the limit of limit or reporting. Measured Sb and Se concentrations were low (0.006 and 0.02 mg/L respectively).
    - Pb and Sn were not mobilised above the limit of limit or reporting.

Ongoing work will continue during operations to conduct metalloids leachate assessments to inform the AMD risk assessment and operational management practices as operations progress. Progress on this action will be reported in each update to this MCP.

Table 5-33: Maximum concentration of metals and metalloids in leachates with sample AMD classifications

Elements	Max conc. (mg/l)	Leach pH	Rock Types Max conc. Samples	Drinking water health guidelines	Stock Water guidelines
Ag	<LDL	-		0.1	
Al	0.28	7.8	Detritals	0.1	5
As	0.019	6.7	Wittenoom Formation	0.01	0.5
B	0.5	8.9	Marra Mamba	4	5
Be	<LDL	-	-	0.06	-
Ca	330	8.9	Marra Mamba	-	-
Cd	0.0008	6.7	Dolerite	0.002	0.01
Cl	89	7.2	Wittenoom Formation	250	-
Co	0.546	6.7	Dolerite	-	1
Cr	0.009	6.8	Wittenoom Formation	0.05	1
Cu	0.125	6.7	Dolerite	2	0.5
F	5	8.9	Marra Mamba	1.5	2
Fe	1.49	6.7	Dolerite	-	-
Hg	<LDL	-	-	0.001	0.002
K	190	8.9	Marra Mamba	-	-
Mg	320	8.9	Marra Mamba	-	-
Mn	2.15	8.9	Marra Mamba	0.5	-
Mo	0.15	7.9	Marra Mamba	0.05	0.15
Na	365	8.9	Marra Mamba	180	-
Ni	0.73	6.7	Dolerite	0.02	1
P	<LDL	-	-	-	-
Pb	<LDL	-	-	0.01	0.1
Sb	0.006	6.8	Wittenoom Formation	0.003	-
Se	0.02	6.8	Wittenoom Formation	0.01	0.02
Si	10.8	7.8	Detritals	80	-
Sn	<LDL	-	-	-	-
SO4	1650	8.9	Marra Mamba	-	-
Sr	0.191	7.6	Marra Mamba	-	-
Th	<LDL	-	-	-	-
U	0.005	8.9	Marra Mamba	0.02	0.2
Zn	1.02	6.7	Dolerite	3	20

Note LDL = limit of detection

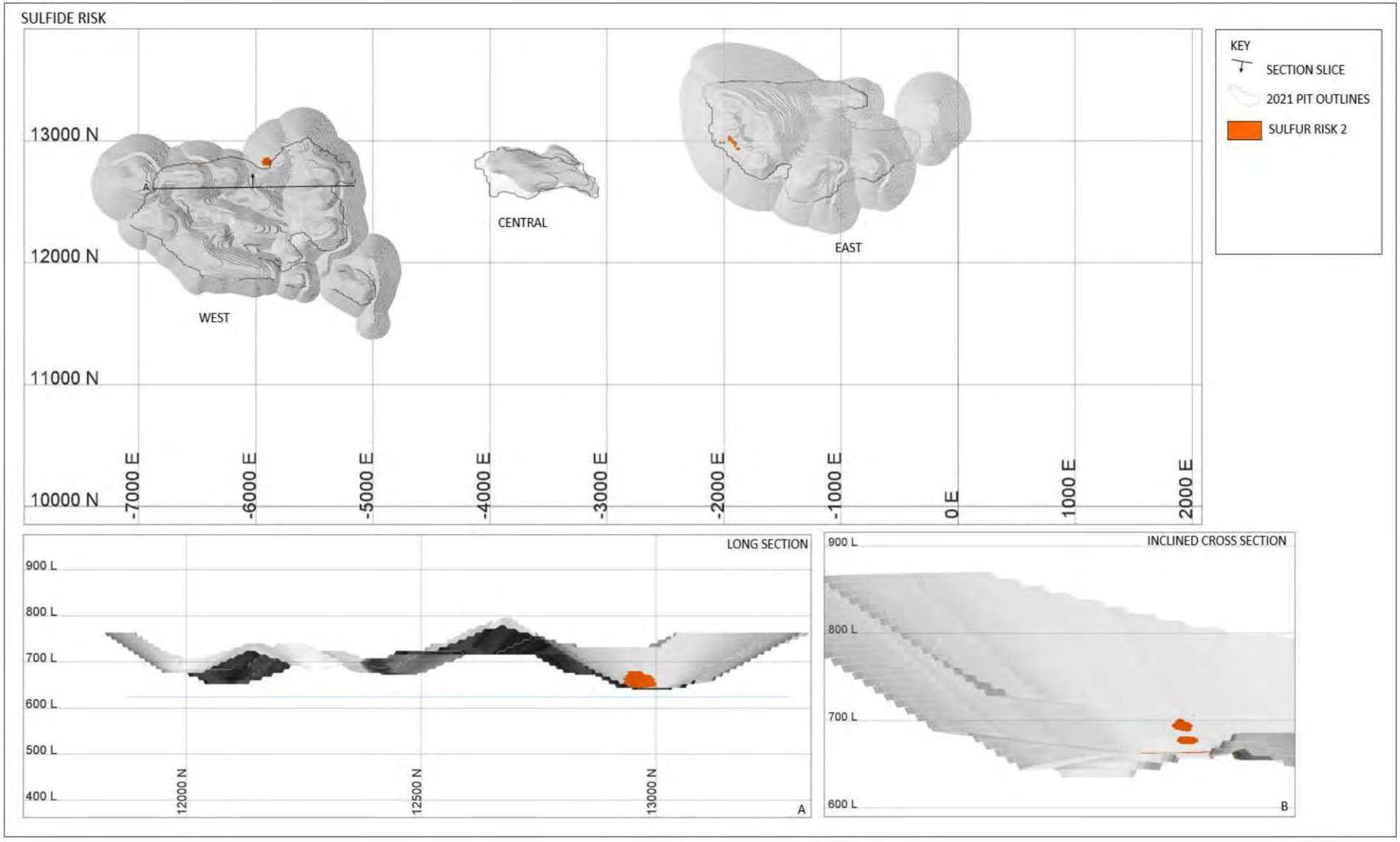


Figure 5-20: Modelled lithology exposures on the proposed Western Hill pit shell; PAF exposures include black shale in MCS and MTS

5.8.4. PAF operational management

All RTIO mining operations follow the procedures detailed in the SCARD Management Plan (Rio Tinto 2021c), which includes ongoing assessment of waste rock to identify PAF rock types that have not been previously identified during ore block modelling, procedures for PAF material segregation and storage to avoid environmental, safety and health risks. Based on the mine model, PAF material (Sulfide Risk 2) is predicted to be encountered in Deposit A-West, Deposit A, Deposit C, Deposit D, Deposit E, Deposit F and Western Hill (Table 5-34). It is noted that further refinement of the predicted PAF volumes will continue during the study and mining phase. This refinement may result in re-classification of PAF material to non-PAF material. However, based on the AMD Risk Assessment (MWM, 2021 and Rio Tinto, 2022), future PAF management practices will be required for Deposit A-West, Deposit A, Deposit C, Deposit D, Deposit E, Deposit F and Western Hill.

Table 5-34: PAF and fibre material predicted to be mined.

Deposit	Pit Name	Fibre Risk 3		Sulfide Risk 2	
		Waste Tonnes (t)	Pit exposures (m^2)	Waste Tonnes (t)	Pit exposures (m^2)
Dep A West	AW1	0	0	814	1,320
	AW2	0	0	0	0
	AW3	0	0	0	0
Dep A	Cake - Pit	0	0	0	0
	Gumleaf	0	0	0	0
	depa_uf21	15,087	6,922	150,366	0
	WPS/WPS-cutback(2020)	0	0	0	0
Dep B	Deposit B	264,031	41,767	0	0
Dep C	C1	0	0	0	0
	C2	129	7,581	65,066	539
	C3	77,289	15,145	0	0
Dep D	D1	1,098,675	67,126	1,497,415	87,629
	D2	0	673	0	0
	D3	1,084	4,663	0	0
	D4	0	0	0	0
	D5	0	0	0	0
Dep E	DepE East	56,331	4,566	15,282	1,261
	DepE West	1,045	3,451	0	0
Dep F	DFE	0	0	5,510	23
	DFEE - (MARLU)	0	0	0	0
	DFN1	0	0	0	0
	DFS1	0	0	0	0
	DFSW	0	0	0	0
	DFW	8,670	7,991	0	0
	DEP-F North	0	0	44,419	4,963
Dep G	G1	10,068	20,429	0	0
	G2	N/A	1,143	0	0
	G3	N/A	6,226	0	0
	G4	18,804	34,216	0	0

Deposit	Pit Name	Fibre Risk 3		Sulfide Risk 2	
		Waste Tonnes (t)	Pit exposures (m^2)	Waste Tonnes (t)	Pit exposures (m^2)
Dep H	DEP H - EAST	2,202	3,533	0	0
	DEP H - WEST	21,447	1,362	0	0
MTEE	MTEE	0	0	0	0
Dep WHILL	Westpod	0	0	0	0
	West Pit	0	0	0	6,600
	Central Pit	0	0	187,975	0
	East Pit	0	0	0	5,082

5.8.5. Fibrous minerals

Naturally occurring fibrous minerals can be found in many parts of Western Australia but are particularly prominent in banded iron formations of the Pilbara. At Rio Tinto Pilbara operations fibrous minerals are generally encountered in waste material from Marra Mamba Iron Formation but have also been encountered in other stratigraphic units including the Brockman Iron Formation. Fibrous minerals may also occur as clasts found within overlying alluvium cover. Fibrous minerals pose a risk when fibres of a respirable size become airborne and are inhaled.

Riebeckite is the most common mineral associated with fibrous minerals encountered at West Angelas. Riebeckite is usually found in fresh (unweathered) Banded Iron Formation (BIF). The asbestiform variety of riebeckite is crocidolite, or blue asbestos. The presence of riebeckite does not necessarily pose a fibrous mineral risk, but it is a precursor mineral to crocidolite, therefore, there exists a likelihood of encountering crocidolite. If present, crocidolite seams would primarily occur within the unmineralised Marra Mamba Iron Formation. In addition, crocidolite may also occur in BIF clasts found within overlying alluvium cover.

Fibre monitoring is undertaken during drilling operations across all West Angela deposits. Where fibres were visually identified, the samples were submitted for scanning electron microscopy analysis to determine mineralogy. Of the 29,770 in-pit samples sent for analysis, only 375 samples were confirmed to contain asbestiform minerals. Fibrous minerals are expected to be mined from the following pits as presented in Table 5-34.

The small volume of potentially fibrous material that has been mined to date has been encapsulated in the Deposit A North waste dump. Similarly, fibrous material exposed in the Deposit A West Pit North final pit wall has since been backfilled and poses a low risk at closure. Fibrous materials excavated during the construction of the rail loop have been appropriately disposed within nominated fibrous materials burial areas. Potentially fibrous material has also been stored in Deposit B East waste dump, and Deposit E South waste dump, with Deposit C&D waste dump proposed for fibrous storage in the future. Detailed rehabilitation designs developed to support progressive rehabilitation of several faces of the dumps are discussed in Section 11.2.4, and will take into account that potentially fibrous material needs to remain encapsulated in the final design.

Studies to determine if potentially fibrous material areas may occur in pit walls that will form the West Angelas post-mining landform are ongoing and will be presented in future iterations of this MCP.

Fibrous materials management

The *Rio Tinto Iron Ore (WA) Fibrous Minerals Management Plan* (FMMP) (2008) details the management of fibrous minerals encountered during mining and at closure and commenced implementation across Rio Tinto Iron Ore sites in 2009. Control measures employed during operations to reduce the potential health risk posed by exposure to fibrous material, as detailed in the FMMP, include:

- avoidance or minimisation of re-handling;

- disposal locations are not readily accessible by the public and/or site personnel, and which are not expected to be disturbed in the future;
- 3D plans of the locations and volumes of fibrous material in WDs;
- encapsulation with an appropriate amount of non-fibrous NAF mineral waste;
- construction of lateral containment bunds to prevent potential sediment run off;
- In-pit disposal should be considered a priority over construction of external WDs;
- The number of sites containing designated hazardous waste and the footprint of the waste dumps should be minimised; and
- The WD or backfill area should be located near sources of non-fibrous NAF mineral waste material for encapsulation and capping.

5.8.6. Rehabilitation materials

Often during rehabilitation activities, erodible and fibrous materials are planned to be encapsulated as part of making the site safe and stable. Materials suitable for armouring at West Angelas (Table 5-35) will be segregated and stockpiled during operations for rehabilitation purposes. Mineral waste characterisation data for hydrated waste at West Angelas is presented in Table 5-7.

Table 5-35: Materials available for special rehabilitation purposes

Waste type	Use	Location	Volume available (Mm^3)
Hydrated waste	Armouring of erodible dumps	Deposit A West (two stockpiles)	6.3
		Deposit E and F (one stockpile)	4.1

5.8.7. Implications for closure and knowledge gaps

Closure implications associated with mineral waste materials include:

- Final landform design will be based on the physical characteristics of the waste material. Ongoing studies are occurring to determine the physical characteristics of West Angelas waste rock to refine landform design. Future work will include consideration of requirement for internal placement of high erodible waste exposures, or use of conservative batter geometries.
- Final landform design will need to consider the physical characteristics of waste material. Consideration of high erodible waste, PAF material and topsoil availability will need to be undertaken when designing and implementing the closure landforms.
- The geochemical assessment of the waste rock will be reviewed and updated periodically or following changes to the pit design. Expansion of the existing ABA knowledge for all deposits within this Proposal will be undertaken.
- Ongoing multi-element analysis of waste rock samples and associated leach testing will continue during operations to continue to improve site specific knowledge of the West Angelas operation.
- Where practical, highly erodible material will be prioritised to pit backfill or will be placed internally within the WRL to increase landform stability and reduce the risk of erosion.
- Based on the high volume of high erodibility waste rock, it is currently anticipated that ongoing stockpiling of rehabilitation materials with specific characteristics to enable rock armouring or encapsulation will be required.

Closure knowledge gaps associated with mineral waste materials, as summarised in Table 6-1, include:

- Characterisation of waste material to define geotechnical and geochemical properties and erosion classes. Further site-specific waste characterisation will be progressively undertaken when each mineral waste unit becomes available during mining operations.
- Mapping of pit wall exposures of fibrous materials in the closure landscape, risk assessment and closure to be further refined as closure approaches.
- Refine pit backfill strategy and determine location and types of waste materials remaining ex-pit at closure. This will inform final rehabilitation design requirements.
- Determine final closure strategy for high erodibility waste dumps.
- Rehabilitation designs to be developed for all permanent ex-pit landforms.
- Determine implication of site-specific waste types on the feasibility of achieving safe and stable rehabilitation outcomes using alternative landform design approaches (e.g. geomorphic options).
- Determine armouring material balance once final closure strategy for high erodibility waste has been determined.

5.9. Hydrogeology

5.9.1. Conceptual Hydrogeology

The groundwater system is characterised as a large basin-type aquifer with water storage within the weathered Wittenoom Formation, mineralized Marra Mamba Iron Formation and overlying alluvial dolecrete / dolerite units.

The Wittenoom Formation is found in the valleys between the low-lying sub-cropping Marra Mamba Iron Formation and Fortescue Group core of the Wonmunna anticline and the higher relief Brockman Iron Formation hills to the north and south. Permeability within the Wittenoom Formation can be enhanced through development of secondary permeability associated with dissolution of dolomitic units. These secondary features have significant hydraulic conductivity and storage.

The Wittenoom Formation is generally overlain by a detrital sequence of variable thickness, which when saturated forms part of the regional aquifer.

Orebody aquifers also occur in the mineralised sections of the Marra Mamba Iron Formation and the overlying West Angelas Member of the Wittenoom Formation. Where hydraulic connection with the Wittenoom Formation or saturated detritals exists, the orebody aquifer forms part of the regional aquifer.

In other situations, the synclinal structure of the Marra Mamba Iron Formation which contains the mineralised (and permeable) Mt Newman Member is underlain and bounded by low permeability, non-mineralised units including the Macleod and Nammuldi Members of the Marra Mamba Formation and the Jeerinah Formation of the Fortescue Formation. This results in localised orebody aquifers commonly referred to as “bathtubs” that are not connected to the regional aquifer.

The water table within this aquifer is relatively deep (between 50 – 120 mbgl) across the closure boundary with a relatively flat gradient from east to west for most mining areas. Due to a groundwater divide, possibly associated with a dolerite dyke between Deposit C2 and C3, the groundwater flow direction in the area of Deposit C3, G and B is reversed, from west to east, with the same relatively flat lying gradient.

Due to the substantial depths to groundwater, recharge is usually negligible and estimated to be approximately a small percentage of rainfall.

5.9.2. Hydrogeological setting

Deposit A

The pre-mining water level in Deposit A was approximately 640 mAHD (approximately 120 mbgl). A very low hydraulic gradient from east to west was recorded. The orebody aquifer is considered to be a bathtub type aquifer due to the low permeability of the surrounding rock, the very low hydraulic gradients within the orebody aquifer and the steep hydraulic gradients between the Mt Newman and Jeerinah units (Rio Tinto 2007). Analysis of hydraulic gradients and flow directions indicate minimal drawdown impacts to the Jeerinah Formation are recorded as a result of dewatering of the orebody aquifer.

Deposit A West

A dolerite dyke, trending northwest-southeast, hydraulically separates Deposit A from Deposit A-West. The pre-mining water level was approximately 627 mAHD (approximately 100 mbgl) with a very low hydraulic gradient from east to west towards Deposit D.

Deposit B

The pre-mining water level was approximately 630 AHD (approximately 100 mbgl), with a slight hydraulic gradient from the south-east to the north-west. Below water table mining commenced in 2019, with approximately 50 m of BWT mining.

Deposit C

Due to a groundwater divide, possibly associated with a dolerite dyke between Deposit C2 and C3, the groundwater flow direction in the area of Deposit C3, G and B is reversed, from west to east, with the same relatively flat lying gradient.

Groundwater levels in Deposit C1 and C2 are relatively flat at 623 mAHD (approximately 45 mbgl), while groundwater levels in Deposit C3 are around 636 mAHD (approximately 40 mbg).

Deposit D

Groundwater levels range from 625 mAHD in the east to 623 mAHD in the west and show negligible responses to recharge due to the large depths to groundwater (greater than 50 mbgl). Dewatering associated with the development of Deposit A, to the east of Deposit D, commenced in 2009. The effects of this are negligible in the monitoring bores in Deposit D, with groundwater levels recording minimal variation.

Groundwater discharge is conceptualized to occur via evapotranspiration from shallow water tables at the potential GDE in KNP.

Deposit E

The pre-mining groundwater level in Deposit E ranged from 669 mAHD in the east to 667 mAHD in the west (approximately 100 mbgl). Mining in Deposit E commenced in 2012 and was then halted in 2014 following a large-scale redesign of the pit. BWT mining is currently scheduled to begin in 2026. Dewatering, for mine supply, has continued in Deposit E despite no active mining in the pit. Current water levels range from 660 mAHD in the east pit to 661 mAHD in the west pit.

Deposit F

The pre-mining groundwater level ranged between 686 mAHD in Deposit F West (approximately 95 mbgl) 670 mAHD in Deposit F South and South West (approximately 100 mbgl).

Deposit F North

Geologically, Deposit F North is a localised east-west trending syncline with mineralised Mt Newman Member surrounded on all sides by low permeability unmineralised Macleod and Nammuldi Members (Rio Tinto 2018). The deposit is covered by up to 25 m of AWT detrital cover and separated from Deposit F to the south by a raised hill of unmineralised Nammuldi and Macleod members of the MMIF.

A fault (striking SSE, dipping SW) cross-cuts the mineralisation (above water table only) and results in Macleod member being offset over a small portion of the mineralisation. Several dolerite dykes have been identified however, it has not been established if these cause any compartmentalisation of groundwater.

Deposit F North forms a ‘bathtub’ style aquifer being surrounded by the impermeable Nammuldi and Macleod members of the Marra Mamba Iron Formation. Groundwater levels in Deposit F North range between 716 mAHD and 717 mAHD and are approximately 77 m below ground level. The water table at Deposit F North is approximately 46 m higher than in Deposit F (East Extension) to the south, which suggests a disconnect between these orebodies (Rio Tinto 2018).

Deposit G

The pre-mining groundwater level is approximately 640 mAHD with a slight gradient to the east.

Deposit H

The aquifer that hosts the orebody is bounded by low-permeability, unmineralised Marra Mamba Iron Formation members that encapsulates the interior zone of the deposit (Rio Tinto 2020). The conceptualisation of the Deposit H local groundwater suggests the deposit is hosted within an aquifer which is bound in all directions by the impermeable unmineralised units of the Marra Mamba Iron

Formation that encapsulates the interior zone of the deposit. Groundwater through flow into the deposit is likely minimal with the low permeability hydrostratigraphy surrounding the deposit having limited connection to the orebody aquifer. Pumping tests indicate that the aquifer has low transmissivity and storage parameters. Similarly, outflow from the orebody aquifer is likely minimal and would most likely consist of shallow groundwater flow through alluvials in eroded channels that incise the low permeability material that bounds the deposit. This is supported by pumping tests which indicate that the aquifer has low transmissivity and storage parameters.

Groundwater levels at Deposit H are approximately 735 mAHD (Rio Tinto 2020). There is a slight groundwater gradient from south to north, consistent with elevation and drainage patterns. Geophysical water levels interpreted from grade drilling have recorded groundwater levels ranging from 733 mAHD to 736 mAHD, indicating a small gradient to the north-east.

Groundwater flow in the bowl-like Deposit H aquifer is restricted to a small recharge component that essentially overtops the aquifer, spilling along the northern boundary via alluvial and colluvial channel fill in streams incised into the unmineralized and impermeable Strata that bounds the aquifer. Groundwater recharge is minimal and occurs with infiltration of rainwater falling directly onto the surface above the aquifer (point source recharge). Observed groundwater level variation of up to 0.2 m correlates with site rainfall and is consistent with the stated groundwater flow and recharge processes.

Ephemeral pools, to the north of Deposit H within drainage lines, have been surveyed and place these pools above the Deposit H water level and effectively dominated and supplied by surface water flow. Periodic observations of water levels within these pools show their ephemeral nature and demonstrate this surface water dependence.

Western Hill

Western Hill is located 3 km north-west of Deposit C. Western Hill is a Brockman Iron Formation deposit consisting of several ore bodies along an 8 km E-W trending synclinal structure. Three distinct AWT pits are planned at Western Hill, and whilst mineralisation BWT does exist at two of these pits, currently no mine dewatering is proposed at Western Hill due to the potential for impact to the nearby KNP, which is approximately 1.5 km to the west of the western-most pit. Groundwater is proposed to be abstracted for supply purposes.

A regionally significant dolerite dyke exists to the east of Western Hill that is known to impart a 13 m head difference across it and act as an aquitard (Rio Tinto 2021d). The groundwater table is relatively flat across the Western Hill area at approximately 624 mAHD, however a slight gradient can be interpreted in a westerly direction.

Groundwater within the Wittenoom Formation surrounding Western Hill is inferred to flow in a south westerly direction towards an alluvial channel beneath Turee Creek East approx. 9 km south-west of Pit 1 in an area of shallow groundwater within KNP. The Wittenoom Formation to the south is hydraulically connected to the Deposit C orebody aquifer, and the Wittenoom Formation to the north is conceptually bounded by a Marra Mamba Iron Formation range 3.5 km to the north of the pits. No abstraction induced drawdown has yet been observed in the Wittenoom Formation domain that is hydraulically connected to Western Hill. However, from 2022/23 the Deposit D managed aquifer recharge (MAR) scheme is scheduled for implementation (RTIO, 2021d), which will act to support groundwater levels in the area of the MAR scheme to ensure no drawdown across the KNP boundary.

Managed Aquifer Recharge

Deposits C and D are located in proximity to KNP with no current evidence of any hydraulic barriers between the orebodies and the park boundary. Unmitigated groundwater drawdown from dewatering at Deposit C and D has been modelled to propagate past the KNP boundary. MS 1113 Condition 6-1 and condition 3 of EPBC Act Decision Notice 2018/8299 require that there is no drawdown or impact to the quality (DN 2018/8299 only) of groundwater associated with the Project at the boundary of, or within, KNP. Groundwater levels at the KNP boundary will be monitored during operations and as necessary

mitigated via a Managed Aquifer Recharge (MAR) scheme between KNP and Deposits C and D during the mining of these deposits. This scheme will utilise water from the West Angelas dewatering operations to recharge the aquifer during operations to ensure no permanent drawdown of groundwater levels is recorded inside KNP.

As the 2019/2020 trial proved that MAR using reinjection bores is practicable, the planned West Angelas MAR scheme was developed and is envisaged to comprise four phases:

- Phase 1 – to mitigate drawdowns from dewatering in Deposit D and A West (tentatively 2023 to 2028);
- Phase 2 – to mitigate drawdown from active dewatering in Deposit C2 (tentatively 2028 to 2036);
- Phase 3 – to reinstate water levels in Deposit D and A West to pre-mining water levels (tentatively 2028 to 2038); and
- Phase 4 – to reinstate water levels in Deposit C2 to pre-mining water levels (tentatively 2036 – 2046).

Post mining, Deposit C and D pits are planned to be backfilled to 2 m above pre-mining water levels, unless an alternative appropriate strategy is identified to maintain groundwater levels at the KNP boundary.

Dewatering

Whilst mining will leave the regional groundwater system intact, dewatering activities and supply borefield abstraction may impact the local aquifer system. Dewatering of BWT pits and abstraction at borefields creates a cone of depression in the water table which can extend from a few to several kilometres beyond the area dewatered. This can reduce the amount of groundwater available for any groundwater dependent vegetation and local permanent pools (if present), and therefore efforts are made to reduce the zone of this impact as much as practicable.

Dewatering is proposed for development of Proposal pits Deposit H and Deposit F North, in addition to the dewatering already occurring on-site. Closure implications associated with an increase in dewatering include consideration of site wide dewatering impacts on local aquifers from current and planned operations in combination. Table 2-1 outlines the BWT pits – both approved and proposed for the West Angelas Operation.

In-pit water storage

Preliminary data indicates that surplus water from dewatering will be produced from existing operations and may require temporary storage within completed below water table pit voids during operations. Prior to any pit being utilised for in pit temporary storage, mine planning, engineering and environmental constraints, as well as hydrogeological suitability of pits will be assessed. Temporary in-pit water storage is being considered for the operational mining phase only and any pits used for water storage will be closed as per the strategies presented within this mine closure plan and consistent with requirements of current approvals**.**

5.9.3. Groundwater quality

Groundwater within the Marra Mamba Formation in Greater West Angelas area is dominantly circum-neutral (field pH ~6.5-8.1 pH units) and fresh (median total dissolved solids = 584 mg/L). Metal concentrations are variable and overall low. Nitrate concentrations vary and are generally smaller than 35 mg/L (Rio Tinto, 2019).

Bores screened within the Jeerinah Formation have a distinct water chemistry. They are notably more saline (median TDS = 1900 mg/L), with a highly variable pH (ranging from acidic to alkaline), more elevated metal concentrations and are dominated by sulfate ions. The Jeerinah Formation bores reported notably lower nitrate concentrations (median = 0.1) compared to other West Angelas bores (Rio Tinto, 2019). Overall, groundwater quality is relatively stable over time (Rio Tinto, 2019).

Deposit H

Groundwater chemistry at Deposit H is characteristic of a regionally isolated aquifer with limited throughflow. The point source recharge mechanism creates a consistent hydrochemical signature across the aquifer, with a strong chloride signature compared to Pilbara wide averages. This reinforces the processes of point source recharge and locally bounded aquifer, connecting the groundwater chemistry to the physical structure and nature of the aquifer.

Groundwater is fresh (425 mg/L TDS), pH is neutral, alkalinity is low (<28 mg/L), and metal concentrations are low indicating limited rock-water interaction and hydrochemical development (Rio Tinto 2020).

5.9.4. Current operations groundwater recovery modelling

Groundwater recovery modelling has been undertaken for Deposits A, B and E. The modelling indicates that water recovery will be slow, and that levels will not rebound completely to pre-mining levels in all locations (Table 5-36).

The backfill level that would be required to avoid the formation of a permanent pit lake has not yet been determined, but is expected be a lower elevation than the pre-mining water table as losses of water through evaporation and infiltration are taken into account (as outlined in Table 2-2). There would be some degree of permanent groundwater drawdown immediately around the pit in this scenario; the spatial extent of which will be defined as mining progresses and modelling is refined with monitoring inputs. Groundwater recovery modelling has not been undertaken for Deposits F, G, and H. In the absence of such information it has conservatively been assumed for determining an appropriate backfill level to base this on pre-mining water table levels. This will continue to be refined throughout mining as dewatering and recovery modelling is updated.

Table 5-36: Predicted groundwater level and approximate time to recovery

Deposit	Pit[7]	Pre-mining level (mRL)	Predicted water recovery level assuming backfill to AWT (mRL)[8]	Estimated time (years)[9]
Deposit A	CEPN	641	610	70 - 80
Deposit A	CEPS	640	630	65
Deposit A	WEPS	640	630	65
Deposit A West	AW1	627	627 Recovery modelling NC, due to connection to KNP groundwater, backfill to above pre-mining water table assumed. Water table will recover to pre-mining levels via the MAR.	During operations
Deposit A West	AW2	627	627 Recovery modelling NC, due to connection to KNP groundwater, backfill to above pre-mining water table assumed. Water table will recover to pre-mining levels via the MAR.	During operations

[7] Only pits that are mined BWT are included in this table.

[8] NC = not complete

[9] Recovery levels are based on the continuation of current climate conditions.

Deposit	Pit[7]	Pre-mining level (mRL)	Predicted water recovery level assuming backfill to AWT (mRL)[8]	Estimated time (years)[9]
Deposit A West	AW3	627	627 Recovery modelling NC, due to connection to KNP groundwater, backfill to above pre-mining water table assumed. Water table will recover to pre-mining levels via the MAR.	During operations
Deposit B	DBC4	630	625	20 - 30
Deposit B	DBC5	630	625	20 - 30
Deposit C	C2	624	624 Recovery modelling NC, due to connection to KNP groundwater, backfill to above pre-mining water table assumed. Water table will recover to pre-mining levels via the MAR.	During operations
Deposit C	C3	636	636 Recovery modelling NC, due to connection to KNP groundwater, backfill to above pre-mining water table assumed. Water table will recover to pre-mining levels via the MAR.	During operations
Deposit D	D1	624	624 Recovery modelling NC, due to connection to KNP groundwater, backfill to above pre-mining water table assumed. Water table will recover to pre-mining levels via the MAR.	During operations
Deposit D	D2	625	625 Recovery modelling NC, due to connection to KNP groundwater, backfill to above pre-mining water table assumed. Water table will recover to pre-mining levels via the MAR.	During operations
Deposit D	D3	625	625 Recovery modelling NC, due to connection to KNP groundwater, backfill to above pre-mining water table assumed. Water table will recover to pre-mining levels via the MAR.	During operations
Deposit E	East	668	650	TBC
Deposit E	West	668	650	TBC
Deposit F	DFW	686	To be completed	TBC
Deposit F	DFS1	670	To be completed	TBC
Deposit F	DFE	670	To be completed	TBC
Deposit G	G1	640	To be completed	TBC

Deposit	Pit[7]	Pre-mining level (mRL)	Predicted water recovery level assuming backfill to AWT (mRL)[8]	Estimated time (years)[9]
Deposit G	G4	640	To be completed	TBC
Deposit H	East	735	To be completed	TBC
Deposit F	North	716	To be completed	TBC

5.9.5. Implications for closure and knowledge gaps

Closure implications associated with groundwater include:

- The risk of drawdown of groundwater associated at the boundary of, or within, KNP will be managed during operations via a MAR scheme and at closure by pit backfill. Groundwater monitoring will continue through closure to confirm the success of these strategies.
- The hydrogeology of deposits at West Angelas mine is compartmentalised, resulting in cones of depressions around the pit voids. Water is not expected to rebound to pre-mining water table levels in all areas. This will have implications for final pit backfill levels.

Closure knowledge gaps associated with the hydrogeology of the West Angelas operations, is summarised in Table 6-1 and include:

- Undertake groundwater recovery modelling where not yet completed to determine closure backfill levels for all below water table pits and recovery periods. This will continue to be addressed at each MCP update.
- Site wide groundwater modelling is required to assess interactions between existing and proposed mining operations and associated impacts on groundwater resources.
- Assess closure implications of surplus water storage in pit voids.
- Determine operational strategy for pit backfill and mining schedules to maintain MAR capability.

5.10. Hydrology

5.10.1. Regional and local hydrology

Regionally, the majority of the West Angelas deposits are located within the upper reaches of the Turee Creek East Catchment in an area of approximately 330 km^2, which forms part of the regional Ashburton River Catchment. The large spatial domain of the deposits means that additional sub-catchments are included within the closure boundary, including the Angelo River and Weeli Wolli Creek sub-catchments (Figure 5-21). Weeli Wolli Creek catchment forms part of the regional Upper Fortescue River catchment, to the west of the regional Ashburton River catchment. The catchments have a complex drainage pattern characterised by intermittent flow and infrequent wide-spread flooding, depending on the occurrence of high intensity rainfall events.

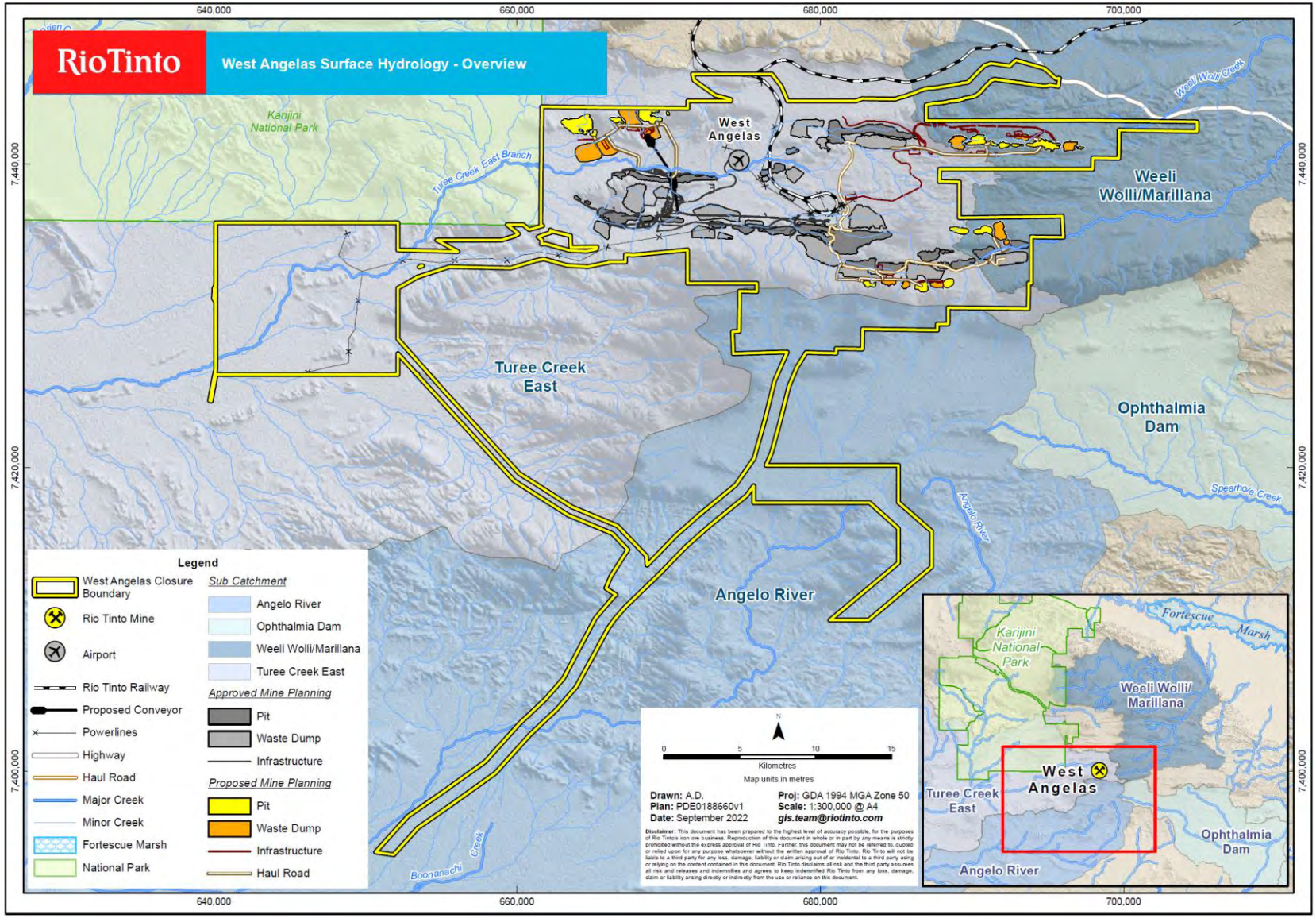


Figure 5-21: West Angelas surface hydrology

West Angelas has undergone significant hydrological changes since mining began, with blocking of some tributary catchments via dumps and pits, restriction of flows where linear infrastructure is present, and catchment diversion to allow mining at Deposits B, F, C and D. Despite these changes, catchment connectivity has been retained with a general east-west movement of water across the site to Turee Creek East. The creek flows into Karijini National Park to the west of Deposits C and D, joining Turee Creek main branch 70km downstream. This eventually reaches the Ashburton River after 90km which has its outlet at the Indian Ocean to the west.

West Angelas is surrounded by steep ranges with multiple short drainage lines conveying flow to broad, flat valley plains. Because of the flat gradient throughout the lower parts of the catchment, the main channel of Turee Creek East does not exhibit the features of a high-energy creek system. At the far eastern extent of West Angelas is a poorly defined catchment divide, with parts of Deposit F and F North flowing to Weeli Wolli Creek. Deposit H is located completely within the Pebble Mouse Creek catchment, a tributary of Weeli Wolli Creek that drains to the terminal sink of Fortescue Marsh.

The potential cumulative reduction in catchment area is shown in Table 5-37 relative to the total catchment area of Turee Creek East (2,059km^2), and the local catchment area of Turee Creek East to the Karijini National Park boundary (430 km^2).

Table 5-37: Potential cumulative Turee Creek East catchment area reduction

Deposits	Associated catchment area reduction (km^2)	Full catchment (2,059 km^2)	Catchment to Karijini National Park (430 km^2)
		Reduction of area (%)	Reduction of area (%)
Deposits A, B, E, F, G, A west	92	4%	21%
With Deposits C & D	110	5%	26%
With Beyond 2020 development	125	6%	29%

5.10.2. Key surface water features

Deposit H ephemeral pool

An ephemeral rock pool at the base of a gorge and waterfall system exists downstream from the proposed western pit and waste dump at Deposit H (Figure 5-22). Water levels and flows to the pool have been monitored since 2018 and provide evidence of an intermittent pool which has surface water following rainfall and flow events in the catchment. Multiple small, incised tributaries contribute to a single creek system, which flows through the orebody to the pool. This pool, and the culturally important ecological values of the gully downstream of the pool, have been identified as being culturally significant to the Ngarlawangga People.

Figure 5-22: Deposit H ephemeral rock pool (August 2020)

Mining of Deposit H may remove up to ~88% of the contributing catchment for the pool and depending on the final footprint of pits and dumps at Deposit H, no more, but potentially less of the catchment could be removed. This will result in a reduction in flow volumes delivered to the pool. Given the small storage volume of the pool relative to the catchment area, the pool is expected to still intermittently store surface water following large rainfall events, but the period of inundation and volume of throughflow will be reduced.

Mount Ella East ephemeral pools

An ephemeral rock pool and heritage area is located to the south of the proposed Mount Ella East development (WA-18-ETH-01). The rock pool and heritage area are inclusive of minor surface water pools WB-WAJ1 and WB-WAJ2, which were identified as minor pools, approximately 1 m apart in the same rocky gully. During an assessment of the minor pools in June 2018, it was noted that they contained water, most likely resultant of high rainfall at the time of monitoring. During a subsequent visit following the lack of rainfall between June and October, the pools were drying up, indicating that they provide only temporary sources of water following periods of rain

The pools, heritage exclusion areas and all contributing catchments are located outside (and upstream) of the closure boundary and are not expected to require specific management to meet closure objectives.

***Gajiringu* - heritage site**

The *Gajiringu* heritage site is located on a tributary of Turee Creek East, adjacent to Deposit D. The site is currently managed under the West Angelas Deposit C and D YINHARR-20 (*Gajiringu*) Management Plan. Deposit D is within the upstream catchment of this site, and it is recognised that retention of surface water flows to the area is required to maintain cultural value. To achieve this, diversion drains and earth embankments have been constructed at Deposit D to convey water around pits and waste dumps and retain flow to the site. A small reduction to the volume of water passing through the development will occur as a result of the capture of small creeks into pits where diversion structures are not possible, but most of the upstream catchment has been retained.

The proposed development of the Beyond 2020 (the Proposal) deposits will not result in any incremental increase in impact to the site, as there is no development planned within the contributing catchment.

Guburingu – heritage site

This site is located within KNP at the western extent of Western Hill at the confluence of two creeks. The mining footprint of Western Hill is located within the catchment of the heritage area. Monitoring is in place in the confluence zone within the heritage site with permission from Yinhawangka group. Based on investigations to date there is no evidence of persistently available surface or groundwater at the site. As such this location is representative of a typical ephemeral creek confluence zone.

Development of Western Hill is within the eastern contributing catchment of this site and will result in ~4km^2 reduction in catchment area. This constitutes 6% of the eastern catchment (60km^2), and 2% of the total contributing catchment (151km^2). The closest development is the western pit, which is still over 4km along the flow path from the Guburingu area, across very flat slow draining terrain. As such there is a very low risk of sediment transport towards the site.

Turtle Pool

Turtle Pool, as it is known colloquially is a semi-permanent surface water feature located approximately 700 m east of Deposit H, outside of the Revised Development Envelope, in a tributary of Weeli Wolli Creek. It has been identified as a significant place of high social, cultural, heritage and aesthetic value to Ngarlawangga People.

5.10.3. Flood modelling

Flood modelling and hydrology assessments have been completed for the West Angelas deposits for both the current operations and the new deposits described within the Proposal. These assessments

have been used to assess the risk and suitability of final closure landforms as closure planning progresses and are included as Appendix 9 and Appendix 11.

Given the respective timelines of the Proposal in comparison to the planned triennial MCP compliance updates, hydrological modelling studies have progressed separately to date, with the intention these will be combined into a site-wide model domain to accommodate the proposed new closure boundary in subsequent revisions of this MCP. Modelling completed to date include:

- For existing operations, the Rio Tinto TUFLOW model was updated to include a site-wide model domain to simulate flood flows in Turee Creek East and upper Weeli Wolli Creek (Advisian, 2022).
- Additional TUFLOW modelling was undertaken to support the Proposal for inclusion of Beyond 2020 deposits (Rio Tinto, 2021a).

Current operations

Previous modelling undertaken to inform closure planning included a site wide flood assessment to identify and understand operational flood risks as well as closure risks associated with overtopping of pit crests and creek capture. Hydraulic modelling was completed over the entire mine site for the 1:100, 1:1,000 and 1:10,000 annual exceedance probability (AEP) flood events. The models included operational flood protection measures and life-of-mine pit designs/extents for existing approved deposits. These are presented in Figure 5-23 to Figure 5-25. However, this modelling did not consider closure landforms and regulator feedback identified the need to develop designs for surface water structures that maintain the quantity and quality of surface water flows to Karijini National Park, reinstate natural flow paths, and provide a safe, stable and non-polluting closure landform. Action WAN-08; *Complete flood modelling for areas not yet defined in detail* is included in the West Angelas closure action register (Appendix 4).

Across the site, there are a series of levees and diversions that provide operational flood protection, designed for events up to the 1:100 AEP event. Examples of key risk areas associated with the operational flood protection include Turee Creek East at Deposit C and Southern Turee Creek east tributary at Deposit D. The operational levee at Deposit C may overtop and fail during flood events larger than the 1:100 AEP (depending on upstream infrastructure), with water spilling over the pit crest and into C3 pit void, which will result in subsequent geotechnical stability issue of the pit crest. Overtopping failure of the diversion at pit D1 pit along the Southern Turee Creek east tributary will lead to capture of flows from a 45 km² catchment area and a potential reduction of 35% in flow volume reporting to Karijini National Park (assuming complete capture of the southern tributary). This infrastructure requires upgrades to meet Rio Tinto's closure objectives. Modelling was undertaken to help inform preferred strategies for closure of pits adjacent to creeks at West Angelas (currently completed for Deposits B, C, D and F). The adopted design criteria specified levees to accommodate the 1:10,000 AEP on major waterways and the 1:1,000 AEP on minor waterways, with rock protection based on peak velocity.

During Advisian's (2022) surface water assessment of the West Angelas operation, the following areas were identified as having key surface water risks on closure:

- Deposit B: The berm and diversion channel, along with the haul road and rail culverts, restrict flows downstream to Deposit C. Closure landforms are yet to be designed for the area, however, with Deposit B located away from major drainage lines and with the diversion drain preventing overtopping for events up to the 1:2,000 AEP, long-term landform stability risks associated with flooding are considered low.
- Pit C3 Diversion: The existing operational levee has been designed for the 1:100 AEP, with restricted flows from upstream. Removal of the Deposit B haul road crossing upstream will increase the peak flows at this location. The creek flow at this location is directed perpendicular to Pit C3, presenting a higher risk of scour and erosion. As indicated, events greater than the 1:100 AEP could be captured in the pit, which could impact flow volumes reaching Karijini National Park to the west.

- Deposit D Diversions: Flood modelling indicated that there is overtopping and bypass of the existing Pit D1 south operational levee (design for the 1:50 AEP event) during the closure design event, indicating a requirement for infrastructure upgrades at closure. There are also high velocities and potential overtopping of the Pit D1 north and Pit D3 operational diversion and levees. Failure of the diversion at pit D1 pit will lead to capture of flows from a 45 km² catchment area and a potential reduction of 35% in flow volume reporting to Karijini National Park (assuming complete capture of the southern tributary).
- Deposit F Diversion: The diversion drain intercepts and directs runoff from an approximately 14 km² catchment east towards Weeli Wolli Creek. The drain will overtop in a 1:100 AEP (operational design was for a 1:50 AEP event). The drain will require upgrade at closure, potentially with consideration of geomorphological input.
- Deposit A and Deposit E: Given there are no large-scale floodplain interactions in this area, operational flood management measures are largely limited to minor drains and culverts. Backfill of pits to above pre-mining water table is proposed, and only minor stream training may be required to divert inflows to pit crest locations with competent material.
- Deposit G: Consists of three potential pits that are yet to be designed.

In consultation with Rio Tinto, Advisian proposed three closure options for the key risk areas:

- Option 1: Operational Levees Upgrades for the closure design event. Minimal changes to the levee alignments or changes to backfilling strategies outlined in the MCP.
- Option 2: Floodplain Reinstatement at Pit C3. This location was identified as the highest risk of levee failure and creek capture. To mitigate this risk, a portion of Pit C3 could be backfilled to pre-mining levels to reinstatement the floodplain. The levee with the highest failure risk could then be removed.
- Option 3: Deposit B Spillway. Excavation of a spillway at Deposit B to reduce flows downstream, particularly at Pit C3.

For all options, the closure strategies at Deposits D and F, upgrading operational levees, were consistent. Deposits A and E did not require any specific closure infrastructure owing to their location in the upper catchment and small catchments draining to these locations.

The three options were tested and compared using flood modelling, geotechnical assessment and comparative material estimates to assist in selecting a preferred option. Flood modelling of the closure options was completed using TUFLOW modelling software with closure landform and infrastructure assumptions defined in the basis of design included in the model. The modelling determined closure levee heights and the benefits associated with partial backfilling of Pit C3 and spillways at Deposit B for the design events (1:1,000 AEP and 1:10,000 AEP events). Peak velocities from the flood modelling were also used to inform rock protection design for levees in accordance with Austroads (2019) Guidelines.

Modelling identified that the upgrades to existing operational levees was a feasible option (Option 1) for closure of these areas and is currently preferred as there are fewer associated uncertainties and construction complexities and has lower earthwork volumes. Locations of levees and diversions related to this option are presented in Figure 5-26.

Updated modelling of Deposit A-West shows drain failure toward the A-West pit voids is possible, and surface water flows will need to be further managed to achieve landform stability objectives over relinquishment and closure timeframes. Closure considerations to be incorporated into designs for A-West features include:

- maintaining flows westwards to the Gajiringu heritage site at Deposit D and Karijini National Park; and
- limiting impacts to the West Angelas Cracking Clay Priority 1 ecological community north of the development.

Closure modelling for Deposit G shows the main risk to stability of pit voids is the potential for rarer flood events to cause floodwater to be impounded behind the rail embankment and extend to the pit crest, which may cause erosion and ultimately capture of Turee Creek East. Ongoing modelling is required to further determine risks at this deposit and develop appropriate closure designs.

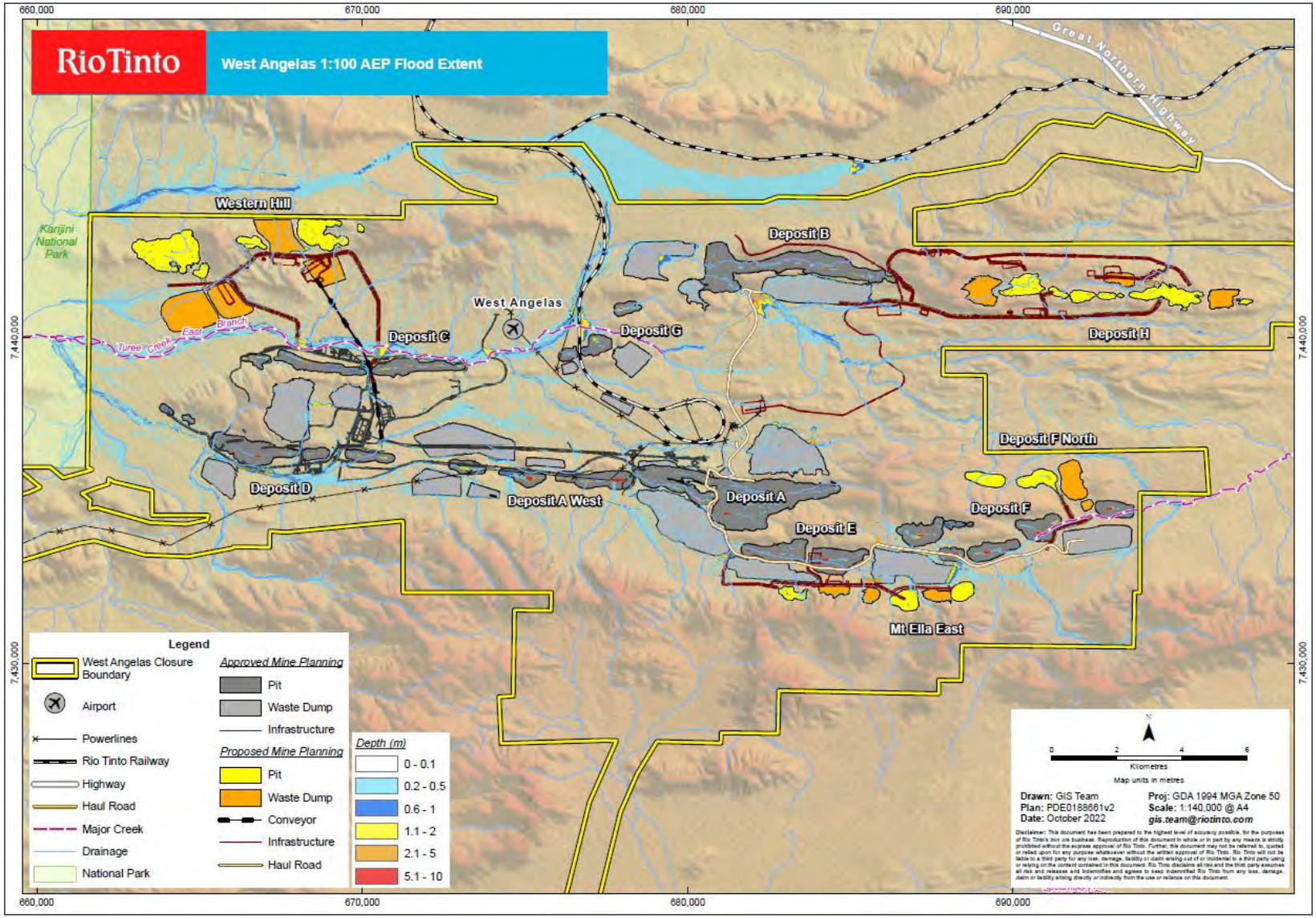


Figure 5-23: 1:100 AEP maximum flood depths scenario

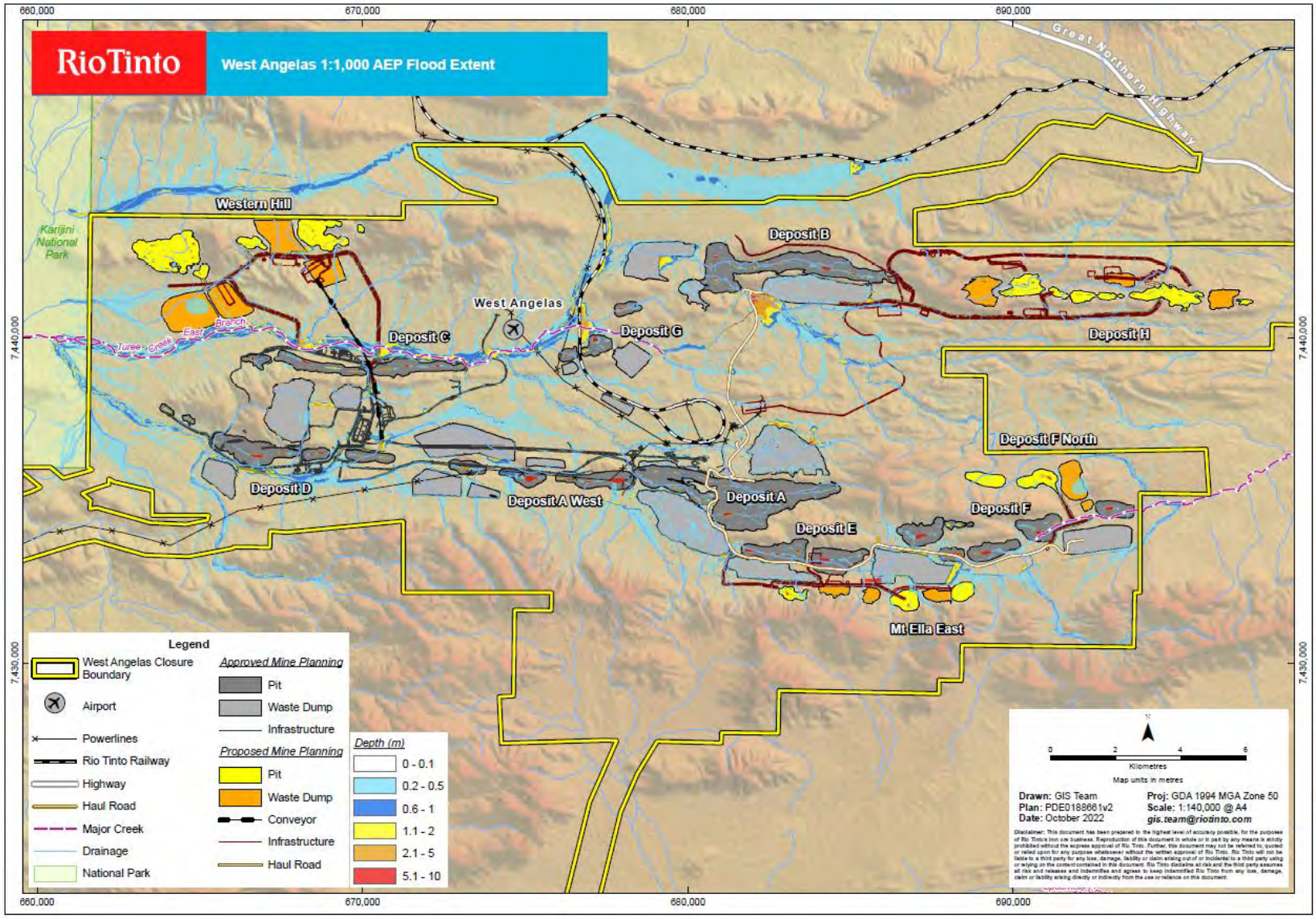


Figure 5-24: 1:1,000 AEP peak flood depths scenario

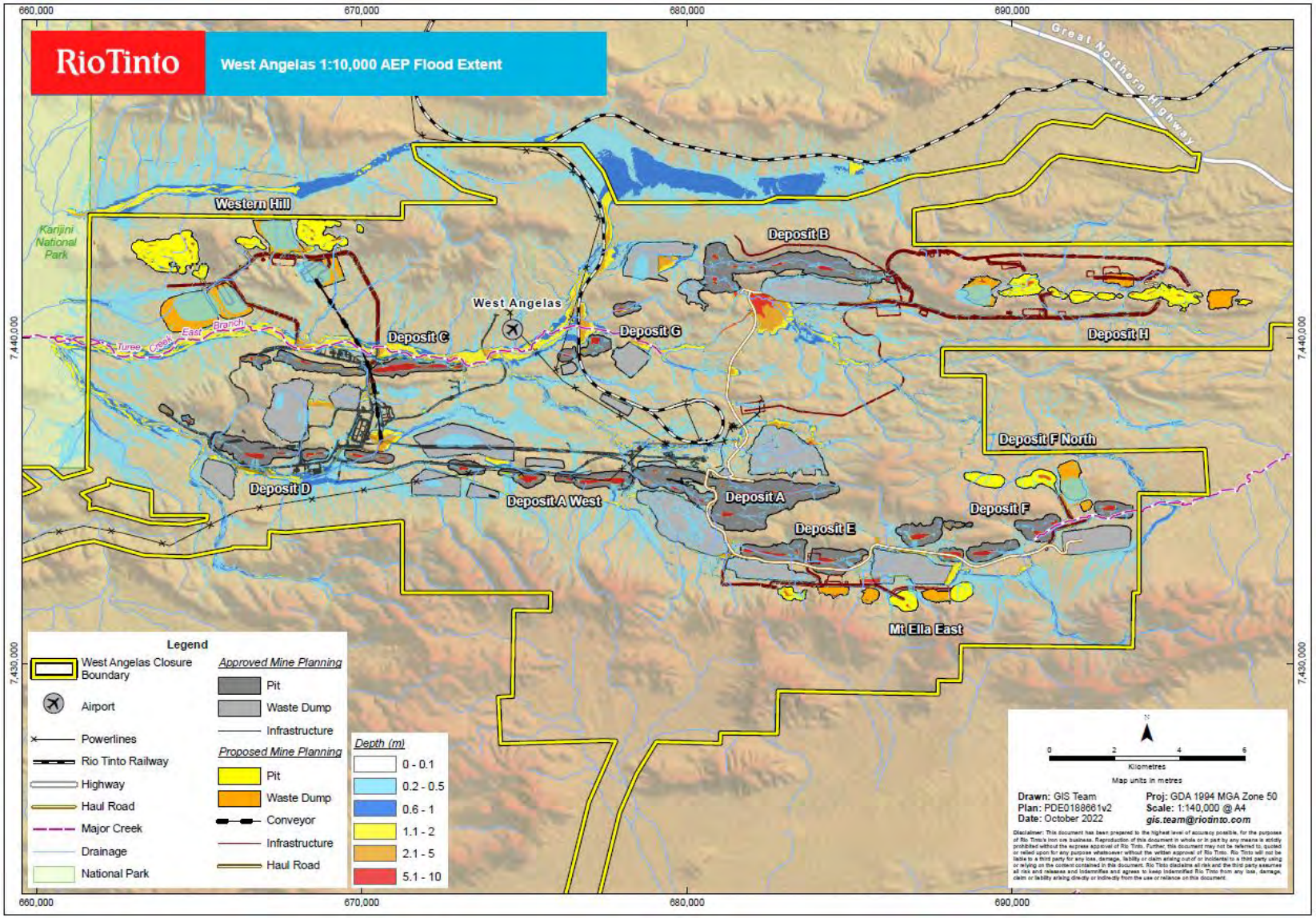


Figure 5-25: 1:10,000 AEP peak flood depths scenario

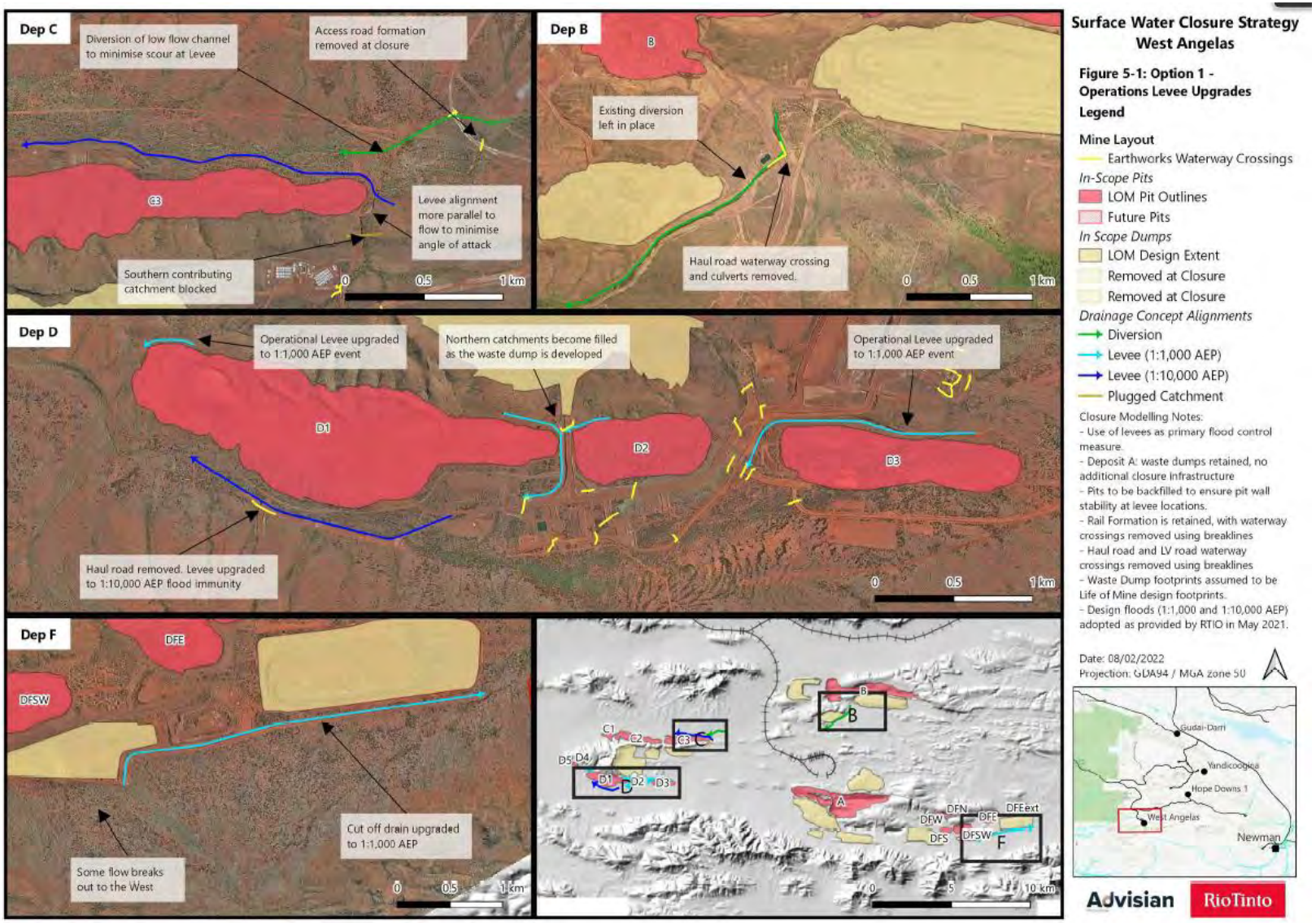


Figure 5-26: Locations of levees and diversion at West Angelas based on option 1

Proposed Operations

Pre- and post-development flooding was evaluated for the four Beyond 2020 deposits (the Proposal deposits) for design storm events of between 1:2 and 1:200 AEPs. Closure surface water and landform stability risks were evaluated using regional TUFLOW modelling of rare to extreme flooding, including the 1:1000 and 1:10,000 AEP design flood events. These are presented in Figure 5-27- and Figure 5-28-. The Beyond 2020 deposits are located away from the floodplains of the major creek systems in the area, being Turee Creek East and its larger tributaries and as such do not introduce any new large-scale closure risks in relation to surface water management.

Western Hill - The pit voids of Western Hill are in an elevated position within the ridgeline between Turee Creek East and a valley to the north. Western Hill will impact a number of relatively small catchments, of which the largest is 4.1 km². There is no potential for interaction between the floodplain of any major creek and the pit voids. Waste dumps and stockpiles have also been placed in an elevated position away from the floodplain. The dump at the south-western corner of the deposit is outside of the 1:10,000 AEP floodplain of Turee Creek East. Small hillslope catchments are likely to be captured by the pit void at closure. Dump and stockpile designs in the vicinity of the Karijini National Park will need to apply appropriate stand-off from the park boundary and floodplain of Turee Creek East and minimise interference with overland flow paths to prevent mobilisation of sediment. No flood protection is required for pits which are located on upper hillslopes and catchment divides.

Deposit F North - Both proposed pits and waste dumps are located away from major watercourses and are unlikely to introduce significant surface water risks at closure. Small catchments to the south of the pit voids, with the largest approximately 0.3 km², will likely be captured at closure, and the proposed waste dump location is located on a hillslope and will not intercept drainage lines. No flood protection is required for the current pit design given the small upstream catchments. Potential expansions of the pit to the east may require small diversion drains to protect the pit from flooding.

Deposit H - Deposit H is located in an elevated position away from large creek systems. The pit voids will lead to capture of smaller local drainage lines, and waste dumps will also act to remove parts of the catchment area. The western pit at Deposit H will intercept a small creek with a catchment of 1.5km^2. This is likely to permanently reduce flow through the ephemeral pool at Deposit H, and to the potential GDE area located further downstream (see Section 5.13.5). No landform stability risks have been identified for the deposit, and standard waste dump rehabilitation is expected to be adequate.

There is an ephemeral rock pool, with a catchment area of approximately 3.3 km², downstream from the proposed Western Pit and waste dump. Development of the pit and waste dump could remove up to 2.2 km² of the total catchment area. Two options to divert upstream runoff and maintain catchment flow to the pool are currently being considered. Both options will retain flow volume to the pool at approximately 30% of baseline (pre-development), which would maintain pool hydrological functioning. Diversion options have only been assessed at order of magnitude level. The closure approach is yet to be finalised, however, with the Deposit H pits not proposed to be backfilled to surface, the proposed diversion drain at the western pit will likely need to be retained at closure to maintain flows to the pool. Further work is required to understand the risk at closure, sizing of the drain, etc.

Mount Ella East – The pits at Mount Ella East are located in upper hillslopes and only intercept smaller drainage lines from the ranges, and as such do not present a significant risk with regard to landform stability adjacent to watercourses. The conceptual waste dumps at the western end of the deposit will intercept minor creeks and pond water but do not interact with larger drainage lines. The eastern conceptual waste dumps are located within sheet flow areas which have larger catchment areas associated with them which may require modification or small amounts of stream training to divert flows around the waste dump toe.

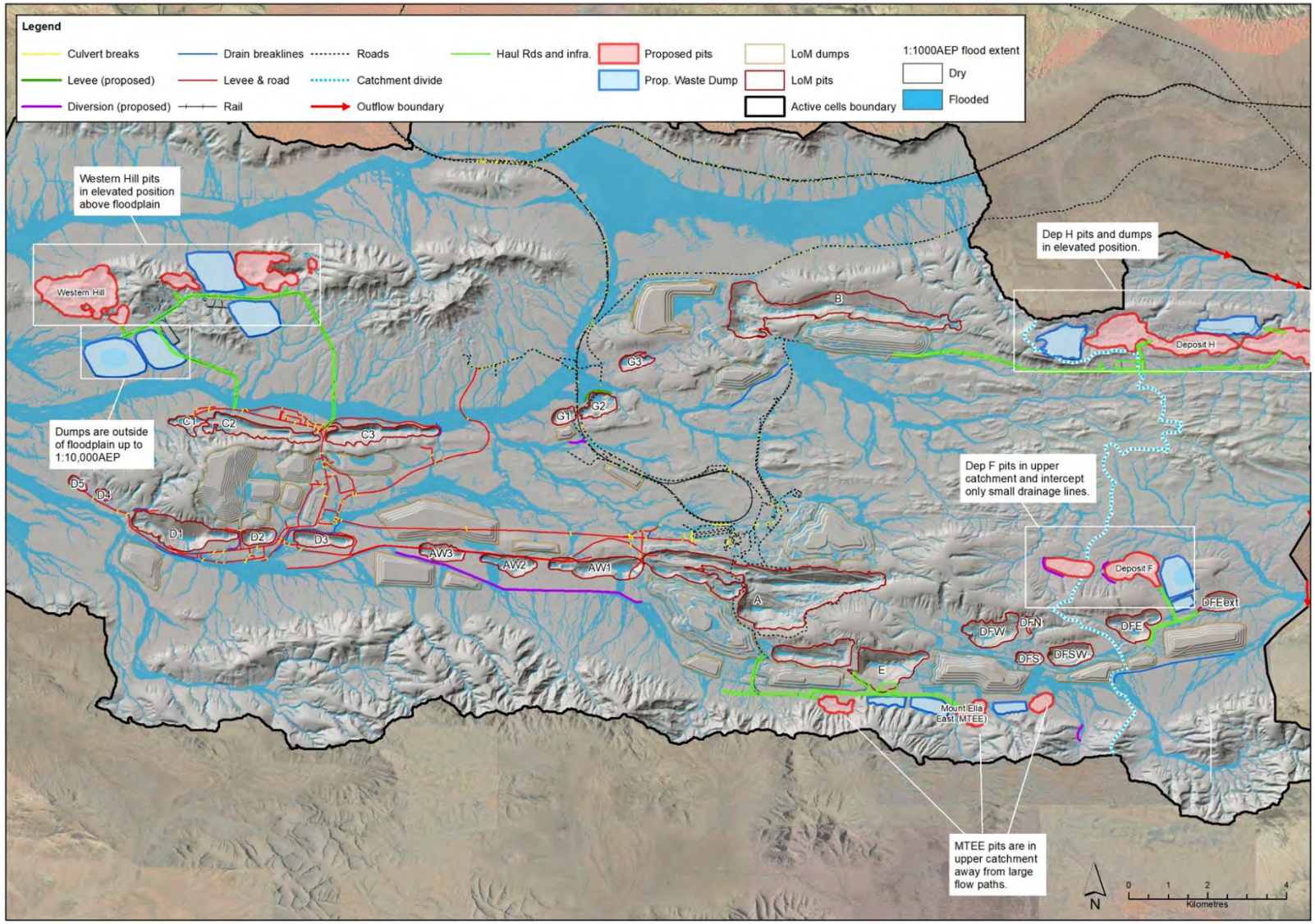


Figure 5-27-: 1:1,000 AEP peak flood depths scenario – Proposed operations

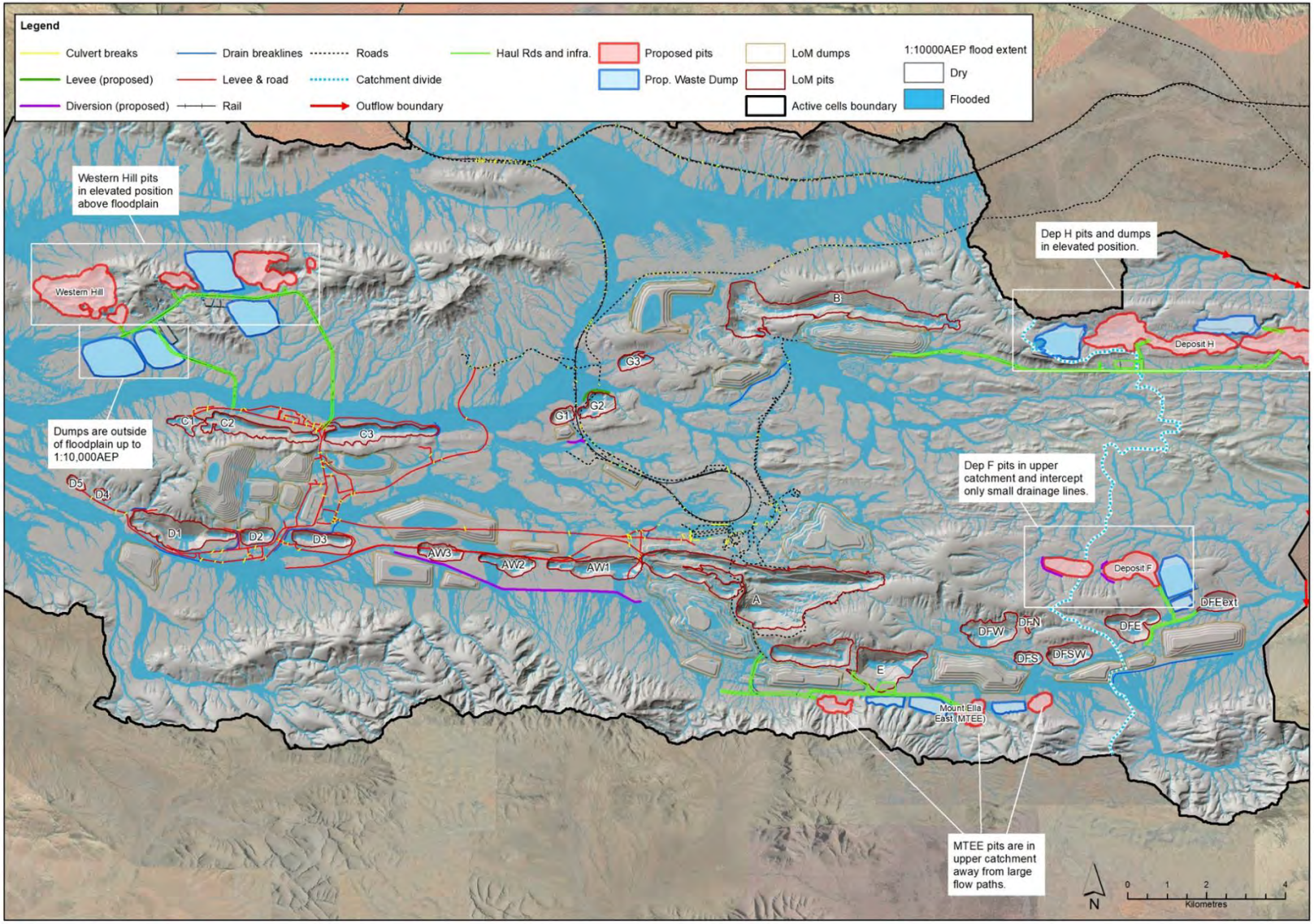


Figure 5-28-: 1:10,000 AEP peak flood depths scenario – Proposed operations

5.10.4. Implications for closure and knowledge gaps

Closure implications associated with hydrology include:

- Current flood modelling suggests that various pits will intercept surface water flows under flood conditions, as well as landforms impeding flows.
- Flood management structures will be implemented to enable the West Angelas deposits to be mined safely and maintain downstream flows in Turee Creek East and into Karijini National Park, and at Deposit H Waterhole in the long term.
- A material inventory of fit-for-purpose waste rock is required to determine if sufficient quantities are available to construct permanent surface water diversions and pit buttressing to closure designs.
- Key surface water features are of environmental and cultural heritage significance and need to be considered in the closure strategy to ensure closure outcomes can be achieved.

Closure knowledge gaps associated with hydrology, as summarised in Table 6-1, include:

- Further refinement of the hydrological model to better evaluate and define closure designs for currently planned and future permanent surface water diversions and pit buttressing, to be included in each MCP update.
- Further refinement of the hydrological model and mine plan in relation to significant surface water pools to support consultation with nominated Yinhawangka / Ngarlawangga representatives and refine rehabilitation outcomes.
- Development of detailed scour assessments, based on sediment sampling and flood modelling, to improve rock protection quantity estimates.

5.11. Contaminated sites

Registers are maintained for potentially contaminating activities and known or suspected contaminated sites, which have been formally reported under s11 of the *Contaminated Sites Act 2003* (WA). The registers are informed by regular review of operations and, where required, by preliminary or detailed site investigations to assess contaminants associated with such activities and assess their risk of harm to human health, the environment and environmental values.

Rio Tinto has reported the West Angelas Power Station (Portion of Miscellaneous Licence L47/409, Unallocated Crown Land, Newman WA 6753) as a Suspected Contaminated Site following a 51kl diesel spill. Subsequently on 24 May 2023, The Department of Water and Environment Regulation (DWER) classified the West Angelas Power Station site under the CS Act as Contaminated – restricted use (CRU). RTIO are currently in the process of implementing a package of works to delineate hydrocarbon impacts and determine if any risks to human health, the environment and/or environmental value remain.

All potentially contaminating activities and land uses identified on the site register are managed as part of the ongoing mining operation. Prior to closure as part of the decommissioning process, a contaminated site assessment will be undertaken. Based on this assessment, specific plans will be developed to remediate or manage contaminants, where required, to support the post-mining land use

5.11.1. Implications for closure and knowledge gaps

Closure implications associated with contaminated sites include:

- As part of the decommissioning process contaminated sites assessment will be undertaken in areas where known or suspected contaminating activities may have occurred throughout mine life.
- Where required, specific plans will be developed to remediate or manage contaminants to ensure the post-mining land use is not precluded.

Closure knowledge gaps associated with contaminated sites, as summarised in Table 6-1, include:

- Contaminated sites assessment as part of decommissioning and development of remediation or management plans, as required.
- Location and volume of contaminated soils and groundwater underneath infrastructure areas that may require remediation.

BIOLOGICAL ENVIRONMENT

5.12. Conservation Significant Areas

5.12.1. National Parks

The closest conservation reserve to West Angelas is Karijini National Park (KNP). KNP is located to the west of the closure boundary and protects 627,400 ha of land within the Pilbara bioregion.

5.12.2. Threatened and Priority Ecological Communities

No Threatened Ecological Communities (TECs) as defined by the BC or EPBC Act occur within the Revised Development Envelope. The closest TEC is the Ethel Gorge Aquifer Stygobiont Community, located approximately 110 km east of the Development Envelope.

The Revised Development Envelope of the proposal includes mapped areas of the 'West Angelas Cracking-Clays' Priority 1 Priority Ecological Community (PEC). The PEC is described as open tussock grasslands of *Astrebla pectinata*, *A. elymoides*, *Aristida latifolia*, in combination with *Astrebla squarrosa* and low scattered shrubs of *Sida fibulifera*, on basalt derived cracking clay loam depressions and flow lines. The major risks facing this PEC are mining, weed invasion and changes to fire regimes

No clearing within the West Angelas Cracking Clay Priority Ecological Community; PEC-2015-5 is permitted during operations or closure as specified in MS 1113. This includes direct disturbance that could occur as waste dump footprints are expanded during rehabilitation in order to create stable landforms. Up to 20 ha of disturbance to other expressions of the PEC is currently authorised under MS 1113.

Notwithstanding controls against direct disturbance of PEC areas, there is the potential for indirect impacts resulting from changes to surface water flow regimes caused through the altered landform. This is a risk that will need to be evaluated when final landscaping profiles have been developed, and passive mitigation measures adopted where appropriate. Task WAN-12 is included in the closure task register (Appendix 3) to evaluate the final landform design with respect to the potential for impacts to cracking clay communities.

Potential groundwater dependent ecosystem of Karijini National Park

Biological surveys conducted at West Angelas have identified a *potential* GDE located inside the KNP boundary. The potential GDE is defined by stands of *Eucalyptus victrix* and *Eucalyptus camaldulensis* at elevated densities. Rio Tinto will manage the West Angelas operation so that there is no groundwater drawdown beneath KNP as per the requirements of Condition 6 of MS 1113.

5.12.3. Implications for closure and knowledge gaps

Closure implications for West Angelas associated with Conservation Significant Areas include:

- Conservation significant areas are key values in the landscape and factor into closure planning related to post closure land use, access to the landscape and closure outcomes.

Closure knowledge gaps associated with Conservation Significant Areas, as summarised in Table 6-1, include:

- Consideration of the impacts of closure strategy on conservation significant areas.
- Proposed closure landscapes and their impacts on surface water flows in relation to conservation significant areas.

5.13. Flora and Vegetation

Flora and vegetation surveys have been conducted within or overlapping the West Angelas Revised development envelope to inform the Part IV approvals process (Figure 5-29), the results of which have been consolidated into a Biological Knowledge Database (Appendix 10).

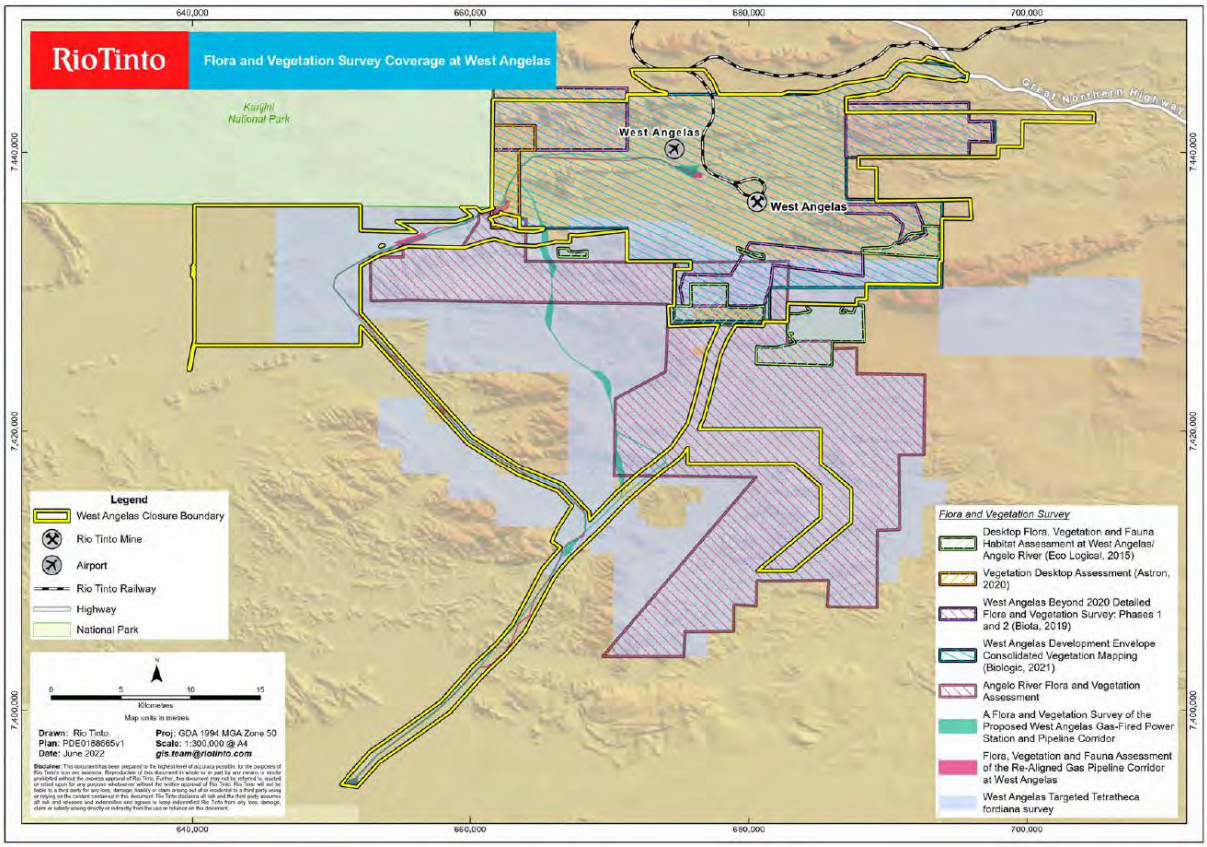


Figure 5-29: Flora and vegetation survey coverage at West Angelas

5.13.1. Vegetation communities

Forty-seven (47) vegetation types have been described within the Revised Development Envelope (Biologic 2021a) The most widespread Dominant vegetation types include:

Table 5-38: Dominant vegetation associations

Vegetation association	Description
M1: *Acacia 'aneura'*,	*Acacia pruinocarpa* low open woodland/*A. aneura*, *A. catenulata* subsp. *occidentalis* and/or *A. pruinocarpa* low woodland to low open forest - *Eremophila forrestii* subsp. *forrestii* open shrubland *Triodia pungens* open hummock grassland/*T. pungens* very open hummock grassland (occupying 5,352 ha (15%) of the Development Envelope).
H4: *Acacia inaequilatera*	Scattered tall shrubs *Triodia wiseana* open hummock grassland (occupying 3,755 ha (10%) of the Development Envelope)
H7: *Eucalyptus leucophloia* subspecies	Scattered low trees *Acacia maitlandii* scattered shrubs *Triodia vanleeuwenii, T. pungens* open hummock grassland (occupying 2,283 ha (6%) of the Development Envelope).

Of the vegetation types recorded in the Development Envelope, 45 were broadly associated with four major landforms: Drainage Lines (11 vegetation types); Gullies/Gorges (three vegetation types); Stony Hillslopes, Hill Crests and Foothills (15 vegetation types); and Stony Plains, Sand Plains and Clay Plains (16 vegetation types). The remaining two vegetation types are considered a mosaic of the others.

5.13.2. Vegetation condition

Vegetation condition within the Revised Development Envelope ranges from excellent to completely degraded, with the majority classified as being in either excellent (15,571 ha, 42.3%) or very good (11,612 ha, 31.6%) condition (Biota 2020, Biologic 2022b). Native vegetation within the Revised Development Envelope is largely considered to be in better condition than other areas of the Pilbara, based on the lack of historical pastoral activities and associated disturbance (Biota 2020). Most of the vegetation within the Extension Areas is classified as either excellent (6,546 ha, 77.4%) or very good (1,528 ha, 18.1%).

Approximately 28,907 ha (78.6%) of vegetation within the Revised Development Envelope is in 'good to excellent condition' and 7,857 ha (21.4%) is classified as being completely degraded due to impacts from Existing Operations, including clearing undertaken for mining exploration activities for the Proposal. Approximately 383 ha (4.5%) of the Extension Areas is classified as being Completely Degraded.

5.13.3. Threatened and Priority Flora

Significant flora includes species listed under the EPBC Act, the BC Act, or Priority species identified by DBCA as requiring further protection (EPA 2016). Significant flora can also include species that are locally endemic or associated with a restricted habitat type, occur as range extensions, are a new species or have anomalous features that indicate a potential new species, represent a restricted subspecies, varieties or hybrids, or are relictual representatives of taxonomic groups that no longer occur widely in the broader landscape. No threatened flora species have been identified at West Angelas. Twenty eight species of Priority flora taxa P2 (7), P3 (17) and P4 (4) have been recorded within the Revised Development Envelope (Table 5-39).

Table 5-39: Conservation significant flora identified at West Angelas

Flora taxon	Conservation status WA	Habitat comments
Aristida lazaridis	Priority 2	Sand or loam.
Eremophila pusilliflora	Priority 2	Flat terrain, low in landscape, base of broad valley, stony gibber plain above shallow drainage line, red clay loam.
Eremophila sp. West Angelas (S. van Leeuwen 4068)	Priority 2	High in landscape, summit of hill, gently undulating to steep terrain, skeletal red gritty soil over massive banded iron of the Brockman Iron Formation.
Euphorbia inappendiculata var. *inappendiculata*	Priority 2	
Hibiscus sp. Gurinbiddy Range (M.E. Trudgen MET 15708)	Priority 2	Near summit of hill, high in landscape, skeletal red brown stony soil over massive ironstone of the Brockman Iron Formation.
Oxalis sp. Pilbara (M.E. Trudgen 12725)	Priority 2	Gully. Brown red loam, cobbles and pebbles.
Tetratheca fordiana	Priority 2	Shale pocket amongst ironstone.
Acacia effusa	Priority 3	Stony red loam. Scree slopes of low ranges.
Acacia subtiliformis	Priority 3	Rocky calcrete plateaux.
Aristida jerichoensis var. *subspinulifera*	Priority 3	Hardpan plains
Dolichocarpa sp. Hamersley Station (A.A. Mitchell PRP 1479)	Priority 3	Cracking clay, basalt. Gently undulating plain with large surface rocks, flat crabholed plain.

Flora taxon	Conservation status WA	Habitat comments
Eremophila naaykensii (A.L.Curtis & K.R.Thiele)	Priority 3	NA
Euphorbia clementii	Priority 3	Sandplains, gravelly hillsides, stony grounds.
Grevillea saxicola	Priority 3	Breakaways and scree slopes, orange-brown loam soils.
Indigofera gilesii	Priority 3	Pebbly loam amongst boulders and outcrops.
Isotropis parviflora	Priority 3	Valley slope of ironstone plateau.
Olearia mucronata	Priority 3	Schistose hills, along drainage channels.
Pilbara trudgenii	Priority 3	Skeletal, red stony soil over ironstone. Hill summits, steep slopes, screes, cliff faces.
Rhagodia sp. Hamersley (M. Trudgen 17794)	Priority 3	Broad plain at the base of hills (enclosed on all sides). Red brown clay/loam. Ironstone pebbles.
Solanum kentrocaule	Priority 3	Hillsides and mountaintops, or occasionally creek-beds, in skeletal red-brown soil over ironstone or on basalt scree.
Swainsona thompsoniana	Priority 3	NA
Themeda sp. Hamersley Station (M.E. Trudgen 11431)	Priority 3	Red clay. Clay pan, grass plain.
Triodia sp. Mt Ella (M.E. Trudgen 12739)	Priority 3	Light orange brown, pebbly loam. Amongst rocks and outcrops, gully slopes.
Vittadinia sp. Coondewanna Flats (S. van Leeuwen 4684)	Priority 3	Flat plain. Red sandy clay loam.
Acacia bromilowiana	Priority 4	High in landscape, summit of hill and on steep slope, skeletal red gritty soil over massive basalt type rock.
Eremophila magnifica subsp. magnifica	Priority 4	Skeletal soils over ironstone. Rocky screes.
Lepidium catapycnon	Priority 4	Skeletal hills, hillsides.
Sida sp. Barlee Range (S. van Leeuwen 1642)	Priority 4	Skeletal red soil pockets. Steep slopes.

5.13.4. Riparian Vegetation

In the Pilbara riparian vegetation is typically represented by that increasingly dense vegetation which establishes surrounding the low flow channel of moderate to major sized drainage systems, and where the overstorey is typically comprised of keystone tree species such as *Eucalyptus camaldulensis*, *E. victrix* and to a lesser extent other common riparian tree species such as *E. xerothermica*. They cover approximately 392 ha of the Revised Development Envelope.

5.13.5. Groundwater Dependent Ecosystems

Within the Development Envelope, only one potential example of GDV was identified as part of the detailed flora and vegetation survey, predominantly due to its association with Turee Creek and the presence of *E. victrix*. A subsequent GDE assessment was commissioned, using multiple lines of biological evidence (including remote sensing) and basic hydrologic evidence to identify vegetation features with a moderate or greater likelihood of groundwater dependence (SLR 2022)

The GDE assessment identified four vegetation features within and around the Proposal exhibiting a moderate likelihood of groundwater dependence based on the biological evidence:

- Feature 1a (19 ha). 'Low-moderate' groundwater dependence likelihood. *E. camaldulensis* woodland over *E. xerothermica* low open woodland associated with an upper tributary of Turee Creek between Western Hill and Deposit H, and thought to be accessing a relatively small scale perched (potentially seasonally) groundwater source located in a local clay feature; inferred depth to regional groundwater >45 m. This feature presents some of the best biological evidence for vegetation groundwater access within the Revised Development Envelope, however the associated landforms and setting determine that the nature of the supporting water source is still unclear. As this feature overlies basaltic parent rock possessing generally negligible hydraulic conductivity, any drawdown related to the proposal is highly unlikely to be able to propagate into this area, and as such, regardless of the nature of its supporting water resource, potential for indirect impact is considered negligible.
- Feature 12 ('Turtle Pool') (>1 ha). 'Low-moderate' groundwater dependence likelihood. Woodland of *E. victrix* and *E. camaldulensis* co-dominant, *E. xerothermica* also common over *Acacia* shrublands; located outside of the Revised Development Envelope to the east of Deposit H; inferred depth to regional groundwater >50 m so considered to be accessing a seasonally perched water resource that appears predominantly surface water fed. As a result, potential for impact to this feature is considered very low.
- Feature 14 (14.6 ha)). 'Low-moderate' groundwater dependence likelihood. Woodland of *E. victrix* and *E. camaldulensis* co-dominant, *E. xerothermica* also common over *Acacia* shrublands; located outside of the Revised Development Envelope to the north of Deposit H where the inferred depth to regional groundwater is >50 m; vegetation appears severely water limited, indicating association with at least a seasonal water resource, probably a local perched aquifer.
- Feature 22. 'Moderate' groundwater dependence likelihood. This feature is the previously described potential GDE located outside the Revised Development Envelope to the west within Karijini National Park and associated with Turee Creek East (EPA 2019).

None of these features are considered to be reliant to any extent on the regional groundwater resource (Wittenoom Formation) or local groundwater formations that will be impacted by the Proposal.

5.13.6. Weeds

A total of 24 introduced flora species (weeds) have been recorded within the West Angelas closure boundary. These species are largely found in low lying areas and along creek lines. None of these species are listed as Weeds of National Significance or declared plants for the Pilbara region under the *Biosecurity and Agriculture Management Act 2007* (WA).

The Department Biodiversity, Conservation and Attractions (DBCA) Weed Species Ranking takes into account the potential distribution, current distribution, ecological impact, invasiveness and feasibility of control to derive a final broad qualitative weed species ranking corresponding to specific management actions.

5.13.7. Implications for closure and knowledge gaps

Closure implications associated with flora and vegetation include:

- Exclusions zones around conservation significant flora species will be maintained through the decommissioning, closure and rehabilitation implementation phases.
- Vegetation assemblages impacted by weeds on site.

Closure knowledge gaps associated with flora and vegetation as summarised in Table 6-1, include:

- Flora species recorded in baseline surveys and analogue site monitoring will be used to inform rehabilitation seed mixes.

- Vegetation mapping will be used to inform the selection of reference sites and inform the development of revegetation completion criteria (species richness, percentage cover and percentage weed cover) and monitor against progressive rehabilitation.

5.14. Fauna and habitat

Fauna surveys have been completed wholly or partially within the West Angelas closure boundary as part of original operational approval requirements. Additional surveys to support the Proposal have been completed with the revised closure boundary, with coverage shown in Figure 5-30. A summary of the West Angelas fauna knowledge base is provided in Appendix 10.

5.14.1. Terrestrial fauna habitat

There are six habitat types identified within the West Angelas Revised Development Envelope. These habitats include Gorge/Gully; Drainage Line; Hillcrest/Hillslope; Mixed Acacia Woodland; Footslopes and Plain; and Cracking Clay (Biologic 2021b (Figure 5-31). Characteristics of these habitat types are provided in Table 5-40.

Hilltops, gullies and creek habitats are of high value due to the diversity of microhabitats and potential to support conservation significant fauna species, while plain and valley habitats have lower value.

Table 5-40: Characteristics of fauna habitats within West Angelas closure boundary

Landform	Basic description
Hillcrest/Hillslope	Hillcrest/Hillslope habitat tends to be more open and structurally simple than other fauna habitats. A common feature of this habitat is a rocky substrate, often with exposed bedrock, and skeletal red soils. These can contain cracks and crevices, but not to the same extent as within rocky upland areas of Gorge/Gully habitat. This habitat is usually dominated by open *Eucalyptus* woodlands, *Acacia* and *Grevillea* scrublands and *Triodia* low hummock grasslands. Widespread within Revised Development Envelope and wider region. Significance rating presumes presence of caves considered critical for survival of Ghost Bat populations.
Gorge or gully	Gorges and gullies are rugged, steep-sided valleys incised into the surrounding landscape. Gorges tend to be deeply incised, with vertical cliff faces, while gullies are more open (but not as open as Drainage Line habitat or valleys). Caves and deep, rocky crevices are most often encountered in this habitat type, as are water pools. Vegetation can vary and can be dense and complex in areas of soil deposition or sparse and simple where exposed outcropping or erosion has occurred. Limited extent within the Revised Development Envelope and widely distributed across the Pilbara.
Footslope or plain	Footslopes and Plain habitat comprises low-lying open plains and the rolling hills below upland areas. Vegetation within this habitat varies in composition; however, is generally dominated by scattered mulga and *Acacia pruinocarpa* forming an over-storey, with a mid-storey comprising *Eremophila* and *Ptilotus* spp., over low hummock grasslands of *Triodia wiseana, T. basedowii, T. longifolia* and *T. pungens*. Scattered *Corymbia hamersleyana, Eucalyptus leucophloia* and *E. gamophylla* were also present. Widespread within Revised Development Envelope and wider region.
Mixed *Acacia* woodland	Mixed Acacia Woodland habitat comprises areas where vegetation is a dense mix of Acacia, with a mixture of mulga (*Acacia aneura*), *Acacia maitlandii* and *Acacia pruinocarpa* over a mixture of sparse small shrubs and grasses, such a Triodia and *Senna* species and *Ptilotus* sp. Dense leaf litter, and woody debris is a common feature of this habitat type. The soils consist of loam clay with continuous layers of small ironstone pebbles on the surface. The habitat is mostly flat with no or very small drainage channels. Limited extent within the Revised Development Envelope but widespread through the Pilbara region.

Landform	Basic description
Cracking clay	Characterised by sand-clay to clay soils with an undulating surface caused by crabholes and gilgai. Rocks and pebbles were very rare and when present, the rock type was consistently ironstone. This habitat supports very few trees or tall shrubs and is characterised by open and sparse low vegetation with approximately half of its area being bare ground. Isolated shrubs of *Salsola australis, Boerhavia paludosa* and *Ptilotus nobilis* subsp. *nobilis* were present over open tussock grassland of *Aristida* sp., *Brachyachne* sp. and *Astrebla pectinata.* This habitat is identified as Priority 1 ecological community due to its restricted distribution across the Pilbara, and contains species which are both rare and edaphically restricted (i.e. distribution is influenced by the soil rather than by the climate). This habitat zone will be protected as far as practicable during mining activities and will be present in undisturbed areas to the north of Deposit A West and south of Deposit B. The soil profile required to restore this habitat is not compatible with the closure landform; although, following further investigation, opportunities may exist to establish a community in an appropriate locations by relocating habitat scheduled to be destroyed (e.g. areas under Deposit B waste dumps).
Drainage Line	Drainage Line habitat is variable in structure and condition. Temporary, semi-permanent – permanent water pools can occur within this habitat, usually after rainfall events. Vegetation within this habitat is often dominated by *Eucalyptus* or *Melaleuca* species over a variable understory comprising mixed small to medium shrubs (Acacia sp.) and tussock grasses over sandy creek beds. Vegetation adjacent to the main channel or channels is denser, taller and more diverse than adjacent terrain. The structure and condition of vegetation often varies seasonally, particularly following rainfall events. Vegetation condition often subject to heavy cattle grazing. This habitat zone will be present in undisturbed areas outside of the mine. Disturbed creek habitat, i.e. access roads that cross creeks and discharge related infrastructure, will be rehabilitated with the aim of returning the land to functional creek habitat.

5.14.2. Conservation significant fauna

Fauna survey coverage is shown in (Figure 5-30) and Table 5-41 lists the 12 significant fauna species that have been recorded within the West Angelas Revised Development Envelope or are likely to occur based on nearby records and suitable habitat presence and availability.

Table 5-41: Significant fauna and its relationship to habitat at West Angelas

Common Name	Scientific Name	Conservation status WA	EPBC Act status	Habitat occurrence
Northern quoll	*Dasyurus hallucatus*	Schedule 2	Endangered	Gullies Disturbed
Pilbara leaf-nosed bat	*Rhinonicteris aurantia*	Schedule 3	Vulnerable	Gullies Hilltop
Olive python	*Liasis olivaceus barroni*	Schedule 3	Vulnerable	All hill habitats
Grey falcon	*Falco hypoleucos*	Schedule 3	Vulnerable	Acacia woodland Mulga woodland All drainage habitats

Common Name	Scientific Name	Conservation status WA	EPBC Act status	Habitat occurrence
Ghost bat	*Macroderma gigas*	Schedule 3	Vulnerable	Gullies Hilltop
Fork-tailed swift	*Apus pacificus*	Schedule 5	Migratory	All drainage habitats
Peregrine falcon	*Falco peregrinus*	Schedule 7	-	All habitats
-	*Anilios ganei*	Priority 1	-	All habitats
Pilbara barking gecko	*Underwoodisaurus seorsus*	Priority 2	-	All hill habitats
Western pebble-mound mouse	*Pseudomys chapmani*	Priority 4	-	All hill habitats
Short-tailed mouse	*Leggadina lakedownensis*	Priority 4	-	All
Brush-tailed Mulgara	*Dasycercus blythi*	Priority 4	-	Footslopes and Plain

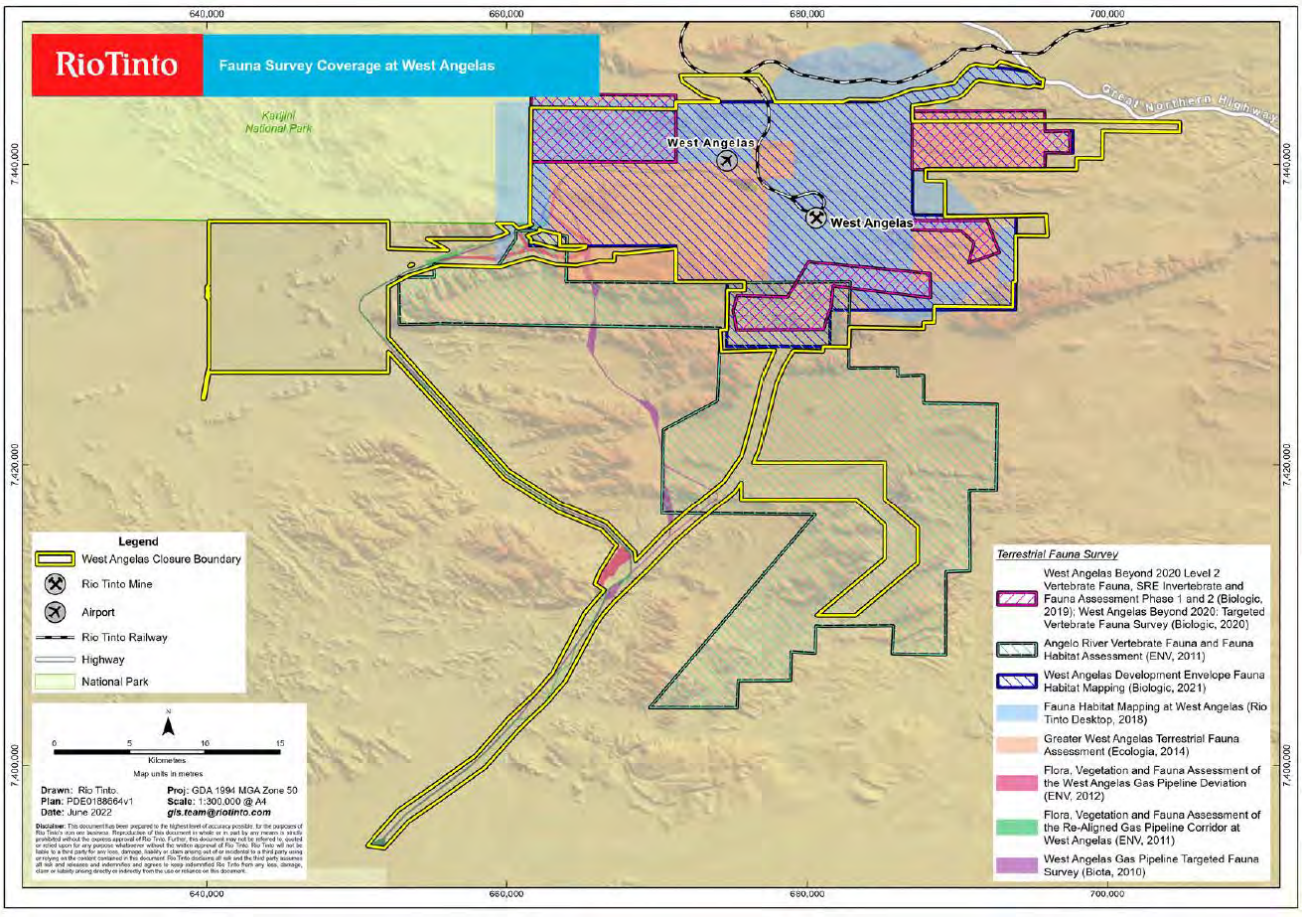


Figure 5-30: Fauna survey coverage at West Angelas

5.14.3. Short range endemic fauna

Of the broad habitat types within the West Angelas closure boundary, one habitat feature (Gorge/Gully) was identified as having intrinsic value to short range endemic (SRE) fauna.

Six higher order taxonomic groups with the potential to include SRE species were recorded in the survey, however, none of these included taxa currently confirmed as SREs.

In total, 75 unique taxa have been recorded within the Revised Development Envelope. Thirty eight of these taxa are considered Potential SREs (Appendix 10).An additional nine potential SRE taxa were recorded within the Revised Development Envelope that could not be identified to species or subspecies level. All of these specimens were collected in multiple or widespread habitats and are not considered further in this assessment. None of the taxa recorded represent Confirmed SREs.

5.14.4. Subterranean fauna

Subterranean fauna includes troglofauna (terrestrial subterranean fauna) and stygofauna (aquatic subterranean fauna). Both groups have ecological importance due to their species richness, evolutionary history and adaptation to their environment (Humphreys 2017). Subterranean fauna species have the potential to have restricted distributions and as a result short-range endemism is common in this group (Harvey 2002).

The main geological/ hydrogeological formations which provide habitat for subterranean fauna comprise:

- Weathered/ fractured bedrock habitats of the hills and ranges, including:
    - Dales Gorge and Joffre Members of the Brockman Iron Formation, Mt Newman Member of the Marra Mamba Formation, and Wittenoom Dolomite in the valleys (typically BWT).
- Detrital habitats on the lower flanks and valleys, including:
    - Unconsolidated or porous alluvium/ colluvium, and colluvium and weathered/ fractured calcrete within the synclinal valley.

Stygofauna

Sixteen subterranean fauna surveys have been undertaken across the West Angelas region since 1998. A total of 490 stygofauna specimens representing 23 stygofauna species (or species-level taxa) were recorded within the Revised Development Envelope and immediate surrounds.

Twelve stygofauna taxa considered relevant to the Proposal represented six taxonomic Orders comprising Amphipoda (4 taxa), Bathynellacea (2 taxa), Harpacticoida (1 taxon), Podocopida (1 taxon), Tubificida (3 taxa), and Isopoda (1 taxon). The majority of the stygofauna were recorded within the synclinal aquifer south of the Western Hill Deposit area, and at reference areas such as Turee Creek borefield and the Central borefield in the centre of the anticline. Stygofauna sampling at Mt Ella East and Deposit F North was constrained by groundwater occurrence at considerable depth from surface and limitations on the depth of drilling resulting in relatively few bores/ drill holes intercepting groundwater.

Troglofauna

A total of 165 troglofauna specimens representing 77 troglofauna species (or species-level taxa) of which 42 were relevant to the Proposal, were recorded within the Proposal Development Envelope and immediate surrounds. The 42 relevant troglofauna represented 12 taxonomic orders from groups that are well represented from subterranean fauna surveys in similar geological settings regionally (i.e. Araneae (5 taxa), Blattodea (2 taxa), Symphyla (4 taxa), Diplura (2 taxa), Diptera (1 taxon), Hemiptera (2 taxa), Isopoda (2 taxa), Palpigradi (5 taxa), Pauropoda (6 taxa), Pseudoscorpiones (7 taxa), Scolopendrida (1 taxon) and Zygentoma (5 taxa)).

The species richness is considered to be moderately high compared to other similar surveys in the Pilbara region, mostly attributed to the size of the Revised Development Envelope, the spatial distance between sampled areas, variety in geologic habitats and overall survey effort (Biologic 2022a).

5.14.5. Introduced fauna

Feral carnivores known to occur in proximity to the mine (e.g. cats, dogs, foxes) can create locally increased predation pressure on native fauna as well as increase competition with native species for resources such as space (territory), water and food. Introduced herbivores can also have a significant impact in Rangeland areas, such as the Pilbara. In dry times, grazing pressure reduces the abundance of palatable native species, impacting biodiversity and can create conditions that encourage weeds to grow. Foot traffic impacts the soil conditions, and in combination with over grazing, can encourage erosion and cause damage to cultural sites.

5.14.6. Implications for closure

Closure implications associated with fauna and habitat values include:

- Any relevant restricted zones around priority fauna habitat will be maintained through the decommissioning, closure and rehabilitation implementation phases.
- Progressive rehabilitation of disturbed areas, no longer required for operational purposes, will be undertaken to re-establish native self-sustaining vegetation.

There are currently no closure knowledge gaps associated with fauna.

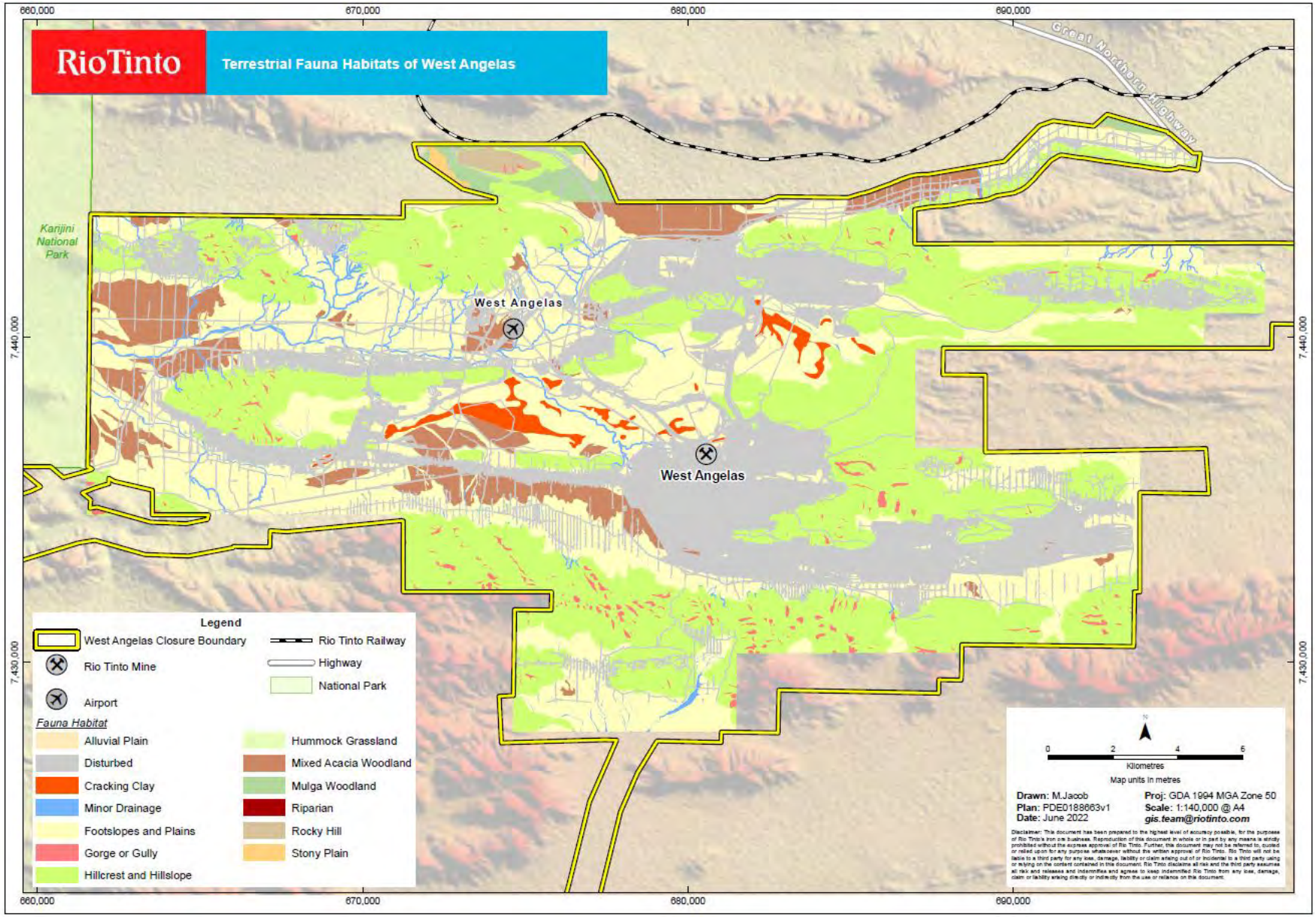


Figure 5-31: Terrestrial fauna habitat within West Angelas closure boundary

5.15. Rehabilitation monitoring and closure trials

5.15.1. Progressive rehabilitation monitoring

Rio Tinto undertakes progressive rehabilitation activities across its operations, which allows for the trialling of rehabilitation methods and strategies. The learnings taken from these trials inform future closure activities across the business.

Within the West Angelas closure boundary, all disturbed areas that can be accessed safely (except for pit floors and walls, and backfilled pits >10 m from natural surface) will be rehabilitated. A total disturbance area of 617.7 ha at West Angelas has been rehabilitated to date (Q1 2022), ranging from low disturbance areas to highly disturbed waste landforms. A West Angelas Progressive Rehabilitation Summary has been prepared to summarise Rio Tinto's internal completion reports and annual rehabilitation monitoring program for the West Angelas operations (Appendix 12). The objective of the rehabilitation program is to evaluate successional development of the rehabilitation and, thereby, provide feedback for the improvement of rehabilitation techniques, and to help assess progress towards long term rehabilitation goals and closure completion criteria.

Current rehabilitated features at West Angelas which are monitored utilising the vegetation transect method are summarised below and detailed in the Progressive Rehabilitation Summary (Appendix 12).

Rehabilitation not included in Table 5-42 are the historic progressive rehabilitation locations that do not have vegetation monitoring transects installed, such as exploration sites and decommissioned infrastructure areas, and recently completed rehabilitation which is yet to be monitored.

Implementation of progressive rehabilitation will occur, where possible, during the operational phase of West Angelas. Progressive rehabilitation will enable opportunities to undertake trials, reduce West Angelas' financial closure liability and demonstrate to key stakeholders Rio Tinto's commitment to meet the social and environmental licence to operate.

To date, 617.7 ha of rehabilitation has been completed at West Angelas, summarised below in Table 5-42 and in further detail in Appendix 12.

Table 5-42: Progressive rehabilitation completed at West Angelas

Year of rehabilitation	Domain / Area	Scope of rehabilitation	Status
Roads and other disturbance			
2004	Highway Access Road	Rehabilitation of access roads, involving ripping and spreading of topsoil, all located on flat topography. Seed was not applied.	The area has been monitored on four occasions since rehabilitation was completed. The most recent monitoring event conclude that rehabilitation was performing well as determined by transect and RQA monitoring methods. Vegetation was dominated by shrubs which were dense and provided good potential cover for fauna.
2015	West Angelas Access Road	Rehabilitation of access roads, involving ripping and spreading of topsoil, all located on flat topography. Seed was not applied.	The area has been monitored on four occasions since rehabilitation was completed and has been subject to wildfire events during this time. Current species density and plant density trends observed are characteristic of early-stage rehabilitation where colonising species establish quickly in the initial years and the short-lived species senesce shortly after.
Ex-pit waste landform (inert)			
2012	Deposit A East and South Waste Dump	Rehabilitation of 7.29 ha was undertaken in 2012. Works included re-profiling /dozing of waste dump slopes (to a maximum of 17 degrees), seeding, contour ripping and spreading of topsoil.	The area has been monitored on five occasions since rehabilitation works were completed. The rehabilitation was progressing well, particularly at the East Waste Dump. All native perennial cover and other vegetation density parameters achieved values within the reference site range or were similar to at least one reference site. Multiple vegetation layers were present on the rehabilitation, with spinifex mostly dominant and spinifex cover exceeding the reference sites.
2020	Deposit B West Waste Dump	Rehabilitation of 28.1 ha was undertaken in 2020. Rehabilitation followed generic design requirements, with a linear slope and back sloping berm design. Works involved clearing, re-profiling by dozing of slopes to the final landform design, hauling and spreading of topsoil, construction of crest and toe bunds, contour ripping and seeding. Some difficulty during topsoil application was reported due to it being described as soft and powdery.	Two monitoring events have been, with results from the second event currently pending and not discussed in this section. Initial results show varied early development in measured vegetation rehabilitation parameters.
2021	Deposit A South Western Dump	Rehabilitation of 78.1 ha was undertaken in 2021. Works involved re-profiling of slopes for final landform design, spreading of topsoil and subsoil, construction of crest and containment bunds, and contour ripping and seeding. Seed species were selected based on surrounding vegetation assessments, nearby rehabilitation reference sites, local provenance zones and legal obligations. Final ripping and seeding were completed in three stages between December 2020 and May 2021. A slightly higher	One monitoring event has so far been conducted on the landform, given the recent occurrence of the works. Initial results show positive early development in measured vegetation rehabilitation parameters.

Year of rehabilitation	Domain / Area	Scope of rehabilitation	Status
		than recommended rate of seed application was applied at the site. The increased rate was due to having both topsoil and subsoil trialled in different areas at the site, and to have consistency across both types of growth mediums.	
2021	Deposit A North Waste Dump Stage one and two	Rehabilitation of 100.6 ha was undertaken in 2021 in two stages. Works involved re-profiling of slopes for final landform design, spreading of topsoil and subsoil, construction of crest and containment bunds, and contour ripping and seeding.	
2022	North Waste Dump stage 3 and South Waste Dump Stage 2	Earthworks completed of approximately 114 ha at the two waste dumps.	

5.15.2. Research, investigations and trials

Research and trials which have occurred at West Angelas and have informed the closure and rehabilitation strategy, are detailed in. These projects are on-going at the time of writing this MCP and are presented in Table 5-43.

Table 5-43 Research and trials at completed / proposed at West Angelas

Date	Scope	Outcome	Relevance to closure strategy
2022	Alternative landform design	TBA – ongoing project	Assessing the option to landform waste dumps at West Angelas for greater erosion control and visual amenity.
2022	Waste Characterisation and inventory	TBA – ongoing project	Waste characterisation and inventory of materials to construct closure infrastructure such as creek diversions to ensure material used is appropriate and volumes are present.

6. CLOSURE KNOWLEDGE GAPS

This section provides a summary of all current closure knowledge gaps identified during closure planning and development of closure strategy for West Angelas. The closure knowledge for West Angelas informs the closure risk assessment (Section 7) and the West Angelas closure action register (Appendix 4).

Each iteration of the West Angelas MCP will include a review and refinement of the closure knowledge gaps, which will be progressively addressed through the Rio Tinto risk management process.

Table 6-1: Current closure knowledge gaps for West Angelas

Factor	Closure knowledge gap	Comment/timing	Associated task/action
Cultural Heritage			
Rehabilitation seed mix	The final rehabilitation seed mix will be finalised in consultation with Traditional Owners to ensure inclusion of appropriate species of ethnobotanical significance.	Current and on-going	• Ongoing consultations with Traditional Owners to further refine seed mix for rehabilitation. Ongoing research is needed to ensure continual improvement for rehabilitation performance and most efficient use of seed resources[10].
Access	Safe post-closure access routes to cultural heritage sites and other places of cultural value	To be progressively addressed through on-going engagement with Traditional Owners and consideration of the mine plan.	• Investigate the potential for cultural heritage values to be impacted post-closure (check that sites fall outside of ZOI), and evaluate the implications of impacts if they arise [515191]; • Develop closure strategies to maintain cultural heritage values (e.g. buttressing of deposit E 'pillar' to maintain its integrity post-closure, access maintained to petroglyphs north of deposit D following closure) [515192] • Engage with Traditional Owners regarding post closure land use objectives and expectations.
Closure	Consultation on closure outcomes and completion criteria based on consultation with Traditional Owners.	To be progressively addressed through on-going engagement with Traditional Owners	• Ongoing consultation with Traditional Owners to refine closure outcomes and completion criteria • Implementation of Traditional Owner engagement strategy for closure and rehabilitation [763062]

[10] Tasks/actions without an Archer reference identification number are considered to be inherently included in closure planning, as they are due more than 5 years from now and/or are undertaken as part of closure studies and as such are not stored in Archer.

Factor	Closure knowledge gap	Comment/timing	Associated task/action
		and consideration of the mine plan.	
Artefacts	Strategy for the safe keeping or return of any artefacts or materials salvaged.	To be progressively addressed through on-going engagement with Traditional Owners and consideration of the mine plan.	• Discuss the post closure strategy of salvaged artefacts with Traditional Owners.
Cultural heritage values	Potential for long-term indirect impacts to cultural heritage sites from areas of geotechnical instability, surface water movement and sediment transport	To be progressively evaluated with each update to the MCP.	• Assess potential for long-term indirect impacts to cultural heritage sites from areas of geotechnical instability, surface water movement and sediment transport as part of each MCP update. • Develop closure strategies to maintain cultural heritage values (e.g. buttressing of deposit E 'pillar' to maintain its integrity post-closure, access maintained to petroglyphs north of deposit D following closure) [515192] • Investigate the potential for cultural heritage values to be impacted post-closure (check that sites fall outside of ZOI), and evaluate the implications of impacts if they arise [515191]
Climate			
Climate Change	Consideration of climate change at West Angelas on: • revegetation success; • erosion resistant landforms; • the rebounding water table and its implications on backfill levels; and • flood modelling and closure surface water controls.	On-going; currently being addressed as part of the Rio Tinto Pilbara climate change risk assessment.	• Finalise site specific seed list for West Angelas [725551] • Undertake further site specific waste characterisation to better define dump erosion potential. [515185] • Undertake groundwater modelling where not yet completed to determine backfill levels for all pits [722362] • Develop designs for permanent diversions where required. [515187]
Soils			
Soil resources	There is a topsoil surplus for the landforms associated with current operations. However further investigation into topsoil availability for the proposed waste landforms are	TBA	• Further investigation into topsoil availability post completion of the proposed waste landforms

Factor	Closure knowledge gap	Comment/timing	Associated task/action
	required once all designs have been completed, and backfill planning refined.		
Geotechnical			
PUPEZ and Abandonment bunds	PUPEZ associated with final pit voids, abandonment bund locations and surface water management implications.	Current and on-going	• Ensure pit wall stability (ZOIs) and therefore Abandonment bunds at West Angelas do not compromises closure outcomes relating to environmental / heritage and waterway receptors. [1037933] • Confirm abandonment bund locations for areas not yet defined in detail [515186] • Geotechnical assessment of pit wall buttressing requirements [722196]
Mineral Waste			
Waste material characterisation	Characterisation of waste material to define geotechnical and geochemical properties and erosion classes. Further site-specific waste characterisation will be progressively undertaken when each mineral waste unit becomes available during mining operations.	Waste characterisation project currently being undertaken. Proposed to be completed by H2 2023, with future studies to completed pending outcome and future mining of waste units.	• Undertake further site specific waste characterisation to better define dump erosion potential. [515185] • Determine closure strategy for creek diversions [799551] • Review availability of competent materials to ensure sufficient volume of material is available to meet closure requirements [1038234]
Landform Design	The implication of site-specific waste types on the feasibility of achieving safe and stable rehabilitation outcomes using alternative landform design approaches (e.g. geomorphic options).	Ongoing	• Undertake further site specific waste characterisation to better define dump erosion potential. [515185] • Develop new rehabilitation designs for existing waste dumps (e.g. Deposit A) that may not have not be constructed to readily facilitate stable rehabilitation slopes. [515184]
	Determine final closure strategy for high erodibility waste dumps.	Current and ongoing	• Undertake further site specific waste characterisation to better define dump erosion potential. [515185]

Factor	Closure knowledge gap	Comment/timing	Associated task/action
	Refine pit backfill strategy and determine location and types of waste materials remaining ex-pit at closure. This will inform final rehabilitation design requirements.	On going	• Review availability of competent materials to ensure sufficient volume of material is available to meet closure requirements [1038234]
	Rehabilitation designs to be developed for all permanent ex-pit landforms	On going	• Develop rehabilitation designs for waste dumps that are currently located within zones of instability (Deposit A South dump and Deposit E South dump) that ensure these dumps are outside the zone of instability. [515183] • Develop rehabilitation designs for waste dumps that are currently located within zones of instability (PIV proposed deposits) that ensure these dumps are outside the zone of instability [1053374]
	Determine armouring material balance once final closure strategy for high erodibility waste has been determined.	On going	• Review availability of competent materials to ensure sufficient volume of material is available to meet closure requirements [1038234]
Fibrous material	Mapping of pit wall exposures of fibrous materials in the closure landscape, risk assessment and closure to be further refined as closure approaches.	On-going	• Undertake a detailed site investigation to identify, classify and develop remediation strategy for potentially contaminated sites [851228] • Evaluate closure landform designs with respect to managing the potential for exposure/re-exposure of fibrous materials and incorporate design changes where required. [515181]
Hydrogeology			
Groundwater modelling	Undertake groundwater modelling where not yet completed to determine backfill levels for all pits. This will continue to be addressed at each MCP update.	On-going	• Undertake groundwater modelling where not yet completed to determine backfill levels for all pits [722362]
Groundwater modelling	Site wide groundwater modelling is required to assess interactions between existing and proposed mining operations and associated impacts on groundwater resources.	On-going	• Undertake groundwater modelling where not yet completed to determine backfill levels for all pits [722362] • Managed Aquifer reinjection (MAR) trials to be carried out to firm up reinstatement methodology. multi-phase MAR Scheme to be planned [803830]
Surplus Water	Assess closure implications of surplus water storage in pit voids.	On-going	• Undertake groundwater modelling where not yet completed to determine backfill levels for all pits [722362] • Update Water Balance with (22LOM, 23LOM etc.) [1037819]

Factor	Closure knowledge gap	Comment/timing	Associated task/action
Managed Aquifer Recharge	Determine operational strategy for pit backfill and mining schedules to maintain MAR capability.	On-going	• Managed Aquifer reinjection (MAR) trials to be carried out to firm up reinstatement methodology. multi-phase MAR Scheme to be planned [803830]
Hydrology			
Hydrological model	Further refinement of the hydrological model to better evaluate and define closure designs for currently planned and future permanent surface water diversions and pit buttressing, to be included in each MCP update	On-going	• Complete flood modelling for areas not yet defined in detail [754160] • Develop designs for permanent diversions where required. [515187] • Geotechnical assessment of pit wall buttressing requirements [722196]
Hydrological model	Further refinement of the hydrological model and mine plan in relation to significant surface water pools to support consultation with nominated Yinhawangka / Ngarlawangga representatives and refine rehabilitation outcomes	Ongoing	• Evaluate the final landform design with respect to the potential for impacts to cracking clay communities [515189] • Complete flood modelling for areas not yet defined in detail [754160] • Build a West Angelas specific closure engagement strategy that includes SCHMP consultation commitments [802388]
Scour assessment	Development of detailed scour assessments, based on sediment sampling and flood modelling, to improve rock protection quantity estimates	Ongoing	• Complete flood modelling for areas not yet defined in detail [754160] • Review availability of competent materials to ensure sufficient volume of material is available to meet closure requirements [1038234] • Undertake further site specific waste characterisation to better define dump erosion potential. [515185]
Contaminated sites			
Site assessment	Contaminated sites assessment as part of decommissioning and development of remediation or management plans, as required. Location and volume of contaminated soils and groundwater underneath infrastructure areas that may require remediation.	5 years from planned closure	• Undertake a detailed site investigation to identify, classify and develop remediation strategy for potentially contaminated sites [851228]
Conservation significant areas			

Factor	Closure knowledge gap	Comment/timing	Associated task/action
TECs	Consideration of the impacts of the closure strategy on conservation significant areas	Ongoing	• Evaluate the final landform design with respect to the potential for impacts to cracking clay communities [515189]
	Proposed closure landscapes and their impacts on surface water flows in relation to conservation significant areas.	Ongoing	
Flora			
Flora	Flora species recorded in baseline surveys and analogue site monitoring will be used to inform rehabilitation seed mixes	Ongoing	• Finalise site specific seed list for West Angelas [725551]
Vegetation	Vegetation mapping will be used to inform the selection of reference / analogue sites and inform the development of revegetation completion criteria (species richness, percentage cover and percentage weed cover) and monitor against progressive rehabilitation.	Ongoing	• Determine analogue vegetation monitoring sites / transects based on vegetation mapping. • Develop revegetation completion criteria informed by the results of analogue monitoring sites / transects.

7. CLOSURE RISK ASSESSMENT

Risk assessment and management is an integral component of Rio Tinto's business framework and approach to closure planning. The objectives of risk management are to improve execution and reduce risk exposure. To achieve these objectives, Rio Tinto manages all business risks using the RSA Archer Integrated Risk Platform which provides the business with a consolidated and clear view of risks, including version and history tracking and unique identification of risks, controls and actions for tracking purposes.

Risk assessments are undertaken to qualitatively and semi-quantitively guide the selection of closure options, assess specific risk and identify controls for the design and execution of closure. Successful management of risks requires the implementation of a clear risk management strategy supported by adequate resources, a strong risk-aware culture, and maintaining an up-to-date risk register that is regularly reviewed.

7.1. Risk Assessment Process

All Rio Tinto closure risk assessments are facilitated by competent personnel, involving a range of technical and subject matter experts.

The aims of the closure risk assessment process are to:

- identify potential hazards that could influence successful closure of the mine;
- evaluate the risks given the management controls/strategies described within the MCP and consideration of the risk likelihood and consequences (using the descriptors included within the Rio Tinto HSEC 5 x 5 risk determination matrix, refer to Table 7-1) to establish an overall risk class, which can range from Class I (Low) to Critical IV (Critical);
- identifying additional control measures (actions) for significant threats rated as either Class III (High) or Class IV (Critical) to ensure the residual risk rating is as low as reasonably practicable (ALARP);
- reviewing and updating risk, control effectiveness and action status; and
- communicating risk information.

Issues are assessed against set consequence criteria (environment, health and safety, cost of closure, community trust, and compliance) and risk is evaluated based on the maximum reasonable outcome consequence and the likelihood of that consequence occurring to derive an inherent risk rating, prior to the application of treatments, and a residual risk rating, inclusive of current management and commitments. The ALARP principle is to be used when determining which risk treatments to apply.

Table 7-1: Risk class determination

Likelihood	Most serious consequence				
	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

The risk classification identifies the level of management action that must be taken to mitigate the threat (Table 7-2). A risk determination of Class III or Class IV reflects a material risk that requires active management and consideration of additional control measures. All Actions associated with risk management and mitigation are captured in Archer and reflected in the West Angelas closure action register (Appendix 4).

Table 7-2: Risk management response

Risk class - Threats	Management response	Risk class - opportunities
Class I	Risks that are below the risk acceptance threshold and do not require active management.	**Class I**
Class II	Risks that lie on the risk acceptance threshold and require active monitoring.	**Class II**
Class III	Risks that exceed the risk acceptance threshold and require proactive management.	**Class III**
Class IV	Risks that significantly exceed the risk acceptance threshold and need urgent and immediate attention.	**Class IV**

A control effectiveness rating is determined for each risk to evaluate whether the control will effectively mitigate the risk. If controls are deemed Marginal or Weak then actions are assigned to improve the control effectiveness.

- **Good** – control is considered adequately designed and is operating effectively on almost all occasions.
- **Satisfactory** – control is considered adequately designed and is operating effectively on most occasions.
- **Marginal** – control is considered inadequately designed or is only operating to partial effectiveness on most occasions.
- **Weak** – there is no control designed or the control is operating ineffectively on all occasions.

7.1.1. Risk evaluation

The risks (threats and opportunities) were defined by considering the likelihood of different outcomes occurring at West Angelas given the nature of the local environment established through collection of baseline data.

- The inherent risk presents the conditions that may result without implementing controls during operations or closure.
- The residual risk was determined by considering the likelihood of the consequences occurring after the nominated controls are implemented. When evaluating residual risk, Rio Tinto considers that future controls cannot be considered and therefore residual risk reflects the current risks status. Rio Tinto has not evaluated a final or treated risk.

Risks within the closure risk registers are reviewed and updated as conditions changes. The closure risk register is also systematically reviewed and updated at least every three years in support of the update to the West Angelas MCP.

7.2. Current Risk Profile for West Angelas

A summary of the current risk profile (Appendix 3) for closure of West Angelas is presented as Figure 7-1 which shows that there are 14 open risks (2 Class I, 3 Class II, 7 Class III and 2 Class IV).

Actions are assigned to risks that exceed the risk acceptance threshold and therefore require additional control measures to reduce the risk at closure to an acceptable level. Actions are also assigned to address knowledge gaps where it is assessed that further information is required to reduce uncertainty. This would typically be the case in the early stages of operations where the detailed knowledge of the issues may be low. These actions are captured in Appendix 4.

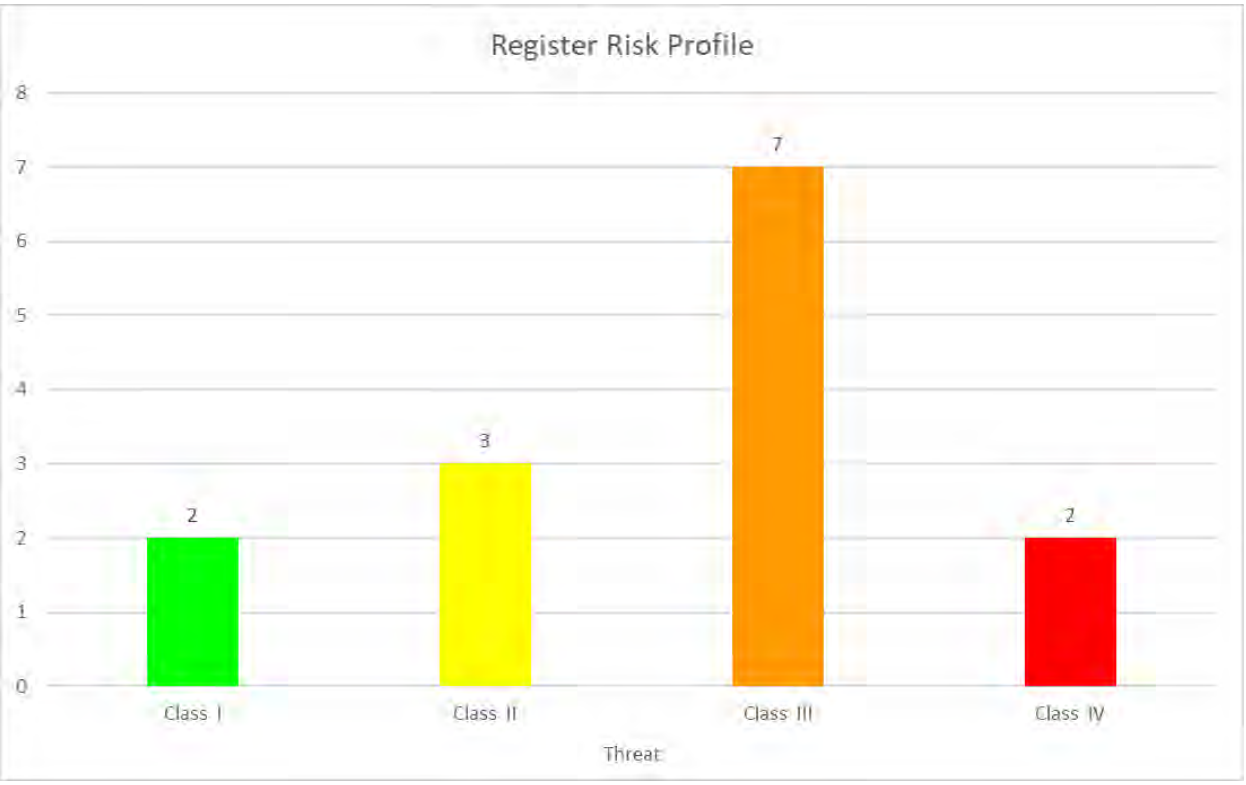


Figure 7-1: Risk Profile for closure of West Angelas

7.2.1. Closure Class IV risks

A total of two Class IV risks were identified following the review of the closure risk register in March 2022. The threats assigned this risk classification are summarised below.

Risk 515550 - Implementation of the closure strategy does not result in the agreed environmental outcome.

This risk has shifted from a Class II to Class IV due to updates to RTIO risk hygiene practices, nomenclature and uncertainties arising from recent operational developments. The risks from the 2021 West Angelas MCP; *Environmental Outcomes outside of disturbance areas do not align with approved environmental impacts, Degradation of regional groundwater quality or levels and Adverse impacts to Cracking clay Priority 1 ecological communities (PEC) or habitat critical to endangered / vulnerable fauna species* have been amalgamated into a single risk—'*Implementation of the closure strategy to achieve the agreed environmental outcome*'.

The risk has also increased due to identification of the following potential impacts:

- Creek discharge having the potential to create ecosystems and habitat for Matters of National Environmental Significance (MNES), complicating the removal of the water source and the return to ephemeral conditions.
- If the MAR initiative was to fail, which could contribute to declining groundwater levels, impacting the KNP
- Clearing restrictions on sensitive environmental receptors adding further complexity to closure planning.

- Incorrect storage practices of PAF material potentially cause acid mine drainage (AMD), seeping into waterways
- Potential surface water contamination resulting from the discharge of water that has been in contact with pit wall exposures through dewatering or MAR.

Risk 515545 - Pit wall stability at West Angelas compromises closure outcomes. – Increase from Class III

The risk was titled *Geotechnical zone of instability compromises closure outcomes* in the 2021 West Angelas MCP and has been updated to '*Pit wall stability at West Angelas compromises closure outcomes'* to better align with current RTIO risk nomenclature. It has increased from a Class III to a Class IV due to the following:

- Identification of several areas that geotechnical failure of a pit wall would result in creek capture, causing adverse environmental impact to downstream receptors, requiring rehabilitation rework during the active post-closure maintenance period.
- Several existing waste rock landforms (WRL's) are located within the PUPEZ of adjacent pits and will require rehandle of the effected areas or buttressing of pit walls to ensure a geotechnically stable closure landscape.
- The anticipated subsidence of waste materials used for backfilling pit voids may be higher or lower than anticipated and could potentially affect pit wall stability.

The causes, impacts, existing controls, evaluation rationale and planned actions for each of these threats are detailed within Appendix 3 and Appendix 4

7.2.2. Closure Class III risks

A total of seven Class III risks were identified following the review of the closure risk register in March 2022. The threats assigned this risk classification include:

Risk 804079 - Insufficient material for backfill/capping increases closure liability and complexity.

This is a new risk (i.e. not in the 2021 West Angelas MCP). Designated a Class III risk rating due:

- The need to construct engineered landforms at creek capture risk areas
- Deposit E pits potentially requiring buttressing to maintain access to the pillar heritage site
- High proportion of highly erodible materials mined and stored in waste dumps may impact on capping requirements for permanent landforms.

Risk 722921 – Inadequate management of surface water results in increased closure complexity and costs.

The risk was previously title '*inadequate surface water management results in a failure to achieve closure outcomes'*. There has been no change to the risk classification.

Risk 707951 – Consultation fails to identify and/or address stakeholder concerns.

This risk has increased from a Class II to Class III due to the ever-changing stakeholders environment and expectations regarding mine closure and the conflicting expectations between regulators and Traditional Owner groups.

Risk 515552 – Implementation of the closure strategy does not achieve the required cultural heritage outcomes.

The risk has increased from Class II to Class III due to concerns related to the maintaining consultation with the Traditional Owners groups throughout the LoM and closure implementation phases. Traditional Owners have also identified that the construction of abandonment bunds may inadvertently impede access to heritage sites. There is also a notable lack of agreement with Traditional Owner groups concerning the visual amenity of the closure landscape.

Risk 515549 – The safety risk for people entering West Angelas after it has been rehabilitated has not been effectively mitigated.

There has been no change to the risk classification from the 2021 West Angelas MCP

Risk 515547 – Rehabilitation outcomes at West Angelas do not meet closure objectives.

This risk was previously titled ' Self-sustaining and resilient vegetation is not established on rehabilitated areas at West Angelas' and has been updated to match current RTIO nomenclature. The risk has also increased from a Class II to a Class III due to changing Traditional Owner expectations regarding the design and appearance of closure landforms. Traditional Owners would like them to be more natural looking and sympathetic with the natural environment which may require significant re-work and larger footprints for existing waste dumps.

Risk 515546 – Waste dumps and land-bridges are subject to excessive erosion.

Previously titled 'Waste dumps are subject to excessive erosion'. The risk classification has increased from a Class II to a Class III due to planned additional waste landforms that will contain a high proportion of highly erodible material that will require smaller lifts and gentler batters and/or rock armouring using a suitable capping material to prevent excessive erosion.

The causes, impacts, existing controls, evaluation rationale and planned actions for each of these threats are detailed within Appendix 3 and Appendix 4

8. MANAGEMENT OF KEY ISSUES

Within the DMIRS Mine Closure Plan guidelines (DMIRS 2020), there is a list of potential mine site rehabilitation and closure issues. An evaluation of the relevance of each of these issues determined that several are identified as key issues at West Angelas.

A summary of the relevant data and information previously presented in Section 5 of this MCP is provided in Table 8-1. Details of how relevant issues will be managed are included in Section 11.2.

Table 8-1: Management of key closure issues at West Angelas

Issue	Evaluation of issue
Hazardous materials	Hazardous materials (e.g. hydrocarbons, ammonium nitrate) at West Angelas will be removed prior to, or during, decommissioning activities.
Hazardous and unsafe facilities	All above ground infrastructure at West Angelas will either be decommissioned and disposed of, or legally transferred to a third-party or the State in accordance with the State Agreement requirements.
Contaminated sites	There is one portion of the West Angelas Power Station currently considered to be a contaminated site (Contaminated – restricted use). There is a work package in place to investigate and treat this site further. A contaminated sites investigation programme will be undertaken prior to closure to inform remediation strategies and monitoring requirements. All activities will be conducted in accordance with DWER guidance, and any known or suspected site will be reported to DWER Contaminated Sites Branch.
Acid and metalliferous drainage	The majority of waste rock produced by mining operations at West Angelas has been determined to be a low AMD risk through geochemical studies. Studies for the proposed pits at Western Hill have identified a moderate AMD risk. PAF material is expected to be mined at Deposit A-West, Deposit A, Deposit C, Deposit D, Deposit E, Deposit F and Western Hill and will require management of PAF material as detailed in the SCARD Management Plan (Appendix 6). The mobility of metalloids in waste materials is a knowledge gap that needs to be addressed at West Angelas (Archer Action ID: 882795) and progress is discussed in this MCP.
Radioactive materials	No naturally occurring radioactive materials (NORM) are expected to be encountered during mining at West Angelas. No radioactive instrumentation will exist in the processing plant at West Angelas.
Fibrous materials	A small volume of potentially fibrous material has been mined to date and encapsulated in waste dumps. Potentially fibrous material areas are predicted to be present pit walls from the West Angelas deposit. Fibrous material is predicted to be mined at a number of deposits across West Angelas.
Mine pit lakes	Ministerial Statement 1113 requires pit backfill to above water table to prevent the formation of pit lakes in all below water table pits at West Angelas. Proposed pits mined below water table will also be backfilled to prevent the formation of pit lakes in accordance with the West Angelas Revised Proposal's Proposal Content Document (PCD).
Waste fines storage facilities (WFSF)	There are no existing or proposed WFSF for West Angelas.
Dispersive, sodic and erosive materials	There is a high proportion of erodible mineral waste anticipated at West Angelas which requires specific management.
Rehabilitation materials availability	There is no topsoil or rehabilitation material deficit predicted for West Angelas. It is anticipated that, in addition to topsoil, materials will be required for store and release covers, upgrade of surface management structures, capping of erodible waste dumps and abandonment bunds.

Issue	Evaluation of issue
Dust emissions	Closure dust management will be consistent with operational dust controls at West Angelas. Closure implementation is not expected to require additional management measures above those adopted during operations.
Flora and fauna diversity / threatened species	Management of disturbance in proximity of conservation significant species and communities will be consistent with operational controls at West Angelas. Ministerial condition 5 of the existing Ministerial Statement requires protection for the West Angelas Cracking Clay Priority Ecological Community (PEC-2015-5) and Ghost Bat (*Macroderma gigas*) roosts through the implementation of the Environmental Management Plan. Controls within this plan will be implemented as applicable at closure.
Challenges associated with rehabilitation and revegetation	Progressive rehabilitation at West Angelas has included roads and other infrastructure areas and more recently some waste landforms, with rehabilitation monitoring not highlighting any specific issues to date. It has been identified that West Angelas operations includes mineral waste types that require specific management, including significant volumes of high erodibility waste and small volumes of PAF geological units and fibrous materials. The availability of materials to undertake rehabilitation and closure activities (backfilling, cover, armouring, topsoil) requires further investigation; weeds are present at the site and will require management throughout operations and closure.
Visual amenity	Visual amenity is considered a key issue for the Traditional Owner groups.. Visual impact assessment of the anticipated closure landform will be undertaken during closure study stages in consultation with the Traditional Owners. As per Section 5.15.2 investigation into alternative landform designs for existing and proposed waste dumps has begun.
Cultural heritage values	Cultural heritage values have been identified by Traditional Owners and closure strategies are required to ensure values are protected. Post-closure access to agreed sites of significance will be established in consultation with respective Traditional Owner groups.
Community issues	There are no townships, remote communities or pastoral stations which will be impacted by the closure of West Angelas.
Geotechnical stability and risk of inadvertent public access	Geotechnical stability of pits is discussed in Section 5.7. The PUPEZ for each pit will be updated as pit designs change through the LOM. The risk of inadvertent public access is also discussed in Section 5.7. Abandonment bunds will be required to restrict inadvertent public access to open voids. Agreed access to the area for Traditional Owners is required post-closure.
Surface water / groundwater quality	No significant impacts on surface water or groundwater quality are anticipated.
Alteration of the direction of groundwater flow and alteration of the depth to water table of the local aquifer	Alterations to the direction of groundwater flows are expected to be localised and not have significant impacts. Depth to water in the local mine area will be affected from mine dewatering with steep cones of depression around pit voids. Groundwater levels are not expected to rebound to pre-mining levels in all areas. Below water table pits will be backfilled to above pre-mining water table to prevent the formation of pit lakes. Managed aquifer recharge is planned during operations to prevent permanent drawdown of the water table to the aquifer underlying Karijini National Park as required by Condition 6 of MS 1113.
Alteration of the hydrology and flow of surface waters	Surface water closure modelling has been completed for the current indicative mine layouts (Appendix 9). As the site layout is finalised and pit and WRL designs progressed, surface water management at closure will include permanent surface water management structures where the toe of WRLs or pit abandonment bunds are modelled to interact with high velocity flood water. These structures will be engineered to withstand 1:10,000 flood events. Current closure knowledge for post closure surface water diversions at some West Angelas landforms is presented in Figure 5-26. Ongoing studies are planned to further improve understanding of post closure surface water management requirements for additional West Angelas landforms. Outcomes will be presented in future iterations of this MCP

9. POST-MINING LAND USE, CLOSURE OUTCOMES AND CRITERIA

9.1. Pre-Mining Land Use

West Angelas is located on the traditional lands of the Yinhawangka and Ngarlawangga Peoples (Figure 2-3) and the pre-mining land use included their customs and cultural practices. Since European settlement, land uses in the region have included cattle grazing (pastoralism), exploration, mining and conservation, and continued traditional cultural practises.

West Angelas is located on unallocated crown land. Turee Creek Pastoral station overlaps small areas of the closure boundary to the west and south (Figure 2-4), however there is no pastoral activity in the immediate vicinity of the mine. Juna Downs (N050471), approximately 20 km to the north, and Rocklea Station (N050372), approximately 75 km to the west. Juna Downs is operated by Hamersley Iron Pty Ltd, which is wholly owned by Rio Tinto.

9.2. Post-Mining Land Use

The post-mining land use needs to be clearly articulated to allow for the development of specific closure objectives, which are used in the development and formalisation of closure criteria. In accordance with the Statutory Guidelines (DMIRS 2020), the proposed post-mining land use should be:

- relevant to the wider regional environment;
- achievable in the context of post-mining land capability;
- acceptable to Rio Tinto stakeholders; and
- ecologically sustainable in the context of the local and regional environment.

Options for commercial post-mining land use are limited in the Pilbara region, with mining and pastoralism the only industries that have historically proven viable. Inland regions are sparsely populated, with the largest inland towns (such as Tom Price, Paraburdoo and Newman) established specifically to support the mining industry. Beneficial uses for the mining area (e.g. recreation or aquaculture) that might have potential in areas supported with a higher population base are unlikely to be viable.

The proposed post-mining land uses for West Angelas have been developed using the Australian Land Use Management (ALUM) Classification system, which was developed by the Australian Federal Government's Department of Agriculture and Water Resources (Australian Bureau of Agricultural and Resource Economics and Sciences division {ABARES}) to provide a consistent framework for describing land use in Australia. Adopting an ALUM classification approach allows closure to be undertaken in such a manner that maximises the potential future land use opportunities. The system focuses on the suitability of land for agricultural purposes, but it provides a comprehensive and concise definition of land uses that are also consistent across other land planning institutions across Australia. The ALUM classifications have been adopted by WABSI in their framework for developing mine site completion criteria. The WABSI completion criteria framework is endorsed by DMIRS as a tool to assist with the development of an MCP.

A map of site features showing proposed post-mining land use and associated ALUM codes is shown in Figure 9-1 and summary of the post-mining land uses at West Angelas is shown in Table 9-1. These post-mining land uses will not come into effect until tenement relinquishment.

The proposed ALUM code post-mining land use includes large areas classified as 'Class 1 - Conservation and Natural Environments - 1.3.4 Rehabilitation', which is consistent with the surrounding area's land use of Unallocated Crown Land. A change to pastoral activity is not considered a viable post-closure land use for the entire mine area due to the pre-existing landforms and the nature of the mining activity undertaken. The final landform will include large pit voids and waste dumps, which do

not provide suitable range land for grazing. Abandonment bunds will be constructed around the pits voids and waste dumps to restrict inadvertent access to these areas by the general public. Many post-mining land uses will not be suitable for areas of the site, which will be designated 'Extractive Industry - not in use' (ALUM 5.8.4). These enclosed areas will be rehabilitated to develop self-sustaining, functioning ecosystems, but such rehabilitation will not attempt to fully restore the pre-mining environment.

The proposed post-mining land uses will continue to be refined as further investigations are completed and as additional consultation is held with stakeholders. Alternative land use options will continue to be investigated throughout the mine life, in consultation with all relevant key stakeholders.

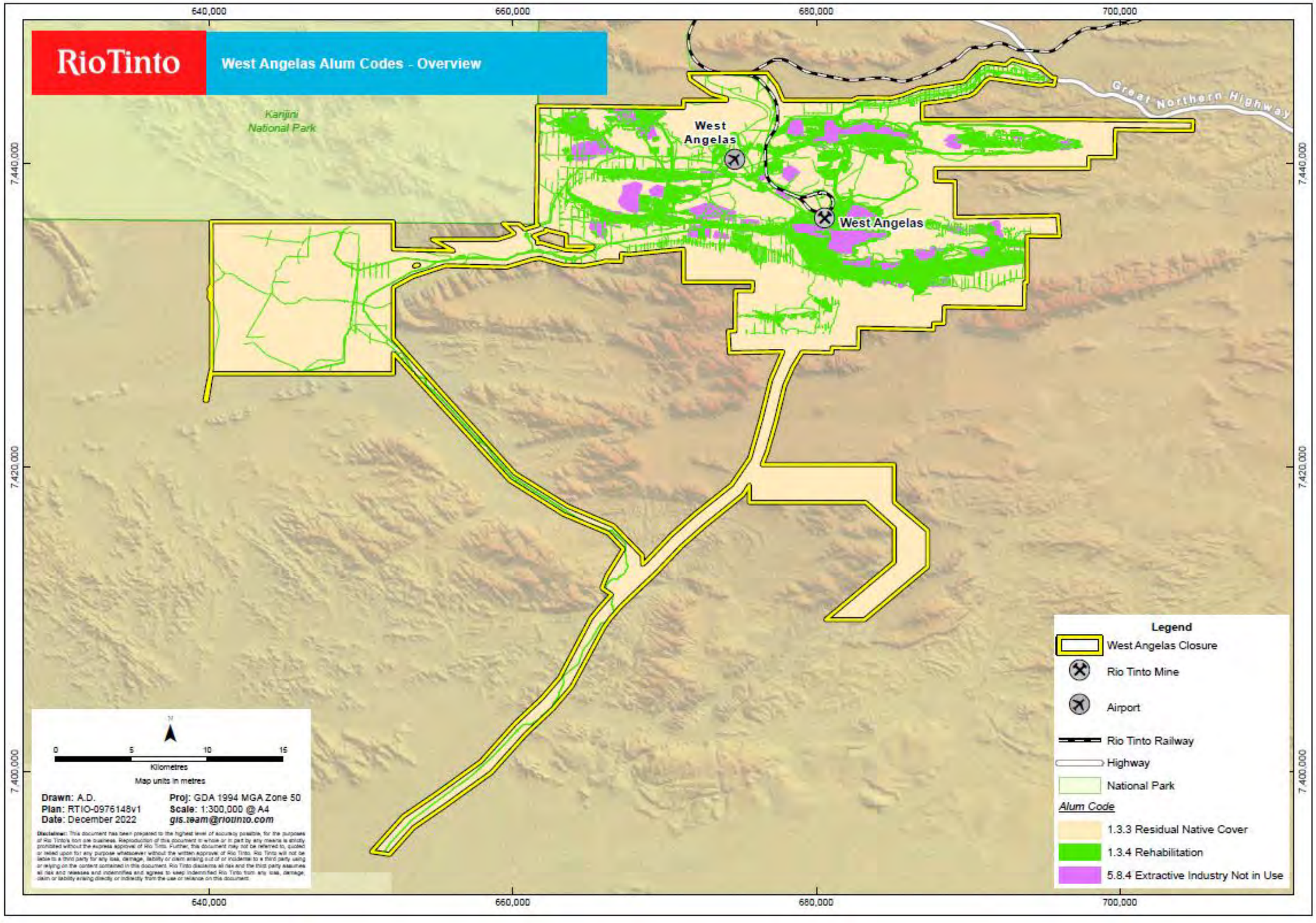
Table 9-1: Proposed post-mining land uses at West Angelas

Land use classification	Relevant domains	Land use descriptions
1.3.3 Residual native cover	Undisturbed	Land that has not been disturbed by mining activity and will not be subject to future beneficial land use.
1.3.4 Rehabilitation	Infrastructure areas Stockpiles Borrow pits Roads and other disturbance Ex-pit waste landforms RoM Landfills	Land that has been restored to a standard that approaches the natural state. Waste landforms, stockpiles and landfills will be rehabilitated to develop self-sustaining, functioning ecosystems, but such rehabilitation will not attempt to fully restore the pre-mining environment.
5.8.4 Extractive industry not in use	AWT pits BWT pits Permanent surface water diversions	Land formally used for extractive industry but no longer in use and no new use observed.

9.2.1. Access to West Angelas post closure

Post closure it is anticipated that the Yinhawangka, Ngarlawangga, Nharnuwangga and Nyiyaparli people will return to having unfettered access to most of their traditional lands. However, it is acknowledged that not all areas of the West Angelas mine site will be suitable for the practice of cultural activities, mainly due to safety constraints imposed by the geotechnical hazards of the post mining landscape and disturbed nature of the ecosystem. Areas that encompass partially backfilled pits, as an example, are hazardous due to potential geotechnical instability, rock fall and slope dangers and will not be suitable for cultural practices.

Post mining land uses that are sympathetic of Traditional Owner cultural land uses, practices and interests will continue to be refined over the LoM in consultation with the relevant groups, maintaining the heritage of the Yinhawangka, Ngarlawangga, Nharnuwangga and Nyiyaparli People ensuring the safety and stability of the landscape in accordance with the requirements of regulatory bodies and other key stakeholders.


RioTinto
West Angelas Alum Codes - Overview
Karijini National Park
West Angelas
West Angelas
Great Northern Highway
640,000
660,000
680,000
700,000
7,440,000
7,420,000
7,400,000
Legend
West Angelas Closure
Rio Tinto Mine
Airport
Rio Tinto Railway
Highway
National Park
Alum Code
1.3.3 Residual Native Cover
1.3.4 Rehabilitation
5.8.4 Extractive Industry Not in Use
N
0 5 10 15
Kilometres
Map units in metres
Drawn: A.D.
Plan: RTIO-0976148v1
Date: December 2022
Proj: GDA 1994 MGA Zone 50
Scale: 1:300,000 @ A4
gis.team@riotinto.com
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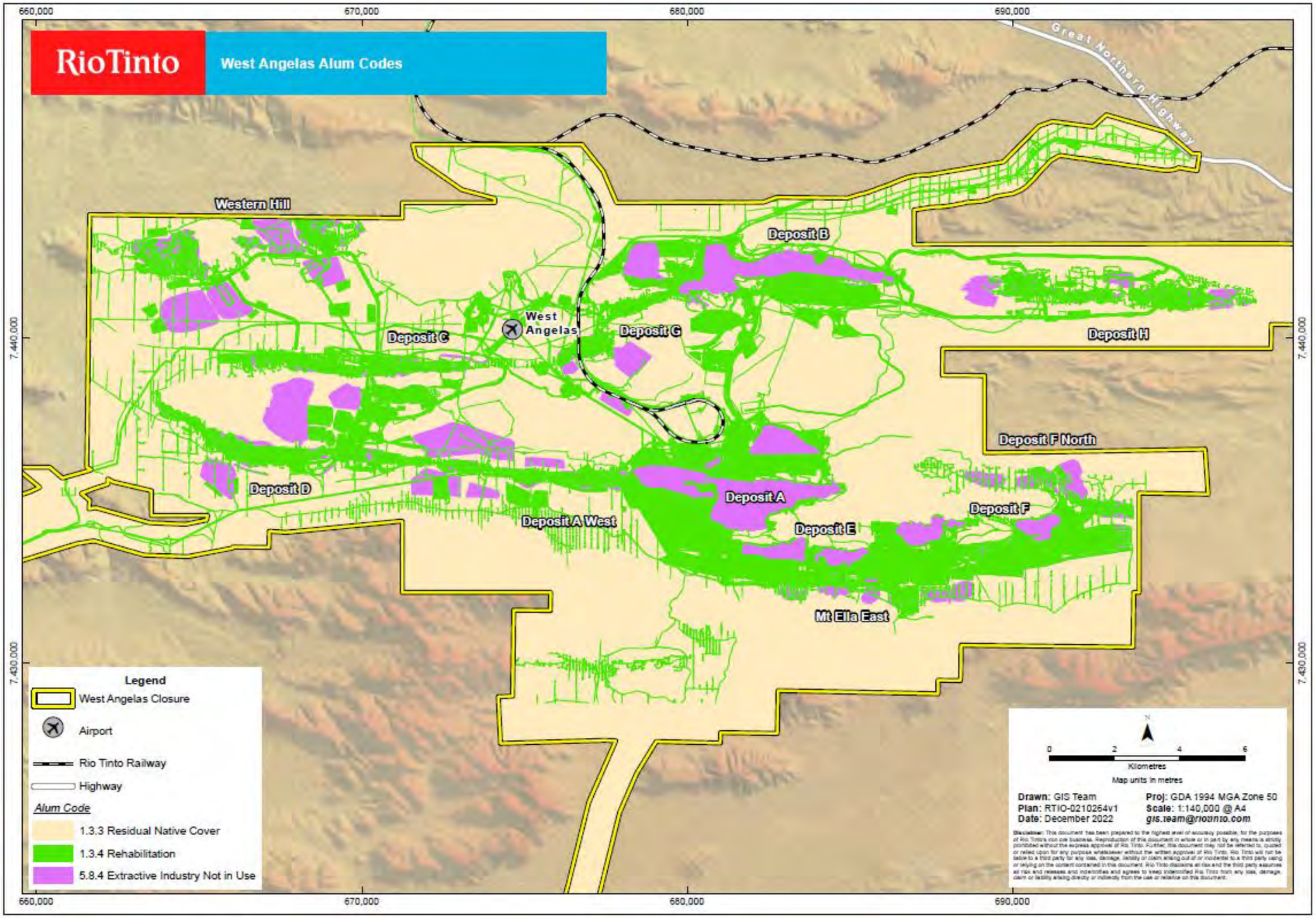

Figure 9-1: West Angelas ALUM codes proposed post-mining land uses

9.3. Closure Outcomes

Rio Tinto's general vision for closure is to:

- Relinquish its mining leases to the Western Australian State Government.
- Develop landforms that are safe, stable, non-polluting and compatible with the surrounding environment and post-mining land use.
- Preserve, protect and manage the cultural heritage values of the area in cooperation with the Traditional Owners and other stakeholders.
- Develop and implement strategies for closure that consider the implications on local communities.
- Achieve completion criteria that have been developed with stakeholders and agreed with WA Government.
- Implement a workforce strategy that addresses the impacts of closure on employees and contractors.
- Achieve successful closure in a cost-effective manner.

The goal of mine closure at West Angelas is to relinquish the site to the State Government. This goal will be achieved once the government, stakeholders and community agree that the condition of the site is compatible with an agreed post-mining land use.

Closure outcomes set out the long-term goals for closure and must be based on the post-mining landform and use (DIIS 2016). Closure outcomes are an essential component of the rehabilitation process, providing transparency for stakeholders as to what the proponent commits to achieve at relinquishment. Development of closure outcomes must consider each of the environmental factors impacted by the operation (DMIRS 2020).

Closure outcomes reflect the aspects of the MCP that the government and community stakeholders have indicated are key to evaluating the site condition. They do not represent the full range of issues that need to be addressed upon closure; rather they represent the key outcomes against which the ability to relinquish will be assessed.

Closure outcomes for West Angelas contained in the 2020 MCP were approved by DWER in June 2021 and are presented below in Table 9-2. Small modifications have been made to some of the outcomes in this MCP to better reflect current Rio Tinto nomenclature, also presented in Table 9-2.

Due to the early stages of the operation, these outcomes have yet to be agreed with Traditional Owners and other key stakeholders and are likely to evolve in future versions of this plan as knowledge of closure issues progress and detailed closure discussions commence.

Table 9-2: Current approved closure outcomes and proposed new outcomes for West Angelas

Number	Current outcome	Proposed outcome
1	The final landform[11] is stable and considers hydrological factors.	The final landform is stable, and its design considers hydrological and ecological factors.
2	Contamination[12] risks have been appropriately managed.	Contamination risks have been appropriately managed and do not preclude the agreed post-mining land uses(s).
3	Vegetation on rehabilitated land is self-sustaining and compatible with the post-mining land use.	Vegetation on rehabilitated land is self-sustaining and compatible with the post-mining land use.
4	Public health and safety hazards have been appropriately managed.	Public health and safety hazards have been appropriately managed.
5	Infrastructure has been appropriately managed.	Infrastructure has been appropriately managed.[13]
6	Cultural heritage values have been preserved where possible.	Cultural heritage values have been preserved where possible, in consultation with stakeholders.
7	The closure strategy ensures that no drawdown of groundwater or impact to quality occurs as a result of the West Angelas operation at the boundary of, or within, Karijini National Park.	The closure strategy ensures that no drawdown of groundwater or impact to quality occurs as a result of the West Angelas operation at the boundary of, or within, Karijini National Park.

Closure outcomes require the development of relevant and measurable completion criteria, to demonstrate and determine when the objectives and successful rehabilitation have been achieved. Section 9.4 presents the current status of closure criteria, as informed by the project impacts, supporting studies and stakeholder engagement.

9.4. Completion Criteria

Completion criteria are defined as the indicators used to determine whether closure outcomes have been met. They are used to measure the success of closure implementation against outcomes and to facilitate relinquishment of environmental obligations for specific closure domains (DMIRS 2021).

The completion criteria, as detailed in Table 9-3, have been developed in consideration of the predicted closure outcomes. Measurement processes and the associated supporting data (evidence and / or metrics), that could be used to evaluate the success of closure are also described in Table 9-3.

9.4.1. Completion criteria refinement framework

Rio Tinto Iron Ore is currently undertaking a review of existing closure outcomes and completion criteria against the framework established in the DMIRS endorsed WABSI (2019) *A Framework for developing mine-site completion criteria in Western Australia* and other relevant guidelines. The key objectives of the project are to:

[11] Landform' includes all post-mining constructed features; waste dumps, stockpiles, land-bridges, abandonment bunds and mine voids.

[12] Contamination – in relation to land, water or a site, means having a substance present in or on that land, water or site at above background concentrations that presents, or has the potential to present, a risk of harm to health, the environment or any environmental value.

[13] Appropriately managed in this context broadly refers to ensuring infrastructure is made available to others or decommissioned and rehabilitated, to the commitments and legal obligations we have with stakeholders and under State Legislation

- develop an internal framework which establishes milestones whereby Rio Tinto Iron Ore Pilbara assets require increasing refinement of completion criteria;
- tabulate closure outcomes and completion criteria in a format similar to that presented in Table 2.12 of the WABSI 2019 framework;
- establish S.M.A.R.T completion criteria for each closure outcome; and
- determine knowledge and/or data gaps for each completion criteria to enable definition of research priorities to allow for ongoing refinement of completion criteria.

This framework will be applied to all Rio Tinto Iron Ore Pilbara mine sites and assets (rail, utilities, ports, desalination plants, salt operations, agricultural projects and towns) over the next four year period. Prioritisation for refinement of asset completion criteria has been determined by consideration of the expected closure date, when the next closure plan is due for regulatory submission, specific regulatory and other key stakeholder feedback, and the availability and quality of monitoring data to inform completion criteria.

9.4.2. Status of completion criteria

The completion criteria are subject to ongoing review and update, informed by the outcome from studies, monitoring of progressive rehabilitation and trials, research and stakeholder consultation.

Given the number of years until scheduled closure, the completion criteria contained in this plan are considered preliminary with further review required. The next iteration of the West Angelas MCP will include the reviewed and refined closure outcomes and completion criteria.

Table 9-3: Preliminary completion criteria for closure of West Angelas

Preliminary completion criteria	Verification process/method	Evidence
The final landform is stable, and its design considers hydrological and ecological factors.		
1. No erosion features that compromise landform integrity are present and if present, erosion features are stable.	• Rehabilitation monitoring program including quantitative evaluation of behaviour of rills and gullies (if required) over time. • Analysis of aerial imagery to provide qualitative analysis of landform stability. • Post-closure landform review to confirm that risks have been appropriately managed.	• Rehabilitation monitoring results. • Survey data assessment. • Post-closure landform evaluation report. • Analysis of aerial imagery
2. The final landform was designed and constructed with consideration given to its stability during intense rainfall and large flood events.	• Flood modelling of 1:100, 1:1000 and 1:10,000 AEP events on LoM layout • Engineered design of flood protection structures and management measures to prevent creek capture and sedimentation from WRL's during a 1:10,000 AEP flood event	• Flood modelling report • Flood protection structures design report. • Flood protection construction/validation report. • Flood protection structures inspection reports/photos
3. Final landforms are outside predicted zones of instability of pits.	• Post-closure landform review to confirm that risks have been appropriately managed. • Analysis of aerial imagery to provide qualitative analysis of landform stability. • Geotechnical stability assessment of landform designs prior to closure implementation. • Post-closure monitoring of landforms for signs of geotechnical instability (see Section 12.4.2	• Post-closure landform evaluation report. • Remote sensing imagery assessment. • Geotechnical assessment reports • Post-closure monitoring reports.
4. Surface water diversions are maintained at closure in an appropriate capacity		
Contamination risks have been appropriately managed and do not preclude the agreed post-mining land use(s).		
1. Requirements under the *Contaminated Sites Act 2003* (WA) have been met for the identification, recording, management, remediation and transfer of any contaminated sites as appropriate.	• The site has been appropriately assessed for the presence of suspected or known contaminated sites. • Suspected or known contaminated sites have been appropriately reported under the *Contaminated Sites Act 2003*. • Post-closure monitoring to verify that remediation has achieved a contamination level that does not prevent the ability to conduct agreed post-mining land use(s) (see Section 12.9). • Process for transfer of residual liabilities is documented.	• Contaminated sites investigation report/s in accordance with DWER Contaminated Sites Guidelines and the National Environment Protection (Assessment of Site Contamination) Measure 1999. • Reports submitted to DWER. • Notice of Classification under the *Contaminated Sites Act 2003*. • Liability transfer agreement/s (if required
2. Restriction on use as defined on the Notice of Classification does not prevent the ability to conduct agreed post-mining land use(s).		

Preliminary completion criteria	Verification process/method	Evidence
3. Passive AMD and fibrous material control measures have been implemented	• Pit wall mapping of PAF exposures and fibrous materials • Closure geochemical risk assessment and evaluation for pits and landforms • Monitoring in accordance with the SCARD Management Plan and Fibrous Materials Management Plan • Surface water, groundwater and soil monitoring	• Closure geochemical risk assessment report • Closure Source-Pathway-Receptor model report • Final pit backfill report • Post-closure monitoring results (if required)
4. The consequence of potential impacts from unexpected release of AMD is compatible with post-mining land use		
Vegetation on rehabilitated land is self-sustaining and compatible with the post-mining land use.		
1. Seed used in rehabilitation works is determined using data from baseline surveys, monitoring data (from rehabilitation and reference sites), species from RTIO provenance zones, and includes species of cultural significance to Yinhawangka and Ngarlawangga Peoples	• Seed list and relevant seed batch information • Seed management plan. • Ethnobotanical surveys • Consultation with Traditional Owners	• Rehabilitation seed list. • Rehabilitation close-out reports. • Seed database • Consultation register
2. Native plants within rehabilitated areas are observed to flower and/or fruit.	• Rehabilitation monitoring/site inspections (see Section 12.6 for monitoring methodology). • Remote sensing/analysis of aerial imagery where appropriate. • Analysis of historical monitoring data. Rehabilitation monitoring reports • Rehabilitation close-out reports	• Rehabilitation monitoring reports • Rehabilitation close-out reports
3. Recruitment of native perennial plants is observed.		
4. Species richness of native perennial plants within rehabilitated areas is not less than reference sites.		
5. Any weed species recorded within rehabilitation areas are present within the local area.		
Public health and safety hazards have been appropriately managed.		
1. Public health and safety risks have been mitigated to an acceptable level prior to relinquishment	• Risk assessment conducted. • Independent audit(s)/review to confirm that hazard mitigation measures have been implemented. • Relevant stakeholders have been engaged on risk mitigation measures to be employed.	• Risk assessment report/section of the MCP. • Audit report to confirm effectiveness of controls. • Records of stakeholder engagement.
2. Measures to mitigate the identified public safety (and fauna where		

Preliminary completion criteria	Verification process/method	Evidence
appropriate) and human health hazards have been agreed with key stakeholders and have been implemented	• Engineer inspection to verify access control measures have been constructed to DOIR 1997 specifications and at the locations identified in the approved MCP.	• Engineer certified construction completion report. • DMIRS Safety Branch verification.
3. Any residual liabilities have been transferred to the appropriate future land managers prior to relinquishment	• Documented process for transfer of residual safety liabilities.	• Liability transfer agreement/s
Infrastructure has been appropriately managed.		
1. Legal agreement/s to transfer infrastructure and residual liability have been completed prior to relinquishment and in accordance with/subject to State Agreement Act obligations.	• Appropriate agreements and transfer processes in place and communicated for any infrastructure remaining post-closure.	• Liability transfer agreement/s.
2. Where transfer of liability is not established, infrastructure has been decommissioned and removed during the closure implementation phase	• Infrastructure has been decommissioned, removed and site inspected by certified engineer.	• Engineer certified decommissioning and demolition completion report.
3. Infrastructure removal waste streams have been managed in accordance with relevant legislation during the closure implementation phase	• Closure landfills have been constructed, operated and rehabilitated in accordance with a license issued under Part V of the *Environmental Protection Act 1986*. • Controlled wastes have been disposed in accordance with the *Controlled Waste Regulations 2004*.	• Annual Audit Compliance Report against Part V licence conditions. • Engineer certified closure completion report. • Controlled waste tracking receipts.
Cultural heritage values have been preserved where possible, in consultation with stakeholders		
1. Safe post-closure access to sites of cultural significance has been designed and implemented in consultation with Traditional Owners	• Designated access routes have been identified and agreed prior to closure. • Restricted access areas have been identified and communicated prior to closure. • Agreed access pathways have been established during the closure implementation phase. • Abandonment bund restriction areas are communicated.	• Stakeholder consultation records. • Post-closure Access Protocol. • Maps of designated access pathways. • Maps of abandonment bund locations and restriction areas.

Preliminary completion criteria	Verification process/method	Evidence
2. Heritage sites have not been impacted by closure implementation where practicable.	• Heritage survey confirms heritage sites of significance have not been impacted. • Ethnographic survey and/or site inspection.	• Heritage and ethnographic survey verification report
3. Closure strategies have been developed in consultation with Traditional Owner representatives	• Stakeholder consultation	• Records of stakeholder engagement
4. The final landform has been subject to visual impact assessment.	• Visual impact assessment. • Stakeholder engagement records	• Visual impact assessment report • Records of stakeholder engagement
The closure strategy ensures that no drawdown of groundwater or impact to quality occurs as a result of the West Angelas operation at the boundary of, or within, Karijini National Park.		
1. Pits are backfilled to a level that prevents the formation of permanent pit lakes where appropriate.	• Modelling and engineering specifications/designs confirmed in the final landform. • As constructed reports	• Post closure landform evaluation report.
2. Deposit C, D and A West aquifer is recharged to a level that maintains groundwater levels at the KNP boundary.	• Monitoring and comparison to baseline data and predictive groundwater modelling trends.	• Post closure landform evaluation report. • Agreement of stakeholders. • Groundwater baseline, monitoring and modelling validation reports.
3. Groundwater quality at or within KNP is not impacted.		

10. CLOSURE PLANNING

Closure planning is an iterative process integral to achieving a closure vision and specific strategies for each operation. Closure planning commences during the planning phase of a project and is regularly updated and refined during the operational phase. The detail of each MCP increases as the knowledge base develops.

Closure plans are updated to account for changes resulting from:

- amendments to the mine plan;
- improvements of the site closure knowledge base (e.g. through daily activities, technical studies, research actions and progressive rehabilitation);
- new or amended regulation;
- changes to surrounding land uses; and
- evolving stakeholder expectations.

A key output of closure planning is the development of a closure cost estimate. Closure provisions are subsequently integrated into Rio Tinto business planning processes to ensure funds will be available to close the site effectively. Refer to Section 13 for more information.

As part of the Rio Tinto Closure Standard (2021a), closure studies are required at intervals as the site, or a discreet area of the site suitable for partial closure, approaches the end of mine life. Like development projects, closure studies are progressed through several evaluation stages: from Order of Magnitude (OoM) to Pre-Feasibility (PFS) and Feasibility (FS) level.

Progressive rehabilitation is also planned, undertaken and monitored to inform the closure planning process and closure outcomes, as detailed in Section 11.3. The final closure plan will be prepared as an output of the Feasibility stage of closure study and submitted to the relevant Government agencies to approve for implementation. In the final closure plan, location specific management plans will be provided for each closure domain. These detailed plans cover the physical closure, dismantling and subsequent rehabilitation implementation requirements. The supporting technical reports that have been used to define the post-closure outcomes will be appended to the final closure plan.

11. CLOSURE IMPLEMENTATION

Closure implementation occurs progressively throughout the life of mine and is an integral part of mine planning to ensure that resources (materials, machinery and personnel) are available to complete rehabilitation and closure tasks in accordance with the post mining land use.

An outline of the general closure strategies to be implemented at West Angelas are:

Collection of baseline and operational data

- Baseline studies and investigations;
- Closure research, investigations and trials, as discussed in Section 5.15.2; and
- On-going monitoring during operations.

Materials handling and utilisation

- Harvesting and stockpiling of topsoil for use during rehabilitation;
- Identification and segregation of PAF, metal-rich and fibrous mineral waste rock;
- Temporary stockpiling of competent benign waste rock for use during rehabilitation; and
- Progressive backfill of mine pits.

Design and construction of landforms

- PAF, metalliferous or fibrous mineral encapsulation.

Identification and management of site contamination

- Areas with the potential for contamination will be assessed and managed in accordance with DWER requirements the *Contaminated Sites Act 2003.*

Decommissioning and removal of infrastructure

- Progressive removal of support infrastructure where possible and not being retained for handover to a stakeholder;
- Placement of topsoil or alternative growth medium, and shallow ripping; and
- Dispersal of native seed mixes containing local provenance species.

Rehabilitation of landforms

- Rehabilitation of waste landforms will meet requirements specific to each facility, particularly relating to placement of covers and / or encapsulation layers, prior to cover with growth medium;
- Landforms will be reshaped prior to cover with growth medium;
- Construction of pit abandonment bunds and surface water diversion bunds; and
- Dispersal of seed mixes containing local provenance species.

Post closure monitoring and maintenance

- Monitoring of rehabilitation performance as presented in Section 12.6; and
- Maintenance of rehabilitation works, where required, as presented in Section 12.9.

11.1. Closure Domains

To aid implementation of the MCP, areas of the operation with similar features and with similar decommissioning, rehabilitation and closure requirements have been grouped into domains. The domains for West Angelas are listed below Table 11-1 and presented in Figure 11-1.

Table 11-1: West Angelas domains

Domain	Features	Sub-features	Proposed new features	Alum Code
Pits	AWT	Deposit A WEPN	WH Pit 1 West;	5.8.4
		Deposit A- Gumleaf		
		Deposit A- Cake	WH Pit 2	
		Deposit B DBC3		
		Deposit C C1	WH Pit 3 East	
		Deposit D D4		
		Deposit D D5	MTEE Pit 1	
		Deposit F DFN1		
		Deposit F DFSW	MTEE Pit 2	
		Deposit F Marlu	Deposit H Pit 1	
		Deposit G G2	Deposit H Pit 2	
		Deposit G G3		
	BWT	Deposit A CEPN	Deposit F DFN	5.8.4
		Deposit A CEPS		
		Deposit A WEPS		
		Deposit A West AW1		
		Deposit A West AW2		
		Deposit A West AW3		
		Deposit B DBC4		
		Deposit B DBC5		
		Deposit C C2		
		Deposit C C3		
		Deposit D D1	Deposit H Pit 3	
		Deposit D D2		
		Deposit D D3		
		Deposit E East		
		Deposit E West		
		Deposit F DFW		
		Deposit F DFS1		
		Deposit F DFE		
		Deposit G G1		
		Deposit G G4		
	Inert (includes stockpiles)	Deposit A South WD	WH WD 2	1.3.4
		A West WD1		

Domain	Features	Sub-features	Proposed new features	Alum Code
Ex-pit waste landforms[14][15]		Deposit A Spine WD	WH LG 1	
		Deposit B West WD	WH LG 2	
		Deposit D WD3	Deposit H WD1	
		Deposit E West WD	Deposit H WD2	
		Deposit F West WD	Deposit H LG 1	
		Deposit G South WD1	Deposit F North LG	
		Deposit G South WD2	MTEE WD1	
		Deposit G South WD3	MTEE WD2	
		Deposit G LG	MTEE WD3	
		Deposit F LG	MTEE LG1	
		Deposit C&D HGA	MTEE LG2	
		Deposit D LGS		
		Deposit D LGA		
		Deposit C LG		
		Deposit B LG		
		Deposit A West LG		
		Deposit A West LG		
	Fibrous /PAF/Potential future PAF landforms	Deposit A North WD	WH WD 1	
		Deposit B East WD	Deposit F North WD	
		Deposit C WD1		
		Deposit C&D WD2		
		Deposit E South WD		
		Deposit F East WD	A West WPS	
Processing infrastructure	Plant area and crushers, conveyors, process water pond, plant workshop, assay laboratory, core yard, bulk fuel storage, warehouse, hazardous materials storage, batch plant.			1.3.4
Non-processing infrastructure	Airport, Solar PV Farm, communications infrastructure, borefield (MAR), pump stations, wash downs, ANFO facilities, water treatment facilities,			1.3.4

[14] Proposed ex-pit waste landforms are conceptual only and are yet to be fully defined with regards to being classified as inert / PAF / fibrous. Further definition will be presented in subsequent iterations of this MCP.

[15] Hydrated material stockpiles currently exist on site (AW Pit and DepE/DepF dumps) but are not included as a closure domain as they will be utilized as capping material for closure and as such not be present as a final closure landform.

Domain	Features	Sub-features	Proposed new features	Alum Code
	workshops, laboratories, buildings, camps, fuel facilities, landfill, powerlines, pipelines, rail, communications cable.			
ROM	ROM Pad	PC2 RoM		1.3.4
		RoM 1		
		RoM 2		
		RoM 3		
Borrow pits	Borrow pits			1.3.4
Post closure surface water diversions	Permanent surface water diversions	Deposit D Levee		5.8.4
		Deposit C Diversion		
		Deposit F Diversion		
		Deposit C Levee		
Roads and other disturbance	Haul roads, roads, tracks, laydowns, operational surface water diversions	Deposit B diversion		1.3.4
		Deposit F diversion,		
		Deposit C diversions		
		Deposit D diversions		
		Landbridges		

11.2. Closure Work Programs

Each closure domain has an associated Closure Work Program summarising closure strategies and tasks required to meet closure outcomes and completion criteria. It is intended that the Closure Work Programs presented in this Section will form the basis of development of a more detailed Decommissioning and Rehabilitation Plan.

Each iteration of the West Angelas MCP will contain progressively more detail of final landform designs, closure strategies and addressing knowledge gaps.

The Closure Work Program for each domain presents key information relevant to each domain, including:

- domain features, status and closure date;
- post-mining land use ALUM classification;
- relevant closure outcomes;
- closure assumptions;
- knowledge gaps;
- closure monitoring and maintenance requirements; and
- closure strategy and key tasks for rehabilitation and closure phases.

The following subsections provide detail of the closure strategy/design for features within the relevant domain.

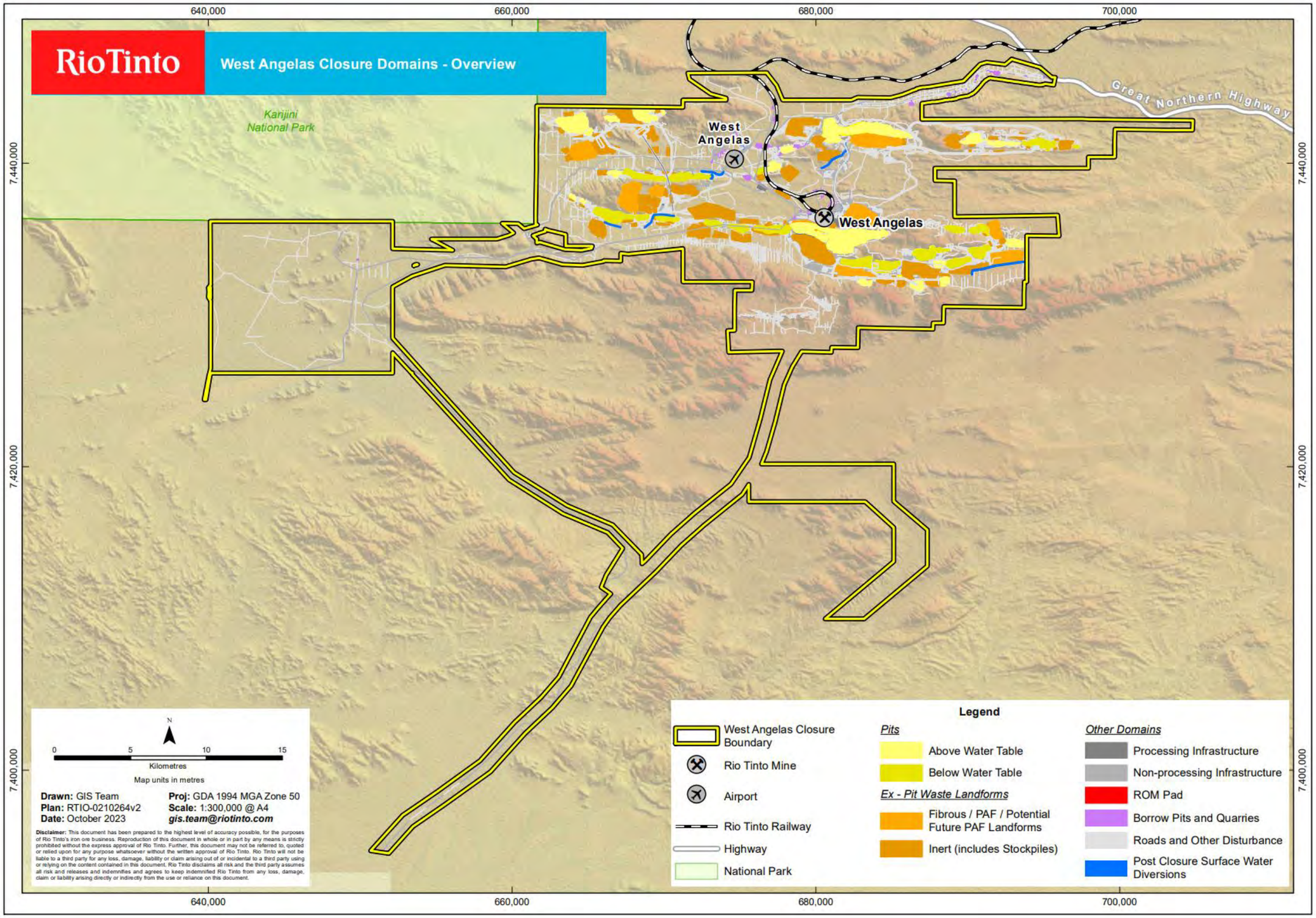

Figure 11-1: West Angelas Closure Domains - Overview

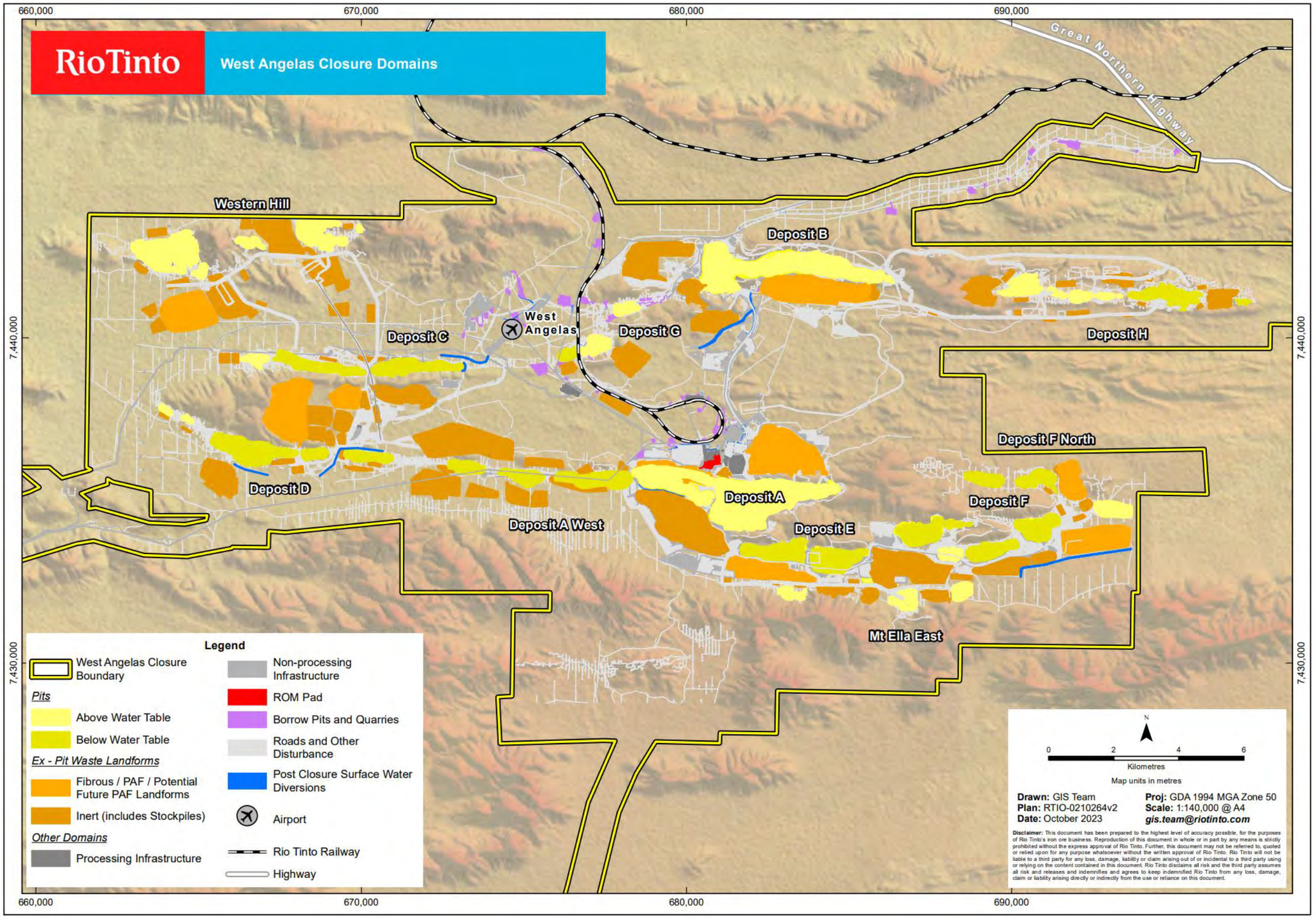

Figure 11-2: West Angelas Closure Domains

11.2.1. Above water table pits

Table 11-2 summarises the closure work program for the AWT Pits domain. The following subsections provide further detail on closure designs relevant to this domain.

Table 11-2: Closure work program – AWT pit voids

Program Aspect	Program Summary
Domain features	• Deposit A, GumLeaf, Cake Pit • Deposit B, DBC3 • Deposit C, C1 • Deposit D, D4 • Deposit F, DFN1, DFSW, Marlu • Deposit G, G2, G3, WEPN • Deposit H, Central and West • WH Pit 1 West; WH Pit 2; WH Pit 3 East; • MTEE Pit 1; MTEE Pit 2; • DH Pit 1 West; DH Pit 2 Central
Status of domain features	Operational / Planned, yet to be mined
Estimated closure date	Various (see Table 2-2)
Post-mining land use	5.8.4 Extractive industry not in use
Relevant preliminary closure outcomes	• Public health and safety hazards have been appropriately managed. • Cultural heritage values have been preserved where possible, in consultation with stakeholders..
Specific closure assumptions	• Abandonment bund will be constructed during operations (when possible), using competent NAF mineral waste. • All permanent ex-pit mining landforms will be located outside the PUPEZ. • Prior to final closure, appropriate evaluation and implementation of measures to restrict inadvertent public access. • In-situ fibrous material exposures, if any, will not pose a health and safety risk at closure.
Landform design	• Pits may be partially or fully backfilled during operations or at closure to: o minimise the volume of waste remaining in ex-pit WRLs; and/or o manage highly erodible material. • No rehabilitation of pit voids is planned at West Angelas unless backfill height is within 10 m of the pit crest. • Indicative locations of abandonment bunds, based on the current mine plan, are presented in Section 5.7. • No backfill required for AWT pit voids, however pit voids may be partially or fully backfilled during operations or at closure to meet business requirements or commitments to stakeholders..
Knowledge gaps	• PUPEZ associated with final pit voids, abandonment bund locations and surface water management implications. • Location/source of appropriate waste rock material for abandonment bund construction. • Safe post-closure access routes to cultural heritage sites • Refine pit backfill strategy and location and types of waste materials remaining ex-pit at closure. This will inform final rehabilitation design requirements. • Mapping of pit wall exposures of fibrous materials in the closure landscape, risk assessment and closure to be further refined as closure approaches. • Assess closure implications of surplus water storage in pit voids.
Closure and rehabilitation materials required	• Competent NAF mineral waste for abandonment bunds and flood levees.

Program Aspect	Program Summary
Closure monitoring and maintenance	• Aerial imagery monitoring (Section 12.3) • Landform monitoring (Section 12.4). • Water monitoring (Section 12.5) • Post-closure maintenance (Section 12.9)
Closure Strategy – key tasks	
Progressive rehabilitation and closure activities	• Construction of abandonment bund as per DoIR 1997 guidelines.
Decommissioning and closure	• Removal of rubbish and remaining infrastructure. • Final closure of abandonment bund and pit ramp. • Rehabilitation of pit backfill surfaces where they are less than 10 m below pit crest. • Installation of signage, if required. • Monitoring / assessment as required.
Premature closure	• Access to pit made safe by construction of abandonment bund (where required) and blocking pit ramps. • Monitoring and maintenance program revised and implemented.

11.2.2. Below water table pits

Table 11-3 summarises the closure work program for the BWT Pits domain. The following subsections provide further detail on closure designs relevant to this domain.

Table 11-3: Closure work program – BWT pit voids

Program Aspect	Program Summary
Domain features	• Deposit A, CEPN, CEPS, WEPS. • Deposit A, West AW1, AW2, AW3. • Deposit B DBC4, DBC5. • Deposit C, C2, C3. • Deposit D, D1, D2, D3, D5. • Deposit E, East and West. • Deposit F, F North, DFW, DFS1, DFE. • Deposit G, G1 and G4. • Deposit H East. • DFN pit. • DH Pit 3
Status of domain features	Operational / Planned, yet to be mined.
Estimated closure date	Various (see Table 2-2).
Post-mining land use	5.8.4 Extractive industry not in use.
Relevant closure outcomes	• Public health and safety hazards have been appropriately managed. • Cultural heritage values have been preserved where possible, in consultation with stakeholders. Contamination risks have been appropriately managed and do not preclude the agreed post-mining land use(s).

Program Aspect	Program Summary
Specific closure assumptions	• Undertake opportunistic backfill during operations or complete backfill to above water table post closure to: o Prevent the formation of pit lakes; o Minimise the volume of waste remaining in waste landforms. • No rehabilitation proposed within pit footprint (unless backfilled to near or above surface). • Prior to final closure, appropriate evaluation and implementation of measures to restrict public access will be undertaken. • Construct abandonment bunds around pit perimeters, outside of the zone of geotechnical instability, as required. • Ensure post-closure access to the significant cultural heritage site is maintained.
Landform design	• Indicative locations of abandonment bunds, based on the current mine plan, are presented in Section 5.7.
Knowledge gaps	• PUPEZ associated with final pit voids, abandonment bund locations and surface water management implications. • Location/source of appropriate waste rock material for abandonment bund construction. • Safe post-closure access routes to cultural heritage sites. • Refine pit backfill strategy and determine location and types of waste materials remaining ex-pit at closure. This will inform final rehabilitation design requirements. • Mapping of pit wall exposures of fibrous materials in the closure landscape, risk assessment and closure to be further refined as closure approaches. • Assess closure implications of surplus water storage in pit voids.
Closure and rehabilitation materials required	• Competent NAF mineral waste for abandonment bunds and flood levees.
Closure monitoring and maintenance	• Aerial imagery monitoring (Section 12.3). • Landform monitoring (Section 12.4). • Water monitoring (Section 12.5). • Post-closure maintenance (Section 12.9).
Closure Strategy – key tasks	
Progressive rehabilitation and closure activities	• Progressive backfilling of pit to above the predicted post-mining water table. • Construction of sections of abandonment bund where possible.
Decommissioning and closure	• Backfilling of pit to above the predicted post-mining water table if not completed during operations. • Removal of rubbish and remaining infrastructure. • Final closure of abandonment bund and pit ramp. • Installation of signage, if required. • Monitoring / assessment as required.
Premature closure	• Access to pit made safe by construction of abandonment bund (where required) and blocking pit ramps. • Ongoing implementation of monitoring and maintenance program.

11.2.3. Inert external waste dumps

Table 11-4 summarises the closure work program for the Inert Waste Landforms domain. The following subsections provide detail on the closure designs for features within this domain.

Landforms within this domain that have been rehabilitated progressively are detailed in Section 5.15 and while listed in Table 11-4, are not discussed further in this section. Landforms that have been partially rehabilitated but require further work as part of the closure work program are included within this section. Preliminary landform designs are presented in Appendix 11.

Table 11-4: Closure Work Program – Inert external waste dumps and low-grade stockpiles

Program Aspect	Program Summary	
	Current Features	**Proposed Features**
Domain features	• A South WD, • A West WPS, • A West WD1 • A Spine WD, • B East WD, • B West WD, • C – WD1 • D - WD3, • E South WD, • E West WD, • F West WD, • F East WD, • G South WD1, • G South WD2, • G South WD3, • E West WD, • F West WD, • F East WD • G South LG, • F LG, • C&D HGA, • D LGS, • D LGA, • C LG, • B LG, • A West LG.	• WH Dump 1 and 2; • WH LG 1 and 2; • MTEE Dump 1 and 2 and LG; • DJ Dump 1, 2, 3 and LG; • DFN Dump 1 and LG; • DH dump 1 and 2 and LG
Status of domain features	Refer to Table 2-3.	
Estimated closure date	Progressively through operations when available, or at closure	
Post-mining land use	1.3.4 Rehabilitation	
Relevant closure outcomes	• Final landform is stable, and its design has considered ecological and hydrological factors. • Public health and safety hazards have been appropriately managed. • Cultural heritage values have been preserved where possible, in consultation with stakeholders. Vegetation on rehabilitated land consists of self-sustaining native species and is compatible with the post-mining land use(s).	
Specific closure assumptions	• Inert waste landforms will be progressively rehabilitated during operations as they become available. • High erodibility material has been preferentially tipped to in-pit locations or within the waste rock landform to avoid exposure on the landform surface where possible. • All waste material stored in the landforms is NAF and has a low risk of metalliferous drainage. • Waste landforms are constructed in accordance with RTIO design criteria and rehabilitated in accordance with RTIO standards and procedures.	

Program Aspect	Program Summary
Landform design	• High erodibility material will be preferentially used as pit backfill where possible. • Application of rock armour on batters of dumps with high erodibility material to prevent long term rilling and gullying. • Scour protection is required where WRL toe is modelled to be at risk of erosion due to high velocity flood water. • Where available, conceptual rehabilitation designs are provided in Appendix 11. • Removal of some sections of landforms may be required to reinstate surface drainage and improve long-term stability outcomes.
Knowledge gaps	• Characterisation of waste material to define geotechnical and geochemical properties and erosion classes. Further site-specific waste characterisation will be progressively undertaken when each mineral waste unit becomes available during mining operations. • Rehabilitation designs to be developed for all permanent ex-pit landforms. • Final closure strategy for high erodibility waste dumps to be defined. • The implication of site-specific waste types on the feasibility of achieving safe and stable rehabilitation outcomes using alternative landform design approaches (e.g. geomorphic options). • It is noted that there is a topsoil surplus for the landforms associated with current operations. However further investigation into topsoil availability for the proposed waste landforms are required once all designs have been completed, and backfill planning refined. • The final rehabilitation seed mix is to be updated and finalised in consultation with Traditional Owners to ensure inclusion of appropriate species of ethnobotanical significance. • Consultation on closure outcomes and completion criteria based on consultation with Traditional Owners. • Potential for long-term indirect impacts to cultural heritage sites from areas of geotechnical instability, surface water movement and sediment transport. • Development of detailed scour assessments, based on sediment sampling and flood modelling, to improve rock protection quantity estimates.
Closure and rehabilitation materials required	• Hydrated waste for armouring of erodible waste dumps (Section 5.8.6). • Growth medium (see Section 5.5.2). • Seed mix.
Closure monitoring and maintenance	• Aerial imagery monitoring (Section 12.3). • Landform monitoring (Section 12.4). • Rehabilitation monitoring (Section 12.6). • Post-closure maintenance as required (Section 12.9).
Closure Strategy – key tasks	
Progressive rehabilitation and closure activities	• Reshaping and rehabilitation of waste landforms no longer required for operations. • Ongoing monitoring of completed progressive rehabilitation.
Decommissioning and closure	• Re-profile batter slopes to closure design criteria. • Construct toe bunds and safety berms to design criteria. • Spread topsoil on all slopes and flat surfaces, rip and seed.
Premature closure	• Finalise detailed closure designs. • Final reshaping and rehabilitation of any waste landforms not completed progressively during operations. • Ongoing monitoring of completed progressive rehabilitation.

11.2.4. Fibrous waste dumps and PAF materials

Table 11-5 summarises the closure work program for the Fibrous Waste Dump domain. The following subsections provide detail on the closure designs for features within this domain.

Landforms within this domain that have been rehabilitated progressively are detailed in Section 5.15 and while listed in Table 11-5, are not discussed further in this section. Landforms that have been partially rehabilitated but require further work as part of the closure work program are included within this section.

Table 11-5: Closure Work Program – Fibrous and Potential Acid Forming waste dumps

Program Aspect	Program Summary
Domain features	• Deposit A, North WD. • Deposit B, East WD. • Deposit C&D, WD1 and WD2. • Deposit E, South WD. • Deposit F Wombat WD. • Deposit F North WD. • Western Hill Central WD.
Status of domain features	Refer to Table 2-3.
Estimated closure date	Refer to Table 2-3.
Post-mining land use	1.3.4 Rehabilitation
Relevant closure outcomes	• Final landform is stable, and its design has considered ecological and hydrological factors. • Cultural heritage values have been preserved where possible, in consultation with stakeholders. Vegetation on rehabilitated land consists of self-sustaining native species and is compatible with the post-mining land use(s).
Specific closure assumptions	• The material within these West Angelas waste landforms has a high erosion potential (see Section 5.8.2). • Waste landforms will be progressively rehabilitated during operations as they become available. • High erodibility material will be preferentially used as pit backfill where possible. • High erodibility material has been preferentially tipped to in-pit locations or within the waste rock landform to avoid exposure on the landform surface where possible.
PAF materials - specific closure strategy assumptions	As per the SCARD Management Plan: • Progressive identification and backfilling of PAF materials where practicable during mine operations. • Progressive identification and encapsulation of PAF materials where possible during mine operations. • Where progressive and selective backfill or encapsulation is not possible (for example on historic waste landforms), the application of 2 m cover materials will be applied where available. Landform closure designs will consider surface water hydrology to reduce erosion and exposure of PAF materials.
Landform design	• All fibrous material has been encapsulated during operations as per the FMMP (RTIO, 2019a). • Waste landforms will be constructed in accordance with RTIO design criteria and rehabilitated in accordance with RTIO standards and procedures. • Landform closure designs will consider surface water hydrology to reduce erosion and exposure of fibrous materials. • Where available, conceptual rehabilitation designs are provided in Appendix 11. • Removal of some sections of landforms may be required to reinstate surface drainage and improve long-term stability outcomes.

Program Aspect	Program Summary
Knowledge gaps	• Characterisation of waste material to define geotechnical and geochemical properties and erosion classes. Further site-specific waste characterisation will be progressively undertaken when each mineral waste unit becomes available during mining operations. • Rehabilitation designs to be developed for all permanent ex-pit landforms. • Final closure strategy for high erodibility waste dumps. • The implication of site-specific waste types on the feasibility of achieving safe and stable rehabilitation outcomes using alternative landform design approaches (e.g. geomorphic options). • It is noted that there is a significant topsoil surplus for the landforms associated with current operations. However further investigation into topsoil availability for the proposed waste landforms are required once all designs have been completed, and backfill planning refined. • The final rehabilitation seed mix. Which is to be updated and finalised in consultation with Traditional Owners to ensure inclusion of appropriate species of ethnobotanical significance. • Consultation on closure outcomes and completion criteria based on consultation with TOs. • Potential for long-term indirect impacts to cultural heritage sites from areas of geotechnical instability, surface water movement and sediment transport. • Development of detailed scour assessments, based on sediment sampling and flood modelling, to improve rock protection quantity estimates.
Closure and rehabilitation materials required	• Hydrated waste for armouring of erodible waste dumps (Section 5.8.6). • Growth medium (see Section 5.5.2). • Seeds.
Closure monitoring and maintenance	• Aerial imagery monitoring (Section 12.3). • Landform monitoring (Section 12.4). • Rehabilitation monitoring (Section 12.6). • Post-closure maintenance as required (Section 12.9).
Closure Strategy – key tasks	
Progressive rehabilitation and closure activities	• Reshaping and rehabilitation of waste landforms no longer required for operations. • Ongoing monitoring of completed progressive rehabilitation.
Decommissioning and closure	• Final reshaping and rehabilitation of any waste landforms not completed progressively during operations. • Ongoing monitoring of completed progressive rehabilitation.
Premature closure	• Finalise detailed closure designs. • Final reshaping and rehabilitation of any waste landforms not completed progressively during operations. • Ongoing monitoring of completed progressive rehabilitation.

11.2.5. Processing infrastructure

Table 11-6 summarises the closure work program for the processing infrastructure domain. The following subsections provide further detail on closure designs relevant to this domain.

Table 11-6: Closure Work Program – Infrastructure

Program Aspect	Program Summary
Domain features	• Main infrastructure area (plant, crushers, process water pond, bulk fuel storage, workshops, batch plant, offices). • Linear infrastructure (conveyor, sealed access road, pipelines, powerline). • Borefields.
Status of domain features	Operational
Estimated closure date	2041
Post-mining land use	1.3.4 Rehabilitation

Program Aspect	Program Summary
Relevant closure outcomes	• Contamination risks have been appropriately managed and do not preclude the agreed post-mining land uses(s).Vegetation on rehabilitated land is self-sustaining and compatible with the post-mining land use. • Public health and safety hazards have been appropriately managed. • Infrastructure has been appropriately managed. • Cultural heritage values have been preserved where possible, in consultation with stakeholders..
Specific closure assumptions	• All above ground infrastructure will be removed and disposed of on-site in approved locations. Should agreements with stakeholders in relation to asset retention and transfer be reached prior to closure, this assumption will be revised. • Below ground infrastructure will be removed to a depth of 1 m below the post-closure landform surface. Infrastructure buried >1 m deep will be left in-situ where it does not present significant environment risk. • All roads and tracks will be removed and rehabilitated except for those required for post-closure access. • Non-recyclable, inert waste generated from decommissioning and infrastructure removal activities will be disposed of in appropriately licensed facilities, typically on site.
Closure design	• Once ore processing has been completed, decommissioning of equipment and facilities prior to demolition and removal will be undertaken. This process will involve: o running down stocks of consumables; o removing inventory no longer required and appropriate for reuse elsewhere (e.g. furniture, signage, storage containers etc.); o make-safe activities such as de-energisation, degassing to release stored energy, and draining and flushing motors, tanks, hydraulic equipment, and pipes. o where appropriate, decontaminate process circuits and storage vessels. • Infrastructure demolition will then commence including above ground infrastructure, concrete foundations and footings, sealed access road, and below ground services. • Scrap steel and other recyclables will be transported offsite for recycling. • Hazardous materials will be transported offsite for disposal at an appropriately licensed facility. • Non-recyclable, inert wastes generated from closure activities will be disposed of in an appropriately licensed landfill that maybe located on-site (e.g. in a pit void) or off-site. If the closure landfill is located on-site, the closure cover will be free-draining and a minimum of 2 m thick. • Any contamination identified as part of future investigations will be appropriately remediated prior to rehabilitation of the infrastructure footprint areas. • The infrastructure footprint areas will be reshaped to ensure they are free-draining and deep cross ripped (max 1 m depth), where safe to do so, to alleviate compaction. • Growth media will be applied prior to ripping and seeding. • Pre-mining drainage along the overland conveyor and sealed access road alignments will be reinstated where possible by removing fill material and culverts from significant drainage lines.
Knowledge gaps	• Location and volume of contaminated soils and groundwater underneath infrastructure areas that may require remediation. • Contaminated sites assessment as part of decommissioning and development of remediation or management plans, as required.
Closure and rehabilitation materials required	• Growth medium (see Section 5.5.2). • Seeds.
Closure monitoring and maintenance	• Water monitoring (Section 12.5). • Rehabilitation monitoring (Section 12.6). • Post-closure maintenance (Section 12.9).
Closure Strategy – key tasks	

Program Aspect	Program Summary
Progressive rehabilitation and closure activities	• Implementation of progressive decommission and rehabilitation during operations as per Rio Tinto standards and procedures.
Decommissioning and closure	• Undertake decommissioning and make safe activities. • Retain or remove infrastructure in accordance with the State Agreement requirements and stakeholder engagement. • Reshape footprint areas to be free-draining and reinstate drainage lines where appropriate. • Remediation or management of confirmed contaminated sites. • Dispose of inert materials that are not retained, reused or recycled in an inert landfill area (may be a used pit area). • Spread growth media, rip, and seed.
Premature closure	• Undertake contaminated sites assessment and remediation measures, if required. • Engage with stakeholders to confirm infrastructure removal assumptions in accordance with the State Agreement requirements. • Implement decommissioning and closure as outlined above.

11.2.6. RoM

Table 11-7 outlines the closure work program for the RoM domain.

Table 11-7: Closure Work Program – RoM

Program Aspect	Program Summary
Domain features	RoM 1, RoM 2, RoM 3 and PC2 RoM
Status of domain features	Active
Estimated closure date	2041
Post-mining land use	1.3.4 Rehabilitation
Relevant closure outcomes	• Public health and safety hazards have been appropriately managed. • Infrastructure has been appropriately managed. • Final landform is stable, and its design has considered ecological and hydrological factors. • Vegetation on rehabilitated land consists of self-sustaining native species and is compatible with the post-mining land use(s).
Specific closure assumptions	• Ore stored on the RoM will be processed prior to closure. • Conveyor and primary crusher infrastructure will be removed as described in Section 11.1 prior to closure of the RoM.
Landform design	• Remove all structures and footings that area above surface or within 1 m of the final land surface. • Utilise earthen mound for pit backfill, capping or encapsulation if required. • Rehabilitate final surface in accordance with standard procedures.
Knowledge gaps	• Nil
Closure and rehabilitation materials required	• Waste rock backfill. • Growth medium (see Section 5.8.6). • Seeds mix.
Closure monitoring and maintenance	• Landform monitoring (Section 12.4). • Rehabilitation monitoring (Section 12.6). • Post-closure maintenance as required (Section 12.9).
Closure Strategy – key tasks	
Progressive rehabilitation and closure activities	• Rehabilitation of the RoM cannot be undertaken progressively as it is required for ongoing ore processing activities.
Decommissioning and closure	• Implement closure design and reshaping, rehabilitation of waste landform • Post-closure rehabilitation monitoring.

Program Aspect	Program Summary
Premature closure	• Finalise detailed closure designs. • Implement closure design and reshaping, rehabilitation of waste landform. • Post-closure rehabilitation monitoring.

11.2.7. Borrow pits

Table 11-8 outlines the closure work program for closure pits and quarries.

Table 11-8: Closure Work Program – Borrow pits and quarries

Program Aspect	Program Summary
Domain features	Borrow pits
Status of domain features	Active / Rehabilitated
Estimated closure date	Varied
Post-mining land use	1.3.4 Rehabilitation
Relevant closure outcomes	• Final landform is stable, and its design has considered ecological and hydrological factors. • Vegetation on rehabilitated land consists of self-sustaining native species and is compatible with the post-mining land use(s).
Specific closure assumptions	• Borrow pits are progressively rehabilitated throughout operations once they are no longer required.
Landform design	• Areas to be recontoured to be free draining. • Final surface to be rehabilitated with shallow ripping and application of 9 kg/ha seed.
Knowledge gaps	• Nil
Closure and rehabilitation materials required	• Seed mix
Closure monitoring and maintenance	• Rehabilitation monitoring (Section 12.6). • Post-closure maintenance as required (Section 12.9).
Closure Strategy – key tasks	
Progressive rehabilitation and closure activities	• Implementation of progressive rehabilitation during operations as per Rio Tinto standards and procedures. • Ongoing monitoring of completed progressive rehabilitation.
Decommissioning and closure	• Final reshaping and rehabilitation of any areas not completed progressively during operations. • Ongoing monitoring of completed progressive rehabilitation.
Premature closure	• Final reshaping and rehabilitation of any areas not completed progressively during operations. • Ongoing monitoring of completed progressive rehabilitation.

11.2.8. Permanent surface water diversions

Table 11-9 outlines the closure work program for surface water diversion infrastructure.

Table 11-9: Closure Work Program – Surface water diversions

Program Aspect	Program Summary
Domain features	Deposit B diversion. Deposit F diversion. Deposit C diversions. Deposit D diversions.
Status of domain features	Operational / Planned
Estimated closure date	2041
Post-mining land use	1.3.4 Rehabilitation
Relevant closure outcomes	• Final landform is stable, and its design has considered ecological and hydrological factors. • Public health and safety hazards have been appropriately managed. • Cultural heritage values have been preserved where possible, in consultation with stakeholders.
Specific closure assumptions	• Sufficient material is available to construct the required diversions and levees. • Adjacent pit walls have been buttressed and are geotechnically stable.
Landform design	• Assess if any additional engineering measures are required to the creek channel bed and banks and if so, implement. • Apply topsoil/subsoil to the levee footprint. • Rip the surface and seed using appropriate riparian native species.
Knowledge gaps	• Refinement of the hydrological model to better evaluate and define closure designs for currently planned and future permanent surface water diversions and pit buttressing. • Development of detailed scour assessments, based on sediment sampling and flood modelling, to improve rock protection quantity estimates.
Closure and rehabilitation materials required	• Competent material for construction of diversions and levees.
Closure monitoring and maintenance	• Aerial imagery monitoring (Section 12.3). • Landform monitoring (Section 12.4). • Water monitoring (Section 12.5). • Rehabilitation monitoring (Section 12.6). • Post-closure maintenance as required (Section 12.9).
Closure Strategy – key tasks	
Progressive rehabilitation and closure activities	• Implementation of progressive rehabilitation during operations as per Rio Tinto standards and procedures. • Ongoing monitoring of completed progressive rehabilitation.
Decommissioning and closure	• Final reshaping and rehabilitation of any areas not completed progressively during operations. • Ongoing monitoring of completed progressive rehabilitation.
Premature closure	• Final reshaping and rehabilitation of any areas not completed progressively during operations. • Ongoing monitoring of completed progressive rehabilitation.

11.2.9. Roads and other disturbance areas

Table 11-10 outlines the closure work program for surface water diversion infrastructure.

Table 11-10: Closure Work Program – Roads and other disturbances

Program Aspect	Program Summary
Domain features	Haul roads and roads Exploration disturbance Laydowns & Hardstands Car Parks Top/subsoil stockpiles Fence lines, firebreaks, tracks and temporary (unsealed) roads, operational diversions/drains, cleared areas Post-closure monitoring access tracks
Status of domain features	Active
Estimated closure date	• Progressively through until 2041. • Post-closure monitoring access tracks will remain until just prior to relinquishment.
Post-mining land use	1.3.4 Rehabilitation
Relevant closure outcomes	• Contamination risks have been appropriately managed and do not preclude the agreed post-mining land uses(s). • Vegetation on rehabilitated land is self-sustaining and compatible with the post-mining land use. • Public health and safety hazards have been appropriately managed. • Infrastructure has been appropriately managed. • Cultural heritage values have been preserved where possible, in consultation with stakeholders.
Specific closure assumptions	• Exploration disturbance is progressively rehabilitated as areas become available (if they are not to be subsequently mined). • Remaining features in this domain, expect for post-closure access tracks, will be rehabilitated at closure. • Prior to relinquishment, final rehabilitation works to close the post-closure access monitoring tracks will be completed. • All roads and water bores will be rehabilitated unless ownership is transferred to a third party. • Disturbance will be rehabilitated to according to relevant Rio Tinto standards and procedures.
Landform design	• Removal of concrete and bitumen from hardstands and carparks. • Deep cross ripping (1 m, where safe) to alleviate compaction in laydown, hardstand, and car park areas. • Areas to be contoured to remove windrows and other impediments to surface water flows. • Final surface to be rehabilitated with application of up to 200 mm growth media (laydowns, hardstands, and car parks only), shallow ripped and seeded Topsoil and subsoil stockpile footprints will be ripped and seeded at a rate of 9 kg/ha. • Fence lines, firebreaks, tracks etc. will have windrows spread to remove surface water drainage impediments. No growth medium will be applied but the areas will be scarified and seeded. • Slopes either side of the haul road to be recontoured. • Cross bunds to be installed where appropriate. • Deep ripping of road surface (1 m) to alleviate compaction. • Removal of existing culverts to reinstate surface water flows in drainage lines.
Knowledge gaps	• Nil
Closure and rehabilitation materials required	• Growth medium (see Section 5.5.2). • Seed mix.
Closure monitoring and maintenance	• Rehabilitation monitoring (Section 12.6). • Post-closure maintenance as required (Section 12.9).

Program Aspect	Program Summary
Closure Strategy – key tasks	
Progressive rehabilitation and closure activities	• Implementation of progressive rehabilitation during operations as per Rio Tinto standards and procedures. • Ongoing monitoring of completed progressive rehabilitation.
Decommissioning and closure	• Final reshaping and rehabilitation of any areas not completed progressively during operations. • Ongoing monitoring of completed progressive rehabilitation.
Premature closure	• Final reshaping and rehabilitation of any areas not completed progressively during operations. • Ongoing monitoring of completed progressive rehabilitation.

11.3. Progressive Rehabilitation

11.3.1. Progressive rehabilitation approach

Progressive rehabilitation activities allow for the trialling of rehabilitation methods and strategies to inform future closure activities and practices. Monitoring of the rehabilitation completed across Rio Tinto's operations is used to indicate the likely success of this and future rehabilitation activities in establishing self-sustaining areas of native vegetation, or if areas of rehabilitation may require rework due to poor performance.

Rehabilitation is conducted in accordance with Rio Tinto standard procedures, which are periodically reviewed and updated to reflect changes in industry standards, reflect new knowledge obtained through research and development and to adopt learnings from progressive rehabilitation.

Current rehabilitation practices are included below. In addition to on-ground activities, management, research and development initiatives, and internal governance practices are applied to improve planning and implementation of rehabilitation.

- Landform specific rehabilitation designs based on mineral waste characterisation and site-specific climatic conditions.
- Survey control of rehabilitation earthworks to ensure conformance to the rehabilitation design.
- Use of local provenance native species mixes for seeding the landform, which are based on species that are local to the area and appropriate for the landform being rehabilitated.
- Production of close-out reports from each substantial earthwork projects to ensure rehabilitation protocols are captured and learnings are shared across the Pilbara mining operations.

The indicative times at which West Angelas deposits become potentially available for rehabilitation based on the 2021 LoM are presented below in Figure 11-3.Figure 11-3: Indicative completion dates of mining across the West Angelas deposits

The decision on whether to progressively rehabilitate an area is based on discussions with many departments to assess whether areas will be re-disturbed in the future, and/or used for another purpose prior to the opportunity for rehabilitation is confirmed. If it is determined that an area could be a rehabilitation opportunity it is captured in forward planning for progressive rehabilitation activities.

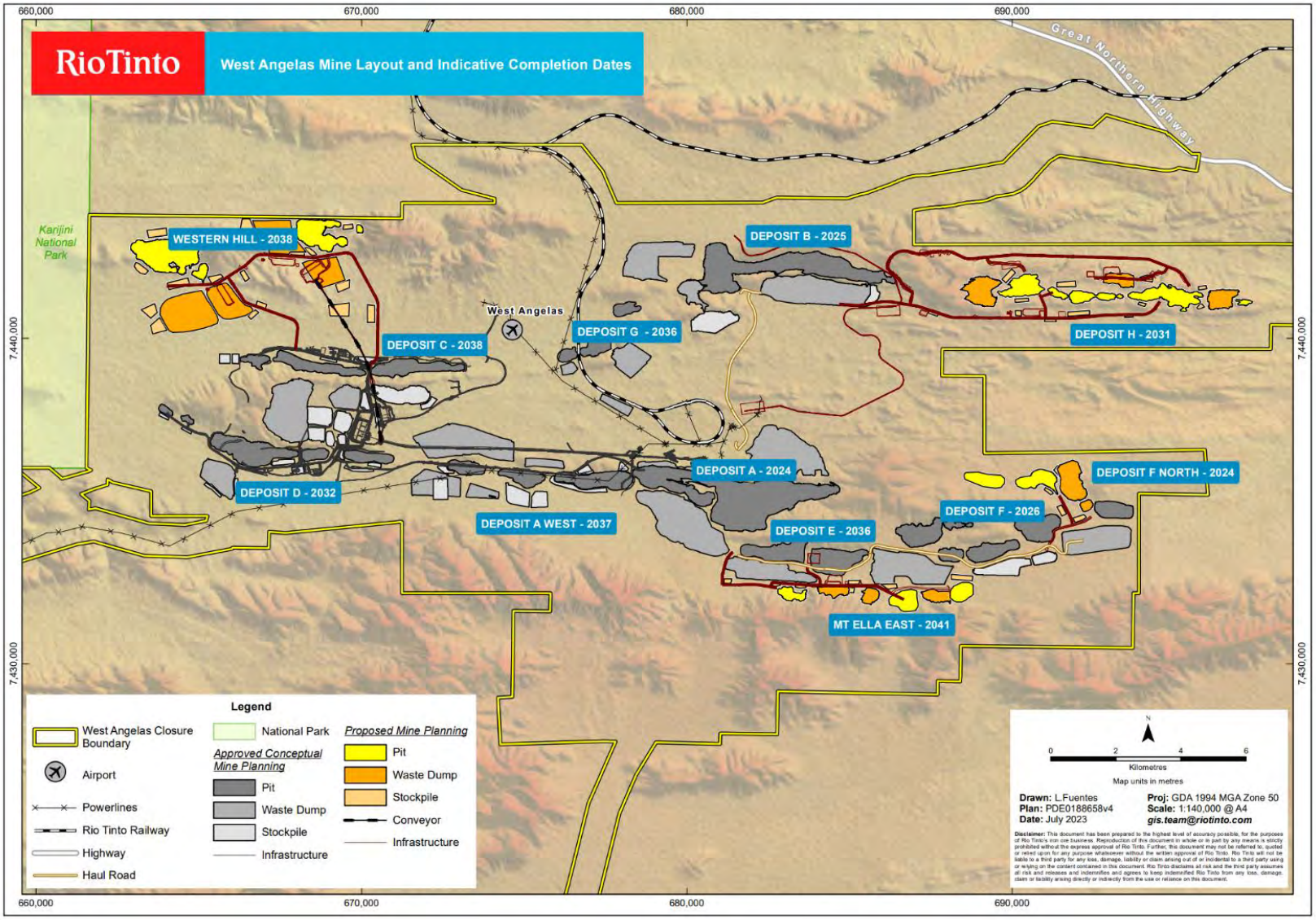

Figure 11-3: Indicative completion dates of mining across the West Angelas deposits

11.3.2. Rehabilitation planning and implementation

Implementation of progressive rehabilitation will occur, where possible, during operations at West Angelas. Progressive rehabilitation will enable opportunities to undertake trials, reduce financial closure liability and demonstrate to key stakeholders Rio Tinto's commitment to meet the social and environmental licence to operate.

11.4. Post Mining and Post Closure Landforms

The post-mining landform is the landform that would be generated as a result of implementation of the mine plan assuming no progressive rehabilitation activities are conducted. The post-closure landform is the final expected landform at the completion of the closure measures outlined in Section 11.2. Conceptual images for post-mining and post-closure landforms for West Angelas are included in Figure 11-4 to Figure 11-13.

Currently, conceptual post-mining landforms for the proposed mining operations at Western Hill, Deposit H, Deposit F-North and Mt. Ella East have not been generated and will be included in subsequent versions of this MCP. Final pit voids for the proposed deposits have been generated and are included in Figure 11-14 to Figure 11-16.

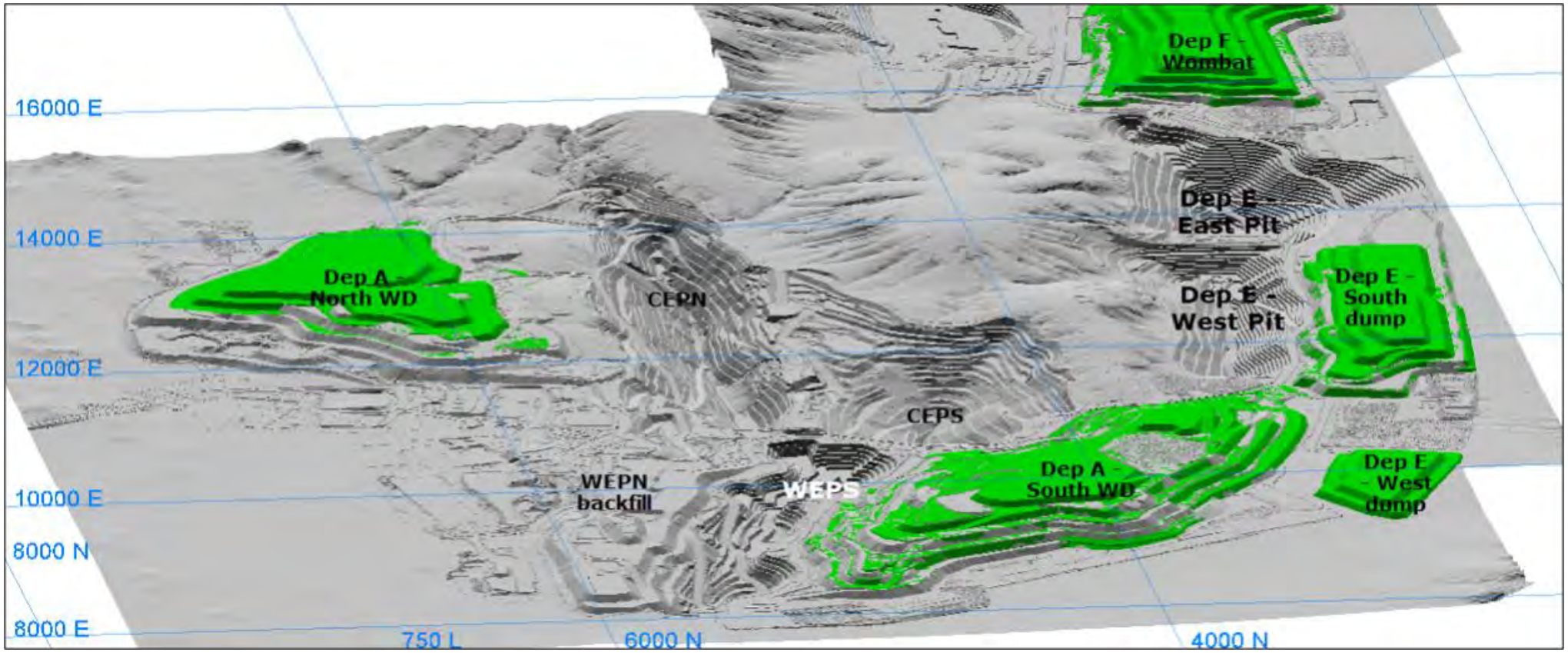

Figure 11-4: Hub AE post-mining landforms

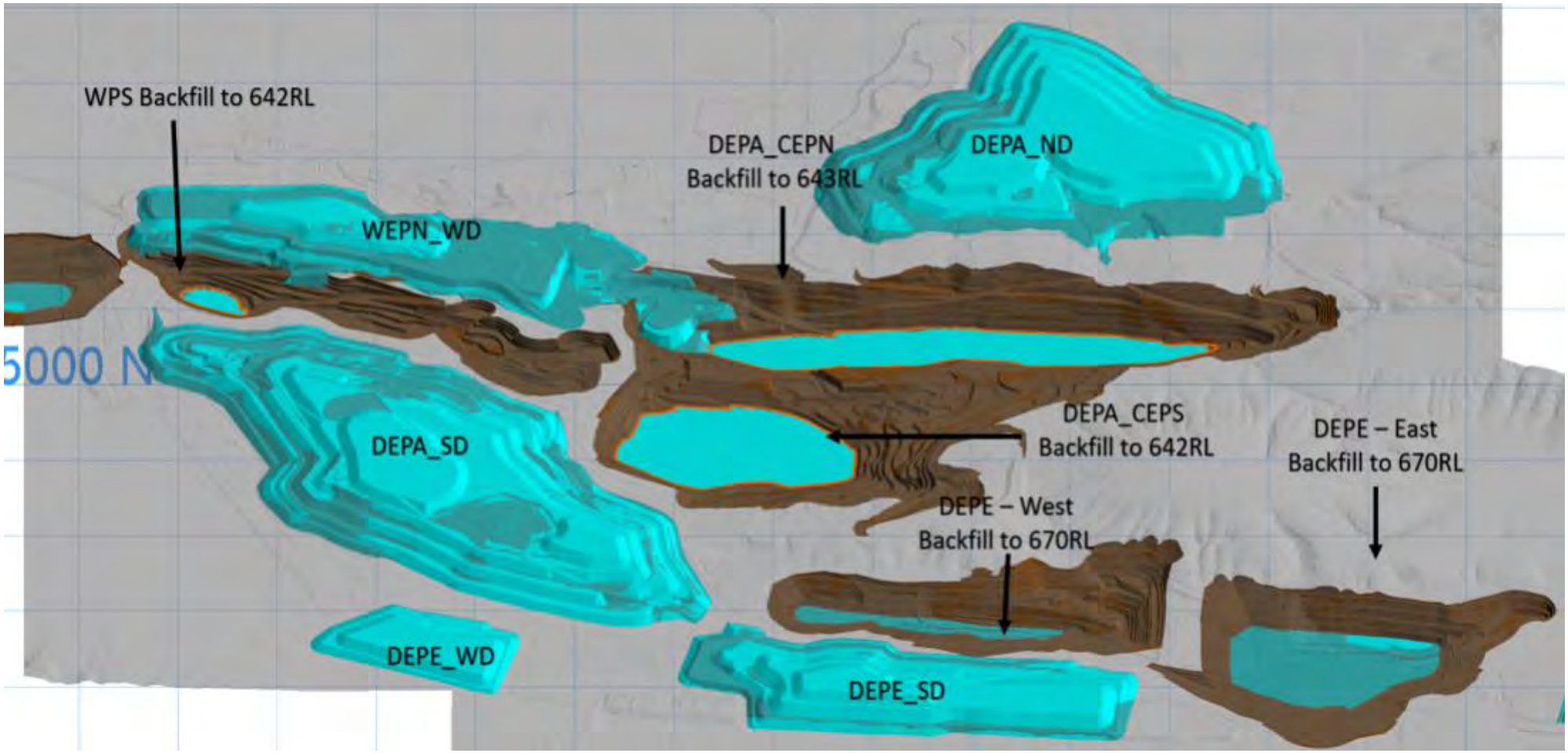

Figure 11-5: Hub AE post-closure landforms including indicative backfill levels

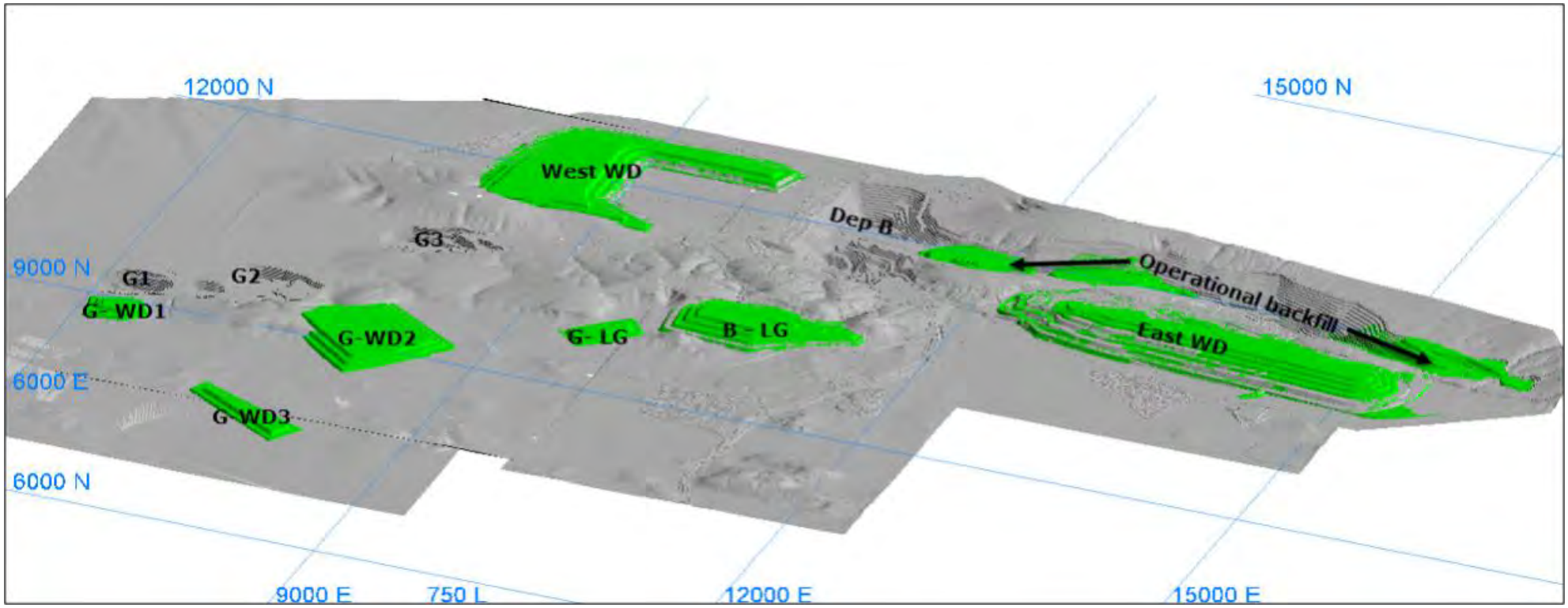

Figure 11-6: Hub BG post-mining landforms

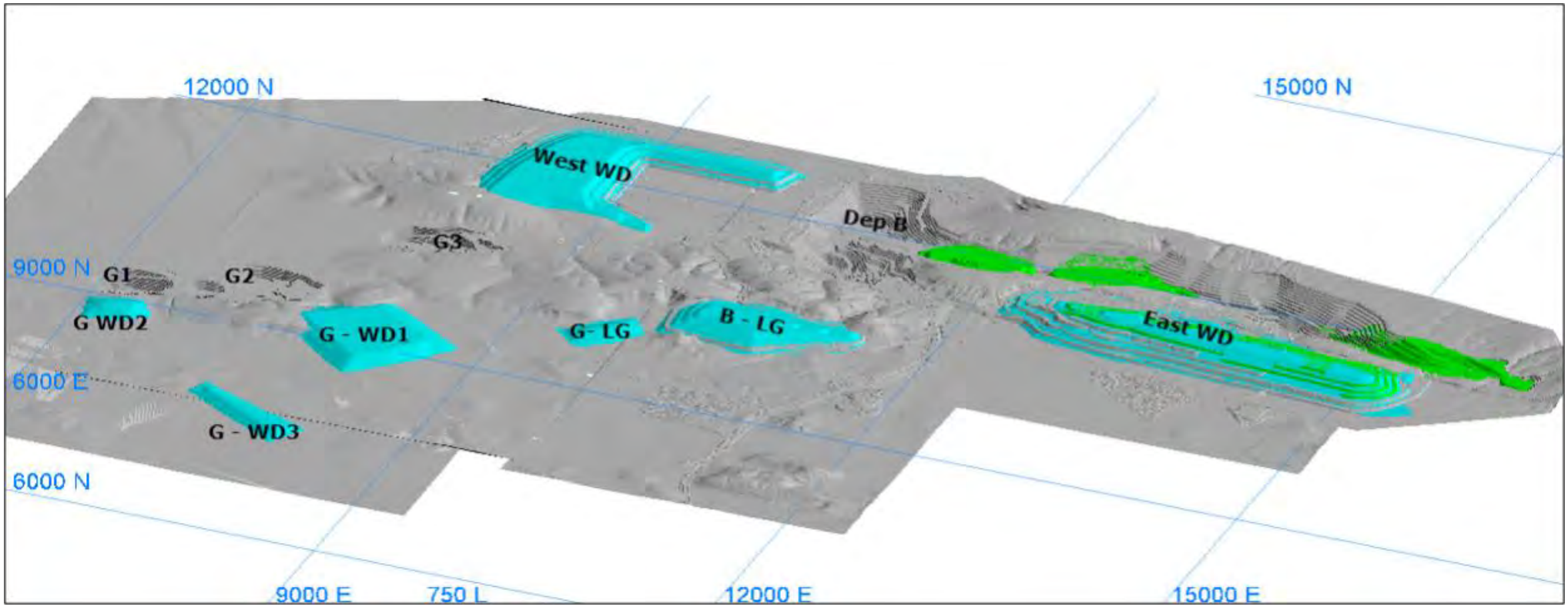

Figure 11-7: Hub BG post-closure landforms including indicative backfill levels

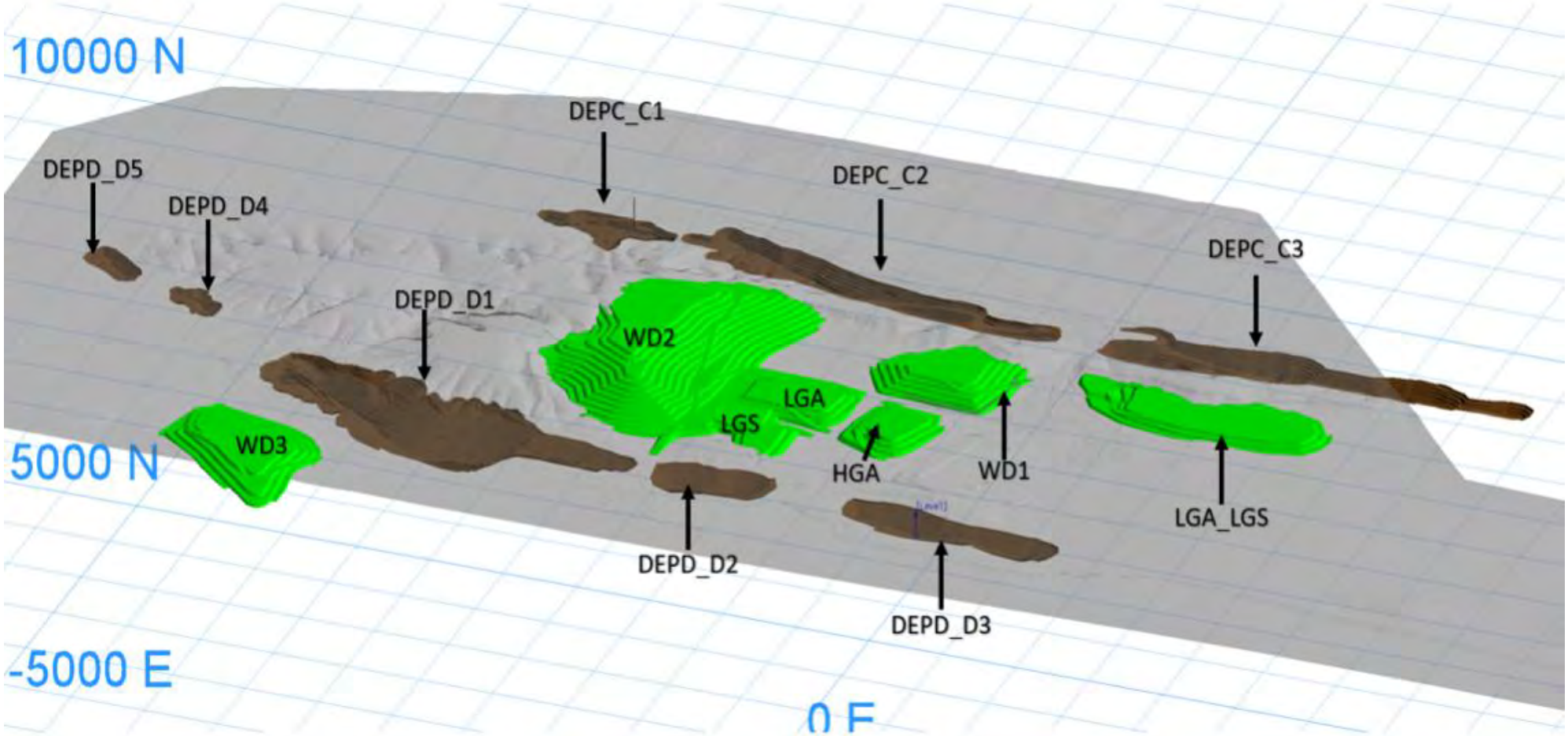

Figure 11-8: Hub CD post-mining landforms

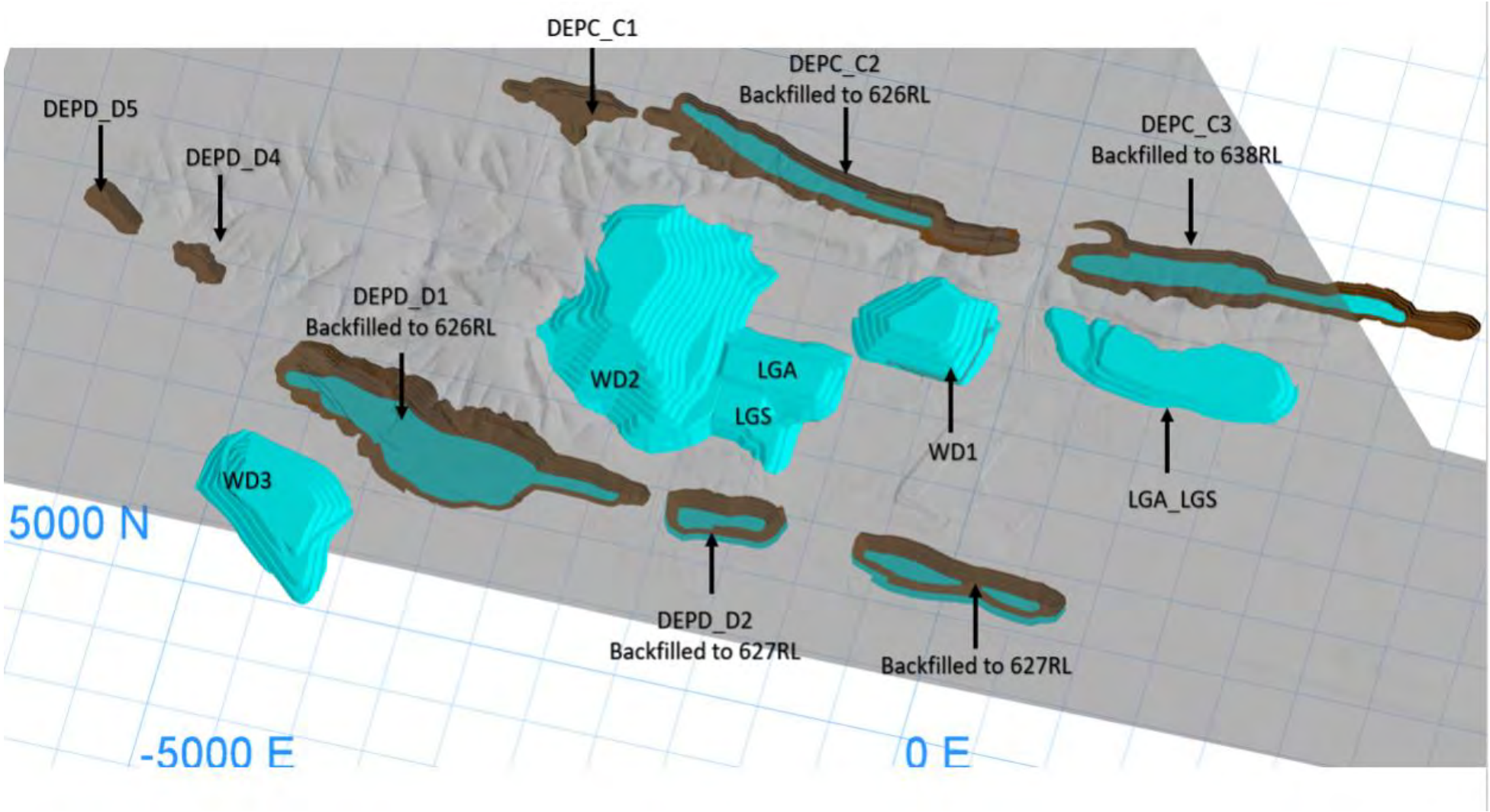

Figure 11-9: Hub CD post-closure landforms including indicative backfill levels

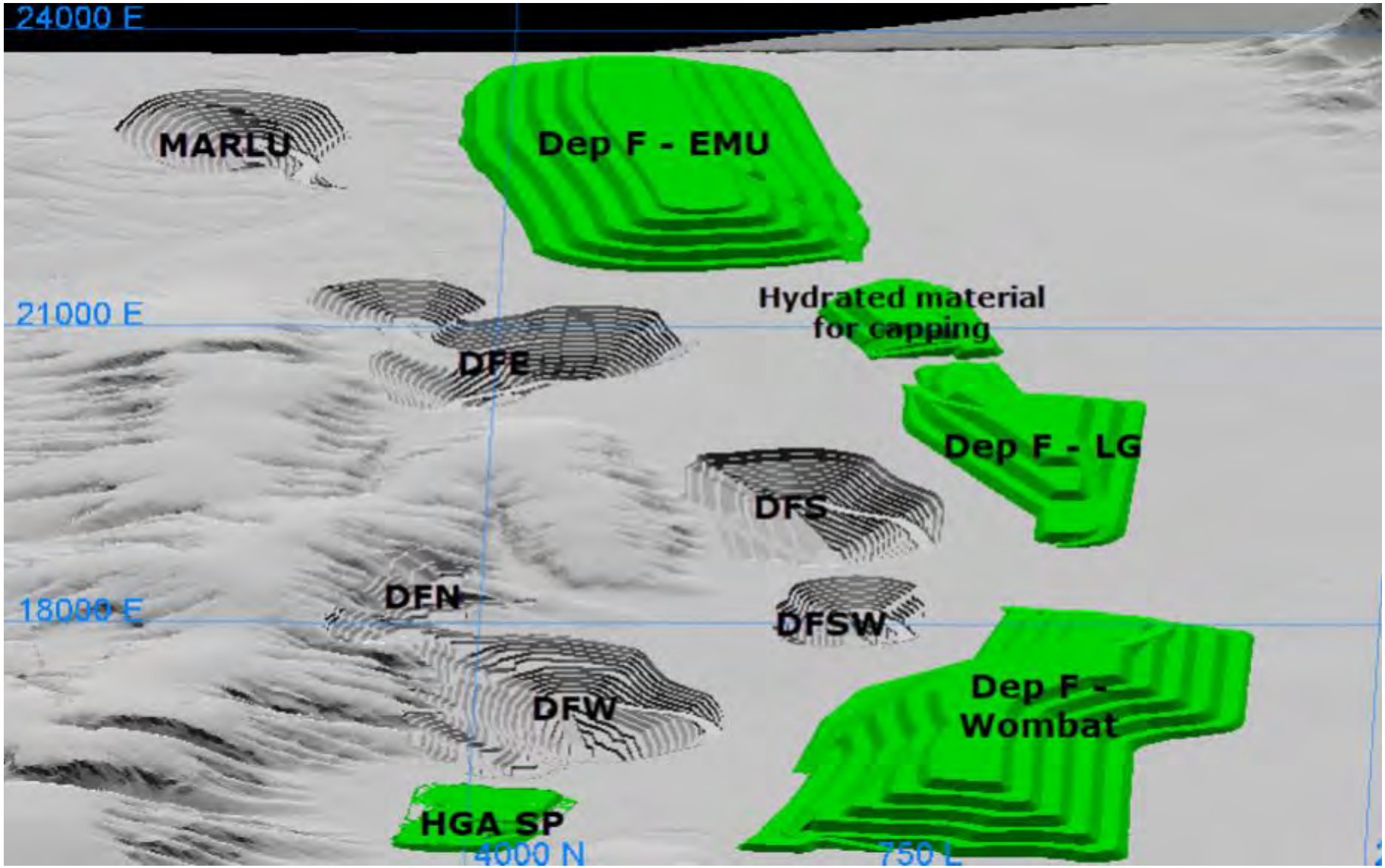

Figure 11-10: Hub F post-mining landforms

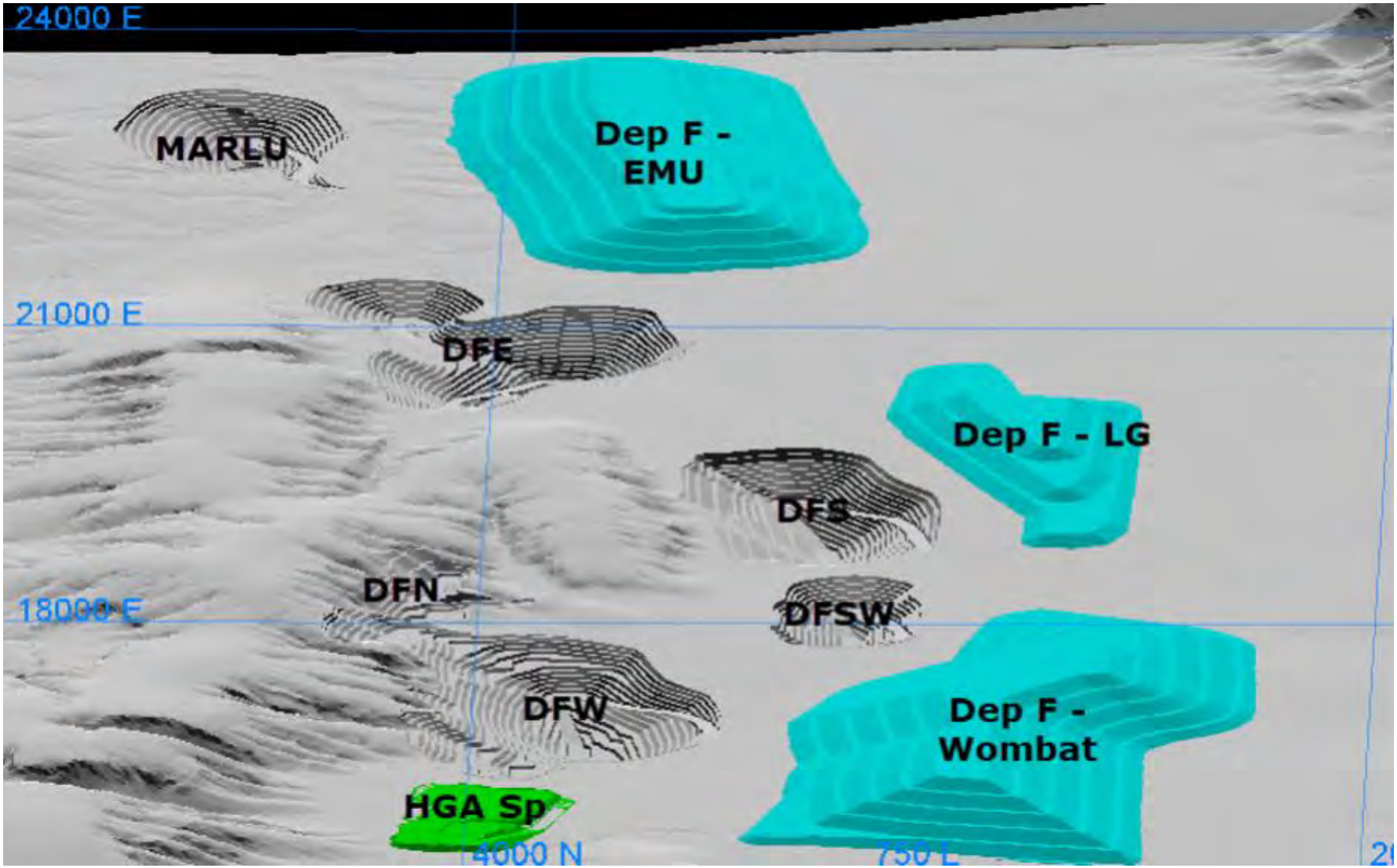

Figure 11-11: Hub F post-closure landforms including indicative backfill levels

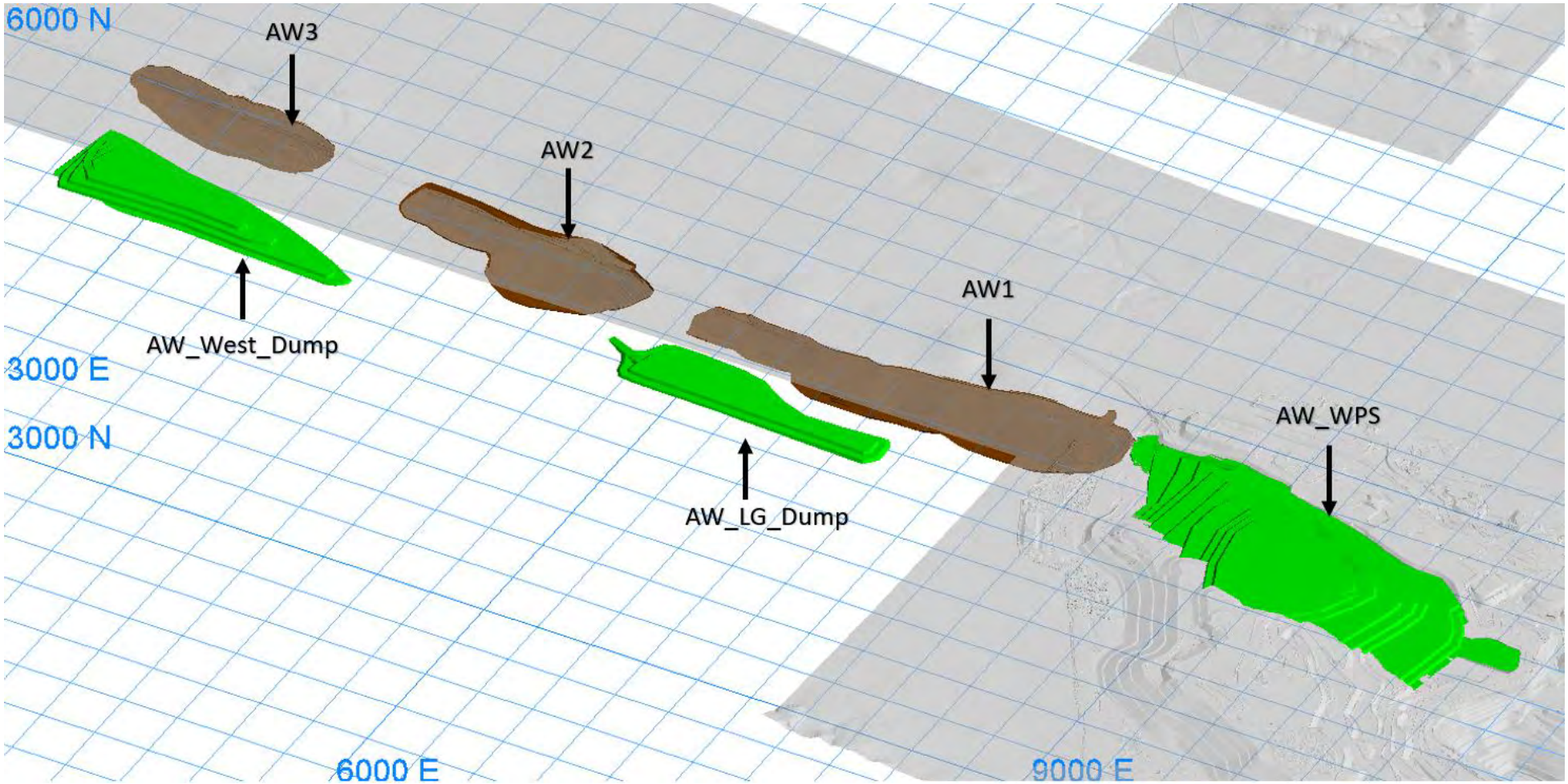

Figure 11-12: A West post-mining landforms

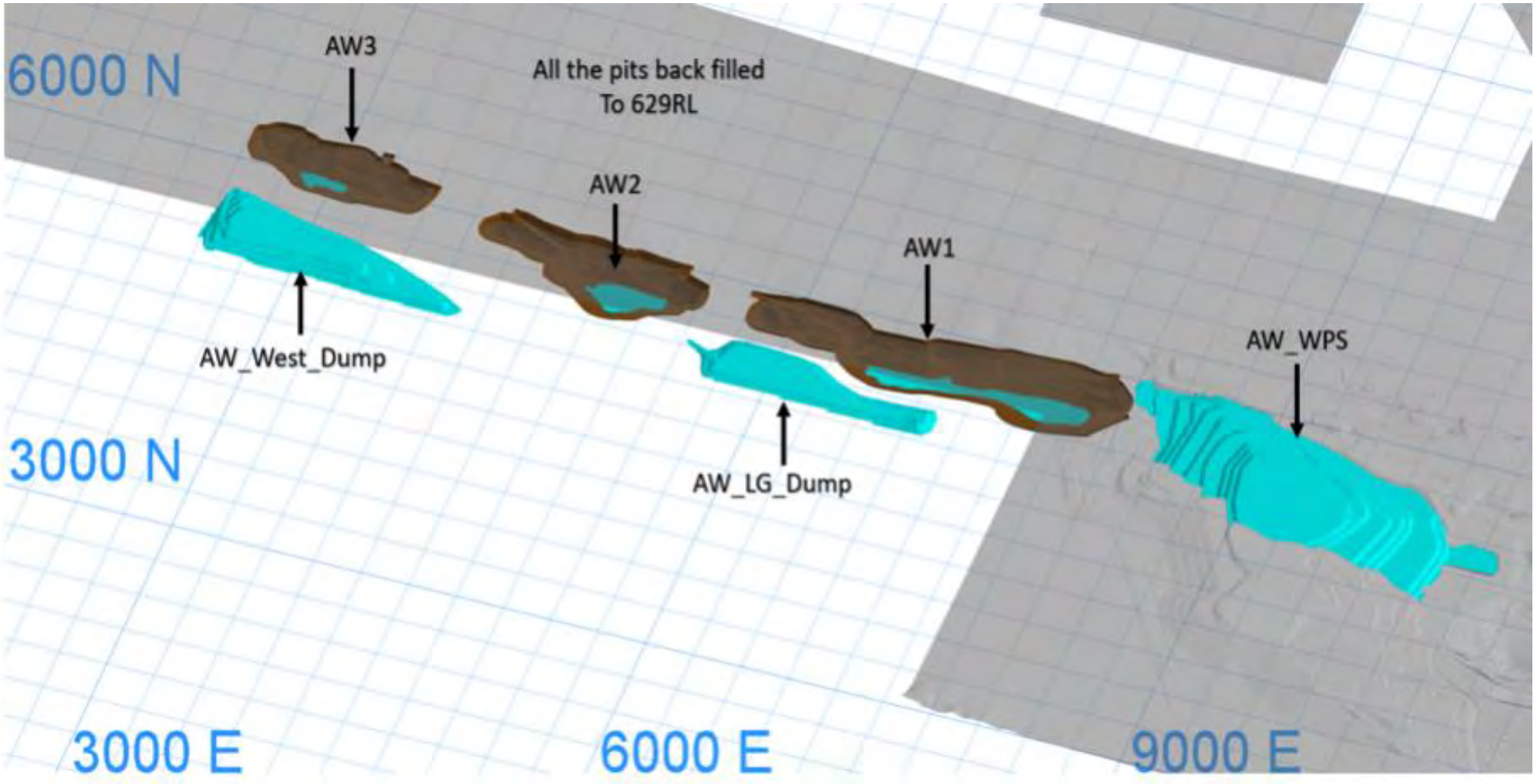

Figure 11-13: A West post-closure landforms including indicative backfill levels

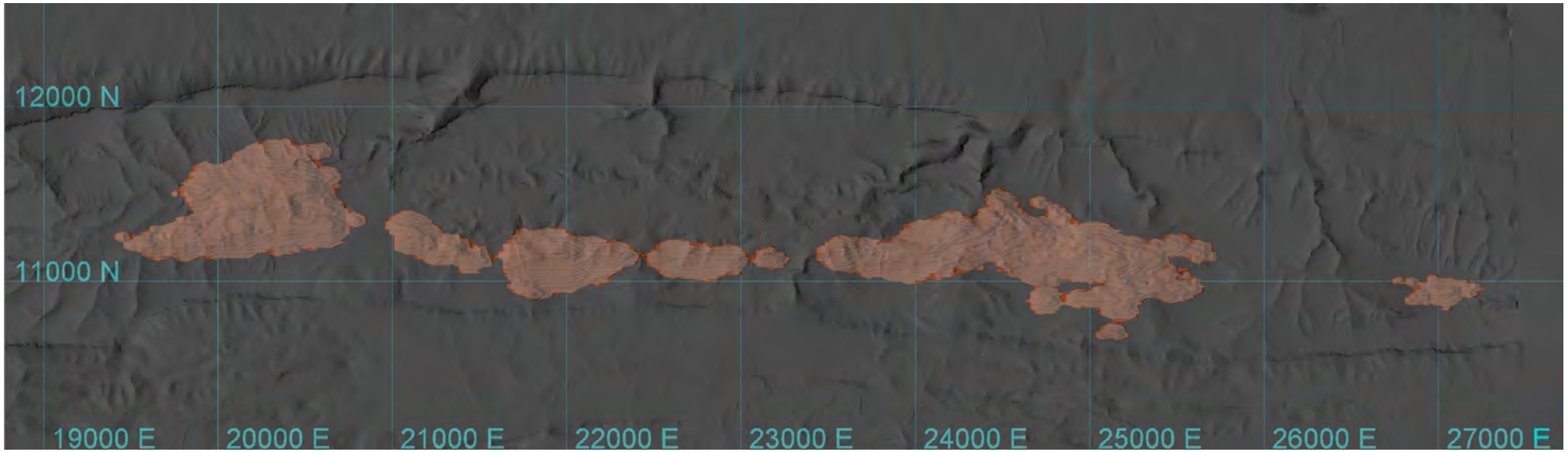

Figure 11-14: Deposit H final pit voids

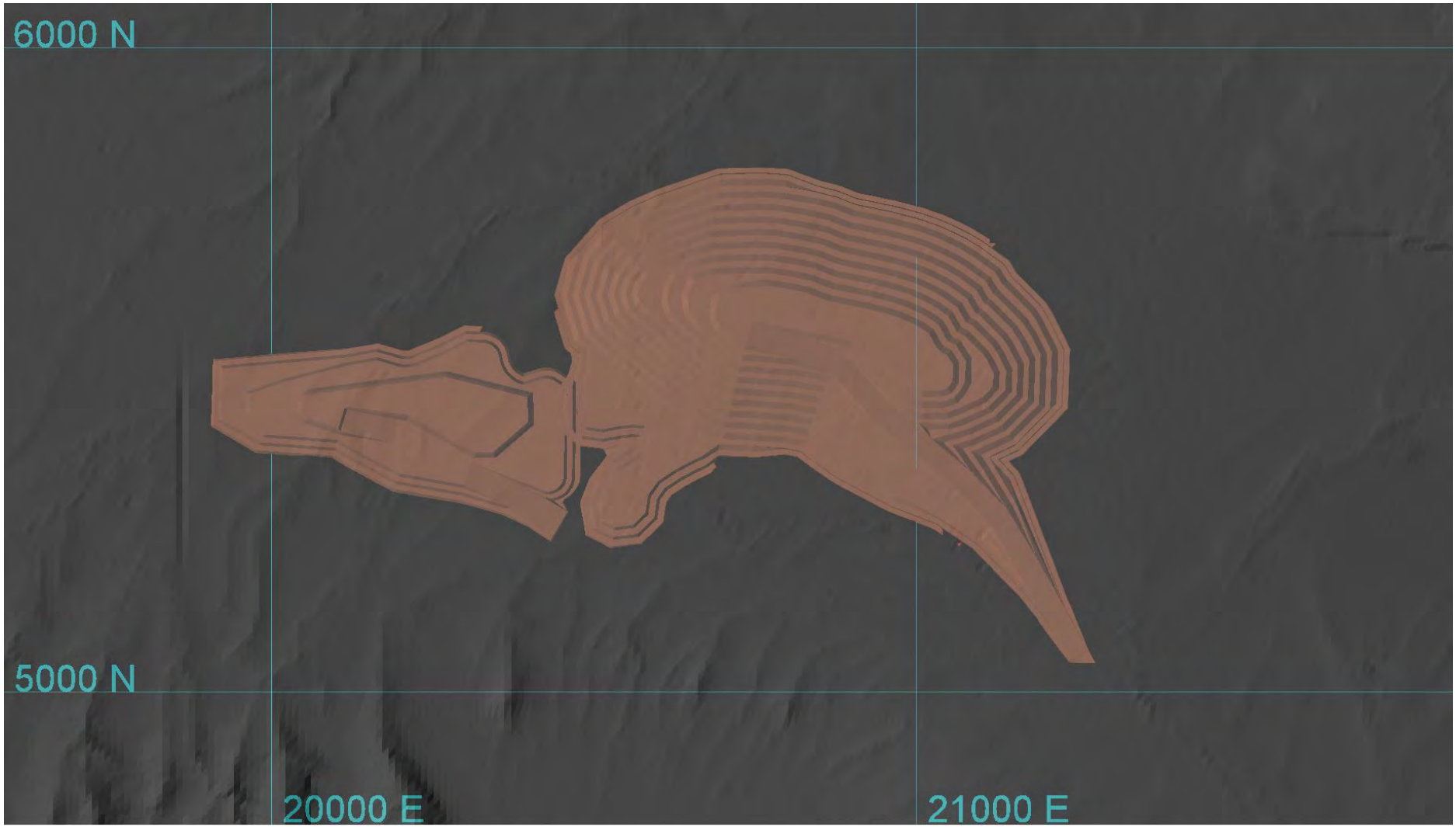

Figure 11-15: Deposit F North final pit voids

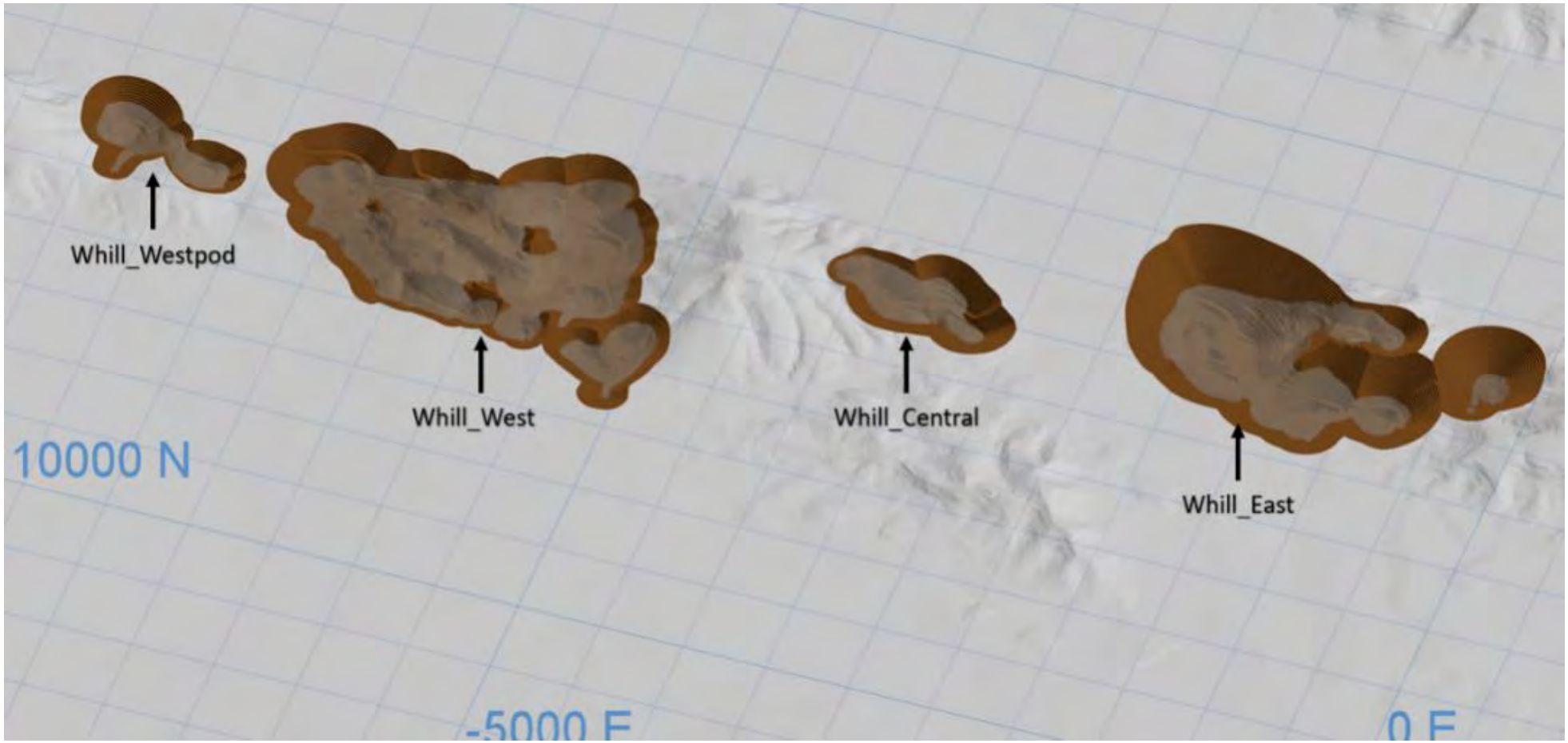

Figure 11-16: Western Hill final pit voids

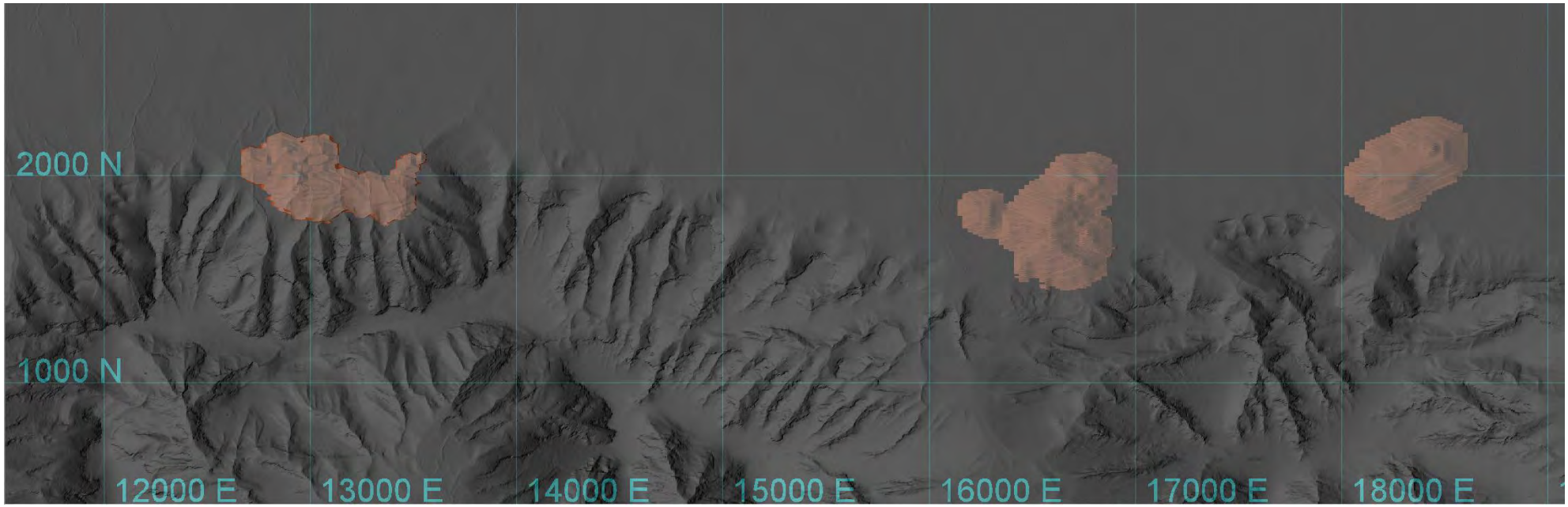

Figure 11-14: Mt Ella East final pit voids

11.5. Unexpected Closure

Premature closure of West Angelas would likely result in modifications of the proposed mine closure strategies detailed in this MCP and its subsequent revisions.

In the event of unexpected or premature closure, revision and update of the environmental risk assessment would occur to determine key areas for closure works and any change in residual risk from premature closure. Outcomes of the review will be used to prioritise closure tasks.

As a result of unexpected closure, a revision and update of the MCP and development of a Decommissioning Plan will be completed to address changed circumstances and gain approval from relevant key stakeholders where strategies may need to be amended.

These plans would require the following as a minimum:

- Stakeholder engagement to communicate the strategy to be implemented and address concerns of key stakeholders.
- Review closure outcomes and completion criteria to determine any which may be difficult to achieve given premature closure. Communicate these with relevant key stakeholders to determine a way to resolve issues.
- Amended landform designs for WFSFs, waste dumps, mining voids and surface water control structures where the proposed design could no longer be met.
- Review of topsoil and other rehabilitation materials balances to determine any deficiencies in materials, and options to address this.
- Undertake contaminated land assessment, and where required, remediation works, of all areas of the Project used to manufacture, store or utilise hazardous materials.
- Update the final void groundwater model where the proposed extent of mining did not occur to determine if the closure strategy requires amendment.
- Finalise any rehabilitation or closure trials to determine if findings are adequate to implement.
- Review and update monitoring and maintenance requirements.
- Revision and update of the closure cost estimate to determine any financial constraints associated with altered designs or deficit of rehabilitation materials.
- Address all safety obligations required under Sections 42 and 88 of the *Mines Safety and Inspection Act 1994* (WA) relating to mine suspension or abandonment. One of those obligations is to notify the relevant DMIRS District Inspector before a mining operation is suspended or abandoned.

11.6. Decommissioning

A Decommissioning Plan will be developed based on the provisional closure budget and MCP for implementation and stakeholder approval where required.

Once ore processing has been completed, decommissioning of equipment and facilities prior to removal of those items not identified to remain post closure will be undertaken. Where appropriate, process circuits and storage vessels will be decontaminated, electrical distributions de-energised and stocks run down prior to decommissioning commencing.

Equipment and facilities that will not remain post closure will either be dismantled for reuse or resale, or demolished for on-site disposal, with the approach selected being based on economic conditions at the time of closure and in consultation with Traditional Owner groups and other key stakeholders.

Contaminated land assessments will be undertaken following removal of infrastructure, or within the vicinity of infrastructure to be handed over to a stakeholder. Where required, remediation activities will occur and the monitoring and maintenance requirements within the MCP updated.

Final landforms will be constructed, including any installation of covers, placement of growth medium, abandonment bunds and surface drainage structures. Where required, soil amendments will be made and seed mixes spread.

Groundwater production and monitoring bores not required for the post closure monitoring program, or being handed over to stakeholders, will be decommissioned to meet DWER requirements.

Monitoring activities will commence within the required timeframes following completion of rehabilitation activities.

Revision and update of the closure cost estimate to determine any financial constraints associated with altered designs or deficient materials.

12. CLOSURE MONITORING AND MAINTENANCE

The primary purpose of closure monitoring is to assess whether the agreed closure completion criteria have been met across the West Angelas closure boundary.

Monitoring will be undertaken in several phases including:

- Pre-closure: monitoring undertaken during operations and as the site approaches closure to inform detailed closure planning and rehabilitation designs. Pre-closure monitoring activities are already underway at West Angelas and will continue until closure. The results of monitoring undertaken to date are detailed in Appendix 12.
- Closure implementation: monitoring during active closure to ensure closure execution is not causing unapproved impacts.
- Post closure monitoring will be undertaken as required until it is determined that the closure outcomes have been met or it is otherwise agreed with Government to allow relinquishment of the site.
- Post-closure maintenance activities may include rework of landform reshaping and/or revegetated areas where monitoring indicates additional work is required to achieve completion criteria. Maintenance activities may also include weed management, maintenance of access restriction measures, as well as maintenance of equipment used in the post-closure monitoring program (e.g. groundwater bores).

This plan considers pre-closure, closure and post-closure monitoring, while baseline monitoring informs the closure knowledge base and development of closure strategies.

12.1. Indicative Closure Monitoring Program

The closure monitoring program will be finalised during the detailed closure planning stages as the site approaches closure. However, the program could be expected to include such components as indicated in Table 12-1. Specific and appropriate monitoring will be conducted to ensure data is obtained to allow assessment of performance against completion criteria (Section 9.4). The monitoring program will be sufficiently flexible to enable adjustments to be made if results indicate that more or less monitoring is warranted at any particular phase. Specific parameters within each aspect are to be defined.

Table 12-1: Indicative plan for closure phase monitoring

Aspect	Phase		
	Pre-closure	During closure implementation	Post-closure
Erosion / landform stability monitoring	✓	✓	✓
Rehabilitation (vegetation) monitoring	✓	✓	✓
Groundwater level monitoring	✓	✓	✓
Groundwater quality monitoring	✓	✓	✓
Surface water quality monitoring	✓	✓	✓
Contaminated sites assessment	✓	✓	✓
Heritage survey	✓	✓	✓
Geotechnical stability	✓	✓	
Climate monitoring	✓	✓	✓
Safety / site access monitoring			✓

12.2. Climate monitoring

Section 5.3 describes the climatic monitoring undertaken nearby and at West Angelas. The BOM station at Newman Aerodrome (station 007176) is assumed to continue operation throughout closure and post-closure phases and will continue to monitor daily temperature and rainfall. Additionally, the West Angelas weather station will continue to operate throughout the closure monitoring phases.

Ongoing climate monitoring will build the closure knowledge base to inform:

- Landform stability monitoring, to help assess resistance to erosion from various rainfall events.
- Vegetation monitoring, to help assess the effect of rain and drought on revegetation performance.
- Groundwater monitoring, to help interpret changes in post-mining groundwater levels.

12.3. Aerial imagery monitoring

Aerial imagery will be a key tool of the closure monitoring program. Rio Tinto will undertake high accuracy and resolution aerial surveys to produce 3D data throughout closure implementation and post-closure to inform site rehabilitation progress. Data capture will be undertaken annually, at a minimum. Aerial surveys will capture a level of data enabling the creation of digital terrain models and assessment of temporal and spatial changes in the landscape including comparison of:

- Vegetation;
- Geotechnical stability; and
- Erosion of landforms and sediment movement in the landscape.

12.4. Landform monitoring

12.4.1. Landform construction

As outlined in Section 9.4 and in Table 9-3, some proposed completion criteria can be certified as achieved when elements of the closure landform have been constructed. Construction quality assurance and control measures will be implemented throughout the closure implementation phase, including conformance surveys at key milestones of rehabilitation of each waste landform; such as:

- At completion of reshaping works, to confirm design slope angles, lift heights, berm widths and backslopes, and bund heights and locations have been achieved.
- At completion of ripping and seeding works, or reclamation works for waste landforms that will be removed at closure, to confirm the as-built landform aligns with the approved closure design.

An appropriately qualified engineer will also inspect the abandonment bunds and provide a report to confirm they have been constructed in accordance with the approved design. Verification from the DMIRS Mines Safety Branch will also be required to demonstrate the abandonment bunds have been constructed to the satisfaction of DMIRS. Rio Tinto will organise a site visit with appropriate DMIRS representative/s once the West Angelas abandonment bunds have been constructed.

12.4.2. Geotechnical stability monitoring

Operational geotechnical stability monitoring of pit walls is undertaken using manual and automatic prisms, extensometers, visual inspections and aerial survey data, and will continue throughout the pre-closure and closure implementation phases. The purpose of this monitoring is to ensure the safety of operational and closure implementation personnel.

Post-closure geotechnical stability monitoring will focus on waste landforms, including those waste landforms remaining within PUPEZs, to identify any signs of large-scale geotechnical instability that would prevent the closure outcome of having stable final landforms from being achieved.

Monitoring methods using remote sensing are considered most appropriate for the post-closure period. Remote sensing methods currently available that may be used for post-closure geotechnical stability monitoring include:

- InSAR (Interferometric Synthetic Aperture Radar): this is a space-based satellite mounted radar system. The radar can detect ground displacements.
- UAV: this method uses photogrammetric methods to detect changes in ground position.

The post-closure geotechnical stability monitoring program will be refined over time and will utilise the most appropriate available technology to demonstrate the closure outcome of safe and stable landforms has been achieved. Should post-closure monitoring identify conditions that do not meet the agreed closure outcomes, maintenance and rework measures will be determined and implemented as appropriate.

12.5. Water Monitoring

Water monitoring during closure will focus on confirming groundwater recovery levels and water quality. A specific program of monitoring will be developed prior to decommissioning and will use the operational water monitoring program as a basis of design.

12.6. Rehabilitation Monitoring

The purpose of the rehabilitation monitoring program is to evaluate successional development of rehabilitation areas and thereby provide useful feedback for the improvement of rehabilitation techniques, and to help assess progress towards long-term rehabilitation outcomes.

The results of rehabilitation monitoring provide vital information to set realistic, achievable and meaningful completion criteria. This occurs through evaluation of trends and trajectories in key parameters, and by comparison of monitoring results from corresponding reference or analogue sites, positioned within local areas of undisturbed native vegetation.

Rehabilitation monitoring will be completed in the cooler months (May to September) each year. The monitoring programme design - monitoring technique and frequency - for each rehabilitated area considers the following factors:

- level of complexity of the rehabilitation and associated rehabilitation quality risk;
- regulatory monitoring requirements;
- rehabilitation age;
- rehabilitation quality;
- rehabilitation area size;
- is it a rehabilitation trial area;
- natural disturbance, such as fire, cyclonic rainfall and drought;
- safe access for monitoring personnel; and
- efficient use of monitoring resources.

Rehabilitation monitoring utilises several techniques which are matched to the level of rehabilitation quality risk. The techniques used are summarised in the following sections.

12.6.1. Vegetation, fauna habitat and erosion quantitative method

The described intensive quantitative method is used on moderate and high-risk landforms.

Vegetation monitoring involves permanent transects up to 100 m in length, comprised of 2 m x 2 m quadrats at intervals of 5 m. Within each quadrat, numbers of all native perennial plant species and

weeds are counted, and their % cover estimated. Total native perennial plant cover is assessed by dividing the 2 m section along the transect baseline into eight, 25 cm sections and recording the number of these that have no cover of any native perennial plant species.

A subjective assessment of total native perennial plant cover (%), for plants rooted within the quadrat, is also recorded. The general condition of the rehabilitation is noted, including new disturbance and fire damage. Photographs are taken from both the start and end point of each transect.

Fauna and habitat monitoring may involve: estimating litter cover; presence of rocks and logs; whole of transect assessment of grazing extent; native animal scats; ant numbers; and indicators of native animal activity.

Erosion monitoring involves identifying gullies, as defined by being greater than 30cm deep, along the same transect, but extended to 150 m, recording the location of each gully and measuring their total width and depth at the deepest point. If erosion is identified elsewhere in the rehabilitation area, then an erosion specific transect would be installed on a representative section of the gully and total width and depth at the deepest point recorded. A photograph is taken of each measured gully.

12.6.2. Rehabilitation quality assessments

Rehabilitation quality assessment will be employed on low-risk areas, historical rehabilitation with no monitoring history, or on areas too small for transects. They can also be used in combination with the above transect methods on large rehabilitation areas to manage monitoring resources efficiently. The purpose is to gain an overview of the rehabilitation quality including erosion, growth medium, vegetation cover, species richness, vegetation structure, plant density, weed presence and general condition. Each characteristic is compared between the rehabilitation and local undisturbed native vegetation and given a score according to the rehabilitation quality assessment field book guidelines. A representative photograph is taken of both the rehabilitation and reference areas.

12.7. Cultural Heritage Monitoring

Heritage assessments will be undertaken prior to closure with the Traditional Owners to ascertain potential cultural heritage impacts from closure implementation and inform the development of alternative strategies if required. Assessments are also undertaken post-closure to confirm that implementation has been undertaken in an appropriate manner.

12.8. Contaminated sites monitoring

Contaminated sites monitoring occurs as per DWER guidelines to determine impacts and areas that require remediation, and / or classification.

12.9. Post-closure Maintenance

Post closure, maintenance will continue as required until it is determined that the closure outcomes have been met or it is otherwise agreed with Government to allow relinquishment of the site.

13. FINANCIAL PROVISION FOR CLOSURE

Rio Tinto considers specifics of the closure cost estimate to be commercially sensitive information, therefore, this section provides an outline of the general process used to develop the closure cost estimate.

13.1. Principles of Rio Tinto closure cost estimation

Closure cost estimates are determined based on methods outlined in the *Rio Tinto Closure Standard* (2021a) and the *Rio Tinto Accounting Policy* (2021c). Closure costs are considered in the following two formats:

- Present Closure Obligation (PCO) - indicative of costs associated with closure of the mine given its current footprint; this accounts for the progressive development of a site over time; and
- Total Projected cost of Closure (TPC) - predicts the cost (in current terms) associated with closure at the end of LOM. The TPC includes areas that are not currently approved, but that feature within the LOM plan and that are considered likely to be developed in the future.

The cost estimates consider the following components[16]:

- pre-closure studies;
- decommissioning (i.e. removal of infrastructure)[17] and final landform construction;
- rehabilitation, biodiversity and heritage management;
- workforce management (i.e. training costs and redundancy payments)[18];
- monitoring costs;
- costs associated with the development of the final closure plan;
- costs associated with undertaking a final shutdown of operations;
- allowance for failed rehabilitation or pollution that may necessitate rework of rehabilitation areas;
- assignment of indirect costs in accordance with *Rio Tinto Accounting Policy* (2021c); and
- a contingency factor.

13.2. Closure cost estimation methods

Closure cost estimation is based on methods outlined in the *Rio Tinto Closure Standard* (2021a) and *Rio Tinto Accounting Policy* (2021c), with the level of accuracy increasing as the site approaches closure[19]. The closure cost estimates are conducted based on the most recent information of mine plans and infrastructure, with the estimate generally undertaken by specialist external consultants.

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[16] Costs associated with decontamination are assessed during MCP development but are costed separately as operating costs.

[17] The decommissioning cost estimate assumes that infrastructure will be demolished and buried on site. The site is sufficiently remote that deconstruction for the purposes of materials salvage and recycling is likely to be cost prohibitive; however, opportunities for salvage and recycling will be sought as the site approaches closure.

[18] Workforce management costs are only included in the TPC.

[19] The level of accuracy applied to Rio Tinto estimates is as follows:

- greater than 10 years from closure: ±30%;
- between 10 and 5 years from closure: ±20%; and
- less than 5 years from closure: ±15%.

The PCO estimate for each site is revised annually to account for incremental mine development during the year. As part of Rio Tinto assurance processes these cost estimates are audited annually by external financial auditors to ensure the processes to generate the provisions are adequate and well maintained. The TPC estimate is revised when a formal MCP update occurs, usually triennially, to capture any changes to the LOM design.

14. MANAGEMENT OF INFORMATION AND DATA

14.1. Information Management System

Rio Tinto operates a comprehensive document management system, with electronic records of all key information and data. The document system, known as the Information Management System (IMS) hosted on SharePoint has replaced the Iron Ore Document Management System (IODMS) previously used by Rio Tinto.

The IMS is linked to other business units within the Rio Tinto group of companies, and processes are in place to ensure that the data contained within this system is appropriately backed up and protected.

IMS will continue to operate following site closure, and all relevant data will be retained according to appropriate data retention requirements. An audit will be conducted prior to closure to ascertain whether there is any additional information stored in hard copy form at the site. Such data will be scanned and entered to IMS to ensure that it is appropriately retained post-closure.

14.2. EnviroSys

EnviroSys is an environmental database that is used by Rio Tinto to manage environmental and hydrogeological data. The tool is used to store, monitor and analyse those parameters and report trends on data collections.

Data collected currently includes:

- groundwater – biological, chemical, field, levels, production;
- marine water – biological, chemical, field;
- soil chemistry;
- surface water – biological, chemical, field, levels, production;
- tonnes and moisture;
- rehabilitation monitoring;
- water meters; and
- weather (rainfall, temperatures etc.).

EnviroSys is used to support the building of closure knowledge bases, as well as ensure compliance with operating licenses pertaining to data management. At closure this data would be appropriately stored to allow for review of post closure completion criteria

14.3. Archer Risk Management

The Archer system is a centralised database of all operational and closure risks. This database is used by Rio Tinto to manage risks and address actions to progress closure related planning during the life of mining.

Archer currently stores risks, controls and actions and the system functionality also enables the user to rate the effectiveness of these risks and controls, as well as verify actions have been completed.

The West Angelas closure risk register is currently stored in Archer, with closure planning actions aiming to address knowledge gaps highlighted in this closure plan. As indicated in Section 8, quarterly review of actions and controls is undertaken for the life of the asset.

15. REVIEWED MINE CLOSURE PLANS

Table 15-1 summaries all other changes made to this MCP since the 2021 submission, reflecting the responses to agency comments and changes in closure knowledge, are provided below in Table 15-1. Contained within Table 15-2 is an update to/current status of, comments made by regulators on approval of Version 2 2021 MCP. As indicated in that table, due to the short time frame between MCP submissions, some technical works are currently ongoing.

Table 15-1: **Summary of changes to 2021 WAN MCP**

Section of this MCP	Change	Reason for change
Figures	Update and revision of all figures, inclusion of new figures to support updates to the Knowledge Base, Closure Domains, and end of mine landforms.	
Various	MCP scope and format update.	Changes to document format to meet the 2020 Statutory Guidelines and align with contemporary RTIO closure planning requirements.
Corporate endorsement	Update of General Manager.	
Executive Summary	Revised and updated to reflect 2023 MCP.	
Acronyms	Updated to reflect relevant changes in naming and content.	
1 Purpose and Scope	Updated to align with Rio Tinto standard wording. Addition of tenements: L47/1027 (pending), L47/1028 (pending) and L52/00072.	
2.3 Mine Operations	Updated to reflect current life of mine information. Inclusion of indicative mining schedule, and waste landform inventory.	End of mine life has an indicative completion of 2041. Aligned with 2020 Statutory Guidelines and contemporary Rio Tinto closure planning requirements.
3 Identification of Closure Outcomes and Commitments	Wording of section revised to align with Rio Tinto standard text. Updated approval history of the project. Closure legal obligations register reviewed and updated.	
4 Stakeholder Engagement	Key stakeholder register reviewed and updated.	Closure boundary expanded, which intersects with Traditional Owner native title rights that the previous closure boundaries did not Figure 2-3.
4.2 Closure Engagement Strategy	Stakeholder engagement strategy updated, and plan included.	Inclusion of engagement focus in Table 4-2 to show engagement topics with relevant stakeholders.
5 Knowledge Base and Supporting Studies	Reviewed and updated to include current knowledge.	Social setting revised to include Nharnuwangga and Nyiyaparli Native Title rights. Ethnographic and archaeological section updated with key sites. Social surrounds updated with recent consultation outcomes.

Section of this MCP	Change	Reason for change
		Climate section updated to reflect RTIO closure planning requirements. Inclusion of land systems and topography section. Update of soil inventory due to new disturbances (planned and approved). Update of geology section to reflect updated geology models. Refinement of PUPEZ due to pit buttressing and inclusion of abandonment bund. Acid and metalliferous drainage (AMD) risk assessment update to include proposed pits and landforms. Update of hydrogeology section to include hydrological setting for each deposit. Update to hydrology section to include key surface water features, flood modelling of 1:100; 1:1,000 and 1:10,000 AEP extents. Update to flora and vegetation section to include vegetation communities, condition, riparian vegetation and groundwater dependent ecosystems. Refinement of fauna and habitat section and inclusion of subterranean fauna. Update of progressive rehabilitation monitoring summary to reflect recent rehabilitation projects.
6 Closure Knowledge Gaps	Knowledge gaps identified in Knowledge Base section have been tabulated in Knowledge Gap Register.	Aligned with 2020 Statutory Guidelines and contemporary Rio Tinto closure planning requirements. Summary of knowledge gaps included in alignment with risk assessment and knowledge base review. Assigned Archer actions and tracking numbers.
7 Risk and Management	Closure risk assessment undertaken and included as appendix, and summary in this section.	Aligned with 2020 Statutory Guidelines and contemporary Rio Tinto closure planning requirements. West Angelas closure risk assessment reviewed and updated with subject matter expert (SME) input. Section updated to reflect current Rio Tinto process and standard wording.
8 Management of Key Issues	Key issues identified and management updated to reflect current knowledge and closure approach.	Aligned with 2020 Statutory Guidelines and contemporary Rio Tinto closure planning requirements. Review and update of management of key issues.

Section of this MCP	Change	Reason for change
9 Post Mining Land Use, Closure Outcomes, Completion Criteria	Post-mining land use updated. Revised and aligned with Australian Land Use Management (ALUM) codes by closure domain. Closure outcomes and completion criteria updated and refined.	Aligned with 2020 Statutory Guidelines and contemporary Rio Tinto closure planning requirements. West Angelas Mine closure outcomes and completion criteria reviewed and updated to match current Rio Tinto nomenclature. Inclusion of cultural heritage outcome and criteria.
11 Closure Implementation	General revision to align text with Rio Tinto standard wording and approach. Revision and further development of closure domains. Inclusion of closure work program for domains.	Aligned with 2020 Statutory Guidelines and contemporary Rio Tinto closure planning requirements. Inclusion of new pits and landforms in work programs. New conceptual pit designs for proposed deposits.
12 Closure monitoring and maintenance	Closure monitoring program update aligned with completion criteria.	Aligned with 2020 Statutory Guidelines and contemporary Rio Tinto closure planning requirements.
13 Financial Provision for closure	General revision to align text with Rio Tinto standard wording and approach.	Aligned with 2020 Statutory Guidelines and contemporary Rio Tinto closure planning requirements.
14 Management of information and data	Inclusion of Archer risk management.	Not previously included.
15. Reviewed Mine Closure Plans	Addition of a table outlining regulatory feedback on previous MCP versions, including Rio Tinto response and actions.	Aligned with 2020 Statutory Guidelines and contemporary Rio Tinto closure planning requirements. All feedback since initial submission with previous and updated response.
17 Appendices	Appendices revised and updated as required. Inclusion of Knowledge Base reports relevant to closure – in place of Rio Tinto Closure Knowledge Database summary.	Aligned with 2020 Statutory Guidelines.

Table 15-2: **Regulatory agency feedback on 2021 West Angelas MCP and Rio Tinto responses**

Section of MCP	Agency Comment – June 2021	Response to Comment	Sections Referenced
Department of Mines, Industry Regulation and Safety			
Baseline Data: Section 7.4 – Mineral waste characterisation and inventory	Section 7.4.1 – Physical Characteristics Whilst the MCP includes a greater level of information on the physical characterisation of waste rock than has previously been reported, it is apparent that significant data gaps exist with respect to actual sampling of waste lithologies from West Angelas. The following lithologies, representing approximately 84% of waste rock generated from the project, have not been characterised using samples from West Angelas: Detritals, Hydrated zone, MacLeod Member, Mt Newman Member and Nammuldi Member. Data presented in the MCP has been derived from other Rio Tinto sites, however, no verification to justify the extrapolation of this data to West Angelas has been presented. Comparison of physical parameters has not been provided to verify that it is appropriate to substitute data between lithologies or between different operations. This is required to demonstrate that the Alluvials unit is representative of the Detritals unit and the Hydrated zone unit at Hope Downs 1 is representative of the same unit found at West Angelas. The MCP states that a comparison of waste rock and soil samples from West Angelas to the Pilbara-wide data indicated that results were consistent, therefore, the slope angles generated from Rio's Pilbara-wide erodibility parameters are considered suitable to West Angelas. This statement is not supported by any evidence. Rio Tinto is required to undertake site-specific sampling of all lithologies, at sample numbers reflecting the relative proportions of the overall waste volume, for physical characterisation and be reported in the next iteration of the MCP.	In March 2021, communications from Rio Tinto to DMIRS stated that a Pilbara wide waste rock sampling program had been commenced and that the Detritals, Hydrated zone, (West Angelas Member) and Mt Newman Member are being specifically targeted at West Angelas operations; along with sampling from specific waste dumps to inform rehabilitation parameters. The Nammuldi Member and MacLeod Members were not included in 2020 sampling program as it makes up very low percentage of total waste. The results from this waste rock sampling program are contained within Section 5.8.2 and Appendix 5 of this MCP. These results show that the physical characteristics are within the aggregated erodibility parameters for samples taken across the Pilbara. A comparison of the aggregated value (where available) and West Angelas specific values have been included within Section 5.8.2 and Appendix 5. Rio Tinto understands that for rehabilitation implementation sources of low erodibility and appropriately sized rock will be required. Rio Tinto communicated in March 2021 (Appendix 2) that at Deposit A West Hydrated Dumps 1 and 2 are stockpiled hydrated waste material (combined volume of 6.7Mm^3). Given its low erodibility, this material has been segregated and stockpile during operations for rehabilitation purposes (i.e. armouring erodible waste dumps). The material in these dumps is planned to be removed prior to or during closure activities and hence a rehabilitation design is not included for these stockpiles. Further to the identification of sources of low erodibility and appropriately sized rock, it has been identified that waste characterisation works to facilitate closure works of structures such as levees and pit buttresses will be required. This	Section 5.8.2 Section 5.8.6 Section 5.15.2 Section 6 Appendix 2 Appendix 5

Section of MCP	Agency Comment – June 2021	Response to Comment	Sections Referenced
	Based on different erodibility waste rock materials, Appendix L presents parameters (lift height and slope angle) for a “stable geometry”, however, the landform closure designs in Appendix F do not reflect the lift heights stated by Landloch. Thirteen of 23 landforms comprise close to or greater than 50% high erodibility waste, yet all have a proposed closure design where lift heights are greater than 10 metres and up to 20 metres. The operational design for the majority of these landforms has a 20 metre lift height, and it is unclear how a 20 metre operational lift will be amended to a five metre lift without significant capping or cut and fill earthworks. The next three yearly review of the MCP is required to provide updated landform closure designs such that they reflect the outcomes of the erosion modelling and demonstrate how the closure design has informed the operational design such that capping, and closure earthworks are minimised."	knowledge gap is acknowledged in Section 5.8.6 and Section 6 of this MCP. Commitment to completing this work is acknowledged in Section 5.15.2 of this Mine Closure Plan. A project to begin the work to close this gap is currently underway and will inform the triennial update to this MCP. Rehabilitation designs will be updated to respond to the updated knowledge of waste characteristics. As those designs are completed they will be provided in the MCP and is an acknowledged Closure Knowledge Gap (Table 6-1).	
Section 7.4.2 – Geochemical characteristics	Whilst a greater level of information regarding the acid mine drainage (AMD) risk assessment and geochemical characterisation has been presented than previously, knowledge gaps exist, or information has not presented, which raises concerns around the adequacy of operational AMD management. Appendix H does not provide an overview of the analysis and calculations completed within Rio Tinto’s acid base accounting (ABA) process, and as full ABA results are not presented it is assumed that a subset of analysis has been conducted. For example, the minerals contributing to acid neutralising capacity (ANC) are not discussed and it is assumed that this has not been determined, even though this has been highlighted as a limitation in Section 3.2 of Appendix H. It is important to note that if ANC is assumed to be attributed to carbonate minerals but is actually associated with slower-reacting neutralising minerals, then the AMD risk may be understated. The absence of a metalloids leachate assessment is a significant knowledge gap that needs to be addressed by Rio	In March 2021, Rio Tinto acknowledged the feedback from DMIRS and suggested that there is a well established process through the SCARD and other management plans that covers geochemical sampling and AMD management. Within this MCP, an updated AMD Source Hazard Risk Assessment is presented (Appendix 7). This document: • outlines the acid base accounting process with acid neutralising discussed including acid buffering characteristic curves. • details the 38 samples that have been analysed for static leach testing. Noting that results from the MRIWA funded study into sequential leaching will be presented if deemed appropriate (i.e. large enough sample size to be representative of the West Angelas site specific conditions) and once the study is complete and released within the public domain. Ongoing geochemical characterisation will be undertaken during the study and mine phases of the project.	Appendix 7

Section of MCP	Agency Comment – June 2021	Response to Comment	Sections Referenced
	Tinto across all of their Pilbara operations. Section 4.1 of Appendix H states that As, Sn, Co, Cr, Cu, Mn, Ni, Pb and Zn "should be considered in any source-pathway-receptor modelling related to AMD impacts", however, this is not noted as a knowledge gap in the MCP. DMIRS is aware of the MRIWA funded ChemCentre project on sequential leaching that Rio Tinto is a project sponsor; these results need to be presented in the next iteration of the relevant MCPs to indicate where kinetic testwork is required to better understand the potential for metalliferous drainage, whether acidic or neutral. Given the three year period between MCP review, where the sequential leaching indicates kinetic testwork is required, this work must have commenced and be significantly progressed such that any required operational management can be implemented. Additional aspects of the ABA characterisation which raise concerns include aspects presented in Section 3.2, Appendix H: • Data gaps exist due to a focus on acquiring data on the ore body, not waste types – DMIRS expect that Rio Tinto would have a well-established sampling program from exploration through to operational grade control to ensure an appropriate level of characterisation and management of any problematic waste rock lithologies. • Use of the XRF method to determine sulphur values has known limitations when sulphur values of a sample are high; an underestimation of Total Sulphur occurs – DMIRS expect that laboratory verification of XRF results occurs as part of Rio Tinto's standard quality assurance / quality control process. Figure 6, Appendix H does not show the locations of AMD characterisation samples from Deposit A and Deposit E, however, data for these deposits is presented in Section 3.2.1 and Section 3.2.2. Throughout Section 3.2 sub-sections it is stated that further investigation is required to determine either, or both, the likelihood of potentially acid-forming (PAF) material exposure in the pit wall and presence in mine waste for the Mt	• Describes the sub-set of samples were analysed by LECO method to verify XRF data. A total of 277 samples across West Angelas have been analysed using this method. This is in acknowledgment of the limitations of XRF and the potential to underestimate total S concentrations when S values are high. • Figure 6 shows the locations of ABA samples across West Angelas deposit. Note that within the report (Appendix 7), sample was considered having ABA data if at a minimum, total sulfur (TS) and acid neutralising capacity (ANC) data was available. Therefore, the environmental geochemical dataset for West Angelas includes ABA data for 209 samples (Figure 6) from five deposits (Deposit A, n = 21; Deposit A West, n = 44; Deposit B, n = 64; Deposit D, n = 27; Deposit F, n = 50; and Not Specified, n = 3). Samples from other deposits with other analysis may be discussed, but if they do not include TS and ANC, the sample locations will not be present on Figure 6. Further, Rio Tinto acknowledges that: • Sample acquisition is typically focused on ore bearing units and not waste units. However sufficient sample is collected over the course of the mine life to characterise all disturbed rock units and develop a risk assessment of AMD. • Further investigation typically refers to additional sampling and analysis of rock units – this will involve additional ABA analysis, leachate and total sulfur. Provision of grade control data to support the AMD Risk Assessment for West Angelas will be considered for the next review of the MCP.	

Section of MCP	Agency Comment – June 2021	Response to Comment	Sections Referenced
	Newman, MacLeod and Nammuldi Members generally and specifically the West Angelas Member in Deposit B and the Whaleback Shale in the Angelo River Deposit. The MCP does not define what “further investigation” entails nor does it present operational grade control data to verify the AMD Risk Assessment. These knowledge gaps need to be addressed in the next three yearly review of the MCP."		
Baseline Data: Section 8.1 – Surface Water	The absence of closure scenario flood modelling is a significant knowledge gap which needs to be addressed in the next iteration of the MCP. As discussed with Rio Tinto in a meeting held 26 October 2020, the closure flood model does not need to be as extreme as a probable maximum precipitation / flood, unless required for a tailings storage facility; however, the model must address a rare / extreme rainfall event up to 1:5,000 year or 1:10,000 year, depending on the specific surface water features and environmental sensitivities of the operation. The planned intersection of Deposit C and Deposit D pits with Turee Creek East and a southern tributary of this creek, has implications on the abandonment bund design, pit crest stability, and the potential for significant unplanned diversion of flows from the watercourses into the pits. As highlighted in the MCP, this could result in unacceptable impacts to surface water flows to Karijini National Park. This risk has not been adequately addressed through the appropriate flood modelling and mitigation, such as permanent diversion or altering the mine plan such that the watercourse floodplains and pits do not intersect. The Appendix N hydrology report discusses a land bridge located between Deposit C and D which blocks natural drainage. This feature, however, is not shown in figures or discussed within the MCP. The impact of this structure on the post closure maintenance of surface water flows, and in the context of existing / proposed waste dumps, needs to be specifically addressed in the next iteration of the MCP. Any drainage diversions which will be modified to become permanent features and are located adjacent to a potentially unstable pit edge zone, or which could interact with a pit	In March 2021, Rio Tinto responded to this comment stating that based on a previous DMIRS engagement on 26th October 2020 to discuss closure scenario flood modelling it was agreed that flood modelling on the operational (life of mine) landscape was acceptable for closure planning purposes. The following was agreed by both parties following the meeting in October 2020 that 'Flood modelling on the post-closure landscape is not required for a standard mine closure plan update, although would be expected when the site is close to closure. Flood modelling is required in every MCP to enable a specific operational design to identify areas of associated closure environmental and/or geotechnical risk and to demonstrate that the conceptual post-closure strategy is site-specific and achievable. The modelling must be updated for every MCP where the operational layout / design is amended.' These extreme events, including PMP flood levels, were modelled and included in Appendix L - Detailed design flood study of "West Angelas Mine Closure Plan, Version 2, March 2021”. Detailed work has commenced to address the risk of significant unplanned diversion of flows from the watercourses into the pits resulting in unacceptable impacts to surface water flows to Karijini National Park. The scope of this project includes appropriate flood modelling and design of permanent flood mitigation structures; such as permanent diversion, pit backfilling and/or pit wall buttressing. The outcomes from these studies will be included in the next triennial iteration of the West Angelas MCP.	Section 5.10 Appendix 9

Section of MCP	Agency Comment – June 2021	Response to Comment	Sections Referenced
	abandonment bund, require the appropriate flood modelling and design details provided in the MCP such that the Resources Safety Directorate of DMIRS can undertake an assessment of geotechnical stability."	Within this MCP, 1:10 000 flood modelling from this work was completed and shown in Figure 5-25. The conceptual surface water management options for closure to ensure appropriate management of long term surface water risks are described in Section 5.10 and Appendix 9	
Section 17: Management of key issues	"The risk assessment (Appendix D) and the relevant sub-sections within Section 17 do not address the following aspects of key issues: 1. Acidic and metalliferous drainage: • Based on the West Angelas AMD risk assessment, further investigation is required regarding specific lithologies, notably, the MacLeod, Mt Newman and Nammuldi Members. • An assessment of leachability / mobility of metals / metalloids from waste rock lithologies is required and forms a significant knowledge gap. • The risk pathway “degradation of regional groundwater quality or levels” lists column leach tests as control, however, the MCP does not present or discuss results of column leach tests from West Angelas. Please correct or remove this information. 2. Dispersive, sodic and erosive materials: • Final landforms need to meet the “stable geometry” determined from the Landloch erodibility assessment; these parameters (lift height and slope angle) are not detailed as key controls / treatments for this risk. • Section 17.3.1 indicates that waste dumps are appropriately located, however, due to the absence of a closure flood scenario model, this has not been demonstrated. 3. Geotechnical instability • Flood flows along Turee Creek East and the southern tributary of Turee Creek East into pits within Deposit C	In March 2021, Rio Tinto responded that the "West Angelas Mine Closure Plan, Version 2, March 2021” had been updated to address these comments. The comments not addressed by Version 2 are noted and will be addressed in the next triennial of the Mine Closure Plan. As part of this MCP, Rio Tinto provides the following updates: 1) Acidic and metalliferous drainage: Updated information on AMD risk is presented Section 5.8, Appendix 7, and Appendix 8. • Appendix 7 details ABA data is available for a total of six stratigraphy groups; Alluvials (ALL), Detritals (DET), Dolerite (DOR), Banded Iron Formation (BIF), Wittenoom Formation (WF) and Marra Mamba Iron Formation (MM). It is noted that MacLeod, Mt Newman and Nammuldi Members form part of the Marra Mamba Formation. Although not categorised down to Member level, ABA data has been collected for MacLeod, Mt Newman and Nammuldi Members. • A discussion on chemical enrichment and mobility is provided in Section 4.4 of Appendix 7. • This has been removed 2) Dispersive, sodic and erosive materials: Further waste characterisation work has been undertaken as detailed in Section 5.8.2 • Landform designs are captured within Section 11.4 and Appendix 11 .	Section 5.8 Section 5.8.2 Section 11.4 Appendix 7 Appendix 8 Appendix 11

Section of MCP	Agency Comment – June 2021	Response to Comment	Sections Referenced
	and Deposit D have not been discussed and pose a significant risk to pit crest stability. • Specific risk controls / treatments relating to surface water flood flows interacting with abandonment bunds and pit crests have not been presented to demonstrate the residual risks are As Low As Reasonably Practicable (ALARP). • The proposed abandonment bund strategy for Deposit C and D must consider the results of the closure scenario flood model to account for surface water flows. 4. Design and management of surface water structures • The rainfall design event must be stated for re-instated / post closure drainage structures; currently operational designs are presented. • A specific risk pathway is required to address a reduction in surface water flows to Karijini National Park from unplanned diversion of Turee Creek East flows into Deposit C and D pits. The risk pathway "self-sustaining and resilient vegetation is not established…" references a wetland rehabilitation trial, however, the baseline data indicates there are no wetlands at West Angelas. Please correct or remove this information."	• Closure flood scenario is being undertaken in 2023 to validate waste dump locations. 3) Geotechnical instability: • Rio Tinto is refining closure scenario flood modelling, and waste characterisation information. The implications for risks will be considered once this is complete. 4) Design and management of surface water structures: • Rio Tinto is refining closure scenario flood modelling and implications for closure surface water structures will be considered once this is complete.	
Closure Outcomes and Completion Criteria – Section 18 and 19	The absence of a closure outcome and associated completion criteria relating to surface water requires specific consideration once the closure scenario flood model has been completed. Where risk treatments will rely on permanent diversions and abandonment / flood bunding to ensure flows to Turee Creek East are maintained post closure, a closure outcome and completion criteria will be required. Where Rio Tinto eliminate the risk through amendment of the mine plan such that pits do not intersect the flood zone, no specific surface water closure outcome and completion criteria will be required.	In 2021, Rio Tinto communicated that detailed work is underway to address this risk. Flood mitigation structures (bunds, permanent diversions, pit backfilling and pit wall buttressing) are expected to significantly reduce the risk and likelihood of impacts to Turee Creek East, ensuring flows are maintained. The outcomes from this work will be included in the next triennial iteration of the West Angelas MCP. Rio Tinto will consider if a closure outcome and associated completion criteria relating to surface water requires specific consideration once this work has been completed and in line with broader reviews to completion criteria being undertaken by Rio Tinto Iron Ore (Section 9.4.2).	Section 9.4.2

Section of MCP	**Agency Comment – June 2021**	**Response to Comment**	**Sections Referenced**
	Updated closure outcomes and associated completion criteria relating to surface water is required to be addressed in the next three yearly review of the MCP.		
Closure Implementation – Section 21 to 22	**Closure Implementation Strategies** The closure implementation strategies provided in Table 44 are generic and require refinement based on addressing the knowledge gaps identified by Rio Tinto, highlighted by DMIRS assessment and as the operation approaches closure. Rio Tinto are reminded that section 9 of the 2020 “Mine Closure Plan Guidance - How to prepare in accordance with Part 1 of the Statutory Guidelines for Mine Closure Plans” contains additional information which DMIRS requires to be presented within the closure implementation section of an MCP. **Post-mining and Post-closure Landforms** The next iteration of the MCP needs to, include locations of permanent surface water diversions and abandonment bunds within the context of the final landforms. All figures require a legend and must be shown at a size (minimum A4) that provides an appropriate level of detail. The above comments are required to be addressed in the next three yearly review of the MCP."	In 2021, Rio Tinto communicated that changes has been made to "West Angelas Mine Closure Plan, Version 2, March 2021” to address the comments regarding the scale of the domain figure and the include specific tasks required to transition a site into care and maintenance, and decommissioning. The As part of this MCP, Section 11 presents updated closure implementation strategies. Within the next triennial update to the MCP, the locations of permanent surface water diversion and abandonment bunds will be provided.	Section 11
General – Knowledge Gaps	There are a number of additional knowledge gaps / closure tasks which need to be noted and addressed in the next iteration of the MCP, as highlighted in the comments in this table. • Additional physical characterisation of West Angelas lithologies. • Closure design details for waste dumps where amendment of the lift height is required. • Metalloids leachate assessment to inform the AMD risk assessment and operational management.	In March 2021, Rio Tinto communicated that the knowledge gaps/closure tasks will addressed by tasks outlined in the mine closure plan. These tasks and the updates to the tasks are listed below. • WAN-14/Archer Action #515185 undertake further site specific waste characterisation to better define dump erosion potential. • Waste rock sampling program had been commenced and that the Detritals, Hydrated zone, (West Angelas Member) and Mt Newman Member were sampled from the West Angelas operations. The Nammuldi Member and MacLeod Members were not included in 2020 sampling program as it	Section 5.8.2 Appendix 5

Section of MCP	Agency Comment – June 2021	Response to Comment	Sections Referenced
	• Closure scenario flood model for all deposits to inform the mine plan amendments or permanent diversion designs, and abandonment bund designs. The above comments are required to be addressed in the next three yearly review of the MCP	makes up very low percentage of total waste. The results of this program are contained within Section 5.8.2 and Appendix 5. • WAN-13/Archer Action #515184 Develop new rehabilitation designs for existing waste dumps (e.g. Deposit A) that may not have not be constructed to readily facilitate stable rehabilitation slopes. • WAN-05/Archer Action #515187 Develop designs for permanent diversions where required.	
DBCA			
Closure Outcomes and Completion Criteria – Section 18 and 19	Completion criteria relating to vegetation on rehabilitated land are considered to be unsuitable for verifying that an appropriate closure outcome is being achieved. Further information is also required in the MCP in relation to the necessary monitoring and post closure outcomes (including monitoring of groundwater levels). Updated closure outcomes and associated completion criteria relating to vegetation on rehabilitated land and information on monitoring (including monitoring of groundwater levels) is required to be addressed in the next three yearly review of the MCP.	In 2021, Rio Tinto responded as follows “Rio Tinto considers the Closure Objectives and indicative Completion Criteria contained within the West Angelas 2020 Mine Closure Plan sufficiently cover the relevant aspects of closure at West Angelas. Rio Tinto acknowledges that the completion criteria are conceptual, but given the stage of operations Rio Tinto considers these appropriate and will move towards more specific, measurable, achievable, relevant and time-bound criteria as closure approaches and in consultation with key stakeholders. Further, progressive rehabilitation will inform the refinement of the completion criteria. Further information in relation to monitoring (including monitoring of groundwater levels) and post-closure outcomes will be included in the next triennial update (2024) as groundwater monitoring data becomes available.” Currently an update of Rio Tinto Iron Ore’s approach to completion criteria development is being progressed (Section 9.4.1). We are expecting to provide revised completion criteria suitable for the stage of closure planning at West Angelas and in consideration of contemporary guidance in the next triennial update of this MCP.	Section 9.4.1
	The current indicative completion criterion relating to weeds does not set clear limits on weed abundance or distribution within the West Angelas development envelope post-	In March 2021, Rio Tinto responded as follows “Rio Tinto acknowledges DBCA's comment regarding the potential for the West Angelas project site to become a source	Section 9.4.1

Section of MCP	Agency Comment – June 2021	Response to Comment	Sections Referenced
	closure. On this basis there is potential for the West Angelas project site to become a source of weed ingress into the adjacent Karijini National Park (R 30082, Class A) or Priority 1 West Angelas Cracking-Clays ecological community (PEC) post-closure. DBCA recommend that completion criteria relating to weeds are designed to include specific information about species type, abundance, and distribution and that the criteria ensure that weed spread within the development envelope and introduction of weeds into adjacent areas is avoided as far as practical during and following closure. DBCA also notes that the closure task register (Appendix E) includes a task to evaluate the final landform design in relation to potential impacts on the PEC during or prior to the next closure plan update. Updated completion criteria relating to weeds and potential impacts on the West Angelas Cracking-Clays PEC is required to be addressed in the next three yearly review of the MCP.	of weed ingress into the adjacent Karijini National Park or the Cracking-Clays post-closure. Rio Tinto will continue to refine all completion criteria, including those related to weeds, throughout the life of the operation. DBCA's comments in relation to PEC are noted. In accordance with the objective of condition 5-1 (2) of MS 1113 there shall be no direct or indirect disturbance to the PEC resulting from rehabilitation or closure activities that results in an irreversible impact. Potential impacts of the closure strategy on the PEC will be suitability evaluated and addressed in closure outcomes and completion criteria within the next revision of the MCP (2024) following the outcomes of this work." Currently an update of Rio Tinto Iron Ore's approach to completion criteria development is being progressed (Section 9.4.1). We are expecting to provide revised completion criteria suitable for the stage of closure planning at West Angelas and in consideration of contemporary guidance in the next triennial update of this MCP.	
	The current closure outcomes or completion criteria do not refer to conservation significant fauna and their habitat (despite monitoring of both being proposed), or feral animals. Provision for suitable fauna habitat, including habitat for conservation significant fauna species, and appropriate management of feral animals (particularly if permanent water sources are proposed) are considered to be important aspects of mine closure planning in Western Australia and should be reflected in closure outcomes and completion criteria. Updated closure outcomes and associated completion criteria relating to conservation significant fauna and feral animal management is required to be addressed in the next three yearly review of the MCP.	In March 2021, Rio Tinto agreed that that the provision of habitat that provides opportunities for faunal recolonisation is an important aspect of mine closure planning. Rio Tinto's rehabilitation practices ensure the following habitat elements are considered as part of the closure landform design: • establishment of native vegetation; • retaining and replacing woody debris; • rapid generation and retention of leaf litter using small-scale • topography (e.g. furrows created from ripping); • introducing or leaving rocky features such as oversized waste burden or scree slopes; • creating greater depths of friable soil (or suitable mineral • wastes) for burrowing fauna; and	Section 9.4.1

Section of MCP	**Agency Comment – June 2021**	**Response to Comment**	**Sections Referenced**
		• managing feral predators and herbivores across both reference and rehabilitated areas. Currently an update of Rio Tinto Iron Ore's approach to completion criteria development is being progressed (Section 9.4.1). We are expecting to provide revised completion criteria suitable for the stage of closure planning at West Angelas and in consideration of contemporary guidance in the triennial update of this MCP.	
Appendix E	DBCA note that the closure task register (Appendix E) includes a task to evaluate the final landform design in relation to potential impacts on the West Angelas Cracking-Clays Priority Ecological Community (PEC) during or prior to the next closure plan update. DBCA recommend that any potential post-closure impacts on the PEC, including altered hydrological regimes associated with landform design, should be suitably evaluated, and addressed through relevant closure outcomes and completion criteria within the next three yearly review of the MCP.	In March 2021, Rio Tinto response that potential impacts of the closure strategy on the PEC will be suitability evaluated and addressed in closure outcomes and completion criteria within the next triennial revision of the MCP following the outcomes of this work. Currently, an update of Rio Tinto Iron Ore's approach to completion criteria development is being progressed (Section 9.4.1). We are expecting to provide revised completion criteria suitable for the stage of closure planning at West Angelas and in consideration of contemporary guidance in the next triennial update of this MCP.	Section 9.4.1

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17. APPENDICES

Appendix 1: Closure Obligations Register

Appendix 1 – Closure Obligations Register

Ministerial Statement 1113 (West Angelas Iron Ore Project – Revised Proposal)	
Condition No.	**Closure conditions**
7-1	The proponent shall manage the implementation of the revised proposal to meet the following environmental objectives: (1) the proponent shall ensure that the revised proposal is rehabilitated and decommissioned in an ecologically sustainable manner; and (2) ensure that closure planning and rehabilitation are undertaken in a progressive manner.
7-2	Within twelve (12) months of the issue of this Statement the proponent shall prepare and submit a Mine Closure Plan in accordance with the Guidelines for Preparing Mine Closure Plans, May 2015, (or any subsequent revisions of the guidelines), to the requirements of the CEO, on advice of the Department of Mines, Industry Regulation and Safety, and the Department of Water and Environmental Regulation.
7-3	The proponent shall review and revise the Mine Closure Plan required by condition 7-2 at intervals not exceeding three (3) years, or as otherwise specified by the CEO, and submit the plan to the CEO at the agreed interval.
7-4	The proponent shall implement the latest revision of the Mine Closure Plan, which the CEO has confirmed by notice in writing, satisfies the requirements of condition 7-2.
7-5	The proponent shall implement the West Angelas Closure Plan (RTIO-HSE-0228290) dated April 2018 until the CEO has confirmed by notice in writing the Mine Closure Plan required by condition 7-2 satisfies the requirements of the CEO on advice of the Department of Mines, Industry Regulation and Safety, and the Department of Water and Environmental Regulation.
Schedule 1, Table 1	This proposal is a revision of the existing West Angelas Iron Ore Project and includes the above and below water table, open-cut iron ore mining from additional deposits and the construction and operation of associated infrastructure including but not limited to the following: dewatering and surplus water management infrastructure, Managed Aquifer Recharge scheme, surface water management infrastructure, linear infrastructure, processing and support facilities. Mine dewatering, which dewaters the ore bodies to allow below water table mining, supplies water for local operational purposes. Surplus dewatering water, exceeding the local operational water requirement, is transferred to the existing operations to supply operational water demand, the Managed Aquifer Recharge Scheme and / or discharged to the Turee Creek East tributary. This proposal will be contained within the revised West Angelas Mine Development Envelope.
Schedule 1, Table 2	Mine and associated infrastructure Clearing of no more than 12,205 hectares (ha) within a 26,700 ha Mine Development Envelope, including: • No clearing within the Ghost Bat Cave AA1, WA-13, WA-21 and WA-23 Exclusion Zones. • No clearing within the West Angelas Cracking Clay Priority Ecological Community, PEC-2015-5. • No more than 20 ha of clearing of other representations of the West Angelas Cracking Clay Priority Ecological Community. • No more than 25 ha of clearing of riparian vegetation. Below water table pits are to be backfilled to a level to prevent the formation of permanent pit lakes.

Iron Ore (*Robe River*) Agreement Act 1964	
Clause No.	**Closure obligations**
10(e)	The parties agree with each other as follows: that on the cessation or determination of any lease license or easement granted hereunder by the State to the Company… the improvements and things erected on the relevant land and provided for in connection therewith other than plant and equipment shall remain or become the absolute property of the State without compensation and freed and discharged from all mortgages and encumbrances and the Company will do and execute such documents and things (including surrenders) as the State may reasonably require to give effect to this projection. In the event of the Company immediately prior to such expiration or determination or subsequent thereto deciding to remove its locomotives rolling stock plant and equipment or any of them from any land it shall not do so without first notifying the State in writing of its decision and thereby granting to the State the right or option exercisable within three months thereafter to purchase at valuation in situ the said plant and equipment or any of them. Such valuation shall be mutually agreed or in default of agreement shall be made by such competent valuer as the parties may appoint or failing agreement as to such appointment then by two competent valuers one to be appointed by each party or by an umpire appointed by such valuers should they fail to agree.

West Angelas Iron Ore Mine – Deposits C, D and G (EPBC 2018/8299)	
Clause No.	**Closure obligations**
3	To minimise impacts to EPBC Act listed threatened species or their habitat the approval holder must ensure that there is: (a) no drawdown of groundwater associated with the proposal at the boundary of, or within, Karijini National Park and (b) no change in groundwater water quality at the boundary of, or within, Karijini National Park.

Mining Act 1978	
Tenement No. ML248SA Sections 068-086 & 112	
Condition No.	**Closure conditions**
NA	Issued pursuant to *Iron Ore* (Robe River) *Agreement Act 1964*

Tenement No. G47/01235	
Condition No.	**Closure conditions**
12	At the completion of operations, all buildings and structures being removed from site or demolished and buried to the satisfaction of the Executive Director, Environment Division, DMP.
15	At the completion of operations or progressively where possible, all access roads and other disturbed areas being covered with topsoil, deep ripped and revegetated with local native grasses, shrubs and trees to the satisfaction of the Executive Director, Environment Division, DMP.
17	All disturbances to the surface of the land made as a result of exploration, including costeans, drill pads, grid lines and access tracks, being backfilled and rehabilitated to the satisfaction of the Environmental Officer, DMIRS. Backfilling and rehabilitation being required no later than 6 months after excavation unless otherwise approved in writing by the Environmental Officer, DMIRS.
23	Management of mine closure to be undertaken in accordance with the latest, relevant approved Mine Closure Plan.
27	Placement of waste material must be such that the final footprint after rehabilitation will not be impacted upon by pit wall subsidence or be within the zone of pit instability to the satisfaction of the Executive Director, Resource and Environmental Compliance, Department of Mines, Industry Regulation and Safety.
28	On the completion of operations or progressively when possible, all waste dumps, tailings storage facilities, stockpiles or other mining related landforms must be rehabilitated to form safe, stable, non-polluting structures which are integrated with the surrounding landscape and support self sustaining, functional ecosystems comprising suitable, local provenance species or alternative agreed outcome to the satisfaction of the Executive Director, Resource and Environmental Compliance, Department of Mines, Industry Regulation and Safety.
29	All activities being carried out in such a manner so as to not have a detrimental effect on the natural water flow through the lease and surrounding areas to the satisfaction of the Environmental Officer, Department of Mines, Industry Regulation and Safety.
Tenement No. G47/01236	
Condition No.	**Closure conditions**
13	At the completion of operations, all buildings and structures being removed from site or demolished and buried to the satisfaction of the Executive Director, Environment Division, DMP.
16	On the completion of operations or progressively when possible, all waste dumps, tailings storage facilities, stockpiles or other mining related landforms must be rehabilitated to form safe, stable, non-polluting structures which are integrated with the surrounding landscape and support self sustaining, functional ecosystems comprising suitable, local provenance species or alternative agreed outcome to the satisfaction of the Executive Director, Resource and Environmental Compliance, Department of Mines, Industry Regulation and Safety
18	All disturbances to the surface of the land made as a result of exploration, including costeans, drill pads, grid lines and access tracks, being backfilled and rehabilitated to the satisfaction of the Environmental Officer, DMIRS. Backfilling and rehabilitation being required no later than 6 months after excavation unless otherwise approved in writing by the Environmental Officer, DMIRS.
20	Unless the written approval of the Environmental Officer, DMIRS is first obtained, the use of drilling rigs, scrapers, graders, bulldozers, backhoes or other mechanised equipment for surface disturbance or the excavation of costeans is prohibited. Following approval, all topsoil being removed ahead of mining operations and separately stockpiled for replacement after backfilling and/or completion of operations.
24	Management of mine closure to be undertaken in accordance with the latest, relevant approved Mine Closure Plan.
29	Placement of waste material must be such that the final footprint after rehabilitation will not be impacted upon by pit wall subsidence or be within the zone of pit instability to the satisfaction of the Executive Director, Resource and Environmental Compliance, Department of Mines, Industry Regulation and Safety.

30	All activities being carried out in such a manner so as to not have a detrimental effect on the natural water flow through the lease and surrounding areas to the satisfaction of the Environmental Officer, Department of Mines, Industry Regulation and Safety.
Tenement No. L47/00041 Purpose: search for groundwater	
Condition No.	**Closure conditions**
10	On the completion of the life of mining operations in relation to Miscellaneous Licence 47/41 the holder shall: • remove all installations constructed pursuant to this licence; • cover over all wells and holes in the ground to such degree of safety as shall be determined by the Inspector; and • on such areas cleared of natural growth by the holder or any of its agents, the holder shall plant trees and/or any other plant as shall conform to the general pattern and type of growth in the area and as directed by the Inspector and properly maintain same until the Inspector advises regrowth is self supporting. Unless the Mining Registrar/Warden or Minister for Mines orders or consents otherwise.
Tenement No. L47/00050 Purpose: to conduct all necessary activities for the design, planning, construction, operation and maintenance of a railway and all associated infrastructure in connection with mining operations pursuant to the *Iron Ore (Robe River) Agreement Act 1964*	
Condition No.	**Closure conditions**
19	Management of mine closure to be undertaken in accordance with the latest, relevant approved Mine Closure Plan.
Tenement No. L47/00052 Purpose: road, pipeline	
Condition No.	**Closure conditions**
4	All disturbances to the surface of the land made as a result of exploration, including costeans, drill pads, grid lines and access tracks, being backfilled and rehabilitated to the satisfaction of the Environmental Officer, Department of Mines and Petroleum (DMP). Backfilling and rehabilitation being required no later than 6 months after excavation unless otherwise approved in writing by the Environmental Officer, DMP.
6	Unless the written approval of the Environmental Officer, DMP is first obtained, the use of drilling rigs, scrapers, graders, bulldozers, backhoes or other mechanised equipment for surface disturbance or the excavation of costeans is prohibited. Following approval, all topsoil being removed ahead of mining operations and separately stockpiled for replacement after backfilling and/or completion of operations.
9	All topsoil and vegetation being removed ahead of all mining operations and being stockpiled appropriately for later respreading or immediately respread as rehabilitation progresses.
11	At the completion of operations, all buildings and structures being removed from site or demolished and buried to the satisfaction of the Executive Director, Environment Division, DMP.
15	On the completion of operations or progressively when possible, all waste dumps, tailings storage facilities, stockpiles or other mining related landforms must be rehabilitated to form safe, stable, non-polluting structures which are integrated with the surrounding landscape and support self sustaining, functional ecosystems comprising suitable, local provenance species or alternative agreed outcome to the satisfaction of the Executive Director, Environment Division, DMP.
20	Management of mine closure to be undertaken in accordance with the latest, relevant approved Mine Closure Plan.
23	All activities being carried out in such a manner so as to not have a detrimental effect on the natural water flow through the lease and surrounding areas to the satisfaction of the Environmental Officer, Department of Mines, Industry Regulation and Safety.
Tenement No. L47/00053 Purpose: road, pipeline, power line	
Condition No.	**Closure conditions**
4	All topsoil and vegetation being removed ahead of all mining operations and being stockpiled appropriately for later respreading or immediately respread as rehabilitation progresses.
5	At the completion of operations, all buildings and structures being removed from site or demolished and buried to the satisfaction of the Director, Environment Division, DMP.
Tenement No. L47/00054 Purpose: road, pipeline, power line	
Condition No.	**Closure conditions**
9	On the completion of the life of mining operation in connection with this licence the holder shall; • remove all installations constructed pursuant to this licence; and • on such areas cleared of natural growth by the holder or any of its agents, the holder shall plant trees and/or shrubs and/or any other plant as shall conform to the general pattern and type of growth in the area and as directed by the Inspector and properly maintain same until the Inspector advises regrowth is self supporting; Unless the Warden or Minister for Mines orders or consents otherwise.
Tenement No. L47/00060 Purpose: repeater station	
Condition No.	**Closure conditions**

5	All topsoil and vegetation being removed ahead of all mining operations and being stockpiled appropriately for later respreading or immediately respread as rehabilitation progresses.
6	At the completion of operations, all buildings and structures being removed from site or demolished and buried to the satisfaction of the Executive Director, Environment Division, DMP.
Tenement No. L47/00061 Purpose: repeater station	
Condition No.	**Closure conditions**
NA	NA
Tenement No. L47/00062 Purpose: repeater station	
Condition No.	**Closure conditions**
NA	NA
Tenement No. L47/00063 Purpose: to conduct all necessary activities for the design, planning, construction, operation and maintenance of a railway and all associated infrastructure in connection with mining operations pursuant to the *Iron Ore (Robe River) Agreement Act 1964*	
Condition No.	**Closure conditions**
7	At the completion of operations, all buildings and structures being removed from site or demolished and buried to the satisfaction of the Executive Director, Environment Division, DMP.
14	Management of mine closure to be undertaken in accordance with the latest, relevant approved Mine Closure Plan.
Tenement No. L47/00409 Purpose: road, pipeline, power line, taking water, communications facility, pump station, bore, power generation and transmission facility, workshop and storage facility	
Condition No.	**Closure conditions**
28	On the completion of the life of mining operations in relation to this licence the holder shall: • remove all installations constructed pursuant to this licence; • cover over all wells and holes in the ground to such degree of safety as shall be determined by the Environmental Officer, Department of Mines and Petroleum; and • on such areas cleared of natural growth by the holder or any of its agents, the holder shall plant trees and/or shrubs and/or any other plant as shall conform to the general pattern and type of growth in the area and as directed by the Environmental Officer, Department of Mines and Petroleum and properly maintain same until the Environmental Officer advises regrowth is self supporting; unless the Mining Registrar or Minister responsible for the Mining Act 1978 orders or consents otherwise.
36	Management of mine closure is to be undertaken in accordance with the Mine Closure Plan (Reg ID 79095) "West Angelas Petroleum Pipeline Realignment Closure Plan" dated 19 March 2019 signed by Stuart Kennedy, GM Rio Tinto Growth and Innovation – Iron Ore Projects and retained on Department of Mines, Industry Regulation and Safety File No. EARS-MPMCP-79095 as Doc ID 6592071.
40	All topsoil and vegetation being removed ahead of all mining operations and being stockpiled appropriately for later respreading or immediately respread as rehabilitation progresses.
Tenement No. L47/00769 Purpose: road, pipeline, power line, taking water, drainage channel, pump station, bore, bore field, water management facility	
Condition No.	**Closure conditions**
11	All topsoil that may be removed ahead of pipelaying operations to be stockpiled for replacement in accordance with the directions of the Environmental Officer, DMIRS.
14	All disturbances to the surface of the land made as a result of exploration, including costeans, drill pads, grid lines and access tracks, being backfilled and rehabilitated to the satisfaction of the Environmental Officer, DMIRS. Backfilling and rehabilitation being required no later than 6 months after excavation unless otherwise approved in writing by the Environmental Officer, DMIRS.
Tenement No. L47/00842 Purpose: road, pipeline, power line, taking water, communications facility, drainage channel, pump station, bore, workshop and storage facility	
Condition No.	**Closure conditions**
23	Management of mine closure is to be undertaken in accordance with the Mine Closure Plan (Reg ID 79095) "West Angelas Petroleum Pipeline Realignment Closure Plan" dated 19 March 2019 signed by Stuart Kennedy, GM Rio Tinto Growth and Innovation – Iron Ore Projects and retained on Department of Mines, Industry Regulation and Safety File No. EARS-MPMCP-79095 as Doc ID 6592071.
27	All topsoil and vegetation being removed ahead of all mining operations and being stockpiled appropriately for later respreading or immediately respread as rehabilitation progresses.
Tenement No. L47/00853 Purpose: road, pipeline, power line, drainage channel, pump station, bore, power generation and transmission facility	
Condition No.	**Closure conditions**

1	The licence is granted in accordance with the provisions of Clause 7AB of the Iron Ore (Robe River) Agreement Act 1964 and construction and operation of infrastructure and other facilities on this licence proceeding in accordance with proposals approved pursuant to this Agreement.
14	Management of mine closure to be undertaken in accordance with the latest, relevant approved Mine Closure Plan.
18	All topsoil and vegetation being removed ahead of all mining operations from sites such as pit areas, waste disposal areas, ore stockpile areas, pipeline, haul roads and new access roads and being stockpiled for later respreading or immediately respread as rehabilitation progresses.
Tenement No. L47/00884 Purpose: road, pipeline, power line, taking water, drainage channel, pump station, bore, bore field, water management facility	
Condition No.	**Closure conditions**
5	All topsoil that may be removed ahead of pipelaying operations to be stockpiled for replacement in accordance with the directions of the Environmental Officer, DMIRS.
Tenement No. L47/00885 (Pending) Purpose: road, pipeline, power line, taking water, drainage channel, pump station, bore, bore field	
Condition No.	**Closure conditions**
Nil	Nil
Tenement No. L47/00910 Purpose: road, taking water, drainage channel, bore, bore field, water management facility	
Condition No.	**Closure conditions**
14	Management of mine closure to be undertaken in accordance with the latest, relevant, approved Mine Closure Plan.
18	Topsoil and vegetation to be removed ahead of mining operations and appropriately stockpiled for later respreading or immediately respread as rehabilitation progresses.
Tenement No. L47/1027 (Pending) Purpose: bore, bore field, bridge, communications facility, conveyor system, drainage channel, meteorological station, minesite administration facility, pipeline, power generation and transmission facility, power line, pump station, road, storage or transportation facility for minerals or mineral concentrate, tunnel, water management facility, workshop and storage facility, taking water	
Condition No.	**Closure Conditions**
Nil	Nil
Tenement No. L47/1028 (Pending) Purpose: bore, bore field, bridge, communications facility, conveyor system, drainage channel, meteorological station, minesite accommodation facility, minesite administration facility, pipeline, power generation and transmission facility, power line, pump station, road, storage or transportation facility for minerals or mineral concentrate, tunnel, water management facility, workshop and storage facility, taking water	
Condition No.	**Closure Conditions**
Nil	Nil
Tenement No. L52/00072 Purpose: Search for groundwater	
Condition No.	**Closure conditions**
2	On the completion of the life of mining operations in connection with Miscellaneous Licence the holder shall: • remove all installations constructed pursuant to this licence; • cover over all wells and holes in the ground to such degree of safety as shall be determined by the State Mining Engineer; and • on such areas as cleared of natural growth by the holder or any of its agents, the holder shall plant trees and/or shrubs and/or any other plant as shall conform to the general pattern and type of growth in the area and as directed by the Inspector and properly maintain same until the Inspector advises regrowth is self supporting. Unless the Mining Registrar or Minister for Mines orders or consents otherwise.
Tenement No. L52/00075 Purpose: to conduct all necessary activities for the design, planning, construction, operation and maintenance of a railway and all associated infrastructure in connection with mining operations pursuant to the *Iron Ore (Robe River) Agreement Act 1964*	
Condition No.	**Closure conditions**
9	On the completion of the life of mining operations in connection with this licence the holder shall: • remove all installations constructed pursuant to this licence; and • on such areas cleared of natural growth by the holder or any of its agents, the holder shall plant trees and/or shrubs and/or any other plant as shall conform to the general pattern and type of growth in the area and as directed by the Inspector and properly maintain same until the Inspector advises regrowth is self supporting; unless the Mining Registrar/Warden or Minister for Mines orders or consents otherwise.
19	All topsoil and vegetation being removed ahead of all mining operations and being stockpiled appropriately for later respreading or immediately respread as rehabilitation progresses.

Tenement No. L52/00153 Purpose: road, pipeline, power line, taking water, communication facility, pump station, bore, workshop and storage facility

Condition No.	Closure conditions
14	On the completion of the life of mining operations in relation to this licence the holder shall: • remove all installations constructed pursuant to this licence; • cover over all wells and holes in the ground to such degree of safety as shall be determined by the Environmental Officer, Department of Mines and Petroleum; and • on such areas cleared of natural growth by the holder or any of its agents, the holder shall plant trees and/or shrubs and/or any other plant as shall conform to the general pattern and type of growth in the area and as directed by the Environmental Officer, Department of Mines and Petroleum and properly maintain same until the Environmental Officer advises regrowth is self supporting; unless the Minister responsible for the Mining Act 1978 orders or consents otherwise.

Native Vegetation Clearing Permit

Permit No. 8382/1

Clause No.	Closure obligations
10	Retain vegetative material and topsoil, revegetation and rehabilitation The Permit Holder shall: (a) retain the vegetative material and topsoil removed by clearing authorised under this Permit and stockpile the vegetative material and topsoil in an area that has already been cleared; (b) within 12 months following completion of clearing authorised under this permit, revegetate and rehabilitate the areas that are no longer required for the purpose for which they were cleared under this Permit by: (i) ripping the ground on the contour to remove soil compaction; and (ii) laying the vegetative material and topsoil retained under Condition 10(a) on the cleared area. (c) within 4 years of undertaking revegetation and rehabilitation in accordance with Condition 10(b) of this Permit: (i) engage an environmental specialist to determine the species composition, structure and density of the area revegetated and rehabilitated; and (ii) where, in the opinion of an environmental specialist, the composition structure and density determined under Condition 10(c)(i) of this Permit will not result in a similar species composition, structure and density to that of pre-clearing vegetation types in that area, revegetate the area by deliberately planting and/or direct seeding native vegetation that will result in a similar species composition, structure and density of native vegetation to pre-clearing vegetation types in that area and ensuring only local provenance seeds and propagating material are used. (d) where additional planting or direct seeding of native vegetation is undertaken in accordance with Condition 10(c)(ii) of this permit, the Permit Holder shall repeat Condition 10(c)(i) and 10(c)(ii) within 24 months of undertaking the additional planting or direct seeding of native vegetation. (e) where a determination by an environmental specialist that the composition, structure and density within areas revegetated and rehabilitated will result in a similar species composition, structure and density to that of pre-clearing vegetation types in that area, as determined in Condition 10(c)(i) and 10(c)(ii) of this permit, that determination shall be submitted for the CEO's consideration. If the CEO does not agree with the determination made under Condition 10(c)(ii), the CEO may require the Permit Holder to undertake additional planting and direct seeding in accordance with the requirements under Condition 10(c)(ii).

Definitions

direct seeding means a method of re-establishing vegetation through the establishment of a seed bed and the introduction of seeds of the desired plant species;
local provenance means native vegetation seeds and propagating material from natural sources within 200 kilometres and the same Interim Biogeographic Regionalisation for Australia (IBRA) subregion of the area cleared;
planting means the re-establishment of vegetation by creating favourable soil conditions and planting seedlings of the desired species;
regeneration means revegetation that can be established from in situ seed banks contained either within the topsoil or seed-bearing mulch;
rehabilitate/ed/ion means actively managing an area containing native vegetation in order to improve the ecological function of that area;
revegetate/ed/ion means the re-establishment of a cover of local provenance native vegetation in an area using methods such as natural regeneration, direct seeding and/or planting, so that the species composition, structure and density is similar to pre-clearing vegetation types in that area.

Permit No. 6545/3

Condition No.	Closure conditions
13	Retain and spread vegetative material and topsoil The Permit Holder shall:

	(a) retain the vegetative material and topsoil removed by clearing authorised under this Permit and stockpile the vegetative material and topsoil in an area that has already been cleared. (b) within 12 months following clearing authorised under this permit, *revegetate* and *rehabilitate* the areas that are no longer required for the purpose for which they were cleared under this Permit by: (i) re-shaping the surface of the land so that it is consistent with the surrounding 5 metres of uncleared land; (ii) ripping the ground on the contour to remove soil compaction; and (iii) laying the vegetative material and topsoil retained under Condition 13(a). (c) within 4 years of laying the vegetative material and topsoil on the cleared area in accordance with Condition 13(b) of this Permit: (i) engage an *environmental specialist* to determine the species composition, structure and density of the area *revegetated* and *rehabilitated*; and (ii) where, in the opinion of an *environmental specialist*, the composition structure and density determined under Condition 13(c)(i) of this Permit will not result in a similar species composition, structure and density to that of pre-clearing vegetation types in that area, *revegetate* the area by deliberately *planting* and/or *direct seeding* native vegetation that will result in a similar species composition, structure and density of native vegetation to pre-clearing vegetation types in that area and ensuring only *local provenance* seeds and propagating material are used.
14	Retain vegetative material and topsoil, revegetation and rehabilitation The Permit Holder shall: (a) *Revegetate* and *rehabilitate* all areas of temporary disturbance cleared prior to 4 July 2015 within the areas crossed-hatched yellow on attached Plans 6545/3A, 6545/3B, 6545/3C, 6545/3D, 6545/3E, 6545/3F, 6545/3G and 6545/3H by: (i) laying vegetative material and topsoil previously retained within the areas cross-hatched yellow on attached Plans 6545/3A, 6545/3B, 6545/3C, 6545/3D, 6545/3E, 6545/3F, 6545/3G and 6545/3H on the cleared areas; and (ii) ripping the ground on the contour to remove soil compaction. (b) Within 4 years of undertaking revegetation and rehabilitation in accordance with Condition 14(a) of this Permit: (i) engage an *environmental specialist* to determine the species composition, structure and density of the area *revegetated* and *rehabilitated*; and (ii) where, in the opinion of an *environmental specialist*, the composition structure and density determined under Condition 14(b)(i) of this Permit will not result in a similar species composition, structure and density to that of pre-clearing vegetation types in that area, *revegetate* the area by deliberately *planting* and/or *direct seeding* native vegetation that will result in a similar species composition, structure and density of native vegetation to pre-clearing vegetation types in that area and ensuring only *local provenance* seeds and propagating material are used.

Definitions

direct seeding means a method of re-establishing vegetation through the establishment of a seed bed and the introduction of seeds of the desired plant species;
local provenance means native vegetation seeds and propagating material from natural sources within 200 kilometres and the same Interim Biogeographic Regionalisation for Australia (IBRA) subregion of the area cleared;
planting means the re-establishment of vegetation by creating favourable soil conditions and planting seedlings of the desired species;
rehabilitate/ed/ion means actively managing an area containing native vegetation in order to improve the ecological function of that area;
revegetate/ed/ion means the re-establishment of a cover of local provenance native vegetation in an area using methods such as regeneration, direct seeding and/or planting, so that the species composition, structure and density is similar to pre-clearing vegetation types in that area;

Permit No. 4830/3	
Condition No.	**Closure conditions**
9	Retain and spread vegetative material and topsoil The Permit Holder shall: (a) retain the vegetative material and topsoil removed by clearing authorised under this Permit and stockpile the vegetative material and topsoil in an area that has already been cleared. (b) within 12 months following clearing authorised under this permit, revegetate and rehabilitate the areas that are no longer required for the purpose for which they were cleared under this Permit by: (i) re-shaping the surface of the land so that it is consistent with the surrounding 5 metres of uncleared land; (ii) ripping the ground on the contour to remove soil compaction; and (iii) laying the vegetative material and topsoil retained under Condition 9(a). (c) within 4 years of laying the vegetative material and topsoil on the cleared area in accordance with Condition 9(b) of this Permit: (i) engage an environmental specialist to determine the species composition, structure and density of the area revegetated and rehabilitated; and (ii) where, in the opinion of an environmental specialist, the composition structure and density determined under Condition 9(c)(i) of this Permit will not result in a similar species composition, structure and density to that of pre-clearing vegetation types in that area, revegetate the area by deliberately planting and/or direct

	seeding native vegetation that will result in a similar species composition, structure and density of native vegetation to pre-clearing vegetation types in that area and ensuring only local provenance seeds and propagating material are used.

Definitions

direct seeding means a method of re-establishing vegetation through the establishment of a seed bed and the introduction of seeds of the desired plant species;
local provenance means native vegetation seeds and propagating material from natural sources within 200 kilometres and the same Interim Biogeographic Regionalisation for Australia (IBRA) subregion of the area cleared;
planting means the re-establishment of vegetation by creating favourable soil conditions and planting seedlings of the desired species;
rehabilitate/ed/ion means actively managing an area containing native vegetation in order to improve the ecological function of that area;
regenerate/ed/ion means re-establishment of vegetation from in situ seed banks and propagating material (such as lignotubers, bulbs, rhizomes) contained either within the topsoil or seed-bearing mulch;
revegetate/ed/ion means the re-establishment of a cover of local provenance native vegetation in an area using methods such as natural regeneration, direct seeding and/or planting, so that the species composition, structure and density is similar to pre-clearing vegetation types in that area.

Permit No. 6016/2	
Condition No.	**Closure conditions**
9	Retain and spread vegetative material and topsoil The Permit Holder shall: (a) retain the vegetative material and topsoil removed by clearing authorised under this Permit and stockpile the vegetative material and topsoil in an area that has already been cleared. (b) within 12 months following clearing authorised under this permit, revegetate and rehabilitate the areas that are no longer required for the purpose for which they were cleared under this Permit by: (i) re-shaping the surface of the land so that it is consistent with the surrounding 5 metres of uncleared land; and (ii) laying the vegetative material and topsoil retained under Condition 9(a). (c) within 4 years of laying the vegetative material and topsoil on the cleared area in accordance with Condition 9(b) of this Permit: (i) engage an environmental specialist to determine the species composition, structure and density of the area revegetated and rehabilitated; and (ii) where, in the opinion of an environmental specialist, the composition structure and density determined under Condition 9(c)(i) of this Permit will not result in a similar species composition, structure and density to that of pre-clearing vegetation types in that area, revegetate the area by deliberately planting and/or direct seeding native vegetation that will result in a similar species composition, structure and density of native vegetation to pre-clearing vegetation types in that area and ensuring only local provenance seeds and propagating material are used.

Definitions

direct seeding means a method of re-establishing vegetation through the establishment of a seed bed and the introduction of seeds of the desired plant species;
local provenance means native vegetation seeds and propagating material from natural sources within 200 kilometres and the same Interim Biogeographic Regionalisation for Australia (IBRA) subregion of the area cleared;
planting means the re-establishment of vegetation by creating favourable soil conditions and planting seedlings of the desired species;
rehabilitate/ed/ion means actively managing an area containing native vegetation in order to improve the ecological function of that area;
revegetate/ed/ion means the re-establishment of a cover of local provenance native vegetation in an area using methods such as regeneration, direct seeding and/or planting, so that the species composition, structure and density is similar to pre-clearing vegetation types in that area.

Permit No. 4394/4	
Condition No.	**Closure conditions**
10	Retain and spread vegetative material and topsoil The Permit Holder shall: (a) retain the vegetative material and topsoil removed by clearing authorised under this Permit and stockpile the vegetative material and topsoil in an area that has already been cleared. (b) within 12 months following clearing authorised under this permit, revegetate and rehabilitate the areas that are no longer required for the purpose for which they were cleared under this Permit by: (i) re-shaping the surface of the land so that it is consistent with the surrounding 5 metres of uncleared land; (ii) ripping the ground on the contour to remove soil compaction; and (iii) laying the vegetative material and topsoil retained under Condition 10(a). (c) within 4 years of laying the vegetative material and topsoil on the cleared area in accordance with Condition 10(b) of this Permit:

	(i) engage an environmental specialist to determine the species composition, structure and density of the area revegetated and rehabilitated; and (ii) where, in the opinion of an environmental specialist, the composition structure and density determined under Condition 10(c)(i) of this Permit will not result in a similar species composition, structure and density to that of pre-clearing vegetation types in that area, revegetate the area by deliberately planting and/or direct seeding native vegetation that will result in a similar species composition, structure and density of native vegetation to pre-clearing vegetation types in that area and ensuring only local provenance seeds and propagating material are used.

Definitions

local provenance means native vegetation seeds and propagating material from natural sources within 200 kilometres and the same Interim Biogeographic Regionalisation for Australia (IBRA) subregion of the area cleared;
planting means the re-establishment of vegetation by creating favourable soil conditions and planting seedlings of the desired species;
regenerate/ed/ion means re-establishment of vegetation from in situ seed banks contained either within the topsoil or seed-bearing mulch;
rehabilitate/ed/ion means actively managing an area containing native vegetation in order to improve the ecological function of that area;
revegetate/ed/ion means the re-establishment of a cover of local provenance native vegetation in an area using methods such as regeneration, direct seeding and/or planting, so that the species composition, structure and density is similar to pre-clearing vegetation types in that area.

Permit No. 3758/2	
Condition No.	**Closure conditions**
8	Retain and spread vegetative material and topsoil The Permit Holder shall: (a) retain the vegetative material and topsoil removed by clearing authorised under this Permit and stockpile the vegetative material and topsoil in an area that has already been cleared. (b) within 12 months following clearing authorised under this permit, revegetate and rehabilitate the areas that are no longer required for the purpose for which they were cleared under this Permit by: (i) re-shaping the surface of the land so that it is consistent with the surrounding 5 metres of uncleared land; (ii) ripping the ground on the contour to remove soil compaction; and (iii) laying the vegetative material and topsoil retained under Condition 8(a). (c) within 4 years of laying the vegetative material and topsoil on the cleared area in accordance with Condition 8(b) of this Permit: (i) engage an environmental specialist to determine the species composition, structure and density of the area revegetated and rehabilitated; and (ii) where, in the opinion of an environmental specialist, the composition structure and density determined under Condition 8(c)(i) of this Permit will not result in a similar species composition, structure and density to that of pre-clearing vegetation types in that area, revegetate the area by deliberately planting and/or direct seeding native vegetation that will result in a similar species composition, structure and density of native vegetation to pre-clearing vegetation types in that area and ensuring only local provenance seeds and propagating material are used.

Definitions

direct seeding means a method of re-establishing vegetation through the establishment of a seed bed and the introduction of seeds of the desired plant species;
local provenance means native vegetation seeds and propagating material from natural sources within 200 kilometres and the same Interim Biogeographic Regionalisation for Australia (IBRA) subregion of the area cleared;
planting means the re-establishment of vegetation by creating favourable soil conditions and planting seedlings of the desired species;
regenerate/ed/ion means re-establishment of vegetation from in situ seed banks contained either within the topsoil or seed-bearing mulch;
rehabilitate/ed/ion means actively managing an area containing native vegetation in order to improve the ecological function of that area;
revegetate/ed/ion means the re-establishment of a cover of local provenance native vegetation in an area using methods such as regeneration, direct seeding and/or planting, so that the species composition, structure and density is similar to pre-clearing vegetation types in that area.

Permit No. 5078/3	
Condition No.	**Closure conditions**
8	Retain and spread vegetative material and topsoil The Permit Holder shall: (a) retain the vegetative material and topsoil removed by clearing authorised under this Permit and stockpile the vegetative material and topsoil in an area that has already been cleared. (b) within 12 months following clearing authorised under this permit, revegetate and rehabilitate the areas that are no longer required for the purpose for which they were cleared under this Permit by: (i) re-shaping the surface of the land so that it is consistent with the surrounding 5 metres of uncleared land;

	(ii) ripping the ground on the contour to remove soil compaction; and (iii) laying the vegetative material and topsoil retained under Condition 8(a). (c) within 4 years of laying the vegetative material and topsoil on the cleared area in accordance with Condition 8(b) of this Permit: (i) engage an environmental specialist to determine the species composition, structure and density of the area revegetated and rehabilitated; and (ii) where, in the opinion of an environmental specialist, the composition structure and density determined under Condition 8(c)(i) of this Permit will not result in a similar species composition, structure and density to that of pre-clearing vegetation types in that area, revegetate the area by deliberately planting and/or direct seeding native vegetation that will result in a similar species composition, structure and density of native vegetation to pre-clearing vegetation types in that area and ensuring only local provenance seeds and propagating material are used.

Definitions

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planting means the re-establishment of vegetation by creating favourable soil conditions and planting seedlings of the desired species;
regenerate/ed/ion means re-establishment of vegetation from in situ seed banks contained either within the topsoil or seed-bearing mulch;
rehabilitate/ed/ion means actively managing an area containing native vegetation in order to improve the ecological function of that area;
revegetate/ed/ion means the re-establishment of a cover of local provenance native vegetation in an area using methods such as regeneration, direct seeding and/or planting, so that the species composition, structure and density is similar to pre-clearing vegetation types in that area.

Permit No. 3419/3	
Condition No.	**Closure conditions**
8	Retain and spread vegetative material and topsoil The Permit Holder shall: (a) retain the vegetative material and topsoil removed by clearing authorised under this Permit and stockpile the vegetative material and topsoil in an area that has already been cleared. (b) within 12 months following clearing authorised under this permit, revegetate and rehabilitate the areas that are no longer required for the purpose for which they were cleared under this Permit by: (i) re-shaping the surface of the land so that it is consistent with the surrounding 5 metres of uncleared land; (ii) ripping the ground on the contour to remove soil compaction; and (iii) laying the vegetative material and topsoil retained under Condition 8(a). (c) within 4 years of laying the vegetative material and topsoil on the cleared area in accordance with Condition 8(b) of this Permit: (i) engage an environmental specialist to determine the species composition, structure and density of the area revegetated and rehabilitated; and (ii) where, in the opinion of an environmental specialist, the composition structure and density determined under Condition 8(c)(i) of this Permit will not result in a similar species composition, structure and density to that of pre-clearing vegetation types in that area, revegetate the area by deliberately planting and/or direct seeding native vegetation that will result in a similar species composition, structure and density of native vegetation to pre-clearing vegetation types in that area and ensuring only local provenance seeds and propagating material are used.

Definitions

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regenerate/ed/ion means re-establishment of vegetation from in situ seed banks contained either within the topsoil or seed-bearing mulch;
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revegetate/ed/ion means the re-establishment of a cover of local provenance native vegetation in an area using methods such as regeneration, direct seeding and/or planting, so that the species composition, structure and density is similar to pre-clearing vegetation types in that area.

Permit No. 5996/2	
Condition No.	**Closure conditions**
9	Retain and spread vegetative material and topsoil The Permit Holder shall:

	(a) retain the vegetative material and topsoil removed by clearing authorised under this Permit and stockpile the vegetative material and topsoil in an area that has already been cleared. (b) within 12 months following clearing authorised under this permit, revegetate and rehabilitate the areas that are no longer required for the purpose for which they were cleared under this Permit by: (i) re-shaping the surface of the land so that it is consistent with the surrounding 5 metres of uncleared land and; (ii) laying the vegetative material and topsoil retained under Condition 9(a). (c) within 4 years of laying the vegetative material and topsoil on the cleared area in accordance with Condition 9(b) of this Permit: (i) engage an environmental specialist to determine the species composition, structure and density of the area revegetated and rehabilitated; and (ii) where, in the opinion of an environmental specialist, the composition structure and density determined under Condition 9(c)(i) of this Permit will not result in a similar species composition, structure and density to that of pre-clearing vegetation types in that area, revegetate the area by deliberately planting and/or direct seeding native vegetation that will result in a similar species composition, structure and density of native vegetation to pre-clearing vegetation types in that area and ensuring only local provenance seeds and propagating material are used.

Definitions

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local provenance means native vegetation seeds and propagating material from natural sources within 200 kilometres and the same Interim Biogeographic Regionalisation for Australia (IBRA) subregion of the area cleared;
planting means the re-establishment of vegetation by creating favourable soil conditions and planting seedlings of the desired species;
rehabilitate/ed/ion means actively managing an area containing native vegetation in order to improve the ecological function of that area;
regenerate/ed/ion means re-establishment of vegetation from in situ seed banks contained either within the topsoil or seed-bearing mulch;
revegetate/ed/ion means the re-establishment of a cover of local provenance native vegetation in an area using methods such as regeneration, direct seeding and/or planting, so that the species composition, structure and density is similar to pre-clearing vegetation types in that area.

Permit No. 3893/4	
Condition No.	**Closure conditions**
7	Retain and spread vegetative material and topsoil The Permit Holder shall: (a) retain the vegetative material and topsoil removed by clearing authorised under this Permit and stockpile the vegetative material and topsoil in an area that has already been cleared. (b) within 12 months following clearing authorised under this permit, revegetate and rehabilitate the areas that are no longer required for the purpose for which they were cleared under this Permit by: (i) re-shaping the surface of the land so that it is consistent with the surrounding 5 metres of uncleared land; (ii) ripping the ground on the contour to remove soil compaction; and (iii) laying the vegetative material and topsoil retained under Condition 7(a). (c) within 4 years of laying the vegetative material and topsoil on the cleared area in accordance with Condition 7(b) of this Permit: (i) engage an environmental specialist to determine the species composition, structure and density of the area revegetated and rehabilitated; and (ii) where, in the opinion of an environmental specialist, the composition structure and density determined under Condition 7(c)(i) of this Permit will not result in a similar species composition, structure and density to that of pre-clearing vegetation types in that area, revegetate the area by deliberately planting and/or direct seeding native vegetation that will result in a similar species composition, structure and density of native vegetation to pre-clearing vegetation types in that area and ensuring only local provenance seeds and propagating material are used.

Definitions

direct seeding means a method of re-establishing vegetation through the establishment of a seed bed and the introduction of seeds of the desired plant species;
local provenance means native vegetation seeds and propagating material from natural sources within 200 kilometres and the same Interim Biogeographic Regionalisation for Australia (IBRA) subregion of the area cleared;
planting means the re-establishment of vegetation by creating favourable soil conditions and planting seedlings of the desired species;
rehabilitate/ed/ion means actively managing an area containing native vegetation in order to improve the ecological function of that area;
regenerate/ed/ion means re-establishment of vegetation from in situ seed banks and propagating material (such as lignotubers, bulbs, rhizomes) contained either within the topsoil or seed-bearing mulch;
revegetate/ed/ion means the re-establishment of a cover of local provenance native vegetation in an area using methods such as regeneration, direct seeding and/or planting, so that the species composition, structure and density is similar to pre-clearing vegetation types in that area.

Permit No. 4722/1	
Condition No.	**Closure conditions**
9	Retain and spread vegetative material and topsoil The Permit Holder shall: (a) retain the vegetative material and topsoil removed by clearing authorised under this Permit and stockpile the vegetative material and topsoil in an area that has already been cleared. (b) within 12 months following completion of clearing authorised under this Permit, revegetate and rehabilitate the areas that are no longer required for the purpose for which they were cleared under this Permit by: (i) re-shaping the surface of the land so that it is consistent with the surrounding 5 metres of uncleared land; and (ii) laying the vegetative material and topsoil retained under Condition 9(a) on the cleared area. (c) within 4 years of laying tile vegetative material and topsoil on the cleared area in accordance with Condition 9(b) of this Permit: (i) engage an environmental specialist to determine the species composition, structure and density of the area revegetated and rehabilitated; and (ii) where, in the opinion of an environmental specialist, the composition structure and density determined under Condition 9(c)(i) of this Permit will not result in a similar species composition, structure and density to that of pre-clearing vegetation types in that area, revegetate the area by deliberately planting and/or direct seeding native vegetation that will result in a similar species composition, structure and density of native vegetation to pre-clearing vegetation types in that area and ensuring only local provenance seeds and propagating material are used.

Definitions

direct seeding means a method of re-establishing vegetation through the establishment of a seed bed and the introduction of seeds of tile desired plant species;
local provenance means native vegetation seeds and propagating material from natural sources within 100 kilometres of the area cleared;
planting means the re-establishment of vegetation by creating favourable soil conditions and planting seedlings of the desired species;
regenerate/ed/ion means re-establishment of vegetation from in situ seed banks and propagating material (such as lignotubers, bulbs, rhizomes) contained either within the topsoil or seed-bearing mulch;
rehabilitate/ed/ion means actively managing an area containing native vegetation in order to improve the ecological function of that area;
revegetated/ion means the re-establishment of a cover of local provenance native vegetation in an area using methods such as natural regeneration, direct seeding and/or planting, so that the species composition, structure and density is similar to pre-clearing vegetation types in that area.

Relevant Legislation	
Closure planning and implementation requires consideration of general legislative requirements beyond those that apply to a specific site. A list of potentially relevant legislation is provided below, but is not necessarily exhaustive. A comprehensive legal review will be required as closure approaches to ensure that all relevant legislative requirements are identified.	
Australian Commonwealth Legislation	**Western Australian State Legislation**
Environmental Protection and Biodiversity Conservation Act 1999	*Environmental Protection Act 1986*
Native Title Act 1993	*Environmental Protection Regulations 1987*
	Environmental Protection (Controlled Waste) Regulations 2004
	Environmental Protection (Unauthorised Discharges) Regulations 2004
	Contaminated Sites Act 2003 and Regulations 2006
	Conservation and Land Management Act 1984 and Regulations 2002
	Mining Act 1978 and Regulations 1981
	Parks and Reserves Act 1895
	Rights in Water and Irrigation Act 1914 and Regulations 2000
	Biodiversity Conservation Act 2016 and Regulations 2018
	Aboriginal Heritage Act 1972
	Mines Safety and Inspection Act 1994 and Regulations 1995
	Occupiers Liability Act 1985

Relevant Guidelines and Standards	
Closure planning and implementation requires consideration of relevant guidelines and standards, some of which may have regulatory consequence through being referenced in regulatory documents. A list of key guidelines and standards that are routinely considered is provided below, but is not exhaustive due to the breadth of the closure planning discipline. This closure plan has been prepared so as to be considered with relevant content of these guidelines and standards.	
Guideline or Standard	**Author**
Guidelines for Mine Closure Plans in Western Australia (2020)	Western Australia Department of Mines, Industry Regulation and Safety
Environmental Objectives Policy for Mining in Western Australia (2020)	Western Australia Department of Mines, Industry Regulation and Safety
Guidance – How to Prepare a Mine Closure Plan in accordance with Part 1 of *Guidelines for Mine Closure Plans in Western Australia* (2020)	Western Australia Department of Mines, Industry Regulation and Safety
Guidance Note – Environmental Risk Assessment for Mining Proposals and Mine Closure Plans (2019)	Western Australia Department of Mines, Industry Regulation and Safety
A framework for developing mine-site completion criteria in Western Australia (2019)	Western Australia Department of Mines, Industry Regulation and Safety, The Western Australian Biodiversity Science Institute
Mine Closure: Leading Practice Sustainable Development Program for the Mining Industry (2016)	Commonwealth Department of Industry, Innovation and Science
Mine Rehabilitation Handbook (1998)	Minerals Council of Australia
Guideline for the Assessment of Environmental Factors: Rehabilitation of Terrestrial Ecosystems (2006)	Western Australian Environmental Protection Authority
Australian and New Zealand Guidelines for Fresh and Marine Water Quality (2018)	Agriculture and Resource Management Council of Australia and New Zealand and the Australian and New Zealand Environment and Conservation Council
Mine Void Water Resource Issues in Western Australia (2003)	Western Australian Water and Rivers Commission
Contaminated Sites guideline series	Western Australian Department of Water and Environmental Regulation
Environmental Notes on Mining: Acid Mine Drainage (2009)	Western Australian Department of Mines and Petroleum
Environmental Notes on Mining: Waste Rock Dumps (2009)	Western Australian Department of Mines and Petroleum
Safety Bund Walls Around Abandoned Open Pit Mines (1997)	Western Australian Department of Industry and Resources
Global Acid Rock Drainage Guide (2014)	International Network for Acid Prevention
Australian Standard 2601: The Demolition of Structures (2001)	Standards Australia
Australian Standard 4976: The Removal of Underground Petroleum Storage Tanks (2008)	Standards Australia
Demolition Work Code of Practice (2015)	Safe Work Australia

Appendix 2: Stakeholder Consultation Register

Consultation Stage	Stakeholder	Year	Topic	Summary of discussion relevant to closure	Response
	Summary of consultation outcomes arising from the ERMP	1999	West Angelas Deposits A and B Environmental Review and Management Program	EPA advice provided for the Deposit A and B referral (relevant to closure) requested: - location and design of waste dumps have no impact on vegetation with high conservation value or cracking clay areas; - original drainage patterns be restored; and - supports the commitment to pit infilling required to prevent evaporation of groundwater bound to the surface by capillary rise in the soil cover.	Robe integrated these requests into its (then) Decommissioning and Rehabilitation Plan, which has since been superseded by this document.
	Summary of consultation outcomes arising from the proposal (which was not formally assessed by the EPA)		West Angelas Deposit E development proposal	CALM advised that the mulga in the Deposit E area is significant	Internal approval processes are required for each parcel of new footprint disturbed, and impacts to areas of environmental significance (e.g. mulga communities) are considered in this process.
	EPA	2013	Update of MS514	EPA proposed the addition of a condition on MS514 requiring submission of a closure plan, and requested removal of Section 8.9 (Closure and Rehabilitation Management Plan) from the EMP to avoid duplication	The EMP no longer contains a section on Closure and Rehabilitation, as this is now addressed by this document.
	DMP	2014	West Angelas Deposit F and A West Referral	Rio Tinto met with the DMP to discuss various aspects of the proposal to develop Deposits F and A West (which had already been submitted to the OEPA Compliance and Assessment Division to comply with Condition 9 of Ministerial Statement 970). Concerns raised by the DMP included: 1. Erosion of the toe of surface water diversion structures resulting in design failures 2. Questions about whether the Deposit A South waste dump was located within the geotechnical zone of instability 3. Abandonment bunds will be required outside the zone of instability 4. The whole site would need to comply with current standards rather than the standards that may have applied at the time that the site commenced operation 5. Any pit lakes would need to be considered in light of the minimum expectation of landforms being safe and stable - given that there would be increased access to a pit lake, expectations are likely to be higher than for a dry pit void. Furthermore, safe egress would need to be considered. 6. Safe access to heritage sites that have the potential to be accessed post-closure would need to be considered.	1. Not considered in this update of the closure plan, but diversion designs (when developed) will consider erosion controls and be presented in future updates of the closure plan. 2. Addressed in this closure plan 3. Noted. The precise location of abandonment bunds will be determined in consultation with the DMP, and be presented in future updates of the closure plan. 4. Noted. 5. Noted. Pit lakes are not currently planned. 6. Not considered in this update of the closure plan, but plans to provide safe access to heritage sites (where appropriate) will be presented in future updates of the closure plan.
	OEPA	2014	OEPA Response to July 2014 closure plan	The OEPA advised that it had sought advice on the July 2014 closure plan from the DMP, and that it could not be approved until nine comments had been addressed: 1. Demonstration of a risk analysis process 2. Specificity of management controls 3. Inclusions of rehabilitation designs for the Deposit B long term low grade stockpile 4. Consultation with the DMP 5. Given that the site is on vacant crown land close to Karijini National Park, the return of a native ecosystem would be supported, and acceptance of pastoralism as a final land use would require consultation with relevant stakeholders. 6. Closure objectives do not encompass all aspects of the site. 7. Waste dumps appear to be within the zone of instability around pits 8. Consultation with the DoW 9. Completion criteria do not address all aspects of the site. A compliance date of December 2015 was provided to address these concerns.	Consultation was conducted on 11 February 2015 (see record below) to discuss these issues.
	DMP	2015	Discussion of OEPA Response to July 2014 Closure Plan	A meeting was held with the DMP to discuss the points raised in the November 2014 OEPA correspondence (see above). As a general comment, the DMP advised that it had not recommended for the closure plan to not be approved, but had advised that there were several improvements that should be addressed in the next closure update. With respect to each of the nine concerns raised: 1. Risk assessment: accepted by Rio Tinto with no further discussion 2. Management controls: DMP indicated that this concern related specifically to the absence of specific waste dump rehabilitation design information in the Implementation section of the closure plan, and reliance of adherence to Landform Design Guidelines without explanation of how these would be specifically applied. 3. Long Term low grade stockpiles: accepted by Rio Tinto 4. DMP consultation: DMP indicated that it was generally comfortable with the level of consultation undertaken by Rio Tinto in relation to closure planning. 5. Final land use: accepted by Rio Tinto 6. Closure objectives: DMP indicated that this concern related specifically to a failure to clearly articulate in the closure objectives that the site would meet the Department's minimum expectation of safe, stable and non-polluting landforms. 7. Zones of instability: accepted by Rio Tinto. The DMP indicated that it may accept waste dumps within the zone of instability of a pit, but that this would need to be approved on a case by case basis. 8. Consultation with the DoW: accepted by Rio Tinto. 9. Completion criteria: accepted by Rio Tinto.	1. A risk assessment has been conducted and is appended to this closure plan. 2. Waste dump construction, design and rehabilitation implementation information is presented in the Implementation section 3. Waste dump data sheets, including low grade stockpiles, are appended to this closure plan. 4. DMP consultation has been undertaken and is discussed in this register. 5. Pastoral activity is no longer discussed as a potential final land use. 6. Rio Tinto has re-evaluated its approach to objectives and criteria over the past several years, and the outcomes are presented in this closure plan. 7. Zones of instability are discussed in the Identification and Management of Closure Issues section of this closure plan. 8. DoW consultation has been undertaken and is discussed in this register. 9. Rio Tinto has re-evaluated its approach to objectives and criteria over the past several years, and the outcomes are presented in this closure plan.

Consultation Stage	Stakeholder	Year	Topic	Summary of discussion relevant to closure	Response
	OEPA	2015	OEPA Response to July 2014 closure plan	A phone meeting was held on 12 February 2015 to discuss the amendments required to the July 2014 closure plan. The assessing officer had sought and received comments from the DMP which indicated there were improvements to be made to the closure plan.	Closure plan was amended to address DMP concerns.
	Yinhawangka Aboriginal Corporation	2015	Yinhawangka Local Implementation Committee (LIC) meeting	A meeting was held with the Yinhawangka Aboriginal Corporation on 8 April 2015 with the following topics covered: 1. What is closure planning? 2. Three stages of mine closure? 3. What do closure plans consider? 4. How do we close the pits? 5. How do we close waste dumps? The West Angelas closure plan for 2015 was drafted by the time of this meeting.	NA
	DMP	2015	DMP Environment Division Inspection	DMP Environment Division undertook an inspection of the West Angelas mine on 14 July 2015. The following points relevant to closure were raised in the corresponding inspection report: 1. The backfilled portion of open cut pits such as Deposit A requires progressive rehabilitation. This is to enable the land to become a self sustaining ecosystem therefore meeting closure objectives of safe stable and non-polluting landform. 2. The establishment of abandonment and pit safety bunds is recommended to be installed in early stages of pit development as it will be easier to implement in regards to gaining access. 3. Rehabilitation of south west dump bottom lift trial was progressing well, and it appears that species diversity and cover is abundant. Rehabilitation of East Dump also appeared to be progressing well with abundant native plant diversity.	The EMP no longer contains a section on Closure and Rehabilitation, as this is now addressed by this document.
	OEPA	2016	Acceptance of 2015 West Angelas MCP	The February 2015 West Angelas MCP was accepted. OEPA was satisfied that the MCP could be implemented until a revised MCP was submitted as part of the referral of Deposits C, D and G.	NA
	DoW	2016	Pre-referral consultation regarding the Deposit CDG proposal	Various stakeholders were consulted prior to submission of environmental referral. Whilst a number of issues were raised, the only issues with direct relevance to closure were raised by the DoW. 1. Concern was raised about the ability to restore the natural groundwater regime at closure, particularly with removal of the dolerite dyke structure through Deposit C. 2. The DoW sought to understand the closure strategy for the proposed diversion of Turee Creek East tributary.	1. The water level at Deposit C3 is higher (~636mRL) than that observed at Deposit C2 to the west (~624mRL). The dyke is assumed to form a groundwater divide between Deposits C2 and C3 and its removal is expected to result in level equilibrating, with a permanent reduction at C3. Groundwater level reductions may extend for an undetermined distance to the east. The impact of this is not expected to be significant and no attempt to restore levels will be made. The proposal is based on the assumption that there may be a long term reduction in groundwater levels of up to 8m at a location within Karijini National Park which hosts a potential groundwater dependent ecosystem. Studies suggest this will not be environmentally significant. 2. Specific designs are yet to be finalised, but the diversion is intended to be permanent.
	EPA Services	2018	Comments received for Deposit C and D Environment Review Document	Comments received on West Angelas Deposit C and D Environmental Review Document from combined regulator agencies; EPA services, DWER and DBCA. 1. Concerns raised that West Angelas MCP does not adequately address the manage of impacts on biodiversity, GDE's or impacts to groundwater resources prior to contamination. 2. Update to Figure 27 closure domain map 3. Update to Figure 15 surface hydrology map 4. Cracking Clay PEC translocation trial is not required or encouraged. 5. SMART completion criteria should be developed and included in the closure plan. 6. Further detailed is required for current and proposed rehabilitation monitoring program. 7. Prepare a Closure Plan consistent with DMP and EPA Guidelines for Preparing Mine Closure Plans (2015), which includes a Closure Objective to ensure that vegetation on rehabilitated land is self-sustaining and compatible with the final land use and also includes methodologies and criteria to ensure progressive rehabilitation of habitat for conservation significant species.	1. The closure plan currently aligns with the ERD document and environmental impact assessment that impacts from the proposal are of low significance. The closure plan makes reference to closure planning process and regular review of risks. If risk presents through the review process then closure strategies will be developed and presented in subsequent closure plan update. 2. Updated in revised plan 3. Updated in revised plan 4. Noted and reference removed 5. Indicative completion criteria have been developed in response to feedback to Feb 2015 plan that was accepted in June 2016 and to align with other Rio Tinto sites. These will become more specific as site moves towards closure based on improved information arising from monitoring, research and trials, and reflecting evolving stakeholder expectations for closure outcomes. 6. Further information included in revised plan. 7. The Plan contains an objective relating to rehabilitation on vegetated land being self-sustaining and compatible with the final land use with relevant criteria relating to the establishment of habitat as described in Table 7. The proponent is committed to progressive rehabilitation as described in Section 13 of the Plan.

Consultation Stage	Stakeholder	Year	Topic	Summary of discussion relevant to closure	Response
	DMIRS	2018	Conceptual abandonment bund plan - West Angelas Deposits C &D	Rio Tinto present the conceptual abandonment bund design for West Angelas. Key concepts presented included: Abandonment bunds within 1% AEP can not be avoided. The use of external haul road windrow as abandonment bunds was generally support however material characteristic of construction materials should be considered especially in regards to scour resistance during flood events. Topographical means of site restriction was supported around C2 pit was support but access to heritage site should be considered more closely in other areas. DMIRS confirmed that inadvertent access includes 4WDs, motorbikes and horses but doesn't include person's adventuring on foot or deliberate access. In regards to conceptual extreme rainfall event structures/controls presented (including weirs, bund height increases and large boulder breaks). DMIRS appeared supportive of the initial concepts. DMIRS are supportive of the upfront consultation regarding abandonment bunds at implementation of projects with a whole of mine solution as well as concept of abandonment bund implementation for Deposit C&D.	Meeting accepted
	DMIRS	2018	Approval for Mining Proposal with Mine Closure Plan	The approval of Mining Proposal on G47/1235, G47/1236 and L47/52 came subject to the requirement for items (noted in Schedule 2) to be addressed in the next closure plan submission dated April 2021 in accordance with revised tenement conditions (noted in schedule 3). Schedule 2 contains feedback on the following section of the closure plan for further development: Section 5 Stakeholder Engagement - It is acknowledged that a process around the identification of key stakeholders has been presented, along with a commitment to continue regular consultation. However, the next iteration of the MCP should clearly outline all of the key stakeholders identified, as well as provide a consultation strategy for the upcoming 3 year period. Section 8 Completion criteria - It is evident that some consultation with key stakeholders has been conducted however, no information has been presented to demonstrate that key stakeholders have been given an opportunity to provide input into the development of completion criteria. Section 10.4.2 Geochemical characteristics - It is indicated that some Acid Base Accounting (ABA) has been conducted however, the scope of the ABA is unclear. It is therefore not possible to determine whether the testing was representative and thorough. DMIRS requests the scope and results of the ABA be presented in the next revision of the MCP. Section 19.5.2 Deposit F diversion - It is noted that the diversion drain at deposit F has been designed with consideration given to a 2% annual exceedance probability (AEP) event. DMIRS expects that at closure, diversion channels will be designed to remain stable during more extreme events than a 2% AEP.	To be addressed in the April 2021 West Angelas Closure Plan update. Minor updates are represent in this version of the Plan.
	Yinhawangka Aboriginal Corporation	2018	Local Implementation Committee (LIC) H2 2018 report	Report sharing the highlights from 1 July to 31 December 2018, specifically operational updates on Paraburdoo and West Angelas.	NA
Approvals	EPA Board DBCA DWER	2019	EPA Board Workshop to discuss agreement position on environmental outcomes	The workshop provided an overview of the proposed two-phase managed aquifer recharge strategy (i.e. re-injection) that has been developed to maintain groundwater levels at the Park boundary. As background, the team noted that the re-injection proposal is quite modest and at a much smaller scale to others in the Pilbara. The feedback from those present in the workshop was positive for our engagement and work on the adaptive management approach. There also seemed to be support for how this managed aquifer recharge program would be implemented and confidence given the scale and relatively low complexity (i.e. water source, minimal infrastructure, available water for re-injection from ongoing mining in the area etc.).	NA
Closure Management	Yinhawangka Aboriginal Corporation	2019	Eastern Range and Channar Mine Closure; West Angelas covered in limited detail	In two separate forums over two days, a 3D mapping model which covers the mine sites relevant to Yinhawangka lands; West Angelas, Western Range, Paraburdoo, Eastern Range and Channar was presented to Yinhawangka representatives. This model is a replica of the internal mapping software used by Rio Tinto and was being provided for external use by Yinhawangka in response to a request during earlier consultation for access to a tool such as this. Relevant closure related topics discussed during these forums included:- 3D model was very well received by the group who discussed multiple uses of the tool;- Strong desire for salvaged artefacts to be returned to country at closure, not necessarily in the locations it came from but using GPS locations as nearby as possible;- Desire by the group to use the land post closure where possible for beneficial uses such as intensive agriculture and request that operational bores are considered to be left for their access/use; - Request that environmental controls are put in place for sea containers being used for artefact storage;- Yinhawangka would like access to the list of flora species used in rehabilitation.	NA
Ministerial Statement Compliance	DWER	2019	Closure Management	Closure Plan requirements to support Part IV Environmental Approvals Following informal discussion and support with DMIRS, Rio Tinto met with DWER to discuss closure plan requirements to support Part IV environmental approvals. Currently Closure plans are being prepared to support part IV environmental review documents, this process can result in additional workload from both company and regulator perspective with additional closure plans being prepared and reviewed from a compliance and approval submission timeframe. The company proposes to maintain 3 yearly closure plan updates for all sites irrespective of the approvals in progress. Environmental Review documents will be supported by a brief closure strategy document which will detail the key closure considerations for the site, proposed strategies, conceptual criteria and alignment with existing closure plans. The existing closure plans will be appended to the closure strategy/ERD as supporting information. Support for this process was provided by DWER Environmental Impact Assessment North Manager.	11 June 2019 - Peter Tapsell from DWER confirmed his support following the discussion.

Consultation Stage	Stakeholder	Year	Topic	Summary of discussion relevant to closure	Response
Closure Management	DMIRS	2019	Approval for Mining Proposal with Mine Closure Plan	The approval of Mining Proposal on L47/409 and L47/842 came with the approval of the 19 March 2019 Mine Closure Plan (West Angelas Petroleum Pipeline Realignment Area Closure Plan).	NA
Approvals	DMIRS	2019	Mining Proposal closure risks	During consultation regarding the Mining Proposal (Registration ID 83485) it was discussed that closure risks for that Mining Proposal could be included into the Mining Proposal documentation and referenced in the respective closure plan. The closure risk register supporting this Plan is to be fully updated during the next MS compliance plan for this site. This approach has been implemented for the update of this closure plan with a commitment to update the West Angelas closure risk assessment to comply with the regulations for the 2020 MCP update to comply with MS1113.	Minor amendments were made to the risk assessment for mining proposal purposes, and a full update will be made during the next compliance plan update.
Closure Management	EPA, DWER, DMIRS	2019	Rio Tinto Rehabilitation and Closure Regulator Forum	Rio Tinto has adopted the use of Australian Land use management Codes (ALUM) to help standardise the classification of the future land use for closure domains. This is in line with approach taken by Argyle Diamonds and aligns with (then draft) WABSI completion criteria guidance. - Rio Tinto communicated that the use of 5.8.4 (Extractive Industry Not In Use) for mining landforms is not intended to infer a lower standard of rehabilitation, it is intended to recognise that these landforms are created and do not have a natural state as required by code 1.3.4 and to use them for an alternative land use in future beyond leaving them as native vegetation could impede rehabilitation outcomes. - Discussion around the reasoning behind why 5.8.4 would be adopted and the fact that it did not mean these areas would not be rehabbed to an agreed standard. - Feedback given that underlying land use is the key and while ALUM codes is a good framework it does not replace the need for stakeholder consultation to determine land use, particularly regarding return to pastoral land use and the assumption regarding no pastoral activity within the abandonment bunds. Rio Tinto has adopted the use of Australian Land use management Codes (ALUM) to help standardise the classification of the future land use for closure domains. This is in line with approach taken by Argyle Diamonds and aligns with (then draft) WABSI completion criteria guidance. - Rio Tinto communicated that the use of 5.8.4 (Extractive Industry Not In Use) for mining landforms is not intended to infer a lower standard of rehabilitation, it is intended to recognise that these landforms are created and do not have a natural state as required by code 1.3.4 and to use them for an alternative land use in future beyond leaving them as native vegetation could impede rehabilitation outcomes. - Discussion around the reasoning behind why 5.8.4 would be adopted and the fact that it did not mean these areas would not be rehabbed to an agreed standard. - Feedback given that underlying land use is the key and while ALUM codes is a good framework it does not replace the need for stakeholder consultation to determine land use, particularly regarding return to pastoral land use and the assumption regarding no pastoral activity within the abandonment bunds.	NA
Closure Management	DMIRS	2020	Approval for Mining Proposal with Mine Closure Plan	The approval of Mining Proposal on G47/1235, G47/1236, L47/50, L47/52, L47/53, L47/63 and L47/853 came with approval of the 11 April 2018 Mine Closure Plan (rather than the January 2020 version which was submitted with the MP. The MCP is due for revision and resubmission in April 2021.	NA

Consultation Stage	Stakeholder	Year	Topic	Summary of discussion relevant to closure	Response
Closure Management	Ngarlawangga Aboriginal Corporation (NAC) and Ngarlawangga People	2021	Social Surroundings Trip 1 Physical environment and rehabilitation	The Ngarlawangga people raised concerns relating to mining, rehabilitation and closure at West Angelas. Ngarlawangga requested the following: - Impacts from the current and proposed West Angelas be rehabilitated - That country is to be rehabilitated back to the original state and where ever possible and if it is not possible to return it to the original state then areas impacted by the expansion should be rehabilitated as close possible or to something that can sustain life and bring back flora/fauna. - That pits and dumps are progressively backfilled during LoM, particularly Deposit H - The use of pre-existing cleared areas for waste material and stockpiles be utilised wherever possible, rather than clearing new land - Rio Tinto to provide pictures and videos of more successful rehab on other mine sites. - Rio Tinto support a NAC Ranger program to assist in culturally appropriate Ngarlawangga employment opportunities and complement the rehabilitation and environmental compliance work within the project areas - NAC rangers to assist in weed management at West Angelas - Rio Tinto assist NAC rangers in seed collection and storage programs	During the Phase 1 Social Surroundings Scoping Consultation, Rio Tinto agreed that they were interested in assiting Ngarlawangga to set up a Ranger Program and seed program that could assist with aspects of rehabilitation work. Rio Tinto also indicated that they would provide pictures and videos of successful rehab on other mine sites, work collaboratively with Ngarlawangga to achieve better rehabilitation outcomes, support Ngarlawangga in facilitating a seed collection and storage program and provide soil profile information.
Closure Management	Ngarlawangga Aboriginal Corporation (NAC) and Ngarlawangga People	2021	Ngarlawangga LIC Meeting minutes	Rio Tinto provided the NAC with an update on the West Angelas operation. Mine closure was discussed and the opportunity for Traditional Owner businesses in closure. Discussion on artefacts and materials during operations and at closure.	Further conversation/meeting with NAC and RTIO in Perth to assist with NLW members being aware of opportunities that could arise with mine closure approaching. Rio Tinto heritage sub-commitee meeting with Ngarlawangga to address artefacts salvage and storage concerns
Closure Management	Ngarlawangga Aboriginal Corporation (NAC) and Ngarlawangga People	2021	Traditional Ecological Knowledge Project	Ngarlawangga led ethnobotanical cultural research assessment focusing on WAN B2020 development areas. Inclusion of seed provenance to be included in seed mix. Traditional Owners wish to include rehabilitation measures for West Angelas.	NA
Closure Management	Yinhawangka Aboriginal Corporation (YAC) and Yinhawangka People	2021	Closure Workshop	October 2021 High level study update as part of discussion. No standardized backfill of pits across site/the Pilbara. Discussions pertaining to closure included: Yinhawangka to establish closure subcommittee with 1-2 members per Apical family, Topsoil management at site Yinhawangka to be included/participate in the annual rehab monitoring program, Wanting to learn and understand the composition of overburden material at West Angelas Closure risks and management Seek to see other closure examples (Argyle)	NA
Closure Management	Yinhawangka Aboriginal Corporation (YAC) and Yinhawangka People	2022	Social Surrounds/ERD	Social Surrounds workshops inclusive of rehabilitation presentation Oct 22 - Rocklea Palms. Addressing Backfilling queries and Response to SSA Recommendations which include some relevant to closure and potential to be considered in closure planning	NA
Closure Management	Ngarlawangga Aboriginal Corporation (NAC) and Ngarlawangga People	2022	Social Surrounds/ERD	Social Surrounds workshops at West Angelas - Oct 22. Deposit A south dump rehabilitation progress discussion	
Closure Management	Ngarlawangga Aboriginal Corporation (NAC) and Ngarlawangga People	2022	Social Surrounds/ERD	Social Surrounds workshops inclusive of rehabilitation presentation held at Dampier Sept 2022 with topic deep dives for Closure, Rehabilitation, Ground Water and Surface Water for the 13th and 14th of September. West Angelas rehabilitation seed mix list discussion with confirmation certain relevant species with cultural value and useage are currently included in the seed mix list.	NA
Closure Management	Yinhawangka Aboriginal Corporation (YAC) and Yinhawangka People	2022	Social Surrounds/ERD	Social Surrounds workshops at West Angelas - Nov 22. Yinhawangka indicated the condition of consent to mine MTEE pits is backfilling of Mt Ella East Pits to the current/recorded surface level	RTIO working on analysis of this request with view to respond to YHW/YAC Q1 2023
Closure Management	Yinhawangka Aboriginal Corporation (YAC) and Yinhawangka People	2023	Mine Closure Working Group (MCWG)	Inaugural mine closure working group meeting held in March. West Angelas Revised Proposal, pit backfill, closure planning process and buisness opportunities discussed. Yinhawangka members expressed strong sentiment for discussing heritage and artefacts, buisness opportunities, water and pit backfill in upcoming MCWG.	NA
Closure Management	Yinhawangka Aboriginal Corporation (YAC) and Yinhawangka People	2023	Mine Closure Working Group	Mine closure working group held in May.	NA
Approvals	OEPA	2023	WAN MCP ERD Agency Review	West Angelas Revised Proposal and MCP sent to the EPA on the 25th of May 2023.	NA
Closure Management	Yinhawangka Aboriginal Corporation (YAC) and Yinhawangka People and Ngarlawangga Aboriginal Corporation (NAC) and Ngarlawangga People	2023	Mine Closure Plan Review	The West Angelas Revised Proposal mine closure plan was submitted to the Yinhawangka Aboriginal Corporation and Ngarlawanagga Aboriginal Coproration in May.	NA

Consultation Stage	Stakeholder	Year	Topic	Summary of discussion relevant to closure	Response
Closure Management	Yinhawangka Aboriginal Corporation (YAC) and Yinhawangka People	2023	Mine Closure Plan Feedback	Feedback on the West Angelas Revised Proposal MCP from YAC received 26th June.	Reponse to comments issued by RTIO with appropriate changes made to MCP.
Closure Management	Ngarlawangga Aboriginal Corporation (NAC) and Ngarlawangga People	2023	Mine Closure Plan Review	Feedback on the West Angelas Revised Proposal MCP from NAC received 21 July.	Reponse to comments issued by RTIO with appropriate changes made to MCP.
Closure Management	Ngarlawangga Aboriginal Corporation (NAC) and Ngarlawangga People	2023	Ngarlawangka and Rio Tinto LoMP	Powerpoint presentation was delivered containing information on RTIO closure planning processes. Ngarlawangka Aborginal Corporation held a closed workshop and presented back some draft closure principles.	
Closure Management	Yinhawangka Aboriginal Corporation (YAC) and Yinhawangka People	2023	Mine Closure Working Group	Mine closure working group meeting held in August. Minutes are pending.	
Closure Management	Yinhawangka Aboriginal Corporation (YAC) and Yinhawangka People	2023	CHLC Meeting	The opportunity to backfill the WEPS pit void with waste from the A West development was discussed with YAC.	NA
Closure Management	Yinhawangka Aboriginal Corporation (YAC) and Yinhawangka People	2023	Mine Closure Working Group	Dedicated session on pit backfill for all assets on Yinhawangka Country held on 3-4 November. Minutes are pending.	
Approvals	OEPA	2023	WAN MCP ERD Agency Review	Comments from regulators received on Environmental Review Document and Mine Closure Plan. Comment was asking for clarification on contaminated sites information.	Clarifications made in the MCP.

Appendix 3: Closure Risk Register

West Angelas Closure Risk Assessment Summary, 2023

Risk ID	Risk Title	Causes	Impacts	Existing Controls	Likelihood - Probability	Local Risk Class	Inherent Likelihood - Probability	Inherent Local Risk Class
515550	Implementation of the closure strategy does not result in the agreed environmental outcome	New (previously unidentified) environmental sites, not considered in existing environmental impact assessment. Changes to environmental conditions due to cessation of artificial support / mitigation activities, e.g. water supplementation. Change to drainage patterns on closure e.g. removal of temporary diversions, drains etc. Concentration of natural groundwater or mineral waste derived salts through evapoconcentration in open water bodies. Groundwater flow through mineral waste with connection to regional aquifer. Density driven saline groundwater flow from groundwater sink-style pit lakes. Downstream groundwater users (people, plants or animals). Potential hydrogeological modelling inaccuracies. PAF material is being mined; however has been assessed to be low risk of generating AMD. Scheduled, listed or declared rare and / or threatened species of flora or fauna present in/adjacent to site Downstream regional area of high value - Karijini National Park (KNP) Environmental conditions post-closure differ significantly from pre-mining conditions Post-mining land use differs from pre-mining land use Creek discharge creates ecosystem/ habitat for MNES causing challenges in removing water source/ return to ephemeral MAR unsuccessful resulting in drawdown of KNP Clearing restrictions applied to sensitive enviro receptors may impact closure planning / mitigation design	LTO CSP ENV LEG	Environmental and groundwater monitoring regime in place during operations. [699589] Groundwater operating and monitoring plan [702372] Baseline flora and fauna surveys [759550] Biological GIS database [782559] Environmental exclusion zones established to protect conservation significant fauna and habitat [832623] Geochemical waste characterisation and column leach tests [702369] Ground disturbance Approval Request system [758266] Managed Aquifer Recharge (MAR) / groundwater injection being implemented to ensure groundwater levels within KNP are maintained [722364] Management of mineral waste to minimise surface water area exposed to evapotranspiration, to minimise salinity [702367] Pit void closure guidance [759544] Pit voids will be backfilled to a level that prevents formation of a permanent pit lakes [722363] Preliminary integrated ground-surface water modelling (with recovery) completed [702368] Water Discharge Monitoirng and Management plan [702366]	POSSIBLE 20% - 50%	Class IV	POSSIBLE 20% - 50%	Class IV

Risk ID	Risk Title	Causes	Impacts	Existing Controls	Likelihood - Probability	Local Risk Class	Inherent Likelihood - Probability	Inherent Local Risk Class
515545	Pit wall stability at West Angelas compromises closure outcomes	Influence of erosion, subsidence, seismicity, wall slip Influence of groundwater recovery and surface water flow on stability. Creek system neighbouring or within zone of instability, potential stream capture Ecosystem downstream of void dependent on surface water flows Poor communication of zone of instability to facilitate identification of important features Geotechnical assessment incorrectly defines the zone of instability. Built landforms (waste dumps/landbridges) within potentially unstable pit edge zone.	Environment LtO TCC	Buttressing design to improve pit wall stability at closure [786838] Closure review of landform designs through MDAS system [758263] Conceptual location for abandonment bunds established [702335] D3 Standard Management of Slope Geotechnical Hazards [758274] Geotechnical assessments for wall stability and zone of collapse as part of mine design reviews, as required [515434] Geotechnical assessments for wall stability and zone of collapse as part of mine design reviews, as required. [519534] Pit void closure guidance [759544] Pit walls design factor of safety 1.3, geotechnical assessment show zone of collapse for high risk locations (near creeks, infrastructure etc.) [702334] Temporary and permanent surface water structures designed to conform with relevant legal and engineering standards. [519543]	POSSIBLE 20% - 50%	Class IV	POSSIBLE 20% - 50%	Class IV
804079	Insufficient material for backfill/capping increases closure liability and complexity	Settlement exceeds estimates (more backfill required). Incorrect assumption on density of waste material Engineering designs required to manage creek capture at concept level, with uncertainty on final design and quantities of material required. Buttressing of pillar at Dep E to maintain access anticipated with uncertainty on final design and quantities of material required. Site in ZOI at Dep E may need buttressing with uncertainty on final design and quantities of material required. Mt Ella may require more backfill based on Traditional Owner concerns. High proportion of highly erodible materials - may impact on capping requirements for permanent landforms.	LTO TCC	Closure Studies process (OoM, PFS, FS) [758192] Landform Design Guidelines [754554] Mine planning updates actively considers backfill opportunities in life of mine strategy [758261] Physical materials characterisation completed for common waste types [519539] Tip to Conformance on RTIO waste dumps [776193]	POSSIBLE 20% - 50%	Class III	POSSIBLE 20% - 50%	Class III

Risk ID	Risk Title	Causes	Impacts	Existing Controls	Likelihood - Probability	Local Risk Class	Inherent Likelihood - Probability	Inherent Local Risk Class
722921	Inadequate management of surface water results in increased closure complexity and costs	Unabated creek flow erodes pit walls, buttressing or levees leading to capture in pit voids and decrease of downstream flow. Altered SW regimes (e.g. ponding, diversion of SW flow, reduction in catchment area, evaporation/seepage),poorly designed/ located abandonment bunds Inadequate assessment of extreme events in consideration of final landforms - consequence is significant engineering designs to protect/divert. Increase in sedimentation in pools Cause to environmental/heritage outcomes risks Decreased catchment area reduces interception and volume to KNP. inadequate surface water management degrades water quality Water in pits creates pit lakes resulting in impacts to groundwater quality and inability to meet closure criteria	LtO TCC CSP Environment	Surface water diversion have been designed for appropriate flood events and closure outcomes [723039] Temporary and permanent surface water structures designed to conform with relevant legal and engineering standards. [519543] Water management strategies during operations prioritize minimization of closure management liability [786840]	UNLIKELY 5% - 20%	Class III	LIKELY 50% - 75%	Class IV
707951	Consultation fails to identify and/or address stakeholder concerns	Conflicting stakeholder expectations or areas of authority e.g. different regulators for environment, heritage, health, economic, tourism. Conflicting legal obligations e.g. State Agreement and EPA. Interactions between catchment land uses, including mining developments, at different points in time.	LtO CSP	Biannual Local Implementation Committee meetings with TO's [758281] Closure legal obligations register [757139] Mine Closure Plan is updated for approval every three years [757145] RTIO - Stakeholder Engagement Strategy for Closure [754125] Stakeholder Engagement Register [757141]	UNLIKELY 5% - 20%	Class III	POSSIBLE 20% - 50%	Class IV
515552	Implementation of the closure strategy does not achieve the required cultural heritage outcomes	Heritage sites have not all been identified. Cultural heritage values, not considered in existing assessment, discussions, agreements or with authority to disturb. Changes to landforms on closure have potential to alter conditions at downstream sites, e.g. consider drainage, landform footprint, erosion implications. Cessation of maintenance of / to heritage site. Cultural values not considered in rehabilitation strategies. The presence of heritage sites in close proximity to mining areas.	LtO CSP Legal TCC	Biannual Local Implementation Committee meetings with TO's [758281] Cultural Heritage Management Guidance Note [759521] Cultural Heritage Management Plan [703848] Ground disturbance Approval Request system [758266] Heritage GIS database [519558] RTIO - Stakeholder Engagement Strategy for Closure [754125] Social Cultural Heritage Management Plan [1310073]	UNLIKELY 5% - 20%	Class III	POSSIBLE 20% - 50%	Class IV

Risk ID	Risk Title	Causes	Impacts	Existing Controls	Likelihood - Probability	Local Risk Class	Inherent Likelihood - Probability	Inherent Local Risk Class
		Plans for repatriation of salvaged artifacts not well understood. Downstream regional area of high value to multiple Traditional Owner groups. Unplanned impact to known heritage site from machinery activity/material movement. Inadequate consultation with TOs during LoM / Closure implementation. TO concerns on impact associated with building AB.		Stakeholder Engagement Register [757141]				
515549	The safety risk for people entering West Angelas after it has been rehabilitated has not been effectively mitigated	Post-closure access / land-use requirements, e.g. for stock, people, heritage, environmental monitoring, adjacent mining activities etc. Potential for general public to create their own access if appropriate access not provided. Long term integrity of abandonment bunds Decommissioning of infrastructure not implemented effectively Some roads retained for post-closure access May not have competent material that is avaible for the abandonment bund	Health & Safety	Abandonment bunds to prevent inadvertent access [782553] Above ground infrastructure made safe or removed [782555] Backfill of pit voids (to varying levels) [782554]	RARE < 5%	Class III	POSSIBLE 20% - 50%	Class IV
	Rehabilitation outcomes at West Angelas do not meet closure objectives	Availability of top soil stockpile soil / poor stockpile management e.g. soil washed away Vegetation established, but does not re-seed in same abundance Limited progressive rehabilitation and ability to source local provenance seed at West Angelas Surface treatment on landforms limits vegetation	LTO Cost of Closure	Annual stockpile reconciliation of topsoil and subsoil stockpiles conducted. [498460] Baseline flora and fauna surveys [759550] Biological GIS database [782559] Progressive rehabilitation is trialed and completed during operations [758285] Rehabilitation monitoring program [759547]				

Risk ID	Risk Title	Causes	Impacts	Existing Controls	Likelihood - Probability	Local Risk Class	Inherent Likelihood - Probability	Inherent Local Risk Class
515547		growth Weed competition Species selection / insufficient species diversity Animal interference i.e. feral animals eating new growth Low moisture retention i.e. hydrophobic soils development, very rocky materials Chemical properties of materials on waste dump / rehab surface e.g. salt circulation, alkalinity		RTIO Rehabilitation handbook [759546] Seed management and procurement program [759225] Traditional Ecological Knowledge Studies [1310071] Soil resource management work practice [759226]	POSSIBLE 20% - 50%	Class III	POSSIBLE 20% - 50%	Class III
515546	Waste dumps and landbridges are subject to excessive erosion	Physical material properties not adequately considered in design. Design does not consider significant rainfall events. Poor drainage and erosion management Landforms /waste dumps not constructed to design requirements Failure of permanent diversion levees The material to build the waste dump is highly erodible	LtO Environment TCC	Closure Monitoring and Maintenance Plan [759549] Closure review of landform designs through JIRA system [758263] Landform Design Guidelines [754554] Physical materials characterisation completed for common waste types [519539] Progressive rehabilitation is trialed and completed during operations [758285] RTIO Rehabilitation handbook [759546] RTIO SCARD management plan [519521] Temporary and permanent surface water structures designed to conform with relevant legal and engineering standards. [519543] Tip to Conformance on RTIO waste dumps [776193]	POSSIBLE 20% - 50%	Class III	LIKELY 50% - 75%	Class III
1166908	Pit void at West Angelas presents an unacceptable environmental risk	Ground water rebound higher than expected - unplanned pit lake formation Backfill does not achieve closure objective of managing groundwater impacts	Closure strategy for void is no longer acceptable due to contamination or other env/heritage impacts. Additional pit backfill required.	Asset Closure Strategy [1166930] Closure Plan [1166933] Engagement with stakeholders [1166936] Regulatory Closure Plan [1166938]	UNLIKELY 5% - 20%	Class II	UNLIKELY 5% - 20%	Class II
515541	Human health impacts arise from fibrous material exposures at West Angelas after closure	Hazardous fibres exposed in situ by mining, mined and moved to encapsulated areas or naturally present in soils disturbed by mining / rehabilitation activities Erosion of materials containing hazardous fibres post-closure Some fibres present in mineral waste materials, surface alluvials and associated with infrastructure installation (cuts through non-mined geology)	Health & Safety	IOWA Fibrous Materials Management Plan [702422] Physical materials characterisation completed for common waste types [519539]	RARE < 5%	Class II	POSSIBLE 20% - 50%	Class III

Risk ID	Risk Title	Causes	Impacts	Existing Controls	Likelihood - Probability	Local Risk Class	Inherent Likelihood - Probability	Inherent Local Risk Class
515538	Inadequate management of contaminating activities at West Angelas during operations results in a closure liability	Poor use or uncontrolled use of chemicals and hydrocarbons during operations. Inadequate housekeeping practice and maintenance of work areas and equipment. Contaminated sites have not been identified. Inadequate clean-up of contamination. Potential contamination source has not been addressed. The full nature and extent of reportable contaminated sites have not been adequately determined. Lag contamination events from historical waste disposal practices. Changes in regulatory expectations and continually developing regulatory understanding of emerging contaminates of concern.	TCC Environment Compliance	Licensing of Prescribed Premises [783245] RTIO Contaminated Sites Strategy [782520] RTIO Environment Design Standard for Infrastructure [782521] RTIO Environment Design Standards Temporary Infrastructure [782523] RTIO Landfarm Work Practice [782519] RTIO Potentially Contaminated Sites Register [793372] RTIO Spill Response Procedure [779354] Spill management kits readily available. [692930]	UNLIKELY 5% - 20%	Class II	POSSIBLE 20% - 50%	Class III
1166904	Mine closure has a significant long-term detrimental impact on local communities	Mine closure has occurred and had an impact on local communities.	Reputational damage	Closure Plan [1166932] Engagement with stakeholders [1166935] Regulatory Closure Plan [1166937]	UNLIKELY 5% - 20%	Class I	RARE < 5%	Class I
515540	Inadequate management of PAF material at West Angelas results in AMD and increased closure complexity and costs	Interaction of water and mineral waste could generate acid / alkaline levels that leach metals / salts from the mineral waste or local environment Presence of temporary or permanent open water bodies, enabling evapoconcentration to occur with creation of alkaline / hypersaline water quality Ability of metals / salts to move through environment to impact a sensitive receptor, to meet definitions in Contaminated Sites Act 2003	LtO Environment Compliance TCC	Groundwater operating and monitoring plan [702372] Backfill of pit voids (to varying levels) [782554] E13 Standard Chemical Reactive Waste [754153] Geochemical waste characterisation and column leach tests [702369] Mine plan avoids disturbance of PAF material [493969] RTIO SCARD management plan [519521] Water Discharge Monitoirng and Management plan [702366] Wet season management plans to control run off [519520]	RARE < 5%	Class I	UNLIKELY 5% - 20%	Class I

Appendix 4: Closure Action Register

Appendix 4 – Closure Action Register

Closure Risk	Closure Risk Action	Timing	Reference
Implementation of the closure strategy does not result in the agreed environmental outcome	• Develop designs for permanent diversions where required. [515187] • Ensure the rehabilitation designs for the proposed waste dumps (PIV proposed deposits) do not encroach into the zone of instability [1053374] • Evaluate the final landform design with respect to the potential for impacts to cracking clay communities [515189] • Managed Aquifer reinjection (MAR) trials to be carried out to firm up reinstatement methodology. multi-phase MAR Scheme to be planned [803830] • Undertake groundwater modelling where not yet completed to determine backfill levels for all pits [722362] • Update Water Balance with (22LOM, 23LOM etc.) [1037819]	2030 2025 2030 2025 2024 2023	WAN-05 WAN-01 WAN-12 WAN-07
Pit wall stability at West Angelas compromises closure outcomes	• Develop rehabilitation designs for waste dumps that are currently located within zones of instability (Deposit A South dump and Deposit E South dump) that ensure these dumps are outside the zone of instability. [515183] • Ensure the rehabilitation designs for the proposed waste dumps (PIV proposed deposits) do not encroach into the zone of instability [1053374] • Geotechnical assessment of pit wall buttressing requirements (Operational Pits, 2021 LOM) [722196]	2024 2025 2024	WAN-01 WAN-01 WAN-02
Insufficient material for backfill/capping increases closure liability and complexity	• Complete backfill reconciliation ensuring volumes align with 5YP of waste dump rehabilitation [804083] • Review availability of competent materials to ensure sufficient volume of material is available to meet closure requirements [1038234]	2024 2023	
Inadequate management of surface water results in increased closure complexity and costs	• Complete flood modelling for areas not yet defined in detail [754160] • Conduct an impact assessment of unplanned post closure diversion of Turee Creek East flows to Deposit C and D pits due to pit crest failure. [882796] • Ensure the rehabilitation designs for the proposed waste dumps (PIV proposed deposits) do not encroach into the zone of instability [1053374] • Geomorphic landform Design / Landform Evolution Modelling Assessments [1038106] • Geotechnical assessment of pit wall buttressing requirements (Operational Pits, 2021 LOM) [722196] • Review availability of competent materials to ensure sufficient volume of material is available to meet closure requirements [1053375]	2036 2024 2025 2023 2024 2023	WAN-08 WAN-19 WAN-01 WAN-02
Consultation fails to identify and/or address stakeholder concerns	• Build a West Angelas specific closure engagement strategy [802388] • Ensure visual assessments / consultations with external stakeholders occur as part of Oom, PFS & FS level studies [722422]	2024 2030	 WAN-06
Implementation of the closure strategy does not achieve the required cultural heritage outcomes	• Develop closure strategies to maintain cultural heritage values (e.g. buttressing of deposit E 'pillar' to maintain its integrity post-closure, access maintained to petroglyphs north of deposit D following closure) [515192] • Ensure consistency between Cultural Heritage Management Plan and Closure Plan with respect to strategies for maintaining cultural heritage values. [515194] • Investigate the potential for cultural heritage values to be impacted post-closure (check that sites fall outside of ZOI), and evaluate the implications of impacts if they arise [515191] • Operational in-pit water storage assessment to determine whether strategy poses risk on forming 'permanent' pit lake [1038250]	2030 2030 2025 2023	WAN-15 WAN-16 WAN-17
The safety risk for people entering West Angelas after it has been rehabilitated has not been effectively mitigated	• Confirm abandonment bund locations for areas not yet defined in detail [515186]	2024	WAN-04
Rehabilitation outcomes at West Angelas do not meet closure objectives	• Develop site specific seed list for West Angelas [725551] • Metalloids leachate assessment to inform the AMD risk assessment and operational management. Including undertaking further investigation on specific lithologies, notably, the MacLeod, Mt Newman and Nammuldi Members. [882795] • Sample subsoil in future soil work [754161] • Test chemical parameters in future soil work [725550]	2036 2024 2036 2036	WAN-11 WAN-18 WAN-10 WAN-09
Waste dumps and landbridges are subject to excessive erosion	• Determine closure strategy for creek diversions [799551] • Develop new rehabilitation designs for existing waste dumps (e.g. Deposit A) that may not have not be constructed to readily facilitate stable rehabilitation slopes. [515184] • Undertake further site specific waste characterisation to better define dump erosion potential. [515185]	2025 2025 2023	 WAN-13 WAN-14
Failure to reach agreement with the State on suitable completion criteria for West Angelas	• Develop a process to determine under performing areas of rehab and their recommended remediation action [762873] • Implement progressive rehabilitation [495568] • Refine MCP template in line with Statutory Guidelines and regulator comments received in June 2020 [763103]	2025 2030 2023	

Human health impacts arise from fibrous material exposures at West Angelas after closure	• Evaluate closure landform designs with respect to managing the potential for exposure/re-exposure of fibrous materials and incorporate design changes where required. [515181]	2030	WAN-03
Inadequate management of contaminating activities at West Angelas during operations results in a closure liability	• Undertake a detailed site investigation to identify, classify and develop remediation strategy for potentially contaminated sites [851228]	2035	
Inadequate management of PAF material at West Angelas results in AMD and increased closure complexity and costs	• Determine either, or both, the likelihood of PAF material exposure in the pit wall and presence in mine waste for the Mt Newman, MacLeod and Nammuldi Members generally and specifically the West Angelas Member in Deposit B [882797]	2024	WAN-20

Appendix 5: Physical Waste Characterisation Report

Landloch

TOOWOOMBA
PO Box 57 HARLAXTON QLD 4350
Phone 07 4613 1825 | **Fax** 07 4613 1826

PERTH
PO Box 5175 SOUTH LAKE WA 6164
Phone 08 9494 2835 | **Fax** 07 4613 1826

NEWCASTLE
PO Box 7017 REDHEAD NSW 2290
Phone 02 4965 7717 | **Fax** 07 4613 1826

Rio Tinto
Level 12, Central Park
152-158 St George's Terrace
PERTH WA 6000

02 May 2022

2079.20f (Rev 1)

Attn: Kjestine McNamara – Rehabilitation Advisor, Studies, Rehab and Closure

Memorandum: Characterisation of erosion potential of mineral wastes for use in developing rehabilitated landform designs, West Angelas

1. Introduction

1.1 Regulatory expectations

Across Australia, mining regulatory bodies provide guidance on the required state of rehabilitated landforms. In Western Australia the Department of Mines, Industry Regulation and Safety (DMIRS) define land rehabilitation as the "return of disturbed land to a safe, stable, non-polluting/non-contaminating landform in an ecologically sustainable manner that is productive and/or self-sustaining and is consistent with the agreed post-mining land use"[1]. In their guidance note on waste rock dumps, DMIRS also state that the geometry of waste dump batter slopes should be designed such that they are not prone to significant erosion[2].

Therefore, fundamental to creating safe, stable, and non-polluting landforms is the development of land surfaces that:

- do not erode at rates likely to be unstable in the long-term;
- are sufficiently stable such that vegetation can establish;
- erode such that the agreed post-mining land use can be achieved; and
- generate sediment levels consistent with those of the surrounding landscape.

1.2 Rio Tinto's historical involvement in erodibility testing and erosion modelling

Rio Tinto Iron Ore (WA) has been involved in the development of erosion assessment methods for mining waste landforms for a long time, with the first application of material erodibility

[1] Department of Mines, Industry Regulation and Safety (2020) *Mine Closure Plan Guidance - How to prepare in accordance with Part 1 of the Statutory Guidelines for Mine Closure Plans*, Version 3.0, Government of Western Australia, https://www.dmp.wa.gov.au/Documents/Environment/REC-EC-112D.pdf, accessed 29 October 2021.
[2] Department of Mines, Industry Regulation and Safety (2021) *Waste Rock Dumps*, Version 2.1, Government of Western Australia, https://www.dmp.wa.gov.au/Documents/Environment/ENV-MEB-223.pdf, accessed 29 October 2021.

testing and erosion models to mining landforms occurring in 1998. Since that time, the use of models has improved and been refined to the point where final landform shapes can be informed through models calibrated using site-specific material erodibility and climate data.

Between 1998 and 2006, Rio Tinto Iron Ore (WA) completed numerous erosion studies, including field-based studies at Tom Price, Paraburdoo, West Angelas, and Nammuldi, and laboratory-based studies for materials from Tom Price, Channar, and Marandoo. Between 2010 and 2021 they have continued to undertake a program of works to generate erodibility data for a range of mineral waste materials from their iron ore mine sites in the Pilbara. Most recently for West Angelas, data for materials were collected in 2021.

These erodibility data have been used to establish a way for a material's erosion characteristics to directly inform rehabilitation planning. Erodibility is defined differently depending on the erosion prediction tool being used. Erodibility has been considered in two ways.

First, material erodibility from the Revised Universal Soil Loss Equation (RUSLE) [3] has been used to rank each mineral waste type into groups that help to broadly consider erosion risk. Erodibility from the RUSLE is linked to a material's particle size distribution (PSD), and when linked with a measure of surface rock cover level, can be used to rank materials into one of three levels of erodibility – low, medium, or high. Second, erodibility has been considered within the WEPP[4] runoff/erosion model to define material-specific landform designs for each mineral waste type. WEPP erodibility parameters are directly related to material erodibility and provide a more robust means of assessing erosion risk.

1.3 Erodibility ranking system using the RUSLE

The erodibility ranking system developed using the RUSLE seeks to broadly rank mineral wastes into one of three levels of erodibility – low, medium, or high. The RUSLE is an empirical equation that calculates long-term annual erosion using five factors that are multiplied together[5]. Two of these factors, erodibility (K-factor) and cover (C-factor), are specifically related to the material. The remaining three factors describe rainfall, batter geometry, and slope conditions.

The K-factor is calculated from a material's fine fraction PSD (<2mm diameter), excluding the coarse fraction (>2mm). The standard procedure for its calculation is detailed by Rosewell and Loch (2002)[6]. The C-factor describes the impact of different cover elements on erosion. For this ranking system, surface rock cover is important in reducing erosion potential. Rock cover is the percentage of the rain-armoured surface that is covered by rock particles. Other cover elements such as litter and vegetation surface cover were not considered as they are typically low in the Pilbara (vegetation surface cover levels are typically <5%).

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[3] Renard, K.G., Foster, G.R., Weesies, G.A., McCool, D.K., and Yoder, D.C., *Predicting soil erosion by water: A guide to conservation planning with the Revised Universal Soil Loss Equation (RUSLE)*, Agricultural Handbook Number 703, US Department of Agriculture.

[4] Water Erosion Prediction Project

[5] $A = R \times K \times LS \times P \times C$ where A is average annual erosion (t/ha/y), R is rainfall erosivity (MJ.mm/ha.h.y), K is soil erodibility (t.ha.h/ha.MJ.mm), LS is the slope length and steepness factor (ratio), P is the support practice factor (ratio), and C in the cover management factor (ratio).

[6] Rosewell, C.J. and Loch, R.J. (2002) *Estimation of the RUSLE soil erodibility factor*, in N. McKenzie, K. Coughlan, and H. Cresswell (eds), Soil Physical Measurement and Interpretation for Land Evaluation, CSIRO Publishing, Collingwood.

Simanton *et al.* (1984)[7], reporting results from their study and two others (Meyer *et al.* (1972)[8]; Box (1981)[9]), found that the RUSLE C-factor can be used to account for changes in rock cover and offer a conservative means of estimating its ability to reduce erosion potential (Figure 1). It was calculated using the RUSLE software (version 1.06) supplied by the US Department of Agriculture.

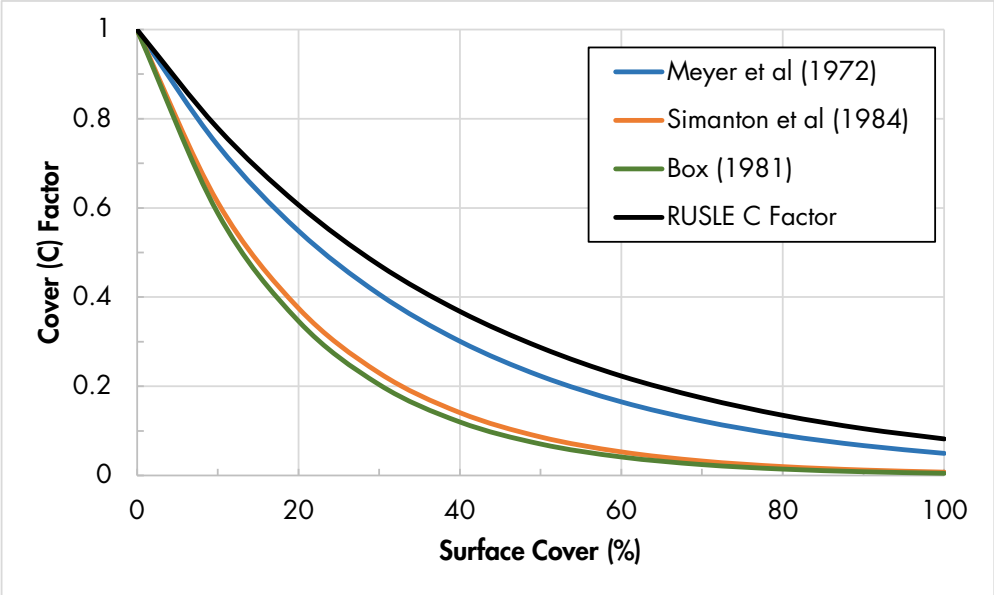

Figure 1: Rock cover and C-factors reported for three studies compared to the RUSLE C-factor relationship (Source: Simanton *et al.* (1984)).

The ranking system was developed using PSD and rain-armoured rock cover levels measured for 36 different mineral wastes sourced from across Rio Tinto's Pilbara iron ore mine sites, including Brockman 4, Hope Downs 1, Mesa A, Mesa J, Nammuldi, Paraburdoo, Tom Price, West Angelas, Western Turner Syncline, and Yandicoogina. The samples had a wide range of PSD and rock cover levels (10-90%). Analysis of the data showed that all K-factors were consistent with highly and very highly erodible materials. By themselves, the K-factors did not explain the observed differences in erosion potential of the wastes. However, when the impact of rock cover was included using the C-factor, it was shown that rock cover strongly influenced erodibility and could explain the observed differences in erosion potential between materials. Mineral wastes that had rock cover levels >70% were ranked as low erodibility and had an erodibility factor (K-factor X C-factor) of <0.001. Materials with rock cover levels of 30-70% were ranked as medium erodibility and had an erodibility factor of 0.02-0.001. Materials with rock cover levels <30% were ranked as high erodibility and had an erodibility factor >0.02.

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[7] Simanton, J.R., Rawitz, E. and Shirley, E.D. (1984) *Effects of rock fragments on erosion of semiarid rangeland soils*, in 'Erosion and productivity of soils containing rock fragments', Special Publication 13, pp. 65–72, Soil Science Society of America, Madison, WI.

[8] Meyer, L.D., Johnson, C.B., Foster, G.R. (1972) *Stone and woodchip mulches for erosion control on construction sites*, J. Soil Water Conserv., 27(6): 264-269.

[9] Box, J.E. Jr (1981) *The effects of surface slaty fragments on soil erosion by water*, Soil Sci. Am. J., 45:111-116.

The erosion that occurs for a material is dependent not only on the material's erodibility, but also on the climate and how the materials are placed (batter geometry). A material that has a low erodibility ranking can be made to erode at high rates if the batter gradients used are too steep or the slope lengths are too long. Vice versa, a material that has a high erodibility ranking can be used to produce stable batter profiles if an appropriate slope geometry is adopted. Therefore, the actual erosion potential of a material is not defined by this erodibility ranking, but by the results of the WEPP erosion modelling, as it considers all the relevant factors (material erodibility, climate, and batter geometry).

1.4 Landform design database

An outcome of the erodibility studies has been the generation of erodibility parameters for a wide range of Rio Tinto's mineral wastes. These erodibility parameters have been used to parameterise the WEPP runoff/erosion model with material-specific parameters. The WEPP model has in turn been used to generate a database of erosionally stable landform batter geometries (combinations of lift height, gradient and profile shape) for Rio Tinto's key mineral wastes. This database is also called the Batter Selector Tool, or BST. Rio Tinto use these batter geometries to develop 3D landform designs that will satisfy long-term erosional stability requirements.

The key mineral wastes were identified by assessment of Rio Tinto's waste drilling records for active mining operations across the Pilbara. Erodibility parameters for these key waste types were then gathered using simulated rainfall and overland flow testing techniques. Site-specific climate sequences were developed using site data and data from nearby Bureau of Meteorology climate stations. WEPP was run using the site-specific climate sequence and material erodibility parameters to develop the database of erosionally stable batter geometries. This process is described in more detail below.

2. WEPP erosion modelling

2.1 The WEPP runoff and erosion model

The WEPP model was used to simulate annual runoff and erosion. It was developed by the United States Department of Agriculture (USDA) and can predict runoff, erosion, and deposition for hillslopes. WEPP has a daily input time step, although sub-daily storm parameters are used to describe the intensity and duration of daily storm events, enabling more accurate estimation of runoff and erosion potential than is generally achievable with daily time step models. When rainfall occurs, soil characteristics are considered to determine the likelihood of runoff. If runoff is predicted to occur, WEPP computes sediment detachment, transport, and deposition along the inputted slope geometry. In this way, WEPP is able to give average erosion over an entire slope length, and erosion rates at any point along the slope (peak erosion rates are calculated using this information).

The model's erosion component uses a steady-state sediment continuity equation as the basis for the erosion computations. Soil detachment in interrill areas is calculated as a function of the effective rainfall intensity and runoff rate. Soil detachment in rills is predicted to occur if the runoff hydraulic shear stress is greater than the critical shear stress at which rilling is initiated, and when the sediment load of the runoff is below its capacity to transport sediment. Deposition in rills is computed when the sediment load of the runoff is greater than the capacity of the runoff to transport it.

Climate data

All WEPP simulations use a 100-year stochastic climate sequence derived from data observed at Rio Tinto's sites and from nearby Bureau of Meteorology climate stations. A total of 9 climate sequences were created to represent 15 mine sites:

- Brockman 4, Brockman 2, and Nammuldi;
- Tom Price and Western Turner Syncline;
- West Angelas;
- Channar, Eastern Range, and Paraburdoo;
- Marandoo;
- Hope Downs 1/2;
- Hope Downs 4;
- Mesa J and Mesa A; and
- Yandicoogina.

Each of the 9 climate sequences contain 36,525 daily climate data sets that describe rainfall, storm duration and intensity, temperature, solar radiation, and wind. The sequences contain a wide range of rainfall events, including several extreme events. Each climate sequence was assessed against the Bureau of Meteorology's Design Rainfall Data System[10] to consider the Annual Exceedance Probability (AEP) and Average Recurrence Interval (ARI) of the larger rainfall events within the sequence. The findings for the Hope Downs 1/2 climate sequence are given in Table 1. The rarest event within the West Angelas climate sequence has an AEP of 0.2%, equivalent to a storm with an ARI of 500 years. This storm is defined within the Australian Rainfall and Runoff Guideline (AR&R) as 'very rare'. For West Angelas, the second rarest rainfall event also has an AEP of 0.2% (500 year ARI) and the third rarest event has an AEP of 1% (100 year ARI). These are also defined as 'very rare' and 'rare' events, respectively.

The West Angelas climate sequence is consistent with long-term averages and includes multiple very rare and rare rainfall events. Therefore, the resultant erosion modelling is also consistent with long-term averages, including the erosion that would occur from multiple very rare events.

Table 1: The Annual Exceedance Probability (AEP) and Average Recurrence Interval (ARI) values of the three rarest rainfall events within the West Angelas climate sequence.

Rainfall Event Details					
Rarest		2nd Rarest		3rd Rarest	
Total & Duration	AEP (%) & ARI (years	Total & Duration	AEP (%) & ARI (years	Total & Duration	AEP (%) & ARI (years
145mm 5 hours	0.2% 500 years	140mm 4 hours	0.2% 500 years	147mm 11 hours	1% 100 years

[10] http://www.bom.gov.au/water/designRainfalls/revised-ifd/

Validation of WEPP modelling

WEPP model validation data are provided to demonstrate that the model is able to adequately predict erosion in a mining context. WEPP has been extensively validated by Landloch for mine site batters (Figure 2).

The data presented were sourced from 27 locations on 12 waste landforms on mine sites in Western Australia. Several sites were located at Rio Tinto's Pilbara iron ore sites. The observed erosion data were collected using 30-50 m wide cross-slope erosion transects located on upper and lower sections of waste dump batters. Batter geometries include both linear and concave cross-sectional profiles. Gradients assessed are consistent with the slopes commonly used for mining landforms (12-20°). Surfaces assessed include loamy soils, clay soils, and rocky soils. The ages of the batters range from 3-8 years. Slope conditions range from minimally eroded to heavily eroded.

The observed cumulative erosion rates show good agreement with rates predicted by WEPP. Given that these data include predictions from both the upper and lower sections of landform batters, WEPP is shown to be able to suitably predict changes in erosion rates with changing slope lengths and gradients. The model can adequately represent both runoff accumulation down the slope and flow concentration across the slope. The accuracy of the predictions shown in Figure 2 also indicates that the methods used to derive the model parameters produce accurate model results. This gives confidence that accurate calibration of the WEPP model can be achieved, provided suitable testing methods are used.

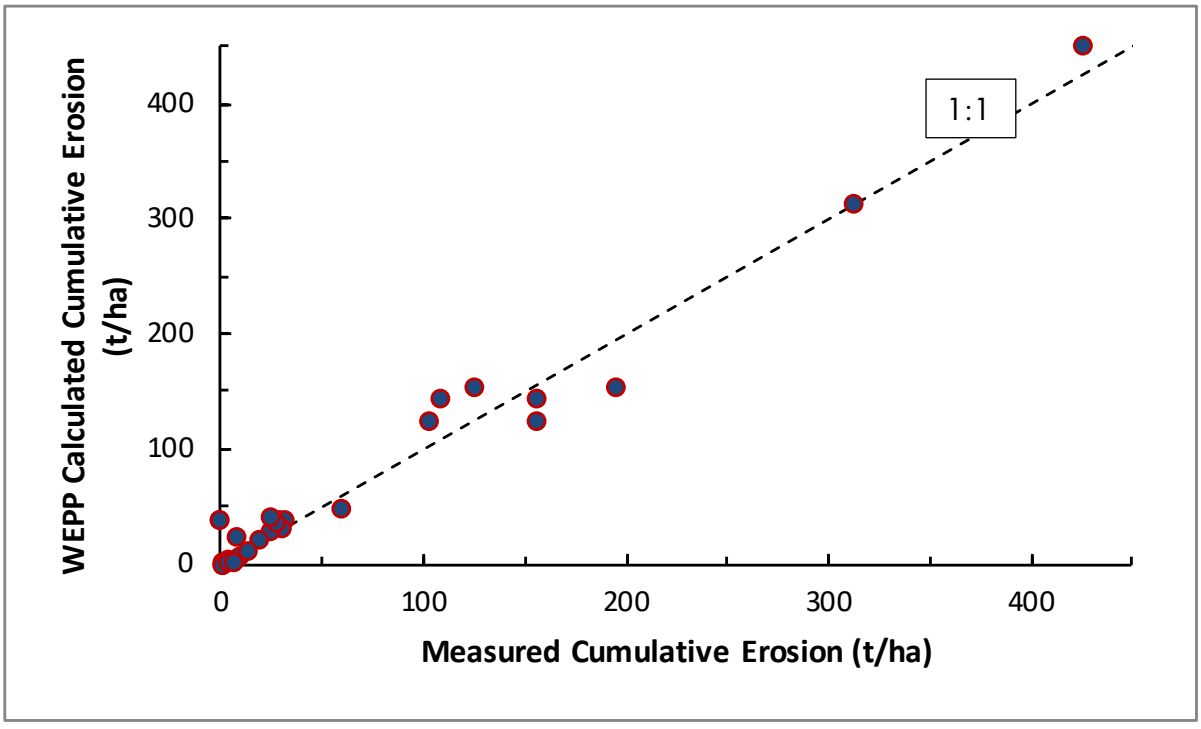

Figure 2: WEPP-predicted cumulative erosion and observed cumulative erosion for 27 locations from Western Australian mine sites.

Establishing acceptable long-term erosion rates

The suitability of the batter geometries found within the Rio Tinto Iron Ore Batter Selector Tool is determined by comparison of the modelled long-term average erosion rates with rates that have been demonstrated to be acceptable. Historically, the acceptable long-term erosion rate has been set based on a desire to limit the initiation of rill erosion. A value of 5t/ha/y was used. More recently, a review of acceptable erosion rate values for the Pilbara region[11] considered acceptability using six different concepts:

- Rates of soil renewal (soil formation and deposition by dust);
- Maintenance of surface soil/growth media quality;
- Rates of naturally occurring erosion in the Pilbara;
- Rates that increase the potential for gully development;
- Water quality and off site impacts; and
- Impacts on vegetation.

The review found that the acceptable rates of long-term erosion were similar regardless of the concept considered. A value of 6t/ha/y for long term average slope erosion was found to be consistent with rates of soil renewal and naturally occurring erosion, and consistent with a surface with a low tendency for rill and gully erosion. Given that the erosionally stable batter geometries adopted by Rio Tinto prior to the more recent review are modelled to erode at rates less than 5t/ha/y, it is concluded by Landloch that the slopes currently within the Batter Selector Tool are suitable, provided surface water control from the dump top and berms, and around the landform are also suitably managed.

2.2 Landform evolution modelling

Other erosion models exist that can be usefully deployed as part of the landform design process at different phases of mining operations. WEPP is used to define erosionally stable two-dimensional landform batter designs. Landform evolution models (LEMs) can be used to consider landforms in three dimensions.

SIBERIA is the most widely adopted LEM for use in mining, particularly in Australia. It is a model tailored to the consideration of the impacts of the 3D shape on the long-term stability of a landform. SIBERIA modifies the 3D shape of a landform in response to erosion and deposition. It is different to a surface water model in that it does not predict or route runoff over the surface. Rather it uses relationships between surface hydrology (contributing areas and discharge rates) and erosion to predict changes in 3D landform shape.

Within the context of mining landforms, SIBERIA has been used to consider the:

- likelihood of the development of rill or gully erosion over time;
- breaching of surface layers designed to encapsulate underlying problematic wastes;
- erosion risk at the interface between a waste dump and adjacent undisturbed land; and
- erosional impact of placement of different materials over the land surface.

[11] Howard, E.J. and Loch, R.J. (2019) *Acceptable erosion rates for mine waste landform rehabilitation modelling in the Pilbara, Western Australia*, in AB Fourie & M Tibbett (eds), Proceedings of the 13th International Conference on Mine Closure, Australian Centre for Geomechanics, Perth, pp. 1545-1560.

SIBERIA is more complex to parametrise than WEPP. It requires parameterisation with time series data of runoff and erosion for a specific combination of material and landform shape. Because it is fitted to time series data for runoff and erosion (not rainfall), SIBERIA cannot easily be used to predict erosion for a single rainfall event. For example, it is not able to be used to predict land changes in response to a single extreme event. The most appropriate use of SIBERIA is to assess long-term changes in landform shape (over decades or hundreds of years).

Given that final 3D landform shapes are not exactly known during the early phases of mining (i.e. feasibility or approvals stage), the usefulness of SIBERIA in these early stages is limited. Two dimensional batter erosion models such as WEPP provide sufficient information in order for the broad shape of a rehabilitation landform to be defined. For example, the erosionally stable slope lengths, heights, and gradients, the batter profile shape (linear, concave etc.), and the required capacity of cross-slope berms and crest bunding, can all be derived from WEPP modelling without the need for SIBERIA modelling. If the broad shape of the landform batter is set based on stable batter geometries defined by WEPP, the resultant 3D landform is likely stable, provided it is coupled with an investigation of surface water flows to account for risks such as flood flows (which SIBERIA is not equipped to do) and intentional flow concentrations (as can occur in more complex 3D shapes).

SIBERIA modelling becomes increasingly useful closer to the point of rehabilitation when more detailed designs are available and where it can address risks associated with how the landform ultimately meshes into the surrounding landscape.

3. Material abundance

Table 2 provides a summary of the percentage of each waste geozone for West Angelas. The proportions for West Angelas are those provided by Rio Tinto (pers. comm. B. Wingfield, 10 August 2020). Detritals, Hydrated Zone, Wittenoom Dolomite (West Angelas Shale), and Mt Newman Member are dominant wastes at West Angelas. They account for 93% of the waste at West Angelas.

Table 2: Waste material summary for West Angelas

Waste	Waste Mass (Mt)	Waste proportion (%)*
Detritals	955.3	49
Hydrated Zone	322.5	16
Wittenoom Dolomite (West Angelas Shale)	288.7	15
Mt Newman Member	247.8	13
MacLeod Member	75.3	4
Other	76.8	3

* The proportion of waste present in individual dumps will vary, but aggregated data is provided for the site to show the broad material types present.

Erodibility studies have been carried out on 90 waste samples from Rio Tinto's Pilbara iron ore mines. Of these 90 samples, 8 were sourced specifically from West Angelas, namely:

- West Angelas Shale (2 samples),
- Mt Newman Member (2 samples),
- Hydrated Zone (1 sample),

- Detritals/Alluvials (2 samples), and
- Topsoil (1 sample).

These samples cover the main wastes from West Angelas and account for 93% of the waste at West Angelas. A total of 13 samples from West Angelas have also been tested for plant growth parameters. They include:

- Mt Newman Member (9 samples),
- Hydrated Zone (1 sample), and
- Detritals/Alluvials (3 samples).

Plant growth materials for similar materials are available for other Pilbara sites:

- Brockman 2/Nammuldi (3 Detritals samples);
- Brockman 4 (1 Detritals, 1 Hydrated Zone, 1 West Angelas Shale sample);
- Gudai-Darri (1 Detritals samples);
- Hope Downs 1/2 (6 Detritals, 3 Mt Newman, 1 Hydrated Zone, 1 West Angelas Shale samples);
- Hope Downs 4 (1 Detritals, 1 West Angelas Shale samples);
- Marandoo (6 Detritals, 2 Mt Newman, 2 West Angelas Shale samples);
- Paraburdoo (3 Detritals, 6 Hydrated Zone samples);
- Tom Price (4 West Angelas material, 1 Detritals, 1 West Angelas Shale , 1 Hydrated Zone samples); and
- Western Turner Syncline (3 Detritals, 1 Hydrated Zone samples).

Data for these materials will be used to discuss plant growth and erosion potential below.

4. Material testing methods

4.1 Plant growth potential

Samples of the fine component (<2mm) of some of these materials were analysed for soil $pH_{1:5}$ (water), $EC_{1:5}$ as a measure of salinity, Exchangeable Sodium Percentage (ESP), and particle size distribution (coarse sand, fine sand, silt, and clay). These properties were used to define risks to vegetation growth inherent in the wastes (e.g. salinity and poor structure). The coarse components (>16mm) were also assessed for properties that indicate their likely durability, tendency to weather, and usefulness as an armour material. Properties assessed include coarse fraction content, rock particle density, and rock water absorption.

4.2 Material erodibility

Assessment of long-term erosion potential for each of the materials was assessed using the WEPP model. WEPP describes erodibility using a number of specific parameters:

- Interrill Erodibility (K_i);
- Rill Erodibility (K_R);
- Critical Shear for Rill Initiation (τ_c); and
- Effective Hydraulic Conductivity (K_e).

These erodibility parameters were derived from data collected using application of:

- Simulated rain to test surfaces and measurement of runoff and sediment in runoff to obtain estimates of K_i and K_e; and
- Simulated overland water flows and measurement of runoff, sediment, and rill characteristics, to obtain estimates of K_R and τ_c.

Simulated rainfall and overland flows

Rainfall and overland flow simulations have been widely used to define the erodibility of mine wastes. The process is briefly described below.

For rainfall simulation, flat fan nozzles mounted on an oscillating manifold positioned ~2m above a test surface produce the simulated rain (Figure 3). The kinetic energy generated by the nozzles is consistent with the energy of natural rainfall at intensities >40mm/hr. The nozzles sweep back and forth across the test surfaces, achieving high spatial distribution uniformity (<10% coefficient of variation). For each material tested, triplicate plots (0.75m square) are subjected to a rainfall event sufficiently intense to ensure runoff occurs (usually 80-100mm/hr). This allows measurement of K_i and K_e.

For overland flow simulations, rill erodibility parameters are derived by applying overland flows at various rates to flumes 0.4m wide and 2.0m long set at gradients ranging from 10-30% (Figure 4). K_R and τ_c are derived based on relationships between flow shear stress and sediment detachment rates measured from these flumes.

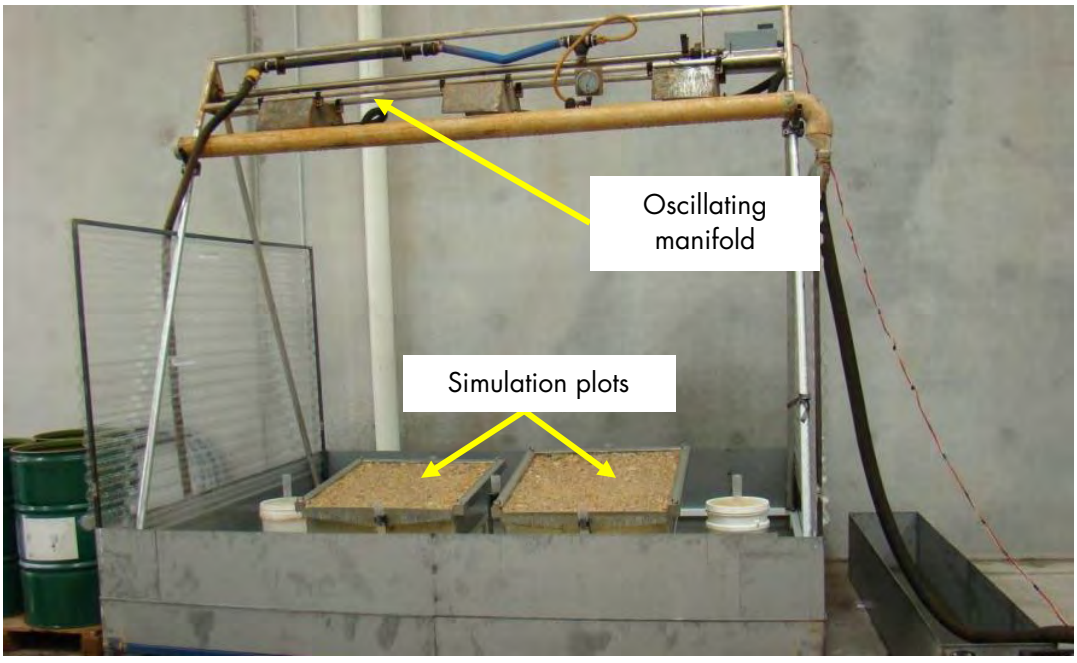

Figure 3: Typical laboratory-based rainfall simulator installation.

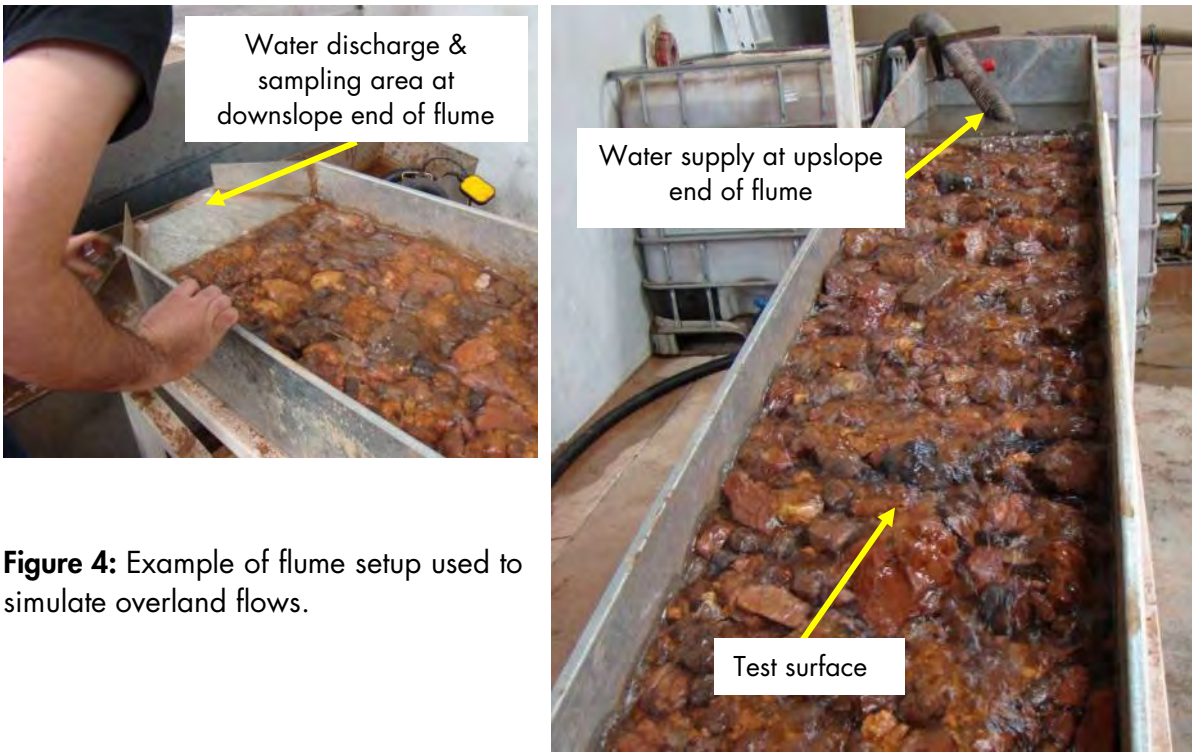

Figure 4: Example of flume setup used to simulate overland flows.

5. Materials of West Angelas

5.1 Plant growth potential

Plant growth data for materials from West Angelas and other sites with similar materials are given in Tables 3 and 4. The materials have the following properties:

- Commonly low salinity, though the West Angelas Shale can be saline. For all materials from West Angelas, $EC_{1:5}$ values are unlikely to adversely affect plant germination or growth.
- Slightly acidic to alkaline pH values, thought the West Angelas Shale can be more acidic than other waste types.
- High coarse fraction content (mean 66%). The West Angelas material, coarse fraction content ranges from 59-82%, with an average of 71%.
- The rock fraction of the samples tested (Table 5) tends to be dense (high rock particle density) and the water absorption rates are low to moderate. The materials are likely to be reasonable for use as armouring, particularly materials that contain BIF.
- The fine fraction (< 2 mm diameter) of the samples tested tends to have a loamy sand to clay loam texture.

Wastes generally have elevated (>6%) Exchangeable Sodium Percentage (ESP). Elevated ESP can indicate a clay fraction with a tendency to disperse and become prone to structural decline. However, these materials would still have a low tendency for structural decline because the clay fraction makes up a very small proportion (typically less than 7%) of the entire material mass, with the majority comprised of non-dispersive sands, gravels, pebbles, and rock.

Table 3: Characteristics of the soil fraction (<2mm) of West Angelas materials, and similar materials from other sites.

Geology	Particle Size Distribution (Fine Fraction)				Soil Texture	$pH_{1:5}$ (Water)	$EC_{1:5}$	ESP
	Coarse Sand	Fine Sand	Silt	Clay				
	%	%	%	%		pH Units	dS/m	%
West Angelas								
Detritals	47	34	9	10	LS	7.5	0.32	-
	48	36	7	10	LS	7.0	0.62	-
	59	36	5	1	S	6.6	0.28	20
Mt Newman	35	29	14	22	L	8.5	0.12	-
	30	32	17	21	L	7.5	0.10	-
	38	31	12	19	L	7.5	0.10	-
	31	24	18	28	CL	7.5	0.16	-
	61	22	3	14	SL	7.5	0.18	-
	63	27	3	7	LS	7.3	0.13	-
	54	32	3	12	SL	7.5	0.40	-
	56	31	10	3	LS	7.2	0.06	17
	41	44	9	6	LS	6.5	0.03	11
Hydrated Zone	58	33	5	5	LS	6.4	0.07	8
West Angelas Shale	28	33	8	32	CL	5.6	0.05	7
Brockman 2/ Nammuldi								
Detritals	39	32	9	20	L	6.0	0.07	-
	41	35	9	15	SL	8.0	0.12	-
Brockman 4								
Detritals	49	26	6	20	SL	7.8	0.23	-
Hydrated Zone	54	28	9	9	LS	7.5	0.16	6
West Angelas Shale	36	16	11	37	C	8.0	2.65	7
Gudai-Darri								
Detritals	52	33	6	9	LS	7.5	0.08	-
Hope Downs 1/2								
Detritals	40	33	7	21	SL	7.0	0.06	-
	30	20	12	38	C	8.0	0.29	-
	59	24	0	16	SL	7.4	1.06	9
	61	7	8	24	CL	6.1	0.07	5
	56	19	10	15	L	7.6	0.07	2
Mt Newman	50	31	10	9	LS	6.7	0.03	20
	42	31	16	11	LS	7.4	0.07	7
	58	22	11	10	LS	7.6	0.06	5
Hydrated Zone	55	25	5	15	SL	8.0	-	-
West Angelas Shale	27	23	16	35	CL	7.7	0.19	5
Hope Downs 4								
Detritals	6	63	6	25	CL	7.4	0.02	5
West Angelas Shale	21	38	40	1	ZL	7.1	0.06	10
Marandoo								
Detritals	52	29	6	13	SL	8.3	0.40	6.27
	58	26	3	13	SL	8.1	0.11	4.26
	60	23	3	14	SL	8.5	0.36	7.82
	24	-	28	48	ZC	6.6	0.07	<0.1

Geology	Particle Size Distribution (Fine Fraction)				Soil Texture	$pH_{1:5}$ (Water)	$EC_{1:5}$	ESP
	Coarse Sand	Fine Sand	Silt	Clay				
	%	%	%	%		pH Units	dS/m	%
	19	-	24	57	C	8.2	0.18	<0.1
Hydrated Zone	52	27	8	13	SL	7.7	0.16	1.34
	45	32	13	10	LS	8.2	0.02	1.53
West Angelas Shale	34	27	18	21	L	8.2	0.07	2.17
Paraburdoo								
Detritals	49	32	7	13	SL	7.9	0.02	7
	59	27	7	7	L	8.0	0.05	16
	70	18	6	6	LC	8.0	0.04	16
Hydrated Zone	45	23	3	29	SCL	5.6	0.10	31
	59	19	10	13	SL	7.6	1.04	13
	39	33	18	10	LS	6.6	0.12	22
	50	29	6	16	SL	6.6	0.18	7
	42	29	11	18	L	6.6	0.10	14
Tom Price								
Detritals	65	23	6	6	LS	6.5	0.03	-
Hydrated Zone	59	27	1	12	SL	8.1	0.55	6
West Angelas Shale	33	-	52	16	ZL	6.7	6.46	8
	33	-	35	32	ZCL	4.7	4.18	26
	54	-	20	27	CL	4.9	3.15	25
	65	-	22	13	L	5.5	0.05	<0.1
	48	30	9	14	SL	7.1	0.4	4
Western Turner Syncline								
Detritals	34	38	10	19	L	8.0	0.08	-
	59	29	7	6	LS	8.5	0.06	-
	47	25	1	27	SCL	6.1	0.20	9
Hydrated Zone	59	25	1	15	SL	6.9	0.29	26

Notes: Coarse sand: 2.0-0.2mm; Fine sand: 0.2-0.02mm; Silt: 0.02-0.002mm; Clay <0.002mm. Texture: SL: Sandy Loam; LS: Loamy Sand; CL: Clay Loam; L: Loam; C: Clay; ZCL: Silty Clay Loam. '-' indicates that no data are available for this parameters. Those samples with no baseline data shown here are included for completeness as they are present in the erodibility testing results.

Table 4: Characteristics of the coarse fraction (>2mm) of West Angelas materials, and similar materials from other sites.

Geology	Full Particle Size Distribution				Coarse Fraction Content	Rock Particle Density	Rock Water Absorption
	Rock	Pebble	Gravel	Fines			
	%	%	%	%	%	g/cm³	%
West Angelas							
Detritals	0	3	72	25	75	-	-
	1	6	65	28	73	-	-
	4	49	28	18	82	3.3	5.7
Mt Newman	3	38	18	41	59	2.9	10.3
	12	45	10	33	67	3.1	5.3
	2	14	50	34	66	-	-
	4	16	41	39	61	-	-
	2	13	67	18	82	-	-
	3	13	47	37	63	-	-
	4	15	54	27	73	-	-
	2	12	65	22	78	-	-
	5	15	55	26	74	-	-
Hydrated Zone	13	43	16	27	73	3.2	3
West Angelas Shale	21	12	39	28	72	-	-
Brockman 2/ Nammuldi							
Detritals	0	0	43	57	43	-	-
	0	36	38	26	74	-	-
	2	47	17	34	66	-	-
Brockman 4							
Detritals	1	13	59	27	73	-	-
Hydrated Zone	2	0	26	72	28	3.4	3.3
West Angelas Shale	2	4	55	39	61	3.1	5.3
Gudai-Darri							
Detritals	0	5	56	39	61	-	-
Hope Downs 1/2							
Detritals	4	6	55	34	66	-	-
	5	5	33	57	43	-	-
	7	6	42	45	55	2.9	5.3
	29	15	35	21	79	-	-
	12	32	32	24	76	3.2	1.4
	20	25	25	31	69	2.3	12.5
Mt Newman	20	18	44	18	82	3.4	1.6
	24	30	30	15	85	3.0	3.5
	14	31	31	25	75	3.4	1.1
Hydrated Zone	60	22	17	1	99	4.6	3.5
West Angelas Shale	7	6	37	50	50	3.1	4.9
Hope Downs 4							
Detritals	2	2	49	47	53	2.6	8.1
West Angelas Shale	-	-	-	-	-	3.1	1.5
Marandoo							
Detritals	6	45	17	32	68	3.5	4.8
	17	34	16	33	67	2.4	11.4

Geology	Full Particle Size Distribution				Coarse Fraction Content	Rock Particle Density	Rock Water Absorption
	Rock	Pebble	Gravel	Fines			
	%	%	%	%	%	g/cm³	%
	7	46	18	29	71	2.9	10.5
	8	11	56	26	74	-	-
Hydrated Zone	16	41	14	29	71	3.1	11.4
	31	39	8	22	78	3.2	3.1
West Angelas Shale	19	46	14	21	79	3.8	4.2
	0	8	12	80	20	-	-
Paraburdoo							
Detritals	8	18	56	18	82	2.7	4.3
Hydrated Zone	7	22	57	14	86	3.4	4.6
	-	-	-	52	48	-	-
	28	37	11	24	76	-	-
	28	36	11	24	76	2.9	3.5
	14	50	12	24	77	3.1	6.1
	0	58	14	28	72	3.3	2.4
Tom Price							
Detritals	11	13	52	24	76	-	-
Hydrated Zone	20	14	42	24	76	2.5	10.5
West Angelas Shale	-	-	-	49	51	-	-
	-	-	-	66	34	-	-
	-	-	-	50	50	-	-
	-	-	-	37	63	-	-
	0	1	48	52	48	1.9	17.4
Western Turner Syncline							
Detritals	6	6	52	35	65	-	-
	0	5	54	41	59	-	-
	0	4	72	24	76	-	-
Hydrated Zone	0	0	72	28	72	-	-

Notes: Rock: >45mm; Pebble: 15-45mm; Gravel: 2-15mm; Fines: <2mm.

5.2 Erodibility

Table 5 shows the site specific erodibility parameters for West Angelas compared to the aggregated parameters adopted for erosion modelling and from which Rio Tinto has developed rehabilitation batter geometries. The impact of this variation in erodibility parameters was assessed by conducting additional modelling with the WEPP model. The results of the erosion modelling are given in Table 6.

Predicted erosion for the Detritals using the aggregated parameters indicates that a stable geometry would be a uniform gradient of 20 degrees and height of 7m. The Detritals from West Angelas are predicted to erode at lower rates than those predicted using the aggregated parameter set, and stable heights for the West Angelas Detritals are ~10m. Based on these results, it can be concluded that the West Angelas detritals are more erosion resistant that the aggregated Detrital from which landform batter geometries have been developed.

Table 5: Site specific erodibility parameters and those generally adopted for erosion modelling.

Material	K_e (mm/h)	K_i (kg.s/m^4)	K_R (s/m)	τ_c (Pa)
Detritals				
Aggregated Value	26	236,317	0.0116	28
West Angelas Sample	9	353,752	0.0119	44
Newman Member				
Aggregated Value	33	203,540	0.0033	28
West Angelas Samples (2 samples)	7	420,311	0.0027	48
Wittenoom Formation (West Angelas Shale)				
Aggregated Value	Not Currently Included in Batter Selector Tool			
West Angelas Samples (3 samples)	25	558,515	0.0028	18
Hydrated Zone				
Aggregated Value	103	63,860	0.0030	28
West Angelas Sample	34	276,491	0.0022	42

Testing of two samples of the Newman Member materials from West Angelas has shown that this material has similar erosion potential to that predicted using the aggregated values. As such, a stable height of 20m and gradient of 20 degrees is suitable for this material.

For West Angelas Shale, these materials are highly erodible. This material poses a risk in terms of erosion and will require specific management (i.e. burial) if slope heights greater than 5m are adopted at West Angelas.

The Hydrated Zone waste from West Angelas is less permeable than the aggregated Hydrated parameters, but less prone to detachment. A stable height of 20m and gradient of 20 degrees is suitable for this material.

The slope gradients for uniform batters within the Batter Selector Tool range from 14-20°. This range was selected as being the maximum gradient (20°) at which machinery could safely operate on a slope, and the lowest gradient (14°) that is typically considered for rehabilitation by Rio Tinto. Results for the 20° gradient slope have been shown in order to demonstrate whether use of the site specific erodibility data yield significantly different results to those of the aggregated erodibility data used in the Batter Selector Tool. It should not be construed as a recommendation that a 20° slope is preferred to a lower gradient slope. Slopes lower than 14° could also be considered if required.

Table 6: Erosionally stable batter heights for the West Angelas materials within the BST and calculated using site specific erodibility data.

Material	Erosionally Stable Batter Geometries in the BST	Erosionally Stable Batter Geometries using Site Samples
Detritals	7m, 20°	10m, 20°
Newman Member	20m, 20°	20m, 20°
Wittenoom Formation (West Angelas Shale)	Not currently in BST	5m, 20°
Hydrated Zone	20m, 20°	20m, 20°

6. Closing

Erosion modelling has used data collected from 90 samples of key wastes across Rio Tinto's Pilbara operations. These samples have been subjected to testing to measure their erodibility, with these erodibility parameters used to model long-term erosion using the WEPP model. The climate sequences used in the modelling contain a wide range of rainfall events including several extreme and rare events.

The model results have been compared against erosion rate values consistent with measured erosion for undisturbed land in the Pilbara, soil renewal rates, and rates at which the risk of rill and gully erosion is low. The model output has been validated at 27 locations on mine sites in Western Australia and shown to agree with observed erosion.

An assessment of the samples specific to West Angelas (and for other sites with similar waste types) show that the batter geometries generated using the aggregated erodibility parameters will be suitable for use at West Angelas, with the exception of West Angelas Shale. This waste was shown to be erodible, and will require specific management (i.e. burial) if batter heights greater than 5m are adopted at West Angelas.

Continued sampling and erodibility testing of materials is required as mining continues at West Angelas in order to continue to build Rio Tinto's knowledge of wastes on site. Further, when coupled with erosion monitoring of waste dumps that includes a measure of an erosion rate, the erodibility data should be used to undertake periodic verification of the rehabilitation profiles includes within the Batter Selector Tool.

Regards

Mr EVAN HOWARD
PRINCIPAL CONSULTANT

Disclaimer

All care and diligence have been exercised in testing, interpreting data and the development of recommendations presented in this document. The monitoring and testing have been undertaken in a skilled, professional manner, according to accepted practices. Specific circumstances and research findings after the date of publication may influence the accuracy of the data and recommendations within this document.

The landscape is not uniform. Because of this non-uniformity, no monitoring, testing or sampling technique can produce completely precise results for any site. Any conclusions based on the monitoring and/or testing presented in this document can therefore only serve as a 'best' indication of the environmental condition of the site at the time of preparing this document. It should be noted that site conditions can change with time.

The information that comprises this document should only be used within the limitations stipulated herein. Landloch does not accept any risks and responsibilities for losses, damages, costs and other consequences resulting from using any information, material and recommendations in this document.

Appendix 6: SCARD Management Plan

Iron Ore (WA)

Spontaneous Combustion and ARD (SCARD) Management Plan

for Operations

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1 Purpose

The Spontaneous Combustion and Acid Rock Drainage (SCARD) Management Plan for operations outline the activities and groups accountable for the management of the environmental, safety, health, reputational and business risks associated with:

- Black shale
- Sulfidic material within detritals
- Sulfidic material within Banded Iron Formation (BIF)
- Elevated-sulfur material within shale, waste and ore.

Due to differing risks, the management of sulfides within black shale has been delineated from that associated with sulfides within detritals and BIF, and material containing sulfates.

This plan enables the development and implementation of appropriate risk reduction measures to lower risk. It sets and implements the appropriate monitoring plans that quantify the actual impacts and compares them with that predicted, to determine if risk reduction methods have been effective.

2 Definitions

2.1 Abbreviations

ABA	Acid Base Accounting
AMD	Acid and Metalliferous Drainage
ANC	Acid Neutralising Potential
ARD	Acid Rock Drainage
BIF	Banded Iron Formation
BS	Black Shale
DG	Dales Gorge Member
FWZ	Footwall Zone
MCS	Mount McRae Shale
NAF	Non-Acid Forming
PAF	Potentially Acid Forming (including black shale and sulfides in BIF and detritals)
SWP	Safe Work Practice
WS	Whaleback Shale Member

2.2 Hazards Definitions

The risks associated with black shale, BIF and detritals are triggered by the presence of sulfides, in particular pyrite (FeS_2) within these material types. Pyrite will remain stable if constantly water-saturated with no exposure to oxygen or ferric iron. Alunite ($KAl_3(SO_4)_2(OH)_6$) and jarosite ($KFe_3(SO_4)_2(OH)_6$) have been identified in AWT waste and ore. When excavated during mining, pyrite can oxidise and sulfate minerals dissolve and generate the following risks to the operation:

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ARD (also known as Acid and Metalliferous Drainage (AMD))

The process of pyrite oxidation results in the release of dissolved acidity, sulfate, iron and other metal ions into drainage waters. The acidic conditions can often induce weathering of clay minerals in the host material and also release dissolved metals such as aluminium, manganese, zinc and/or copper into the drainage. The Acid Neutralising Capacity (ANC) of many of the other waste materials in the Hamersley Group is low and insufficient to neutralise the acidity released from most pyritic waste rocks.

Alunite weathers to an aluminium oxyhydroxide phase (e.g. gibbsite or boehmite, etc.) via dissolution; it can produce acid and buffer the pH in the region of 4.0 to 4.5. The rate of acid release is low and the acidity can be neutralised by any minerals that have the capacity to consume acid.

Risk Areas: Contamination of surface and/or ground water and soil, and potential disturbance to surrounding ecosystems from ARD generated within waste rock dumps and pits or voids. Potential health risks from direct handling or accidental consumption of ARD products.

Premature Blast Detonation

Spontaneous combustion is a major safety concern to RTIO (WA) due to the risk of reaction with explosives in loaded blast holes potentially leading to premature detonation. Ammonium nitrate (NH_4NO_3) based explosives, commonly known as ANFO, are typically used however due to the risk of spontaneous combustion, explosives based on inhibited emulsion blended with ANFO are used if spontaneous combustion may occur.

Risk areas: Potential safety risk from the premature and unexpected detonation of explosives.

Spontaneous Combustion within Dumps

In waste dumps where self-heating occurs, heat may be transferred from hot to cold regions of the dump through the evaporation of moisture (water vapour) in hot areas and subsequent condensation in colder areas. This heat transfer is in addition to the transport of heat by natural convection. Water vapour transport is an important heat transfer mechanism within waste dumps and therefore it is not recommended that water is added to a hot spot. The added water may shift the heat from one region to another. This may be the reason that self-heating is observed in black shale after increases in humidity and rain. If the rate of energy generated by oxidation is greater than the rate at which energy can be dissipated to the environment via conduction, convection and evaporation then the dump will self-heat.

Risk areas: Gas venting from waste dumps, geotechnical instability and increased rates of ARD generation due to the elevated temperatures and oxygen exposures.

Gas Exposures

The major gases produced from the spontaneous combustion of the black shale (and possibly lignite in detritals) are likely to be sulfur dioxide (SO_2), carbon dioxide (CO_2), hydrogen sulfide (H_2S), carbon monoxide (CO) and methane (CH_4). In the open air, the rate of reaction is slow and the heat of reaction is quickly dissipated to the environment. Within waste dumps, the heat cannot dissipate as readily and there can be localised hot spots that promote SO_2 generation. The SO_2 generated can then vent from the waste, potentially causing problems with the establishment of vegetation.

Risk areas: Human exposure to toxic gases and safety risks.

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Dust Exposure

Black shale can be fine and powdery with elevated concentrations of alumina and silica.

Risk areas: Human exposure to dust and safety risks.

2.3 Waste Definition

Waste containing sulfur can have the potential to generate ARD and some materials can also spontaneous combust. The potential for wastes to generate ARD or spontaneously combust is defined at Rio Tinto Iron Ore (WA) operations as:

ARD/AMD potential: The propensity for a material to generate ARD/AMD is determined using a series of tests referred to as Acid Base Accounting (ABA). Without site-specific ABA data, a total sulfur concentration of 0.1% is used as the approximate boundary between non-acid forming and potentially acid forming material. Marra Mamba Iron Formation BIF and detritals are the only material that can use a 0.3% sulfur cut-off value and this is due to the presence of some acid neutralising materials.

Spontaneous Combustion potential: The spontaneous combustion mechanisms of pyritic black shale are poorly understood. However, it is likely to be associated with the following properties of the shale: high surface area, high porosity, small particle size distribution, moisture content, carbon content and sulfur content. All black shale and lignite material is deemed by RTIO (WA) to pose a spontaneous combustion risk (although significant tonnages of lignite are yet to be mined so spontaneously combust has not been observed).

Depending on the potential for ARD generation and/or spontaneous combustion (risk), waste should be classified into one of three categories and it should be dumped in accordance with the specifications for that category (Appendix 1).

Inert waste: Material is currently classified as inert by RTIO (WA) if it does not contain sulfur or carbonaceous material (i.e., S < 0.3% for BIF and detritals located below the water table (BWT); S < 0.1% for elevated-sulfur material located above the water table (AWT); and not including any black shale or lignites). Black shale within the Whaleback Shale Member may be classified as inert waste when it represents a small fraction of a mine block and the average sulfur content of the block is < 0.1%.

Cold black shale/sulfidic BIF/sulfidic siderite: This material is not likely to spontaneously combust within the dump and is managed only to control the ARD risk. Typical material within this category includes:

- Cold black shale (MCS): Represents black shale with low sulfur concentrations. Due to possible variability within the unit, this material requires special management. Whilst the sulfur content is low (i.e., < 0.1%), there is still the potential for metalliferous drainage as a result of oxidation of the organic carbon material within the black shale.
- Dales Gorge Member (DG) black shale: Represents black shale with sulfur concentrations up to 2% and containing some acid neutralising capacity (e.g.,15 kgH_2SO_4/t). Samples are mostly non-acid forming but may be potentially acid forming with low capacity.
- Sulfides within BIF and detritals (siderite): The sulfur concentration in these materials is generally in the range of 0.1% to 0.3% but can reach 15%. The risk of spontaneous combustion in the dump is considered low due to the lack of organic carbon associated with this material.
- Whaleback Shale Member (WS) black shale: If the average sulfur content is > 0.1% or black shale accounts for the majority of the block material, then this material should be placed in a cold black shale dump as there is very low potential for acid generation.

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Hot black shale/Lignite: This material may spontaneously combust in the dump and is managed to control combustion within the dump. Typical material within this category is:

- Hot black shale (MCS): Black shale which generally has significantly higher sulfur concentrations and high organic carbon concentrations typically > 2%.
- Sulfides in lignite: The risk of spontaneous combustion of sulfidic lignite material is currently unknown. Until proven otherwise, sulfidic lignites should be managed to minimise the risk of spontaneous combustion.

Elevated sulfur: The sulfate minerals alunite and jarosite can be found AWT, predominantly in the Dales Gorge Member, Whaleback Shale Member and oxidised MCS. These are found particularly in close proximity to those units containing sulfide minerals, and/or a source of potassium such as dolerite dykes. When alunite or jarosite occur in significant quantities (termed elevated-sulfur material) it will need to be specially managed due to its propensity to release acid and associated metals. Without site specific test work for sulfates, a total sulfur concentration of 0.1% is used as the approximate boundary between non-acid and potentially acid forming material due to the low solubility of these minerals and presence of some acid neutralising materials.

3 Assessing if a Site needs to implement this Management Plan

The RTIO (WA) Mineral Waste Management Plan describes the ARD, spontaneous combustion and mineral waste characterisation work that must be undertaken during Resource Evaluation, Studies and Mine Operations. A detailed ARD Risk Assessment should be undertaken for any new deposits or significant expansions of current operations to identify whether excavated sulfides will represent a risk to health, safety and environment (including the impacts on-site, off-site and to the receiving environment). If risks are deemed to be minimal then a management plan will not be required. If a risk assessment has already been undertaken at a site then for any additional significant resource drilling or expansions of the operation the risk assessment should be updated. For any mine site that exposes or could potentially expose sulfidic or elevated-sulfur material, then this SCARD Management Plan will need to be implemented.

The accountability for the identification and subsequent management of spontaneous combustion and ARD risks associated with black shale and sulfidic BIF and detritals are listed in Section 4 and Section 5. It provides an overview of management at RTIO (WA) operations from initial characterisation and modelling, through project development, mine planning, production and closure. The RTIO (WA) SCARD management strategy is broadly based upon the following principles:

1) Identification of PAF material distribution and character;
2) Minimising the exposure and mining of PAF material to the extent possible;
3) Identification and special handling of PAF material that must be mined;
4) Encapsulation of PAF material inside inert waste rock dumps to limit water contact and allow the dumps to be revegetated, or placement of PAF material below the water table in backfilled open pits to limit oxygen contact; and
5) Monitoring impacts and taking corrective actions (when necessary).

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4 Requirements, Accountabilities and References for Black Shale

Black shale management during mining operations is conducted in accordance with Figure 1 and Figure 2. The mining protocols are designed to:

1) Minimise the risk of unplanned detonations in charged blast holes;
2) Ensure that hot and cold black shale truck loads are transported and placed in designated black shale dumps according to design requirements;
3) Ensure that the location and geometry of all black shale repositories is recorded;
4) Minimise environmental impacts of AMD products; and
5) Refine geological block models and block-out procedures.

Requirements	
4.1	**Mine Planning and Closure**
4.1.1	Mine plans must include estimates for hot and cold BS production and compare to inert waste production to ensure that sufficient material will be available for dump construction.
4.1.2	Ensure that BS dumps are sited to minimise long term environmental impacts and financial liabilities. Obtain signoff from Environment, Hydrogeology and Hydrology.
4.1.3	Ensure that final pit and dump designs are consistent with Appendix 1, Appendix 3, Appendix 4 and the RTIO Landform Design Guidelines. Waste dump designs must be coupled with a rehabilitation design showing how the dump is proposed to be rehabilitated upon closure. The rehabilitation design should be provided to the Rehabilitation team for review. Obtain signoff from Environment, Hydrogeology and Hydrology.
4.1.4	During the mine planning process identify areas that are available for rehabilitation and inform the rehabilitation and closure team.
4.2	**Mine Technical Services - Planning**
4.2.1	Ensure that Medium Term plans predict hot and cold BS production from each pit and delivery to each dump. Ensure that sufficient inert waste will be produced for encapsulation in accordance with the specifications in Appendix 1 and that sequencing will allow dump construction to occur as required.
4.2.2	Major changes to waste dump designs must be reflected in changes to the associated rehabilitation design. Receive sign-off from Environment, Rehabilitation Team, Hydrogeology and Hydrology before major modifications to BS dump designs are implemented.
4.2.3	Plan and design works for final waste rock dump surfaces and inactive open pits in a manner consistent with Appendix 4, Appendix 7 and the RTIO Landform Design Guidelines. Waste dump designs must be coupled with a rehabilitation design showing how the dump is proposed to be rehabilitated for closure. The design should be provided to the Rehabilitation Team for review. Obtain sign-off from Environment, Hydrogeology and Hydrology.
4.2.4	During the mine planning process identify areas that are available for rehabilitation and inform the rehabilitation and closure team.
4.2.5	When planning open pits that will intersect BS, the possibility of dewatering discharge/groundwater becoming acidic must be considered so that appropriate mitigation infrastructure can be installed.
4.2.6	Black shale exposed on the waste rock dumps must be minimised during the wet season (November to April).

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Requirements

4.3 Mine Geology

Blasting

4.3.1 Identify BS in blast hole cones and demarcate using agreed methods.

4.3.2 Alert key personnel in Mine Technical Services Planning and Pit Operations of the location of BS blast holes via e-mail.

Dumping

4.3.3 Based on visual inspection, total S values and stratigraphy, designate holes as cold BS, hot BS or inert waste. Create Block-outs that show contacts between waste types within blast patterns.

4.3.4 Perform periodic reconciliations between the Block-outs and the geological block model.

4.3.5 Collect (as required) representative samples of hot and cold black shale for full ABA and NAG analysis.

4.3.6 Regularly review the boundary between cold BS and hot BS to ensure it is still valid and has not changed as mining progresses deeper. Advise the relevant teams of the results and undertake change management if necessary.

4.4 Survey

4.4.1 Maintain as-built dump designs that include a 3D plan showing approximate locations and volumes of BS.

4.4.2 Ensure that monthly face pick-up surveys are conducted on all active BS waste dumps.

4.5 Operational Planning

4.5.1 Create a “Waste Dump Progression Plan” at least every three months to implement the detailed dump designs in the field.

4.5.2 Create “PLOD” sheets to aid dig operators in waste assignment and check that CAES is working.

4.5.3 Monitor and adjust to reconcile rehabilitation plans with original designs as appropriate.

4.5.4 Perform field inspections to ensure that BS is transported to the proper dump locations and placed as required. Register non-conformances in SAP.

4.5.5 Ensure reports contain hot and cold BS volumes delivered to every dump.

4.5.6 In consultation with Mine Geology perform regular reconciliations between Block-outs, survey and ORDW data for hot and cold BS volumes.

4.5.7 Black shale exposures on the waste rock dumps must be minimised during the wet season.

4.6 Drill, Blast and Development

4.6.1 Ensure all safety procedures related to BS management are followed during the charging and firing of blast holes i.e., temperature logging, timing.

4.6.2 Maintain site specific Drill and Blast SWPs and ensure it is consistent with this management plan and other SWPs and guidance notes.

4.6.3 Submit samples for isothermal reactivity testing for compatibility with ANFO explosives.

4.7 Load and Haul

4.7.1 Ensure that BS is properly identified and placed in the correct dump location consistent with PLOD sheets, CAES mining assignments and the Waste Dump Progression Plan from Operations Planning.

4.7.2 Perform field inspections to ensure that BS is transported to the proper dump locations and placed as required. Register non-conformances in SAP.

4.7.3 Ensure that “Exclusions” in CAES are reviewed and corrected in the field as required.

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Requirements	
4.7.4	The time between blasting and hauling of BS should be minimised and generally should occur within three weeks or less during the wet season (November to April) and within 12 weeks during the dry season (May to October). This will limit the amount of time the material has to oxidise in an uncontrolled manner.
4.7.5	Whenever possible the outer inert waste rock "skin" of a BS lift should be constructed first. This will ensure that BS lifts are not extended beyond the design footprint of the BS dump, will limit convective oxygen transport through the uncompacted sides of the dump lift, and will help contain contaminated contact water on the dump.
4.7.6	Hot BS lifts should be covered as rapidly as possible with the overlying inert waste rock layer, particularly during the wet season. Ideally, hot BS should be covered within two weeks of placement in the waste rock dump. If rapid covering is not possible the paddock-dumped hot BS piles should at least be dozed into a planar surface as soon as possible. This will help minimise infiltration and oxygen transport into the material.
4.7.7	The locations, volumes and sulfur concentrations (if available) of all BS repositories should be recorded so that a three dimensional plan of BS distribution within each dump is maintained by the survey group.

4.8 Hydrogeology/Technical Services

4.8.1	Maintain and implement a site specific "Acid Water Management Plan" and SWPs to deal with poor quality water that has contacted BS exposures or waste dumps. This should include information regarding bunding requirements, water quality monitoring (including the action response and relevant corrective actions including treatment) and disposal or use.
4.8.2	Ensure that water management and storage practices do not cause offsite surface water impacts or groundwater quality degradation in down gradient aquifers.
4.8.3	Provide technical overview and support during planning for above-ground and in-pit BS waste disposal.
4.8.4	Ensure that routine sampling, visual inspection, and analysis is performed for in-pit locations, including: • groundwater monitoring wells (surrounding BS dumps and pits; • dewatering water; and • surface water bodies (including temporary or permanent pit lakes within inactive open pits that contain BS exposures). This should be consistent with the master monitoring schedule for the site.

4.9 WRE Mineral Waste Management Team

4.9.1	Provide site support for the management of mineral waste, as necessary. Facilitate the transfer of knowledge between RTIO sites and studies.
4.9.2	Undertake or update AMD Risk Assessments for significant changes to the pit shell or geochemical risks. Advise the site leadership and environment group for significant changes to risk.
4.9.3	Ensure the SCARD management plan is updated at least every 2 years. More frequent updates may be required for significant changes to risk or the knowledge base.
4.9.4	For pits that intersect the water table, ensure the following information is available which would contribute to a conceptual understanding: • Catchment size; • Depth to pre-mining water table; • Current and ultimate pit depth; • Available water storage within the entire ultimate pit and above the pre-mining water table in the pit; • Predicted runoff volume for a 100 year storm event; • Distance to closest down-gradient permanent surface water body; and • Down-gradient water use. Determine the geochemical risk of the pit. Update this report for any significant changes.

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Requirements

4.9.5 Geochemical, hydrogeology and hydrology modelling to determine contaminant release from the pit should be undertaken if the report (in Item 4.9.4) finds a significant geochemical risk (i.e., a significant amount of PAF material exposed on the pit wall, a significant amount of dewatering occurring over many years, a likely saline and flow through water body, etc.).

4.9.6 For PAF material waste dumps, compile a 'Conceptual Model' report for each site. This report should contain the following information for each waste dump on the site:

- Footprint;
- Up-gradient catchment area;
- Likely material types in the waste dump i.e., oxidised MCS, DG1 BIF;
- Quantify the PAF tonnes and the total tonnes of material within each waste dump;
- Dumping methodology;
- Underlying and down-gradient geology;
- Distance to the closest regionally significant aquifer;
- Distance to closest down-gradient permanent surface water body;
- Down-gradient water use; and
- Closure/rehabilitation plans for the dump (or reference to the appropriate document).

4.9.7 Geochemical modelling to determine long-term contaminant release from the waste dump should be undertaken if the 'Conceptual Model' finds a significant geochemical risk (i.e., a significant amount of PAF material within the waste dump or significant receptors nearby).

4.10 Environment

4.10.1 Perform field inspections to ensure BS management, dump construction, rehabilitation and store and release cover performance is consistent with the requirements of the SCARD Management Plan.

4.10.2 Undertake relevant ecological assessment (appropriate for the scale of the SCARD generation and predicted level of pollution/ecological impacts), develop and implementation appropriate risk reduction measures and monitoring programmes.

4.10.3 Ensure that routine sampling, visual inspection, and analysis is performed for out of pit locations that could potentially be impacted by AMD. This may include

- groundwater monitoring wells surrounding BS dumps and pits (if they can be accessed outside the pit)
- surface water bodies (including abandoned pit lakes, permanent or seasonal natural water bodies, dewatering discharge to creeks).

This should be consistent with the master monitoring schedule for the site.

4.10.4 Record the environment risks related to BS in a site risk register and annually review/verify/validate these risks; verify that the ministerial conditions, legal and other requirements and obligations are met.

4.11 Rehabilitation and Closure

4.11.1 In consultation with relevant stakeholders identify monitoring requirements (e.g. lysimeters) for BS waste dumps following rehabilitation.

4.11.2 Coordinate the review and approval of the BS waste dump design by relevant stakeholders, including the Mineral Waste Management Team to ensure compliance with this document.

4.11.3 Assess the risks that need to be managed as part of the rehabilitation process for BS dump designs, focussing on the SCARD risks and ensure that all key stakeholders are consulted.

4.12 Health and Safety

4.12.1 Monitor the occupational gas and dust exposures surrounding BS. Ensure data is captured in a user friendly database. Ensure problems are brought to the attention of the site Mineral Waste Management Team.

4.12.2 Train occupational exposure groups on the correct use of respiratory equipment and monitors. Competency should be assessed and recorded in SAP.

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Requirements

4.12.3 Ensure the site specific guidance notes on acceptable gas levels, monitoring and demarcation are periodically refined and updated so it is consistent with current best practice.

4.12.4 Record health and safety risks associated with BS in a site risk register and annually review these risks.

4.13 Site Mineral Waste Management Team

4.13.1 A site based Mineral Waste Management Team should be formed and meet on a regular basis (e.g., monthly). It should include representatives of every department that has accountabilities related to SCARD management.

4.13.2 The primary function of the Site Mineral Waste Management Team is to ensure on-going improvement and implementation of the SCARD Management Plan.

4.13.3 Agenda items and meeting minutes should be produced for every meeting.

4.13.4 An overview of issues relating to BS must be included in any introductory training provided to new employees and contractors. The level of training should be commensurate to the level of risk BS poses to the site.

4.13.5 Develop emergency and contingency plans related to spontaneous combustion, ARD and BS management on an as need basis.

4.13.6 Coordinate a technical review of BS management by an external expert every four years. Track progress against outstanding actions at each meeting.

4.13.7 Coordinate all research related to BS characterisation, BS management, spontaneous combustion and ARD.

4.13.8 Ensure that SCARD related SWPs and guidance notes represent current practise and are up to date.

4.13.9 Changes to the SCARD management plan need to be provided to the Water Resource Evaluation Mineral Waste team to be included in future updates.

4.14 Management

4.14.1 Ensure progress is made against outstanding spontaneous combustion and AMD audit actions.

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Figure 1: Black shale (BS) management overview.

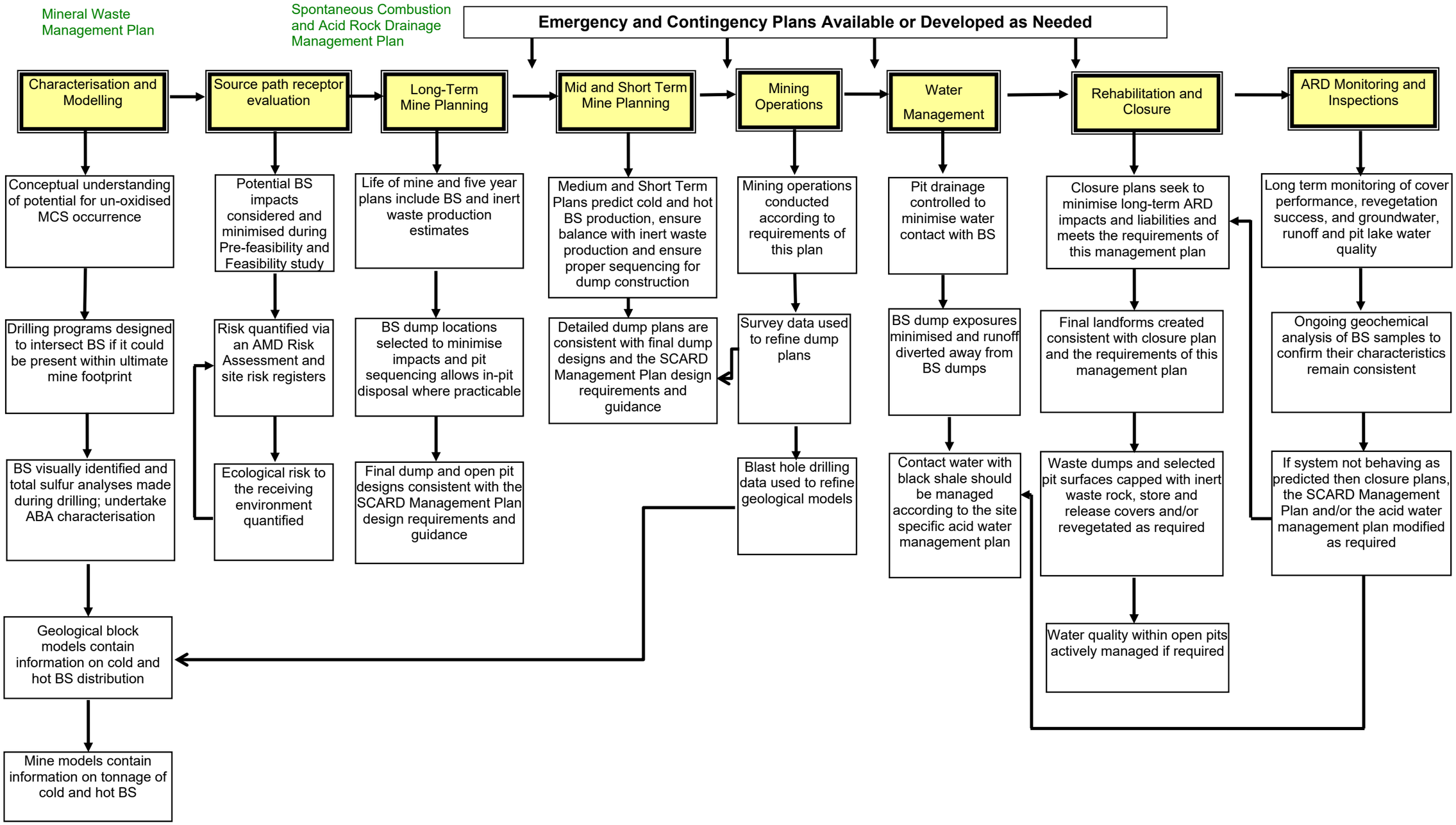

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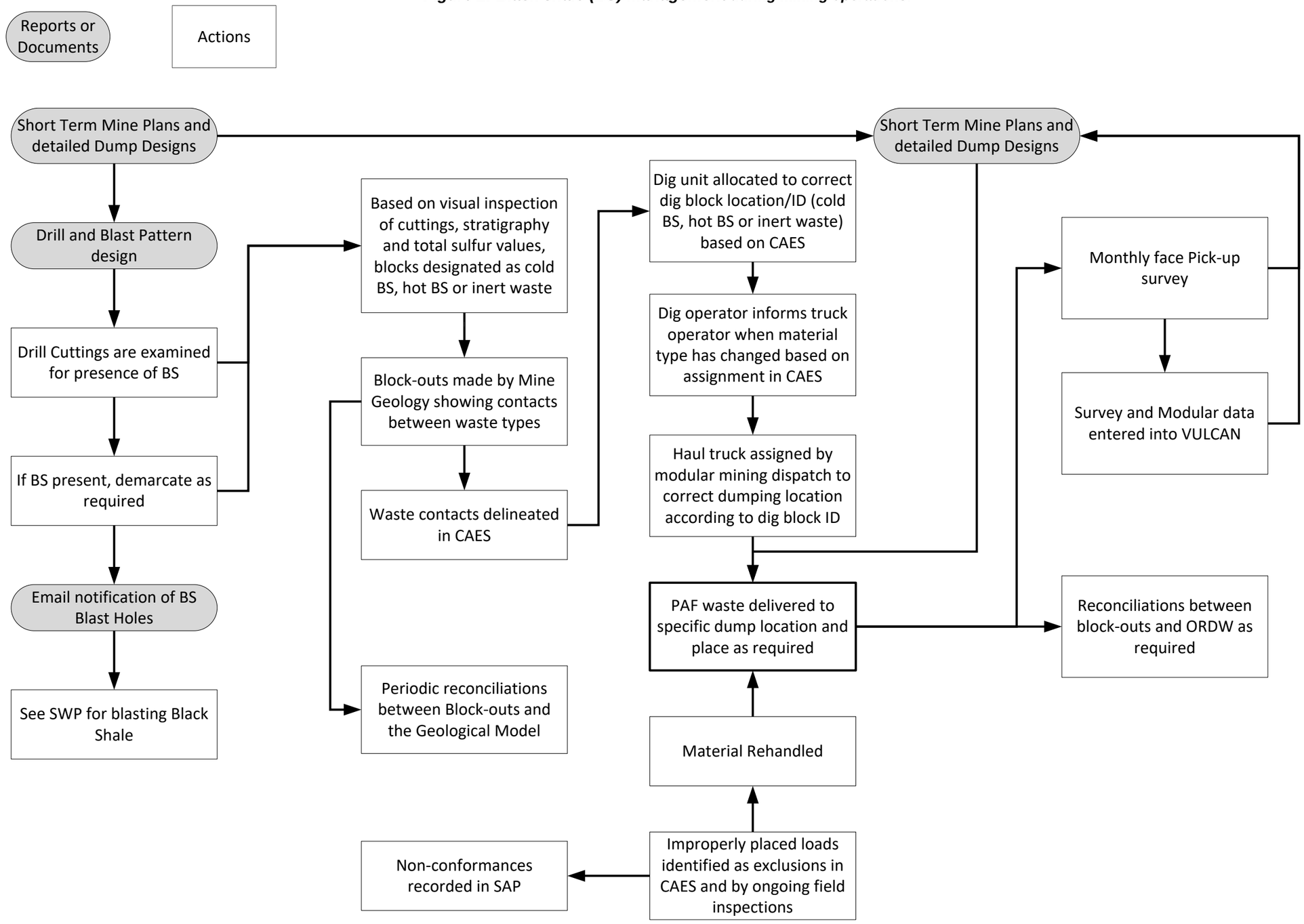
Figure 2: Black shale (BS) management during mining operations.



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5 Requirements, Accountabilities and References for Sulfides within BIF and Detritals

Management of sulfidic BIF and detritals during mining operations is conducted in accordance with Figure 3 and Figure 4. The mining protocols are designed to:

1) Minimise the risk of unplanned detonations in charged blast holes;
2) Ensure that sulfidic BIF and detrital truck loads are transported and placed in PAF dumps according to design requirements;
3) Ensure that the location and geometry of all PAF repositories is recorded;
4) Minimise environmental impacts of ARD products; and
5) Refine geological block models and block-out procedures.

Requirements	
5.1	**Mine Planning and Closure**
5.1.1	Mine Plans must include estimates for production of PAF, neutralising and inert waste material.
5.1.2	Ensure that PAF dumps are sited to minimise long-term environmental impacts and financial liabilities. Obtain signoff from Environment, Hydrogeology and Hydrology.
5.1.3	Ensure that final pit and dump designs are consistent with Appendix 4, Appendix 5, Appendix 6, Appendix 7 and the RTIO Landform Design Guidelines. Waste dump designs must be coupled with a rehabilitation design showing how the dump is proposed to be rehabilitated upon closure. The rehabilitation design should be provided to the Rehabilitation Team for review. Obtain signoff from Environment and Hydrogeology and Hydrology.
5.1.4	During the mine planning process identify areas that are available for rehabilitation and inform the rehabilitation specialist.
5.2	**Mine Technical Services - Planning**
5.2.1	Ensure that Medium term plans predict PAF material and net neutralising material production from each pit and delivery to each dump. Ensure that sufficient inert and net neutralising waste will be produced for encapsulation in accordance to the specifications in Appendix 1 and that sequencing will allow dump construction to occur as required. The tonnes of material with neutralising potential should be quantified and used with PAF dump designs in accordance with Appendix 2.
5.2.2	Major changes to waste dump designs must be reflected in changes to the associated rehabilitation design. Receive sign-off from Environment, Rehabilitation Team, Hydrogeology and Hydrology before major modifications to BS dump designs are implemented.
5.2.3	When planning open pits that will intersect sulfidic material, the possibility of dewatering discharge/groundwater becoming acidic must be considered so that appropriate mitigation infrastructure can be installed.
5.2.4	Lignite exposed on the waste rock dumps must be minimised during the wet season (November to April).
5.3	**Geology**
5.3.1	Identify lignite in blast hole cones and demarcate using agreed method.
5.3.2	Alert key personnel in Mine Technical Services and Pit Operations of the location of lignite blast holes via e-mail.
5.3.3	If the geological block model indicates that sulfur grades may be > 0.3%, then samples from drill hole cuttings should be collected for total sulfur concentration analysis.

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Requirements

5.3.4 Review total S results and demarcate holes that contain > 0.3% S (for drill and blast identification).

5.3.5 Based on visual inspections, total S values and stratigraphy, designate holes as PAF, net neutralising or inert waste. Create Block-outs that show contacts between waste, net neutralising material and the PAF material within blast pattern.

Material blocked out for the PAF dump include:

- BIF: S > 0.3%
- Detrital Siderite: S > 0.3%
- Detrital Lignite: All (to manage neutral mine drainage risks in additional to PAF risks)

5.3.6 Perform periodic reconciliations between the Block-outs and the geological block model.

5.3.7 Collect (as required) representative samples of sulfidic material associated with BIF and detritals for full ABA and NAG analysis. Ensure results are communicated to the relevant teams.

5.4 Survey

5.4.1 Maintain as-built dump designs in Vulcan that include a 3D plan showing approximate locations and volumes of sulfidic material.

5.4.2 Ensure that monthly face pick-up surveys are conducted on all active sulfidic material waste dumps.

5.5 Operational Planning

5.5.1 Create a “Waste Dump Progression Plan” at least every three months to implement the detailed dump designs in the field.

5.5.2 Create “PLOD” sheets to aid dig operators in waste assignment and check modular mining system is working.

5.5.3 Monitor and adjust to reconcile rehabilitation plans with original designs as appropriate.

5.5.4 Ensure that operational reports contain sulfidic material volumes delivered to every dump. Confirm that sulfidic material has been transported to the correct dump and register non-conformances in SAP.

5.5.5 In consultation with Mine Geology perform six-monthly reconciliations between Block-outs, survey and operational data for sulfidic material volumes.

5.5.6 Sulfidic material exposures on the waste rock dumps must be minimised during the wet season. Lignites should be covered rapidly during the wet season to reduce the spontaneous combustion risk (i.e. 1 month)

5.5.7 The location, volume and sulfur concentration (if available) of all PAF (sulfidic material) repositories should be recorded so that a three dimensional plan of the distribution within each dump is maintained.

5.6 Drill and Blast

5.6.1 Ensure all safety procedures related to pyritic material and in particular lignite are followed during the charging and firing of blast holes.

5.6.2 Annually submit samples for isothermal reactivity testing for compatibility with ANFO explosives.

5.7 Load and Haul

5.7.1 Ensure that sulfidic material is properly identified and placed in the correct dump location consistent with PLOD sheets, CAES mining assignments and the Waste Dump Progression Plan from Operations Planning.

5.7.2 Ensure that “Exclusions” in CAES Mining are reviewed and corrected in the field as required.

5.7.3 The outer inert waste rock “skin” of a sulfidic material lift should be constructed first. This will ensure that sulfidic material lifts are not extended beyond the design footprint of the sulfidic material dump, will limit convective oxygen transport through the uncompacted sides of the dump lift, and will help contain contaminated contact water on the dump.

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Requirements	
5.7.4	Lignite material should be covered rapidly (i.e. 1 month) with net neutralising material during the wet season to reduce the risk of spontaneous combustion.

5.8 Hydrogeology/Technical Services

5.8.1 Maintain and implement the site specific "Acid Water Management Plan" and SWPs to deal with poor quality water that has contacted sulfidic material exposures or waste dumps. This should include information regarding bunding requirements, water quality monitoring (including the action response and relevant corrective actions including treatment) and disposal or use.

5.8.2 Ensure that water management and storage practices do not cause offsite surface water impacts or groundwater quality degradation in down gradient aquifers.

5.8.3 Provide technical overview and support during planning for above-ground and in-pit sulfidic material waste disposal.

5.8.4 Ensure that routine sampling, visual inspection, and analysis is performed for in-pit locations, including:

- groundwater monitoring wells (surrounding BS dumps and pits;
- dewatering water; and
- surface water bodies (including temporary or permanent pit lakes within inactive open pits that contain BS exposures).

This should be consistent with the master monitoring schedule for the site.

5.9 WRE Mineral Waste Management Team

5.9.1 Provide site support for the management of mineral waste, as necessary. Facilitate the transfer of knowledge between RTIO sites and studies.

5.9.2 Undertake or update AMD Risk Assessments for significant changes to the pit shell or geochemical risks. Advice the site leadership and environment group for significant changes to risk.

5.9.3 Ensure the SCARD management plan is updated at least every 2 years. More frequent updates may be required for significant changes to risk or the knowledge base.

5.9.4 For pits that intersect the water table, ensure the following information is available which would contribute to a conceptual understanding:

- Catchment size;
- Depth to pre-mining water table;
- Current and ultimate pit depth;
- Available water storage within the entire ultimate pit and above the pre-mining water table in the pit;
- Predicted runoff volume for a 100 year storm event;
- Distance to closest down-gradient permanent surface water body; and
- Down-gradient water use.

Determine the geochemical risk of the pit. Update this report for any significant changes.

5.9.5 Geochemical, hydrogeology and hydrology modelling to determine contaminant release from the pit should be undertaken if the report (in Item 5.9.4) finds a significant geochemical risk (i.e. a significant amount of PAF material exposed on the pit wall, a significant amount of dewatering occurring over many years, a likely saline and flow through water body etc).

5.9.6 For PAF material waste dumps, compile a 'Conceptual Model' report for each site. This report should contain the following information for each waste dump on the site:

- Footprint;
- Up-gradient catchment area;
- Likely material types in the waste dump i.e., LIG, SID, CAL.
- Quantify the PAF tonnes and the total tonnes of material within each waste dump;
- Dumping methodology;
- Underlying and down-gradient geology;
- Distance to the closest regionally significant aquifer;
- Distance to closest down-gradient permanent surface water body;

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Requirements

- Down-gradient water use; and
- Closure/rehabilitation plans for the dump (or reference to the appropriate document).

5.9.7 Geochemical modelling to determine long term contaminant release from the waste dump should be undertaken if the 'Conceptual Model' finds a significant geochemical risk (i.e. a significant amount of PAF material within the waste dump or significant receptors nearby).

5.10 Environment

5.10.1 Perform field inspections to ensure sulfidic material management, dump construction, rehabilitation and store and release cover performance is consistent with the requirements of the SCARD Management Plan.

5.10.2 Undertake relevant ecological assessment (appropriate for the scale of the SCARD generation and predicted level of pollution/ecological impacts), develop and implementation appropriate risk reduction measures and monitoring programmes.

5.10.3 Ensure that routine sampling, visual inspection, and analysis is performed for out of pit locations that could potentially be impacted by AMD. This may include

- groundwater monitoring wells surrounding BS dumps and pits (if they can be accessed outside the pit)
- surface water bodies (including abandoned pit lakes, permanent or seasonal natural water bodies, dewatering discharge to creeks).

This should be consistent with the master monitoring schedule for the site.

5.10.4 Record sulfidic material environment risks in a site risk register and annually review/verify/validate these risks; verify that the ministerial conditions, legal and other requirements and obligations are met.

5.11 Rehabilitation and Closure

5.11.1 Ensure that the rehabilitation process is completed as outlined within the Progressive rehabilitation – process and responsibilities and Rehabilitation design and approval process documents.

5.11.2 In consultation with relevant stakeholders identify monitoring requirements (e.g. lysimeters) for waste dumps following rehabilitation.

5.11.3 Coordinate the review and approval of the design by relevant stakeholders including the mineral waste team to ensure compliance with this document.

5.11.4 Assess the risks that need to be managed as part of the rehabilitation process for BS dump designs, focussing on the SCARD risks and ensure that all key stakeholders are consulted.

5.12 Health and Safety

5.12.1 Monitor the occupational gas and dust exposures surrounding sulfidic material (and gas generation if appropriate for lignite material). Ensure problems are brought to the attention of the site Mineral Waste Management Team.

5.12.2 If spontaneous combustion is likely to occur, train occupational exposure groups on the correct use of respiratory equipment and monitors. Competency should be assessed and recorded in SAP.

5.12.3 Ensure health and safety guidance notes relating to spontaneous combustion gas generation and dust are developed, periodically refined and updated so it is consistent with the current best practice.

5.12.4 Record sulfidic material health and safety risks in a site risk register and annually review these risks.

5.13 Site Mineral Waste Management Team

5.13.1 A site based Mineral Waste Management Team should be formed and meet on a regular basis. It must include representatives of every Department that has responsibilities related to ARD management.

5.13.2 The primary function of the Mineral Waste Management Team is to ensure on-going improvement and implementation of the SCARD Management Plan.

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Requirements
5.13.3 Agenda items and meeting minutes should be produced for every meeting.
5.13.4 An overview of PAF issues must be included in any introductory training provided to new employees and contractors. Further training of those groups involved in the mining of PAF should be commensurate to the level of risk PAF material poses to the operation.
5.13.5 Develop site specific emergency and contingency plans related to spontaneous combustion, ARD and sulfidic material management on an as needs basis.
5.13.6 Coordinate a technical review of ARD management by an external expert every four years. Track progress against outstanding actions at each meeting.
5.13.7 Coordinate all research related to sulfidic material characterisation, management, spontaneous combustion and ARD.
5.13.8 Ensure that related SWPs and guidance notes represent current practise and are up to date.
5.13.9 Changes to the SCARD management plan need to be provided to the Water Resource Evaluation Mineral Waste Team to be included in future updates.
5.14 Management
5.14.1 Ensure progress is made against outstanding spontaneous combustion and AMD audit actions.

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Figure 3: Sulfidic material in BIF and detritals management during mining operations

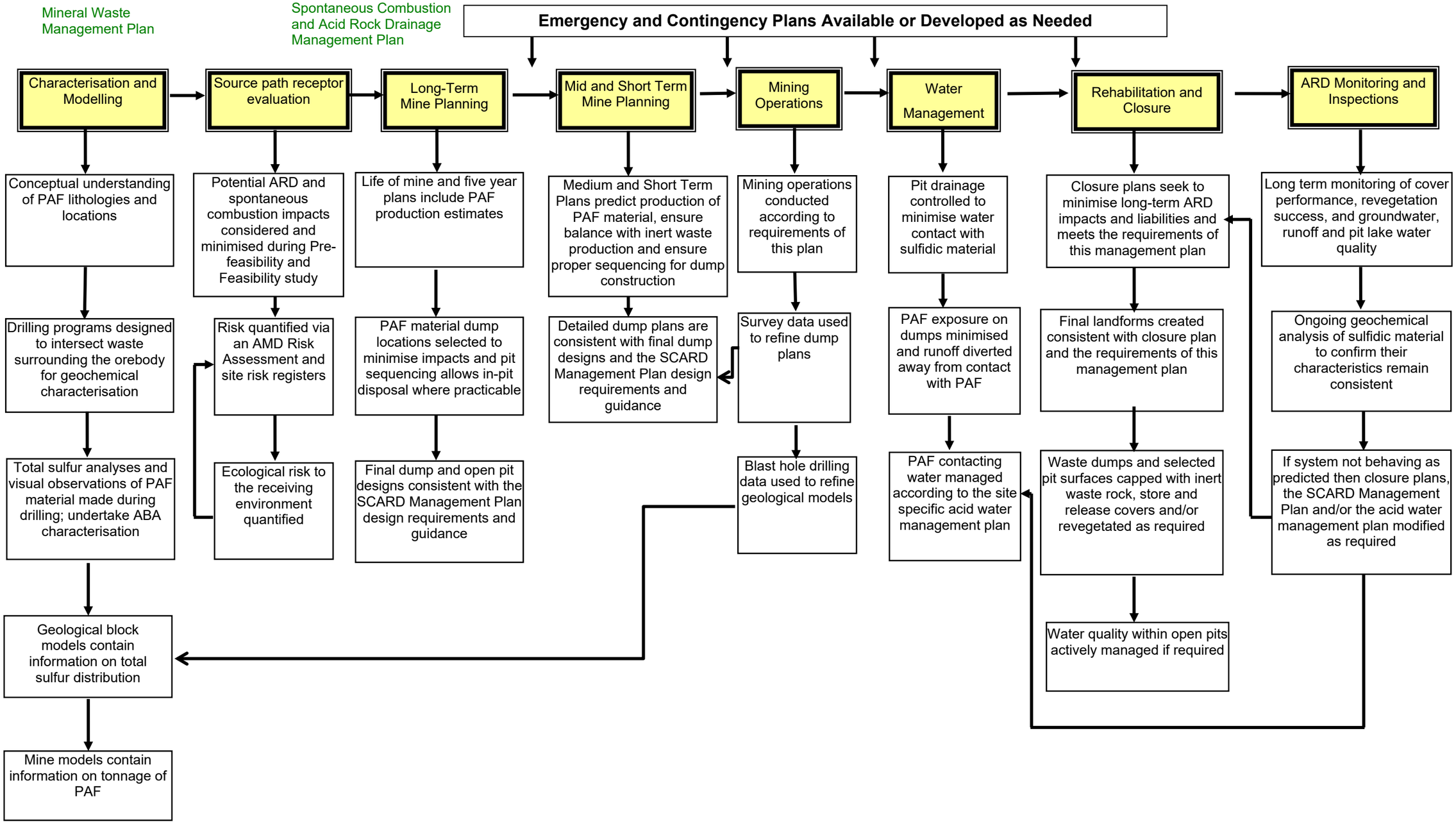

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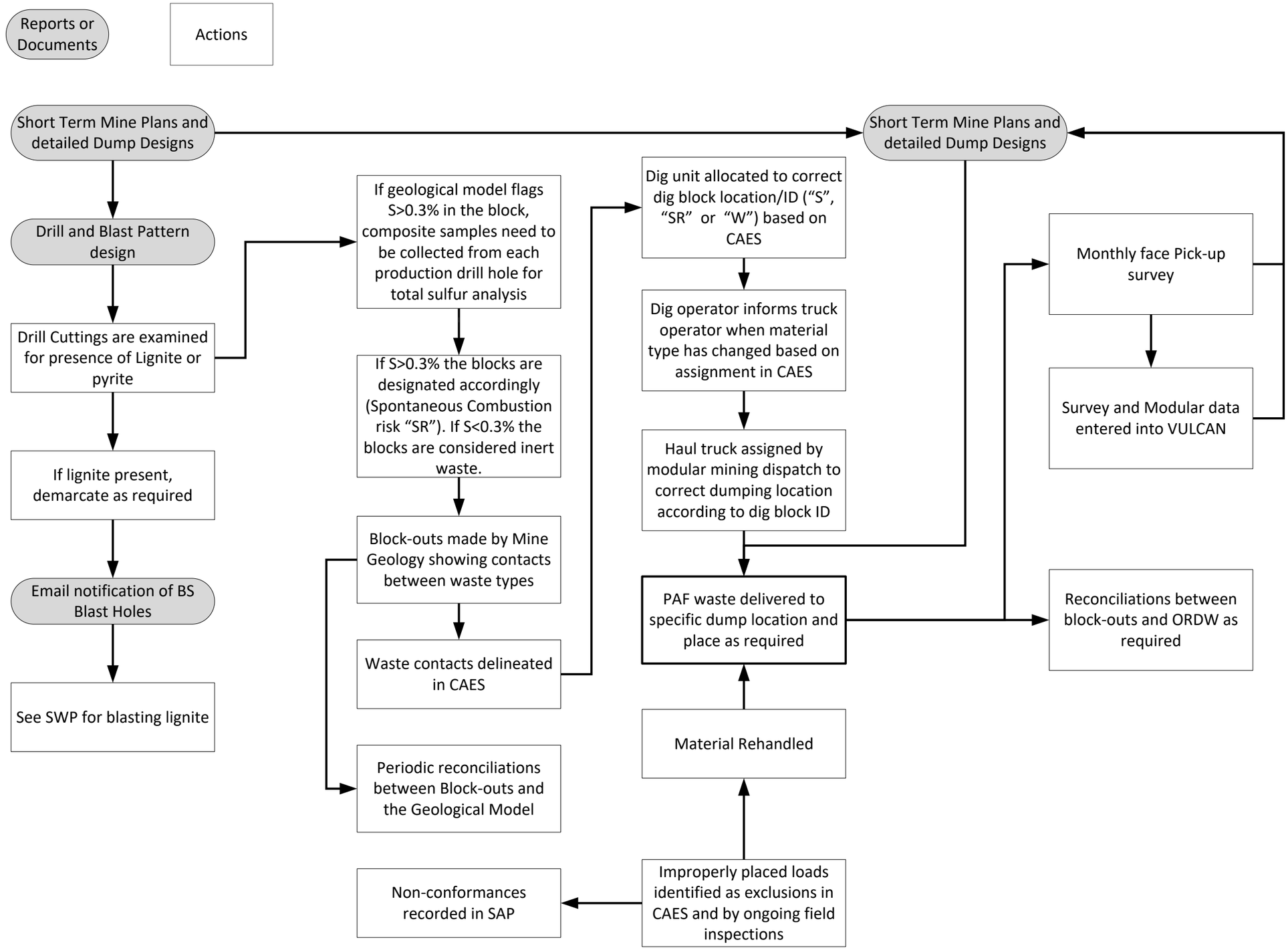
Figure 4: Sulfidic material in BIF and detritals management during mining operations



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6 Requirements, Accountabilities and References for Elevated Sulfur Material (including alunite)

It is expected that elevated sulfur presents an ARD risk but not a spontaneous combustion risk. This is based on the fact that the sulfur bearing mineral is sulfates rather than sulfides (AEISG, 2017).

Requirements	
6.1	**Mine Geology**
6.1.1	Identify from the geological model waste and low grade blocks estimated to contain elevated sulfur. Use these to create block-outs to show the contacts between elevated sulfur material and waste and low grade types within the blast patterns.
6.1.2	Collect (at least every five years) representative samples of elevated sulfur material for full ABA and NAG analysis. Ensure results are communicated to the relevant teams.
6.2	**Mine Technical Services - Planning**
6.2.1	Design elevated sulfur waste dump and low grade stockpiles such that the elevated sulfur material is not located within one metre of the outer surface at closure.
6.3	**Survey**
6.3.1	Monitor the construction of the dump such that elevated sulfur will not be located on the outer surface.
6.4	**Operational Planning**
6.4.1	Ensure material flagged as elevated sulfur is scheduled in CAES such that material is sent to the correct dump/stockpile.
6.5	**Load and Haul**
6.5.1	Ensure that elevated sulfur material is delivered to the correct location as assigned by mine geology.
6.5.2	Ensure that elevated sulfur material is dumped (where possible) from a tip head to ensure blending with inert material. If this is not achievable then paddock dumping will be satisfactory.
6.6	**Hydrogeology**
6.6.1	Ensure background water quality is established from water bores surrounding dumps and stockpiles where elevated sulfur material is stored. Undertake analysis of monitoring bores as required during dump construction and at closure.

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Appendices

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Appendix 1 Dump Specifications for Black Shale and Elevated Sulfur Material

Management of sulfates or sulfides within black shale, BIF or detritals needs to be considered during all phases of waste rock dump design, from initial selection of dump locations during the long-term planning process (five year and longer time horizon) to the detailed dump designs generated during short term planning (time horizon less than a year). The Waste Dump Design Checklist is to be filled in for all new waste dump designs to help ensure environmental issues are adequately considered.

A1.1 Selection of Dump Locations

When designing new PAF material dumps, the dump location and footprint should be selected to minimise potential long term environmental impacts and financial liabilities. Selection and design criteria that must be considered include:

- Under no circumstances should PAF material be used for works such as windrows, construction fill, ramps, fantails, roads or any other use that would disperse the material over a broad area in an uncontrolled manner.
- The PAF dump location should not receive runoff from surrounding areas. In particular waste dumps must not be sited in established drainages with significant upstream catchments.
- In pit disposal should be considered a priority instead of the construction of above ground waste rock dumps. However, hydrogeology investigations are required to evaluate water recovery levels and timeframes, and connection of the void to receptors.
- Placement of PAF material within pits that already contain PAF wall exposures is preferable to placement in pits that do not have these exposed on the pit walls.
- PAF dumps should not be placed over or adjacent to significant regional aquifers such as saturated valley fill alluvial deposits or fractured bedrock aquifers such as the Wittenoom Formation.
- PAF dumps should not be placed over ore grade or near ore grade CID or BIF-derived deposits. These not only have potential economic value, but may act as significant local aquifers.
- PAF dumps should not be placed over, adjacent to, or where there is a connection to significant seeps or springs.
- Avoid siting new PAF dumps in catchment basins that do not already contain PAF material.
- The number of sites containing PAF material and the footprint of these dumps should be kept to a minimum.
- PAF dumps should be located near sources of clean waste rock for encapsulation.
- Background groundwater quality surrounding the dump location must be measured before any material is dumped. This will require the installation of groundwater monitoring bores. These bores will be used to provide a temporal record of groundwater quality in the vicinity of the dump.

A1.2 In-Pit Disposal Requirements

In pit disposal of PAF material is generally more secure than disposal in above ground waste rock dumps. Where practicable, in pit disposal should be considered the preferred disposal alternative because it:

- Reduces the risk of erosion exposing PAF material in the long term;
- Inhibits convective oxygen transport because the waste is surrounded by relatively impermeable rock walls;

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- Reduces the footprint of the waste disposal facilities;
- Reduces the volume of inert or net neutralising waste needed to encapsulate the PAF material; and
- May help to prevent the formation of acidic or hyper-saline pit lakes if the pit can be filled to above the post-mining water table.

Note that in some pits it may be possible to place PAF material both above and below the water table with a minimum 10 metre thick inert waste layer placed against the predicted mean post-mining water table. If PAF material is placed BWT, hydrogeology investigations are required to determine the water recovery level, rate of recovery and if there are any connections to receptors.

A4.2.1 In Pit Disposal Below the Water Table

If PAF material is placed below the post-mining water table, it will become permanently flooded which will control subsequent oxidation and acid release. In the long term, placement below the water table is the most secure and low risk disposal option. It is particularly beneficial for hot black shale because it removes the long-term risk of spontaneous combustion. If a pit can be backfilled so that the fill elevation is above the pre-mining water table level, it is possible that the water table will eventually rebound to or near the pre-mining elevation. If the pit is only partially backfilled to below the pre-mining water table, it is likely that a shallow intermittent, seasonal or permanent pit lake will form on top of the fill material.

Elevated sulfur material (i.e., containing sulfate minerals such as alunite or jarosite) should not be placed below the post-mining water table as the release of acid is controlled by the dissolution of the minerals and is not a kinetic controlled reaction as is the case for sulfidic PAF materials.

For sulfidic PAF material placed below the post-mining water table the following minimum design criteria apply:

- For pits backfilled above the predicted post-mining water table, the top of the PAF material backfill must be at least 5 metres below the mean predicted post-mining water table (Figure 19).

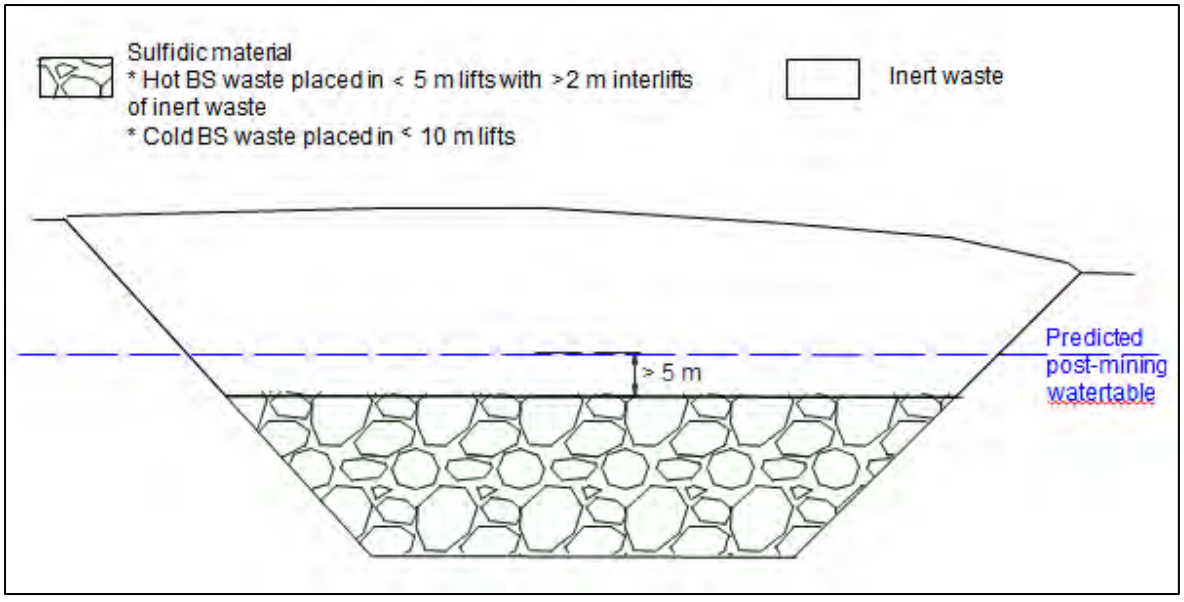

Figure 5: Example of PAF material placed BWT and with the pit completely backfilled.

- For pits that are only partially backfilled to below the pre-mining water table, the top of the PAF material backfill must be at least 5 metres below the estimated mean pre-mining water table and at least 5 metres below the predicted post-backfilling water table (Figure 20). In this situation it can generally be assumed that the mean post-mining water table will be at the top of the backfill. Thus, the PAF waste will be covered by at least 5 metres of inert waste.

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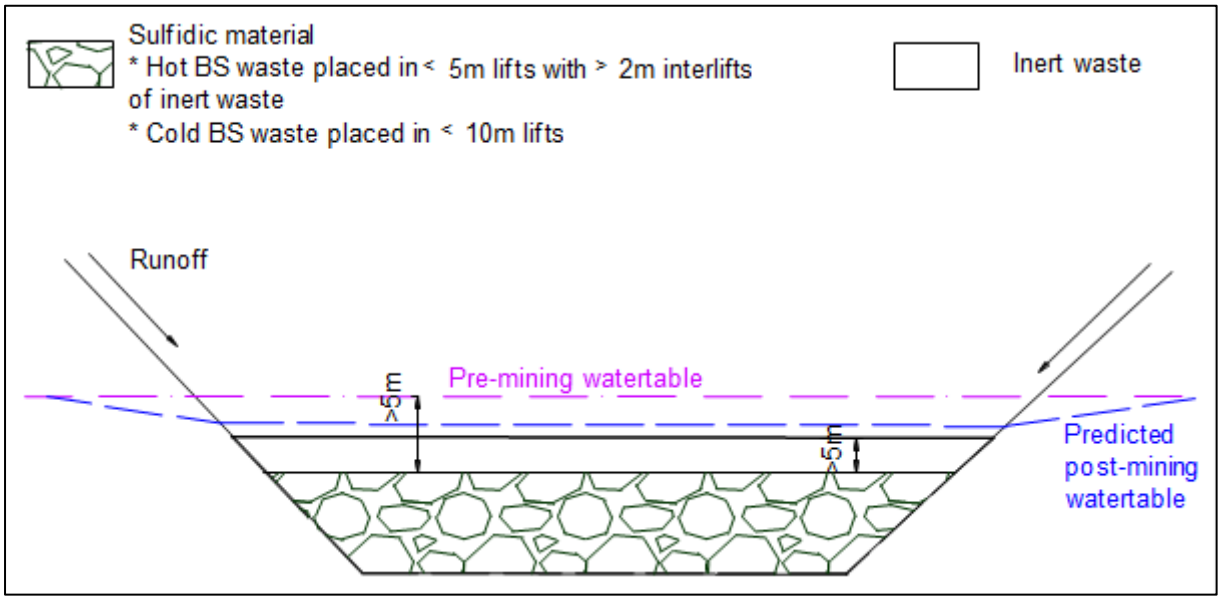

Figure 6: Example of PAF material placed below the water table and with the pit partially backfilled.

- The thickness of each hot black shale material lift must not exceed 5 metres followed by a minimum 2 metre lift of inert or net neutralising waste rock between each hot black shale layer.
- The thickness of each cold black shale material lift must not exceed 10 metres. No inert or net neutralising waste rock layer is needed between cold black shale lifts.
- The uppermost lift of both cold and hot black shale material must be covered with a minimum 5 metre layer of inert or net neutralising waste rock.
- Each lift must be placed so that it ties into the pit walls on all sides to minimise the risk of convective oxygen transport until the waste is flooded.
- If backfilled to above the post-mining water table, the upper inert waste rock surface must be revegetated.
- A store and release cover is not needed if all PAF material in a pit is placed below the water table.

In addition to the minimum design requirements listed above, the optimum design for in-pit disposal below the water table also includes:

- Enough inert or net neutralising backfill should be placed on top of the PAF waste to raise the fill level to at least above the post-mining water table (preventing the formation of a pit lake) and preferably above the pit walls so that runoff is not directed into the pit fill (see Figure 19).
- If required, flooding of the backfilled pit should be enhanced by diverting surface water flows into the pit or directing dewatering water from active open pits into the backfilled pit. The more rapidly the waste can be inundated, the less pyrite will ultimately oxidise. Rapid flooding will minimise the build-up of soluble sulfide oxidation products in the material. As long as geotechnical safety requirements are met, construction of waste lifts into standing water on the pit floor is acceptable. Figure 21 demonstrates that less than 50% of the sulfidic material oxidises if the water table is recovered within 100 years and less than 15% oxidises if the water table is recovered in 30 years. This may differ from site to site, however this example clearly demonstrates the advantage of BWT PAF storage and rapid water recovery.

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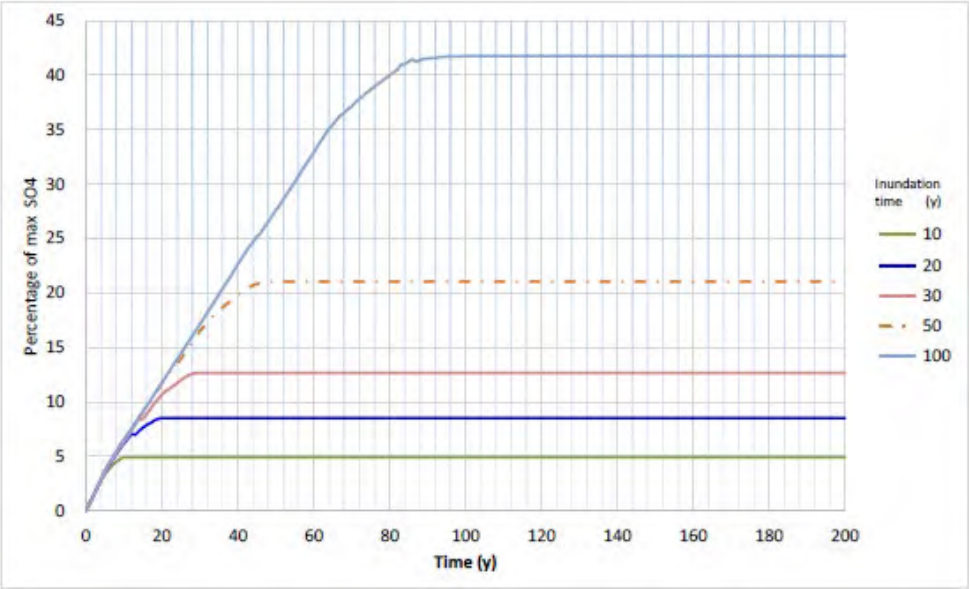

Figure 7: An example of modelling the effects of different inundation time on sulfate generation.

A4.2.2 In Pit Disposal Above the Water Table

If PAF material is placed above the post-mining water table, it must be ensured that long-term variations in the water table elevation do not allow water to rise into the overlying PAF material. Intermittent contact with infiltrating water from above must also be minimised. For PAF material placed above the post-mining water table the following minimum design criteria apply:

- The base of the PAF material backfill must be at least 5 metres above the predicted mean post-mining water table.
- At least 5 metres of inert or net neutralising waste rock must be placed at the base of the open pit before PAF backfill is placed. The most likely location for a perched water table to form is at the base of the backfilled pit because of the permeability contrast between the bedrock and the backfill.
- The thickness of each hot black shale material lift must not exceed 5 metres followed by a minimum 2 metre lift of inert or net neutralising waste rock between each hot black shale layer.
- The thickness of each cold black shale material lift must not exceed 10 metres. No inert or net neutralising waste rock layer is needed between cold black shale material lifts.
- The uppermost lift of both cold and hot black shale material must be covered with a minimum 2 metre layer of inert or net neutralising waste rock. This will prevent runoff water from contacting the underlying PAF material until the store and release cover can be constructed.
- If the pit can be completely backfilled so that no high walls are exposed above the inert waste rock fill, then each inert, cold and hot black shale material layer should tie into the pit walls on all sides to minimise the risk of convective oxygen transport (see Figure 22 and Figure 23 for examples).

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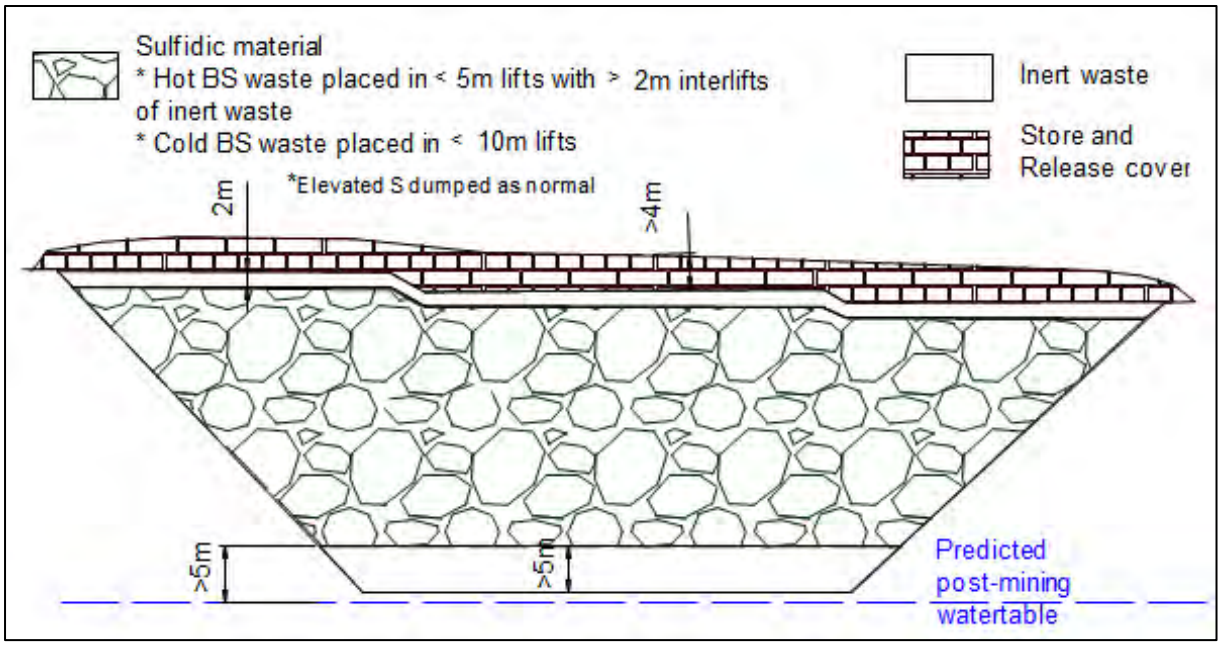

Figure 8: Example of PAF material placed in a dry pit that is completely backfilled.

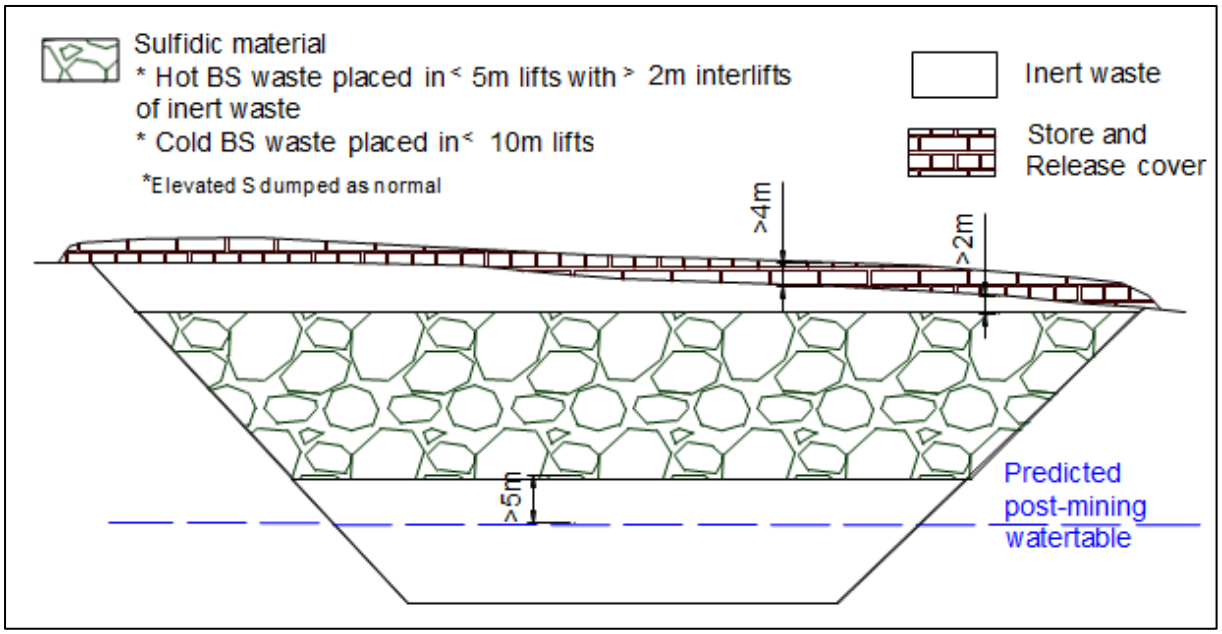

Figure 9: Example of PAF material placed above the water table and with the pit completely backfilled.

- If the pit will only be partially backfilled so that highwalls are exposed above the final backfill surface and that the runoff from the remaining highwalls will flow towards the backfill, a minimum five metre (measured both horizontally and vertically) buffer of inert waste rock must be placed between the pit walls and each PAF material lift where possible (see Figure 23 for an example). A 2 metre high by 5 metre wide abandonment bund will also need to be placed adjacent to the exposed high walls to prevent run on water from infiltrating into the cover over the PAF material.

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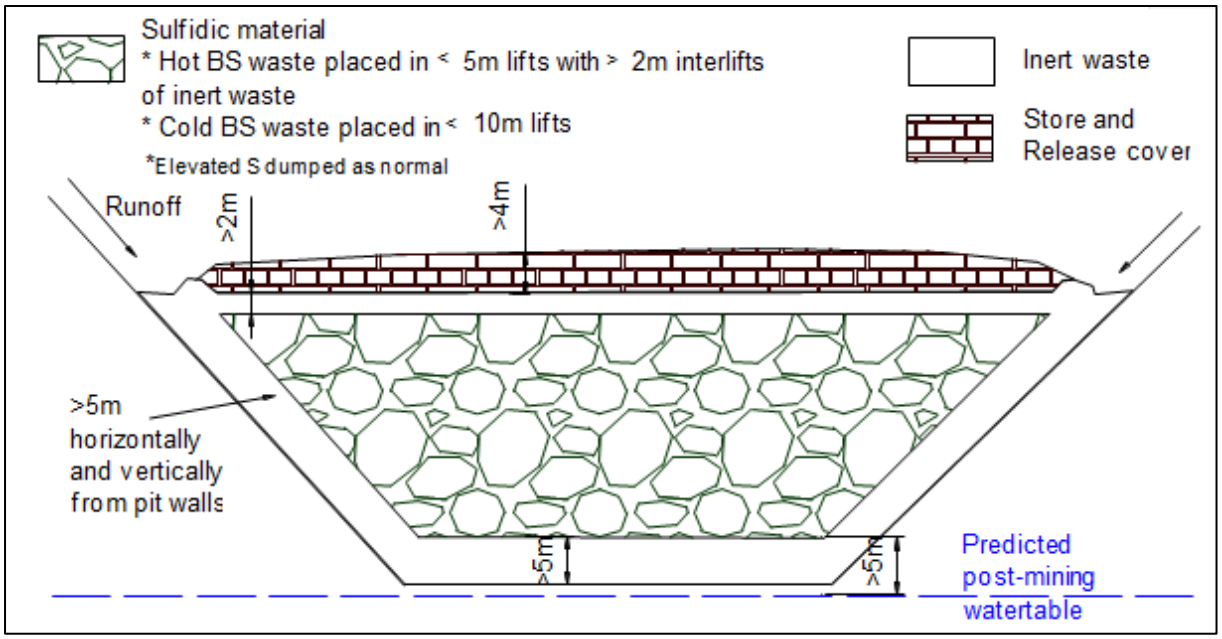

Figure 10: Example of PAF material placed above the water table and with the pit partially backfilled.

In addition to the minimum design requirements listed above, the optimum design for in-pit disposal above the water table also includes:

- If possible, the pit should be backfilled above the lowest point on the pits walls so that the final backfill surface can be sloped to allow runoff water to flow out of the pit footprint.
- The optimum design would be to backfill the pit so that there are no highwalls exposed that could direct runoff onto the store and release cover and underlying PAF material (see Figure 22 and Figure 23).

A1.3 Above Ground Disposal Requirements

If PAF material waste rock dumps are to be constructed on top of the original ground surface, more stringent design criteria are required than for in-pit disposal because of the risk of erosion exposing encapsulated PAF material and because of the likelihood of the convective transport of oxygen through the side slopes of the dump. Design criteria for hot black shale dumps are also more stringent than for cold black shale dumps and elevated-sulfur dumps.

A1.3.1 *Design of Outer Waste Rock Dump Slopes*

To the extent possible, cold and hot black shale material should be excluded from beneath final waste rock dump slopes. There are several issues associated with the placement of cold and hot black shale beneath waste rock dump slopes:

- There is an increased risk of slope erosion damaging vegetation and covers in the short term, or in the long term exposing the underlying material.
- The probability of convective oxygen transport to the sulfidic material is higher than for cold and hot black shale material only placed in the dump interior.
- Store and release covers cannot be built on slopes because they are constructed with more erodible fine-grained materials. It is likely that infiltration rates into the underlying cold and hot black shale material will be higher on slopes than on flat surfaces with a store and release cover, which could result in increased AMD.

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- Uncertainties with the requirements for final dump slopes may require the importation of additional inert material to achieve the final landform design to ensure the preservation of the minimum 5 metres of inert cover over the sulfidic material.
- The berm and batter design of final slopes would direct water through the slopes and into the underlying PAF material.

The minimum design criteria in the following section reduce but do not completely mitigate these risks. **For this reason, hot black shale should not be placed under final slopes, and the volume of cold black shale should be minimised wherever possible**[1]**.** The greatest benefit can be derived from excluding hot black shale material from beneath the slopes because it not only has the potential to spontaneously combust, but also has anywhere from 2 to 70 times more acid producing potential on average than the cold black shale material.

A1.3.2 *Hot Black Shale*

Figure 25 shows the optimum design for the waste rock dumps in which hot black shale is completely excluded from beneath the footprint of the final recontoured slope.

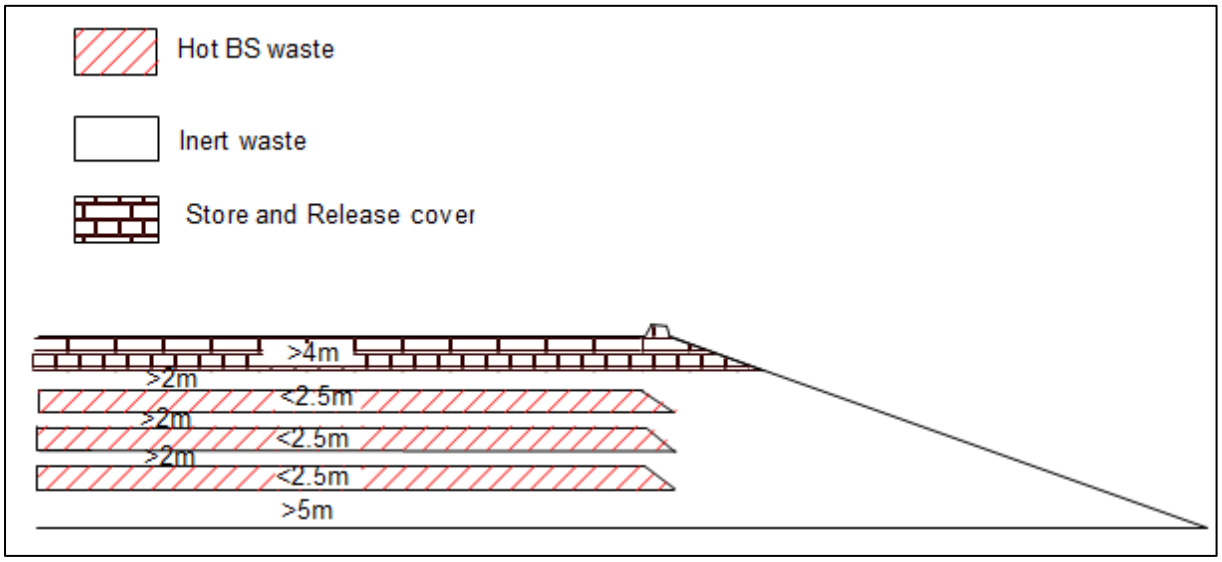

Figure 11: Example of the design for hot black shale dumps.

The minimum design criteria for hot black shale dumps are:

- A minimum of 5 metres of inert or net neutralising waste rock must be placed on the original land surface at the base of the dump.
- Enough inert waste rock must be placed against hillsides so that PAF material is not located within 5 metres of the hillside as measured both vertically and horizontally.
- The thickness of each hot black shale material lift must not exceed 2.5 metres followed by a minimum 2 metre lift of inert or net neutralising waste rock. Lifts are to be constructed by paddock dumping (or reverse paddock dumping and pushing out) so that the hot black shale can cool and so that incident vehicle traffic helps create a compacted layer every 2 to 2.5 metres to inhibit water movement and convective oxygen transport.
- Enough inert or net neutralising waste rock must be placed on the outer skin of the hot black shale waste rock dump so that no hot black shale material is located under the final slopes.[2]

[1] Effective from the 2016 SCARD update. Earlier designs and dumps can still contain hot black shale under slopes.

[2] Effective from the 2016 SCARD update. Dumps designed and built prior to 2016 can continue to dump hot black shale under slopes, however it must be located > 5 metres (measured across the shortest distance) from the final dump slope.

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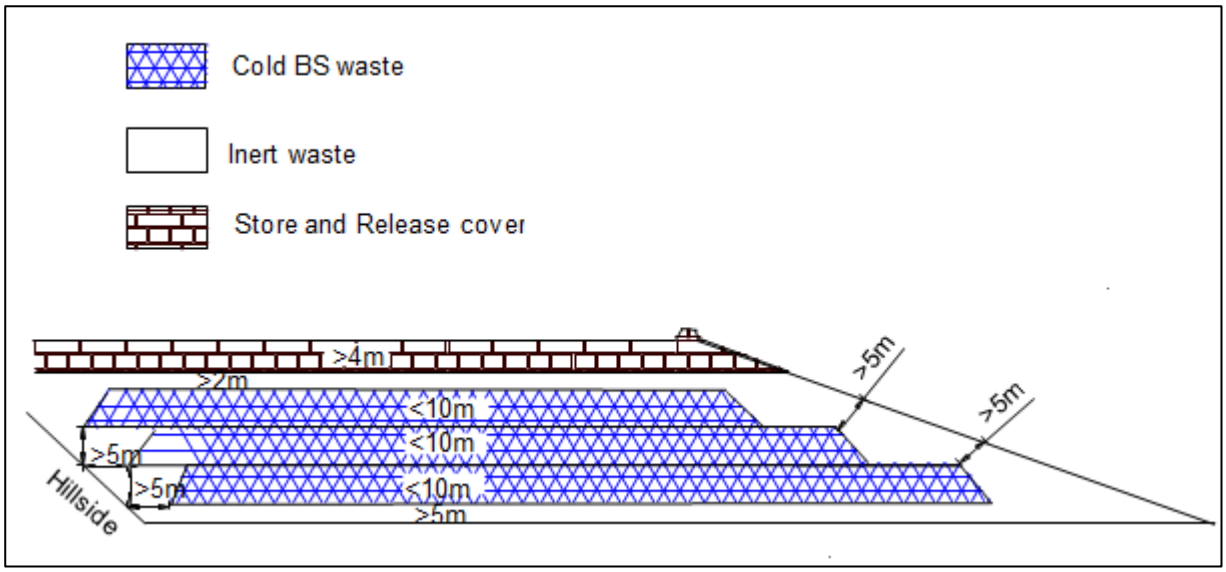
- Hot black shale may be mixed with Elevated S material in dumps, however elevated sulfur material should not be used on the outer slopes.
- The final lift on a hot black shale waste rock dump must be composed of a minimum 2 metre-thick inert or net neutralising layer. This will prevent runoff water from contacting the underlying PAF material until the minimum 4 metre-thick store and release cover can be constructed.
- During construction and at closure, the upper dump surface of the hot black shale waste dump should be designed so that it only receives incident rainfall with no run-on from adjacent areas.

A1.3.3 *Cold Black Shale*

An example of a cold black shale waste rock dump constructed according to the minimum dump design criteria is shown in Figure 26. The minimum design criteria for cold black shale dumps are:

- A minimum of 5 metres of inert or net neutralising waste rock must be placed on the original land surface at the base of the dump.
- Enough inert waste rock must be placed against hillsides so that cold black shale is not located within 5 metres of the hillside as measured both vertically or horizontally.
- The thickness of each lift of cold black shale must not exceed 10 metres. This will create a vehicle compacted layer every 10 metres in the dump to inhibit water movement and convective oxygen transport[3].
- No inert or net neutralising waste rock layer is needed between cold black shale lifts.
- Enough inert or net neutralising waste rock must be placed on the outer skin of the cold black shale waste rock dump so that no material is located within 5 metres of the final dump surface after the slope has been re-contoured at closure.
- The final lift on a cold black shale waste rock dump must be composed of a minimum 2 metre-thick inert or net neutralising layer. This will prevent runoff water from contacting the underlying material until the minimum 4 metre-thick store and release cover can be constructed.
- During construction and at closure, the upper dump surface of the cold black shale dump should be designed so that it only receives incident rainfall with no run-on from adjacent areas.



[3] Note that this has been changed from 5 m lifts as the gas movement through waste dumps has been shown during ANSTO testing to be diffusive and it is likely that the difference in ARD generation between 10 and 5 m lifts will be negligible.

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Figure 12: Example of the minimum design criteria for cold black shale dumps. *Error! Bookmark not defined.*

A1.3.4 *Elevated S*

An example of an Elevated S waste rock dump constructed according to the minimum dump design criteria is shown in Figure 27. The minimum design criteria for elevated-sulfur dumps are:

- Inert or net neutralising waste rock must be placed on the original land surface at the base of the dump.
- At least one (1) metre of inert material is located on the outer surface of the waste dump at closure.
- Elevated-sulfur material can be mixed with inert material and dumped accordingly.
- Co-disposal of elevated-sulfur waste with materials containing excess available neutralising capacity is recommended.
- During construction and at closure, the upper dump surface of the elevated-sulfur dump should be designed so that it only receives incident rainfall with no run-on from adjacent areas.

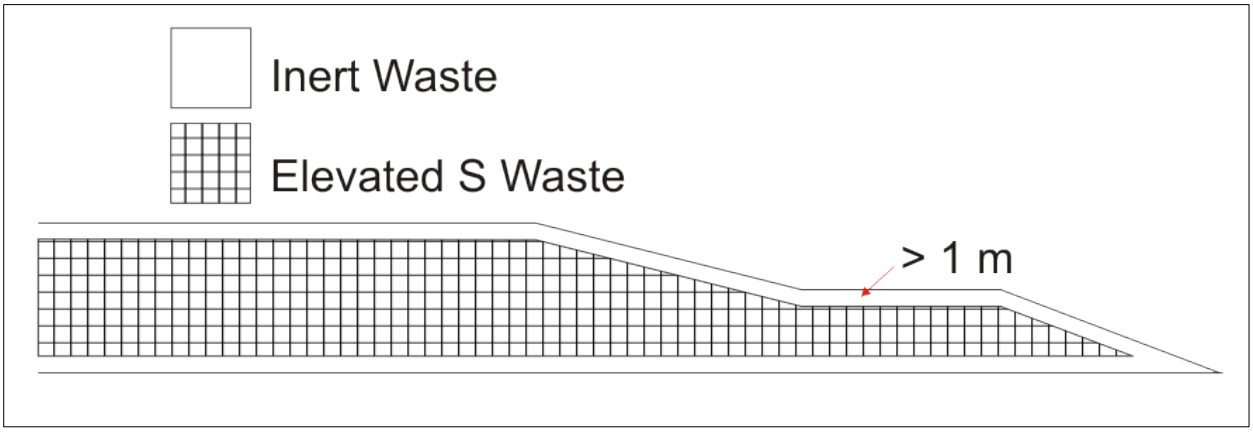

Figure 13: Example of the minimum design criteria for Elevated S dumps. No store and release cover is required and only 1 metre inert material cover at surface required.

A1.3.5 *Composite Designs*

Figure 28 shows an example of a composite hot and cold black shale dump in which hot black shale is excluded from the beneath the slope and cold black shale is placed below the slope. Composite dumps of this kind may significantly reduce the residual risk associated with the dump slopes without significantly reducing the total storage capacity for sulfidic material within the dump. There must be at least a one metre buffer (measured horizontally or vertically) between the hot and cold black shale material where they are in close contact on the outer slopes of the hot black shale repository.

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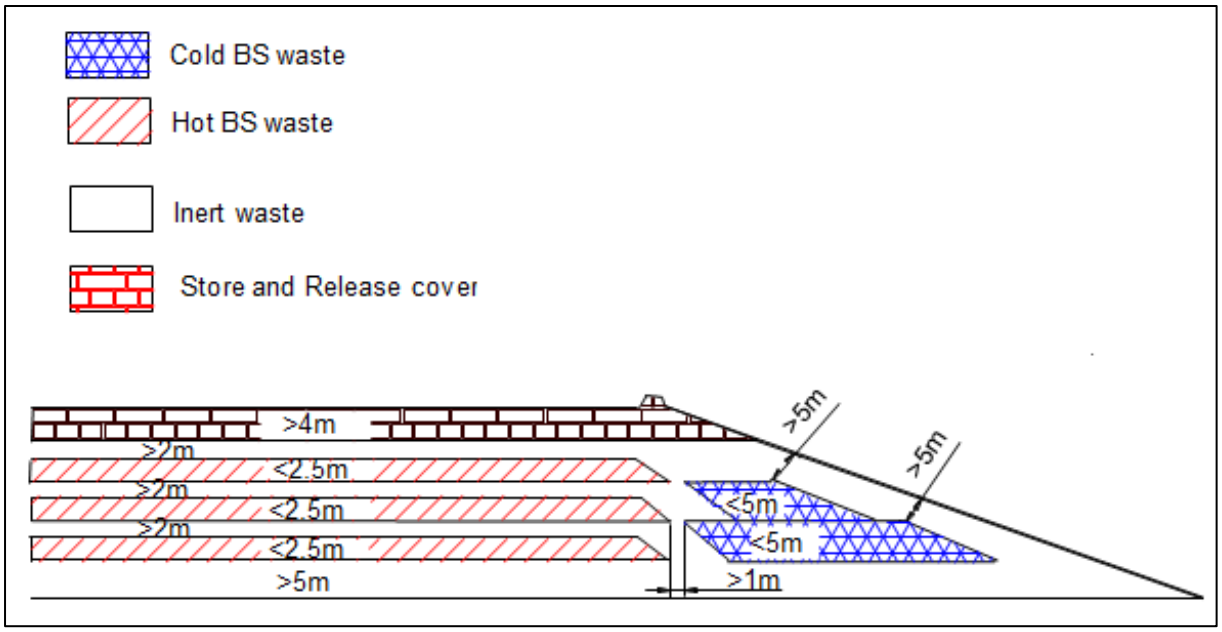

Figure 14: Example of optimum composite designs for cold and hot black shale dumps.

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Appendix 2 Dump Designs for Material with Neutralising Potential

A2.3 Dumping Scenarios

The following dump designs were developed specifically for cases where neutralising material is available. Calcrete is the preferred net neutralising material, however if calcrete is not available then dolomite from the Wittenoom Formation can be used as net neutralising waste. Please note that only the dolomite within the Wittenoom Formation has sufficient neutralising material and it is not mapped separately within geological models and could be difficult to source.

A2.3.1 *Above Ground Disposal Requirements*

An example of the minimum dump design criteria is shown in Figure 29.

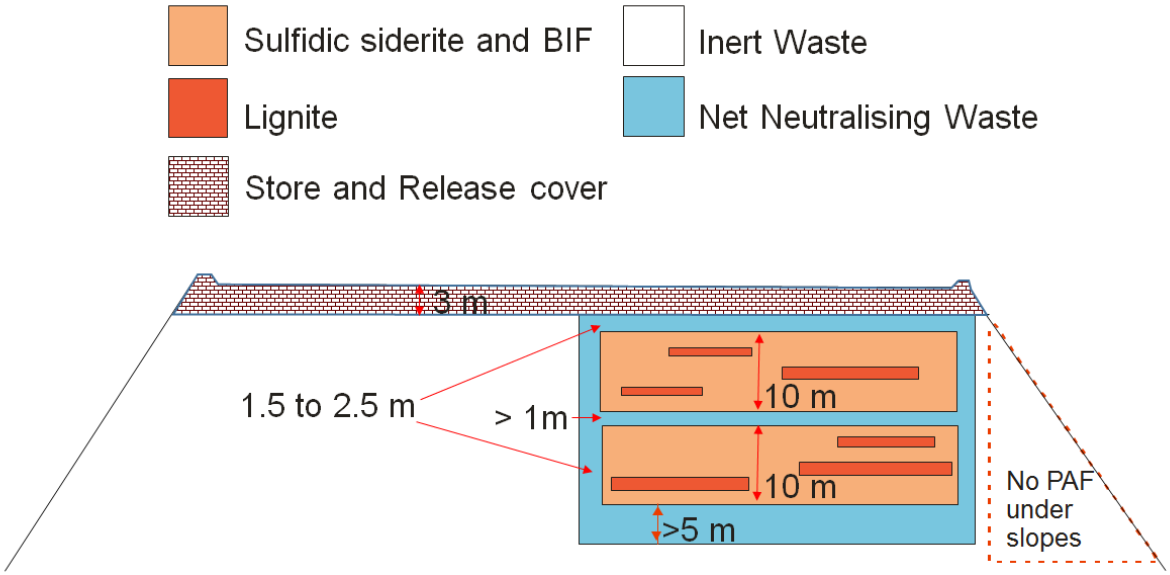

Figure 15: Example of minimum design for a combined sulfidic BIF and siderite with lignite dump – Permanent storage

The minimum design criteria for AWT PAF dumps are:

- No PAF material is to be placed under the final rehabilitation slopes of the waste dump.
- Minimum of 5 metre of net neutralising waste rock must be placed as a basal layer prior to PAF placement within the dump. This material can be end tipped. This basal layer can be reduced in thickness to 2.5m, if the PAF cell is located higher in the waste dump. The mineral waste team should assess this.
- A 1.5 – 2.5 metre layer of net neutralising waste should be placed at the top, sides and base of each PAF lift i.e. a net neutralising waste bund should be created prior to PAF placement. This will reduce the lateral flow of incident rainfall.
- If spontaneous combustion is a risk, the thickness of each lignite material lift must not exceed 2.5 metre followed by a 1.5 to 2.5 metre lift of net neutralising waste rock. Lifts are to be constructed by paddock dumping so that lignite material can cool and so that incident vehicle traffic helps create a compacted layer every 1.5 to 2.5 metres to inhibit water movement and convective oxygen transport.
- The thickness of each lift of sulfidic BIF and siderite material must not exceed 10 metre. A 1.5 – 2.5 metre paddock dumped layer of net neutralising waste should then be placed on top of the PAF lift.

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- The 10 metre PAF layer should be paddock dumped in a number of small lifts to limit the risk of material segregation and tightly compact the waste dump to prevent oxygen ingress i.e. 4 x 2.5 metre thick PAF layers. The dumping of PAF material during the wet season should be avoided, where possible.
- The final lift on the PAF waste rock dump must be composed of a minimum 1.5-2.5 metre thick inert or net neutralising layer. This will prevent runoff water from contacting the underlying sulfidic material until the minimum 3 metre thick store and release cover can be constructed.
- Only incident rainfall and no run-on from adjacent areas should pass through the dump.
- If there is insufficient PAF to create the 10 metre lift, the >1 metre net neutralising waste layer can be constructed at <10 metre.
- If spontaneous combustion is a risk, lignite material should be covered with net neutralising material within 1 month during the wet season (due to the spontaneous combustion risk). Where possible, the sulfidic BIF and sulfidic siderite material should be covered with net neutralising waste during the wet season.
- If PAF is temporarily stored within a waste dump, the previous criteria still applies, however PAF can be stored underneath the final slopes, as long as there is a 10 metre offset (consisting of calcrete closest to the PAF and inert waste) (Figure 30). If PAF is placed on 30m of inert material, it would need to be rehandled within 20 years. If there is a delay in rehandling then the placement of a temporary cover on the dump should be considered.

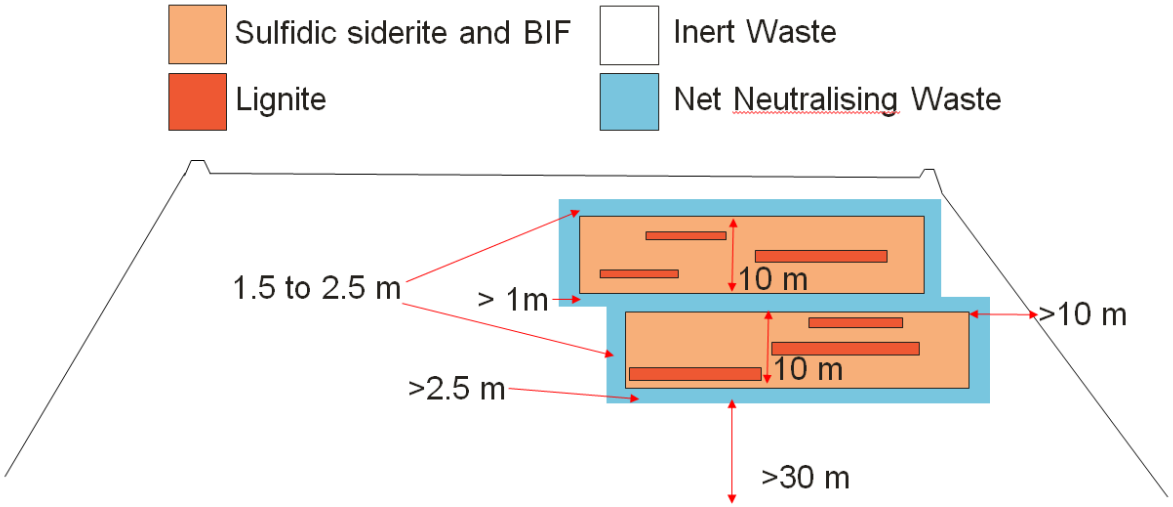

Figure 16: Example of minimum design for a combined sulfidic BIF and siderite with lignite – Temporary storage

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Appendix 3 Rehabilitation and Closure

A3.1 Final Landforms

To reduce the risk of erosion and to minimise infiltration, final landforms should be designed in accordance with the following criteria:

- Final landform design should be designed in accordance with the Rio Tinto Iron Ore (WA) Landform Design Guidelines.
- Final landforms must be designed so that runoff is not directed onto surfaces that are underlain by sulfidic material.
- A back-sloping crest bund must be placed around the top of each dump slope and berm. This will prevent runoff water flowing from the dump surface over the slopes and causing erosion.
- If PAF material is exposed during the re-contouring of waste rock dumps that were created before waste rock segregation was practiced, it must be covered with at least 2 metres of inert waste rock. This will help ensure that the entire final dump surface is able to support vegetation.
- Wrapping the PAF dump is preferred rather than dozing down the slope.

A3.2 Store and Release Covers

A3.2.1 *Design*

Store and release covers must be constructed on all flat surfaces over PAF waste dump repositories and over some sulfide/black shale exposures within open pits. Store and release covers are designed to limit infiltration into the underlying waste rock by maximising the evapo-transpiration of incident rain water. The cover is designed to store water near the surface during the wet season so that it can be removed from the cover material and returned to the atmosphere during the dry season by evaporation and plant transpiration.

Waste rock that is used to construct store and release covers must contain sufficient fine-grained material to have both a high moisture retention capacity and a relatively low permeability (i.e. large boulders should not be placed on the cover). Waste rock composed of well-graded clayey, silty, sandy gravel or clayey silty gravely sand makes the best store and release cover material. As a rough guide, waste rock containing more than 1/3 coarse sand size and finer particles (< 5 mm) will make a suitable cover material. **Blocky BIF composed of gravel with very little silt, sand or clay is not ideal** for use in cover construction and should be avoided if another more suitable waste type is available (Figure 31).

Where possible, 4 metres of oxidised shale should be used in preference to 4 metres of BIF on flat top covers. If detrital material is available, then a cover constructed out of 4 metres of detrital material overlying 2 metres of oxidised shale has been shown to reduce net percolation and salt uptake. Topsoil should be preferentially placed on covers as the vegetation can significantly reduce the amount of net percolation through the cover. If the cover will be less than 6 metres thick then advice should be sought from the mineral waste management team. For guidance on the covers on slopes please see the Rio Tinto Iron Ore (WA) Landform Design Guidelines.

A3.2.2 *Construction*

During construction there should be regular quality control checks to ensure large boulders have not been placed into the cover.

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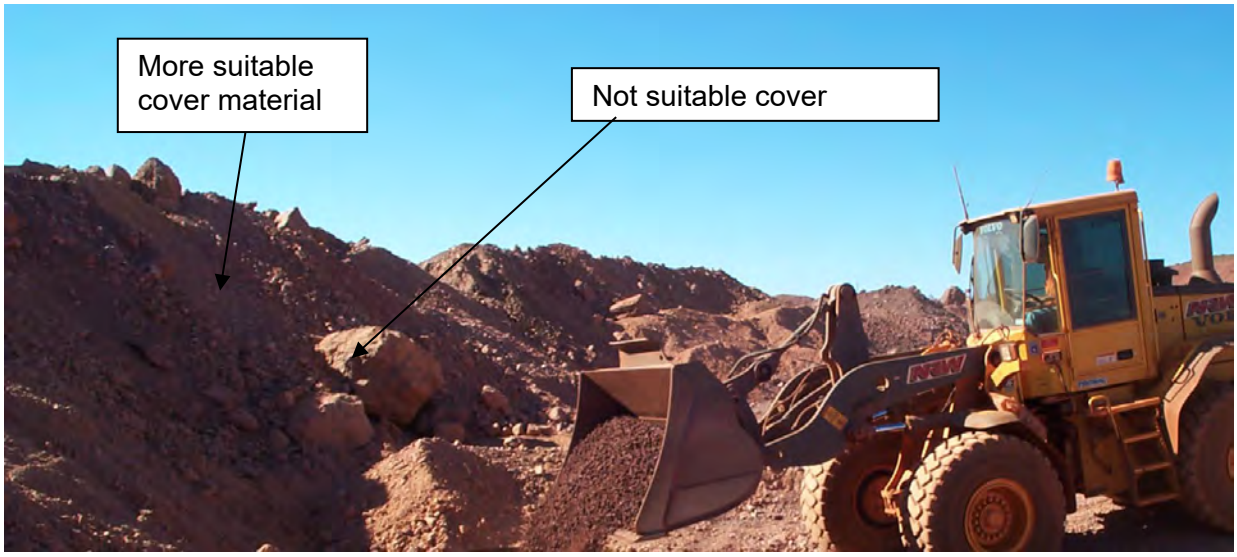

Figure 17: An example of suitable and not suitable material to be used in the construction of a store and release cover.

Waste rock that is used to construct store and release covers must also be able to support vegetation, so materials with high salinity, and acidic or very basic pH should be avoided. The waste rock should be placed in a manner that minimises segregation of the material into coarse and fine particles. For this reason covers should be paddock dumped, they should never be constructed by dumping in four metre lifts.

Store and release covers should be constructed as follows (Figure 32):

- Paddock-dump store and release cover material on top of a vehicle compacted surface so that the average depth of the cover material is greater than 2 metres.
- A dozer should then be used to knock down the crest of each paddock dump pile and to fill in the depressions between piles to create a trafficable surface.
- Paddock-dump a second layer of store and release cover material on top of the first lift so that the average depth of the second lift is greater than 2 metres. Vehicle traffic during this dumping will create a compacted layer on top of the first store and release cover layer.
- A dozer should again knock down the crest of each paddock dump pile in the second layer and fill in the depressions between piles to create a surface that is nearly planar.
- Topsoil should be placed on top of the second store and release cover layer. The surface should then be ripped and seeded. Ripping needs to be deep enough (> 0.3 metres) to mix in the topsoil and to ensure that there are not compacted zones that could inhibit plant growth and rooting on top of the upper layer.

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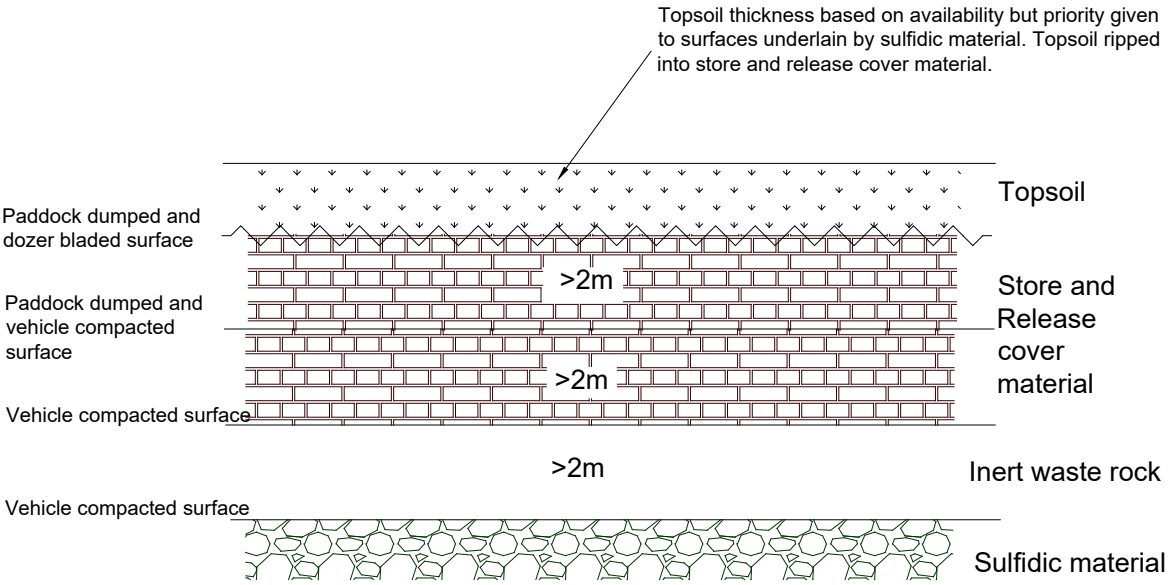

Figure 18: Detail of store and release cover design.

A3.3 Topsoil Management

Topsoil placement can greatly accelerate the establishment of native vegetation on waste rock surfaces. This in turn will help to maximise evapo-transpiration, minimise infiltration into the underlying waste rock and inhibit erosion on dump slopes. If topsoil resources are limited, the most benefit for ARD management can be gained by preferentially utilising topsoil for the revegetation of waste rock dumps that contain sulfidic material. In decreasing order of importance, topsoil should be placed on:

1. Dump slopes underlain by hot black shale/lignites material;

2. Dump slopes underlain by cold black shale/sulfidic BIF/sulfidic siderite material;

3. Flat store and release cover dump surfaces underlain by hot black shale/lignites material;

4. Flat store and release cover dump surfaces underlain by cold black shale/sulfidic BIF/sulfidic siderite material;

5. Store and release covers within open pits;

6. Waste rock dumps that were created before waste rock segregation was practiced and which may contain dispersed black shale or material containing sulfides;

7. Assessable inert waste rock surfaces within pits that contain black shale or sulfidic material exposures; and

8. Waste rock dumps that do not contain any black shale or sulfidic material.

For further information on topsoil management refer to the RTIO Soil Resource Management Work Practice.

A3.4 Open Pit Closure

The geology and hydrogeology of an open pit will largely control the potential closure issues associated with the final void. Open pits that are located above the water table and which do not contain any black shale or sulfidic material exposures should not pose any geochemical risks at closure. Open pits that intersect the water table but do not contain any black shale or sulfidic

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material exposures may ultimately contain saline water bodies with neutral pH that could impact down gradient groundwater. Open pits that contain black shale or sulfidic material exposures will likely contain ephemeral or permanent acidic and potentially saline water bodies that could impact down gradient groundwater and could represent a direct exposure risk to wildlife or humans.

Hypersaline pit lakes may be considered acceptable on relinquishment as long as down-gradient beneficial use is not impacted. Further consultation with stakeholders would be required for specific locations. Mitigation measures will likely be required if net acid generating materials such as pyritic black shale are exposed on the final pit walls. In pits with extensive exposures of pyritic black shale that will not be backfilled to above the water table, long term mitigation measures will likely be required to attain the proposed water quality criteria.

The hydrogeological and geochemical behaviour of each pit should be predicted so that it can be managed appropriately at closure to minimise significant groundwater impacts and surface water exposures to wildlife and humans. As discussed previously, the most protective pit closure strategy is to completely backfill the pit or to backfill the pit to above the estimated pre-mining water table where practicable. Backfilling to above the pre-mining water table should lead to a near complete recovery of the water table elevation and should cut off oxygen to the majority of black shale or sulfidic material exposed on the pit walls.

In order of decreasing benefit, pit backfilling should be prioritised as follows: 1) pits with black shale or sulfidic material exposures that intersect the water table and will discharge to groundwater at closure, 2) pits with black shale or sulfidic material exposures that intersect the water table but that will not discharge to groundwater at closure, 3) pits with black shale or sulfidic material exposures that are above the water table, 4) pits without black shale or sulfidic material exposures that intersect the water table and that will discharge water to groundwater at closure, 5) pits without black shale or sulfidic material exposures that intersect the water table but that will not discharge to groundwater at closure, and 6) pits that do not contain any black shale or sulfidic material exposures and that are above the water table. The proximity to nearby regionally significant aquifers or ecologically significant seeps and springs should also be considered when evaluating potential pit closure issues.

Extensive backfilling is not practicable for many open pits because of the size of the final void and because of pit sequencing issues. Where backfilling is not practicable the following actions should be taken:

- Haul roads and accessible benches that are underlain by inert waste rock should be ripped and seeded to minimise runoff, to promote vegetation establishment and to maximise evapo-transpiration.
- A minimum 4 metre store and release cover system should be constructed on top of accessible black shale or sulfidic material exposures for those portions of the pit that will be located above the water table and that will not be periodically flooded by cyclone events.
- A minimum 5 metre lift of inert or net neutralising rock should be placed on top of accessible black shale or sulfidic material exposures for those portions of the pit that will be located below the water table or that will be periodically flooded by cyclone events.
- Consideration should be given to covering black shale or sulfidic material exposed on pit highwalls with inert or net neutralising material pushed or dumped from the sides.

An example of these pit closure strategies is illustrated in Figure 33.

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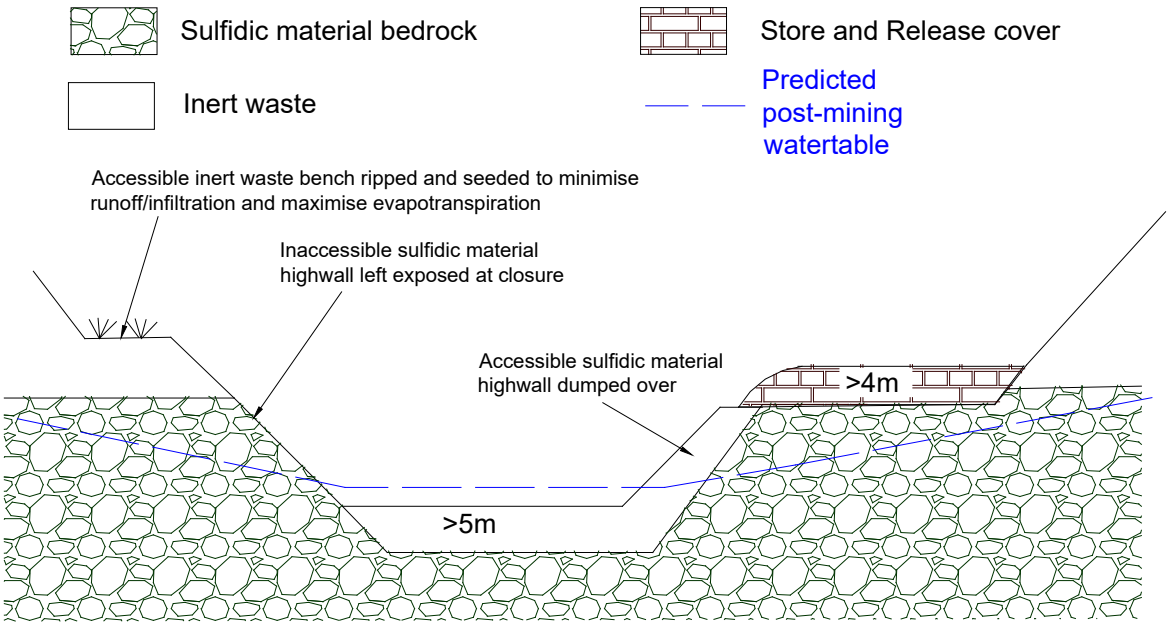

Figure 19: Examples of closure strategies for a pit with sulfidic material that will not be backfilled.

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Appendix 4 Contingency Planning

Contingency plans for most upset conditions and unexpected impacts related to sulfidic material management will need to be developed on a case by case basis. Contingency plans will generally be developed by the site Mineral Waste Management team or at a minimum they must be approved by the Team. Contingency plans for spontaneous combustion and inert materials shortages are outlined in the following sections.

A4.1 Spontaneous Combustion

Site specific pit safety procedures should be followed.

All occurrences of burning black shale or lignites must be reported to the mine supervisor and the pit safety team as soon as possible. If possible, fires should be extinguished by rapid burial of the burning material under at least five metres of inert waste rock (see relevant SWPs). For locations where this may be difficult such as beneath pit ramps, the black shale or lignite should be covered with as much inert material as practicable. The inert material should be placed so that the upper surface is well compacted and so that side slopes are adequately covered to prevent lateral convective transport of oxygen to the burning rock mass. If rapid coverage is not an option, the material can be excavated and transported to the toe of an advancing inert dump lift where it can be rapidly buried. Water should not be used to extinguish the fire because this could actually enhance the spontaneous combustion risk of black shale or lignite that is not already burning and because the volumes of water that would be required are generally prohibitively high.

A4.2 Inert Materials Shortages

Medium and short term mine plans should be designed so that inert waste rock is produced in adequate volumes and at appropriate times to allow timely encapsulation of PAF material. Hot black shale and lignite material requires the highest volumes of inert material (approximately 1:1) because of the requirement for an inert interlayer every 2.5 metres. If there were temporary shortages of inert material, hot black shale or lignite dumps could be designed with cold black shale or sulfidic BIF and siderite material if it contains a low sulfide concentration, some neutralising potential and low organic carbon (i.e. no black shale or lignite) material. The appropriate material to use in the heat dissipating interlayer should be confirmed as appropriate by Mine Geology. But under no circumstances should black shales or lignites with both elevated sulfide and organic carbon concentrations be used. If acid base accounting tests prove the material to be non-acid forming, coarse tails could be used as inert waste in dumps. If there is a shortage of inert material then inert waste in other waste dumps may need to be rehandled and transported to the black shale waste dump.

A4.3 Surface Water Management

Every endeavour should be made to divert surface water runoff from contacting black shale or sulfides exposed on pit walls. Site specific acid water and flood management plans should be developed that plan for the appropriate disposal of potentially acidic water in pits with PAF exposures. Some strategies to manage surface water runoff include:

- Slope pit floor away from pit PAF exposure
- A sump should be constructed below the PAF exposure to collect acidic water.
- Surface water runoff from inert exposures should be segregated from coming in contact with acidic water.

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- Bund upper catchment to run over competent material such as BIF rather than PAF exposures.

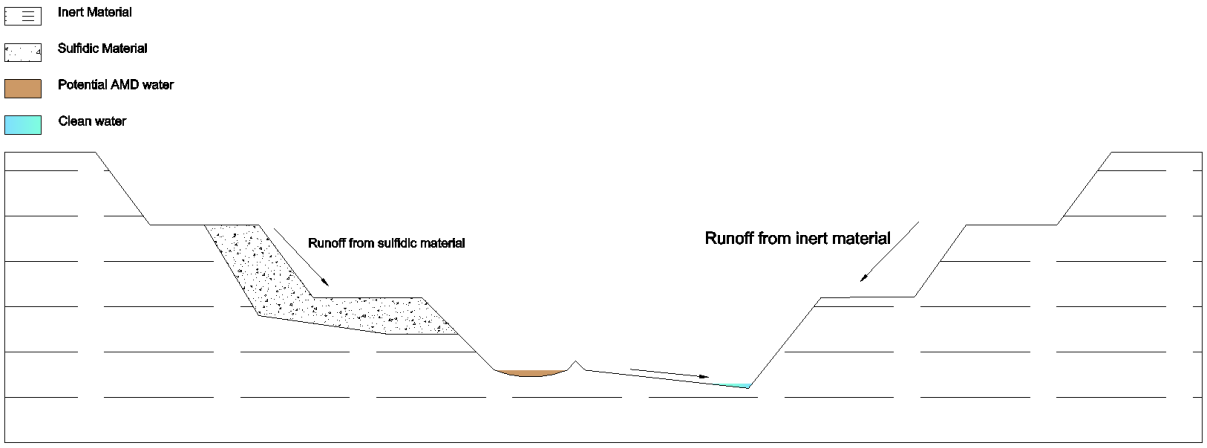

Figure 20: Suggested surface water management for sulfide exposures.

Where possible, PAF exposures in waste dumps should be covered with inert material during the wet season, particularly hot black shale and lignites. A bund at the top of the waste dump surface will reduce any surface water from travelling over the sulfidic material and transporting contaminated drainage into the surrounding environment.

Pipelines transporting acidic water should be shut down and repaired if there is a leak. Acid water pipelines should be labelled with purple stripes and non-acidic pipelines can be labelled with green stripes (as per Australian Standards).

A4.4 Geotechnical Stability

A6.4.1 Pit Walls

Pit walls excavated in MCS are designed with the same concept as for other stratigraphic units. That is, generally the design is for a Factor of Safety of at least 1.20 and a Probability of Failure of around 10% on the inter-ramp scale and up to 30% for the batter scale. The management of slopes excavated in MCS is therefore no different from that of any other stratigraphic unit, whereby a process called Geotechnical Design Management is utilised. This involves identifying hazards and hence risks associated with the geotechnical design and undertaking a risk management strategy to minimise these risks. Actions include design review, geotechnical investigation, mapping, conformance to design and monitoring. Contingency plans are established through Slope Management Plans in consultation with mine management.

The occurrence of MCS is of little consequence to the geotechnical management process.

A6.4.2 Dump failures

Whilst no specific stability analyses have been undertaken on black shale waste dumps, they can generally be considered stable due to the process of encapsulation of the material well within a dump. Also, the process of undertaking earthworks to prepare the encapsulation is considered to add a significant contribution to the stability of the dump location. It is anticipated that future stability analyses may be documented in a Waste Dump Management Plan.

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Appendix 7: AMD Risk Assessment

AMD Source Hazard Risk Assessment

West Angelas Mine

25 June 2021

J-AU0122-002-R-Rev1

MINE WASTE MANAGEMENT
GREENROAD GROUP

RioTinto

AMD Source Hazard Risk Assessment

West Angelas Mine

Document Number: J-AU0122-002-R-Rev1

Document Date: 25 June 2021

Prepared for:

Rio Tinto Iron Ore Pty Ltd

Central Park, Level 10, 152-158 St Georges Terrace, Perth 6000 WA

Prepared by:

Mine Waste Management Pty Ltd

Suite 2, 435 Vincent Street W, West Leederville, WA 6007 AUSTRALIA

+61 8 6272 0290

www.minewaste.com.au

REVISION	DATE	AUTHOR	RECORD OF REVIEW
RevA	14 February 2021	MF	JP
Rev0	14 June 2021	MF	JP
Rev1	25 June 2021	MF	JP

EXECUTIVE SUMMARY

Mine Waste Management Pty Ltd (MWM) completed an update of Rio Tinto Iron Ore's (RTIOs) existing acid and metalliferous drainage (AMD) risk assessment for the West Angelas deposits with consideration to their internal risk assessment approach.

This AMD risk assessment utilised the West Angelas sulfur assay database to assess the bulk acid generation potential of the deposits. The assay database was used to assess the chemical enrichment of the deposit with respect to average crustal abundances. To complement the assay datasets, RTIO's environmental geochemical database was used to further assess the acid base accounting (ABA) characteristics and element mobility potential of the West Angelas geological materials. The inferred AMD characteristics were then assessed in context of the proposed mine plans. Tonnages of higher AMD risk material were estimated along with potential surface are exposures within the pits. This information was then combined with site specific pathway and receptor information to populate RTIO's internally developed ARD Hazard Score Sheets to provide a risk rating for each of the deposits.

It should be noted that the pit shells will change over time and updates to the geological and mining models will be made; the tonnages reported in this document are subject to change.

Key findings of the assessment are as follows:

- Assay results for in-pit material suggest a low risk of acid generating potential.
- Of the 209 West Angelas ABA samples within the environmental geochemical database:
    - 19 samples were classified as potentially acid forming (PAF). Ten of these PAF samples are low-moderate sulfur samples (0.09-0.17 wt%S); 13 WF samples, 5 MM samples, and 1 DOR sample.
    - ANC is generally low with median values ≤3 kg H_2SO_4/t for most stratigraphies and low-moderate (7 kg H_2SO_4/t) for the ALL and BIF samples. ABCC results suggest that ANC is readily availability in the ALL, DET, and WF samples. Variable ANC availability was observed in the 15 MM samples tested ($ENC_{4.5}$ 18-153% of titrated ANC) suggesting an inconsistency in the presence of fast reacting carbonate ANC.
    - Median NAPP values are negative for all stratigraphy groups. Reflective of Pilbara iron ore deposits with low sulfur and low ANC, median NAPP values are only slightly negative (-6 to -0.5 kg H_2SO_4/t).
- Extensive assay sampling has identified several elements (As, Cr, Fe, Pb, and Sn) enriched relative to average crustal abundances. Acid digestion testing on a subset of samples identified additional elements (B, S, Sb, and Se) to be enriched. However, enrichment does not imply mobility at concentrations harmful to a given receptor.
- Generally, mobility of trace elements is low with leachates slightly acidic to alkaline (5.8-8.9) and containing low to moderate salinity (21-889 µS/cm). Fe, Mn, Si, and Zn were the only elements measured above 1 mg/L.

- No waste rock within the mining models was assigned by RTIO a sulfide risk rating or 3 (e.g., high AMD risk classification; *BS-HOT*). No unoxidised black shale is predicted for any of the deposits (to be mined or to remain in final pit surfaces).

- 3.4 Mt of *BS-COLD* waste rock is predicted (0.1% of the total waste rock). Deposit D (44.5%), Deposit J (45.3%), and Deposit A (9%) contain the greatest quantities of predicted BS-COLD tonnages. FWZ (142 Kt) and MCS (1,306 Kt) waste rock classified as BS-COLD, typically higher AMD risk lithologies, is predicted from Deposit J. However, TS is low for these waste blocks (median and average TS <0.1 wt%S) and is predicted within pits 1, 2, and 3, at elevations of 776-936 mRL. Exposures of FWZ and MCS BS-COLD material are predicted for Deposit J (136,270 m^2); approximately 8% of the total final pit surface area for Deposit J.

- 145 Mt of *BS-OXIDE* waste rock is predicted, representing 5.2% of the total West Angelas waste rock. *BS-OXIDE* waste rock is expected from all deposits except the B, C, and D deposits. Deposit J (28%) and Western Hill (54%) contain the greatest quantities of predicted BS-OXIDE tonnages. All MCS and FWZ waste blocks classified as BS-OXIDE are from Deposit J and Western Hill and are generally low TS waste blocks. BS-OXIDE (MCS and FWZ only) exposures are predicted for Deposit J and Western Hill (35,820 m^2 and 52,370 m^2 respectively); approximately 2% of the total final pit surface area for both deposits.

- As presented in the below table, combined hazard scores for Deposit A, Deposit A West, Deposit B, Deposit C, Deposit D, Deposit E, Deposit F, Deposit G, Deposit H, and Mount Ella East Extension are low. Combined hazard scores for Deposit J and Western Hill are moderate. Although these deposits have a moderate risk score, minimal below water table mining is expected and any measured sulfur is likely sulfate.

DEPOSIT	PRELIM. SCORE	DETAILED SCORE	COMBINED SCORE	RISK RANKING
Deposit A	52	15	28	LOW
Deposit A West	44	15	26	LOW
Deposit B	48	16	28	LOW
Deposit C	49	17	29	LOW
Deposit D	45	17	28	LOW
Deposit E	45	17	28	LOW
Deposit F	43	15	26	LOW
Deposit G	39	15	25	LOW
Deposit H	39	17	27	LOW
Deposit J	44	20	31	MODERATE
Mount Ella East Extension	29	18	25	LOW
Western Hill	51	19	32	MODERATE

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1 INTRODUCTION

Mine Waste Management Pty Ltd (MWM) has prepared this acid and metalliferous drainage (AMD) source hazard risk assessment for Rio Tinto Iron Ore's (RTIO's) West Angelas Mine (West Angelas). This report has been prepared with consideration to RTIO's internal AMD source hazard risk assessment method, including *RTIO's AMD Risk Assessment Summary Sheet* (Appendix A) and *ARD Hazard Score Sheet* (Appendix B). This report was completed in accordance with the proposal J-AU0122-002-P-Rev0 (31 August 2020) provided to RTIO.

1.1 Objectives

The primary objectives of the work completed were:

- To complete an AMD source hazard risk assessment for West Angelas to support a mine closure plan (MCP) for the operations.
- Highlight any AMD at-risk geological materials requiring management during operations and into closure.

1.2 Scope of Work

The scope of work completed to achieve the objectives were:

- Provide a draft table of contents for approval by RTIO personnel.
- Liaised with key RTIO personnel to collect the necessary datasets.
- Reviewed provided data.
- Assessed AMD source hazard risk as per RTIO's standard approach (*RTIO AMD Risk Assessment Summary Sheet*; Appendix A). This included interrogation of West Angelas:
    - assay database:
    - environmental geochemical dataset; and
    - mining models.
- Estimated the potential surface area exposures of black shale to remain on final pit surfaces.
- Updated RTIO's ARD Hazard Score Sheets for West Angelas by incorporating up-to-data assay data, environmental geochemical data, and mine plans.

Prepared a report that includes site background information, identified potential pathways and receptors, assessment results from the assay database, environmental geochemical dataset, and mining model interrogation.

2 BACKGROUND INFORMATION AND SURROUNDING ENVIRONMENT

The following section provides relevant background information for West Angelas.

2.1 Site Location and Description

The West Angelas Operations are located approximately 130 km west of Newman in the Pilbara region of Western Australia. For this assessment, a total of 12 deposits encompassing 37 pits, for which mining models and pit shells were provided, were included in the assessment (Figure 1).

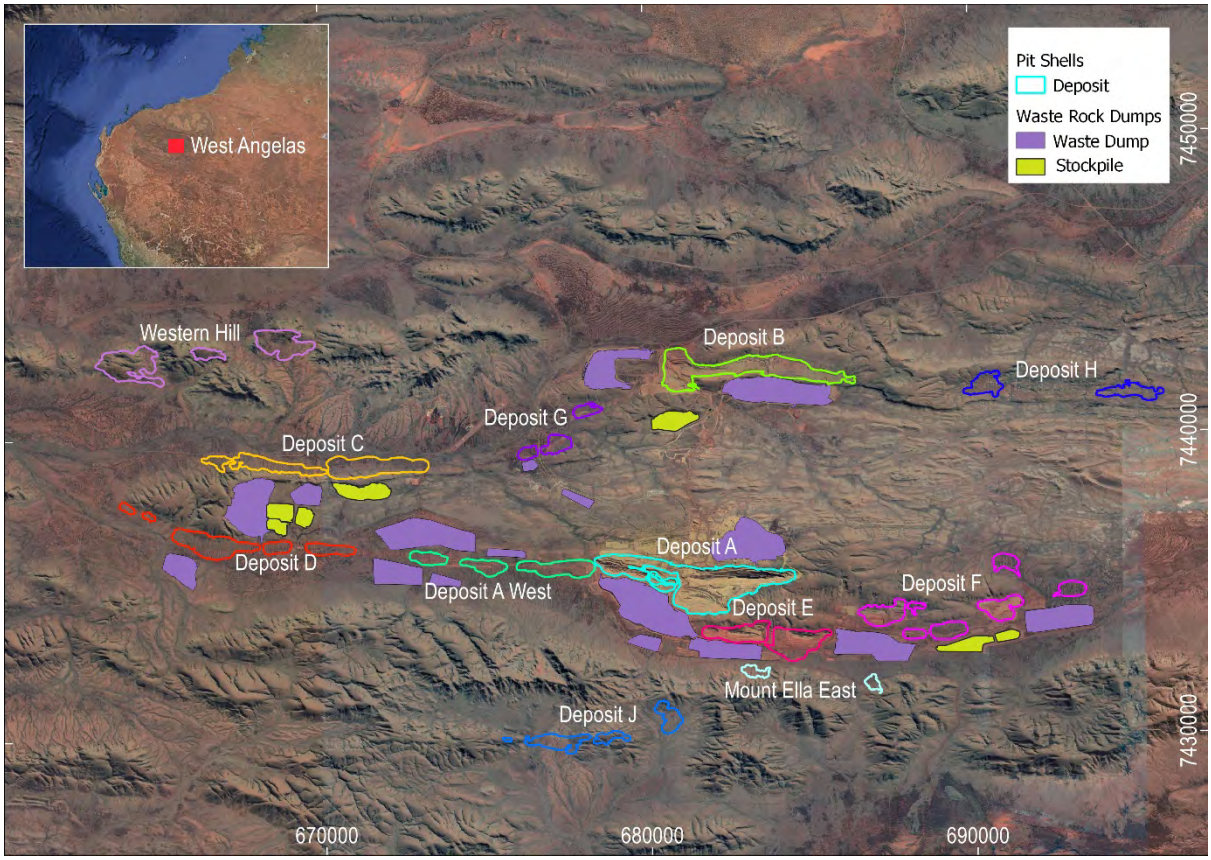

Figure 1: Location of deposits, pit shells, waste rock dumps, and ore stockpiles within the West Angelas mining area.

West Angelas has been mined for iron ore since 2002 by conventional open-cut drilling, blasting, loading and hauling methods. Waste rock is transported to designated waste rock dumps (WRDs) and iron ore is crushed and processed on site before being transported by rail link to the Cape Lambert port for export.

Indicative life of mine material quantities for West Angelas are presented in Table 1. Waste rock quantities are split as above water table (AWT) and below water table (BWT) quantities.

Table 1. Indicative mining material quantities for West Angelas (RTIO, 2018a and mining models).

DEPOSIT	NUMBER OF PITS	PIT MATERIAL (Mt)		
		ORE	$WASTE_{AWT}$	$WASTE_{BWT}$
Deposit A (DepA)	2	758	1,061	114
Deposit A West (DepA West)	3	42	178	3
Deposit B (DepB)	1	178	345	4
Deposit C (DepC)	3	85	122	21
Deposit D (DepD)	5	71	162	45
Deposit E (DepE)	2	69	249	31
Deposit F (DepF)	7	88	213	<1
Deposit G (DepG)	3	32	53	2
Deposit H (DepH)	2	43	25	<1
Deposit J (DepJ)	4	51	65	<1
Mount Ella East (MTEE)	2	16	15	<1
Western Hill (WSTH)	3	182	149	<1

2.2 Regional Geology

Regional geology is characterised by late Archean to Paleoproterozoic sedimentary and volcanic rocks of the Hamersley Basin. The Hamersley Basin consist of three groups including the Fortescue, the Hamersley and the Turee Groups.

The Fortescue Group presents the oldest sequence and is comprised of sedimentary and volcanic rocks. The Hamersley Group overlie the Fortescue Group and contains units of banded iron formations (BIF) that characterise the Hamersley Basin. In addition to containing BIF, the Hammersley Group includes chert, dolomite, siltstone and mudstones. The Turee Group presents the youngest geological sequences of the aforementioned groups and is comprised of sandstone, siltstone, diamictite and dolostone (Geoscience Australia, 2020). Following a series of late Archaean to Proterozoic tectonic events the geological deposits became folded and faulted with dolerite dyke swarms intruding the formations in the region.

A stratigraphic column of the Hammersley Group, which hosts the ore bodies mined at West Angelas, is presented in Figure 2.

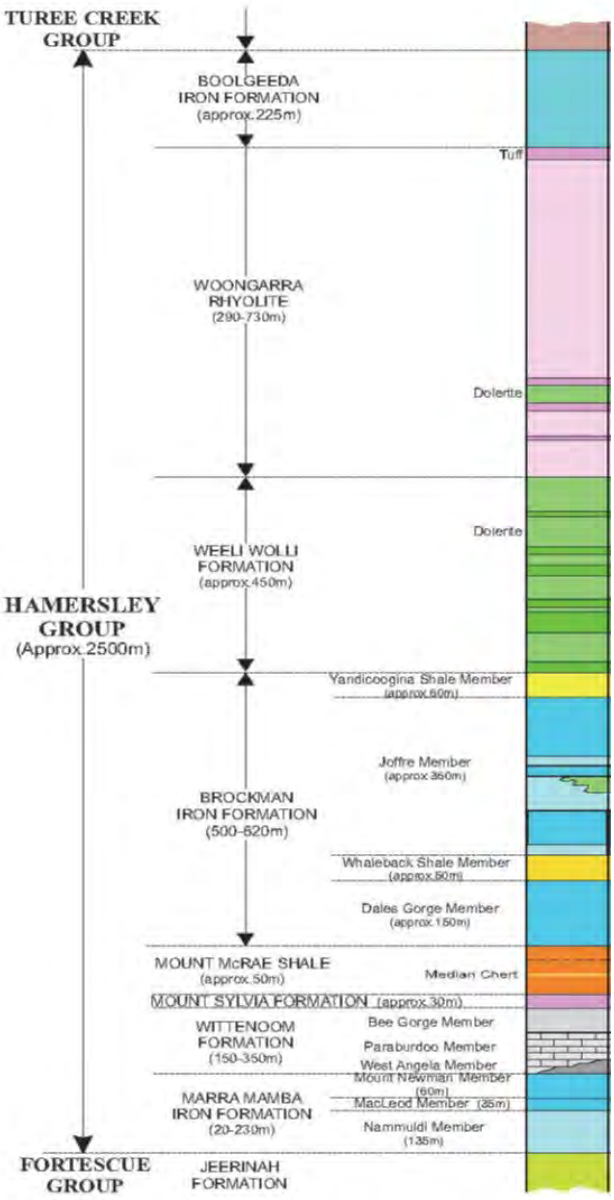

Figure 2: Stratigraphic column for the Hamersley (Green & Borden, 2011).

2.3 Local Geology

The West Angelas project area includes sixteen discrete areas of mineralisation. These deposits lie on the limbs of the east-west trending, west plunging Wonmunna Anticline located in the eastern part of the Ophthalmia Fold Belt. The West Angelas deposits, are comprised mainly of the Marra Mamba Iron Formation with mineralisation occurring in both NE1 and NE2 of the Mt Newman Member. Mineralisation is found in limited quantities in the Macleod Member and the lower portion of the West Angelas Member below AS3. Tertiary Detrital material derived from both the Marra Mamba and Brockman Iron Formations also accumulates throughout the project area.

Material from the MacLeod and Mt Newman Members of the Marra Mamba Iron Formation has been observed to contain pyrite and based on drill hole assay data material from the MacLeod and Nammuldi Members are expected to pose a low to moderate risk of AMD (RTIO 2016).

Deposits A, D, E F, and J are located on the southern limb of the Wonmunna anticline and Deposits B, C, G and H are located along the northern limb (RTIO, 2010). A geological cross section of Deposit A is presented in Figure 3.

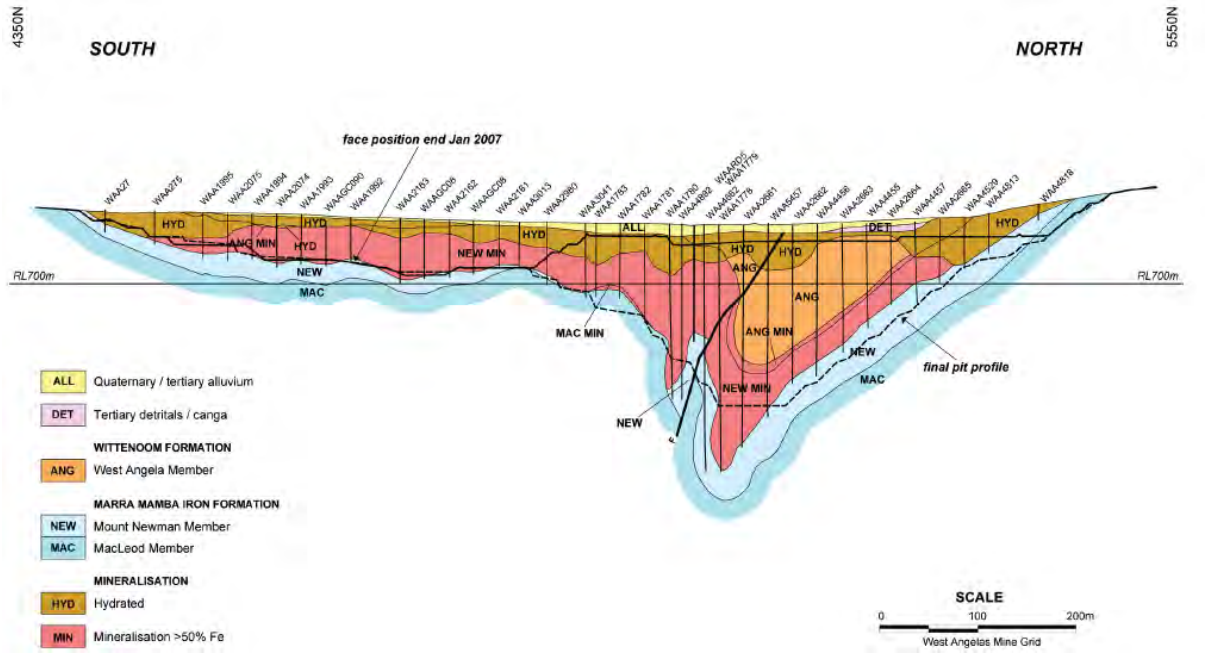

Figure 3: Cross-section of Deposit A – looking west (RTIO, 2010).

2.3.1.1 Deposit A (2 Pits)

Deposit A is situated on the Southern Limb of the Wonmunna anticline. Mineralisation occurs within second order synclines. It has a strike length of 6.5 km and varies in width from 400 m to 1,500 m. Most of the iron enrichment occurs in the upper two thirds of the Mt Newman Member of the Marra Mamba Iron Formation, with minor mineralisation in the lower 6 m of the overlying West Angela Member of the Wittenoom Formation.

2.3.1.2 Deposit A West (3 Pits)

Deposit A West, sits on the southerly limb of the west plunging, east west trending Wonmunna Anticline. It strikes west for approximately 6.4 km from the western extent of A Deposit. Bedding at Deposit A West is typically dipping south at approximately 35 degrees and characterised by minor folding along the strike. Mineralisation in Deposit A West is predominately contained in the Mt Newman Member, mostly in the N2U and N2L layers. Mt Newman Member mineralisation is typically goethite-hematite rich material. Detrital units are typically low grade with thick clay and waste, with minor amounts of mineralised limonitic and mature detrital.

2.3.1.3 Deposit B (1 Pits)

Deposit B is located on the northern limb of the Wonmunna anticline. The strike length is approximately 7.6 kilometres long and is structurally complex, existing as a doubly plunging syncline that is truncated by two shallow dipping thrust faults to the West. High-grade hematite-goethite mineralisation occurs generally in the Mt Newman Member of the Marra Mamba Iron Formation. Lower grade mineralisation occurs occasionally within the lower West Angela Member of the Wittenoom Formation and in the MacLeod Member of the Marra Mamba Formation. Detrital mineralisation is discrete occurring as pods in paleo-channels.

2.3.1.4 Deposit C (3 Pits)

Deposit C is in the eastern part of the Ophthalmia Fold Belt, sitting on the western closure of the northerly limb of the west plunging, east west trending Wonmunna Anticline. The strike length is approximately 8 km. The deposit has two distinct regions, the east is relatively simple, with bedding typically dipping north at approximately 30 degrees and is characterised by minor folding along strike. In the west, bedding becomes strongly folded. Bedding mineralisation in the deposit is typical Marra Mamba sequence, with thick Wittenoom Formation shale, into Mt Newman, McLeod and Nammuldi Members. Mineralisation is typically goethite-hematite rich material that is predominately contained in the Mt Newman member, primarily in the N2U and N2L layers. Hydrated, bedded mineralisation and detritals cover much of the deposit. The detrital units intersected are generally of a lower grade and are pisolitic or limonitic in lithology.

2.3.1.5 Deposit D (5 Pits)

West Angelas Deposit D is in the eastern part of the Ophthalmia Fold Belt and sits on the western closure on the southerly limb of the Wonmunna Anticline. It strikes for approximately 15 km from the nose of the fold to the western most extent of Deposit A. Structurally, Deposit D has two distinct regions. The eastern region is relatively simple, with bedding typically dipping south at approximately 35 degrees and characterised by minor folding along strike. In the west, bedding becomes somewhat more complicated with a synclinal structure interpreted. Bedding in the deposit is typical Marra Mamba sequence, with thick Wittenoom Formation shales, into Mt Newman, McLeod and Nammuldi Member. The Mt Newman Member makes up most of the resource material with the N2U and N2L preferentially mineralised when compared to the NE1. Newman mineralisation is hematite and goethite rich, with variable amounts of hydrated material recorded close to surface.

2.3.1.6 Deposit E (2 Pits)

The West Angelas Deposit E is situated on the southern limb of the west plunging, east-west striking Wonmunna Anticline. The deposit extends approximately 3.5 km in strike, 300 m in width, with varying thickness of 45 m to 60 m. Deposit E is defined by strong folding and faulting of the West Angela Member and the underlying Marra Mamba Iron Formation. Most of the bedded mineralisation occurs within the Mt Newman Member of the Marra Mamba Iron Formation. This mineralisation occurs predominantly within the NE2 unit with occasional low-grade enrichment within the NE1 unit. Minor low grade (>50% to <58% Fe) to high grade (>58% Fe) mineralisation occurs within the West Angela Member.

2.3.1.7 Deposit F (7 Pits)

Deposit F is located on the southern limb of the anticline, approximately 5 km ESE of Deposit A and abuts Deposit E to the east. The orebody has an interrupted geometry of approximately 7.5 km in strike length and up to 1 km in width. Mineralisation is found in the tertiary mature detritals that blanket the paleo-topography, as well as the E-W striking folded Marra Mamba Iron Formation, with economic interest focussed on the mineralised Mt Newman Member. The iron ore resource at Deposit F North is found within tertiary mature detritals that blanket the paleo-topography and in the E-W striking folded Marra Mamba Iron Formation. Mature detritals intermittently overlie a hydrated bedded material that transitions into mineralised Mt Newman and sometimes the Macleod Member. Immature detrital, clay and quaternary alluvial material overlies the mineralised zone with thicknesses from 2 to 80 metres.

2.3.1.8 Deposit G (3 Pits)

The West Angelas deposits lie within the east-west fold belt associated with the Wonmunna Anticline, part of the Archean-Proterozoic Ophthalmia Fold Belt. The bedded mineralisation in the deposit is divided into a northern orebody and a southern orebody that is separated by the northern fault. The Northern orebody is present mostly under cover and is constrained by synclinal structure which gently plunges to the west. The Southern orebody is northerly dipping, getting steeper as you go west. It is localised within a series of antiform and synform structures within an interpreted graben structure which is controlled by two WNW-ESE trending normal faults in the area. Most of the bedded mineralisation occurs within the Mt Newman Member of the Marra Mamba Iron Formation. The Mt Newman Member makes up the majority of the resource material with the NE2 (N2U and N2L) preferentially mineralised when compared to NE1. Enrichment within the Mt Newman Member nearly always extends at least to the base of NE2.

2.3.1.9 Deposit H (2 Pits)

Deposit H is the eastern most West Angelas deposit on the northern half of the Wonmunna Anticline. The 5.5 km long deposit is approximately 3.5 km east of adjacent Deposit B, and 9 km north-east of infrastructure at West Angelas Mine. Geologically Deposit H is similar to the eastern part of Deposit B, with the majority of mineralisation occurring in the limbs of the anticline, with limited mineralisation in the surrounding hills. Structurally Deposit H is an asymmetric doubly plunging syncline of mineralised and unmineralised Marra Mamba Members. Bedded mineralisation is primarily observed in the upper Newman Members, with low grade material also found in the West Angela Shale and MacLeod Members. Detritals are primarily unmineralised.

2.3.1.10 Deposit J (4 Pits)

Deposit J lies on the southern limb of the Wonmunna Anticline. Locally the area contains a series of tight E-W striking parasitic folds. The deposit is divided into an Eastern and Western side by an open colluvium valley. The stratigraphic sequence of the Eastern Hill includes a strongly folded sequence of Mt Sylvia to Joffre. On the Western side of the colluvium valley, the Dales Gorge and McRae Shale outcrop as a series of tight upright to overturned folds. Mineralisation is discontinuous and generally confined to the Dales Gorge Member with isolated patchy mineralisation in the Joffre Member and Whaleback members.

2.3.1.11 Mount Ella East (2 Pits)

Mount Ella East (MTEE) is predominantly a detrital deposit. It is a mostly concealed deposit with some altered Brockman mapped in the hills to the south. Mineralisation occurs in layers of variably pisolitic/magnetic detritals, hematite-rich with siliceous clay matrix, overlying a distinctly limonitic/goethitic detrital sequence. There are some pods of general mature detritals, pisolitic waste, and internal or basal clay.

2.3.1.12 Western Hill (3 Pits)

Western Hill (WSTH) lies along the Northern limb of the Wonmunna Anticline, and consists predominantly of lower Brockman Iron Formation rocks, flanked by secondary detrital deposits.

2.4 Climate

The region is predominantly arid to semi-arid with hot summers and mild winters. The area receives summer rainfall, typically associated with episodic events such as tropical depressions or cyclones.

Average annual rainfall has been reported as 341 mm for rainfall records between 2005 and 2018 (RTIO, 2019). Due to the episodic nature of these rainfall events annual rainfall would be expected to have significant variation from year to year. The annual mean Class A pan evaporation rate is expected to range between 3,200 and 3,600 mm per year based on an average evaporation map produced by the Bureau of Meteorology (BOM, 2006).

2.5 Hydrogeology

The mineralised Mt Newman Member of the Mara Mamba Iron Formation and the Wittenoom Formation (where mineralised or weathering has occurred) has been identified as the main aquifers at West Angelas. The low permeability basal units of the Mara Mamba Iron Formation (consisting of the un-mineralised MacLeod and Nammuldi Members) are in turn considered to form a hydraulic barrier to groundwater flow (RTIO, 2018a). Similarly, the mudstone, basalt and shale of the Jeerinah Formation (Fortescue Group) would be expected to have low permeability generally presenting an aquitard (RPS, 2015).

In general groundwater flow is expected to be from east to west at the majority of mining areas. A dolerite dyke located between Deposit C2 and C3 is considered to present a potential groundwater divide, with groundwater flow at Deposit C3, G and B being from the west to the east (RTIO, 2018a). For deposits where dewatering is required for open pit mining, localised groundwater flow will be expected to be towards the pits and dewatering bores/dewatering sumps.

Based on groundwater quality data from Deposit A, groundwater is circumneutral to slightly alkaline (with reported pH values between 7.4 and 8.2). Salinity levels are low to moderate, with reported total dissolved solids concentrations between 490 and 820 mg/L (RTIO, 2018a).

2.6 Surface Water

The majority of the West Angelas deposits (including Deposits A, A West, B, C, D, E, the four western pits of Deposit F, Deposit G, MTEE and WSTH) are located within the upper reaches of the Turee Creek catchment that forms part of the Ashburton River catchment. Deposit F straddles the Turee Creek and Weeli Wolli catchments, with the three eastern pits of Deposit F located in the upper reaches of the Weeli Wolli Creek catchment that forms part of the Upper Fortescue River catchment (RTIO, 2018a). Deposit H is also located within the catchment of Weeli Wolli Creek, on an adjacent tributary to that draining Deposit F (Pebble Mouse Creek). Deposit J is located within the Angelo River Catchment, a tributary of the Ashburton River (Figure 4; Table 2).

All WRDs and ore stockpiles are within the Turee Creek East catchment, except for the eastern most WRD and eastern most ore stockpile for Deposit F, which are within the Weeli Wooli Creek catchment (Table 2).

Turee Creek East (the eastern branch of the Turee Creek) is the most significant named watercourse in the area and flows generally west across the West Angelas operation. Turee Creek East continues west south-westerly, through the Karijini National Park before merging with Turee Creek that ultimately drains into the Ashburton River (RTIO, 2018a). The confluence of Turee Creek and the Ashburton River is located more than 100 km from the West Angelas deposits.

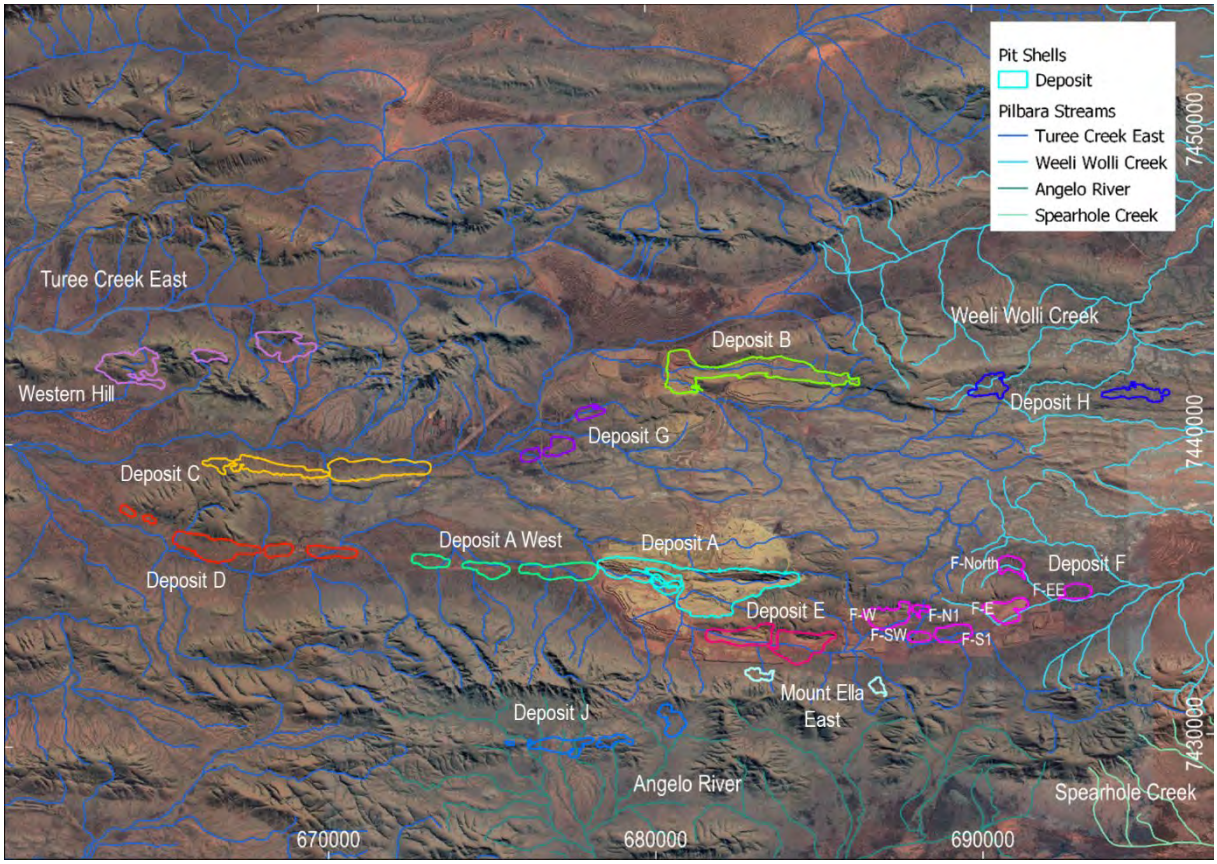

Figure 4. Surface water features which drain the West Angelas deposits.

Table 2. Mine domains per catchment.

DEPOSIT	PITS	WRDS OR STOCKPILES	CATCHMENT
DepA	DEPA	wadf_hydrated_dump_fs_astipped	Turee Creek East
DepA West	AW1; AW2; AW3	awest_hyd2_new_cut; awest_hyd1_new_cut; awest_dump_adjusted_cut; awest_lg_new_cut	
DepB	DEPB	depb_wwd_uwf02; depb_lg_uwf01; depb_ewd_uwf09	
DepC	C1; C2; C3	c_fs_wd1_cf; c_fs_lga-lgs_cf; c_fs_hga_cf,	
DepD	D1; D2; D3; D4; D5	d_fs_wd3_cf; d_fs_wd2_cf_v3; d_fs_lgs_cf_v3; d_fs_lga_cf_v3	
DepE	E-East; E-West	dewd_uwf01; desd_uwf02.1	
DepF	F-W; F-N1; F-SW; F-S1	wadf_west_dump_fs_astipped_opt3_cut; wadf_lg_dump_fs_astipped_cut	
DepG	G1; G2	depg_wd_2_v2; deg_wd_3	
MTEE	MTEE-East; MTEE-West		
WSTH	Pit1; Pit2; Pit3		
DepF	F-North; F-E; F-EE	wadf_east_dump_fs_astipped_cut, swd_uwf15	Weeli Wolli Creek

DEPOSIT	PITS	WRDS OR STOCKPILES	CATCHMENT
DepH	H-East; H-West		Weeli Wolli Creek (via Pebble Mouse Creek)
DepJ	Pit1; Pit2; Pit3; Pit4		Angelo River

Due to evaporation generally far exceeding rainfall, rainfall events below approximately 20 mm tend to be insufficient to generate runoff (RPS, 2015). Consequently, creek flow is ephemeral, diffuse recharge to regional groundwater systems occur at low rates and groundwater recharge occurs predominantly during rainfall runoff events along the main creeks and areas of surface water concentration (such as surface water pools). In order to manage flood flows, stream diversion infrastructure has been constructed at Deposit B and Deposit F. Diversion channels at Deposit C and Deposit D are proposed (RTIO, 2018a).

Surface water flows along Turee Creek East naturally pond behind Mt McRae Shale outcrops that cross the creek, which result in the formation of surface water pools that persist for an extended period of time following flow events in the ephemeral creek (RTIO, 2018a). The closest semi-permanent or permanent surface water feature is Paperbark Spring on Turee Creek East, located more than 60 km from West Angelas (RTIO, 2018b).

Surplus dewatering water, exceeding operational water demand, is discharged to Turee Creek East under Licence L7774/2000. While the licence allows for discharge of up to 6 GL/a, discharge reportedly rarely exceeds 30% of the licenced limit (RTIO, 2018b).

2.7 Water Supply and Groundwater Use

The mine borefield provides water for operations with groundwater licenced to be abstracted under Groundwater Licence GWL 98740. The abstraction licence was issued under the *Rights in Water and Irrigation Act 1914* (the RIWI Act) and includes abstraction for dewatering and water supply purposes. Water uses include dust suppression, water for earthwork and construction purposes, exploration drilling operations, industrial processing and power plant supply. The licence allows for abstraction of up to 5.38 GL/a. The production bores associated with the mine borefield are located within close-proximity and within deposit A, B, E and F (RTIO, 2019).

Potable water for the West Angelas operations is supplied through the Turee B Borefield, located approximately 35 km west of the mine operations. Water is abstracted under groundwater Licence GWL 103136 issued under the RIWI Act, with the licence allowing for the abstraction of approximately 3.1 GL/a of water for potable use (RTIO, 2018b).

2.8 Groundwater Dependant Ecosystems

RTIO has identified potential groundwater dependant ecosystem (GDE) within the alluvial channel of Turee Creek East, located within the Karijini National Park. As presented in Figure 5, the potential GDE is located approximately 7 km to the west and downgradient of Deposit C (RTIO, 2018a).

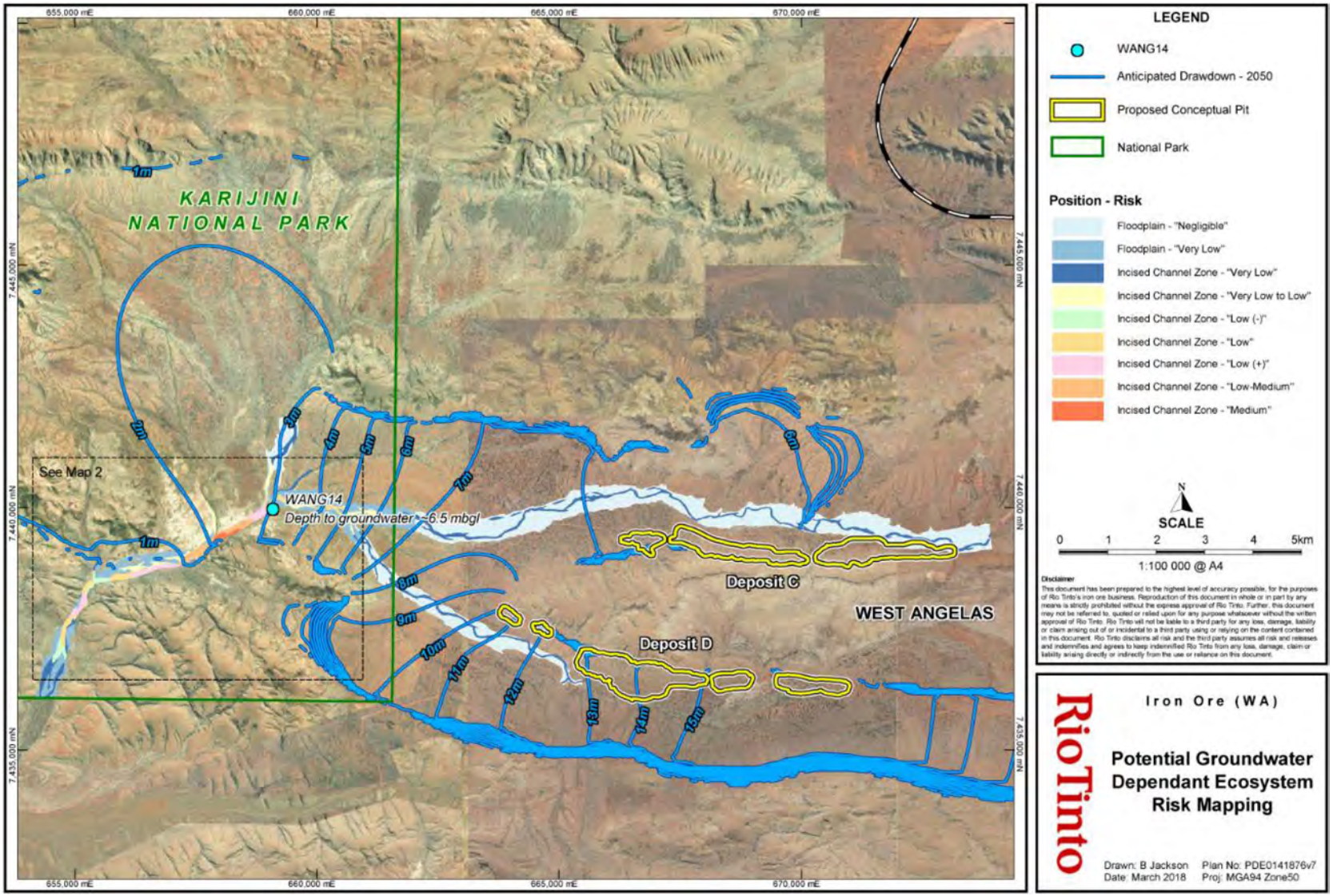

Figure 5. Potential Groundwater Dependent Ecosystem risk mapping (*taken from* RTIO, 2018).

3 AMD SOURCE HAZARD ASSESSMENT METHODS

The following section details the methods employed to assess the AMD source hazard risk for the West Angelas Operations. An introduction to AMD basics and standard methods is provided in Appendix C.

For the purpose of this assessment, AMD is defined in accordance with *Preventing Acid and Metalliferous Drainage – Leading Practice Sustainable Development Program for the Mining Industry* (DITR, 2016), that is, acid and metalliferous drainage (AMD), which includes acidic drainage (acid rock drainage; ARD), pH neutral metalliferous drainage (NMD), and saline drainage (SD), is generally caused by the oxidation of sulfide minerals, or the leaching of secondary sulfide oxidation products. Potential sources of AMD are sulfide minerals within fresh rock (e.g., pyrite, FeS_2) and/or soluble or sparingly soluble secondary acid generating sulfate minerals within partially weathered rock (e.g., melanterite, alunite, jarosite).

The types of AMD, can be defined as:

- Acidic Drainage: A form of AMD, characterised by low pH, elevated trace metal/metalloid concentrations, high sulfate concentrations and high salinity.
- Neutral-Metalliferous Drainage (NMD): A form of AMD characterised by near-neutral pH, elevated metal/metalloid concentrations, and high sulfate salinity.
- Saline Drainage (SD): A form of AMD, characterised by high sulfate salinity but near-neutral pH and low concentrations of metals/metalloids.

3.1 Supplied Data

MWM reviewed the provided data in the context of identifying potential AMD source hazards as well as already identified, by RTIO, pathways and receptors. Table 3 presents the data sources provided.

Table 3. Data sources provided.

DATA SOURCE TYPE	FILE NAME
Env. Geochem. Database (Nov 2019)	• RTIO- POWER-BI-DATASHEET.xlsx
Previous Geochemical Characterisation Programs	• Acid Gen. Potential, Selected Core Samples Mt Newman Member BIF (Golder Associates, 1998); • ARD Characterisation of West Angeles Sample (ANSTO, 2007); • Geochem. charact. of Paraburdoo Lens 2, Dales Gorge and West Angelas Samples (SRK, 2008); • Geochem. Charact. of Banded Iron Formation Samples from the West Angelas Mine (SRK, 2010); • Geochemical Assessment of Samples from West Angelas (EGi, 2013); • Geochemical Characterisation of Waste Rock from West Angelas Deposit F (EGi, 2014); and • Greater West Angelas AMD Risk Assessment (RTIO, 2016).

DATA SOURCE TYPE	FILE NAME	
Groundwater Reports and Supporting Data	• Triennial Aquifer Review 2016 – 2018 (RTIO, 2019); • AHGF_Mapped_Stream_Major.shp; and • AHGF_Mapped_Stream_Minor.shp.	
Closure Plan	• West Angelas Closure Plan (RTIO, 2018)	
Assay Database Exports (Sept 2020)	• DEPA_2020geolSampleDetails.csv; • DEPAW_2020geolSampleDetails.csv; • DEPB_2020geolSampleDetails.csv; • DEPC_2020geolSampleDetails.csv; • DEPD_2020geolSampleDetails.csv; • DEPE_2020geolSampleDetails.csv;	• DEPF_FN_2020geolSampleDetails.csv; • DEPG_2020geolSampleDetails.csv; • DEPH_2020geolSampleDetails.csv; • DEPJ_2020geolSampleDetails.csv; • MTEE_2020geolSampleDetails.csv; and • WSTH_2020geolSampleDetails.csv.
Mining Models	• waapr2_DepA_20161026_004.bmf; • waapr2_DepA_20191025_014.bmf; • waepr_DepB_20200324_007.bmf; • waepr_DepC_20200218_007.bmf; • waepr_DepE_20181016_025.bmf; • waipr_DepAwest_20190715_015.bmf; • waipr_DepD_20200702_003.bmf;	• waipr_DepF_20200123_019.bmf; • waipr_DepG_20191126_032.bmf; • waipr_DepH_20200129_005.bmf; • waipr_DepJ_20180618_011.bmf; • waipr_mtee_20180605_002.bmf; and • waipr_whill_20200113_006.bmf.
Mining Model Exports (clipped to pit shells)	• waapr2_DepA_20161026_004.csv; • waapr2_DepA_20191025_014.csv; • waepr_DepB_20200324_007.csv; • waepr_DepC_20200218_007.csv; • waepr_DepE_20181016_025.csv; • waipr_DepAwest_20190715_015.csv; • waipr_DepD_20200702_003.csv;	• waipr_DepF_20200123_019.csv; • waipr_DepG_20191126_032.csv; • waipr_DepH_20200129_005.csv; • waipr_DepJ_20180618_011.csv; • waipr_mtee_20180605_002.csv; and • waipr_whill_20200113_006.csv.

DATA SOURCE TYPE	FILE NAME	
Pit Shells and Spatial Files	• AW1_CF11_surface.shp; • AW2_CF10_surface.shp; • AW3_CF07_surface.shp; • C1S1_PIT_UF_06_surface.shp; • DEPA_UF21.0.2_osurface.shp; • DEPC_C2_UF03_surface.shp; • DEPC_C3_UF09.1_surface.shp; • DEPD_D2_UF01_surface.shp; • DEPD_D3_UF01_surface.shp; • DEPD_D4_UF01_surface.shp; • DEPD_D5_UF01_D5_surface.shp; • DEPE_UF16.5.3_surface.shp; • DEPE_UF16.5.3_WEST_surface.shp; • DEPG1_REV3_surface.shp; • DEPG2_REV6_surface.shp; • DEPH_EAST_US100_CUT_surface.shp;	• DEPH_WEST_US100_CUT_surface.shp; • DEPJ_SH32_V3_surface.shp; • DFE_UF202C_surface.shp; • DFEE_UF100_surface.shp; • DFN1_CF02.7_surface.shp; • DFS1_UF2.7_surface.shp; • DFSW_UF100_surface.shp; • DFW_CF2.6.5_surface.shp; • FNORTH_UF101_CUT_surface.shp; • MTEE_SH21_V2_surface.shp; • WA_DEPG3_UF05_surface.shp; • WAB_UF17.10_surface.shp; • WAD_D1_UF1._surface.shp; • whill_sh23_awt_surface.shp; and • WPS_CUTBACK_OP7_surface.shp.

3.2 AMD Source Hazard Risk Assessment Method

RTIO has developed an internal process for assessing AMD source hazard risk, which is detailed in *Geochemical Risk Assessment Process for Rio Tinto's Pilbara Iron Ore Mines* (Green and Borden, 2011) and in *Mineral Waste Management in the Pilbara: A Position Statement* (Brown, 2012). A risk-based process is used to identify those rock types which require specific management to mitigate the impacts associated with AMD (RTIO, 2016).

Mineral waste is defined as waste rock and tailings that are exposed or produced during operations. The innate AMD hazard associated with a project area and its type of mineral waste is assessed by the *AMD Hazard Score* (Appendix B). This score takes into account geology/geochemistry, incipient risk, the scale of disturbance, transport pathways, and receiving environments. It should be noted that the AMD Hazard Score used here has been modified specifically for RTIO Pilbara operations to be more reflective of conditions at those sites; for instance, an iron ore operation may score as posing a high AMD hazard relative to other RTIO operations, however it may only pose a moderate AMD hazard relative to a copper operation (RTIO, 2016).

It is recognised that sulfur-related AMD includes acid drainage (elevated sulfate and metals/metalloids at low pH), neutral drainage (elevated sulfate and metals/metalloids at near-neutral pH), and saline drainage (elevated sulfate at near-neutral pH) (INAP, 2010; DITR, 2016). For those rock types associated with sulfides or some sulfate minerals, it is understood that metalliferous drainage requires, at a minimum, low-pH conditions on a microscopic scale as a mechanism to initially solubilise contaminants. If the potentially acid forming (PAF) rock also has sufficient acid neutralising capacity (ANC), the acid generated is subsequently neutralised; however, as a result of this reaction, concentrations of some contaminants (e.g., Zn, As, Ni, and Cd) do not precipitate at near-neutral pH, and remain in solution resulting in poor-quality drainage (DITR, 2016). An analysis of total sulfur in mineral waste will identify the likelihood for that rock type to generate acidity which may lead to poor quality drainage characterised by both low-pH and near-neutral pH (RTIO, 2016).

With regards to sulfur-related AMD as defined above, RTIO characterises mineral waste by undertaking a geochemical assessment based on an analysis of total sulfur assay values. Sulfur trigger values have been pre-determined by RTIO based on the results of static ABA, mineralogy, and kinetic column leach tests which RTIO has completed over multiple decades to identify the potential for certain rock types to generate acidity. These tests have been completed by RTIO using nationally and internationally recognised methods (e.g., Sobek, 1978; Miller, 1997, as referenced in Maest et al. (2005); AMIRA, 2002) (RTIO, 2016).

RTIO has previously concluded that existing ABA data for Pilbara-wide black MCS confirms that a sulfur cut-off of 0.1 wt%S could be adopted as the boundary value to delineate acid forming waste rock and tailings from inert/non-acid forming (NAF) waste rock and tailings. RTIO refers to black MCS with sulfur values generally less than 0.1 wt%S as cold black MCS[1], where black MCS with sulfur values generally greater than 0.1 wt%S is referred to by RTIO as hot black MCS. The latter may pose a moderate to high acid drainage risk, depending on the actual sulfur (sulfide) content. For other lithologies such as BIF and detrital rock types, a 0.3 wt%S value was determined by RTIO as the most appropriate trigger value (Brown, 2008). The applicability of this higher trigger value is based on low net acid generation derived from sulfate minerals and relatively high ANC (RTIO, 2016). Therefore, sulfur cut-off levels of both 0.1 wt%S and 0.3 wt%S are considered for the purpose of this assessment.

In oxidised waste rock and tailings, sulfur is likely present as either non-acid generating sulfate (gypsum-type sulfur) or acid generating sulfate (alunite-type sulfur). Although alunite-type sulfur through dissolution can generate acidity, it generates less acidity than sulfide-type sulfur per molar equivalent and can be kinetically constrained. However, to account for this potential low-capacity acidity source, a sulfur cut-off value of 0.1 wt%S in oxidised samples is used by RTIO to designate waste rock and tailings as having elevated sulfur.

3.2.1 Acidic Drainage Potential

The key data sources interrogated were the geological assay database, the mining model, the proposed pit shell, and the environmental geochemical dataset. The assay and mining model assessment was restricted to material within the bounds of the proposed pit shell as well as material to remain in the pit wall following mining.

The environmental geochemical dataset was used to assess the geochemical properties of key materials via standard industry AMD characterisation procedures (Appendix C). Acid base accounting (ABA) was conducted to predict the acid generation characteristics of a waste rock material through determination of the acid neutralising capacity (ANC) and the maximum potential acidity (MPA). The environmental geochemical dataset was assessed to facilitate the refinement, where needed, of the current understanding of potential AMD hazard risk of key materials. The environmental geochemical dataset provides detailed results regarding the potential acidity, neutralising potential, metals and metalloids, and salts.

The mining model provides the primary data source for the assessment of potential AMD hazards. Additional mining model parameters assessed include spatial coordinates, waste block tonnages, black shale classifications, proximity to the pre-mining groundwater table, and predicted assay elemental concentrations (e.g., sulfur). Tonnages of waste rock per black shale classification are tabulated and assessed as well as waste tonnages per lithology. Data processing and visualisation software Microsoft PowerBI was used to analyse the datasets and estimate the potential AMD hazard.

[1]

The RTIO Mineral Waste Management Plan provides guidelines for assigning a sulfide risk variable in the geological model. In general, sulfide risk is allocated by assigning all mining blocks into one of four categories:

- 0 = no risk;
- 1 = low risk for AMD (oxidised MCS and WS waste should be assigned a 1 at a minimum; referred to as *BS-OXIDE* in mining model);
- 2 = moderate risk for AMD (includes un-oxidised MCS located below water table where sulfur is generally <0.1%;
- 3 = high risk for AMD and spontaneous combustion (un-oxidised MCS located below water table where sulfur is generally >0.1%; *BS-HOT* generally within this category); and
- 4 = potentially high neutralising material (e.g., calcrete).

MWM notes that these classifications were pre-assigned within the supplied mining model due to earlier work completed by RTIO. Validation of the mining model codes has not been completed and MWM assumes all mining model designations are correct and as intended by RTIO.

The management of the MCS during mining, using this profile and the associated sulfide risk variable in the model as a guideline, is outlined in the RTIO Spontaneous Combustion and ARD (SCARD) Management Plan. The SCARD Management Plan provides guidelines for how to mitigate acid drainage and spontaneous combustion in the waste dumps, how to manage gas and dust exposure, and also addresses the spontaneous combustion risk relating to premature blast detonation associated with hot black MCS.

Although the mining model represents the primary source of data, the drillhole assay database, clipped to the proposed pit shell, was interrogated to assess raw assay data. This is completed as a quality control step to assess whether geochemical information pertinent to AMD risk has been captured through extrapolation and interpolation modelling processes.

Estimation of final pit shell surface areas per sulfide risk categories 1, 2, and 3 (oxidised, cold, and hot black shale) was undertaken to assess the potential for exposed hot and cold black MCS surfaces to generate AMD. The method used was as follows:

- Mining models and pit shells were loaded into Maptek's Vulcan software.
- The pit shells strings were triangulated to create a 3D surface.
- A 3D surface showing the intersections of triangulated pit shells and the mining model was created to identify exposures of sulfide risk categories 1, 2, and 3.

3.2.2 Neutral Metalliferous and Saline Drainage Potential

This assessment is designed to identify neutral metalliferous drainage (NMD) and/or saline drainage (SD) characteristics (e.g., high sulfur, high ANC) for key material domains within the proposed pit that are associated with sulfide oxidation. It was completed to highlight lithologies and/or mine domains that may pose a higher NMD/SD risk.

The key data sources interrogated to assess the NMD/SD source hazard potential of waste rock and wall rock at West Angelas were, the geological assay database, the mining model, the proposed pit

shell, and the environmental geochemical dataset. The assessment was restricted to material within the bounds of the proposed pit shell as well as material to remain in the pit wall following mining.

High sulfate is a characteristic of both NMD and SD, therefore, in the absence of elevated sulfur, NMD and SD would be unlikely. Sulfur and ANC were interrogated within the environmental geochemical dataset to identify high sulfur material (0.5-1 wt%S and >1 wt%S) with accompanying negative net acid production potential (NAPP) values. The potential for NMD/SD is not limited to high sulfur materials that also contain high ANC materials. For instance, co-disposal of high ANC waste rock with high sulfur waste rock as a management approach can lead to elevated sulfate and/or metal/metalloid concentrations. Therefore, the assessment of NMD and SD was not limited to materials containing both high sulfur and high ANC and was also considered when recommending waste rock disposal options.

The NMD and/or SD hazard potential was also assessed using other environmental geochemical data, specifically sulfur speciation, NAG, and mineralogy.

3.2.3 Elemental Composition

Solid phase total or near-total analysis is achieved in two major steps. In the first step, the sample is digested in a strong acid combination or hot chemical flux. This is followed by analysis of the digestion solution by a technique such as inductively coupled plasma (ICP) or x-ray fluorescence (XRF). Total elemental analysis can be used to identify elements enriched relative to average crustal abundances. However, an enrichment in a specific element does not imply mobility or bioavailability.

Relevant to acidic, neutral metalliferous, and saline drainage potential, an elemental enrichment assessment was completed using the Geochemical Abundance Index (GAI; Förstner et al. 1993). The GAI quantifies an assay result for a particular element in terms of the average crustal abundance of that element. The GAI (based on a log-2 scale) is expressed in 7 integer increments (viz. 0 to 6). A GAI of 0 indicates that the content of the element is less than, or similar to, the average crustal-abundance; a GAI of 3 corresponds to a 12-fold enrichment above the average crustal-abundance; and so forth, up to a GAI of 6 which corresponds to a 96-fold, or greater, enrichment above average crustal abundances. Generally, a GAI of 3 or greater signifies enrichment that warrants further examination. The average-crustal-abundances of the elements for the GAI calculations are based on the values listed in Field Geologists' Manual (AusIMM, 2011) supplemented with data from Bowen (1979) for mean crustal abundance for the elements Al, Ca, Fe, K, Mg, Na, P, S, and Ti.

4 RESULTS

The following section details the results of the AMD Source Hazard Risk Assessment. Existing environmental geochemistry assessment reports, environmental geochemistry data, tabulated assay database results, and key mining model outputs are provided in:

- Appendix A – RTIO AMD Risk Assessment Sheets;
- Appendix B – ARD Hazard Score Sheets;
- Appendix D – Existing Environmental Geochemistry Reports;
- Appendix E – Environmental Geochemistry Data;
- Appendix F – Drillhole Assay Data; and
- Appendix G – Mining Model Data.

4.1 Environmental Geochemical Dataset

A summary of previously completed geochemistry assessments for West Angelas is presented in Table 4. Data from these geochemical testing programs is incorporated into RTIO's environmental geochemistry dataset that has been used for this analysis. Reports are provided in Appendix E.

Table 4: Summary of completed West Angelas geochemical assessments.

PROGRAM	YEAR	PROGRAM SUMMARY
Golder Associates	1998	Acid Generating Potential, Selected Core Samples Mt Newman Member BIF, West Angeles Deposit A Open Pit. 5 samples analysed for paste pH/EC, total sulfur (TS), acid neutralising capacity (ANC), and net acid generating (NAG) testing. A subset of samples analysed for sulfate sulfur (SO_4-S) (*n* = 3).
ANSTO	2007	ARD Characterisation of West Angeles Sample. 1 sample analysed for TS, total carbon (TC), paste pH/EC, ANC, NAG, and intrinsic oxidation rate (IOR).
SRK	2008	Geochem. Charact. of Paraburdoo Lens 2, Dales Gorge, and West Angelas samples. 8 samples analysed for TS, ANC, paste pH/EC, and major element assay. A subset of samples analysed for NAG (*n* = 3), multi-element analysis (*n* = 3), deionised (DI) water leach extraction (1:5 and 1:2) (*n* = 3), acid buffering characteristics curve (ABCC) (*n* = 2).
SRK	2010	Geochem. Charact. of BIF Samples from the West Angelas Mine. 10 samples analysed for paste pH/EC, TS, TC, ANC, NAG, and multi element assay. Subset of samples analysed for SO4-S (*n* = 5), carbon spec. (*n* = 5), DI water leach extraction (*n* = 5), ABCC (*n* = 3), mineralogy (XRD) (*n* = 3), kinetic NAG testing (*n* = 2), and IOR (*n* = 1).
EGi	2013	Geochemical Assessment of Samples from West Angelas. 135 samples analysed for paste pH/EC, TS, and ANC. A subset of samples analysed for NAG testing (*n* = 32), ABCC (*n* = 16), total organic carbon (TOC) (*n* = 16), chromium reducible sulfur (CRS) (*n* = 7), SO4-S (*n* = 7), kinetic NAG (*n* = 5), sequential NAG (*n* = 4), multi-element scans on solids (*n* = 20), and multi-element scans on water extracts (*n* = 20).
EGi	2014	Geochemical Characterisation of Waste Rock from West Angelas Deposit F. 50 samples analysed for paste pH/EC, TS, ANC. A subset of samples analysed for NAG testing (*n* = 6), ABCC (*n* = 4), multi element scans on solids (*n* = 10), and multi-element scans on water extracts (*n* = 10).

4.1.1 Acid Base Accounting Summary

A sample was considered having ABA data if at a minimum, total sulfur (TS) and acid neutralising capacity (ANC) data was available. Therefore, the environmental geochemical dataset for West Angelas includes ABA data for 209 samples (Figure 6) from five deposits (Deposit A, *n = 21*; Deposit A West, *n = 44*; Deposit B, *n = 64*; Deposit D, *n = 27*; Deposit F, *n = 50*; and Not Specified, *n = 3*).

ABA data is available for a total of six stratigraphy groups; Alluvials (ALL), Detritals (DET)[2], Dolerite (DOR), Banded Iron Formation (BIF), Wittenoom Formation (WF) and Marra Mamba Iron Formation (MM). A summary of median ABA results is presented in Table 5 (*n = 209*). Also presented are acid generating classifications. These have been assigned with consideration to:

- TS content. Samples with total sulfur ≤0.05 wt%S are considered NAF;
- the AMIRA Classification System (AMIRA, 2002) for samples with TS, ANC, and NAG pH data available at a minimum; and
- the Price Classification System (Price 2009) for samples with TS and ANC data at a minimum.

The ranges of total sulfur, ANC, NAPP, and neutralisation potential ratio (NPR) per lithology are presented in Figure 7. Median total sulfur values are low[3] (<0.1 wt%S) for all stratigraphy groups. It should be noted that the sample population with ABA data is naturally skewed towards higher sulfur samples as higher sulfur samples are more likely to be acid generating, and therefore have been given higher priority in the ABA sample selection process. This can be observed by comparing the median values within Table 5 to sulfur data presented in following sections.

Most median paste pH values are circum-neutral ($pH_{1:2}$ 7-8) and fresh ($EC_{1:2}$ <400 µS/cm). The exception is a slightly alkaline paste pH for the BIF sample and a slightly saline median EC value for the ALL stratigraphy. Median maximum potential acidity (MPA) values are low (≤1.8 kg H_2SO_4/t) for all stratigraphies.

ANC is generally low with median values ≤3 kg H_2SO_4/t for most stratigraphies and low-moderate (7 kg H_2SO_4/t) for the ALL and BIF samples. Acid buffering characteristic curves (ABCC) are available for 25 samples (Table E4 and Figure E2, Appendix E). The quantity of acid a sample can buffer to pH 4.5 during the ABCC test, referred to as effective neutralising capacity ($ENC_{4.5}$), can be used in comparison with the standard titrated ANC value to give a fairer indication of the proportion of readily available ANC. Of the 25 samples with ABCC curves, 23 have estimated ENC values (Table 6).[4] ABCC results suggest that ANC is readily availability in the ALL, DET, and WF samples ($ENC_{4.5}$ >75% of titrated ANC) tested. Less than half of the measured ANC within the single DOR sample submitted for ABCC testing is readily available (Figure 8). Variable ANC availability was observed in the 15 MM samples tested ($ENC_{4.5}$ 18-153% of titrated ANC) suggesting an inconsistency in the presence of fast reacting carbonate ANC.

Median NAPP values are negative for all stratigraphy groups. Reflective of Pilbara iron ore deposits with low sulfur and low ANC, median NAPP values are only slightly negative (-6 to -0.5 kg H_2SO_4/t).

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[2] No calcrete (DET-CAL) or lignite (DET-LIG) samples were identified in the West Angelas env. geochemical dataset.

3 To relatively assess results within the environ. geochemical dataset, for the purpose of this assessment, TS is considered low if less than 0.1wt%S, low-moderate if between 0.1-0.3 wt%S, moderate if between 0.3-0.5 wt%S, and high if ≥0.5 wt%S.

4 ENC4.5 values are not available for all 25 samples with ABCC data. Only samples with either ABCC raw data or high resolution ABCC curves facilitated $ENC_{4.5}$ estimation.

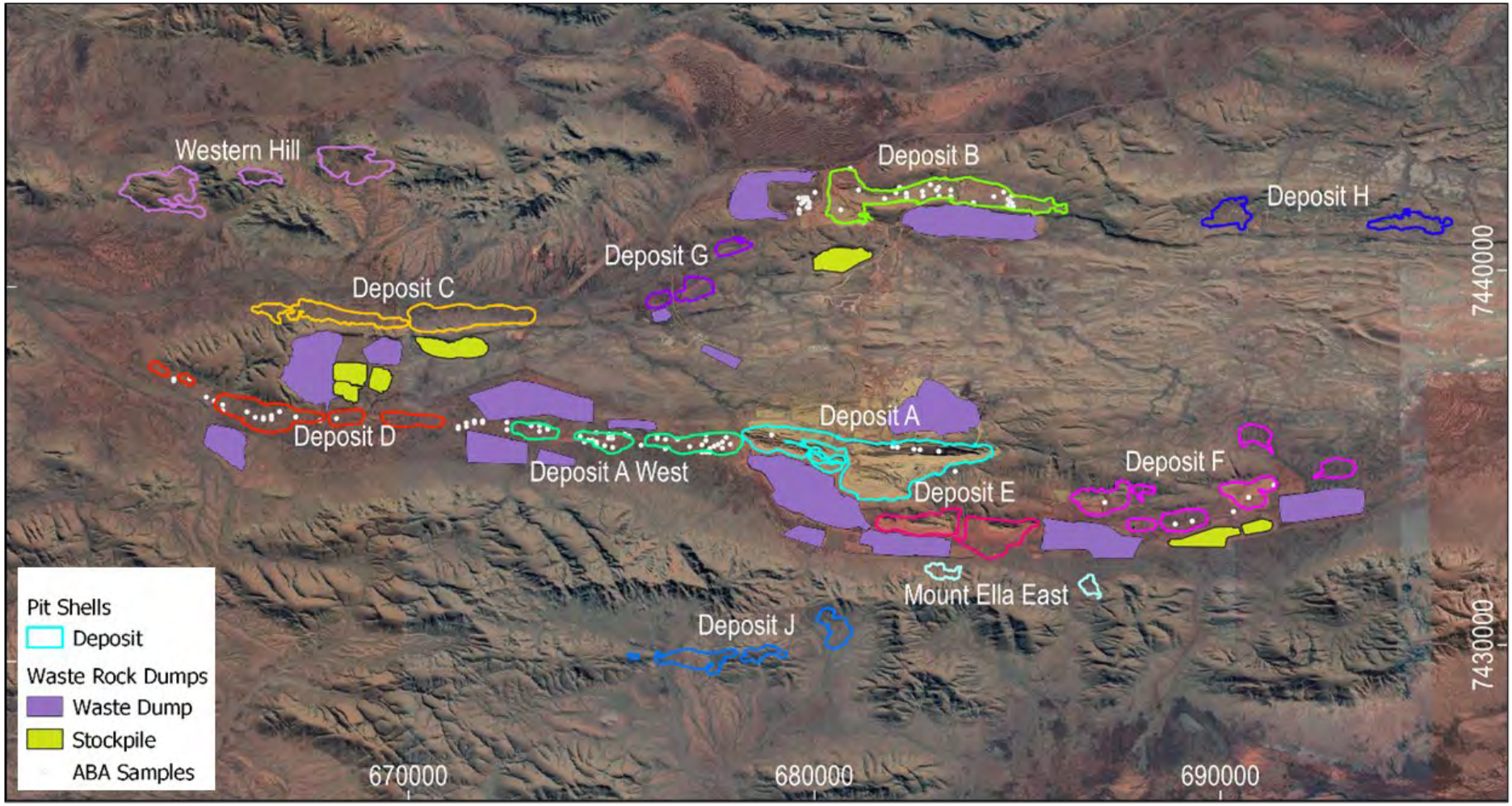

Figure 6. Location of ABA samples used in assessment for West Angelas.

Table 5: Median ABA results for stratigraphic units sampled from West Angelas.

	PARAMETER	pH$_{1:2}$	EC$_{1:2}$	TS	ANC	MPA	NAPP	NPR	ACID GENERATING CLASSIFICATIONS			
	UNITS	-	µS/cm	wt%S	kg H_2SO_4/t	kg H_2SO_4/t	kg H_2SO_4/t	-	NAF	UC-NAF	UC-PAF	PAF
STRAT	*n* = 209 LOR	0.1	10	0.01	0.5	0.5	0.5	0.1	*n* = 175	*n* = 15	*n* = 0	*n* = 19
ALL	3	7.3	559	0.05	6.9	1.5	-6.0	7.5	3	-	-	-
DET[1]	52	7.4	182	0.03	3.0	0.9	-1.5	2.6	46	6	-	-
DOR	5	7.8	154	0.04	1.8	1.2	-1.1	2.8	4	-	-	1
WF	53	7.3	174	0.03	1.7	0.9	-0.4	1.3	35	5	-	13
BIF[2]	1	8.4	56	0.06	6.5	1.8	-4.7	3.5	1	-	-	-
MM	95	7.6	155	0.03	1.7	0.9	-0.8	2.0	86	4	-	5

[1]No calcrete (DET-CAL) or lignite (DET-LIG) samples were identified in the env. geochemical dataset. [2]Only one BIF sample, therefore data presented represents actual data for this sample.

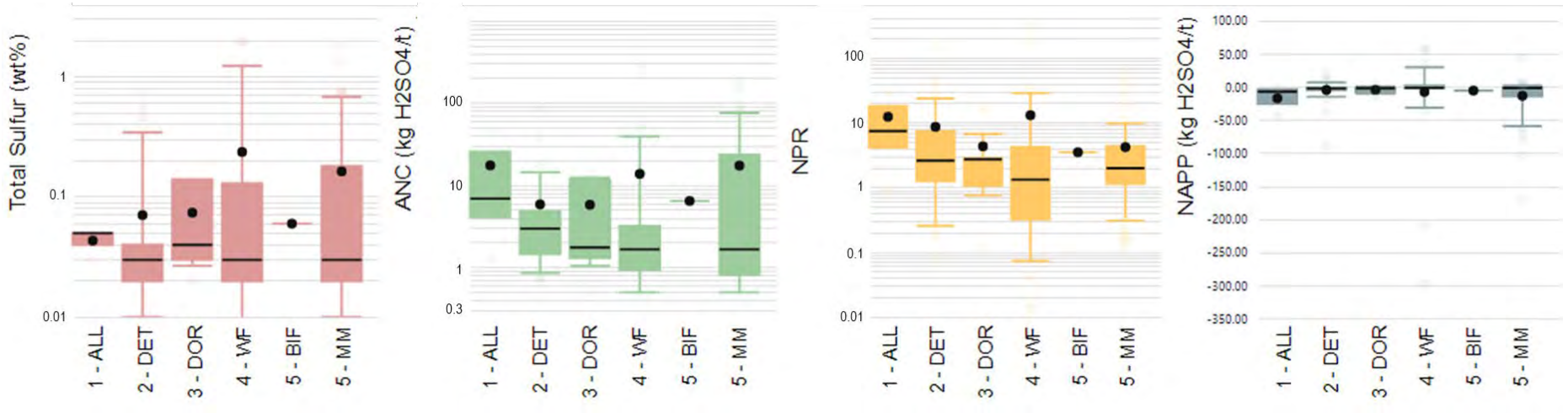

Figure 7: Total sulfur, ANC, NPR, and NAPP box plots. Total sample numbers per stratigraphy group are presented in Table 5. Boxes represent values between the 25th and 75th percentiles. Whiskers represent 5th and 95th percentiles. Outliers represent values <5th percentile or >95th percentile.

Table 6. Comparison between ANC and $ENC_{4.5}$ for West Angelas samples with ABCC data.

SAMPLE ID	DEPOSIT	STRAT	ANC (kg H_2SO_4/t)	ENC4.5 (kg H_2SO_4/t)	% READILY AVAILABLE ANC
FNC563	Deposit B	ALL	44.7	36	81%
FQR817	Deposit A West	DET	38.0	40	105%
FRD062	Deposit A West	DET	89.4	96	107%
EYT782	Deposit B	DET	9.9	8	81%
FRM221	Deposit D	DET	11.9	11	92%
FRM113	Deposit D	DOR	11.8	5	42%
ECP052	Deposit A	MM-MAC	82.1	94	114%
ECP165	Deposit A	MM-MAC	101.0	83	82%
FNC467	Deposit B	MM-MAC	39.8	34	85%
FOG111	Deposit B	MM-NAM	144.0	65	45%
FOH416	Deposit B	MM-MAC	19.5	13	67%
FOH824	Deposit B	MM-MAC	25.6	6	21%
FOH843	Deposit B	MM-MAC	80.0	37	46%
FOH852	Deposit B	MM-NAM	11.1	17	153%
FOH853	Deposit B	MM-NAM	44.1	53	120%
FOH858	Deposit B	MM-NAM	34.9	33	95%
FWP080	Deposit F	MM-MAC	30.0	14	47%
FWP092	Deposit F	MM-MAC	21.9	4	18%
FWP156	Deposit F	MM-NEW	49.8	62	125%
FYN843	Deposit F	MM-NEW	50.4	53	105%
ECP355	West Angelas	MM-MAC	55.3	16	29%
FOM940	Deposit D	WF	297.5	261	88%
FRI220	Deposit D	WF	27.3	21	77%

[1]Calculated using $ENC_{4.5}$ of 0.5 kg H_2SO_4/t.

MM-NEW = Mt Newman Member; MM-MAC = Macleod Member; MM-NAM = Nammuldi Member.

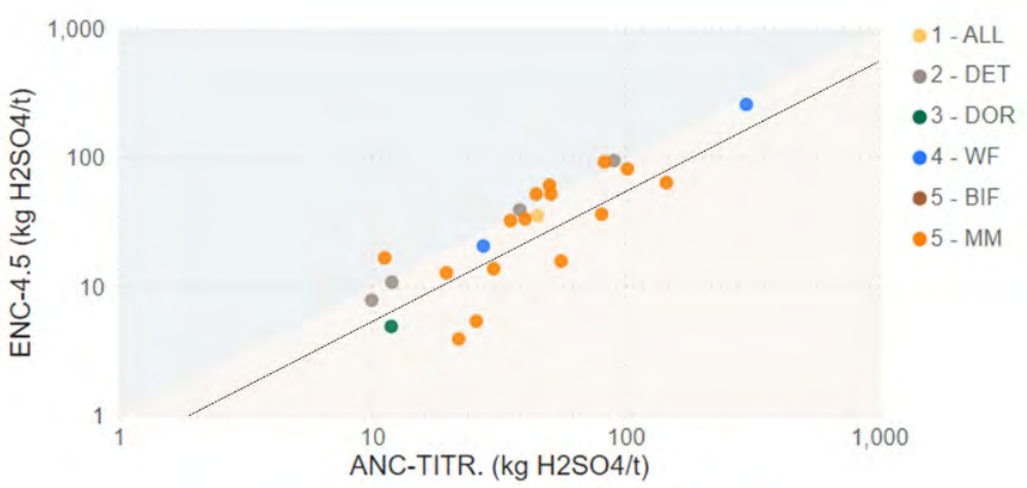

Figure 8. Titrated ANC vs $ENC_{4.5}$. Samples below the black dashed line all have <50% readily available ANC.

Within the West Angelas environmental geochemical dataset, the WF stratigraphy group represents the greatest source of potentially acid forming (PAF) samples (n_{PAF} = 13). These samples were collected from Deposit A (n = 5), Deposit A West (n = 1), and Deposit B (n = 7). The MM stratigraphy group represents the next greatest source (n_{PAF} = 5) with one sample collected from Deposit A, three samples collected from Deposit B, and one from Deposit F. The only other sample classified as PAF was a Deposit A West DOR sample.

Key findings for each lithology are as follows:

- ALL: The three Deposit B samples are classified non-acid forming (NAF) due to low TS (≤0.05 wt%S) and low to moderate ANC (1.3-45 kg H_2SO_4/t). Although one sample produced a slightly positive NAPP (0.3 kg H_2SO_4/t) and a neutralisation potential ratio (NPR) of <1, this is due to low TS (0.5 wt%S) and low ANC (1.3 kg H_2SO_4/t) and is unlikely to generate acidic drainage. Paste extracts are circum-neutral ($pH_{1:2}$ 6.7-7.4) with low to moderate salinity ($EC_{1:2}$ 346-976 µS/cm).
- DET: Paste extracts are slightly acidic to slightly alkaline ($pH_{1:2}$ 6.3-8.3) with low to moderate salinity ($EC_{1:2}$ 24-1,150 µS/cm). The majority (n =46) of DET samples are classified non-acid forming (NAF) due to low TS (≤0.07 wt%S) and low to high ANC (0.7-89 kg H_2SO_4/t). Although five samples produced slightly positive NAPP values (0.3-1.1 kg H_2SO_4/t) and NPR's of <1, these low TS and low ANC samples unlikely to generate acidic drainage. Six samples from Deposit A West, Deposit D, and Deposit F are classified as UC-NAF due to conflicting positive NAPP values (0.2-22 kg H_2SO_4/t) and NAG pH values >4.5. These clay, pisolite, mature, and immature detrital samples have low to high TS (0.11-0.77 wt%S), low ANC (≤3.4 kg H_2SO_4/t), slightly acidic NAG pH values (NAG pH 5.4-6), and low NAG_7 capacity (4.2-6.3 kg H_2SO_4/t).
- DOR: One Deposit A West sample is classified PAF due to a positive NAPP of 3.8 kg H_2SO_4/t and acidic NAG pH of 3.2. This PAF sample has low-moderate TS (0.14 wt%S) and negligent ANC (<1 kg H_2SO_4/t) and could be considered low capacity PAF. The remaining four samples from Deposit A West and Deposit D are classified NAF due to negative NAPP values with low to low-moderate TS (0.02-0.14 wt%S). Paste extracts are circum-neutral ($pH_{1:2}$ 7.1-7.9) with low salinity ($EC_{1:2}$ 139-176 µS/cm).

- WF: Paste extracts are acidic to slightly alkaline ($pH_{1:2}$ 5.1-8.2) with low to moderate salinity ($EC_{1:2}$ 16-981 µS/cm). The majority (*n* =35) of WF samples are classified NAF due to low TS (≤0.05 wt%S) and low to high ANC (<1-297 kg H_2SO_4/t). Although three samples produced slightly positive NAPP values (0.1-0.6 kg H_2SO_4/t) and NPR's of <1, these low TS and low ANC samples are unlikely to generate acidic drainage. Two Deposit A samples are classified as UC-NAF due to high TS (0.92-1.25 wt%S), moderate ANC (26-32 kg H_2SO_4/t), and NPR's close to 1 (0.7-1.1). Three samples from Deposit B and Deposit D are classified as UC-NAF due to conflicting positive NAPP values (0.9-59 kg H_2SO_4/t) and NAG pH values >4.5. These Deposit B and Deposit D UC-NAF samples have low to high TS (0.09-2 wt%S), low ANC (≤1.9 kg H_2SO_4/t), slightly acidic to circum-neutral NAG pH values (NAG pH 5.3-7.2), and low NAG_7 capacity (<0.5-1.1 kg H_2SO_4/t). Five Deposit A samples, collected during blasthole drilling over a 5 m interval due to observed pyrite, are classified as PAF due to moderate to high TS (0.42-1.9 wt%S), positive NAPP values (8.7-57 kg H_2SO_4/t), and acidic NAG pH values (NAG pH 2-2.2) for two samples submitted for NAG testing. Three of these Deposit A samples submitted for sulfate analysis suggests sulfur is sulfidic (97-99% of TS). Eight samples from Deposit A West (*n* = 1) and Deposit B (*n* = 7) are classified PAF due to positive NAPP values (2.6-37 kg H_2SO_4/t) and acidic NAG pH values (NAG pH 2.5-3.9). The Deposit A West PAF sample has high TS (1.2 wt%S) and generated high NAG acidity (NAG_7 34 kg H_2SO_4/t). The seven Deposit B samples have low-moderate TS (0.0.1-0.17 wt%S), negligent ANC (<1 kg H_2SO_4/t), and generated low to low-moderate NAG acidity (NAG_7 3.1-7.4 kg H_2SO_4/t).
- BIF: The single BIF sample was classified as NAF due to low TS (0.6 wt%S), a negative NAPP value. And NPR >2. ANC for this sample was 6.4 kg H_2SO_4/t and it generated a slightly alkaline paste pH ($pH_{1:2}$ 8.4) with low salinity (56 µS/cm).
- MM: Paste extracts are slightly acidic to alkaline ($pH_{1:2}$ 6.1-9) with low to slightly moderate salinity ($EC_{1:2}$ 35-568 µS/cm). Measured ANC for the MM stratigraphy group is variable (<1-180 kg H_2SO_4/t). The majority (*n* =86) of MM samples are classified NAF, largely due to negative NAPP values, although 14 NAF samples have slightly positive NAPP values due to low TS (≤0.05 wt%S) and low ANC (≤1.1 kg H_2SO_4/t). TS for NAF samples is low to high (0.01-1.35 wt%S). All samples with TS >0.1 wt%S have been submitted for NAG testing and generated NAG pH values >4.5. Four samples from Deposit A West, Deposit B, and Deposit D are classified as UC-NAF due to conflicting positive NAPP values (1.1-8.7 kg H_2SO_4/t) and NAG pH values >4.5. These UC-NAF samples have low to moderate TS (0.07-0.4 wt%S), negligible to moderate ANC (<1-11 kg H_2SO_4/t), slightly acidic to circumneutral NAG pH values (NAG pH 5.3-7.3), and low NAG_7 capacity (4-5.7 kg H_2SO_4/t). Five samples from Deposit A (*n* = 1), Deposit B (*n* = 3), and Deposit F (*n* = 1) are classified PAF due to positive NAPP values (2.3-45 kg H_2SO_4/t) and acidic NAG pH values (NAG pH 2.6-4.3). It should be noted the Deposit F PAF sample was from 188-190 m below ground level and is from below the expected base of the proposed pits for Deposit F (130-150 m below ground level).

4.1.2 Kinetic Testing Summary

RTIO completed kinetic testing of one West Angelas shale sample (WF stratigraphy group) (ANSTO, 2007) and one Deposit A MM sample (SRK, 2010). Measured IOR values were 18.4^{E-11} and $1.6E^{-10}$ kg O_2/kg/sec for the WF and MM samples, respectively. ANSTO noted that although the low TS

(0.06 wt%S) WF sample was classified as NAF, the material may have been suitable for use as an oxygen consuming layer to surround PAF material within a waste rock dump. Although the high sulfur (0.76 wt%S) MM sample could also be considered for similar use due to its NAF classification and faster IOR, oxidation of this higher sulfide material may release sulfate and metals/metalloids as neutral metalliferous (NMD) or saline drainage (SD).

Kinetic NAG tests were completed in 2008 on two WF Deposit A samples (1 PAF and 1 NAF) (SRK, 2008), in 2010 on two MM Deposit A NAF samples (SRK, 2010), and in 2013 on four Deposit B PAF samples, two WF and two MM samples, and one WF Deposit A West PAF sample (EGi, 2013). Kinetic NAG data and figures are provided in Table E3 (Appendix E).

The kinetic NAG results for the two WF Deposit A samples suggest that the onset of acidification would be delayed (SRK, 2008). The kinetic NAG results for the two MM Deposit A NAF samples suggest that the sulfide minerals are relative slow reacting, and the rate of neutralisation may be sufficient to neutralise any acidity concurrently produced (SRK, 2010).

The kinetic NAG test results on the five PAF samples from Deposit A West and Deposit B can be summarised from the EGi report (2013) as follows:

- The results for WF Deposit B sample FRK244 suggest that materials represented by this sample may have a short lag period of months to a year before onset of acid conditions. Sulfides within this low-moderate TS (0.17 wt%S) sample are likely slow reacting.
- As pH remained between 4-4.5 for the duration of the test for WF Deposit B sample FTI114, materials represented by this sample may have a long lag period.
- The results for MM Deposit B sample FRK393 suggest that materials represented by this sample may have a short lag period of months to a year before onset of acid conditions.
- The quick pH drop to <4 at the beginning of the test for WF Deposit A West sample FQR860 suggests that materials represented by this sample may have a short lag period of weeks to months before onset of acid conditions. Sulfides within this high TS (1.22 wt%S) sample are likely moderately reactive.
- As pH remained between 4-4.5 for the duration of the test for MM Deposit B sample FQR860, materials represented by this sample would likely have a long lag period of two or more years. Sulfides within this high TS (0.73 wt%S) sample are likely slow reacting.

No long-term column leach testing has been completed on waste rock from West Angelas.

4.2 Acidic Drainage Potential

This section presents results of sulfur analysis within the assay database and mining models.

4.2.1 Sulfur Assay Analysis

An analysis of sulfur values in drillhole data extracted from the RTIO database in September 2020 was undertaken to identify rock types that require further investigation related to acid-forming potential (and the related impact of metalliferous drainage). An outcome of this analysis included determining the likelihood that a particular rock type would pose an acid drainage risk (via total sulfur analysis) and whether it was enriched in any elements relative to average crustal abundance. For the purpose of this

assessment, samples were grouped into rock types based on their “geozone”. It should be noted that the following factors may also influence the interpretations within this report:

- Total sulfur was measured using XRF rather than LECO. The XRF method may underestimate the total sulfur concentration when sulfur values are high.
- Exported sulfur values recorded as “-99’ or “0” indicate that sulfur was not assayed and samples with these values were excluded from this analysis.
- Negative assay results represent concentrations below the detection limit (excluding -99 values, which were considered as representing no data) and were considered half the limit of detection. This approach is conservative, as the true values for these assays may be below the halved detection limit value.
- CLA, CAL, DI, and DM were grouped into a DET undifferentiated group. DG1-DG3 were grouped into a DG undifferentiated group. J1-J5 were grouped into a JOF undifferentiated group. WS1 and WS2 were grouped into a WS undifferentiated group.
- Some rock types have been grouped into the OTHER rock type category due to being represented in the assay database by very few samples (n < 500; or <0.05% of total assay samples, excluding samples from the Joffre Member). Rock types grouped into the OTHER category were CA, CAV, FILL, FOR, LIG, ROD, SID and WW.
- A substantial quantity of early assay results from Deposit A do not have assigned geozone codes (or strand codes) in the assay database exports provided. However, the 2016 AMD risk assessment has assigned these samples to key lithologies and therefore, this assessment references the previous AMD risk assessment’s results for Deposit A (RTIO, 2016).
- Samples were separated into waste and ore material type based on assigned geozone codes. Geozone codes less than 10 or ending in 0 and 1 were classified as waste. Geozone codes ending in 2 or 6 and geozone 18 were classified as ore. Geozones ending with 5 were classified as hydrated ore.
- The drillhole database for the deposits is extensive but there are less assay results on waste material. Information on all waste material that has or will be mined in the future may be missing due to the focus on characterisation of the orebody rather than the waste material.
- Limited information exists related to the neutralising potential of the drillhole samples; the presumed risk of acid drainage may be over-stated if the available neutralising capacity of that rock type is unaccounted for.

Table 7 provides a summary of the sulfur assay data available for the entire West Angelas project area. Figure 9 presents borehole locations and Figure 10 highlights those boreholes with sulfur greater than 0.3 wt%S or between 0.1-0.3 wt%S. Table 8 provides a summary of the assay dataset clipped to within the pit shells, as provided by RTIO, with Figure 11 presenting the locations of these in-pit samples. As presented in Table 8, the TS content for the West Angelas in-pit material is low. Only 2.8% of all in-pit samples have TS greater than 0.1 wt%S and a minor proportion (0.2% of all in-pit samples) have TS greater than 0.3 wt%S. Table F1 (Appendix F) presents in-pit TS assay summary data per deposit. Figure F1 (Appendix F) presents the relative proportions of assay samples per stratigraphy with TS greater than 0.1 wt%S, for each of the deposits.

Table 7: West Angelas project area sulfur assay summary.

ROCK TYPE	TOTAL S ASSAY SAMPLES	S >0.1 wt%S		S >0.3 wt%S		AVERAGE S wt%S	
	n	*n*	% of total *n*	*n*	% of total *n*	of n_{TOT}	*of* $n_{S>0.1wt\%S}$
ALL	6,847	209	3.1%	19	0.3%	0.034	0.191
DET-CLA	71,153	355	0.5%	80	0.1%	0.019	0.287
DET-CAL	2,916	10	0.3%			0.019	0.156
DET	63,237	952	1.5%	174	0.3%	0.026	0.245
DOR	2,942	84	2.9%	20	0.7%	0.027	0.288
WS	628	167	26.6%	36	5.7%	0.108	0.289
DG	17,460	675	3.9%	75	0.4%	0.033	0.221
FWZ	4,170	193	4.6%	11	0.3%	0.034	0.176
MCS	6,217	373	6.0%	176	2.8%	0.114	1.529
MTS	1,023	39	3.8%	18	1.8%	0.068	1.181
WF	12,003	535	4.5%	169	1.4%	0.035	0.388
ANG	60,159	2,767	4.6%	202	0.3%	0.028	0.180
NEW	69,348	449	0.6%	31	<0.1%	0.011	0.161
MAC	27,240	1,806	6.6%	243	0.9%	0.036	0.200
NAM	6,925	401	5.8%	90	1.3%	0.035	0.251
DET-ORE	30,258	1,294	4.3%	155	0.5%	0.034	0.192
WS-HYD	461	149	32.3%	12	2.6%	0.092	0.180
DG-ORE	20,286	913	4.5%	87	0.4%	0.036	0.207
DG-HYD	6,216	763	12.3%	40	0.6%	0.058	0.170
FWZ-ORE	4,999	349	7.0%	8	0.2%	0.042	0.142
WF-ORE	1,215					0.009	
ANG-ORE	16,377	240	1.5%			0.018	0.129
ANG-HYD	12,546	428	3.4%	38	0.3%	0.031	0.193
NEW-ORE	74,268	730	1.0%	40	0.1%	0.016	0.157
MAC-ORE	7,938	1,154	14.5%	15	0.2%	0.048	0.146
NAM-ORE	765	63	8.2%	3	0.4%	0.044	0.155
MM-HYD	36,400	1,856	5.1%	118	0.3%	0.041	0.169
OTHER	911	154	16.9%	41	4.5%	0.098	0.432
UNKNOWN	302,098	7,940	2.6%	682	0.2%	0.024	0.195
TOTALS	867,006	25,048	2.9%	2,583	0.3%	0.026	0.218

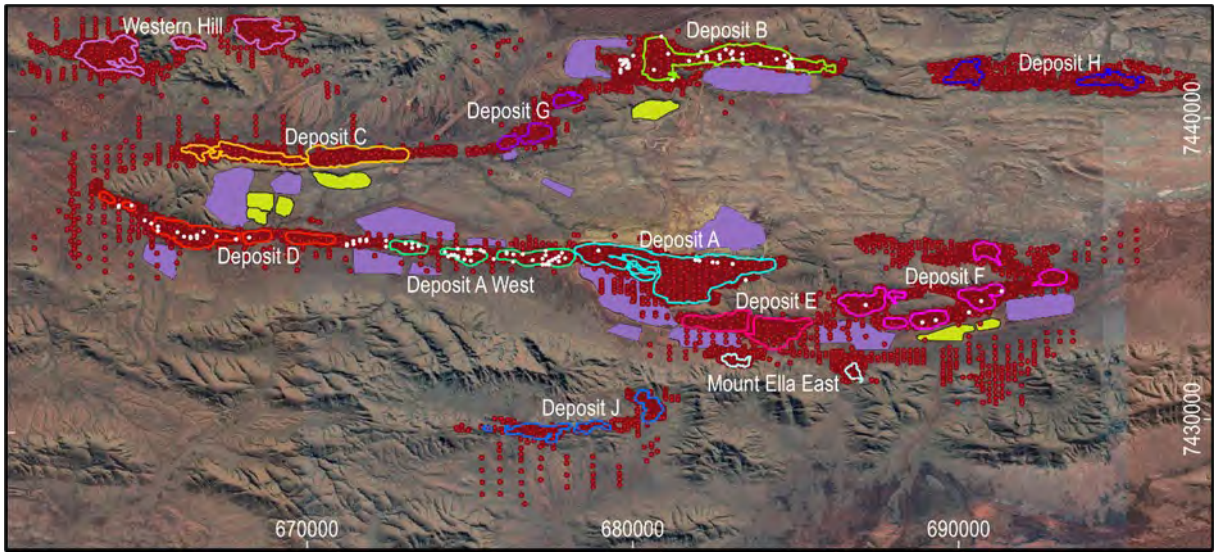

Figure 9. West Angelas assay samples (red solid circles) and ABA samples (white solid circles).

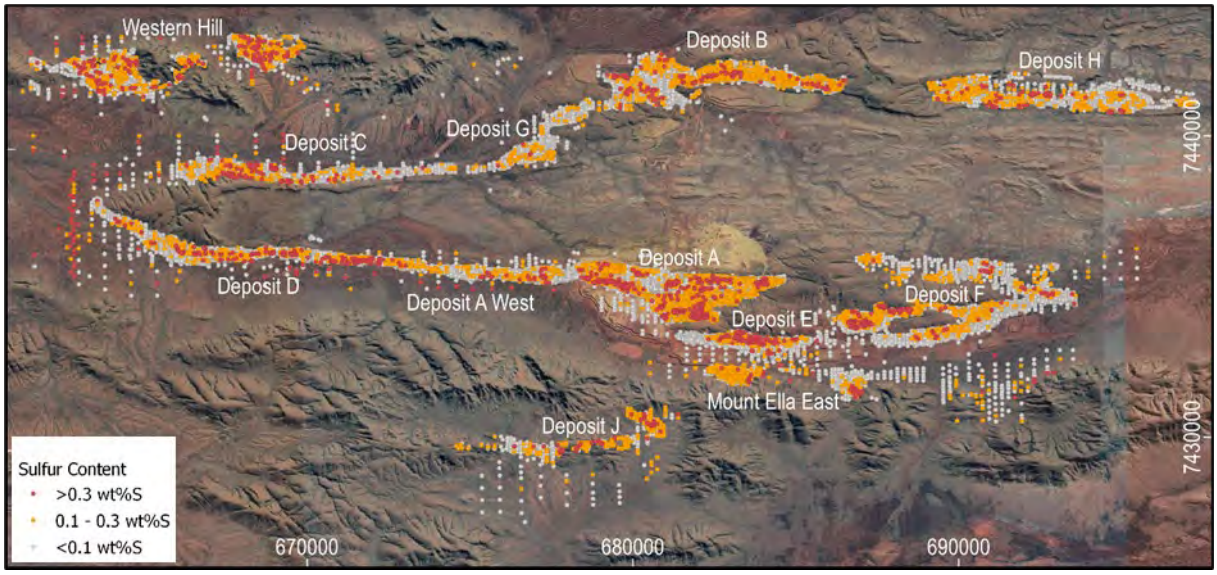

Figure 10. Location of assay samples with <0.1 wt%S, 0.1-0.3 wt%S, and >0.3 wt%S.

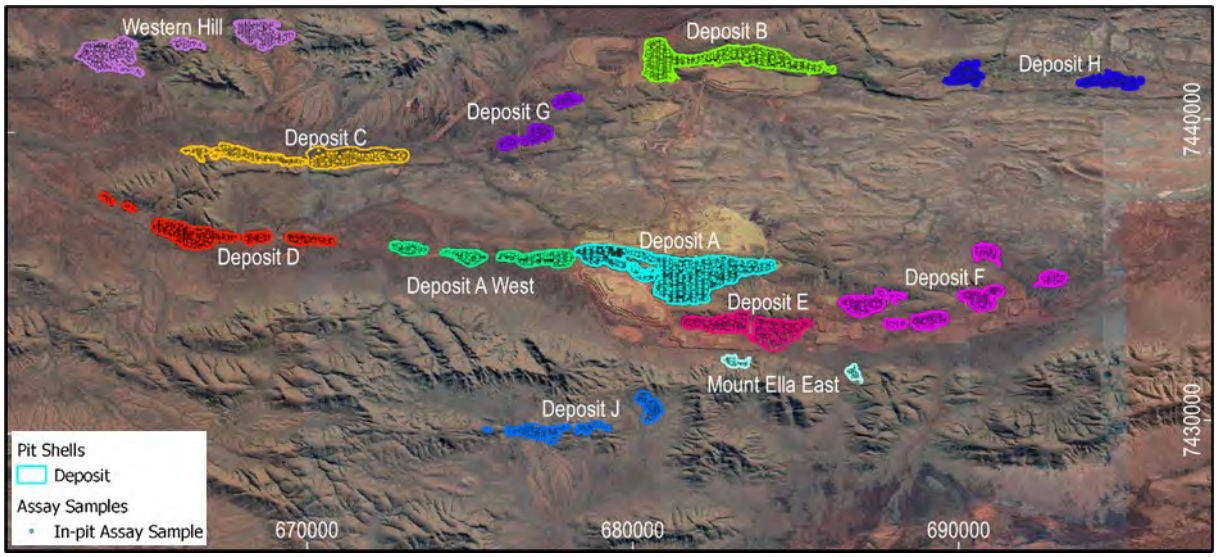

Figure 11: West Angelas assay samples (solid circles) within final pit shells.

Table 8: In-pit West Angelas sulfur assay summary.

ROCK TYPES	TOTAL S ASSAY SAMPLES	S >0.1 wt%S		S >0.3 wt%S		AVERAGE S wt%S	
	n	*n*	% of total *n*	*n*	% of total *n*	of n_{TOT}	*of* $n_{S>0.1wt\%S}$
ALL	5,208	193	3.7%	17	0.3%	0.036	0.191
CAV	4					0.048	
DET-CAL	533	1	0.2%			0.019	0.171
DET-CLA	37,548	106	0.3%	7	<0.1%	0.018	0.233
DET	31,662	414	1.3%	51	0.2%	0.025	0.199
DOR	820	6	0.7%	2	0.2%	0.020	0.368
WS	385	104	27.0%	27	7.0%	0.116	0.322
DG	3,398	194	5.7%	22	0.6%	0.041	0.188
FWZ	250	25	10.0%			0.043	0.142
MCS	150	12	8.0%	1	0.7%	0.042	0.178
MTS	3					0.045	
WF	1,139	7	0.6%	2	0.2%	0.021	0.607
ANG	25,852	2,277	8.8%	95	0.4%	0.041	0.161
NEW	11,542	107	0.9%	1	<0.1%	0.014	0.134
MAC	2,650	149	5.6%	21	0.8%	0.038	0.228
NAM	149					0.012	
FOR	1					0.026	
FILL	15					0.028	
DET-ORE	16,844	797	4.7%	110	0.7%	0.036	0.198
WS-ORE	47	17	36.2%			0.076	0.148
WS-HYD	245	68	27.8%	8	3.3%	0.093	0.198
DG-ORE	8,126	419	5.2%	35	0.4%	0.039	0.204
DG-HYD	3,005	354	11.8%	21	0.7%	0.058	0.173
FWZ-ORE	513	53	10.3%	2	0.4%	0.047	0.160
WF-ORE	245					0.007	
ANG-ORE	8,785	206	2.3%			0.022	0.128
ANG-HYD	7,817	349	4.5%	15	0.2%	0.035	0.168
NEW-ORE	47,999	575	1.2%	38	0.1%	0.018	0.162
MAC-ORE	2,651	492	18.6%	6	0.2%	0.053	0.146
NAM-ORE	38					0.007	
MM-HYD	20,144	842	4.2%	61	0.3%	0.040	0.173
UNKNOWN	236,330	5,651	2.4%	384	0.2%	0.024	0.176
TOTAL	474,098	13,418	2.8%	926	0.2%		

Key findings per Deposit are as follows:

- DEPOSIT A: A large proportion of samples from Deposit A do not have a geozone or strand code assigned and therefore have been grouped within the UNKNOWN category (*n* = 227,903). As presented in Table F1 (Appendix F), the UNKNOWN category represents most of the Deposit A samples with TS greater than 0.1 wt%S. The maximum TS value for Deposit A is also an UNKNOWN sample (3.37 wt%S). A minor proportion (0.16%) of the total Deposit A samples have TS greater than 0.3 wt%S.

  Overall, due to the low proportion of the total Deposit A samples with TS greater than 0.1 wt%S, equivalent to approximately 3 kg H_2SO_4/t acidity should all measured sulfur be pyritic, **the sulfur risk for Deposit A is low**. Only three samples with TS greater than 0.1 wt%S were collected from below the pre-mining water table (640 mAHD; RTIO, 2018a), suggesting measured sulfur in the majority of elevated sulfur samples is likely oxidised (RTIO, 2016). However, the environmental geochemical dataset, through targeted sampling, suggests pyritic sulfur is present. However, the bulk of the waste rock likely reflects a low sulfur risk.

- DEPOSIT A WEST: Samples with TS greater than 0.1 wt%S are predominantly associated with the Detritals stratigraphy (maximum TS of 0.559 wt%S). Less than 1% of the total Deposit A West samples have TS greater than 0.1 wt%S and an order of magnitude less samples have TS greater than 0.3 wt%S (Table F1; Appendix F). Therefore, **the sulfur risk for Deposit A West is low**.

- DEPOSIT B: The proportion of total Deposit B assay samples with TS in excess of 0.1 wt%S is 7.1% and 0.2% of total assay samples have TS in excess of 0.3 wt%S. The ANG, DET-ORE, and MAC-ORE all have approximately 10% of their total samples within the 0.1 wt%S subset. Only one Deposit B sample has been collected from below the pre-mining groundwater level (approximately 630 mAHD; RTIO, 2018a). This would suggest elevated sulfur is likely present as either non-acid generating gypsum-type sulfur or potentially acid generating alunite-type sulfur. With less than 2% of the waste rock to be mined at Deposit B to be mined from BWT (approximately 4 Mt), the initial sulfur risk could be considered low.

  However, although RTIO's internal sulfur assessment criteria for non-black shale lithologies (e.g., BIF and detrital rock types) is 0.3 wt%S (RTIO, 2016), the environmental geochemical dataset presents several Deposit B samples classified as PAF with TS between 0.1-0.2 wt%S. These WF and MM samples were sampled from various depths between 10 and 72 m below ground level. These results suggest the presence of pyritic sulfur in these samples and therefore **the sulfur risk for Deposit B is moderate**.

- DEPOSIT C: A minor proportion of total Deposit C samples (1.3%) have TS greater than 0.1 wt%S and less than 0.5% have TS greater than 0.3 wt%S (Table F1; Appendix F). A small amount of ANG and MAC waste rock samples have TS in excess of 1 wt%S. These shallow samples were collected from between 0-30 below ground level and are likely contain sulfur as either non-acid generating gypsum-type sulfur or potentially acid generating alunite-type sulfur. **The sulfur risk for Deposit C is low**.

- DEPOSIT D: A minor proportion of total Deposit D samples (1.1%) have TS greater than 0.1 wt%S and less than 0.5% have TS greater than 0.3 wt%S (Table F1; Appendix F). Only four samples (DET, MAC, and WF waste rock samples) have TS in excess of 1 wt%S. These shallow samples were collected from between 0-30 below ground level and are likely contain sulfur as either non-acid generating gypsum-type sulfur or potentially acid generating alunite-type sulfur. **The sulfur risk for Deposit D is low**.

- DEPOSIT E: A minor proportion of total Deposit E samples (1.4%) have TS greater than 0.1 wt%S and less than 0.2% have TS greater than 0.3 wt%S (Table F1; Appendix F). No Deposit E samples have TS in excess of 1 wt%S. **The sulfur risk for Deposit E is low**.

- DEPOSIT F: Almost 2% of the total Deposit F samples have TS greater than 0.1 wt%S and less than 0.5% have TS greater than 0.3 wt%S (Table F1; Appendix F). However, only 1.2% of total waste samples have TS greater than 0.1 wt%S, mainly from the ANG stratigraphy. Higher sulfur ore samples are from the DET, ANG, and MAC stratigraphies. **The sulfur risk for Deposit F is low**. With BWT mining not expected for Deposit F, the minimal sulfur measured is likely oxidised and would therefore further support a low-risk classification.

- DEPOSIT G: A minor proportion of total Deposit G samples (0.8%) have TS greater than 0.1 wt%S and less than 0.1% have TS greater than 0.3 wt%S (Table F1; Appendix F). No Deposit G samples have TS in excess of 0.5 wt%S. **The sulfur risk for Deposit G is low**.

- DEPOSIT H: The proportion of total Deposit H assay samples with TS in excess of 0.1 wt%S is 4.2% with less than 0.2% of total assay samples having TS in excess of 0.3 wt%S. All samples with TS greater than 0.1 wt%S were collected between 0-24 m below surface. This would suggest sulfur is likely present as either non-acid generating gypsum-type sulfur or potentially acid generating alunite-type sulfur. Only one waste assay sample from the ANG stratigraphy has TS greater than 0.5 wt%S. With BWT mining not expected for Deposit H, the sulfur measured is likely oxidised and would therefore support a low-risk classification. **The sulfur risk for Deposit H is low**.

- DEPOSIT J: The proportion of total Deposit J assay samples with TS in excess of 0.1 wt%S is 8.6% with 0.8% of total assay samples having TS in excess of 0.3 wt%S. All samples with TS greater than 0.1 wt%S were collected above 800 mAHD, up to 70 m above groundwater as indicated by the mining model. This would suggest sulfur is likely present as lower risk sulfates. Only one waste assay sample from the DOR stratigraphy has TS greater than 1 wt%S, and only 17 DOR waste samples have TS greater than 0.5 wt%S. With significant BWT mining not expected for Deposit J (i.e., groundwater intercepts base of pit), the sulfur measured is likely oxidised and would therefore support a low-risk classification. **The sulfur risk for Deposit J is low**.

- MOUNT ELLA EAST EXTENSION (MTEE): The proportion of total MTEE assay samples with TS in excess of 0.1 wt%S is 8.5% with 0.6% of total assay samples having TS in excess of 0.3 wt%S. However, only 2 WS waste samples have TS greater than 0.2 wt%S and no waste samples have TS in excess of 0.3 wt%S. With BWT mining not expected for MTEE, the minimal sulfur measured is likely oxidised and would therefore further support a low-risk classification. **The sulfur risk for MTEE is low**.

- WESTERN HILL: The proportion of total Western Hill assay samples with TS in excess of 0.1 wt%S is 6.2% with 0.6% of total assay samples having TS in excess of 0.3 wt%S. The majority of mining at Western Hill will be above water table mining (<1 Mt BWT waste rock). Waste samples with TS greater than 0.1 wt%S are predominantly from the DET, DG, and WS stratigraphies, with minor quantities also from the MCS stratigraphy. As BWT mining is only anticipated at the base of the pit, this would suggest sulfur is likely present as lower risk sulfates. **The sulfur risk for Western Hill is low-moderate**.

Table 9: In-pit total sulfur assay summaries per Deposit.

DEPOSIT	TOTAL S ASSAY SAMPLES	S >0.1 wt%		S >0.3 wt %		AVERAGE S wt %	
	n	*n*	% of total *n*	*n*	% of total *n*	of n_{TOT}	*of* $n_{S>0.1wt\%S}$
Deposit A	235,881	5,547	2.4%	372	0.2%	0.024	0.176
Deposit A W	20,445	170	0.8%	15	0.1%	0.021	0.172
Deposit B	54,352	3,856	7.1%	87	0.2%	0.036	0.151
Deposit C	18,041	242	1.3%	39	0.2%	0.027	0.235
Deposit D	26,402	291	1.1%	63	0.2%	0.021	0.241
Deposit E	42,650	599	1.4%	75	0.2%	0.021	0.193
Deposit F	40,115	767	1.9%	115	0.3%	0.024	0.212
Deposit G	6,165	48	0.8%	3	<0.1%	0.024	0.154
Deposit H	5,730	243	4.2%	8	0.1%	0.030	0.146
Deposit J	4,355	376	8.6%	37	0.8%	0.045	0.202
MTEE	2,230	190	8.5%	14	0.6%	0.048	0.175
Western Hill	17,477	1,089	6.2%	99	0.6%	0.042	0.192

4.2.2 Sulfur and Sulfide Risk in the Mining Model

This section provides an assessment of sulfide risk designation tonnages within the supplied mining models and estimates of waste blocks pit exposures with sulfide risk designations 1, 2, 3, or 4.

The supplied mining models provide life of mine total tonnages for West Angelas. Predicted waste rock tonnages for each deposit per lithology and per sulfide risk category are provided in Table G1, Appendix G. Table 10 presents mining model summary tonnages per deposit per sulfide risk category and

Table 11 presents mining model summary tonnages per TS bin per sulfide risk category.

Key findings are as follows:

- SULFIDE RISK = 0 and 1: These no AMD risk and low AMD risk classifications have been assigned to 94.6% and 5.1% of the total West Angelas waste rock. Waste rock assigned a no AMD risk classification is represented at all deposits. Waste rock classified as Sulfide Risk 1 is represented at all deposits except Deposits B, C, and D. The predicted median and average TS values within the mining model for the total Sulfide Risk 0 and 1 waste rock are <0.05 wt%S.

- SULFIDE RISK = 2: Approximately 3 Mt of waste rock is assigned a Sulfide Risk 2 classification (moderate AMD risk). This represents a minor component of West Angelas waste rock (0.1% of total) and is expected to be mined from the A, C, D, E, and J deposits. Above water table low TS MCS (maximum TS of 0.06 wt%S) from Deposit J represents 46% of the total Sulfide Risk 2 waste rock. MAC waste rock represents 47% of the total Sulfide Risk 2 waste rock. The majority of this is expected from Deposit D, below the water table low TS (maximum TS of 0.05 wt%S). The remaining 6% of the total Sulfide Risk 2 waste rock is elevated TS WF waste rock from Deposit A and C (maximum and median TS of 0.79 wt%S and 0.34 wt%S, respectively).

- SULFIDE RISK = 3: No waste rock has been assigned this high AMD risk classification within the West Angelas mining models. That is, no unoxidised black shale is predicted for any of the deposits. Relatively minor waste rock tonnages of WS, MCS, and MTS with TS less than or equal to 0.2 wt%S are expected from above the water table from Deposit J and Western Hill. A minor quantity (28.5 Kt) of below water table FOR waste rock is predicted from Deposit B, although TS is predicted to be less than 0.05 wt%.

- SULFIDE RISK = 4: Approximately 6.5 Mt of potential calcrete waste rock is assigned a Sulfide Risk 4 classification (potential acid neutralisation material). This represents a minor component of West Angelas waste rock (0.2% of total) and is expected to be mined from above the water table at the C, D, and G deposits.

Table 10: Mining model tonnages of waste blocks per sulfide risk category for West Angelas.

DEPOSIT	SULFIDE RISK = 0 (t)	SULFIDE RISK = 1 (t)	SULFIDE RISK = 2 (t)	SULFIDE RISK = 4 (t)	TOTALS (t)
Deposit A	1,168,528,000	157,500	158,800	-	1,168,844,300
Deposit A West	176,549,700	20,900	-	-	176,570,600
Deposit B	336,407,300	-	-	-	336,407,300
Deposit C	136,639,200	-	32,200	1,239,400	137,910,800
Deposit D	199,153,100	-	1,463,900	4,681,700	205,298,700
Deposit E	273,267,500	130,900	14,900	-	273,413,300
Deposit F	195,184,400	11,287,400	-	-	206,471,800
Deposit G	47,065,100	5,494,000	-	611,400	53,170,500
Deposit H	22,858,600	31,700	-	-	22,890,300
Deposit J	19,704,900	40,215,100	1,437,100	-	61,357,100
MTEE	5,287,000	8,914,800	-	-	14,201,800
WSTH	66,450,800	75,294,300	-	-	141,745,100
TOTAL	2,647,095,600	141,546,600	3,106,900	6,532,500	2,798,281,600
% TOTAL WASTE	94.6%	5.1%	0.1%	0.2%	100%

Table 11: Mining model tonnages of waste blocks per sulfide risk category per TS bins.

TS BINS	SULFIDE RISK = 0 (t)	SULFIDE RISK = 1 (t)	SULFIDE RISK = 2 (t)	SULFIDE RISK = 4 (t)	TOTALS (t)	% OF TOTAL
0.05	2,351,729,600	115,701,800	2,875,300	6,525,500	2,476,832,200	88.5%
0.10	239,686,200	19,195,200	40,700	7,000	258,929,100	9.3%
0.15	41,420,400	3,569,100	-	-	44,989,500	1.6%
0.20	9,452,400	822,600	-	-	10,275,000	0.4%
0.25	2,560,800	532,600	17,400	-	3,110,800	0.1%
0.30	1,063,300	420,800	22,100	-	1,506,200	0.1%
0.35	523,100	419,600	79,400	-	1,022,100	<0.1%
0.40	221,700	404,600	27,100	-	653,400	<0.1%
0.45	130,700	432,700	28,600	-	592,000	<0.1%
0.50	110,500	20,500	7,400	-	138,400	<0.1%
100	196,900	27,100	8,900	-	232,900	<0.1%
TOTAL	2,647,095,600	141,546,600	3,106,900	6,532,500	2,798,281,600	100%

Table 11 show that 97.8% of total waste rock tonnes fall within the lowest two TS bins (i.e., TS <0.1 wt%S) and 99.4% fall within the lowest three (i.e., TS <0.15 wt%S). With respect to ore tonnes within the mining model, 98.6% of total ore tonnes fall within the lowest two TS bins (i.e., TS <0.1 wt%S) and 99.7% fall within the lowest three (i.e., TS <0.15 wt%S).

RTIO also have black shale flags within the mining model that particularly target both unoxidised and oxidised MCS, FWZ, MTS, and WS. Although, the flags are not restricted to black shale stratigraphies. As presented in Table 12, no waste blocks are classified as *BS-HOT* (which correlates with the Sulfide Risk 3 classification.

As presented in Table 12, total *BS-COLD* waste tonnages (3.4 Mt) are similar to Sulfide Risk 2 classification deposit distribution and tonnage totals. The *BS-COLD* waste tonnages represent a minor component of West Angelas waste rock (0.1% of total) and is expected to be mined from the A, A West, C, D, E, F, and J deposits. Waste blocks classified as *BS-COLD* are expected from both above and below water table in relatively even quantities and include the DET, DOR, FWZ, MCS, WF, ANG, MAC, and NEW stratigraphies.

The deposits containing the largest *BS-COLD* waste tonnages are Deposit D (44.5% of total *BS-COLD* waste tonnes) and Deposit J (45.3% of total *BS-COLD* waste tonnes). Deposit A contains approximately 9% of the total predicted *BS-COLD* tonnages which is mainly elevated sulfur ANG waste blocks (median and average TS 0.28 wt%S). FWZ (142 Kt) and MCS (1,306 Kt) waste rock classified as *BS-COLD*, typically higher AMD risk lithologies, is predicted from Deposit J. Generally, TS is low for these waste blocks (median and average TS <0.1 wt%S). Figure 12 presents cross-sections for Deposit J showing the *BS-COLD* distribution. FWZ and MCS is predicted within pits 1, 2, and 3, at elevations of 776-936 mRL (Table 13).

As presented in Table 12, approximately 145 Mt of *BS-OXIDE* waste rock is predicted, which is similar to the tonnages predicted for the sulfide risk 1 classification (low AMD risk). The *BS-OXIDE* waste

tonnages represent 5.2% of the total West Angelas waste rock. BS-OXIDE waste rock is expected from all deposits except the B, C, and D deposits.

Table 12: Mining model tonnages of waste blocks classified as *BS-HOT*, *BS-COLD*, and *BS-OXIDE*.

DEPOSIT	BS-HOT (t)	BS-COLD (t)	BS-OXIDE (t)	SUB-TOTAL (t)	% OF TOTAL WASTE
Deposit A	-	292,200	152,700	444,900	<0.1%
Deposit A West	-	800	324,500	325,300	<0.1%
Deposit B	-	-	-	-	<0.1%
Deposit C	-	34,300	-	34,300	<0.1%
Deposit D	-	1,497,300	-	1,497,300	0.1%
Deposit E	-	15,300	145,700	161,000	<0.1%
Deposit F	-	400	11,551,000	11,551,400	0.4%
Deposit G	-	-	5,456,300	5,456,300	0.2%
Deposit H	-	-	39,000	39,000	<0.1%
Deposit J	-	1,526,300	40,551,300	42,077,600	1.5%
MTEE	-	-	8,997,600	8,997,600	0.3%
WSTH	-	-	77,635,200	77,635,200	2.8%
TOTALS	-	3,366,600	144,853,300	148,219,900	
% TOTAL WASTE	-	0.1%	5.2%	5.3%	5.3%

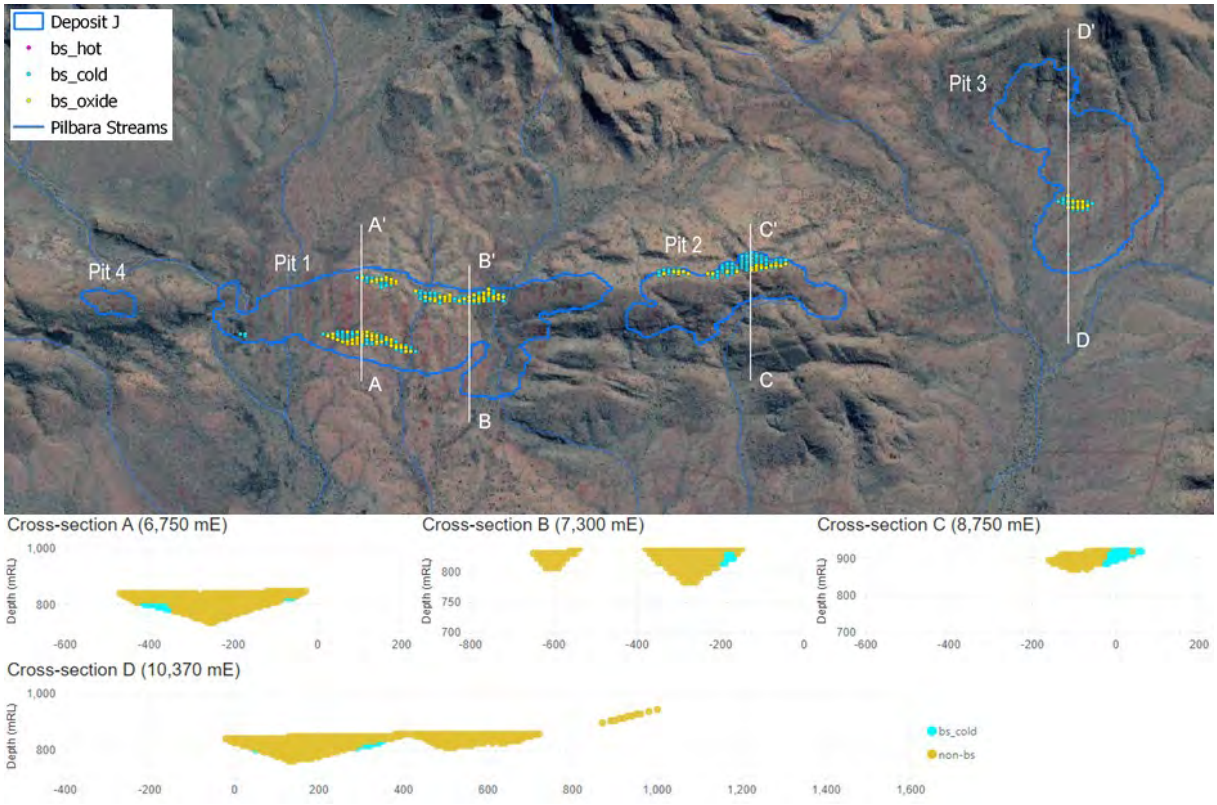

Figure 12. Cross-sections showing *BS-COLD* distribution within Deposit J. Depth and width not to scale. Approximate pre-mining groundwater level is 736 mRL.

Table 13: Estimated elevations of predicted *BS-COLD* waste rock for each deposit.

DEPOSIT	BS-COLD (t)	MIN-RL	MAX-RL	% OF TOTAL	AWT/BWT
Deposit A	292,200	698	784	8.7%	AWT
Deposit A West	800	636	636	<0.1%	AWT
Deposit C	34,300	652	708	1.0%	AWT
Deposit D	1,497,300	548	620	44.5%	AWT
Deposit E	15,300	648	672	0.5%	AWT/BWT
Deposit F	400	670	670	<0.1%	BWT
Deposit J	1,526,300	776	936	45.3%	AWT
TOTAL	3,366,600				

The deposits containing the largest *BS-OXIDE* waste tonnages are Deposit J (28% of total *BS-OXIDE* waste tonnes) and Western Hill (53.6% of total *BS-OXIDE* waste tonnes). All MCS and FWZ waste blocks classified as *BS-OXIDE* are from these two deposits (approximately 4.5 Mt from each deposit) and are generally low TS waste blocks (median and average TS <0.05 wt%S).

Table 14: Estimated elevations of predicted *BS-OXIDE* waste rock for each deposit.

DEPOSIT	*BS-OXIDE* (t)	MIN-RL	MAX-RL	% OF TOTAL	AWT/BWT
Deposit A	152,700	752	784	0.1%	AWT
Deposit A West	324,500	660	716	0.2%	AWT

DEPOSIT	*BS-OXIDE* (t)	MIN-RL	MAX-RL	% OF TOTAL	AWT/BWT
Deposit E	145,700	720	744	0.1%	BWT
Deposit F	11,551,000	670	790	8.0%	BWT
Deposit G	5,456,300	588	756	3.8%	AWT/BWT
Deposit H	39,000	794	834	<0.1%	AWT
Deposit J	40,551,300	752	952	28.0%	AWT
MTEE	8,997,600	720	824	6.2%	AWT
WSTH	77,635,200	608	848	53.6%	AWT/BWT
TOTAL	144,853,300				

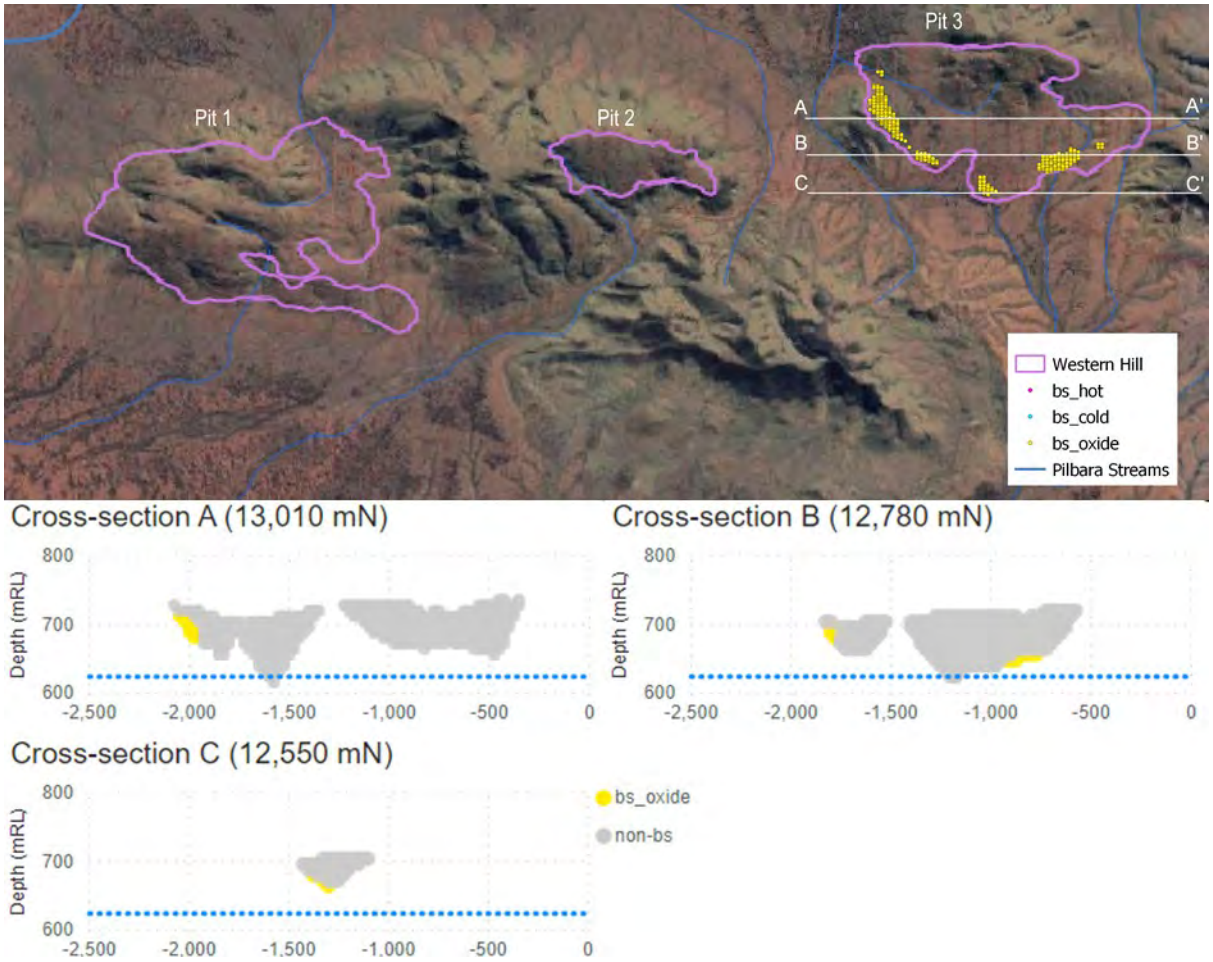

Figure 13. Cross-sections showing *BS-OXIDE* (MCS and FWZ only) distribution at Western Hill. Depth and width not to scale. Blue dotted line represents approximate pre-mining groundwater level (736mRL).

Figure 14 (Deposit J) and Figure 15 (Western Hill) present the visual outputs from the surface area modelling. Table 15 (Deposit J) and Table 16 (Western Hill) present the estimated surface areas. As

shown, exposures of *BS-COLD* material are predicted for Deposit J (136,270 m^2). This represents approximately 8% of the total surface area of Deposit J. *BS-OXIDE* (MCS and FWZ only) exposures are predicted for Deposit J and Western Hill (35,820 m^2 and 52,370 m^2 respectively). This represents 2% of the total surface area for both the Deposit J and Western Hill deposits.

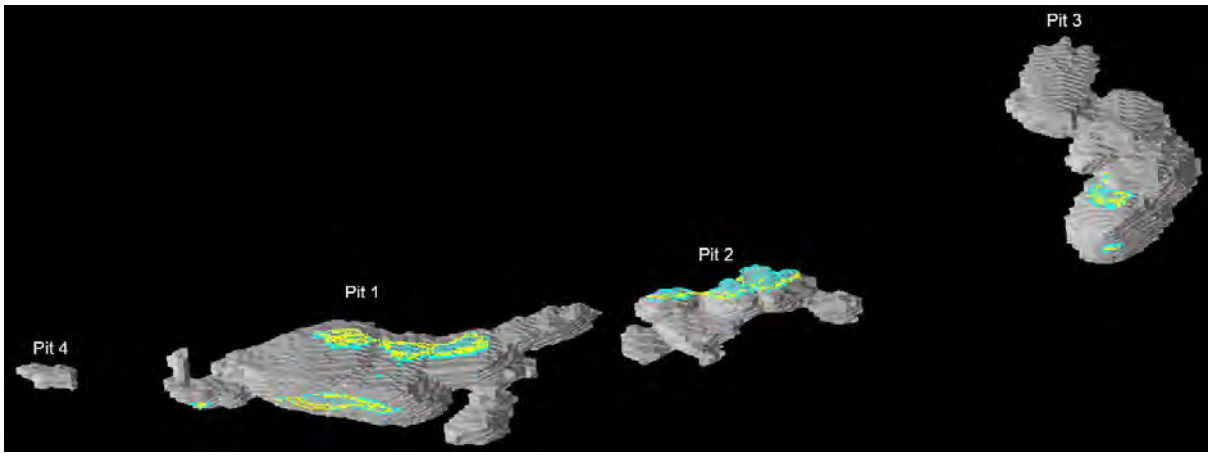

Figure 14. *BS-COLD* (blue) and *BS-OXIDE* (MCS and FWZ only) exposures on Deposit J final pit shells.

Table 15: Estimated surface areas of *BS-COLD* and *BS-OXIDE* in Deposit J final pit shells.

MM CODE	PIT 4 (m^2)	PIT 1 (m^2)	PIT 2 (m^2)	PIT 3 (m^2)	TOTAL (m^2)
BS-COLD	0	81,580	39,760	14,930	136,270
BS-OXIDE	0	26,340	5,080	4,400	35,820

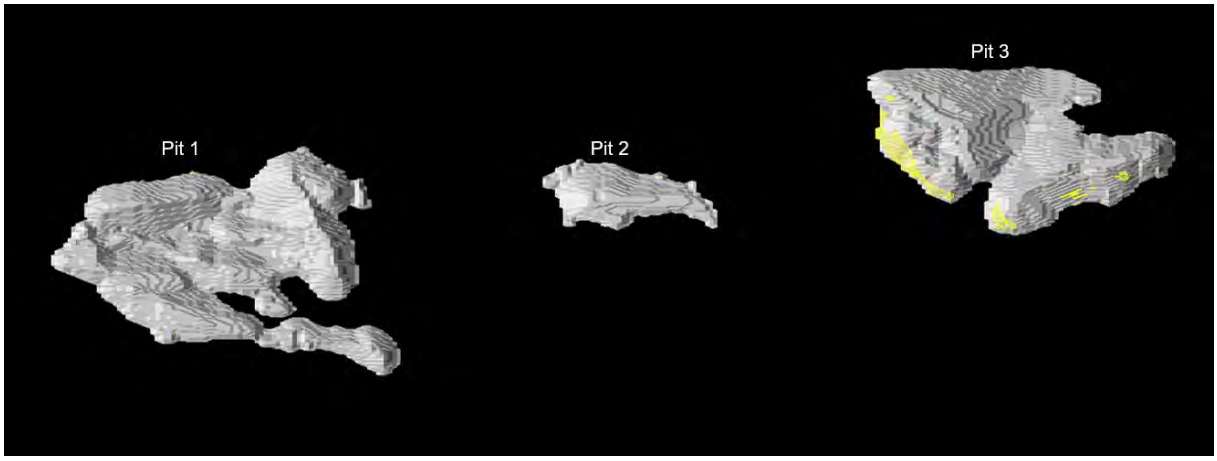

Figure 15. *BS-OXIDE* (MCS and FWZ only) exposures on Western Hill final pit shells.

Table 16: Estimated surface areas of *BS-OXIDE* in Western Hill final pit shells.

MM CODE	PIT 1 (m^2)	PIT 2 (m^2)	PIT 3 (m^2)	TOTAL (m^2)
Oxidised MCS	220	130	52,020	52,370

4.3 Neutral Metalliferous and Saline Drainage Potential

The risk of generating neutral metalliferous drainage (NMD) or saline drainage (SD) associated with neutralisation of oxidation products is unlikely. Generally, the deposit contains very little sulfur with

moderate (≥0.5 wt%S) and high (≥1 wt%S) TS assay samples restricted to less than 0.1% and 0.05% of the total assay database respectively. When considering the high TS samples within the environmental geochemistry database, only one MM sample has a negative NAPP. When considering the moderate TS samples within the environmental geochemistry database, 40% of the samples have negative NAPP values. Therefore, the proportion of samples within the assay database that have moderate or high sulfur and may have sufficient ANC to be classified as NAF, is likely very low.

When interrogating the mining model:

- An insignificant quantity of waste blocks has predicted TS ≥1 wt%S (3,900 t). This ANG material is expected from below the water table at Deposit F.
- Only minor quantities of waste rock with predicted moderate TS of 0.5-1 wt%S, is expected from West Angelas. These 229 Kt is expected from the A, C, F, J, Mount Ella East Extension, and Western Hill deposits.

4.4 Chemical Enrichment and Mobility

Approximately 950,000 samples from across the West Angelas project have been analysed for routine chemical element suite of Al, Ca, Fe, K, Mg, Mn, Na, P, S and/or Ti, as well as, Ba, Cl, Co, Cr, Cu, Ni, Pb, Si, Sn, Sr, V, Zn and Zr. As part of the ABA suite of tests, and to support the liquid extract analyses 48 samples have been analysed for an extended elemental suite Table 17. To investigate the potential for identified enriched elements to mobilise, static leach testing (liquid extract analysis) has been completed on 38 samples.

Table 17. XRF (assay samples), total elemental (e.g., acid digest), and liquid extract data available per parameter.

PARAMETER	ASSAY SAMPLES		TOTAL ELEMENTAL SAMPLES	LIQUID EXTRACT SAMPLES
	TOTAL	IN-PIT		
Al	902,921	485,882	48	38
As	735,564	363,296	43	38
Ba	734,908	362,692	43	38
Ca	869,204	467,495	48	38
Cl	733,886	362,501	0	35
Co	735,563	363,295	43	38
Cr	735,563	363,295	43	33
Cu	871,688	472,367	43	38
Fe	863,439	462,426	48	38
K	882,631	477,295	48	38
Mg	884,653	478,523	48	38
Mn	871,718	469,414	43	38
Mo	0	0	43	38
Na	723,011	358,909	48	38

PARAMETER	ASSAY SAMPLES		TOTAL ELEMENTAL SAMPLES	LIQUID EXTRACT SAMPLES
	TOTAL	IN-PIT		
Ni	735,564	363,296	40	38
P	903,044	485,997	43	38
Pb	884,337	478,385	40	38
S	867,006	463,992	48	8 (SO_4; 38)
Si	902,914	485,877	18	38
Sn	735,564	363,296	40	38
Sr	734,932	362,692	43	38
Ti	874,476	470,381	48	5
V	735,564	363,296	40	8
Zn	874,228	470,091	40	38
Zr	734,931	362,691	30	0
Extended Suite Parameters			Ag (43), Au (13), B (13), Be (30), Bi (43), Cd (43), Ce (30), Cs (30), F (10), Ga (30), Ge (30), Hf (30), Hg (43), In (20), La (30), Li (30), Nb (30), Rb (30), Sb (43), Sc (30), Se (40), Th (43), Tl (30), U (43), W (30) Y (33)	Ag (38), B (38), Be (30), Bi (8), Cd (38), F (38), Hg (38), N (5), Sb (38), Se (38), Th (35), U (35)

As presented in Table 18, several rock types have median enrichments of 3 or greater in As and/or Fe, when assessing the assay dataset. Other elements with median GAI values greater than 0 include Cr, Pb, and Sn. When assessing the total elemental dataset (or acid digest dataset) Table E6 (Appendix E), B, S, Sb, and Se also present enrichment. It should be noted that although a material may be enriched relative to average crustal abundances, it does not imply this element will be mobilised at levels harmful to a specific receptor.

A total of 38 West Angelas samples have been submitted for short-term leach testing; DET (*n* = 6), DOR (*n* = 2), WF (*n* = 12), and MM (*n* = 18). The following key findings are noted from the static leach testing:

- Generally, mobility of trace elements is low with leachates slightly acidic to alkaline (5.8-8.9) and containing low to moderate salinity (21-889 µS/cm). Fe, Mn, Si, and Zn were the only elements measured above 1 mg/L.
- Sulfate concentrations are generally low (<500 mg/L). The exception is three Deposit A MM samples with sulfate between 555-1,650 mg/L.
- Of the elements identified through GAI analysis as being enriched:
    - As was not mobilised above 0.02 mg/L.

- Fe was only mobilised from one Deposit A West DOR sample in excess of 1 mg/L (1.5 mg/L).
- Cr was mobilised above the limit of reporting in two samples at low concentrations (0.003 and 0.009 mg/L).
- Sb and Se were only measured in one WF sample above the limit of limit or reporting. Measured Sb and Se concentrations were low (0.006 and 0.02 mg/L respectively)
- Pb and Sn were not mobilised above the limit of limit or reporting.

Table 18. Median (and maximum) GAI values as derived from the assay database for As and Fe, as well as other elements with GAI values of 1 or 2.

STRAT	MEDIAN As GAI (MAX As GAI)	MEDIAN Fe GAI (MAX Fe GAI)	MEDIAN GAI >0 (MAX GAI)
ALL	3 (6)	2 (3)	Sn (5)
DET-CLA	2 (6)	1 (3)	
DET-CAL	0 (5)	1 (2)	
DET	2 (7)	2 (3)	
DOR	2 (5)	1 (3)	
WS	3 (8)	2 (3)	
DG	2 (7)	2 (3)	
FWZ	4 (7)	2 (3)	
MCS	5 (8)	1 (2)	Pb (3)
MTS	5 (5)	1 (1)	Pb (1)
ANG	3 (7)	2 (3)	
MAC	1 (5)	2 (3)	
NAM	0 (4)	2 (2)	
NEW	1 (6)	2 (3)	Sn (5)
UNKNOWN	3 (7)	2 (3)	Cr (2), Sn (5)
DET-ORE	2 (5)	2 (3)	
WS-ORE	3 (5)	2 (3)	
DG-ORE	2 (7)	3 (3)	
FWZ-ORE	3 (7)	2 (3)	
ANG-ORE	3 (7)	2 (3)	Sn (4)
NEW-ORE	1 (6)	3 (3)	Sn (7)
MAC-ORE	1 (5)	2 (3)	
NAM-ORE	1 (2)	2 (3)	

5 RTIO ARD SCORE SHEET

Individual ARD Score Sheets were completed for each of the West Angelas deposits. Table 19 provides the summary results with each completed ARD hazard score cards provided in Appendix B.

Table 19. RTIO ARD hazard score cards.

DEPOSIT	PRELIM. ASSESS. SCORE	DETAILED ASSESS. SCORE	COMBINED HAZARD SCORE	RISK RANKING
Deposit A	52	15	28	LOW
Deposit A West	44	15	26	LOW
Deposit B	48	16	28	LOW
Deposit C	49	17	29	LOW
Deposit D	45	17	28	LOW
Deposit E	45	17	28	LOW
Deposit F	43	15	26	LOW
Deposit G	39	15	25	LOW
Deposit H	39	20	30	LOW
Deposit J	44	23	34	MODERATE
Mount Ella East Extension	29	21	28	LOW
Western Hill	51	22	35	MODERATE

6 CONCLUSIONS

The AMD risk for the West Angelas deposits has been investigated in line with RTIO's standard approach (Appendix A).

- Assay results for in-pit material suggest a low risk of acid generating potential:
    - Approximately 2.8% of all in-pit samples had greater than 0.1 wt%S.
    - Approximately 0.2% of all in-pit samples contained sulfur above 0.3 wt%S.
    - Although the sulfur risk for Deposit B is low, a number of PAF samples within the environmental geochemical dataset suggest the potential for pyrite and could therefore be considered a moderate sulfur risk.
- Of the 209 samples within the West Angelas environmental geochemical database with ABA data:
    - The WF stratigraphy group represents the greatest source of PAF samples (n_{PAF} = 13). These samples were collected from Deposit A (n = 5), Deposit A West (n = 1), and Deposit B (n = 7). The MM stratigraphy group represents the next greatest source (n_{PAF} = 5) with one sample collected from Deposit A, three samples collected from Deposit B, and one from Deposit F. The only other sample classified as PAF was a Deposit A West DOR sample.
    - Most median paste pH values are circum-neutral ($pH_{1:2}$ 7-8) and fresh ($EC_{1:2}$ <400 µS/cm).
    - ANC is generally low with median values ≤3 kg H_2SO_4/t for most stratigraphies and low-moderate (7 kg H_2SO_4/t) for the ALL and BIF samples. ABCC results suggest that ANC is readily availability in the ALL, DET, and WF samples. Variable ANC availability was observed in the 15 MM samples tested ($ENC_{4.5}$ 18-153% of titrated ANC) suggesting an inconsistency in the presence of fast reacting carbonate ANC.
    - Median NAPP values are negative for all stratigraphy groups. Reflective of Pilbara iron ore deposits with low sulfur and low ANC, median NAPP values are only slightly negative (-6 to -0.5 kg H_2SO_4/t).
- Extensive assay sampling has identified several elements (As, Cr, Fe, Pb, and Sn) enriched relative to average crustal abundances. Acid digestion testing on a subset of samples within the environmental geochemistry database identified additional elements (B, S, Sb, and Se) to be enriched. However, enrichment does not imply mobility at concentrations harmful to a given receptor.
- Generally, mobility of trace elements is low with leachates slightly acidic to alkaline (5.8-8.9) and containing low to moderate salinity (21-889 µS/cm). Fe, Mn, Si, and Zn were the only elements measured above 1 mg/L.
- No long-term column leach testing has been completed on waste rock from West Angelas.
- IORs values were 18.4^{E-11} and $1.6E^{-10}$ kg O_2/kg/sec for the WF and MM samples tested.

- No waste rock within the mining models was assigned by RTIO a sulfide risk rating or 3 (e.g., high AMD risk classification; *BS-HOT*). No unoxidised black shale is predicted for any of the deposits.
- A total of 3.4 Mt of *BS-COLD* waste rock is predicted (0.1% of the total waste rock). The *BS-COLD* tonnages correlate closely with the sulfur risk 2 waste block tonnages and deposit distribution.
- The deposits containing the largest *BS-COLD* waste tonnages are Deposit D (44.5% of total *BS-COLD* waste tonnes) and Deposit J (45.3% of total *BS-COLD* waste tonnes). Deposit A contains approximately 9% of the total predicted *BS-COLD* tonnages which is mainly elevated sulfur ANG waste blocks (median and average TS 0.28 wt%S).
- FWZ (142 Kt) and MCS (1,306 Kt) waste rock classified as *BS-COLD* is predicted from Deposit J. Generally, TS is low for these waste blocks (median and average TS <0.1 wt%S) and is predicted within pits 1, 2, and 3, at elevations of 776-936 mRL.
- A total of 3.4 Mt of *BS-COLD* waste rock is predicted (0.1% of the total waste rock). The *BS-COLD* tonnages correlate closely with the sulfur risk 2 waste block tonnages and deposit distribution.
- Approximately 145 Mt of *BS-OXIDE* waste rock is predicted, which correlates to the tonnages predicted for the sulfide risk 1 classification (low AMD risk). The *BS-OXIDE* waste tonnages represent 5.2% of the total West Angelas waste rock. *BS-OXIDE* waste rock is expected from all deposits except the B, C, and D deposits.
- The deposits containing the largest *BS-OXIDE* waste tonnages are Deposit J (28% of total *BS-OXIDE* waste tonnes) and Western Hill (53.6% of total BS-OXIDE waste tonnes). All MCS and FWZ waste blocks classified as *BS-OXIDE* are from these two deposits (approximately 4.5 Mt from each deposit). and are generally low TS (median and average TS <0.05 wt%S).
- No exposures of *BS-HOT* waste rock are expected in the final pit walls.
- Exposures of *BS-COLD* material are predicted for Deposit J (136,270 m^2); approximately 8% of the total final pit surface area for Deposit J.
- *BS-OXIDE* (MCS and FWZ only) exposures are predicted for Deposit J and Western Hill (35,820 m^2 and 52,370 m^2 respectively); approximately 2% of the total final pit surface area for both deposits.
- Combined hazard scores for Deposit A, Deposit A West, Deposit B, Deposit C, Deposit D, Deposit E, Deposit F, Deposit G, Deposit H, and Mount Ella East Extension are low.
- Combined hazard scores for Deposit J and Western Hill are moderate. Although these deposits have a moderate risk score, minimal below water table mining is expected and any measured sulfur is likely sulfate.

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8 LIMITATIONS

Attention is drawn to the document “Limitations”, which is included in Appendix D of this report. The statements presented in this document are intended to provide advice on what the realistic expectations of this report should be, and to present recommendations on how to minimise the risks associated with this project. The document is not intended to reduce the level of responsibility accepted by Mine Waste Management, but rather to ensure that all parties who may rely on this report are aware of the responsibilities each assumes in doing so.

MINE WASTE MANAGEMENT

GREENROAD GROUP

Appendix 8: West Angelas AMD Risk Assessment

Pilbara Iron Company (Services) Pty Ltd
Level 18
Central Park
152-158 St Georges Terrace
Perth WA 6000
Australia
T +61 (8) 9327 2000

From	Sarah Fyfe
Department	WRE - Mineral Waste
To	Steven Lee
Reference	RTIO-PDE-0190973
Date	8 June 2022

WANG AMD Risk Assessment Review 2022

Introduction

A review of the acid and metalliferous drainage (AMD) risk at West Angelas has been undertaken to support the Part IV approval and the Mine closure plan (MCP). This review aims to compare previously reported mine plan and pit shells with updated information since the 2021 WANG AMD Risk Assessment (MWM, 2021).

Background

A full AMD Risk Assessment was undertaken by Mine Waste Management in 2021 and encompassed pits from Deposit A, Deposit A-West, Deposit B, Deposit C, Deposit D, Deposit E, Deposit F, Deposit G, Deposit H, Deposit J, Mount East Ella Extension and Western Hill. Details of the block models and pit shells used in the 2021 reporting are presented in Appendix 1. The 2021 Risk Assessment identified the overall AMD risk of Deposit J and Western Hill as moderate. All other deposits risks were ranked as low (MWM, 2021).

Data Comparison

In the following sections is a review of changes of in-pit drillhole sulfur data, block model estimates, pit shell geometries and exposures of at-risk material. This review encompasses all proposed and active pits from West Angelas and compares data presented in the 2021 AMD risk assessment with revised mine plans and up to date drilling data.

A-West

The number of samples at A-West has increased from 20,445 in 2021 to 21,187 in 2022 due to a drilling program undertaken in 2021. This has not affected the overall sulfur assessment with the percentage of samples with S greater than 0.1 wt% and 0.3 wt% remaining at 0.8% and 0.1%, respectively (Table 1).

Table 1: Deposit A-West drillhole analysis of in pit sulfur samples

Pit Name	Year	Count of S samples	Number of S>0.1	Percentage of Samples with S>0.1%	Average of S Value if >0.1	Number of S>0.3	Percentage of Samples with S>0.3%	Average of S wt%
DEP A-West	2022	21,187	174	0.80%	0.17	14	0.10%	0.02
	2021	20,445	170	0.80%	0.17	15	0.10%	0.02

The new block model for A-west has estimated 814 t of sulfide risk 2 material in AW1, previously no sulfide risk 2 or 3 material was expected at A-West. An exposure of 1,320 m^2 in AW1 final pit void has been predicted and should be accounted for in the mine closure plan (Figure 1).

Table 2: Deposit A-West comparison of sulfur and fibre risks

Pit Name	Pit Surface Area (m^2)		Fibre Risk 3 (t)		Fibre (m^2)		Sulfide Risk 2 (t)		Sulfide Risk 2 (m^2)	
	2022	2021	2022	2021	2022	2021	2022	2021	2022	2021
AW1	1,424,000	1,316,000	-	-	-	-	814	-	1,320	-
AW2	829,926	662,153	-	-	-	-	-	-	-	-
AW3	608,024	520,488	-	-	-	-	-	-	-	-

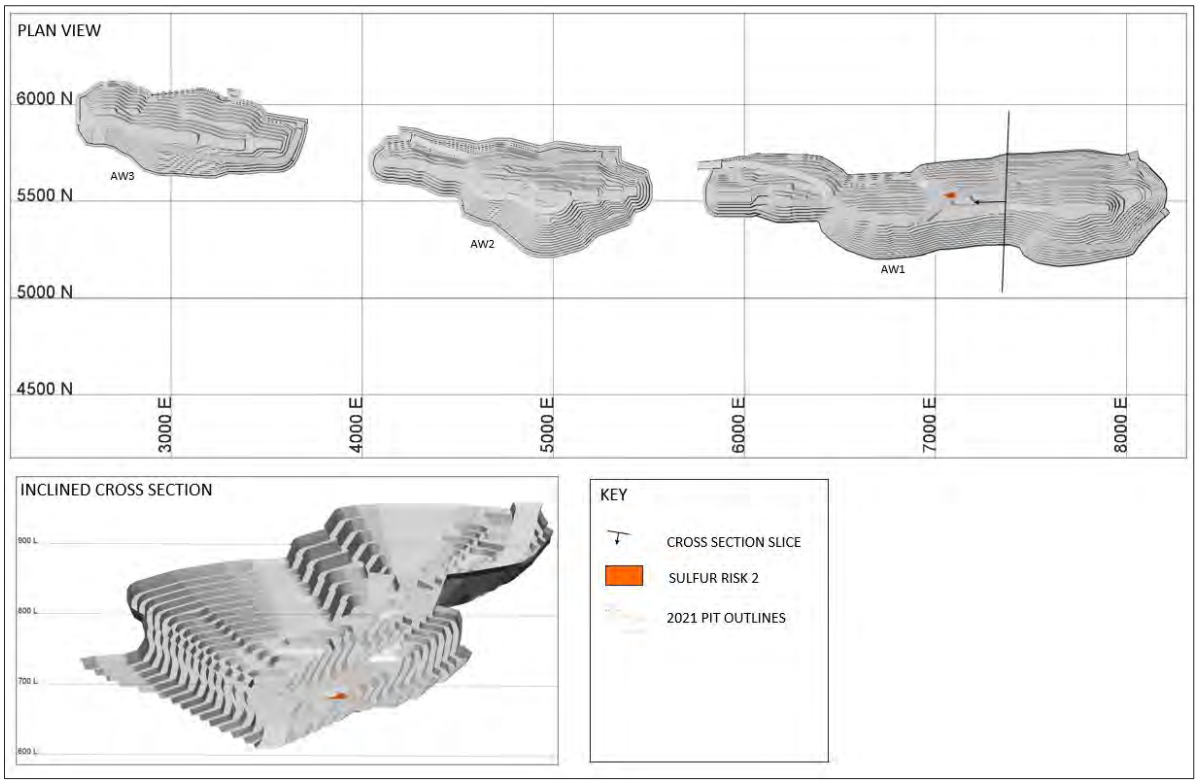


Figure 1: Deposit A-West pit shells with Sulfur Risk 2 exposures.

Deposit A

Since the 2021 there has been a decrease in the number of samples in Deposit A. This is likely attributed to changes in shell geometry. The percentage of samples with greater than 0.1 wt % sulfur has increased from 2.4% to 2.5% since the AMD risk assessment (Table 3). The percentage of samples with greater than 0.3 wt% S has remained at 0.2%.

Table 3: Deposit A drillhole analysis of in pit sulfur samples

Pit Name	Year	Count of S samples	Number of S>0.1	Percentage of Samples with S>0.1%	Average of S Value if >0.1	Number of S>0.3	Percentage of Samples with S>0.3%	Average of S wt%
DEP A	2022	234,933	5,780	2.5%	0.17	373	0.2%	0.02
	2021	235,881	5,547	2.4%	0.18	372	0.2%	0.02

Two pit shells have been added to Deposit A since the 2021 AMD risk assessment, neither the Gum pit nor the Cake pit contain exposure of sulfide risk 2 or fibre risk 3 material (Table 4). Model updates have reduced the estimated tonnes of sulfide risk 2 material from 158,800 t in 2021 to 150,366 t in 2022 (Table 4). The fibre risk at Deposit A has increased from 15,087 t to 18,700 t, while surface exposures of fibre risk have not changed with 6,922 m^2 exposure in the depa_uf21.0.2 (Figure 4).

Table 4: Deposit A comparison of sulfur and fibre risks

Pit Name	Pit Surface Area (m^2)		Fibre Risk 3 (t)		Fibre (m^2)		Sulfide Risk 2 (t)		Sulfide Risk 2 (m^2)	
	2022	2021	2022	2021	2022	2021	2022	2021	2022	2021
Cake - Pit	219,920		-	-	-	-	-	-	-	-
Gumleaf	62,676		-	-	-	-	-	-	-	-
Depa_uf21	6,433,000	6,433,000	15,087	18,700	6,922	6,922	150,366	158,800	-	-
WPS/WPS-cutback(2020)	302,326	294,649	-	-	-	-	-	-	-	-

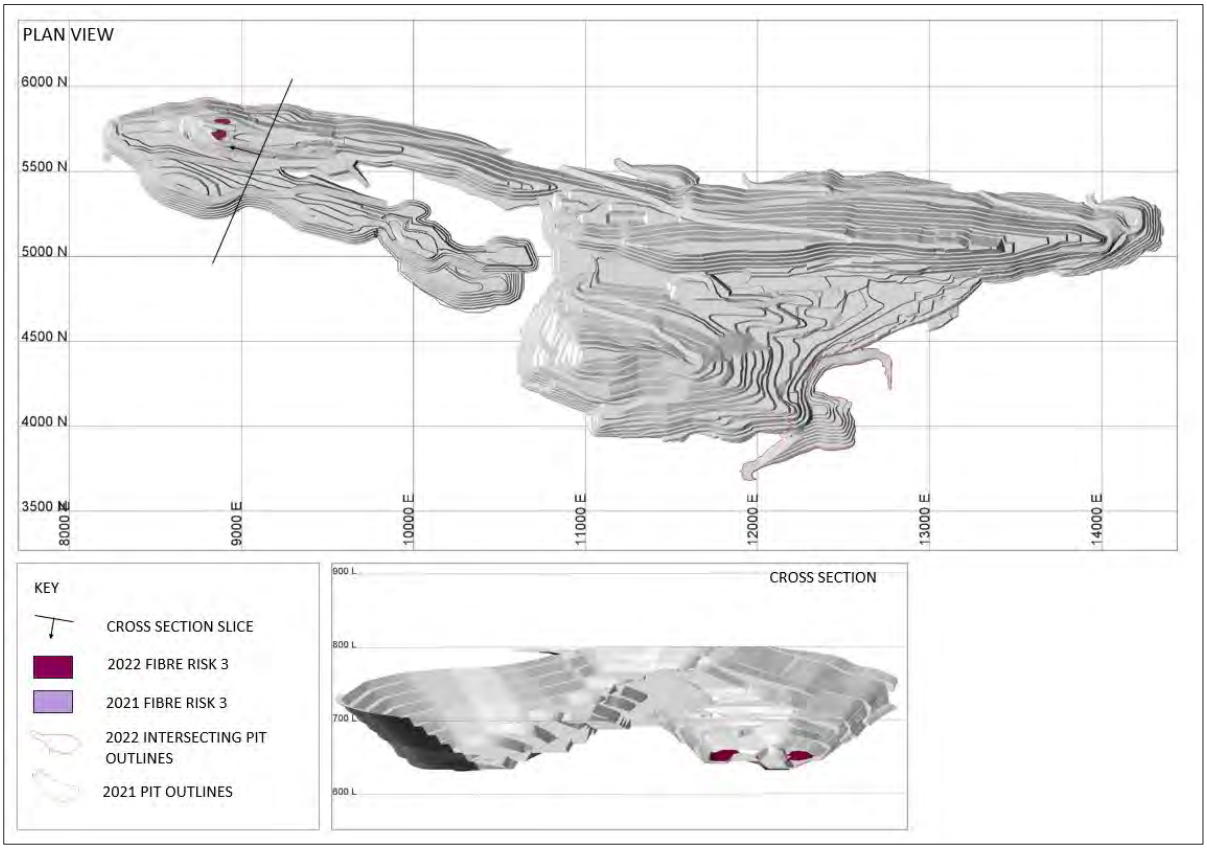


Figure 2: Deposit A pit shell with exposures of fibre risks

Deposit B

Drilling undertaken in 2021 has increased the number of in-pit samples from 54,352 to 54,985 (Table 5). This has increased the percentage of samples with greater than 0.1 wt% S from 7.1% to 7.5% (Table 5). The percentage of samples with S greater than 0.3 wt% has remained the same (Table 5).

Table 5: Deposit B analysis of in pit sulfur samples

Pit Name	Year	Count of S samples	Number of S>0.1	Percentage of Samples with S>0.1%	Average of S Value if >0.1	Number of S>0.3	Percentage of Samples with S>0.3%	Average of S wt%
DEP B	2022	54,985	4,142	7.5%	0.15	96	0.2%	0.04
	2021	54,352	3,856	7.1%	0.15	87	0.2%	0.04

There has been no change to the Deposit B pit shell since the 2021 AMD risk assessment. The sulfide risk has remained the same between model updates with no sulfide risk 2 or 3 material modelled in the

pit shell (Table 6). The exposure of Fibre risk 3 has marginally increased in the updated block model, from 41,202 m^2 to 41,767 m^2 (Figure 3).

Table 6: Deposit B comparison of sulfur and fibre risks

Pit Name	Pit Surface Area (m^2)		Fibre Risk 3 (t)		Fibre (m^2)		Sulfide Risk 2 (t)		Sulfide Risk 2 (m^2)	
	2022	2021	2022	2021	2022	2021	2022	2021	2022	2021
Deposit B	No Change	3,994,000	264,031	266,578	41,767	41,201	-	-	-	-

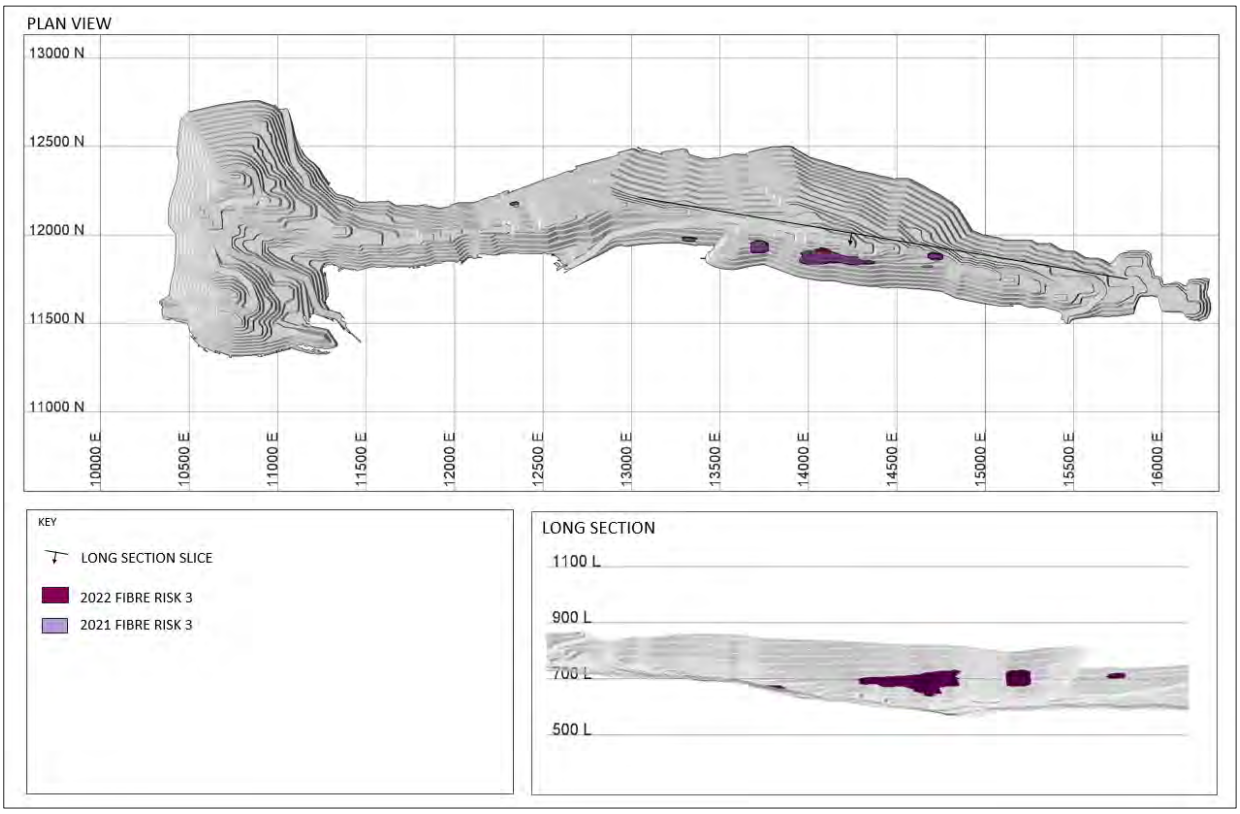


Figure 3: Deposit B pit shell with exposure of fibre risks

Deposit C

The number of in pit samples drilled at Deposit C have increased by 315 since 2021. The sulfur statistics show a small decrease in the percentage of samples with sulfur greater than 0.1 wt%, reducing from 1.3 to 1.2 % (Table 7). The number of in-pit samples with elevated sulfur has reduced from 242 to 223, this is a result of changes in pit geometries (Table 7).

Table 7: Deposit C drillhole analysis of in pit sulfur samples

Pit Name	Year	Count of S samples	Number of S>0.1	Percentage of Samples with S>0.1%	Average of S Value if >0.1	Number of S>0.3	Percentage of Samples with S>0.3%	Average of S wt%
DEP C	2022	18,356	223	1.2%	0.24	38	0.2%	0.03
	2021	18,041	242	1.3%	0.24	39	0.2%	0.03

The overall tons of sulfide risk 2 material increased from 32,200 to 65,066 t since the last AMD risk assessment (Table 8). This is attributed to an updated estimation in 2021. The exposure of sulfide risk 2 material has not changed with 539 m^2 estimated to be exposed. The amount of fibre risk 3 material

has decreased in pit C2 and increased in the C3 pit. Estimates of fibre risk 3 exposures have not changed with 7,581 m^2 and 15,145 m^2 of material in C2 and C3, respectively (Figure 4).

Table 8: Deposit C comparison of sulfur and fibre risks

Pit Name	Pit Surface Area (m^2)		Fibre Risk 3 (t)		Fibre (m^2)		Sulfide Risk 2 (t)		Sulfide Risk 2 (m^2)	
	2022	2021	2022	2021	2022	2021	2022	2021	2022	2021
C1	297,386	310,612	-	-	-	-	-	-	-	-
C2	1,133,000	1,229,000	129	1,038	No Change	7,581	65,066	32,200	539	539
C3	1,221,000	2,231,000	77,289	28,478	No Change	15,145	-	-	-	-

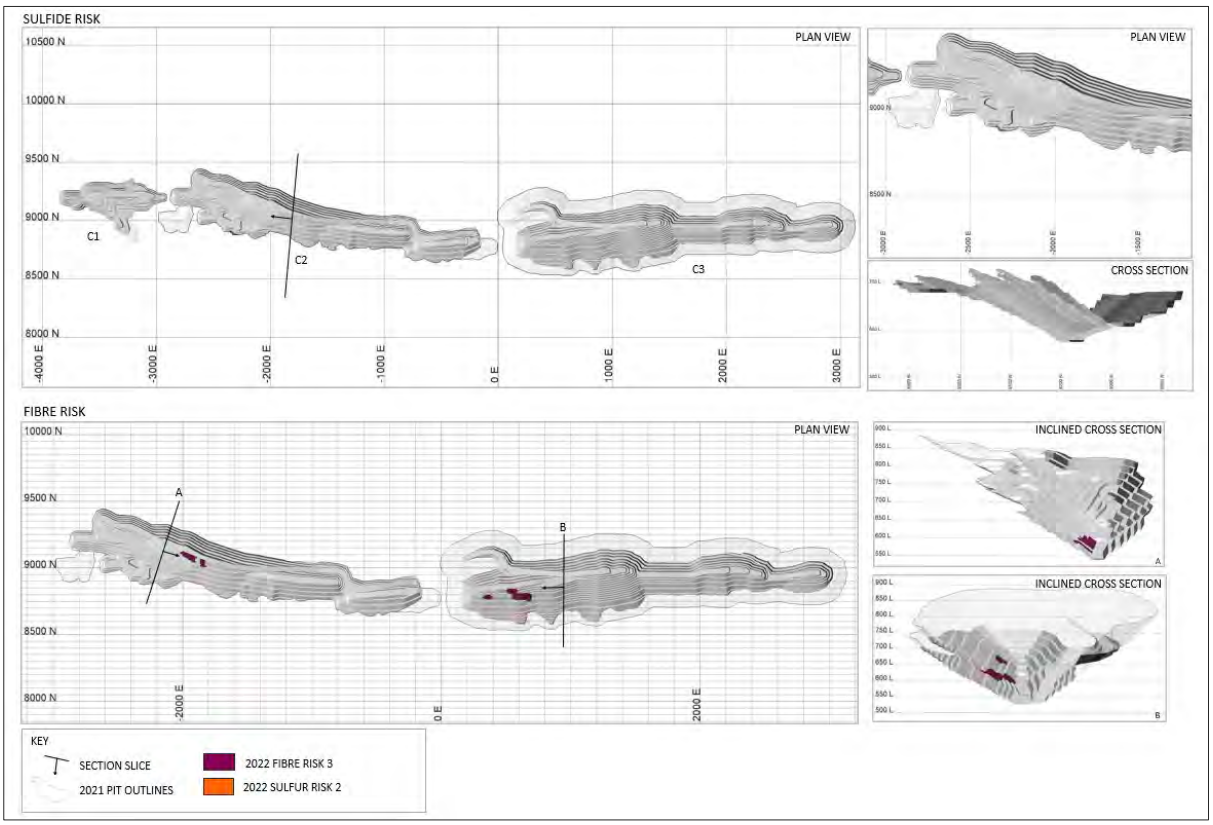


Figure 4: Deposit C pit shell with exposure of fibre and sulfur risks

Deposit D

There has been no change in the percentage of elevated sulfur samples since the 2021 AMD risk assessment. A reduction in the number of in-pit samples is attributed to changes in the pit shells.

Table 9: Deposit D drillhole analysis of in pit sulfur samples

Pit Name	Year	Count of S samples	Number of S>0.1	Percentage of Samples with S>0.1%	Average of S Value if >0.1	Number of S>0.3	Percentage of Samples with S>0.3%	Average of S wt%
DEP D	2022	26,344	292	1.1%	0.24	63	0.2%	0.02
	2021	26,402	291	1.1%	0.24	63	0.2%	0.02

Since the 2021 AMD risk assessment there has been an addition of D4 and D5 pits. Neither of these pit shell contains sulfide risk 2 or 3 material, nor fibre risk 3 material. The tonnes of estimated sulfide risk

3 material in pit D1 has increased slightly from 1,463,900 t to 1,497,415 t (Table 10). The exposure of this material in the final pit shell has marginally increased from 87,347 m^2 to 87,629 m^2 (Figure 5). Fibre risk 3 material is estimated in pits D1-D3, the surface area of these exposures has not changed in the updated model.

Table 10: Deposit D comparison of sulfur and fibre risks

Pit Name	Pit Surface Area (m^2)		Fibre Risk 3 (t)		Fibre (m^2)		Sulfide Risk 2 (t)		Sulfide Risk 2 (m^2)	
	2022	2021	2022	2021	2022	2021	2022	2021	2022	2021
D1	1,714,000	1,781,000	1,098,675	1,098,667	No Change	67,126	1,497,415	1,463,900	87,629	87,347
D2	313,599	314,273	-	-	No Change	673	-	-	-	-
D3	525,239	634,836	1,084	1,084	No Change	4,663	-	-	-	-
D4	93,637	-	-	-	-	-	-	-	-	-
D5	119,754	-	-	-	-	-	-	-	-	-

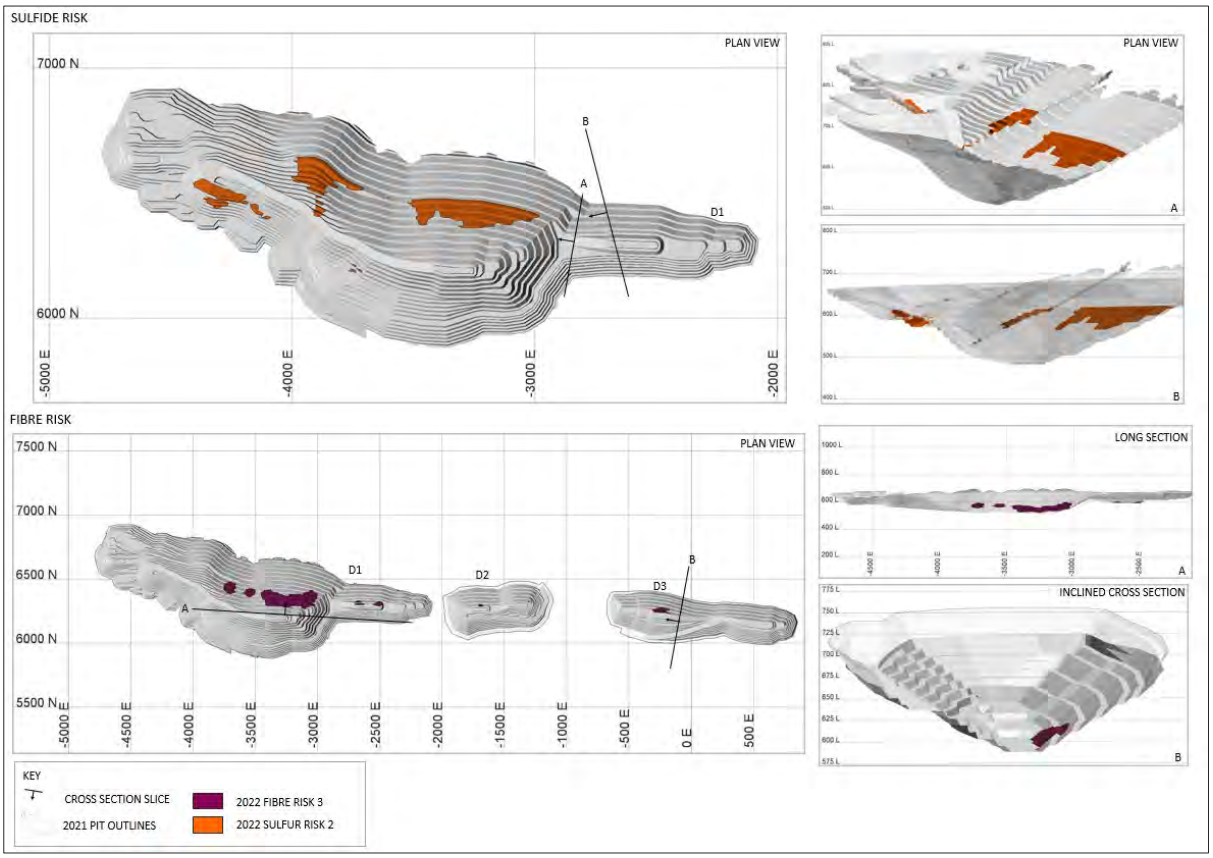


Figure 5: Deposit E pit shell with exposure of fibre and sulfur risks

Deposit E

Since 2021 there has been a decrease in the number of inpit samples, this is due to a discrepancy in methodologies employed by Mine Waste management and Rio Tinto Iron Ore in assigning samples as inpit. Despite this there has been no change in the percentage of samples with sulfur greater than 0.1 and 0.3 wt% (Table 11). Average concentrations have remained the same between 2021 and 2022.

Table 11: Deposit E drillhole analysis of in pit sulfur samples

Pit Name	Year	Count of S samples	Number of S>0.1	Percentage of Samples with S>0.1%	Average of S Value if >0.1	Number of S>0.3	Percentage of Samples with S>0.3%	Average of S wt%
DEP E	2022	42,203	602	1.4%	0.19	76	0.2%	0.02
	2021	42,650	599	1.4%	0.19	75	0.2%	0.02

There has been no change in the surface area of the Deposit E pit shells since the 2021 AMD risk assessment. The updated block model has increased the amount of sulfide risk 2 from 14,900 to 15,282 t (Table 12). This has not affected the exposure surface area with it remaining 1,261 m^2. Fibrous mineral Risk 3 exposures occur in both the East and West pits, the surface area of these have not changed in the recent block model update (Figure 6).

Table 12: Deposit E comparison of sulfur and fibre risks

Pit Name	Pit Surface Area (m^2)		Fibre Risk 3 (t)		Fibre (m^2)		Sulfide Risk 2 (t)		Sulfide Risk 2 (m^2)	
	2022	2021	2022	2021	2022	2021	2022	2021	2022	2021
DepE East	No Change	1,622,000	56,331		No Change	4,566	15,282	14,900	1,261	1,261
DepE West	No Change	1,214,000	1,045		No Change	3,451	-	-	-	-

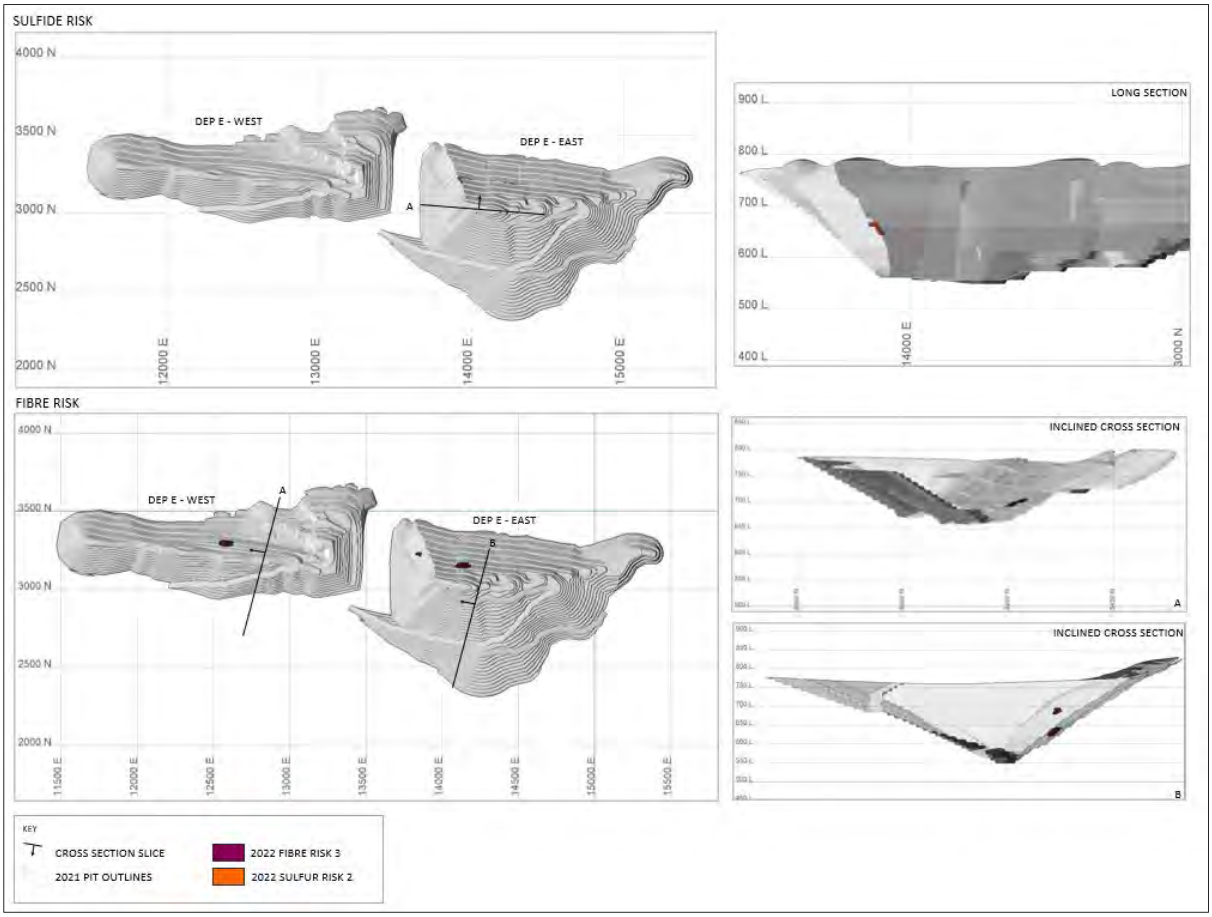


Figure 6: Deposit F pit shell with exposure of fibre and sulfur risks

Deposit F

In pit sample numbers at Deposit F have decreased since the last AMD risk assessment due to changes in the pit shells. The percentage of samples with S greater than 0.1 wt% have increased from 1.9 to 2.2%, while the number of samples with elevated sulfur have reduced (Table 13).

Table 13: Deposit F drillhole analysis of in pit sulfur samples

Pit Name	Year	Count of S samples	Number of S>0.1	Percentage of Samples with S>0.1%	Average of S Value if >0.1	Number of S>0.3	Percentage of Samples with S>0.3%	Average of S wt%
DEPF	2022	34882	763	2.2%	0.21	115	0.3%	0.03
	2021	40115	767	1.9%	0.21	115	0.3%	0.02

The latest model update for Deposit F has resulted in an increase in the sulfide risk 2 material modelled in DFE and F-North pit shells. Exposures of this sulfide risk 2 material has been identified in both these pit shells with 23 m^2 exposed on pit DFE and 4,963 m^2 exposed on F-north (Figure 7). Estimates of fibre risk 3 material have marginally increased from 7,073 to 8,670 t in DFW, with 7,991 m^2 exposed on the final pit shell (Table 14).

Table 14: Deposit F comparison of sulfur and fibre risks

Pit Name	Pit Surface Area (m^2)		Fibre Risk 3 (t)		Fibre (m^2)		Sulfide Risk 2 (t)		Sulfide Risk 2 (m^2)	
	2022	2021	2022	2021	2022	2021	2022	2021	2022	2021
DFE	6,55,558	904,817	-	-	-	-	5,510	-	23	-
DFEE - (MARLU)	No Change	465,569	-	-	-	-	-	-	-	-
DFN1	134,081	132,203	-	-	-	-	-	-	-	-
DFS1	No Change	663,259	-	-	-	-	-	-	-	-
DFSW	No Change	285,369	-	-	-	-	-	-	-	-
DFW	991,483	989,400	8,670	7,073	7,991	5,950	-	-	-	-
DEP-F North	No Change	434,303	-	-	-	-	44,419	-	4,963	-

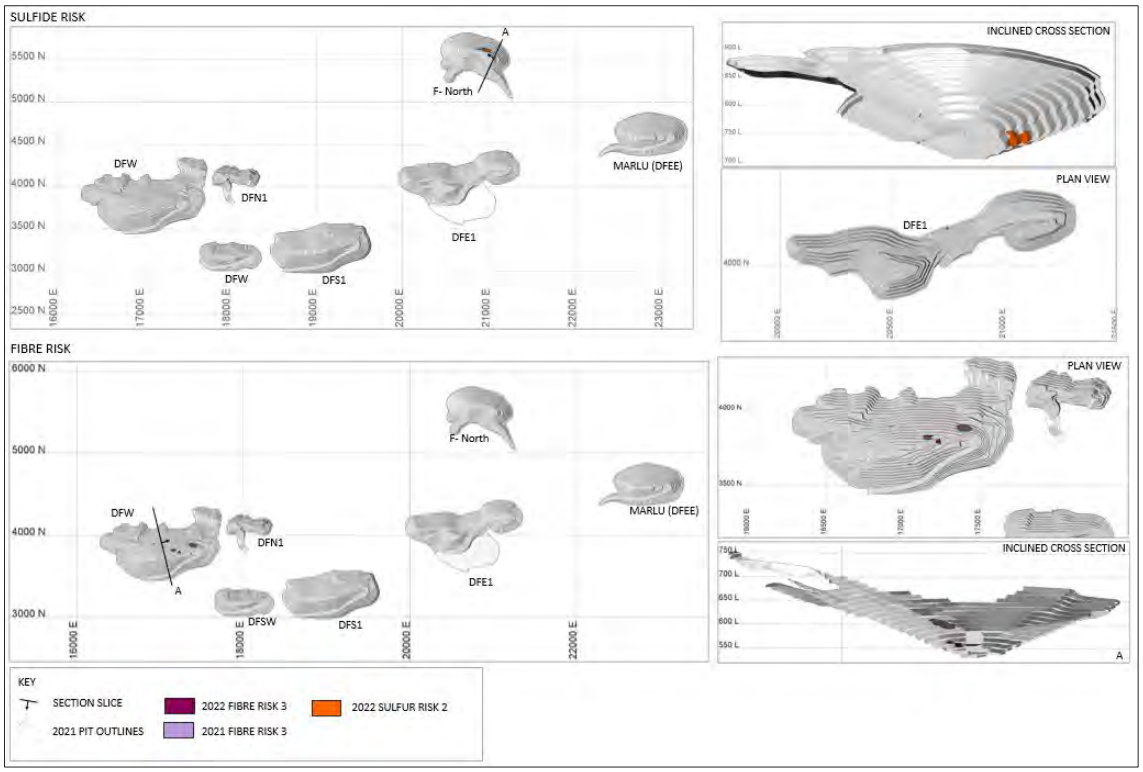


Figure 7: Deposit F pit shell with exposure of fibre and sulfur risks

Deposit G

For Deposit G the number of samples has increased from 6,165 to 7,969 between the 2021 AMD risk assessment and this review, while the percentage of samples with sulfur greater than 0.1 wt% has reduced from 0.8% to 0.7%. Only three samples from across Deposit G have sulfur exceeding 0.3 wt% (Table 15).

Table 15: Deposit G drillhole analysis of in pit sulfur samples

Pit Name	Year	Count of S samples	Number of S>0.1	Percentage of Samples with S>0.1%	Average of S Value if >0.1	Number of S>0.3	Percentage of Samples with S>0.3%	Average of S wt%
DEPG	2022	7,969	54	0.7%	0.15	3	0.0%	0.02
	2021	6,165	48	0.8%	0.15	3	0.0%	0.02

The sulfide risk at Deposit G remains low with no sulfide risk 2 or 3 material being modelled to occur within the pit shells. The quantity of fibre risk 3 material has increased at Deposit G, with 18,804 t in G4 (G2 and G3 tonnes are contained in the G4 estimate) and 10,068 t in G1 (Table 16). All deposit G pits have exposures of fibrous material left in the final pit voids. Seven percent (7%) of G1 and four percent (4%) of G4 pit surface areas have fibre risk 3 exposures (Figure 8).

Table 16: Deposit G comparison of sulfur and fibre risks

Pit Name	Pit Surface Area (m^2)		Fibre Risk 3 (t)		Fibre (m^2)		Sulfide Risk 2 (t)		Sulfide Risk 2 (m^2)	
	2022	2021	2022	2021	2022	2021	2022	2021	2022	2021
G1	288,084	281,139	10,068	4,219	20,429	13,444	-	-	-	-
G2	529,294	509,213	N/A	N/A	1,143	602	-	-	-	-
G3	342,301	337,378	N/A	N/A	6,226	3,355	-	-	-	-
G4	920,965	-	18,804	3,393	34,216	-	-	-	-	-

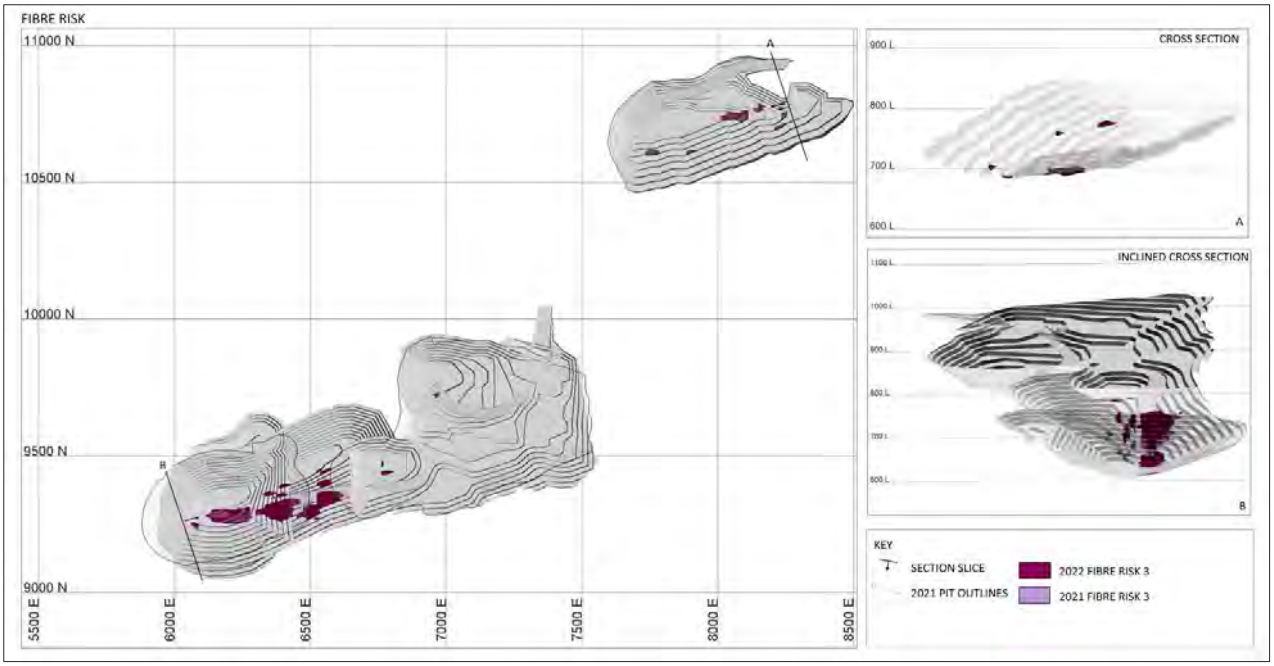


Figure 8: Deposit G pit shell with exposure of fibre risks

Deposit H

For Deposit H the sulfur statistics have remained relatively the same from 2021 to 2022 with the percentage of samples with S>0.1 wt% reducing from 4.2 % to 4%. Less than 10 samples have sulfur concentrations >0.3 wt% (Table 17).

Table 17: Deposit H drillhole analysis of in pit sulfur samples

Pit Name	Year	Count of S samples	Number of S>0.1	Percentage of Samples with S>0.1%	Average of S Value if >0.1	Number of S>0.3	Percentage of Samples with S>0.3%	Average of S wt%
DEPH	2022	5,873	236	4.0%	0.15	7	0.1%	0.03
	2021	5,730	243	4.2%	0.15	8	0.1%	0.03

Since the 2021 AMD risk assessment there has been no change in the surface area of the Deposit H pit shells. No sulfide risk 2 or sulfide risk 3 material has been estimated to occur in the final pits (Table 18). Fibre risk 3 material has been estimated in the current Deposit H block model. Intercepts of fibrous material occur in both the East (1,362 m^2) and West pits (3,533m^2) (Figure 9).

Table 18: Deposit H comparison of sulfur and fibre risks

Pit Name	Pit Surface Area (m^2)		Fibre Risk 3 (t)		Fibre (m^2)		Sulfide Risk 2 (t)		Sulfide Risk 2 (m^2)	
	2022	2021	2022	2021	2022	2021	2022	2021	2022	2021
DEP H - EAST	No change	681,514	2,202	-	3,533	-	-	-	-	-
DEP H - WEST	No change	747,641	21,447	-	1,362	-	-	-	-	-

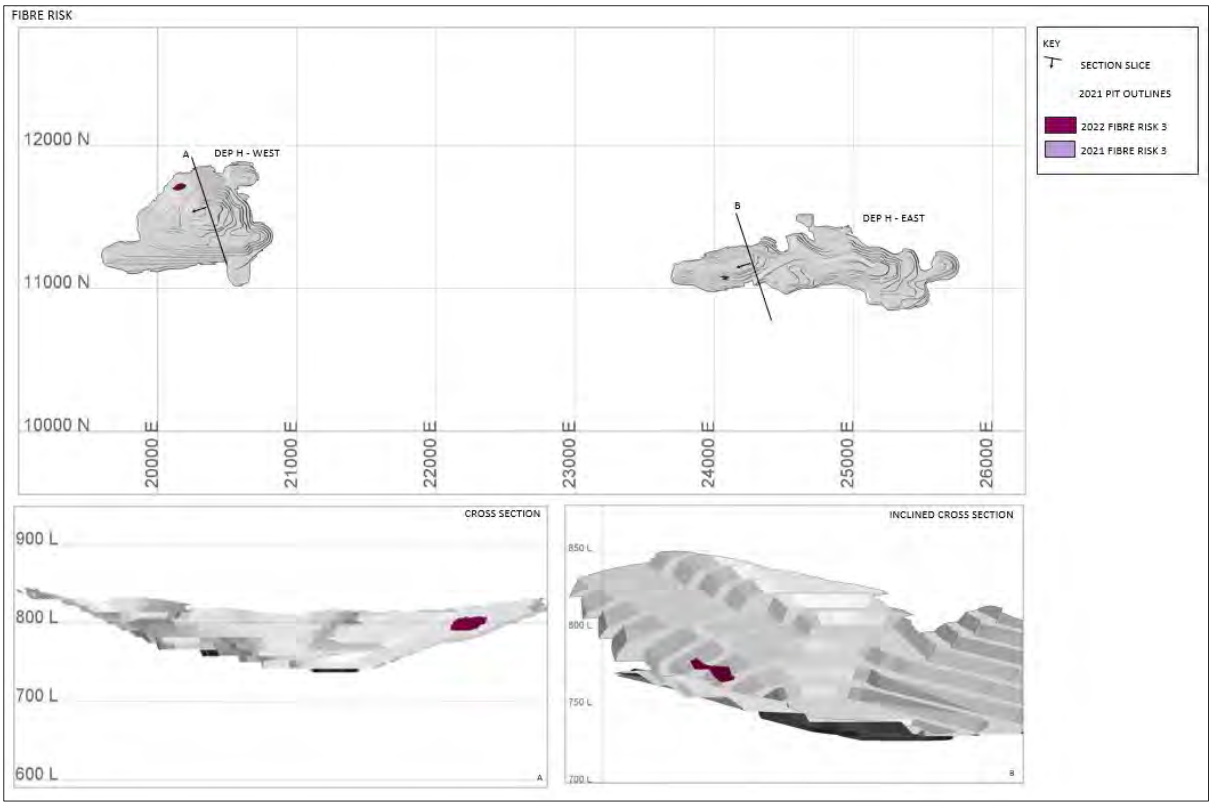


Figure 9: Deposit H pit shell with exposure of fibre risks

Deposit J

Since 2021 there has been minimal change in the Deposit J sulfur statistics with the percentage of samples with S >0.1 wt% increasing slightly from 8.6% to 8.9%. The percentage of samples with sulfur elevated greater than 0.3 wt% has remained the same at 0.8% (Table 19).

Table 19: Deposit J drillhole analysis of in pit sulfur samples

Pit Name	Year	Count of S samples	Number of S>0.1	Percentage of Samples with S>0.1%	Average of S Value if >0.1	Number of S>0.3	Percentage of Samples with S>0.3%	Average of S wt%
DEP J	2022	4,253	379	8.9%	0.20	36	0.8%	0.05
	2021	4,355	376	8.6%	0.20	37	0.8%	0.05

There has been no change in the Deposit J pit shells since the 2021 AMD risk assessment. The quantity of sulfide risk 2 material has increased from 1,420,575 to 1,560,946 t (Table 20). The increase in sulfide risk 2 material has not affected exposure size with 132,490 m^2 estimated to be exposed on the proposed pit shells (Figure 10).

Table 20: Deposit J comparison of sulfur and fibre risks

Pit Name	Pit Surface Area (m^2)		Fibre Risk 3 (t)		Fibre (m^2)		Sulfide Risk 2 (t)		Sulfide Risk 2 (m^2)	
	2022	2021	2022	2021	2022	2021	2022	2021	2022	2021
DEPJ - All Pits	No Change	1,790,000	-	-	-	-	1,560,946	1,420,575	No Change	132,490

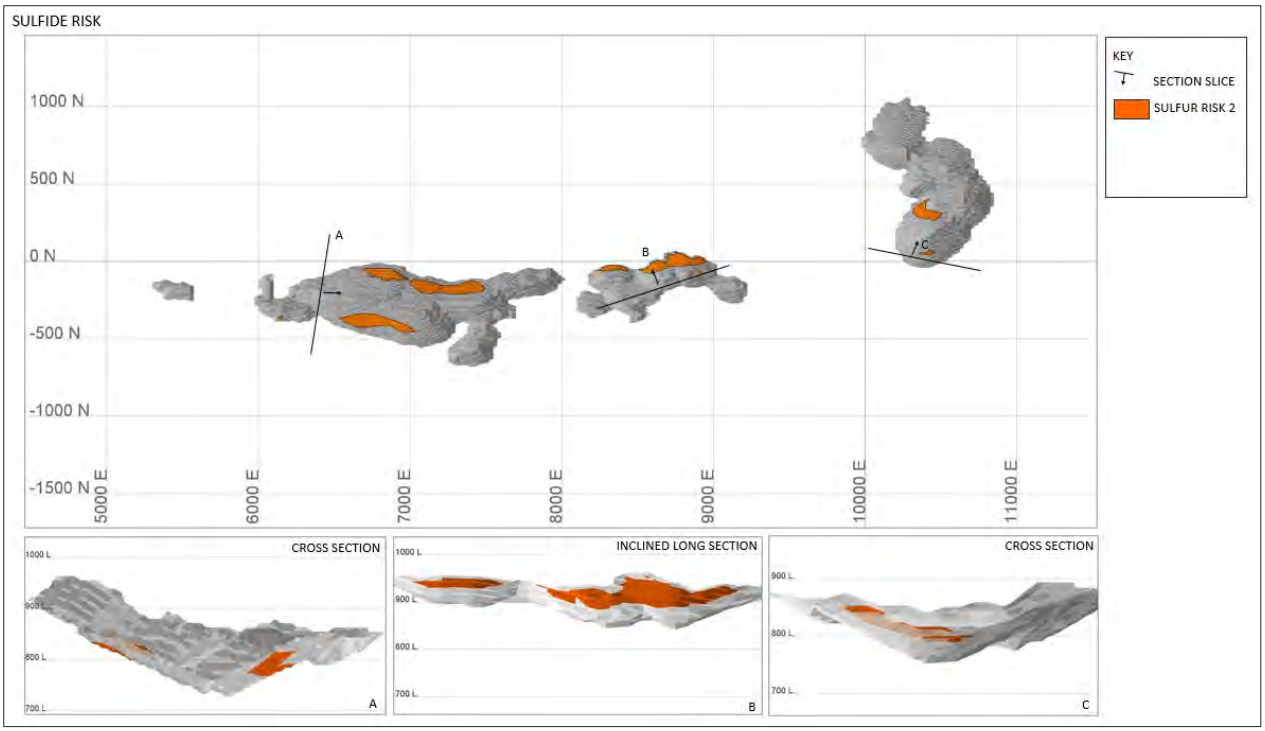


Figure 10: Deposit J pits shell with exposure of sulfide risks

MTEE

Since the last AMD risk assessment, the number of samples in the Mount Ella East deposit has increased from 2,230 to 2,279. The percentage of samples with sulfur greater than 0.3 wt% has increased from 0.6% to 1.1% (Table 21). The average concentration of samples greater than >0.1 wt% has increased from 0.18 wt% to 0.21 wt%.

Table 21: MTEE drillhole analysis of in pit sulfur samples

Pit Name	Year	Count of S samples	Number of S>0.1	Percentage of Samples with S>0.1%	Average of S Value if >0.1	Number of S>0.3	Percentage of Samples with S>0.3%	Average of S wt%
MTEE	2022	2,279	224	9.8%	0.21	24	1.1%	0.05
	2021	2,230	190	8.5%	0.18	14	0.6%	0.05

No sulfide risk or fibrous material has been estimated in the pitshells at Mount East Ella (Table 22).

Table 22: MTEE sulfide and fibrous risks from 2021 compared to 2022

Pit Name	Pit Surface Area (m^2)		Fibre Risk 3 (t)		Fibre (m^2)		Sulfide Risk 2 (t)		Sulfide Risk (m^2)	
	2022	2021	2022	2021	2022	2021	2022	2021	2022	2021
MTEE	No Change	688,660,000	-	-	-	-	-	-	-	-

WESTERN HILL

Since the last assessment Western Hill has had a large drilling program that has increased the number of in pit samples increasing from 17,477 to 24,829 (Table 23). This has affirmed the initial risk assessment with the percentage of samples with S greater than 0.1wt% and 0.3 wt% reducing by 0.1% (Table 23).

Table 23: Western Hill sulfur data from 2021 compared to 2022

Pit Name	Year	Count of S samples	Number of S>0.1	Percentage of Samples with S>0.1%	Average of S Value if >0.1	Number of S>0.3	Percentage of Samples with S>0.3%	Average of S wt%
WHILL	2022	24,829	1,501	6.1%	0.19	128	0.5%	0.04
	2021	17,477	1,089	6.2%	0.19	99	0.6%	0.04

Pit shell geometries have significantly changed since the last AMD risk assessment with the West and East pits increasing in size while the Central pit has reduced in size. Sulfide Risk 2 exposures have been identified in the West Pit and East pit, while no sulfide risk 2 material are assigned in the pit shells (Figure 11). The most recent block model update does not consider recent changes in the pit shell designs. This has resulted in an inconsistency between exposure and tonnes of sulfide risk 2 material in the West and East Pits. The identified exposures should be considered in the mine closure plan and future block model updates will account for the changes in pit shell designs.

Table 24: Western Hill sulfide and fibrous risks from 2021 compared to 2022

Pit Name	Pit Surface Area (m^2)		Fibre Risk 3 (t)		Fibre (m^2)		Sulfide Risk 2 (t)		Sulfide Risk 2 (m^2)	
	2022	2021	2022	2021	2022	2021	2022	2021	2022	2021
West Pit	1,857,000	3,835,000	-	-	-	-	0	-	6,600	-
Central Pit	321,156	303,801	-	-	-	-	187,975	-	0	-
East Pit	1,379,000	3,494,000	-	-	-	-	0	-	5,082	-

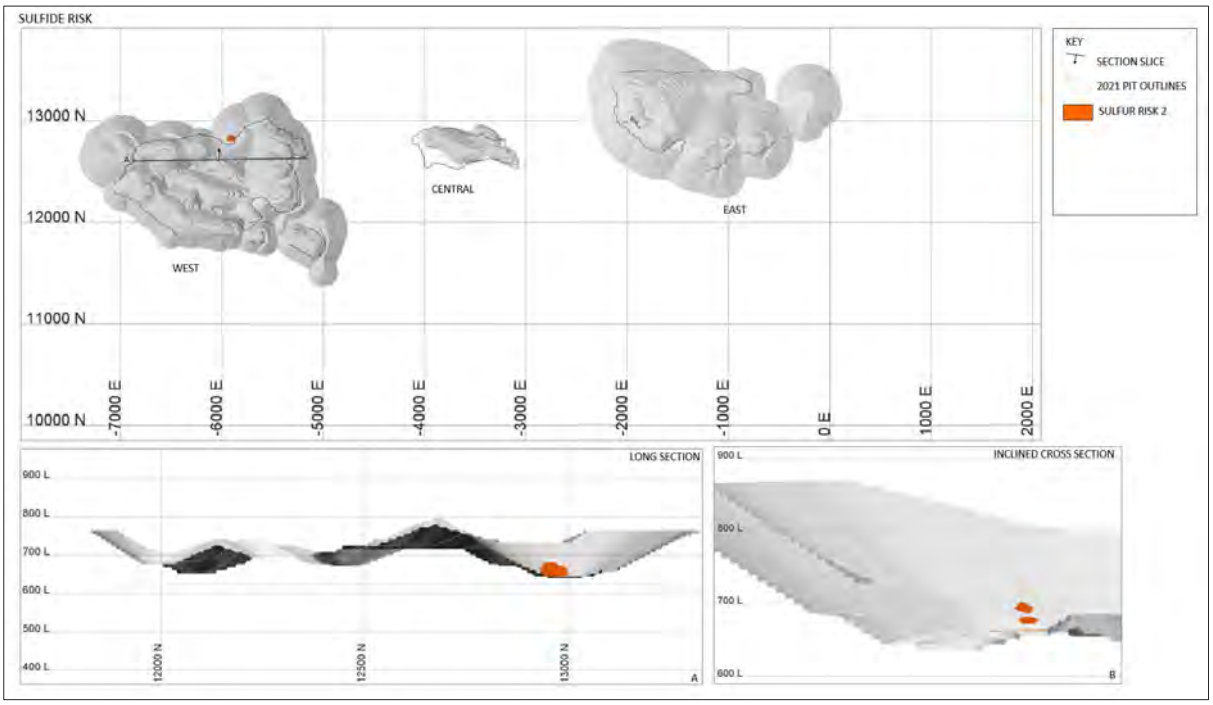


Figure 11: Western Hill pits shell with exposure of sulfide risks

Discussions and Conclusions

From this review it has been determined that the majority of West Angelas deposits have had minimal changes in sulfur risk since the 2021 AMD risk assessment. The exception to this is Mount Ella East deposit where there is an increase in the number of samples with greater than 0.3 wt% S from 0.6 to 1.1%.

Updates in the block models and pit shell revisions have estimated sulfide risk 2 at A-west and Deposit F, with exposures at AW1, F-North and at DFE-1 pits. These deposits did not previously have exposures of sulfide risk 2 material. Additionally, exposures of sulfide risk 2 material have significantly changed at Western Hill with exposure in the final pit walls at West Pit and East pit. It should be noted that there are discrepancies between the estimated tonnes of sulfide risk 2 at Western Hill and the location of exposures, with no sulfide risk 2 tonnes coded in the East and West pits. This should be reviewed at the next block model.

The exposure of fibre risk 3 material has changed minimally at West Angelas since 2021. Notable changes in the fibre risk occur at Deposit G and Deposit H. The exposure of fibre risk 3 material has significantly increased at Deposit G and is in accordance with updates from the 2021 drilling program. Updates in the Deposit H block model has resulted in fibrous exposures in both the East and West pits where previous models had no fibre risk 3 material.

Recommendations

The Western Hill block model should be updated to consider changes in the proposed pit shell designs.

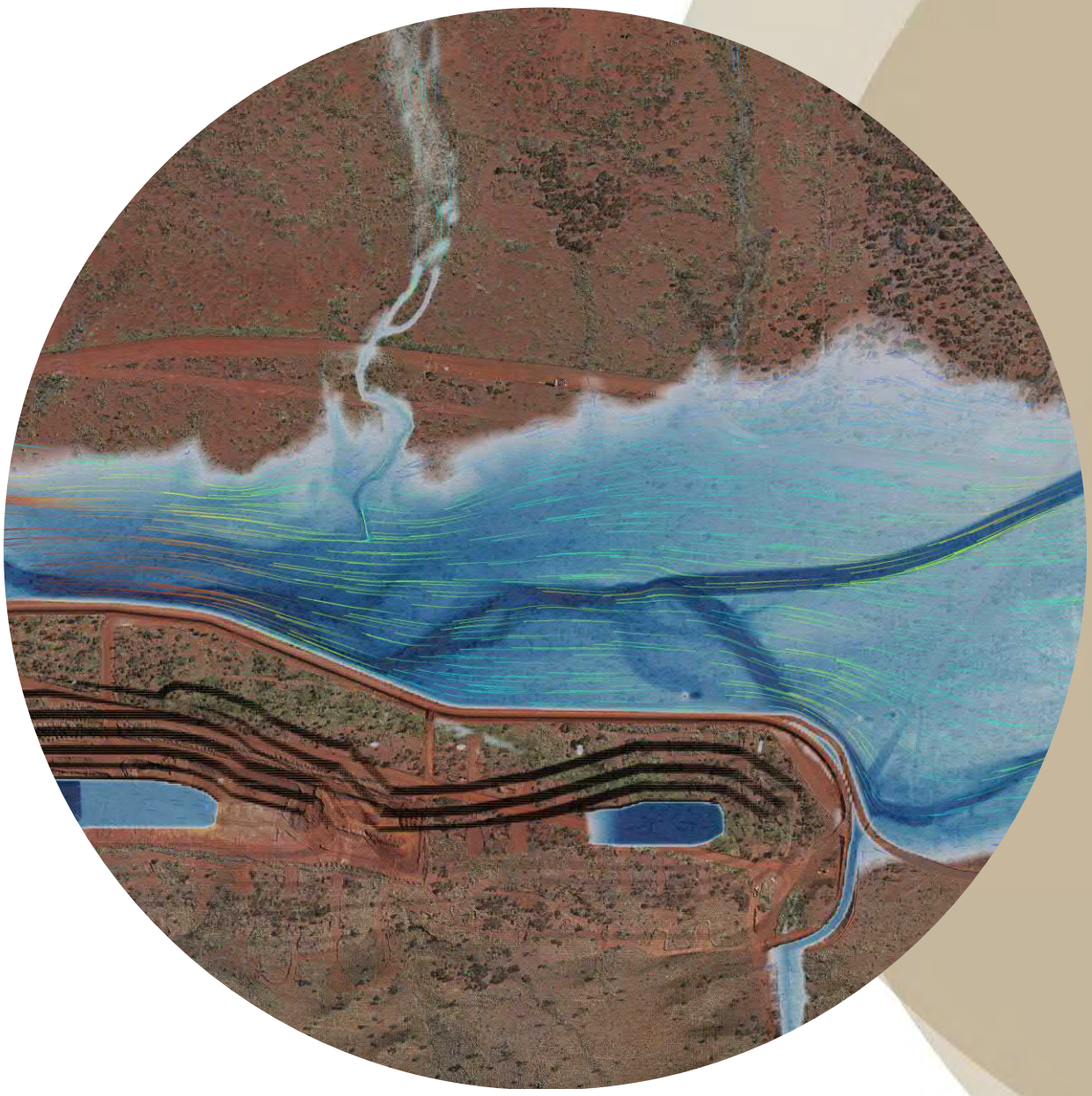
It is recommended that an update to the WANG AMD Risk Assessment should be undertaken using revised pit shells and block models for the next closure plan.

APPENDIX A

Table:A-1: Comparison of pit shells and block models used in the 2021 AMD Risk Assessment compared to those used in this memo.

Deposit	Pit	2021 - AMD Risk Assessment			2022 – Risk Review		
		Pit Shell File	Block Model Name	No. of Pits	Pit Shells File	No. of Pits	Block Model Name
Deposit Awest	AW1	AW1_CF11	waipr_DepAwest_20190715_015	3	AW1_uf11	3	**waipr_DepAwest_20210719_002**
	AW2	AW2_CF10			AW2_uf10		
	AW3	AW3_CF07			AW3_uf07		
Deposit A	**WEPS**	WPS_CUTBACK_OP7	waapr2_DepA_20191025_014	2	**wa_depa_wps_uf08.0**	**6**	**waapr2_DEPA_20210720_22**
	CEPN	DEPA_UF21.0.2			Depa_uf21.0.2		
	CEPS				Depa_uf21.0.2		
	GumLeaf	-			**cepn_gum_us13.2**		
	Cake Pit	-			**DepA_cake_uf2.17T**		
	WEPN	-			N/A (Backfill complete)		
Deposit B	DBC3	WAB_UF17.10	waepr_DepB_20200324_007	3	**wab_uf_17.70**	3	**waipr_DepB_20210707_016**
	DBC4						
	DBC5						
Deposit C	C1	C1S1_PIT_UF_06.	waepr_DepC_20200218_007	3	c1s1_pit_uf07.3.2	3	**waipr_DepC_20210705_006**
	C2	DEPC_C2_UF03			depc_c2_uf03.2		
	C3	DEPC_C3_UF09.1			depc_c3_uf09.1		
Deposit D	D1	WAD_D1_UF1	waipr_DepD_20200702_003	5	wad_d1_uf1.0	5	**waepr_DepD_20201217_005**
	D2	DEPD_D2_UF01			**depd_d2_uf01.1**		
	D3	DEPD_D3_UF01			**depd_d3_uf01.1**		
	D4	DEPD_D4_UF01			depd_d4_uf01		
	D5	DEPD_D5_UF01			depd_d5_uf01		
Deposit E	East	DEPE_UF16.5.3	waepr_DepE_20181016_025	2	depe_uf16.5.3	2	**waepr_DepE_20210709_011**
	West	DEPE_UF16.5.3_West			depe_uf16.5.3_west		
Deposit F	DFW	DFW_CF2.6.5	waipr_DepF_20200123_019	7	dfw_cf_2.6.14	7	**waepr_DepF_20210708_015**
	DFN1	DFN1_CF02.7			dfn1_cf02.10		
	DFS1	DFS1_UF2.7			dfs1_uf2.8		
	DFSW	DFSW_UF100			dfsw_uf100		
	DFE	DFE_UF202C			**dfe1_us211**		
	Marlu	DFEE_UF100			dfee_uf100		
	Fnorth	FNORTH_UF101			fnorth_uf101		
Deposit G	G1	DEPG1_REV3	waipr_DepG_20191126_032	3	**WA_DEPG1_CF01**	**4**	**waipr_DepG_20210719_017**
	G2	DEPG2_REV6			**WA_DEPG2_CF01**		
	G3	WA_DEPG3_UF05			**wa_depg3_uf10.1**		
	G4				**WA_DEPG4_UF01**		
Deposit H	East	DEPH_EAST_US100		2	deph_east_us100	2	**waipr_DepH_20210709_015**
	West	DEPH_WEST_US100			deph_west_us100		
Deposit J	Pit 1	DEPJ_SH32_V3	waipr_DepJ_20180618_011	4	**depj_sh32_selected_v3**	4	**waipr_DepJ_20210709_021.bmf**
	Pit 2						
	Pit 3						
	Pit 4						
Mount Ella	East	MTEE_SH21_V2	waipr_mtee_20180605_002	2	**mtee_sh21**	2	**waipr_mtee_20210716_020**
Western Hill	Pit 1	whill_sh23_awt	waipr_whill_20200113_006	3	**wa_whil_central_ufo1**	4	**waepr_whill_20210712_023**
	Pit 2				**wa_whill_east_uf01**		
	Pit 3				**wa_whill_west_ufo1**		

Appendix 9: West Angelas Surface Water Management Concepts



West Angelas Closure

Surface Water Management Concepts

Rio Tinto

23 February 2022

311012-00921-HYD-REP-001

Advisian
Worley Group

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Company details

Advisian Pty Ltd
ABN 50 098 008 818
Level 14, 240 St Georges Terrace
Perth WA 6000
Australia

T: +61 8 9485 3811
F: +61 8 9289 5888

PROJECT 311012-00921: West Angelas Closure – Surface Water Management Concepts

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B	Client Review	R.Perrigo, T.Halton, A.Walker	M.Rafty	S.Atkinson	25/11/21	-	-
C	Client Review	R.Perrigo, T.Halton, A.Walker	M.Rafty	S.Atkinson	6/12/21	-	-
D	Final	R.Perrigo, T.Halton, A.Walker	S.Atkinson	S.Atkinson	23/2/22	-	-

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Executive summary

Advisian were engaged by Rio Tinto to develop surface water closure strategies for the West Angelas mine site. The mine consists of several open cut deposits that were commenced in 2001 and are planned to continue until 2036. Rio Tinto's mine closure planning requirements include preparation of a Mine Closure Plan (MCP) every three years. The previous iteration, completed in 2020 (Rio Tinto, 2020a), included objectives to preserve heritage values, manage public health and safety hazards, and provide a stable landform that that considers hydrological factors. This assessment presents surface water concepts that meet these closure objectives.

The West Angelas mine site is located east of, and adjacent to, Karijini National Park, within the Turee Creek and Weeli Wolli Creek catchments. Across the site, there are a series of levees and diversions that provide operational flood protection, designed for events up to the 1:100 annual exceedance probability event (AEP). This infrastructure requires modification, upgrades and/or removal to meet the closure objectives.

The project objective is to review existing, identify alternative and recommend preferred, cost effective strategies for closure of pits adjacent to creeks at West Angelas. Concept designs are to be developed for recommended surface water management measures, that provide a safe, stable and non-polluting landform and protects the receiving environments from potential surface water related impacts.

Advisian characterised the site conditions using available data provided by Rio Tinto and developed a basis of design guided by mine closure guidelines and standards in Western Australia. It defined design criteria for surface water infrastructure and outlined the assumptions with regards to existing mine infrastructure that influences flooding across the site. The adopted design criteria specified closure levees to accommodate the 1:10,000 AEP on major waterways and the 1:1,000 AEP on minor waterways, with rock protection based on peak velocity using classifications from Austroads (2019). For the levees and pit walls adjacent to waterways, a Factor of Safety of at least 1.5 was recommended for slope stability.

With regards to the closure assumptions, deposits and pits that have not commenced, and are subject to further design, were excluded from this assessment (Deposit G and Pits AW1 to AW3). Similarly, linear infrastructure (rail and roads) crossings were excluded from the flood modelling to ensure there is no artificial ponding behind culverts that may be removed at closure.

Previous flood modelling undertaken by Rio Tinto (2020b), and initial flood modelling of the operational infrastructure (for the closure design event) in this assessment, identified the following key surface water risk areas across the site:

- Deposit B: The berm and diversion channel, along with the haul road and rail culverts, restrict flows downstream to Deposit C.
- Pit C3 Diversion: The existing operational levee has been designed for the 1:100 AEP, with restricted flows from upstream. Removal of the Deposit B haul road crossing upstream will increase the peak flows at this location. The creek flow at this location is directed perpendicular to Pit C3, presenting a higher risk of scour and erosion.
- Deposit D Diversions: Flood modelling indicated that there is overtopping and bypass of the existing Pit D1 south operational levee during the closure design event, indicating a requirement for infrastructure upgrades. There are also high velocities and potential overtopping of the Pit D1 north and Pit D3 operational diversion and levees.

- Deposit F Diversion: upgrade and redesign of the existing operational levee is required for closure.

Another key risk for the site is the potential for direct and indirect impacts on the Cracking Clay PEC, as per Ministerial Statement 1113. However, the infrastructure outlined above does not currently impact on the catchment areas reporting flows to the PEC and therefore the quantity or quantity of streamflow reporting to the PEC is expected to be maintained following mine closure.

In consultation with Rio Tinto, three (3) closure options were selected for flood modelling and geotechnical assessment:

- Option 1: *Operational Levees Upgrades* for the closure design event. Minimal changes to the levee alignments or changes to backfilling strategies outlined in the MCP.
- Option 2: *Floodplain Reinstatement at Pit C3* This location was identified as the highest risk of levee failure and creek capture. To mitigate this risk, a portion of Pit C3 could be backfilled to pre-mining levels to reinstatement the floodplain. The levee with the highest failure risk could then be removed.
- Option 3: *Deposit B Spillway* Excavation of a spillway at Deposit B to reduce flows downstream, particularly at Pit C3.

For all options, the closure strategies at Deposits D and F, upgrading operational levees, were consistent. Deposits A and E did not require any specific closure infrastructure owing to their location in the upper catchment.

The three options were tested and compared using flood modelling, geotechnical assessment and comparative material estimates to assist in selecting a preferred option. Flood modelling of the closure options was completed using TUFLOW modelling software with closure landform and infrastructure assumptions defined in the basis of design included in the model. The modelling determined closure levee heights and the benefits associated with partial backfilling of Pit C3 and spillways at Deposit B for the design events (1:1,000 AEP and 1:10,000 AEP events). Peak velocities from the flood modelling were also used to inform rock protection design for levees in accordance with Austroads (2019) Guidelines.

A geotechnical assessment was completed to assess the stability of closure levees and pit walls adjacent to waterways. Representative geological cross-sections were generated from data provided by Rio Tinto at selected locations, and imported into the geotechnical slope stability modelling software Slope/W. Where calculations indicated an unacceptably low factor of safety (FoS <1.5 under static conditions and <1.2 under seismic conditions) buttressing was recommended. Buttress designs were developed using the representative cross sections and results of geotechnical slope stability modelling. This occurred at Pits C2 and D1, with further buttressing recommended at Pits D2 and D3 to ensure there is adequate separation between the closure levee and the Potentially Unstable Pit Edge Zone (PUPEZ), the area of geotechnical instability.

Closure options were tested to confirm compliance with the design criteria in the basis of design, then assessed in consultation with Rio Tinto to select the preferred option. The assessment compared earthworks quantities developed for each option using 12D civil design software and considered other criteria such as constructability, environmental and cultural/heritage risks and opportunities. The results of the option assessment are summarised below:

- Option 1 (*Operational Levee Upgrade*) requires less material and mine planning to implement but requires blocking a local catchment, and levee designs to reduce impinging flows, which presents a high risk of scour and erosion.
- Option 2 (*Floodplain Reinstatement at Pit C3*) removes approximately 1,500 m length of levee from the closure infrastructure, including the area of highest risk at Pit C3. Reinstating the floodplain also reduces flow velocities and provides additional catchment connectivity that improves environmental and cultural outcomes. The implementation of Option 2 requires considerable material volumes that, to be economical, would need to form part of operational backfilling to limit material movement, double handling and associated costs. There are also risks associated with long term settlement of backfill material which associated with floodplain activation or channel migration may lead to significant losses or creek capture.
- Option 3 (*Deposit B Spillway*) will be challenging to design and construct and the flood modelling results show only limited reductions in closure levee heights (<0.1 m) downstream at Pit C3. This option was the least preferred of the three options.

Option 1 and 2 both satisfy the basis of design and are considered potentially feasible options for closure. Option 1 was selected as the preferred for the following reasons:

- Option 1 is based on raising operational levees, which has fewer associated uncertainties and construction complexities when compared with reinstating a floodplain over a backfilled pit and has lower earthworks quantities. This scenario assumes adequate volumes of low erodibility mineral waste is available to meet all site closure requirements, however, this assumption will require testing.
- Option 2 requires assessment by Rio Tinto mine planners to determine if it is practical and offers suitable value with regards to closure outcomes. It also has complexities and uncertainties associated with the geotechnical and hydraulic design as well as the management of long-term settlement and stability risks. While potentially feasible and worth exploring further, more detailed assessments are required to confirm the feasibility of the concept.

Option 1 was subsequently progressed to conceptual design and design drawings and material estimates developed for all deposits, as outlined in Table 0-1, Table 0-2 and Table 0-3.

Table 0-1. Option 1: material estimates for closure flood levees at Closure

Location	Existing Levee Length for Operations (m)	Length Upgraded for Closure (m)	Approx. Average Levee Crest Height (mAHD)		Slope (H:V)	Crest Width (m)	Cut (m^3)	Fill (m^3)
			Existing (Operations)	Closure^				
Pit C3 Levee	2,532	1,980	688.8	689.9	2.5:1	5	0	47,855
Pit D1 North Levee	315	0	n/a	n/a	n/a	n/a	n/a	n/a

Location	Existing Levee Length for Operations (m)	Length Upgraded for Closure (m)	Approx. Average Levee Crest Height (mAHD)		Slope (H:V)	Crest Width (m)	Cut (m^3)	Fill (m^3)
			Existing (Operations)	Closure^				
Pit D1 South Levee	1,810	1,810	676.1	677.1	2.5:1	5	0	49,885
Pit D3 Levee	1,695	518	688.5	689.5	2.5:1	5	0	2,420
Deposit F Levee	3,828	759	796.9	797.8	2.5:1	5	0	22,550

^ *Raised section of levee* * *Levee embankment slope*

Table 0-2. Option 1: material estimates for diversion channels at Closure

Location	Length (m)	Start RL (mAHD)	End RL (mAHD)	Bed Slope (%)	Bed Width (m)	Cut Volume (m^3)	Fill Volume (m^3)
Deposit C	1150	690.15	686.04	0.36%	20	47,945	0

Table 0-3. Option 1: material estimates for buttressing adjacent to creeks at Closure

Location	Total Length (m)	Grade (H:V)	Width (m)	Fill (m^3)
Pit C2 Buttress	210	5:1	210	370,295
Pit D1 Buttress	195	5:1	740	2,353,685
Pit D2 Buttress	230	5:1	720	2,897,380
Pit D3 Buttress	240	5:1	1450	5,785,820

* *Slope of pit wall buttressing embankment / landform to backfill level*

The assessment was completed with the available data and information. Requirements for additional information and investigations to improve the assessment and to guide further planning and design were summarised as recommendations in Section 7.2, with the following key themes:

- Characterisation of waste material to define geotechnical and geochemical properties and erosion classes. Establishing a material inventory will allow for consideration of fit-for-purpose use on site and allow for detailed planning of material movement.
- Mine planning (by Rio Tinto) to assess the feasibility of Option 2 (*Floodplain Reinstatement at Pit C3*) within operations.
- Sensitivity testing of flood models with regards to blockages, closure assumptions, climate change and frequent flows. The latter may be achieved by considering cumulative rainfall events over a closure timeframe.
- Detailed scour assessments, based on sediment sampling and flood modelling, to improve rock protection quantity estimates.

Acronyms and abbreviations

Acronym/abbreviation	Definition
ACARP	Australian Coal Association Research Program
AEP	Annual Exceedance Probability
AHD	Australian Height Datum
ARF	Areal Reduction Factor
ARR	Australian Rainfall and Runoff
AWT	Above Water Table
BoD	Basis of Design
BoM	Bureau of Meteorology
BWT	Below Water Table
DEM	Digital Elevation Model
DMIRS	Department of Mines, Industry Regulation and Safety (WA)
DIR	Department of Industry and Resources (WA) – now DMIRS
DNRME	Department of Natural Resource, Mines and Energy (QLD)
FoS	Factor of Safety
GHB	Generalised Hoek-Brown
ILCL	Initial Loss, Continuing Loss
JV	Joint Venture
LiDAR	Light Detection and Ranging
LoM	Life of Mine
LV	Light Vehicle
MC	Mohr-Coulomb
MCP	Mine Closure Plan
OoM	Order of Magnitude
PEC	Priority Ecological Community
PGA	Peak Ground Acceleration
PMP	Probable Maximum Precipitation
PUPEZ	Potentially Unstable Pit Edge Zone
RRMC	Robe River Mining Co
TCE	Turee Creek East
WD	Waste Dump

1 Introduction

Advisian has been engaged by Rio Tinto to assess the surface water closure strategies for the West Angelas mine site, located approximately 105 km west of Newman and east of Karijini National Park in the Pilbara region of Western Australia (Figure 1-1). This report provides a summary of the assessment, including the establishment of a basis of design for surface water features measures required at closure, evaluation of closure options, and development of concept designs. Recommendations for additional investigations required to reduce uncertainty, close knowledge gaps, reduce risk and realise efficiencies are also provided. These recommendations form the basis of forward works for future phases of closure planning at West Angelas.

1.1 Project background

The West Angelas mine consists of several open cut deposits utilising conventional drill-and-blast and load-and-haul mining methods. The deposits, described further in Section 3.1, are held by the participants in the Robe River Iron Associates (Robe), an unincorporated joint venture (JV) comprising Robe River Mining Co. Pty. Ltd (RRMC), Mitsui Iron Ore Development Pty Ltd, North Mining Limited, Pannawonica Iron Associates, and Cape Lambert Iron Associates. These deposits are managed by RRMC, being a member of the Rio Tinto group, as manager and agent for the Robe JV.

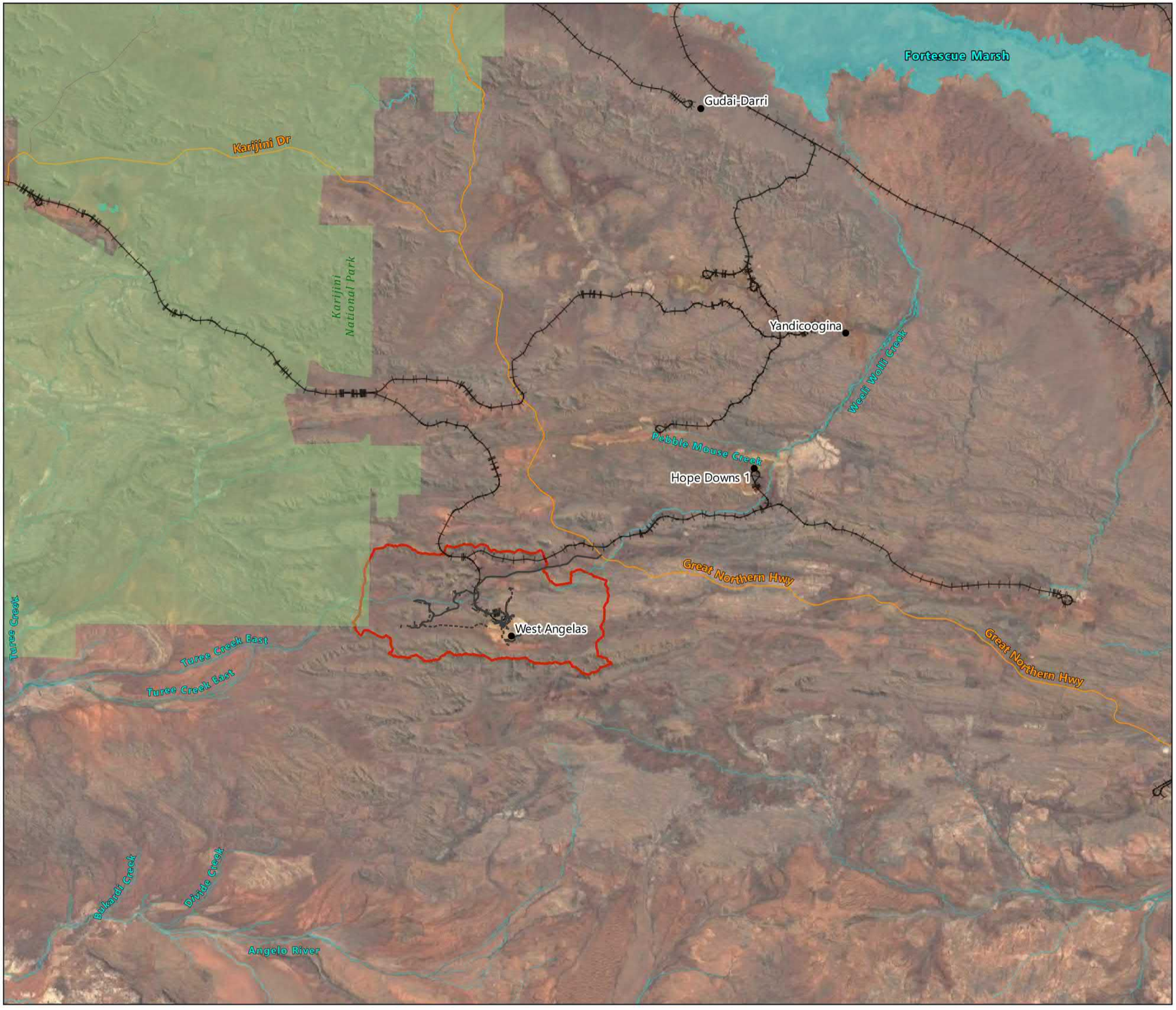
The deposits sit within an area of approximately 330 km^2 (Figure 1-1), across the upper Turee Creek and Weeli Wolli Creek catchments. The flows within these catchments feature a complex drainage pattern and are characterised by intermittent flows and infrequent wide-spread flooding depending on the occurrence of high intensity rainfall events. The deposits at West Angelas intersect flood plains which are currently managed through a series of operational levees and diversions.

Mining commenced in 2001 and is currently planned to continue until 2036. As part of closure planning, Rio Tinto are required to review and revise the Mine Closure Plan (MCP) every three years. The previous iteration of the *West Angelas Mine Closure Plan* (Rio Tinto, 2020a) was finalised in 2020, and contains closure objectives to preserve heritage values, manage public health and safety hazards, and provide a stable landform that considers hydrological factors. The MCP was supported by the *West Angelas Summary of hydrology and operational flood protection* (Rio Tinto, 2020b) which documented the operational levees and diversions and assessed site-wide flood risk. Modelling in the latter did not consider closure landforms. Subsequent consultation with regulatory agencies identified the need to develop designs for surface water structures that maintain the quantity and quality of surface water flows to Karijini National Park, reinstate natural flow paths, and provide a safe, stable and non-polluting closure landform.

This project aims to build on the previous site-wide flood assessment to develop suitable surface water closure strategies and designs that satisfy regulatory requirements for closure.

Surface Water Closure Strategy
West Angelas

Figure 1-1: Location Map



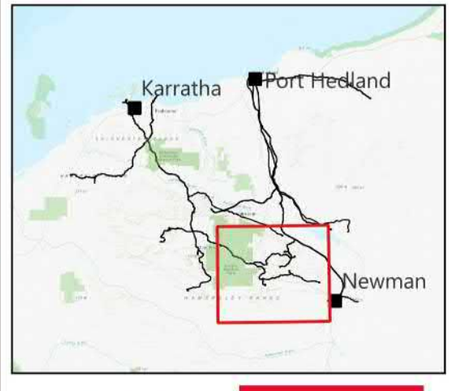
Legend

Infrastructure
- RTIO Mining Areas
- Cities and Towns
- State Road
- Railway Network
- Study Area

Environment and Heritage
- Drainage Lines
- Wetlands and Water Bodies
- National Parks

0 10 20 km

Date: 08/02/2022
Projection: GDA94 / MGA zone 50



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1.2 Project objective

The project objective is to review existing, identify alternative and recommend preferred, cost effective strategies for closure of pits adjacent to creeks at West Angelas. Concept designs are to be developed for recommended surface water management measures, that provide a safe, stable and non-polluting landform and protects the receiving environments from potential surface water related impacts.

A basis of design and design criteria shall be developed to allow the identification, development and comparison of closure options that meet the project objectives. The design criteria are to be based on characterisation of hydrological, geotechnical and geomorphological conditions at the mine site. Closure options are to be evaluated using hydraulic and geotechnical modelling and technical assessments to demonstrate compliance with the design criteria.

1.3 Scope of work

The following scope of works was agreed in consultation with Rio Tinto following project award:

- Review existing knowledge base and conceptual closure strategies.
- Review existing geological, geotechnical, hydrological and hydraulic modelling databases.
- Characterise and conceptualise the geological and geotechnical conditions.
- Review available waste material classification data and identify data gaps. Use available data to select appropriate geotechnical parameters for design of surface water management measures and pit wall buttressing.
- Review and update existing 2D hydraulic models as required for the purposes of this study.
- Review existing geomorphology reports relevant to this study.
- Develop closure objectives and a basis of design with design criteria for surface water management measures and pit wall buttressing at Deposits B, C, D and F.
- Identify alternative closure strategies/options and associated surface water management concepts that can meet the stated closure objectives and address key closure risks.
- Hold a workshop to complete qualitative assessment of options based on a range of criteria (economic, heritage, environmental, etc).
- Select preferred closure option / strategy to take forward to concept design.
- Perform geotechnical and hydraulic modelling/assessments to inform the design of surface water management measures and pit buttressing and demonstrate compliance with the basis of design.
- Prepare concept designs for the preferred closure strategy.
- Extract 3D visualisations of the landform designs associated with the preferred closure strategy.
- Make recommendations for additional investigations required to reduce uncertainty, close knowledge gaps, reduce risk and realise efficiencies. These recommendations are to form the basis of forward works for future phases of closure planning at West Angelas.

The original scope of work included development of *a waste and rehabilitation materials inventory, using existing physical and chemical characterisation data, and identify data gaps* however this was excluded from the scope of work due to the limited availability of waste characterisation data.

Figure 1-2 presents the scope tasks in the order they were completed to deliver the project.

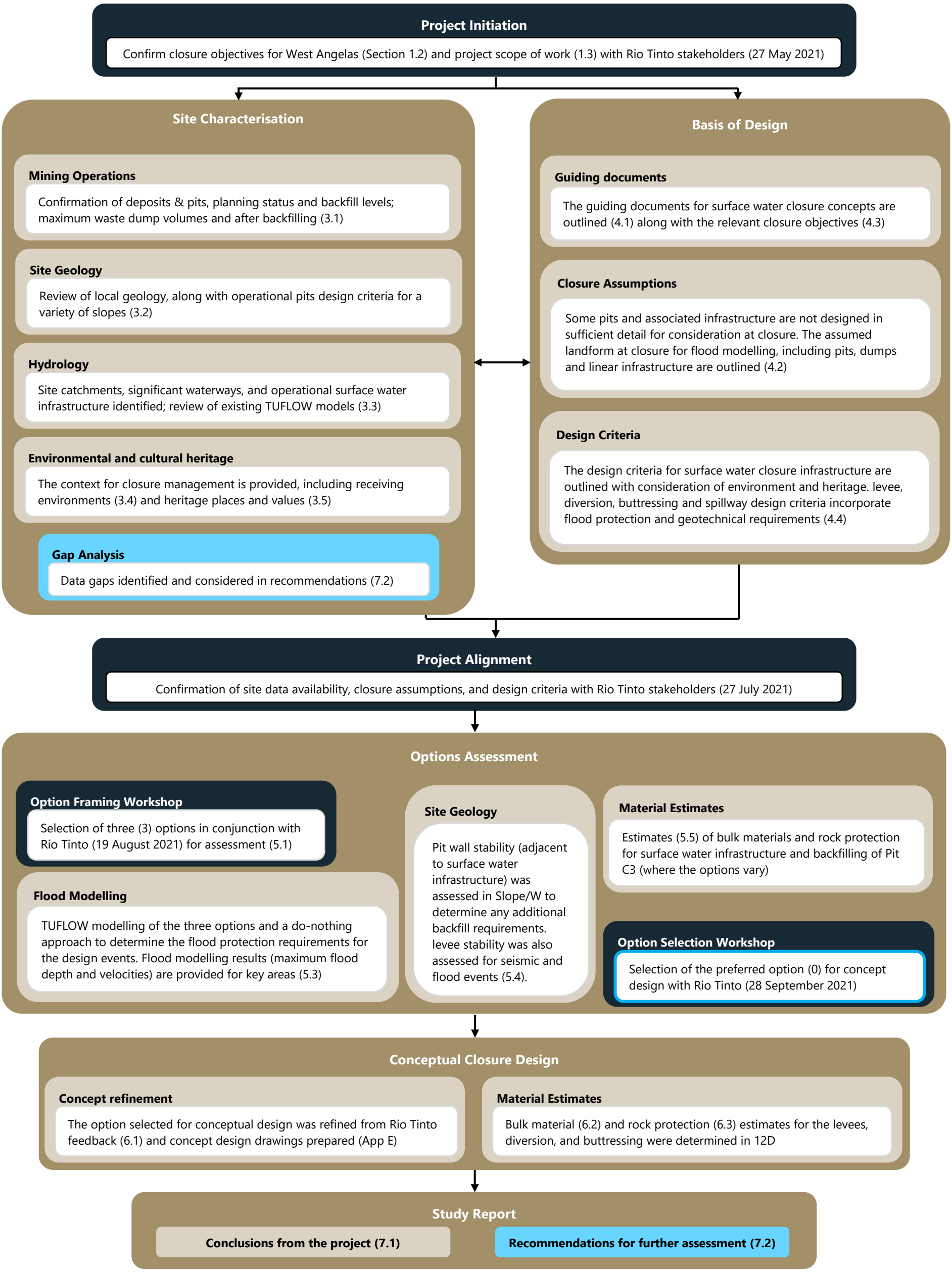


Figure 1-2 Project overview with reference to relevant section headings in report for further information

2 Data availability

The closure concepts are informed by data and information provided by Rio Tinto. A summary of the available data, limitations and uncertainty are described below.

2.1 Data summary

The data supplied by Rio Tinto for this West Angelas Closure study (relied upon information) is summarised in Table 2-1.

Table 2-1. Rio Tinto supplied data summary (relied upon information)

Data / Information	Date received	Format	Description
General Information			
Aerial Imagery	May 2021	*WestAngelas.ecw* *BR03016_RioTinto_WestAngelas01_100 mm_RGB_IXMf50_MGA94z50_01-Mar-2021.ecw*	Captured: 23-24 March 2021 Captured: 1 March 2021
LIDAR 2021	May 2021	*GDA94_MGA_Z50_RTWSO_West_Angelas_02_2103_DEM-GRID_005_Mosaic* *GDA94_MGA_Z50_RTWSO_West_Angelas_02_2103_DEM-GRID_001_Mosaic*	Digital Elevation Model (DEM) of West Angelas mine site in 5m and 1m resolution.
LIDAR 2018	May 2021	*WAN_2018-03_AAM_15cm_1m* *WAN_2018-03_AAM_15cm_1m* *Wang_mosaic_2011-2016_2m*	Older DEM data with wider coverage, used in TUFLOW modelling by Rio Tinto (2020).
Heritage Mapping	May 2021	*Integrated_Heritage_Management.shp*	Key heritage area located, along with protection and approval status
Environmental Mapping	October 2021	*WAN_Cracking_Clays_PEC.shp*	Mapping of the key areas for environmental protection during closure
Mine Planning			
Infrastructure	October 2021	*Wang_Roads_Tracks_Combined.shp* *Wang_RioTinto_Camps.shp* *Wang_RioTinto_Airports.shp*	Mapping of key operational infrastructure for consideration at closure
Waste dump volumes / backfill estimates	June / August 2021	*Mine Planning West Ang 2020_Backfill.xls* *WANG_PCO_2021_v17.xls* *WAN backfill requirements June 2021.ppt*	Summary of backfill targets for pits and waste dump volumes for the mine site.

Data / Information	Date received	Format	Description
Life of Mine (LOM) Pit shells	May 2021	LoM_cut_pits.flt	Utilised for flood modelling and geotechnical stability calculations.
LOM Waste dump outlines	May 2021	LoM_cut_dumps.flt wa_dump_outlines (1).dxf	Used to inform concept designs and included in the flood models.
Geology			
Geological units	August 2021	DXF files georeferenced in WAMG	3D DEMs of geological units present at and around the mine pits that are subject to this study
Geotechnical strength parameters	June 2021	*West Angelas Deposit B Geotechnical Assessment* (Xstract Mining Consultants, 2013) *West Angelas Mine, Deposit E (WAE) Geotechnical Design Report* (Rio Tinto, 2015a) *West Angelas Deposit F Geotechnical FS Slope Designs* (SRK Consulting, 2015) *West Angelas Deposit C Geotechnical Implementation Study* (Mining One Consultants, 2020a) *West Angelas Deposit G North Implementation and Deposit G South Pits* (Mining One Consultants, 2020b)	Various geotechnical design report. Rock mass strength parameters (GHB and/or Mohr-Coulomb) used for pit design, soil strength parameters (Mohr-Coulomb) used for pit design
Hydrology			
RORB Model	May 2021	*RORB_Model (WAN)* *RORB West Angelas GIS*	RORB model from the *West Angelas Summary of hydrology and operational flood protection* (Rio Tinto, 2020b)
TUFLOW model	May 2021	*WAN_MineModel_2021*	Base model from the *West Angelas Summary of hydrology and operational flood protection* (Rio Tinto, 2020b)

2.2 Previous reports

Several existing reports prepared in support of mining operations and closure planning, characterise the site hydrology and local catchment conditions. These reports are referred to in the West Angelas Mine Closure Plan. A brief summary of the previous studies is provided below, with key information relevant to this study, incorporated into the site characterisation Section 3.

West Angelas Summary of Hydrology and Operation Flood Protection (Rio Tinto, 2020b)

A site wide flood assessment was undertaken to identify and understand operational flood risks as well as closure risks associated with overtopping of pit crests and creek capture. Two-dimensional (2D)

hydraulic modelling was completed over the entire mine site for the 1:100, 1:1,000 and 1:10,000 Annual Exceedance Probabilities (AEP) flood events. The models included operational flood protection measures and life-of-mine pit designs/extents for existing approved deposits. Operation flood risks were identified and managed during study and engineering design phases as new deposits have been investigated.

The key risk areas for closure were defined as locations where flood modelling results show floodwater overtopping the pit crests in the 1:10,000 AEP event which can lead to permanent pit capture (i.e where the creek flows directly into the pit void). The high-risk locations identified include Turee Creek East (TCE) at Deposit C, the main TCE southern tributary which runs through Deposit D and the Deposit F diversion.

The TUFLOW model used for this assessment by Rio Tinto (2020b) has been adopted and modified for use in this Closure Study.

West Angelas Deposit C & D DES Hydrology and Hydraulics Study (Jacobs, 2018)

A series of design flood events were assessed using 2D TUFLOW modelling to determine the depth and extent of flooding across the mine area. The modelling considered a range of project stages to determine the suitability of operational surface water measures. The study assessed the C3 Pit and Turee Creek East realignment, D3 diversion drain, A-West Haul Roads and the D2 Pit. The catchment hydrology was revised in accordance with ARR2016, resulting in higher peak flow estimates than adopted previously. The TUFLOW model was used to recommend additional or upgraded surface water measures needed to meet the operational design criteria for flood protection across the site.

Turee Creek East Geomorphology (MWH, 2016)

The geomorphological assessment was undertaken in support of the West Angelas Deposit C and D Pre-Feasibility Study utilising field observations and hydraulic modelling. The hydraulic modelling suggested that the Deposit B diversion and other catchment alterations attenuate flows and reduce shear stress and stream power in the creek at Diversion C and therefore the risk of significant erosion occurring during the Turee Creek East diversion was generally low over the nominal 10-year mine life. The results of the study suggest the Pit B Diversion Channel is also expected to remain relatively stable over the long term.

West Angelas – Deposit F Flooding and Local Drainage Report (Calibre Consulting, 2015)

The report was prepared to assist with the design of drainage infrastructure for the development of Deposit F. This deposit is located on the divide between the Turee Creek East and Weeli Wolli Creek catchments. TUFLOW modelling was undertaken, based on ARR1987 and infrastructure layouts provided by Calibre Global, to determine options for the diversion drain design. The diversion structure drains floodwater from west to east using a combination of an open channel drain and levee, both located within the tenement boundary. The report recommended additional work to investigate the need for additional surface water management structures outside of the tenement boundary.

Detailed Design Flood Study Southwest Diversion Berm and Channel and Haul Road (SKM, 2013)

A Detailed Design Flood Study was undertaken for the Deposit B Definitive Engineering Study and Implementation Design. Deposit B required a haul road that crosses a number of drainage paths and a Diversion Berm and channel to divert flows south of the pit. Three site design conditions were

considered, including pre-development, interim and ultimate development designs. MIKEFlood Modelling confirmed that the Diversion Berm and channel satisfied the design objectives and design criteria. During the 1 in 100 AEP design flood event the area upstream of the Diversion Berm is inundated for approximately 88 hours. Runoff into the catchment downstream of the existing rail is similar to the existing conditions for events up to the 1 in 50 AEP.

2.3 Gap analysis

Review of the available information identified several information gaps and model upgrades that needed to be addressed prior to the commencement of work. In consultation with Rio Tinto, model adjustments were agreed, and assumptions made to progress the work, noting that further investigations may be required to address some of the identified gaps in future project phases. The model upgrades and assumptions made for this project are described below. Details of the recommendations for further investigation, including those identified through the options assessment, are provided in Section 7.2.

The key data gaps and upgrades noted in the review were:

- The previous TUFLOW model provided by Rio Tinto, prepared for the *West Angelas Summary of hydrology and operational flood protection* (Rio Tinto, 2020b), required several updates to make it suitable for use in the current project, which included the following:
  - Utilise the latest version of TUFLOW (2020-10-AA)
  - Improve resolution of results (grid size from 10 m to 2.5 m) at areas of interest using the Quadtree feature
  - Reduce simulation time by excluding externally draining catchments
  - Reflect closure pit and dump footprints within the scope of the study (discussed further in Section 4.2)
- In reviewing the TUFLOW model, it was noted that the point design rainfall depths from Bureau of Meteorology (BoM) had been used for interpolating the 1:10,000 AEP rainfall depth rather than the areally reduced depths, resulting in artificially high 1:10,000 AEP depth estimates. This was corrected in the models for this assessment. Further details are presented in Appendix A. Note that the RORB model was adopted as provided by Rio Tinto unchanged.
- Geotechnical stability models for mine pit design were not provided and models were therefore developed by Advisian using information and data supplied by Rio Tinto.
- The geotechnical properties and quantities of waste material were not well established across the mine site and insufficient the characterise the different material types and selectively choose materials for different closure applications (e.g. levees and buttressing design, rock protection etc). In the absence of waste characterisation geotechnical data (permeability, density and strength data), the waste material was treated as a single homogenous material type with design parameters based on the limited available information. This prevented completion of *a waste and rehabilitation materials inventory, using existing physical and chemical characterisation data, and identify data gaps* as required in the original scope of work for this project. Further characterisation of this material is recommended in Section 7.2.
- There is limited earthquake (seismic) peak ground acceleration information across different AEP events at West Angelas. Therefore, the response of the pit slopes to different earthquake spectra, and the liquefaction potential of levee foundations, could not be evaluated. For this study a

simplistic assumption of a uniform Peak Ground Acceleration (PGA) sourced from the National Seismic Hazard Maps has been adopted. In later design stages a site-specific hazard assessment for earthquakes across a range of AEP should be prepared to address this gap.

- The Rio Tinto (2019) standard D3 – Management of Slope Geotechnical Hazards (HSEC-B-024) does not provide guidance on the selection of AEP for seismic events acting on slopes. Applicable seismic AEP for pit slope stability models were agreed in consultation with Rio Tinto. However, more detailed assessment of seismic stability over the closure timeframe is warranted.

The available data was sufficient to undertake most of the assessment in accordance with the original scope outlined in the Request for Tender documentation. The key departure was the limited waste material characterisation as discussed above. Recommendations are made in Section 7.2 to complete additional work needed to develop a waste and rehabilitation materials inventory.

3 Site characterisation

The West Angelas mine site is located approximately 105 km from Newman in the Pilbara region. The site is located within the upper reaches of the Turee Creek and Weeli Wolli Creek catchments that discharge to Karijini National Park and Fortescue Marsh respectively (Figure 1-1). The site is surrounded by steep ranges with short well incised drainage lines that flow out onto broad, flat valley plains.

Mining operations are dispersed across several deposits located across a 27 km span (Figure 3-1). This section provides a summary of the mining operations at each deposit, along with the geotechnical and hydrological setting. Key environmental and cultural heritage features are also identified to ensure adequate consideration in the development of surface water closure concepts.

3.1 Mining operations

Mining operations at West Angelas commenced in 2001. Mining is carried out as an open cut operation, with ore processed on-site before being transported via rail to either Dampier or Cape Lambert ports for shipping (Figure 1-1). The key mine infrastructure are shown in Figure 3-1 and include the rail, airport, and haul roads.

Mining currently (October 2021) occurs at Deposits A, B, C, D, E and F. These deposits are mined as multiple pits as summarised in Table 3-1 and shown in Figure 3-2. The geology and hydrology for each deposit are described in Sections 3.2 and 3.3 respectively. The position of the pits and mine infrastructure within the respective catchments means flood risk and management must be evaluated in a wholistic manner using a "whole of site" approach to capture and quantify the cumulative effects of mining on surface water flows and develop integrated surface water solutions and strategies for closure.

Note that extension of mining operations beyond 2036 is anticipated based on current planning (Rio Tinto, 2020a). It is noted that additional mining may occur at West Angelas, including at new pits, at existing deposits or further south, outside the area of interest in this project.

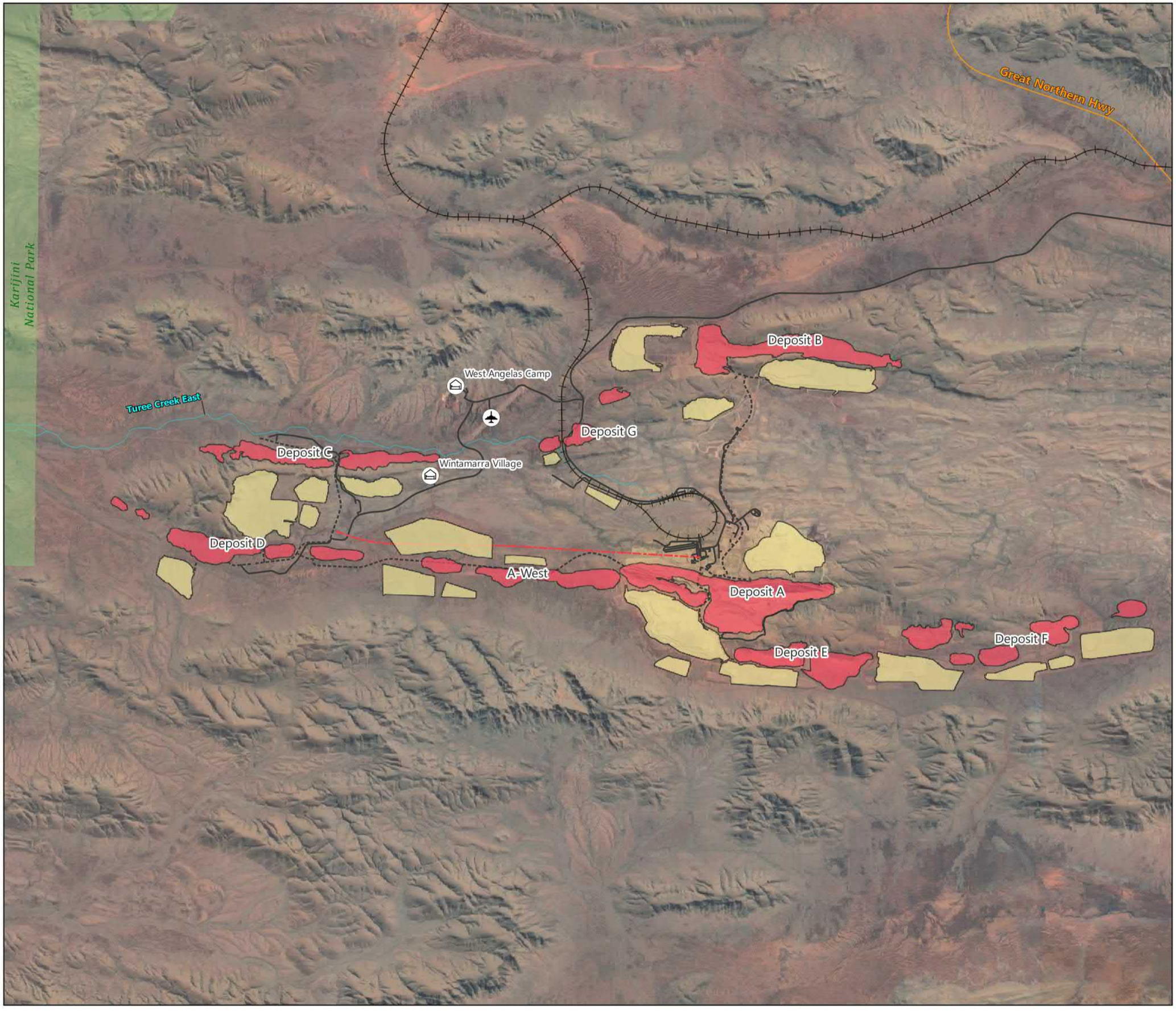
Table 3-1. Deposit Summary (updated from Rio Tinto, 2020a)

Pit	Status	Completion	Above / Below Water Table	Post Mining Pit Crest Level (mAHD)	Post Mining Pit Floor Level (mAHD)	Planned Backfill Level (mAHD)	Minimum Backfill Volume (Mm^3)
Deposit A							
CEPN	Active	2016	BWT	840	560	643	19.3
CEPS	Active	2021	BWT	798	524	642	17.9
WEPN	Active	2010	AWT	750	644	760	49.6
WEPS	2022	2023	BWT	740	628	635	0.1
Gumleaf	2023	2024	AWT	760	716	-	-
Cake Pit	2021	2021	AWT	830	723	-	-
AW1	2026	2040	BWT	720	600	629	2.2

Pit	Status	Completion	Above / Below Water Table	Post Mining Pit Crest Level (mAHD)	Post Mining Pit Floor Level (mAHD)	Planned Backfill Level (mAHD)	Minimum Backfill Volume (Mm^3)
AW2	2031	2040	BWT	712	600	629	1.2
AW3	2030	2040	BWT	712	624	629	0.1
Deposit B							
DBC3	Active	2023	BWT	800	660	632	-
DBC4	Active	2021	BWT	820	580	632	2.0
DBC5	Active	2025	BWT	780	580	632	2.0
Deposit C							
C1	2021	2022	AWT	712	632	-	-
C2	Active	2035	BWT	730	576	626	4.5
C3	2021	2027	BWT	758	576	638	8.4
Deposit D							
D1	Active	2031	BWT	728	480	626	31.4
D2	2022	2024	BWT	696	600	627	0.8
D3	2023	2025	BWT	690	600	627	1.0
D4	2023	2024	AWT	680	640	-	-
D5	2023	2024	AWT	672	624	-	-
Deposit E							
East	2034	2036	BWT	780	548	670	19.9
West	2027	2031	BWT	748	644	670	1.1
Deposit F							
DFW	Active	2021	BWT	866	666	688	0.8
DFN1	Active	2020	AWT	853	786	-	-
DFS1	Active	2023	BWT	794	658	672	0.2
DFSW	2028	2030	AWT	770	698	-	-
DFE	Active	2024	BWT	778	650	672	0.5
Marlu	2022	2025	AWT	778	668	-	-
Deposit G							
G1	2024	2025	BWT	750	619	638	0.2
G2	2023	2025	AWT	760	648	-	-
G3	2020	2021	AWT	735	656	-	-
G4	2025	2026	BWT	760	575	638	2.8

Surface Water Closure Strategy
West Angelas

Figure 3-1: Site Layout



Legend

Mine Layout

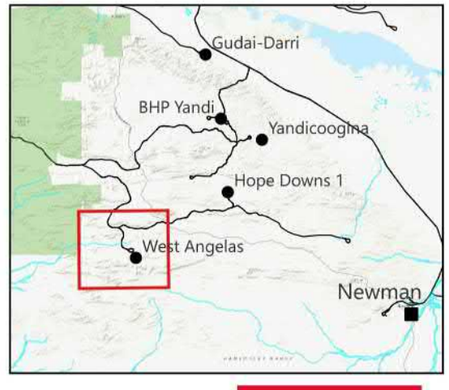
- Airport
- Mine Camps
- Rainway Centreline
- State Road
- Haul Road
- Site Access
- Site Road
- Conveyor
- LoM Pit Outlines
- LoM Waste Dump Outlines

Environment and Heritage

- Drainage Lines
- National Parks

0 2.5 5 km

Date: 23/02/2022
Projection: GDA94 / MGA zone 50



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Surface Water Closure Strategy
West Angelas

Figure 3-2: Pits & Waste Dumps

Legend

Mine Layout
- Rail Network
- State Road
- LoM Pit Outlines
- LoM Waste Dump Outlines

Environment and Heritage
- Drainage Lines
- Heritage Management Sites
- National Park

0 2.5 5 km

Date: 01/02/2022
Projection: GDA94 / MGA zone 50

Advisian
RioTinto

Figure 3-2 shows the current and proposed waste dump footprints. These footprints are based on operational designs as the preliminary closure strategies generally include the utilisation of waste material for backfilling of pits. The proposed final volumes for waste dumps are provided in Table 3-2 (based on Rio Tinto June 2021 estimates), along with typical material types (Rio Tinto, 2020a). It is noted here that all waste material is classified as inert and therefore for the purpose of this study the surface water quality risks posed by mining relate to erosion and sediment loads only.

Table 3-2. Waste Dump Summary (updated from Rio Tinto, 2020a)

Waste Dump	Status	Max estimated waste volume° (Mm^3)	Estimated waste volume after backfill° (Mm^3)	Low erodibility percentage* (%)	High erodibility percentage* (%)	Classification*
Deposit A						
South WD	Active	119	113	46	54	Inert
North WD	Active	102	94	51	49	Inert
West Pit North Backfill	Active	11	11	77	23	Inert
A West WD1*	Planned	126	*TBC*	11	89	Inert
A West LG Stockpile*	Planned	45	*TBC*	48	52	Inert
Deposit B						
East WD	Active	97	97	42	58	Inert
West WD	Active	186	186	63	37	Inert
Dep B LG Stockpile*	Active	25	25	87	13	Inert
Deposit C						
WD1	Planned	17	7	21	79	Inert
Dep C LG Stockpile	Planned	12	12	48	52	Inert
Deposit D						
WD2+	Planned	137	126	27	73	Inert
WD3	Planned	24	0	33	67	Inert
Dep D LGA Stockpile	Planned	16	0	34	66	Inert
Dep D LGS Stockpile	Planned	6	0	34	66	Inert
Deposit E						

Waste Dump	Status	Max estimated waste volume° (Mm^3)	Estimated waste volume after backfill° (Mm^3)	Low erodibility percentage* (%)	High erodibility percentage* (%)	Classification*
South WD	Active	7	7	55	45	Inert
West WD	Active	19	18	44	56	Inert
East WD^	Active	80	64	27	73	Inert
Deposit F						
Dep F LG Stockpile*	Active	15	15	85	15	Inert
East WD	Active	70	69	28	72	Inert
Deposit G						
South WD1*	Planned	24	*TBC*	16	84	Inert
South WD2*	Planned	2	*TBC*	16	84	Inert
South WD3*	Planned	4	*TBC*	16	84	Inert
South LG Stockpile*	Planned	3	*TBC*	68	32	Inert

** From Mine Closure Plan (RTIO, 2020a)*
° From WAN backfill requirements June 2021.ppt (see Table 2-1)
+ Deposit C and D
^ Deposit E and F

3.2 Site geology

The geological setting of the deposits at West Angelas are outlined in this section.

3.2.1 Stratigraphic sequence

The stratigraphic sequence of the West Angelas mine area comprises the following geological units:

- Tertiary deposits – alluvium, colluvium and canga
- West Angela Member of the Wittenoom Formation
- Mount Newman Member of the Marra Mamba Iron Formation
- MacLeod Member of the Marra Mamba Iron Formation
- Nammuldi Member of the Marra Mamba Iron Formation

A stratigraphic column of the regional geological units is shown below as Figure 3-3. Other deposit areas at the West Angelas mine have similar stratigraphic relationships. Figure 3-3 is indicative of the wider geological relationships across the mine site.

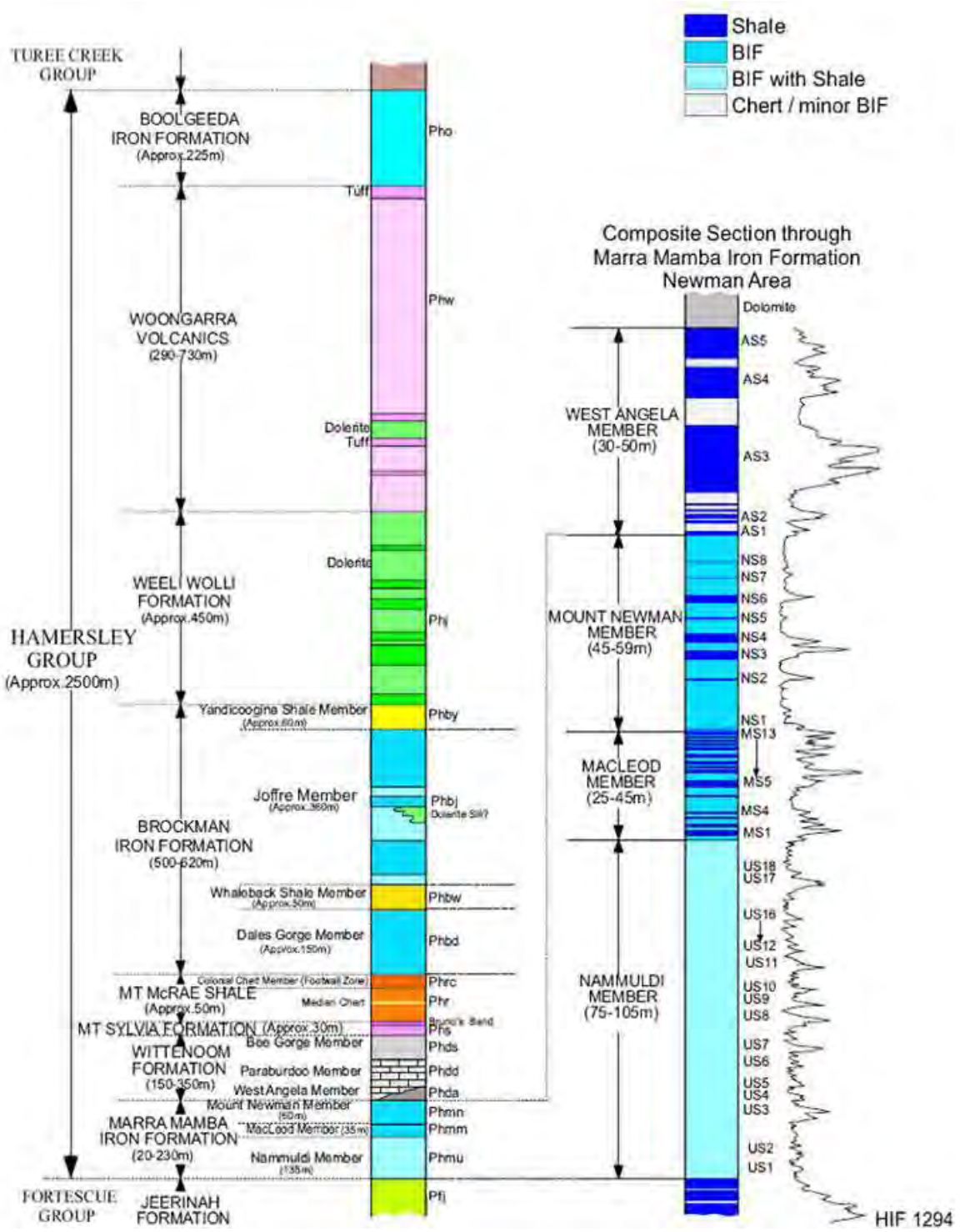

Figure 3-3 Stratigraphic column for West Angelas mine, Deposit C (from Rio Tinto, 2010)

3.2.2 Mineralisation

Mineralisation at the mine, across the different deposits that are mined or planned to be mined, is typically in the middle and upper units of the Mount Newman member. Minor quantities of ore are noted as occasionally present below the Mount Newman member, in the West Angelas shale bands.

3.2.3 Local geology

The West Angelas mine is situated on the northern limb of an east-west trending and west plunging anticline. The anticline is a major regional geological structure that has two major structural components, faulting and folding.

The folds are asymmetrical and north-verging; open to isoclinal and, in places, overturned to recumbent. The folds characteristically have short steep dipping southern limbs and longer, flatter-dipping northern limbs.

The West Angelas mine area has been cut by south-dipping thrust and reverse faults. Faults are noted to commonly occur within, or at the margins of, over-tightened anticlines. The faults have been recognized by Rio Tinto geologists in their technical reports as south block moving over north block. Faults are often identified from field data (borehole logs) where the Mount Newman Member is encountered above the West Angela Member. Figure 3-4 and Figure 3-5, below, show excerpts from the *West Angelas Mine, Deposit E (WAE) Geotechnical Design Report* (Rio Tinto, 2015a) that neatly illustrate the geological units, faulting and folding and the interface with pit design.

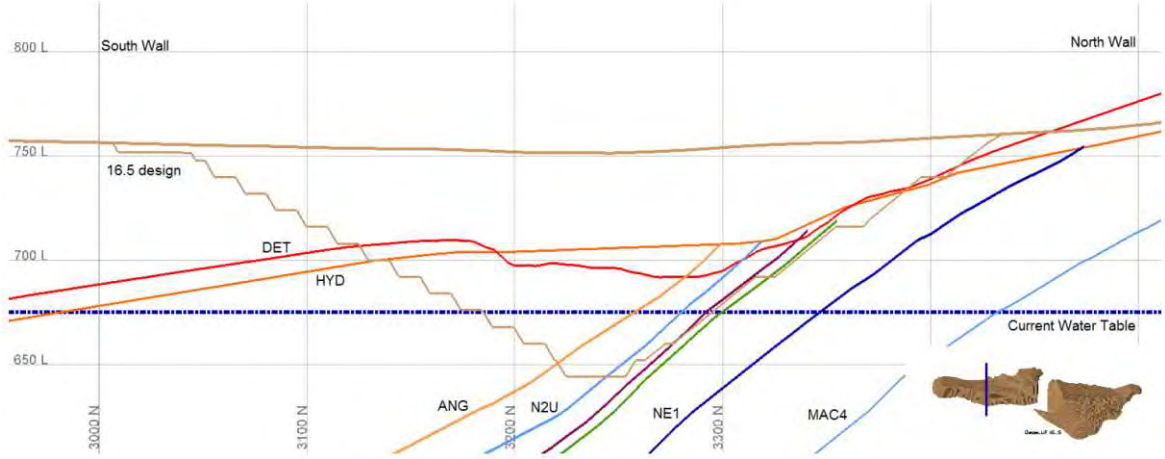

Figure 3-4 North-south cross section of Deposit E (Rio Tinto, 2015a)

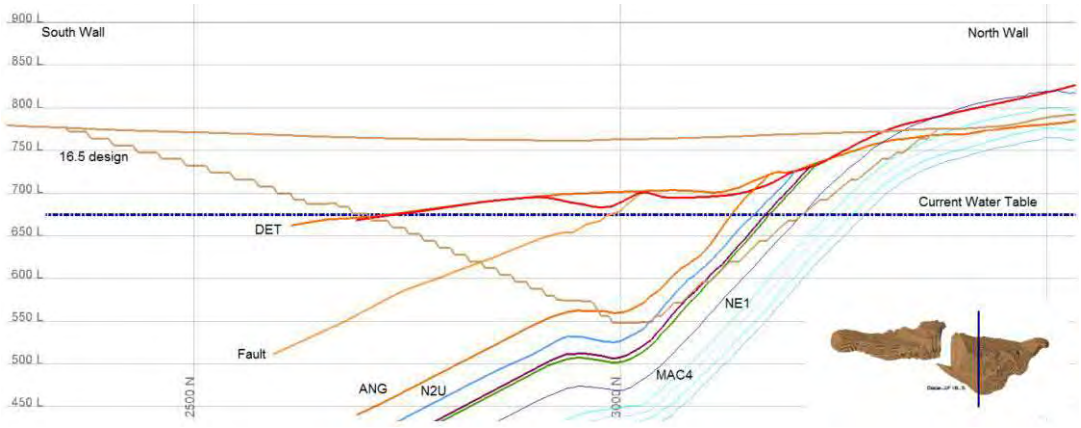

Figure 3-5 North-south cross section of Deposit E (Rio Tinto, 2015a)

3.2.4 Operational pit wall design

Review of the pit design reports provided by Rio Tinto indicates that the operational pit wall design slopes comply with the Rio Tinto (2015b) D3 group standard geotechnical design acceptance criteria (HSEC-B-024, Rev 2). These design acceptance criteria are summarised in Table 3-3 and Table 3-4.

Table 3-3 Operations design criteria for slopes (Rio Tinto, 2015b)

Criteria for slopes		Factor of safety for risk category		Probability of failure for risk category (%)	
Scale	Infrastructure at risk	High	Mod-Low	High	Mod-Low
Single batter (<20 m)	n/a	1.2	1.1	25	30
Double batter (≥20 m)	n/a	1.2	1.1	10	15
Inter-ramp	None	1.2	1.2	10	15
Inter-ramp	Long term ramp	1.3	1.3	10	10
Overall slope	None	1.3	1.2	5	5
Overall slope	Long term ramp	1.3	1.3	5	5
Overall/inter-ramp slope	Fixed and critical	>1.5	1.5	1-3	3-5

Table 3-4 Operations design criteria for dumps and landbridges (Rio Tinto, 2015b)

Criteria for dumps and landbridges		Factor of safety for risk category		Probability of failure for risk category (%)	
Scale	Infrastructure at risk	High	Mod-Low	High	Mod-Low
Dump point / single lift	None	1.1	1.1	20	20
Overall dump / deep seated	None	1.3	1.2	5	10
Overall dump / closure	Fixed (critical)	>1.5	1.5	1-3	3-5

3.3 Hydrology

Most of the mine site is located in the upper reaches of the Ashburton River catchment, extending across the Turee Creek and Weeli Wolli Creek sub-catchments, as shown in Figure 3-6. The creeks within these catchment areas are ephemeral, being dry most of the year and only flowing in response to high intensity rainfall events often associated with cyclonic activity between November and April.

Most of the mining operations are located with the upper reaches of the Turee Creek catchment (Rio Tinto, 2020b) and the most significant named creek within the mine area is Turee Creek East (TCE) which flows west into Karijini National Park. There is also a significant southern tributary that joins Turee Creek East downstream of Deposits C and D.

The south eastern portion of the mine site, including portions of Deposit F, is located within the upper catchment of Weeli Wolli Creek. Runoff from this catchment flows north-east to the Fortescue Marsh. The Weeli Wolli-Turee Creek East catchment divide is poorly defined and flows from the steep ranges disperse over the flat valley plains within the mine area. Runoff through the catchment often infiltrates downstream in creek beds and does not reach Fortescue Marsh, though this is complicated by mining operations downstream in the catchment that discharge mine dewater (CSIRO, 2015).

Numerous pits, dumps and linear infrastructure are located within existing floodplains which has required the construction of levees and diversions to maintain flows downstream and provide operational flood protection (Figure 3-7). The maintenance of downstream flows protects sensitive downstream environments such as Karijini National Park, from surface water related impacts. The levees and/or diversions at each deposit were designed based on localised flood modelling and assessments documented in the reports outlined in Section 2.2.

A site wide assessment of the operational infrastructure was completed in the *West Angelas Summary of hydrology and operational flood protection* (Rio Tinto, 2020b) using RORB and TUFLOW modelling. The assessment considered the performance of the operational infrastructure for the 1:100, 1:1,000 and 1:10,000 AEP flood events, identifying the following key risk areas and priorities for closure planning with respect to surface water (shown in Figure 3-7):

- Turee Creek East at Deposit C; the operational levee may overtop and fail during flood events larger than a 1:100 AEP (depending on upstream infrastructure), with water spilling over the pit crest into the C3 pit void, which will result in subsequent geotechnical stability issues of the pit crest.
- Southern TCE tributary at Deposit D; overtopping failure of the diversion at the pit D1 crest would lead to capture of flows from a 45 km^2 catchment area and a potential 35% reduction in flow volume reporting to Karijini National Park (based on complete capture of the southern tributary).

A summary of the operational surface water management measures in place at each deposit is provided in Table 3-5, including details of previous identified risks for consideration in mine closure planning (Rio Tinto, 2020a).

Table 3-5. Operational surface water management

Deposit	Description	Operational Management	Operational Design Event	Identified Closure Risks
Deposit A and Deposit E	There are no large-scale floodplain interactions in this area. Waste dumps intercept frequent flows from the southern ranges. Flows from smaller catchments drain into pit voids.	No large-scale floodplains and no operational flood protection measures, excluding minor drains and culverts.	N/A	Backfill of pits will occur to above pre-mining water table. Minor stream training may be required to divert inflows to pit crest (spill point) locations with competent material (Rio Tinto, 2020b).
Deposit B	The pit and waste dumps are located away from major drainage lines.	Deposit B is protected from flooding by the diversion berm and drain which redirects floodwater downstream to TCE. Diversion is to the south passing under a haul road.	1:100 AEP	Closure landforms are yet to be designed for the area. Long-term landform stability risks associated with flooding are considered low at Deposit B (diversion prevents over-topping for events up to the 1:2,000 AEP).
Deposit C	TCE runs adjacent to Deposit C. Waste dumps are located to the south between ridges in an internally draining area. Linear infrastructure upstream reduces flood peaks at Deposit C.	The low flow channel and floodplain have been diverted to the north via a system of levees and drains. Events greater than the 1:100 AEP event may be captured in Pit C3 (Rio Tinto, 2020b).	1:100 AEP	The current closure strategy is yet to be defined, but this is a high-risk area given the environmental significance of TCE flowing in Karijini National Park
Deposit D	Deposit D is located on a large southern tributary of TCE. The main floodplain interactions are north of D3 and adjacent to D1 where the channel runs between the pit and waste dump.	A system of levees and diversion drains are under construction to direct flows around Deposit D and maintain flows in a westward direction towards TCE and Karijini.	1:50 AEP	The current closure strategy is yet to be defined. The final closure strategy must consider upstream changes to hydrology caused by mining of Deposit A West.
Deposit F	Located across the catchment divide of TCE and Weeli Wolli Creek. The area is in the respective upper catchments with limited defined waterways.	The Deposit F diversion drain directs approximately 14 km^2 catchment east which formerly flowed west.	1:50 AEP	The operational diversion drain overtops in the 1:100 AEP event and will require upgrade at closure. Geomorphological input to closure design will require consideration.

Deposit	Description	Operational Management	Operational Design Event	Identified Closure Risks
Deposit G	Consists of three pits that are yet to be designed. Floodplain interaction at Pits G2 and G3 are from backwater behind the rail and road alignments	As the pits are yet to be designed, there are no operational surface water features. Pit G3 will receive flows from a small local catchment.	N/A	Closure features at Deposit G will need to consider the presence of rail and road alignments at closure (discussed further in Section 4.2).

Surface Water Closure Strategy
West Angelas

Figure 3-6: Catchments and Waterways

Legend

Mine Layout
- Rail Network
- State Road
- LoM Pit Outlines
- LoM Waste Dump Outlines

Environment and Heritage
- National Parks
- Drainage Lines

River Basins
- Ashburton River
- Fortescue River

Great Northern Hwy
Turee Creek East
TCE Southern Tributary
To Fortescue Marsh
Ashburton River
Fortescue River

0 3 6 km

Date: 01/02/2022
Projection: GDA94 / MGA zone 50

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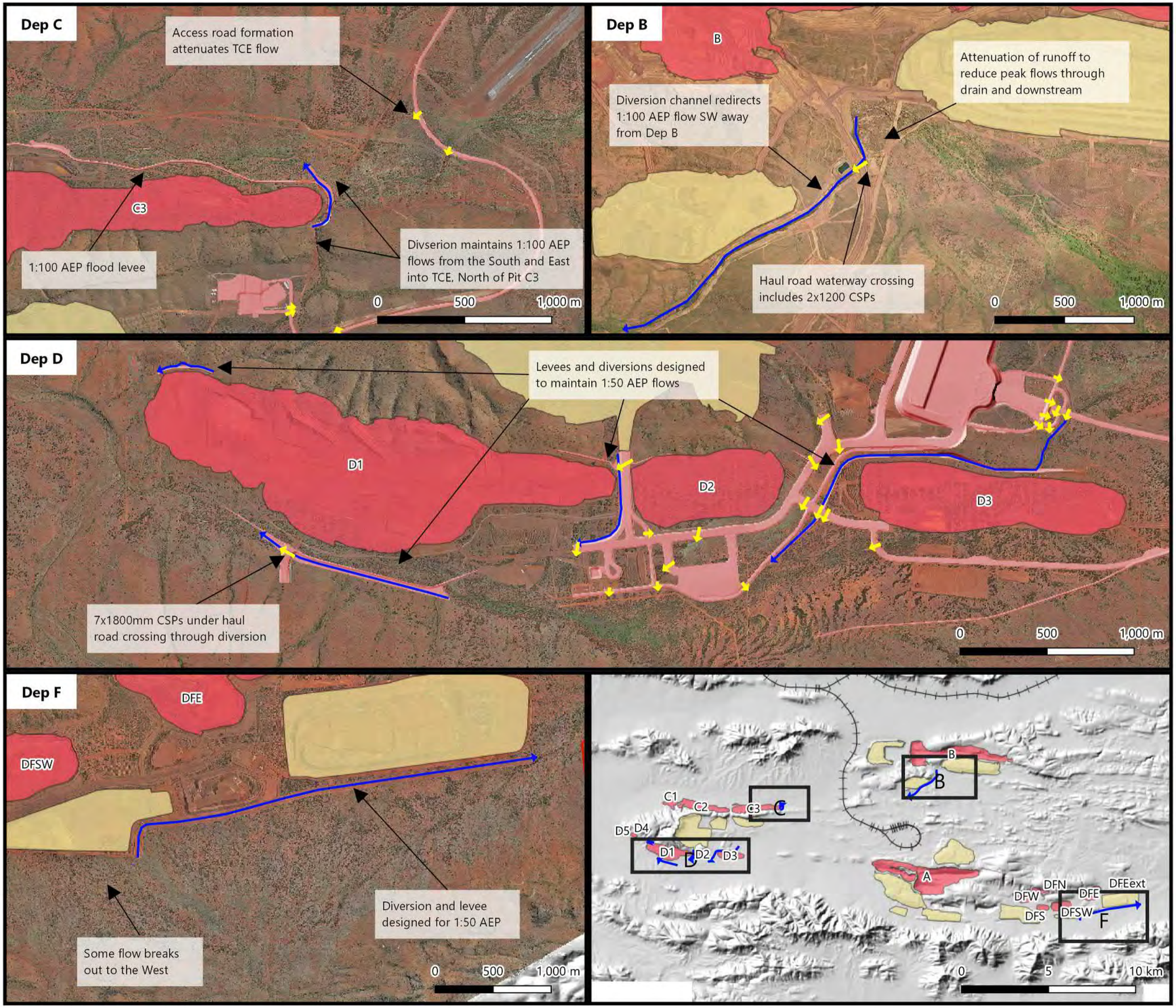
Surface Water Closure Strategy
West Angelas

Figure 3-7: Operations Surface Water Infrastructure

Legend

Mine Layout
- Culvert Banks
- Diversion Drains
- In-Scope Pits
- In-Scope Waste Dumps



Date: 25/01/2022
Projection: GDA94 / MGA zone 50

AJvisian

RioTinto

3.4 Environment

The key environmental features within and adjacent to West Angelas influenced by surface water are provided in Figure 3-8. Karijini National Park is located west of the mining operations and represents many of the geological types, plant and animal communities and landforms of the central portion of the Hamersley Range (DCLM, 1999). Karijini is a place of special cultural significance for Traditional Owners and features many permanent and semi-permanent pools. Turee Creek East flows through West Angelas into the south east corner of Karijini.

The West Angelas Cracking Clay Priority Ecological Community (PEC) is listed as a Priority One community, indicating that there are very few occurrences in in Western Australia. As outlined in the MCP (Rio Tinto, 2020a), these areas are sustained by sheet flows generated by incidental rainfall. The PEC contains open tussock grasslands of *Astrebla pectinata*, *A. elymoides*, *Aristida latifolia*, in combination with *Astrebla squarrosa* and low scattered shrubs of *Sida fibulifera*, on basalt derived cracking clay loam depressions and flow lines (Rio Tinto, 2020a). These areas are protected from unapproved direct and indirect disturbance during operations and closure.

The south east portion of the mine site forms part of the Weeli Wolli Creek catchment that ultimately discharges to the Fortescue Marsh. The marsh is a large ephemeral wetland which is recognised as a key biodiversity area, a wetland of regional and national significance, and of immense cultural significance to traditional owners (DBCA, 2018). As outlined in Section 3.3, surface water flows from the upper catchment reaches (within the mine site) do not necessarily reach the marsh but contribute to groundwater discharge.

The waterways within the site also have their own environmental value, including local pools downstream of Deposit D, riparian vegetation, and habitats. Retaining and rehabilitating the values of these waterways requires consideration during operations and at closure.

3.5 Cultural heritage

West Angelas is located within predominantly within the traditional lands of the Yinhawangka people, with the eastern portion (near Deposit F) on land held by the Ngarlawangga people (Rio Tinto, 2020a). Archaeological and anthropogenic surveys have identified sites and places of important significance, as shown in Figure 3-9.

As noted in the MCP (Rio Tinto, 2020a), intangible cultural heritage has an equally important role in representing continuous living culture of the Yinhawangka and Ngarlawangga people. Intangible values are often associated with the natural landscape features through mythologies, song lines and oral histories. Waterways have a high cultural significance, particularly Turee Creek which is a defining boundary between the Yinhawangka and Ngarlawangga people.

These cultural values across the site are acknowledged and inform the closure basis of design (Section 4), particularly with regards to prevention of creek capture to ensure frequent flows in waterways and catchment connectivity is maintained.

Surface Water Closure Strategy
West Angelas

Figure 3-8: Key Environmental Features

Legend

Mine Layout

- Railway Centreline
- State Roads
- LoM Pit Outlines
- LoM Waste Dump Outlines

Environment and Heritage

- Drainage Lines
- Cracking Clays PEC
- National Parks

Karijini National Park

Great Northern Hwy

Deposit B

Deposit G

Deposit C

Deposit D

A-West

Deposit A

Deposit E

Deposit F

0 2.5 5 km

Date: 03/11/2021

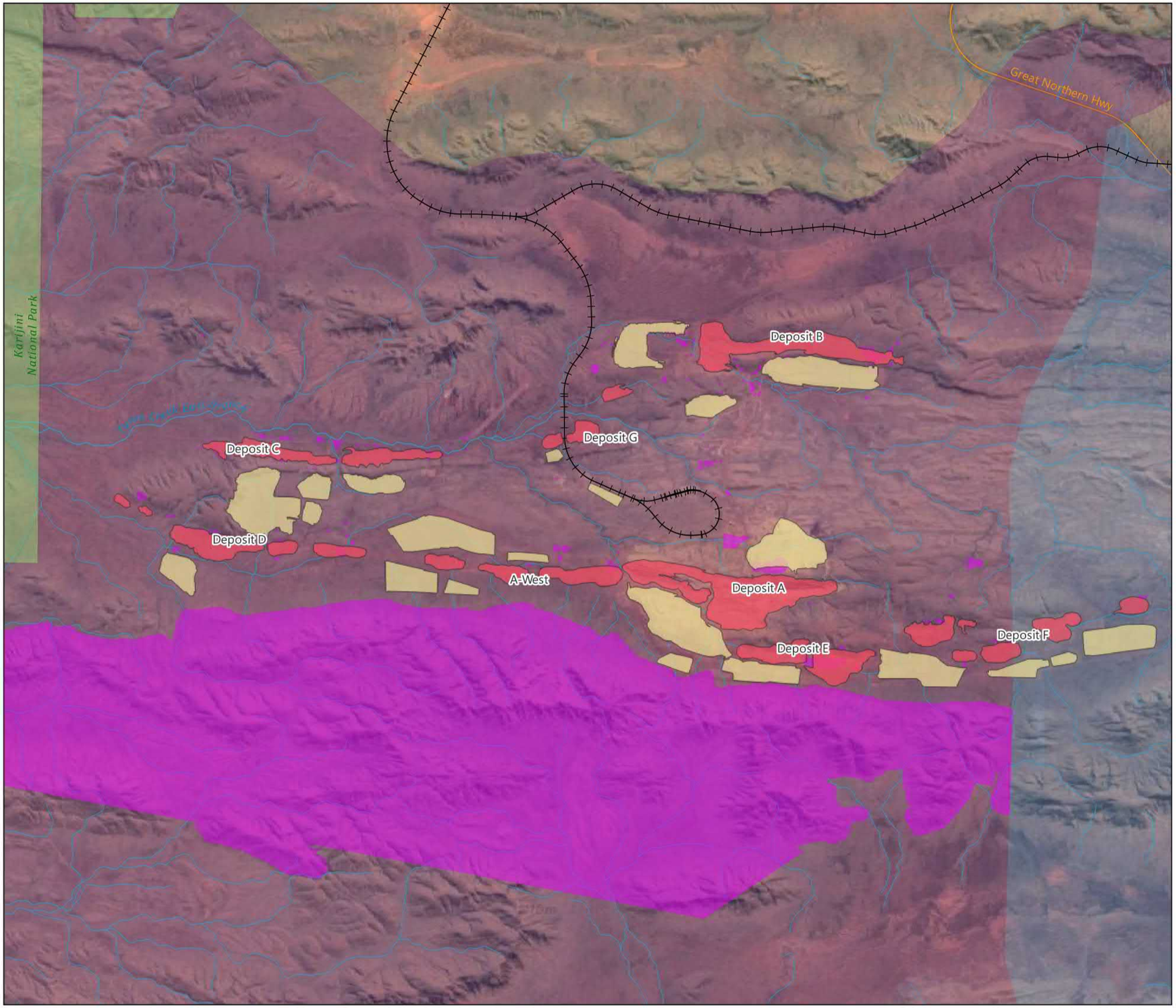
Projection: GDA94 / MGA zone 50

Advisian

RioTinto

Surface Water Closure Strategy
West Angelas

Figure 3-9: Cultural Heritage



Legend

Mine Layout
- Railway Centreline
- State Roads
- LoM Pit Outlines
- LoM Waste Dump Outlines

Environment and Heritage
- Drainage Lines
- National Parks
- RTIO Heritage Management

Native Title Determination
- Ngarlawangga People
- Yinhawangka People

0 2.5 5 km

Date: 03/11/2021
Projection: GDA94 / MGA zone 50

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4 Basis of design

The Basis of Design (BoD) is provided to define the objectives and design criteria for the surface water concepts required for closure of the West Angelas mine. The objectives, design criteria and mine infrastructure assumptions were determined through review of the mine closure guidelines described below and in consultation with Rio Tinto. This section outlines the respective assumptions and requirements for closure.

4.1 Guiding documents

The BoD has been prepared with consideration of mine closure guidelines and standards in Western Australia that reference landform and water resource requirements for closure. The following documents were referenced in preparation of the design criteria:

- Mine Closure Plan Guidance – How to prepare in accordance with Part 1 of the Statutory Guidelines for Mine Closure Plans (DMIRS, 2020a).
- Environmental Objectives Policy for Mining (DMIRS, 2020b).
- Safety Bund Walls Around Abandoned Open Pit Mines Guideline (DIR, 1997).
- A Framework for Developing Mine-Site Completion Criteria in Western Australia (Western Australian Biodiversity Science Institute, 2019).
- Works that Interfere with Water in a Watercourse for a Resource Activity - Watercourse Diversions Authorised under the Water Act 2000 (DNRME, 2019).

There are no published guidelines developed for the design of creek diversions in Western Australia. The DNRME (2019) Guideline is the most recent creek diversion guideline document published in Australia. It refers to current engineering practice and relevant guiding principles from past research conducted, such as ACARP (2000, 2002, 2014). DNRME (2019) guidelines state that channel condition and therefore functional design of permanent watercourse diversions should be judged by whether the diversion meets a list of outcomes/objectives with consideration of the geomorphological, hydrological and ecological components, along with hydraulic and engineering components. When the diversion is to remain following mine closure, the design should satisfy the outcomes/objectives without the need for ongoing maintenance. These documents informed the selection of design criteria.

4.2 Closure assumptions

Future mining operations are planned to occur at Deposits A to G in numerous pits. The status of the pits at each deposit are summarised in Section 3.1 and include several pits that are approved, but not yet designed or constructed. For example, mining in pits AW1, AW2 and AW3 at Deposit A are not scheduled until 2026, 2031 and 2030 respectively and are subject to further planning and design. The uncertainty over their final form makes it difficult to include in the closure planning. Therefore, only active or designed pits have been included within this assessment. Further revisions to the surface water infrastructure will be required to include future pits.

The inclusions and exclusions for the Study Area to be considered for closure are outlined in Table 1 and shown in Figure 4-1.

Table 4-1. Closure flood modelling inclusions/exclusions

Option ID	Inclusion	Exclusion	Comment
Deposit A	Pits: CEPN, CEPS, WEPN, WEPS, Gumleaf, Cake Pit; existing levee/road	Pits: AW1-3; Proposed AW diversion (Rio Tinto, 2020b)	AW pits have not yet been designed, so diversion assumptions may change. The previous assessment (Rio Tinto, 2020b) included a diversion for the AW pits which is not considered in this assessment as the pit design and operational levee have not been designed.
Deposit B	Pits: DBC-5	Haul Road culverts	Assumed that haul road crossings and associated culverts will be removed and the creek bed reinstated (modelled as break in haul road)
Deposit C	Pits: C1-3; diversions	*See Rail*	Flows to Pits C are controlled by upstream rail and light vehicle roads crossings/culverts.
Deposit D	Pits: D1-5; diversion	*See Waste Dumps*	The final waste dump form will be assessed.
Deposit E	-	East and West Pits	Pits not yet designed or constructed and therefore have not been included in this assessment.
Deposit F	Pits: DFW, DFN1, DFS1, DFE, Marlu; Diversion	Local catchment controls	The southern catchment features an operational levee and is assessed as a minor waterway. The northern catchments were relatively small and will require local levees not considered in this assessment.
Deposit G	-	All existing features	Pits not yet designed or constructed and therefore have not been included in this assessment.
Rail	Existing formation	Crossings	The status of the rail is unknown and subject to negotiation with the State Government. In order to provide conservative assessments, the rail crossings are removed from the model.
Other infrastructure	Haul roads and Light Vehicle roads	Road crossings, conveyors and pipelines	It is assumed that crossings for Haul and Light Vehicle roads will be removed at closure
Waste Dumps	Closure waste dumps	Waste dump WD3 (Deposit D) and Dumps associated with Pits AW1-3.	In consultation with Rio Tinto, the waste dumps removed at closure (used for backfilling) were determined and excluded from the flood plain. LOM footprints adopted, noting that closure footprint may increase.
Airport	All infrastructure	-	Whilst the airport facilities are likely to be removed at closure, their inclusion in the flood modelling has little impact on the flooding regime.

Surface Water Closure Strategy
West Angelas

Figure 4-1: Closure Assumptions

Great Northern Hwy

Rail and road waterway crossings removed

Haul Road crossing and existing culverts removed

Deposit G pits not yet designed or constructed

Impact of airport and camps considered minimal, and left in place

West Angelas Camp

Road (land bridge) between Pits C2 and C3 retained at closure

Turee Creek

Wintamarra Village

A

B

C

D

F

Haul Road crossing and existing culverts removed

Existing diversion alignment adopted

A-West Pits and associated diversions excluded

Deposit E pits not yet designed or constructed

Minor waterway managed by operational levee

Small northern catchments requiring local levees to be considered in a future phase

Legend

Mine Layout

- Airport
- Mine Camps
- Railway Centreline
- Haul Road
- Site and Access Rodas
- Conveyor
- Earthworks Waterway Crossings
- WAN_watercourses_clipped_L

LoM Pit Extents

- LOM Pit Outlines
- Future Pits

LoM Waste Dump Outlines

- LOM Design Extent
- Removed at Closure

Closure Modelling Notes:
- Pits to be backfilled to ensure pit wall stability at levee locations.
- Rail Formation is retained, with waterway crossings removed using breaklines
- Haul road and LV road waterway crossings removed using breaklines
- Waste Dump footprints assumed to be Life of Mine design footprints.
- Airport and Mine Camps show minimal impact and left in place.
- Design floods (1:1,000 and 1:10,000 AEP) adopted as provided by RTIO in May 2021.
- Road (land bridge) between Pits C2 and C3 retained at closure, blocking 2.03 km2 of catchment

0 2.5 5 km

Date: 08/02/2022
Projection: GDA94 / MGA zone 50

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4.3 Closure design objectives

The design objectives adopted from the *Mine Closure Plan* (Rio Tinto, 2020a) for this study are:

- Manage public health and safety hazards.
- Maintain downstream values by ensuring flows within Turee Creek East are maintained.
- Preserve cultural heritage.
- Provide a stable landform that considers hydrological factors.

4.4 Design criteria

The qualitative and quantitative closure design criteria in Table 4-2 have been prepared by Advisian to meet the objectives outlined above that are relevant to this assessment. The criteria were discussed with Rio Tinto stakeholders on 27 July 2021. Examples of additional criteria that may be considered in subsequent design stages are provided. These should be refined in subsequent project phases and through feedback from regulators and stakeholders.

Table 4-2. Closure design criteria

Item	Criteria	Included in this assessment
General Site Design Targets	• Retain cultural values in the landscape (qualitative). • Leave heritage areas undisturbed where possible and locate infrastructure outside of associated buffers. • Maintain frequent environmental flows to key heritage sites and sensitive environmental receptors (such as Karijini National Park and Fortescue Marsh). • Streamflow quantity and water quality is similar to pre-development conditions. • Meet legislative requirements and agreements with Traditional Owners. • Create stable pit crests where they intersect flood zones, not requiring ongoing maintenance.	Yes
Flood Levees (Creeks and Waterways)	• Levees to contain the 1:10,000 AEP event within major waterways within overtopping. • Levees to contain the 1:1,000 AEP event within minor waterways without overtopping (Deposit F and near Pit D3). • No freeboard above the design event flood levels • For engineered landforms adjacent major watercourses, where required, apply rock protection to prevent scour and erosion during a 1:10,000 AEP event. • For engineered landforms adjacent minor watercourses, where required, apply rock protection to prevent scour and erosion during a 1:1,000 AEP event. • Rock protection design to be based on modelled peak velocities and methods published by Austroads (2019). • Levee rock protection design to cater for and protect from potential lateral channel migration of watercourses and under-cutting of levee embankments.	Yes

Item	Criteria	Included in this assessment
	• Levees to be geotechnically stable, requiring no ongoing maintenance. • Select construction material and design levees for FoS >1.5 in static and >1.2 in seismic conditions. • Levee crest width to be set at minimum 5 m. • Both fill and scour protection materials to be sourced from durable and geochemically stable materials. • Levees constructed with a 10 m buffer from the slip surface as per guidelines for abandonment bunds (DIR, 1997), as some levees will form part of the pit abandonment bund. • Note that a reduced design criteria (rather than designing to the 1:10,000 or 1:1,000 AEP event) may be adopted where it is impractical or unfeasible to design for a rarer event, or where the consequence of failure is considered not to be significant.	
Flood Levees (Local Catchments)	• Existing operational pit flood protection levees (for local catchments) are to be upgraded to contain the 1:100 AEP event within the creeks without overtopping. • No freeboard above the design event flood levels.	No
Diversion channels	• Geomorphic and hydraulic characteristics and behaviour of diversions should be similar to existing/natural waterways (natural analogues). • Design should cater for development of ecological and geomorphological features that are consistent with natural waterways within the same catchment. • Alluvial or engineered aquifers (blasted rock) should be included if required to support re-establishment of riparian vegetation. • Design FoS >1.5 in static and >1.2 in seismic conditions for cut slopes. • Diversion designs to minimise risk of potential exposure of AMD material.	No
Buttressing	• Select construction material and design FoS minimum of 1.5 for overall slope stability including consideration of long-term degradation of geotechnical characteristics. • Align with Rio Tinto standards. • Consideration of Rio Tinto waste dump closure landform design guidelines.	Yes
Spillways (if required)	• Floods <1:50 AEP event: No flow over spillways – all to be retained in creek. • 1:50 AEP – 1:10,000 AEP events: Minimise the number of spillways activated. • 1:10,000 AEP flood event: No uncontrolled overtopping of pit crests or levees into pit voids (leading to creek capture). • Outlet spillway designs may also need to be considered where there is insufficient pit void capacity. • Design FoS >1.5 in static and >1.2 in seismic conditions for cut slopes. • Rock protection to be sized to manage scour risk for events up to and including the 1:10,000 AEP flood event.	Yes

5 Options assessment

To determine the most effective closure outcome, an options assessment was undertaken (Figure 1-2) in collaboration with Rio Tinto. The assessment process and outcomes are outlined in this Section.

5.1 Options Framing Workshop

Based on the review of site characteristics, key risk areas and the design criteria, Advisian prepared seven preliminary closure options for consideration in consultation with Rio Tinto. These options are summarised in Table 5-1 and include options that adopt varying infrastructure closure assumptions and/or flood protection design criteria.

An Options Framing Workshop was held with key Rio Tinto stakeholders on 19 August 2021 to select the preferred closure options for assessment. Each option was discussed with regards to the BoD, broader closure objectives related to environmental and cultural outcomes, and practical considerations. A summary of these discussions is also provided in Table 5-1.

Table 5-1. Preliminary closure options

Option ID	Title	Description	Flood Design Criteria	Advisian / Rio Tinto evaluation
1	1:10,000 AEP Glass Walls*	Raise operational infrastructure to 1:10,000 AEP event, no change to diversion alignments.	1:10,000 AEP	This option meets most of the BoD, but it requires geotechnical assessment to ensure that closure levee upgrades are not within the Potentially Unstable Pit Edge Zone (PUPEZ).
2	1:10,000 AEP Spillways	As per option 1, however use spillways (either at B, C3 or D3) where competent material may be available.	1:10,000 AEP	The use of spillways at C3 and D3 were considered to offer limited benefit as they are located at the lower parts of the catchment. Deposit B offers better opportunities as it is located higher in the TCE catchment.
3	1:2,000 AEP Glass Walls*	Raise operational infrastructure to 1:2,000 AEP event, no change to diversion alignments.	1:2,000 AEP	Assessing the lower design criteria allows for quantification of material savings by applying a lower design criteria. Owing to the material availability onsite, this option was not supported.
4	1:2,000 AEP Spillways	A combination of Option 2 and Option 3.	1:2,000 AEP	As with the findings for Options 2, a spillway at Deposit B was preferred. However, consistent with Option 3 the lower design criteria was not supported.
5	Reinstate natural waterways	Reinstate diversion B to the north and *naturalise* diversion F drain with meanders.	1:10,000 AEP	Reinstating the pre-mining water course and Deposit B was considered, along with a geomorphic design for the diversion channel at Deposit F. These options were not supported owing to the limited changes to

Option ID	Title	Description	Flood Design Criteria	Advisian / Rio Tinto evaluation
				downstream flows and requirements for significant backfilling and waste dump relocations. Upgrades to the Deposit F drain will be considered in subsequent detailed design beyond this project.
6	Do Nothing	None. Assess the risks associated with the 1:2,000 AEP event.	1:2,000 AEP	Assessment of a do-nothing approach was considered to further assess the operational infrastructure and expand on the *West Angelas Summary of hydrology and operational flood protection* (Rio Tinto, 2020b) using closure landforms (Section 4.2).
7	Turee Creek East realignment	Realign TCE at Pit C3 to reduce the impinging flows. Southern catchment isolated from TCE.	1:2,000 AEP	The existing operational levee at Pit C3 receives impinging flows from TCE resulting in higher forces on the levee, increasing failure risks. Diversion of TCE away from the levee was discussed and considered applicable to all options.

** Note that the term glass wall refers to a hydraulic modelling technique where operational levees are raised artificially high to determine maximum flood depths (and corresponding closure levee design levels).*

5.2 Selected closure options

The Options Framing Workshop (Section 5.1), identified three closure options and a *do-nothing* scenario. The do-nothing scenario was also considered for comparative purposes and to confirm the key risk areas following TUFLOW modifications to incorporate closure assumption and model updates. The *do-nothing* scenario was modelled in TUFLOW (hydrology and hydraulics) however geotechnical assessments were not undertaken. This scenario demonstrates the risks associated without implementing any of the closure concepts.

The three closure options were selected because they were considered likely to satisfy the BoD criteria and broader closure objectives and could be practically implemented on site. The selected options were based on variations of the preliminary options considered in Table 5-1 and developed in consultation with Rio Tinto. The options selected for further assessment were:

1. ***Operational levee upgrades.*** The operational levees are modelled with *glass walls* to determine the closure levee design heights required to contain the 1:10,000 event within the adjacent creek line without uncontrolled overtopping into the pits (Figure 5-1). This option assumes only vertical increases in operational levees heights but with consideration of the adjacent geotechnical stability in pits. To reduce failure risk at Pit C3, the closure levee is reshaped to reduce impinging flows.

2. ***Floodplain reinstatement at Pit C3.*** This option was developed and selected in consultation with Rio Tinto. The Pit C3 levee is a key risk area for the mine site as it is potentially impacted by impinging flows in the adjacent creek. This option involves partially backfilling the C3 pit to reinstate the floodplain. The main channel of the creek will be located outside of the backfill areas, though implementation of this option will require consideration of creek capture risks associated with scour and settlement of backfill material. This option is presented in Figure 5-2.

3. ***Deposit B Spillway.*** The use of a spillway was investigated to determine the potential benefits. The spillway at Deposit B would potentially reduce flows downstream, particularly at Pit C3. Ideally spillways are located and constructed in areas with highly competent rock which is resistant to erosion and forces associated with spillways. Given the lack of geotechnical information outside the ore deposits, the location of the spillway was selected without identification/confirmation of competent material. Further investigations would be required to identify and confirm the suitability of in-situ rock at spillway locations if the use of a spillway is selected as the preferred option. The spillway location, activated in flows ≥1:50 AEP, is presented in Figure 5-3.

The closure landform and infrastructure assumptions adopted at each deposit for each the three options are presented in Table 5-2. Given impinging flows adjacent to the Pit C3 operational levee, an additional diversion channel has been included for all options to reduce flow velocities around the levee and associated rock protection. This diversion is located north of the C3 pit and redirects most of the more frequent flows north and away from the Pit C3 closure levee (see Figure 5-1 to Figure 5-3).

Table 5-2. Closure flood modelling inclusions/exclusions

Option ID	Option 1: Operational levee upgrades	Option 2: Floodplain Reinstatement at Pit C3	Option 3: Spillway at Deposit B
Deposit A	Retention of waste dumps, no additional closure infrastructure.		
Deposit B	Removal of haul road crossings, assessment of 1:10,000 AEP flows in diversion		A spillway activated for ≥1:50 AEP flows at Deposit B
Deposit C	Pit C3 levee and diversion for 1:10,000 AEP event, including blocking flows from a small catchment using mine waste and realignment of the operational levee to the east. A diversion channel on TCE is included to reduce impinging flows adjacent the Pit C3 closure levee.	Backfilling of C3 pit to reinstate the floodplain. A portion of the Pit C3 operational levee will be removed. To consider settlement risks in the backfill material a compaction factor is included in material estimates. A diversion channel on TCE is included as per Option 1.	Levee and diversion for 1:10,000 AEP event, including blocking flows from the small southern catchment using mine waste and realignment of the operational levee to the east. A diversion channel on TCE is included to reduce impinging flows.
Deposit D	Closure levee designed for the 1:10,000 AEP event, including buttressing of the D1 pit wall to maintain stability. The closure levee at Pit D3 will be designed for the 1:1,000 AEP event.		
Deposit F	Closure levee designed for the 1:1,000 AEP event.		
Rail	Existing formation is retained, but crossings are removed in flood modelling. The floodplain width was considered to eliminate backwaters and attenuation of flow.		
Other	Haul roads and LV crossings removed. For minor crossings, a 20 m break was applied, and for major crossings the floodplain width was considered.		
Waste Dumps	Waste dumps retained apart from WD3 at Deposit D which is utilised for backfill.	Waste dumps retained apart from WD3 at Deposit D which is utilised for backfill. Material for reinstatement of floodplain is assumed to be sourced from south of Deposit C (e.g. WD1).	Waste dumps retained apart from WD3 at Deposit D which is utilised for backfill.

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Figure 5-1: Option 1 - Operations Levee Upgrades

Legend

Mine Layout
- Earthworks Waterway Crossings

In-Scope Pits
- LOM Pit Outlines
- Future Pits

In Scope Dumps
- LOM Design Extent
- Removed at Closure
- Removed at Closure

Drainage Concept Alignments
- Diversion
- Levee (1:1,000 AEP)
- Levee (1:10,000 AEP)
- Plugged Catchment

Closure Modelling Notes:
- Use of levees as primary flood control measure.
- Deposit A: waste dumps retained, no additional closure infrastructure
- Pits to be backfilled to ensure pit wall stability at levee locations.
- Rail Formation is retained, with waterway crossings removed using breaklines
- Haul road and LV road waterway crossings removed using breaklines
- Waste Dump footprints assumed to be Life of Mine design footprints.
- Design floods (1:1,000 and 1:10,000 AEP) adopted as provided by RTIO in May 2021.

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Dep C

Diversion of low flow channel to minimise scour at Levee

Access road formation removed at closure

Levee alignment more parallel to flow to minimise angle of attack

Southern contributing catchment blocked

C3

0 0.5 1 km

Dep B

B

Existing diversion left in place

Haul road waterway crossing and culverts removed.

0 0.5 1 km

Dep D

Operational Levee upgraded to 1:1,000 AEP event

Northern catchments become filled as the waste dump is developed

Operational Levee upgraded to 1:1,000 AEP event

D1

D2

D3

Haul road removed. Levee upgraded to 1:10,000 AEP flood immunity

0 0.5 1 km

Dep F

DFE

DFSW

Some flow breaks out to the West

Cut off drain upgraded to 1:1,000 AEP

0 0.5 1 km

C1 C2 C3 C

D5 D4 D1 D2 D3 D

B

A

DFN DFW DFS DFE DFEext DFSW F

0 5 10 km

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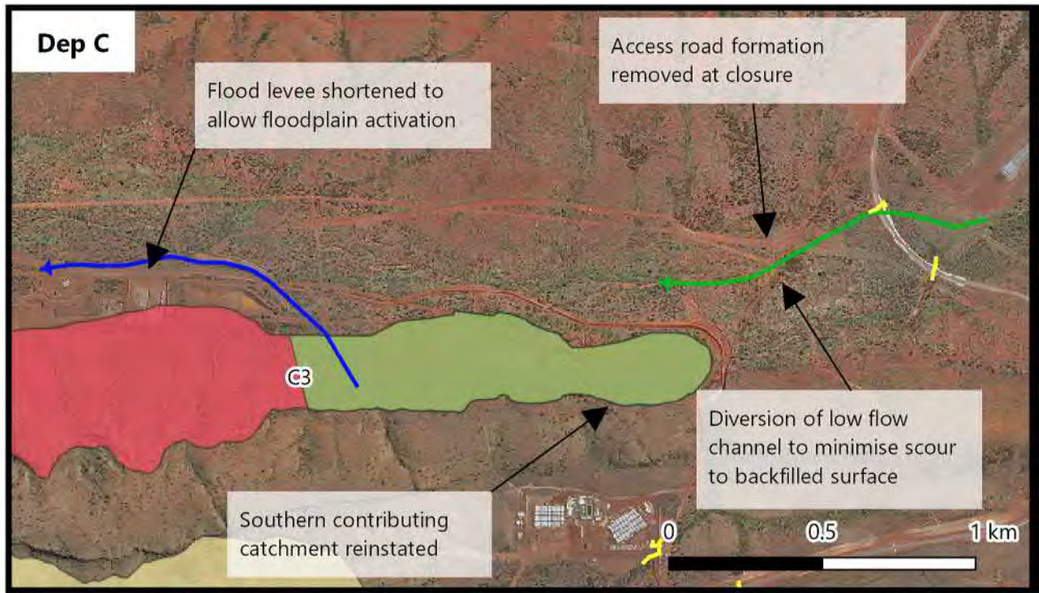
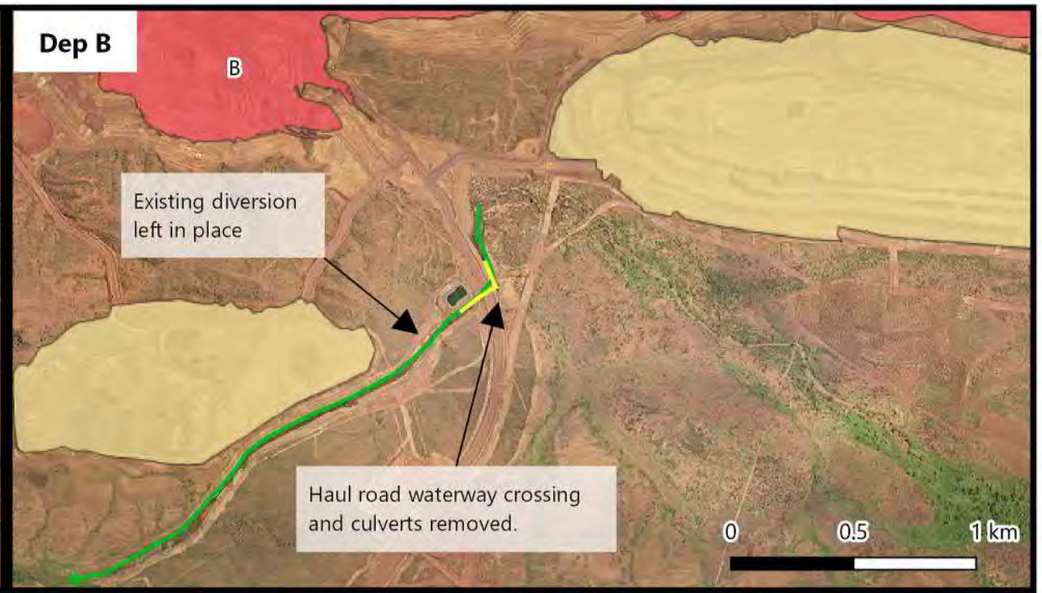
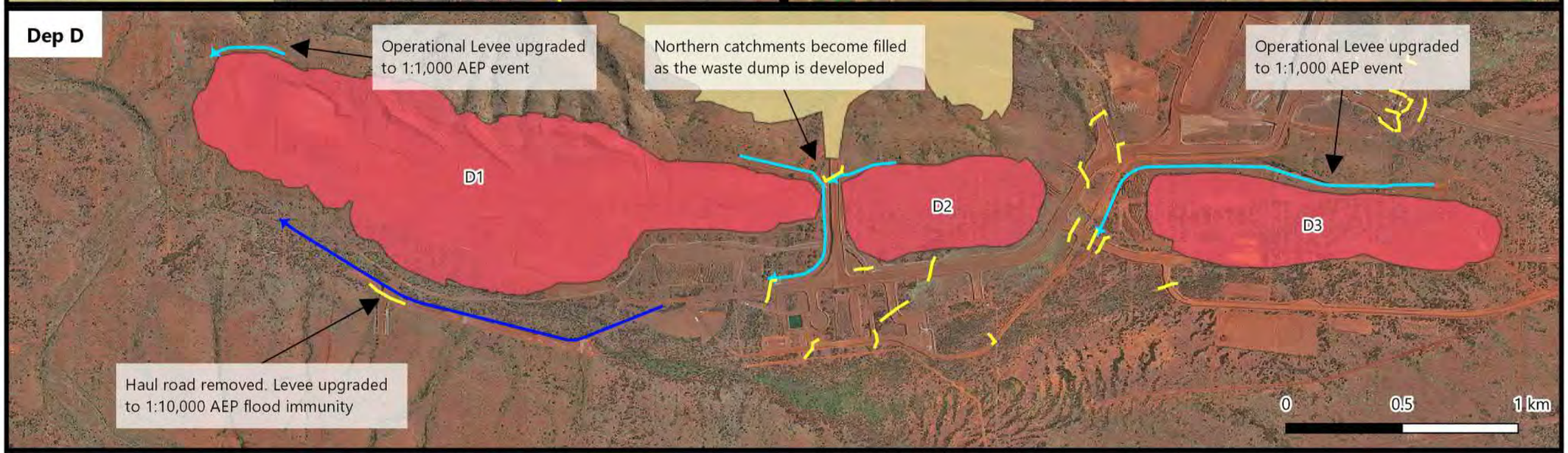
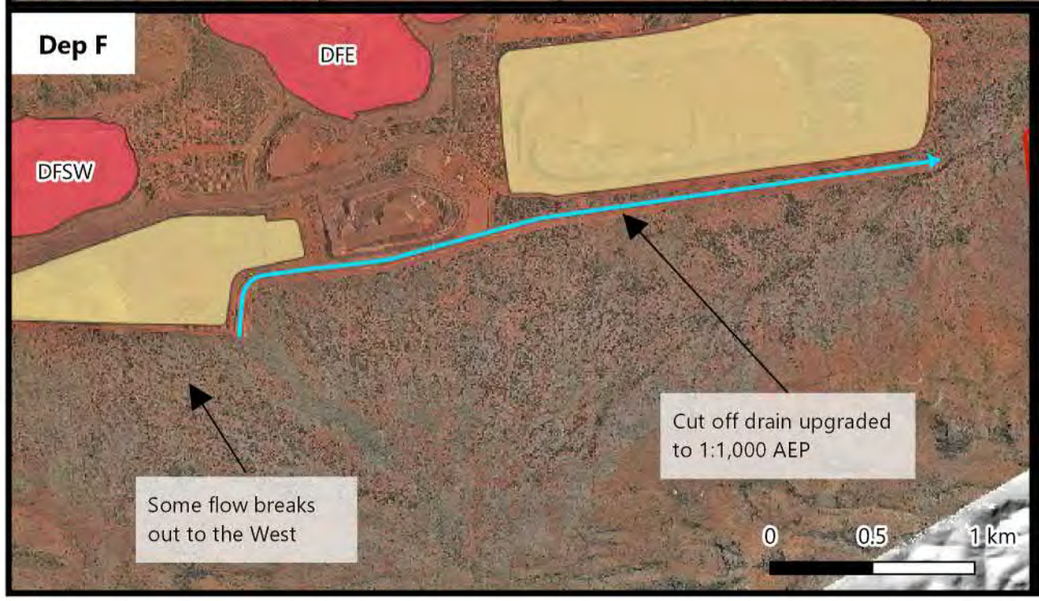
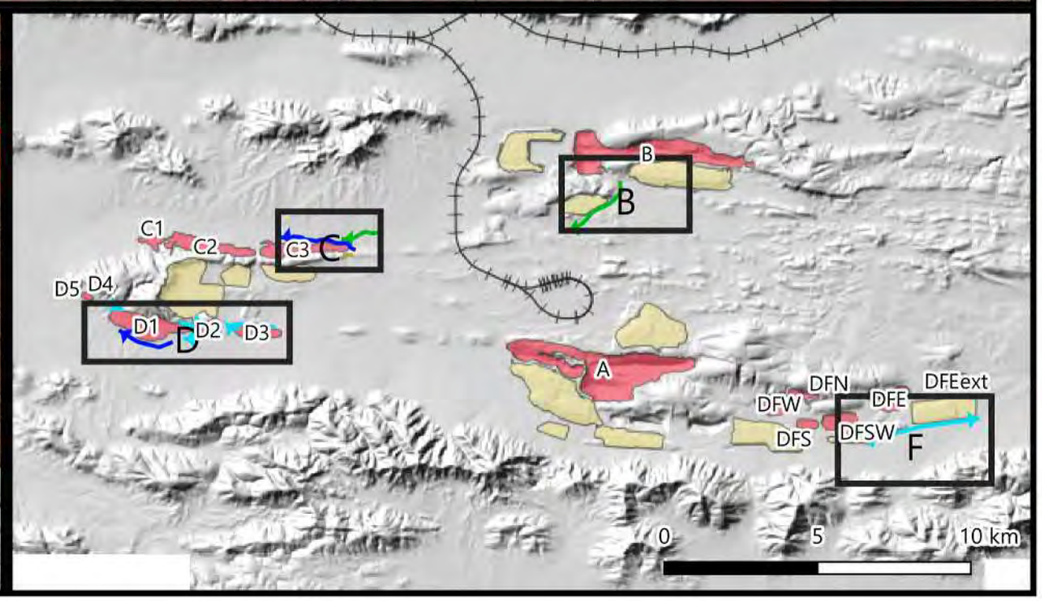
Figure 5-2: Option 2 - Floodplain Reinstatement at Pit C3











Legend

Mine Layout

- Earthworls Waterway Crossings

In-Scope Pits

- LOM Pit Outlines
- Future Pits

In-Scope Dumps

- LOM Design Extent
- Removed at Closure
- Removed at Closure

Drainage Concept Alignments

- Diversion
- Levee (1:1,000 AEP)
- Levee (1:10,000 AEP)
- Plugged Catchment
- WAN_option2_design_R

Closure Modelling Notes:

- Deposit A: waste dumps retained, no additional closure infrastructure
- Pits to be backfilled to ensure pit wall stability at levee locations.
- Rail Formation is retained, with waterway crossings removed using breaklines
- Haul road and LV road waterway crossings removed using breaklines
- Waste Dump footprints assumed to be Life of Mine design footprints.
- Design floods (1:1,000 and 1:10,000 AEP) adopted as provided by RTIO in May 2021.

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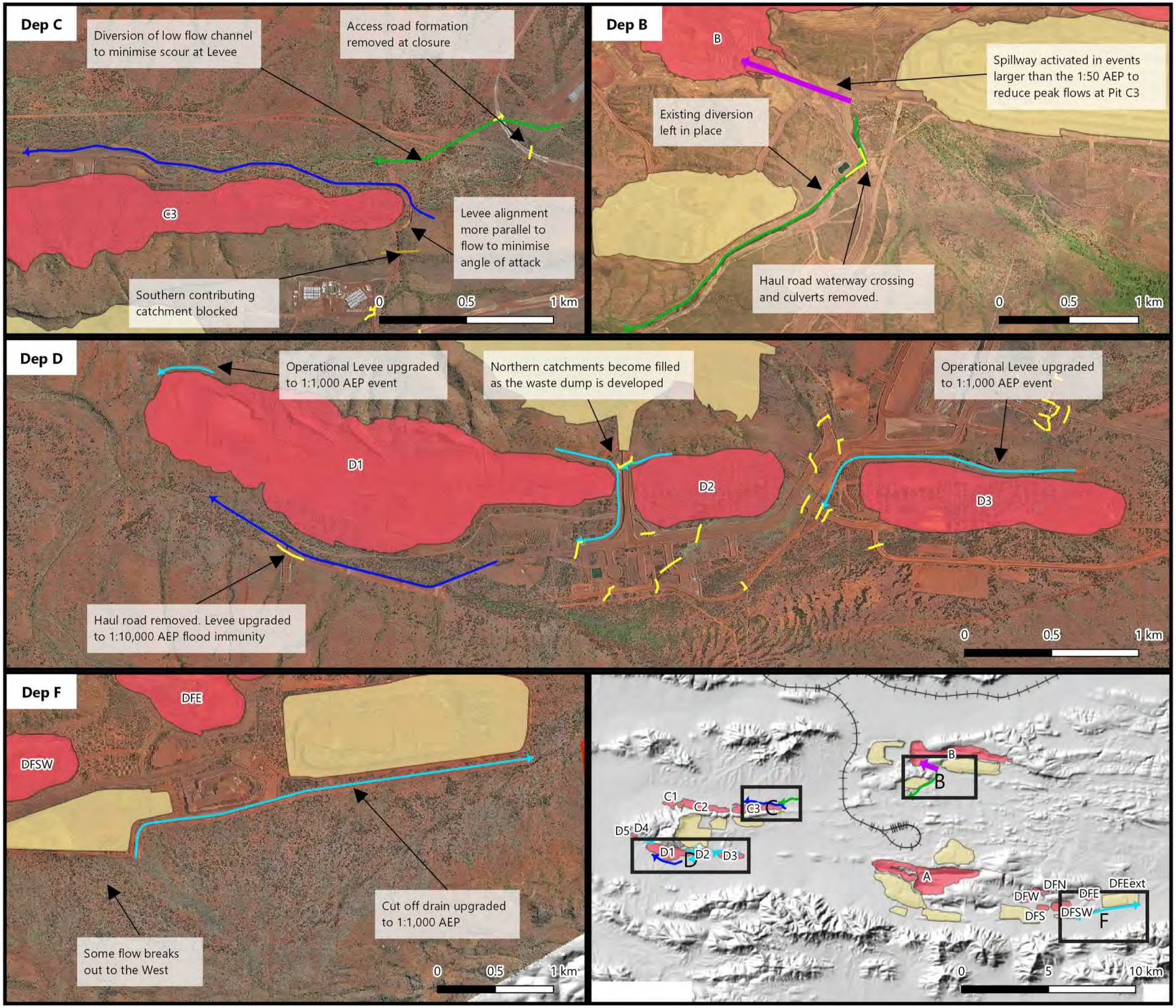
Figure 5-3: Option 3 - Spillway at Deposit B



Legend

- Earthworks Waterway Crossings
- In-Scope Pits
- In-Scope Waste Dumps

Drainage Concept Alignments

- Diversion
- Levee (1:1,000 AEP)
- Levee (1:10,000 AEP)
- Plugged Catchment
- Spillway (>= 1:50 AEP)

Closure Modelling Notes:
- Deposit A: waste dumps retained, no additional closure infrastructure
- Pits to be backfilled to ensure pit wall stability at levee locations.
- Rail Formation is retained, with waterway crossings removed using breaklines
- Haul road and LV road waterway crossings removed using breaklines
- Waste Dump footprints assumed to be Life of Mine design footprints.
- Design floods (1:1,000 and 1:10,000 AEP) adopted as provided by RTIO in May 2021.

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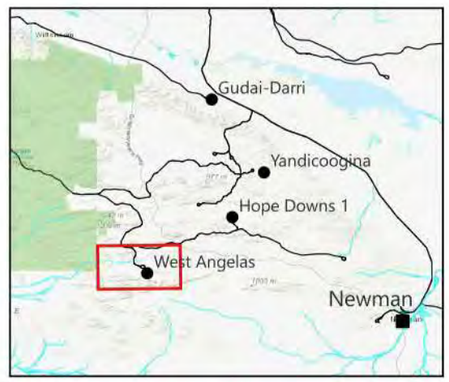

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The three closure options were assessed as follows:

- Flood (hydrology and hydraulics) modelling using TUFLOW to determine the alignment of surface water infrastructure (levees and diversions) and size and assess the closure designs to ensure the design criteria are met (discussed in Section 5.3).
- Geotechnical assessment of pit wall stability adjacent to the surface water infrastructure, including consideration of seismic and flooding events. Closure levee alignment and buttressing requirements were assessed and determined, where required (discussed in Section 5.4).
- Estimates of material quantities for each option in 12D (civil design software).

5.3 Hydraulic modelling

As discussed in Section 2.1, the TUFLOW model developed by Rio Tinto for the site-wide assessment in the *West Angelas Summary of hydrology and operational flood protection* (Rio Tinto, 2020b) was further developed by Advisian for use in this project (TUFLOW HPC version 2020-10-AA). A single, site-wide model domain was adopted to simulate flood flows in Turee Creek East and Weeli Wolli Creek.

The Rio Tinto TUFLOW model was revised to reflect closure landforms at deposits of interest for this study. These changes included removal of waste dumps identified for backfill, removal of road and rail earthworks formations in waterway crossings and exclusion of pits in Deposits A-West, E, and G. The model domain was also trimmed to include only the contributing catchments to deposits of interest to reduce simulation times. Life of Mine (LoM) pit and dump footprints provided by Rio Tinto were adopted, noting that final closure landform may result in a flattened landform with a greater footprint.

Revised design rainfall estimates with Areal Reduction Factors (ARF) were applied to independent contributing catchments at major infrastructure locations: Turee Creek East at Pit C3, Turee Creek East Tributary at Pit D1, and Weeli Wolli Creek at the Deposit F Diversion (described further in Appendix A).

The Quadtree mesh functionality was also utilised to reduce the model resolution from a 10 m cell size in upper catchment areas down to 2.5 m cell size in the deposit areas for examining the closure concepts. Sub-grid sampling was also applied in the model to improve the conveyance through creeks and diversions. Note that the model is applied catchment-wide, and deposit specific models may allow more detailed hydraulic analysis for design.

For Option 3, Deposit B was backfilled to 632 mAHD to ensure the volume of the pit represented the post-closure volume. Pit volume was important to represent the pit storage capacity for floodwater entering the pit over the spillway. For other pits, floodwaters are excluded by levees, so backfill levels were unchanged from the LoM designs (presented in Table 3-1, Section 3.1).

A summary of the key parameters adopted in the TUFLOW model are provided in Table 5-3.

Table 5-3. TUFLOW Model Summary

Item	Parameter	Comment
Terrain		
Topographic data	2 m DEM	Mosaic of LiDAR captured from 2011-2016, provided by Rio Tinto 2020.
	1 m DEM	LoM Pit and Dump designs as provided by Rio Tinto, 2020.
Grid resolution	2.5 m – 10 m	10 m in upper catchment, down to 2.5 m resolution near in areas of interest: Deposit B, Pit C3, Deposit D, and Deposit F.
Sub-grid Sampling	2 m	Terrain sampled at 2m to better represent model cell conveyance.
Model Area	341 km^2	Full rain on grid of Turee Creek East catchment and tributaries to convergence at Karijini National Park boundary. Upper reaches of Weeli Wolli Creek included at Deposit F.
Infrastructure		
Rail Formation	Excluded	Formation earthworks removed from model by triangulation of DEM.
Culverts	20m Breaklines	All culverts and waterways enforced using 20m wide breaks in any earthworks formations.
Levee designs	Breaklines	Levees set >50 m above terrain level (“glass walls”).
Rainfall		
Losses	ILCL	Design losses provided by Rio Tinto, 2020. Applied as global IL and CL values across the model domain. 1:10,000 AEP - IL = 30 mm, CL = 8 mm/hr 1:1,000 AEP - IL = 20 mm, CL = 8 mm/hr
Rainfall depths	BoM IFD, and GSDM PMP	1:10,000 AEP interpolated between 1:1000 and 1:2000 AEP depth, and the PMP, per methods in ARR2019 Book 8
ARF	Based on Area	Catchments calculated to Pit C3 diversion and Pit D1 South diversion for the 1:10,000 AEP, and to the Deposit D and F levees for the 1:1,000 AEP.
Temporal patterns	Rangelands (west) ensemble	Median temporal patterns for the design events were as provided by Rio Tinto, 2020: TP04 for the 1:10,000 AEP and 1:1,000 AEP; and TP01 for the 1% AEP. Selection of the preferred temporal pattern is dependent on the model losses (ILCL) and ARF parameters.
Pre-burst	None	None
Boundary Conditions		
Inflows	None	Full catchment RoG model
Outlet	HQ Boundary	Free-flowing to minimise boundary effects
Roughness Parameter		
Manning’s *n*	*n* = 0.04	Constant value adopted for the entire catchment area, including natural waterways and diversions (selected by Rio Tinto).

5.3.1 Model results

Hydraulic modelling results for the closure options and *do-nothing* scenario are outlined below. Note that all statements of flood characteristics shall be interpreted as being a modelled prediction, containing an unknown margin of error and uncertainty, and is in no way a statement of fact or certainty.

5.3.1.1 Do-nothing

The "*do-nothing*" scenario was included to review the performance of the existing operational surface water management structures under the closure design flood event (1:10,000 AEP). This assessment is similar to the site-wide review in *West Angelas Summary of hydrology and operational flood protection* (Rio Tinto, 2020b) with inclusion of other closure landform considerations described in Section 4.2. The peak flood depths and flow velocities for this scenario are provided in Figure 5-4 and Figure 5-5 respectively. The results show:

- Uncontrolled overtopping of operational flood levees at Pit C3, Pit D3 and Deposit F, and bypass of levees at Pit D1.
- High flow velocities along the Deposit B diversion, Pit C3 and Pit D1 operational levees, including impinging flows at the eastern end of Pit C3.

It should be noted that the existing operational infrastructure is not designed to withstand the high velocities (Figure 5-5) and erosional forces associated with the 1:10,000 AEP event. This is particularly evident adjacent to the Pit C3 levee. The results suggest the 1:10,000 AEP flow velocities would scour the levee embankments resulting in erosion and eventual failure of the operational levee and likely creek capture.

Whilst the *do-nothing* results are as anticipated, they confirm the following key risk areas across the site (Figure 5-4 and Figure 5-5):

- Deposit B diversion (Section 5.3.2.1).
- Pit C3 levee (Section 5.3.2.2).
- Pit D1 south levee (Section 5.3.2.3).
- Pit D1 north levee (Section 5.3.2.4).
- Pit D3 levee (Section 5.3.2.5).
- Deposit F diversion (Section 5.3.2.6).

Note that no significant risks of floodwater overtopping pit crests at Deposit A were identified.

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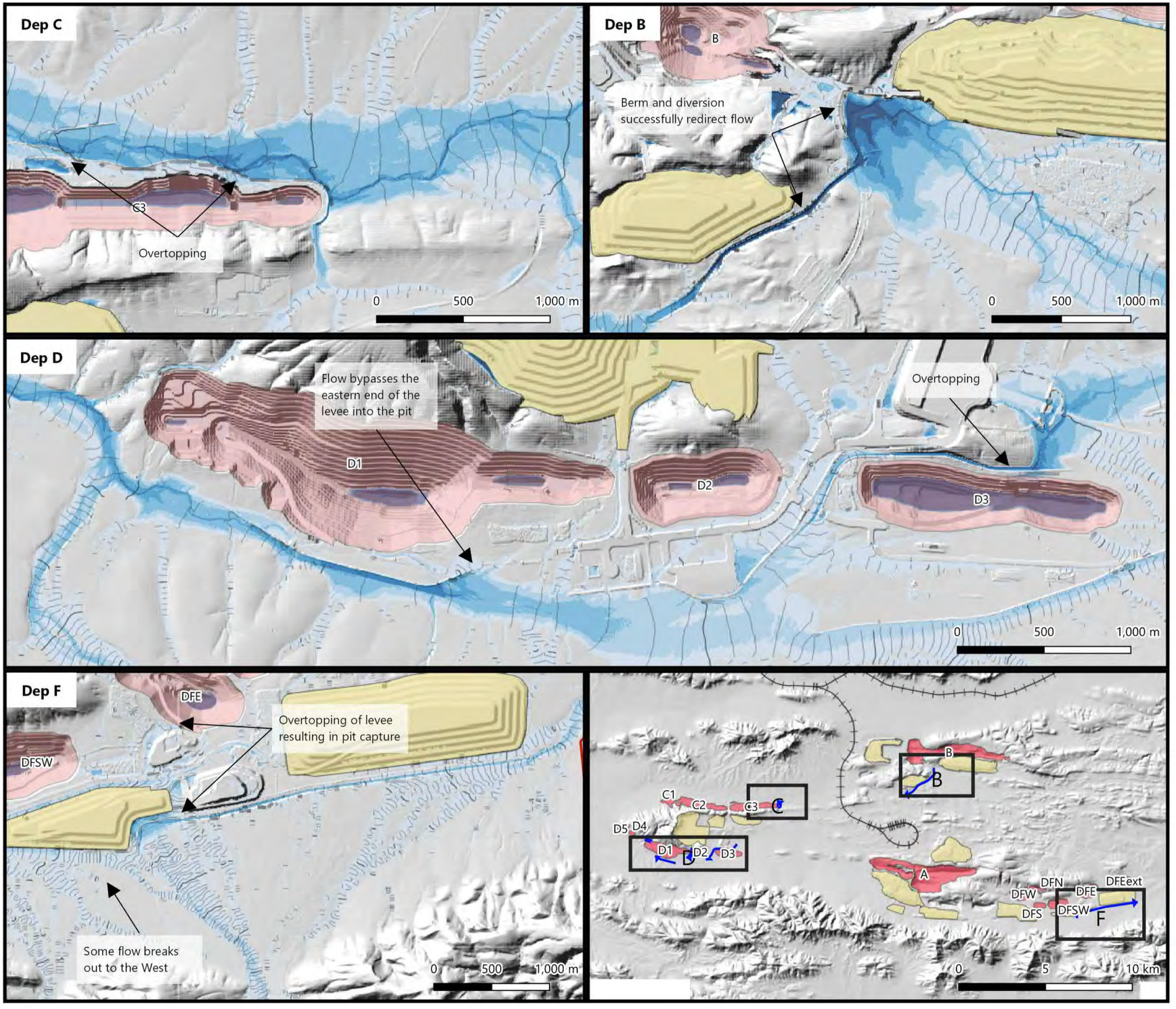
Figure 5-4: Flood Depth Results - Do-nothing 1:10,000 AEP



Legend

Water Surface Elevation Contours
- 0.5 m
- 5.0 m

Flood Depth (m)
- 0.05 - 0.50
- 0.50 - 1.00
- 1.00 - 2.00
- 2.00 - 3.00
- 3.00 - 4.00
- > 4.00

Closure Landform Extents
- Pits
- Waste Dumps

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Figure 5-5: Flood Velocity Results - Do-nothing 1:10,000 AEP

Legend

Flood Velocity (m/s)

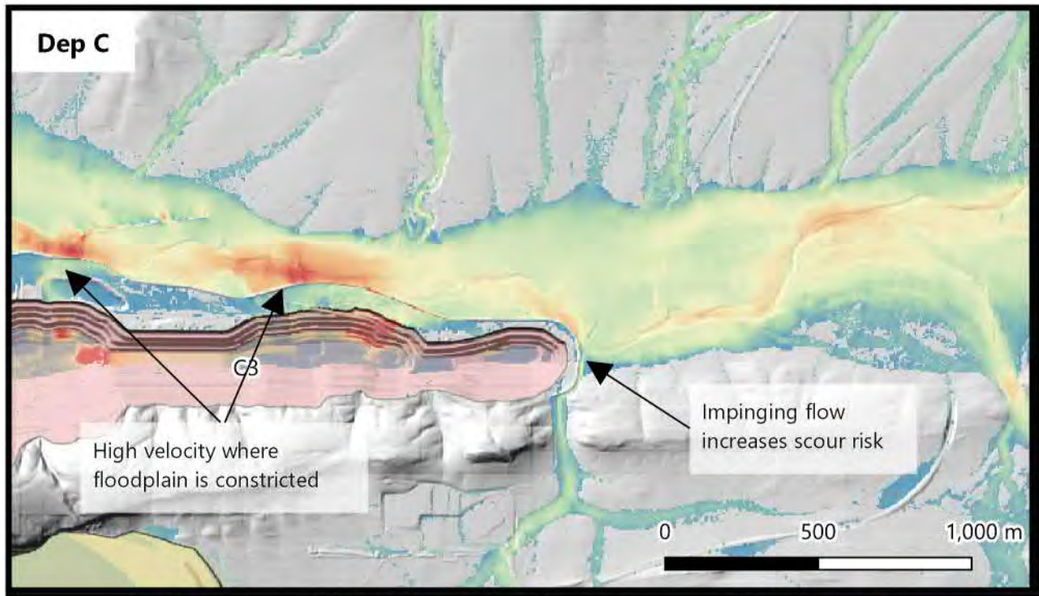
4

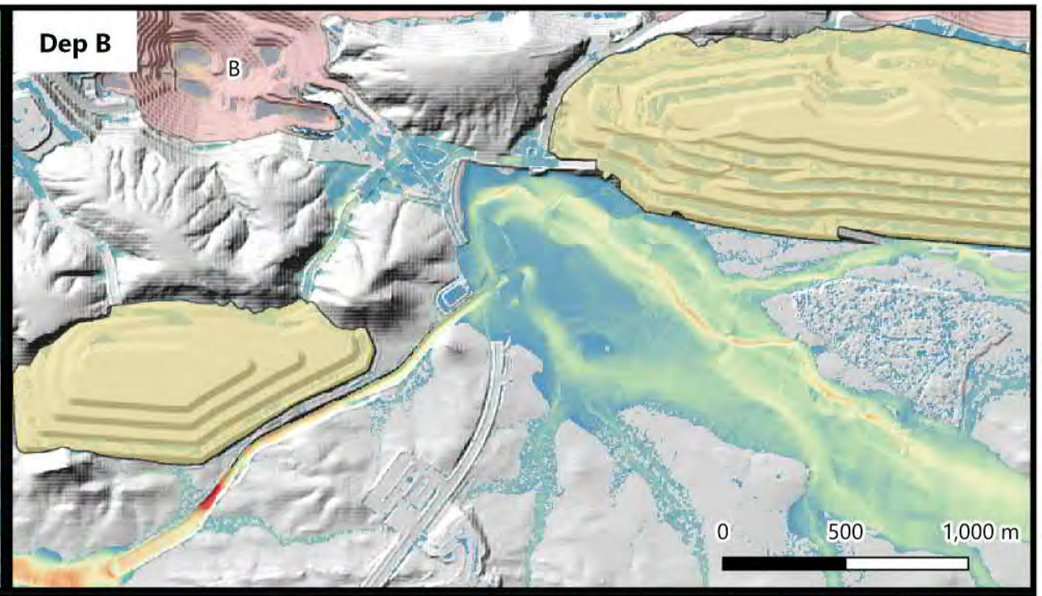
0

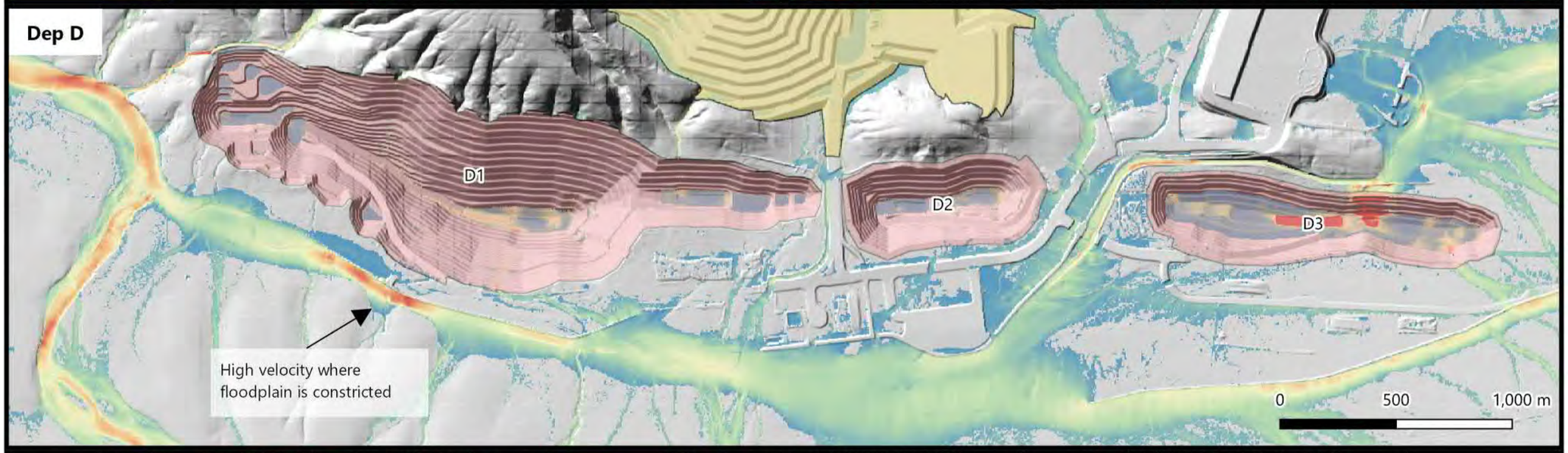
Closure Landform Extents

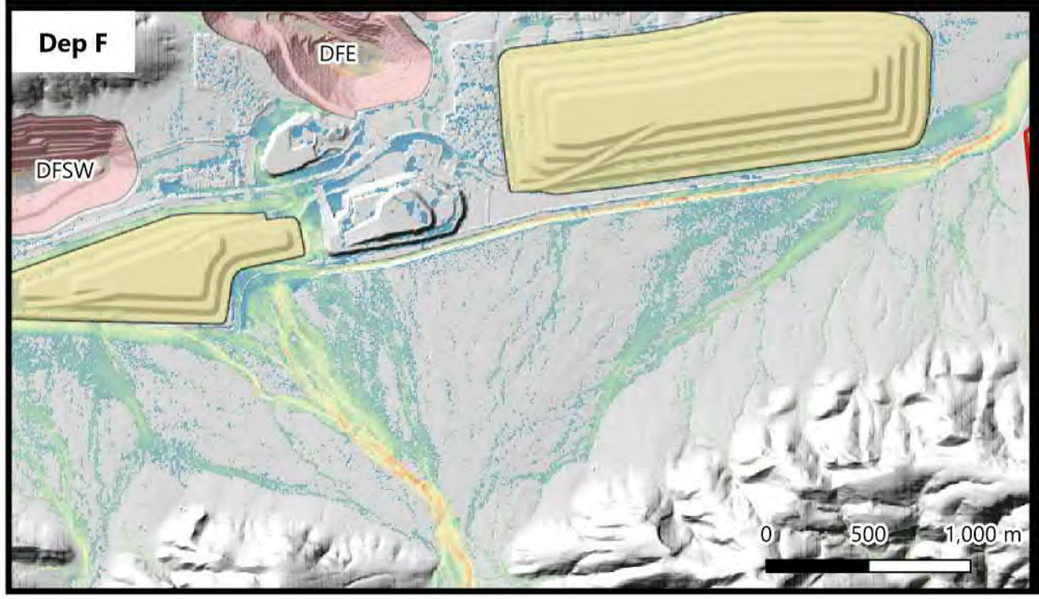
Pits

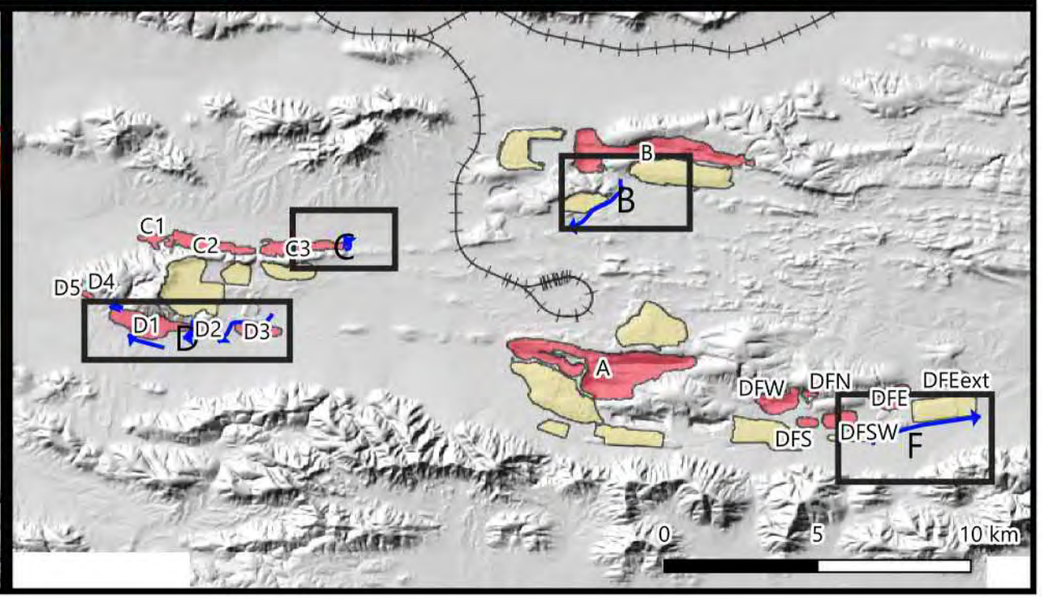
Waste Dumps











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5.3.1.2 Options 1, 2 and 3

The three selected closure options (Options 1, 2 & 3) were assessed in the TUFLOW model and site-wide mapping of the maximum flood depths and flow velocities for the design event (1:10,000 AEP) are provided in Appendix B. Maximum flood depths and flows velocities at key risk areas are provided in Table 5-4. A discussion of the modelling results at key risk areas is provided for each option in Section 5.3.1.2.

Table 5-4. Flood results at key risk areas

Key Risk Area	Max. Depth (m)			Peak Velocity (m/s)		
	Option 1	Option 2	Option 3	Option 1	Option 2	Option 3
1:10,000 AEP						
Deposit B Diversion Inlet	7.32		6.65	1.87		1.71
Deposit B Diversion Outlet	2.56		2.26	6.51		6.10
Pit C3 Levee upstream	3.57	-	3.50	0.28	-	0.27
Pit C3 Levee midpoint	2.68	-	2.62	3.84	-	3.78
Pit C3 Levee downstream	3.22	3.23	3.19	4.04	4.02	3.99
Pit D1 South upstream	4.07			1.24		
Pit D1 South midpoint	3.95			1.53		
Pit D1 South downstream	1.94			2.05		
1:1,000 AEP						
Pit D1 North upstream	0.81			2.07		
Pit D1 North midpoint	1.27			1.28		
Pit D1 North downstream	0.75			2.35		
Pit D3 Levee upstream	2.44			0.25		
Pit D3 Levee midpoint	3.44			1.48		
Pit D3 Levee downstream	2.01			2.58		
Deposit F Levee upstream	1.90			0.50		
Deposit F Levee midpoint	2.45			1.49		
Deposit F Levee downstream	1.74			2.28		

5.3.2 Key risk areas

A summary of the modelling results for each of the key risk areas is provided in this Section.

5.3.2.1 Deposit B diversion

Options 1 and 2 are essentially the same at Deposit B with both having the existing operational diversion channel in place and the downstream haul road crossing and associated culverts removed. The 1:10,000 AEP flood modelling results show floodwater from the upper Turee Creek East catchment flowing west towards Deposit B in wide meandering floodplains. At Deposit B, floodwater is directed south and concentrated by the operational diversion, resulting in high velocities through the diversion channel and >2 m backwater up to 1 km upstream at the haul road crossing. Flood depths in the diversion channel are 7.3 m at the upstream inlet and decrease steadily to 2.5 m depth at the outlet. Peak velocities range from 1.5 m/s at the inlet and 2.7 m/s at the outlet, with a localised maximum reaching 6.6 m/s where the diversion channel is narrow. Downstream of the diversion outlet, the natural channel and floodplain widens, and flood depths reduce to between 1.0 to 1.4 m. Velocities also reduce in response to the increased in floodplain width and corresponding reduction in flood depth.

Option 3 is similar to Option 1 and 2 but with the addition of a spillway, designed to direct excess floodwater into Deposit B for events greater than the 1:50 AEP event, in accordance with the BoD. The aim of this option is to decrease peak flows and water levels at Pit C3 downstream, reducing closure levee heights, peak velocities and associated levee construction material requirements. Figure 5-6 provides a comparison of 1:10,000 AEP flood hydrographs from the Option 1 and Option 3 modelling scenarios and shows the reduction in peak flow with the Option 3 spillway in place. The 1:10,000 AEP flood modelling results suggest the spillway:

- Directs 1.4 million m^3 of floodwater into Deposit B pit.
- Results in a peak flow reduction of 75 m^3/s (or approximately 21%) through the diversion.
- Reduces peak flood depths and velocities at the diversion inlet by 0.67 m and 0.16 m/s respectively (Figure 5-7 and Figure 5-8).

It is noted that the capture estimates are based on an indicative spillway location and crest width so further analysis may be required to identify a more suitable spillway geometry or location with respect to flow capture or competent material for spillway construction. However, the modelling results currently suggest that the Option 3 diversion provides limited reduction in peak flow and therefore limited benefit at Pit C3. This is discussed in more detail in Section 5.3.2.2.

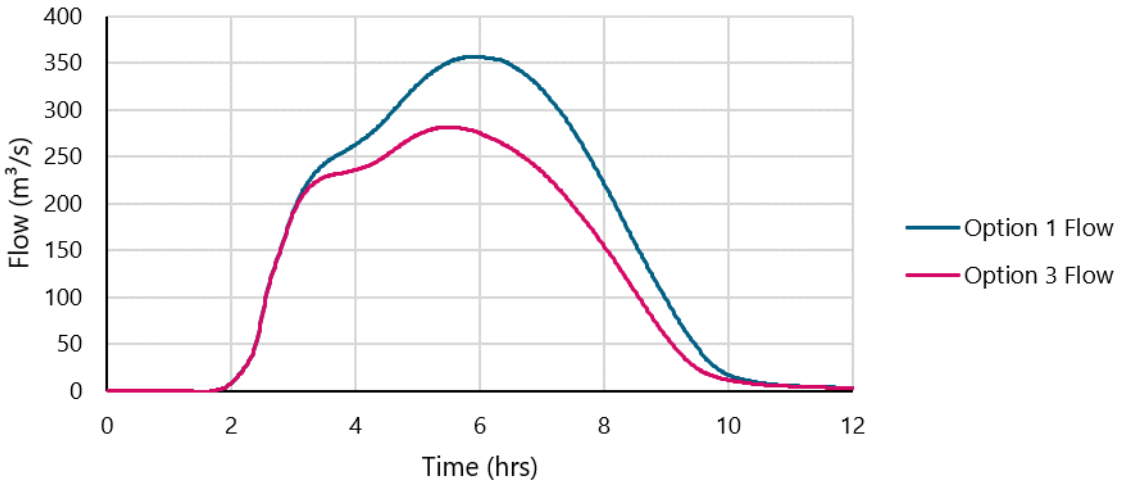


Figure 5-6 Spillway capture hydrographs at Deposit B

Option 1 & 2
1:10,000 AEP

B

5.17

7.31

2.67

Option 3
1:10,000 AEP

B

4.46

6.64

2.36

Surface Water Closure Strategy
West Angelas

Figure 5-7: Options Comparison at Deposit B (Flood Depth)

Legend

- Key Flood Depth Locations (m)

Water Surface Elevation Contours

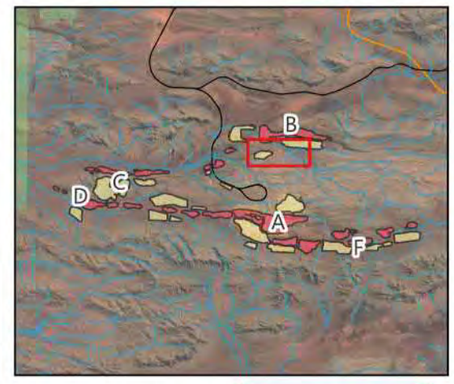
- 0.5 m
- 5.0 m

Flood Depth (m)

- 0.05 - 0.50
- 0.50 - 1.00
- 1.00 - 2.00
- 2.00 - 3.00
- 3.00 - 4.00
- > 4.00

0 0.5 1 km

Date: 04/11/2021
Projection:



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Surface Water Closure Strategy
West Angelas

Figure 5-8: Options Comparison at Deposit B (Flood Velocity)

Legend

Flood Velocity (m/s)

4

0

Option 1 & 2
1:10,000 AEP

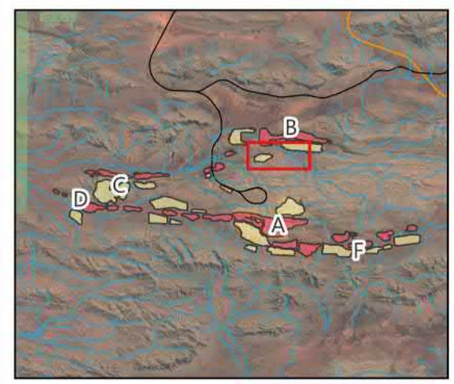
B

Option 3
1:10,000 AEP

B

0 0.5 1 km

Date: 04/11/2021
Projection:



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5.3.2.2 Pit C3 levee

For Option 1, flows from the Deposit B Diversion continue westward, joining tributaries from the north and south before flowing towards the C Deposit. Under operational conditions, the access road and rail restrict flows towards Pit C3, however both features are removed in the closure modelling. The floodplain approaching Pit C3 is approximately 400-500 m wide in the 1:10,000 AEP event, characterised by meandering bifurcations in a wide alluvial channel. Typical flood depths in the low flow channel approach 3.0-3.5 m, and velocities up to approximately 3 m/s. The Pit C3 operational levee constricts the floodplain to approximately 160 m at the narrowest point, resulting in elevated velocity and flood depth at the levee (impinging flows). The low flow channel passes directly adjacent to the levee at this location, reaching flood depths of up to 4.6 m and velocities up to 4.1 m/s. There is a high risk of scour and erosion at this location under the Option 1 scenario and suitable rock protection should be applied.

With Option 3, the spillway upstream aims to reduce the flows (and respective closure levee heights) at Pit C3. Figure 5-9 compares the 1:10,000 AEP hydrographs for Option 1 and Option 3 at Pit C3, and shows the spillway resulting in an approximate 5% reduction in peak flow, equating to a potential closure levee height reduction of <0.1 m (refer to Table 5-4). This is a negligible gain for the significant works required to investigate, design and construct the spillway. The results therefore suggest that the Option 3 spillway concept offers little value at closure.

For Option 2, the eastern half of Pit C3 is backfilled to re-instate the pre-mining surface and increase available floodplain storage. A reduction in water level and velocity is observed in the 1:10,000 AEP event for up to 300 m upstream of the pit. Maximum flood depths and velocities are reduced by up to approximately 1.2 m and 1.5 m/s, respectively, in the low flow channels near this backfilled area at Pit C3. There is negligible change in hydraulic behaviour downstream (Figure 5-10 and Figure 5-11).

For all options an additional east-west orientated diversion channel is included in the hydraulic models, located north-east of Pit C3, to reduce impinging flows at the Pit C3 closure levee. The assumed dimensions for this diversion are based on a trapezoidal channel with 20m base width and 1:3 batters. It is anticipated that this diversion will be refined through future phases of the project to incorporate features more consistent with the natural system so it can demonstrate similar hydraulic and sediment transport behaviour.

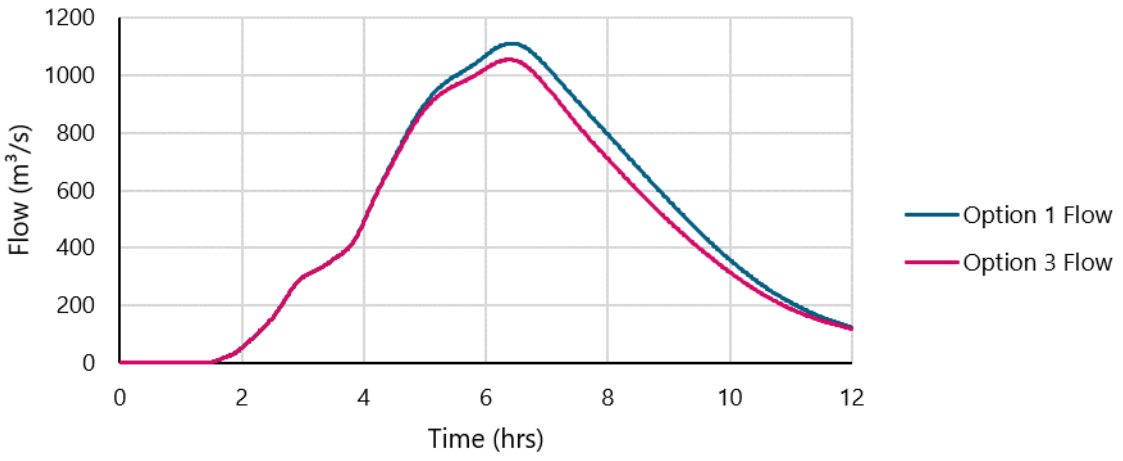
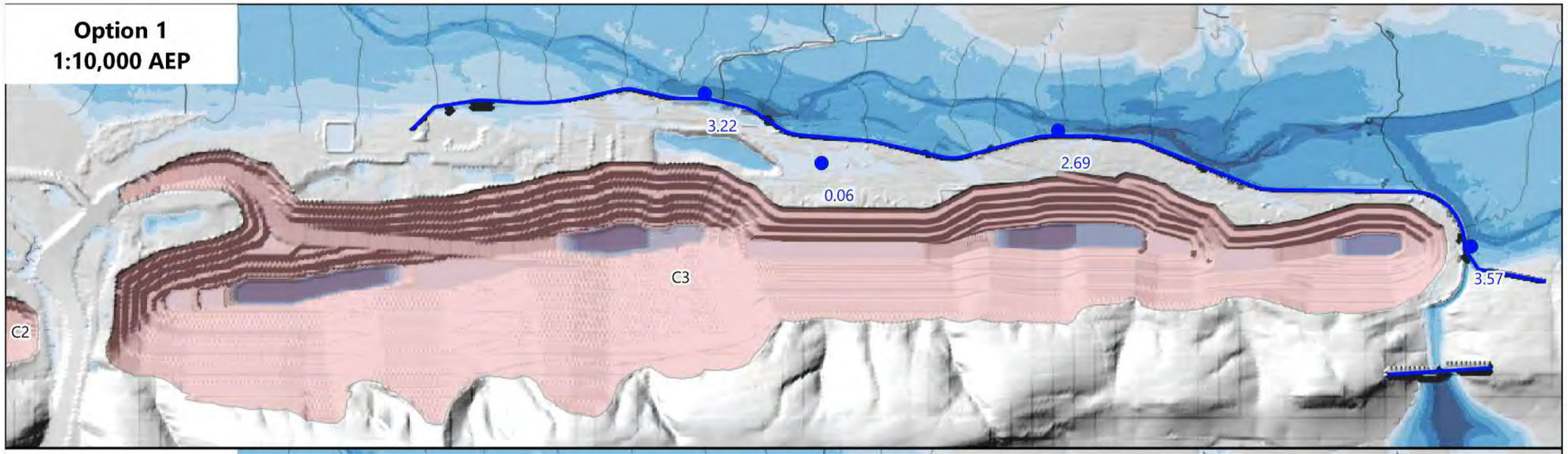
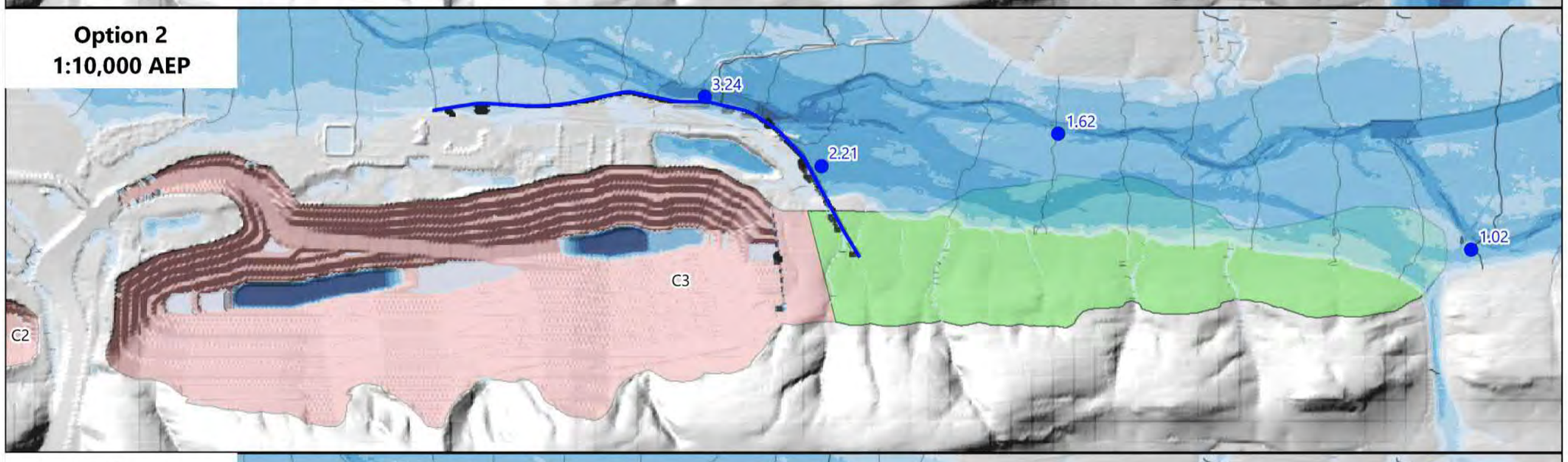


Figure 5-9 Spillway capture hydrographs at Pit C3

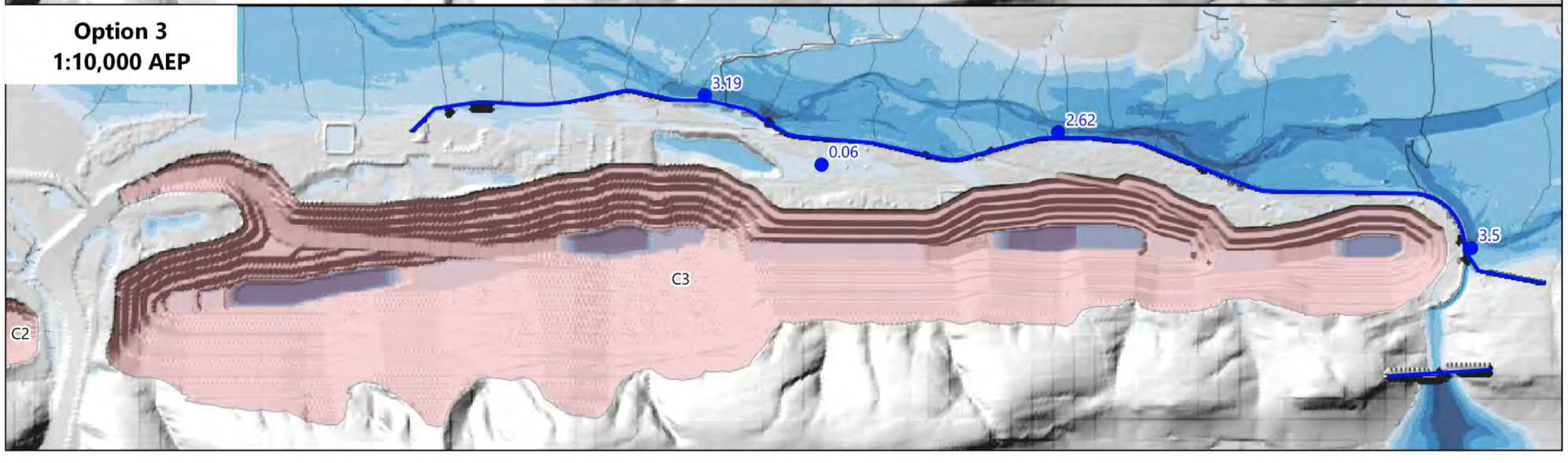
Option 1
1:10,000 AEP



Option 2
1:10,000 AEP



Option 3
1:10,000 AEP



Surface Water Closure Strategy West Angelas

Figure 5-10: Options Comparison at Pit C3 (Flood Depth)

Legend

- Key Flood Locations (m)
- Flood Levee Breaklines

LoM Pits and Dumps

- LOM Pit Outlines
- Out of Scope
- Reinstated Floodplain

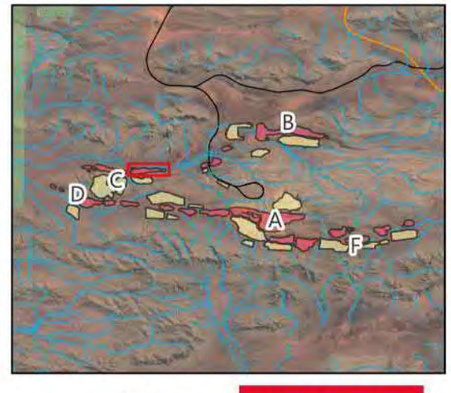
Water Surface Elevation Contours (m)

Flood Depth (m)

- <= 0.05
- 0.05 - 0.50
- 0.50 - 1.00
- 1.00 - 2.00
- 2.00 - 3.00
- 3.00 - 4.00
- > 4.00

0 0.5 1 km

Date: 08/02/2022
Projection: GDA94 / MGA zone 50



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Option 1
1:10,000 AEP

C3

C2

Option 2
1:10,000 AEP

C3

C2

Option 3
1:10,000 AEP

C3

C2

Surface Water Closure Strategy
West Angelas

Figure 5-11: Options Comparison at Pit C3 (Flood Velocity)

Legend

Flood Levee Breaklines

LoM Pit Outlines

LOM Pit Outlines

Out of Scope

Re-instated Floodplains

Flood Velocity (m/s)

0

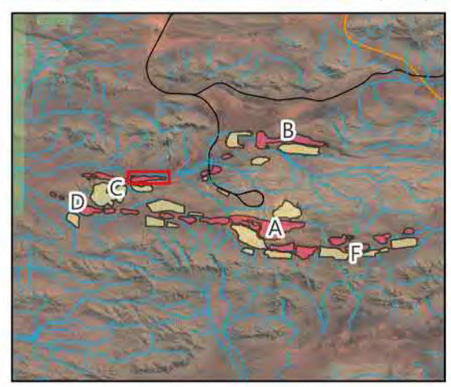
2

4

0 250 500 m

Date: 08/02/2022

Projection: GDA94 / MGA zone 50



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5.3.2.3 Pit D1 south levee

The proposed closure concepts for Deposit D are consistent for all options and include upgrading operational levees consistent with the BoD (Section 4). The operational levee and diversion are located at the transition from the sheetflow regime in the east (wide, shallow overland flows) towards more defined, braided channels.

Pit D1 was previously identified as a key risk area due to its position at the downstream end of the southern tributary of Turee Creek East, and potential constriction of the floodplain due to the waste dump WD3 footprint (Rio Tinto, 2020b). Through the refinement of closure assumptions, the waste material at WD3 is now likely to be used for backfilling of Pit D1 and no longer encroaches into and constricts the floodplain. As shown in Figure 5-12, the modelled flood levels at closure along the Pit D1 levee are lower with the WD3 waste dump removed at the downstream portion (CH1200 to CH1400). Removal of WD3 may also allow for complete removal of the haul road crossing (Figure 5-13).

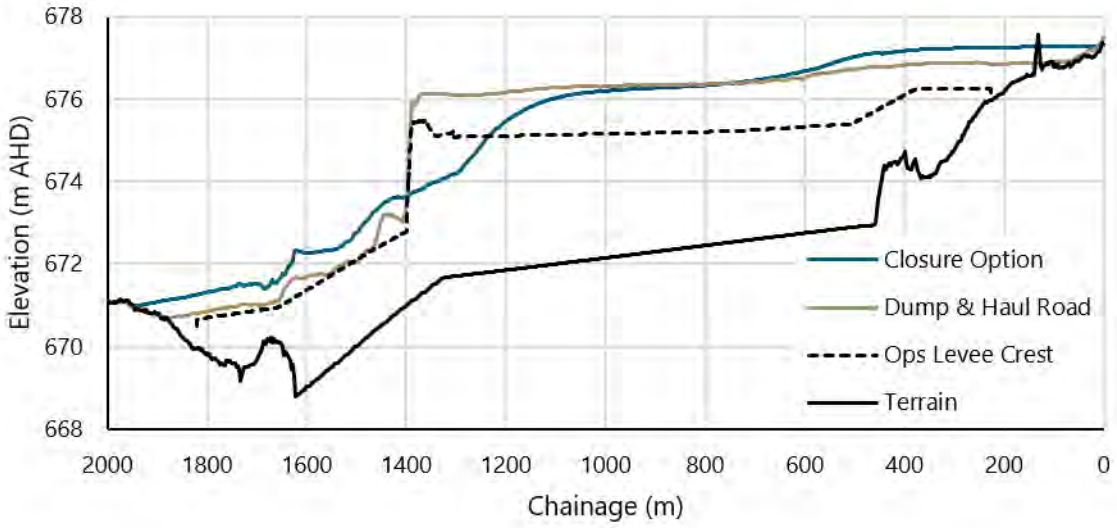


Figure 5-12 Flood levels along Pit D1 South Levee

The 1:10,000 AEP flood modelling results suggest the following:

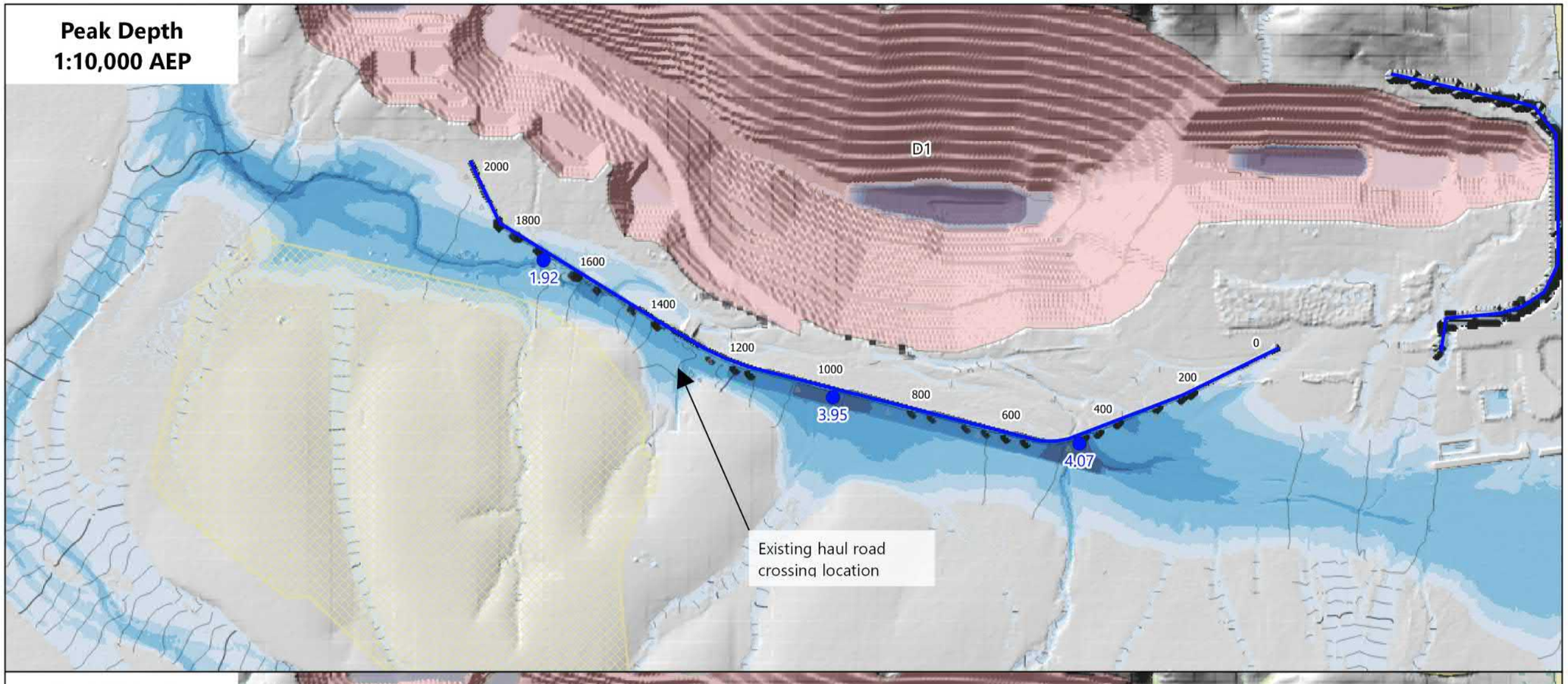
- Flooding upstream of the diversion is typically in the form of shallow overland flow up to 2.1 m deep. The diversion constricts the flow, with peak depths increasing to between 3.9 m and 4.1 m in the upper section. The lower section of the diversion and the reach downstream are characterised by intermittent pools and more defined low flow channels, showing more variable depth, averaging approximately 3.0 m, and ranging from 2.0 m to 4.0 m deep.
- Inlet velocities are typically less than 2.5 m/s and rise to over 4 m/s in the lower section of the diversion where the floodplain is constricted by the hills on the southern bank. Velocities drop to under 2 m/s at the outlet where the floodplain widens, before converging with the downstream tributary (Figure 5-13).

The catchment contributing to Deposit D is significantly impacted by the existing east-west haul road, as well as the proposed conveyor, and the A-West deposits. Further work will be required in this area as the mine plan develops.

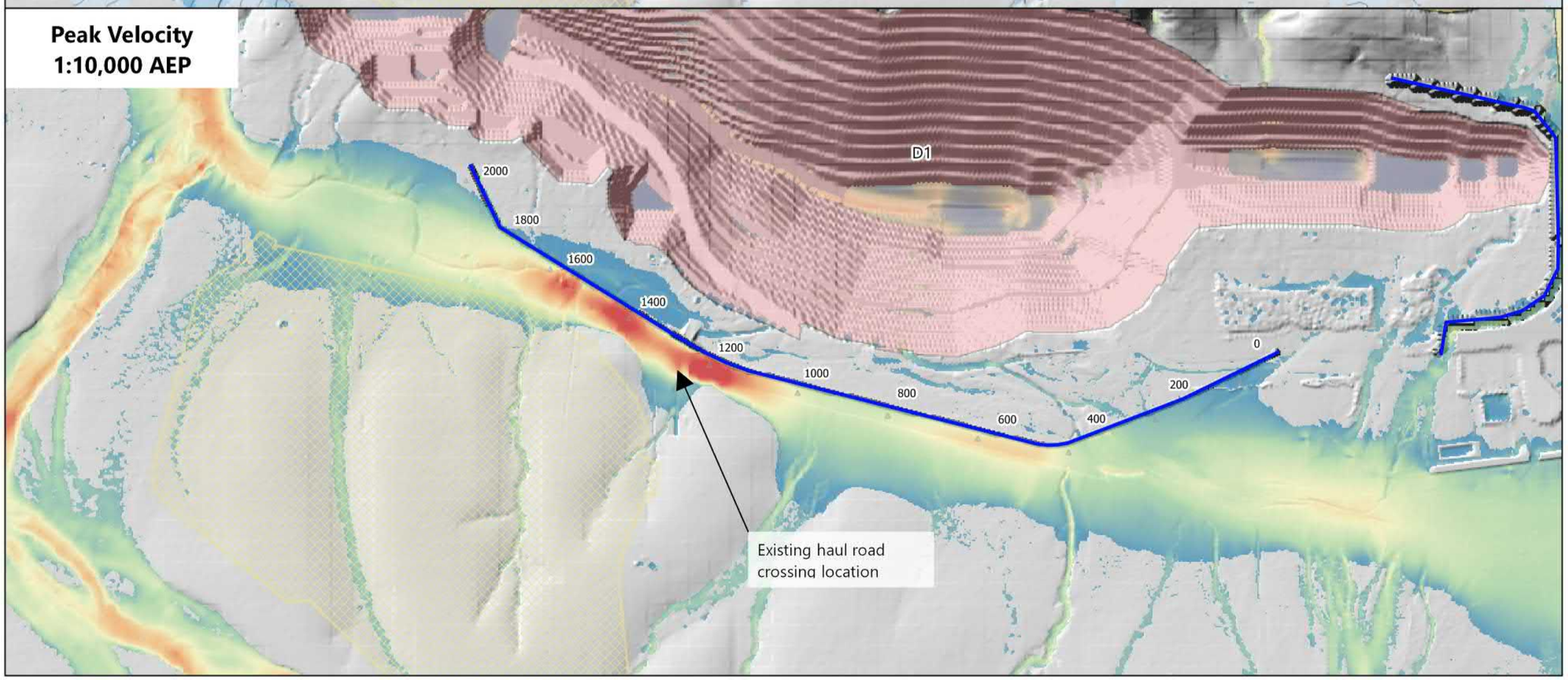
Surface Water Closure Strategy
West Angelas

Figure 5-13: Flood Depths and Velocities at Pit D1 South Levee

Peak Depth
1:10,000 AEP



Peak Velocity
1:10,000 AEP



Legend

- LOM Pit Outlines
- LOM WD (Removed at closure)
- Key Flood Depth Locations (m)
- Flood Levee Breaklines
- Chainage (m)

Flow Velocity (m/s)

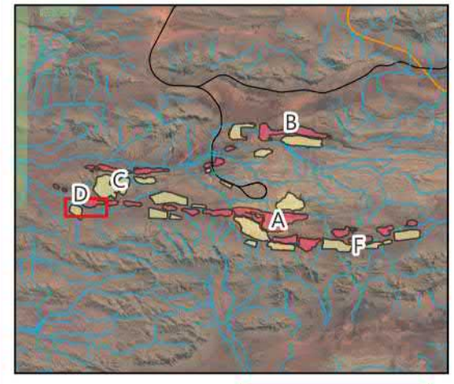
- 0.0
- 1.0
- 2.0
- 3.0
- 4.0

Flood Depth (m)

- <= 0.05
- 0.05 - 0.50
- 0.50 - 1.00
- 1.00 - 2.00
- 2.00 - 3.00
- 3.00 - 4.00
- > 4.00

0 250 500 m

Date: 02/02/2022
Projection: GDA94 / MGA zone 50



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5.3.2.4 Pit D1 north levee

The proposed closure concepts for the Pit D1 north levee are consistent for all options and include upgrading operational levees consistent with the BoD (Section 4). A small, steep and incised creek intersects the north-west corner of Pit D1 and provides flows to downstream pools that have environmental and cultural values.

An existing operational cut-off drain directs flow west around the pit and discharges back into its natural downstream alignment. The 1:1,000 AEP flood depths are typically 0.4 m to 0.6 m upstream and downstream of the diversion, increasing to between 0.8 m and 1.3 m in the upper and lower reaches of the diversion, respectively. The peak velocity exceeds 2.5 m/s at the inlet due to a flow constriction and direction change, before dropping to approximately 1.5 m/s in the flatter middle section. The peak velocity increases to near 3.5 m/s at the outlet due to a sharp increase in bed slope.

Figure 5-14 demonstrates the changes to the flood depths and flow velocities through the flatter middle section of the diversion and Figure 5-15 presents the flood mapping. The results suggest that the operational levee height does not need to increase at this location to contain the 1:10,000 AEP floodwater at closure. Note that flows to the west (towards Pit D2) are currently controlled by haul roads, and removal at closure may require construction of a small levee with appropriate rock protection.

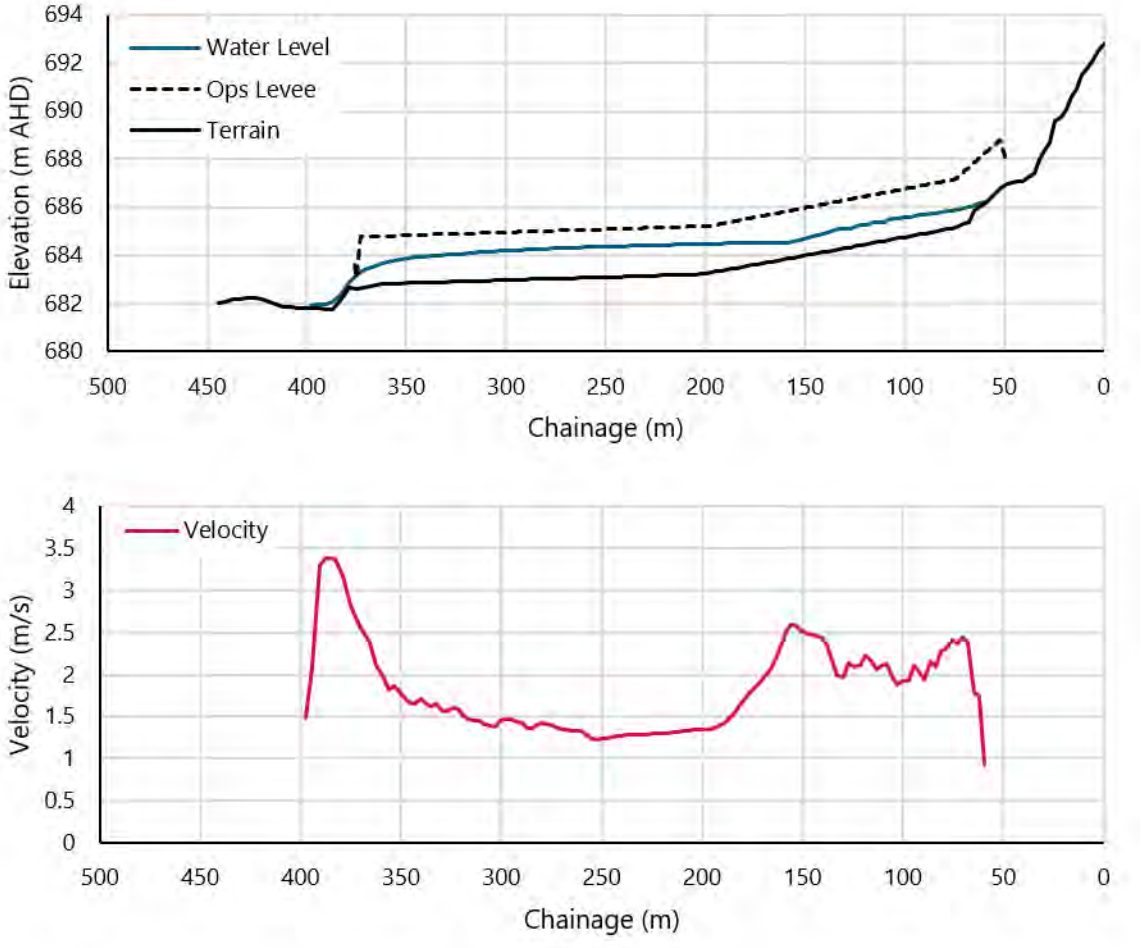


Figure 5-14 Flow depths (top) and velocities (bottom) along Pit D1 North Levee

Peak Depth
1:1,000 AEP

Peak Velocity
1:1,000 AEP

1.27
0.75
0.81
400
350
300
250
200
150
100
50
0
D1

Surface Water Closure Strategy
West Angelas

Figure 5-15: Flood Depths and Velocities at Pit D1 North Levee

Legend

- Key Flood Depth Locations (m)
- Flood Levee Breaklines
- Chainage (m)
- LOM Pit Outlines

Flood Depth (m)

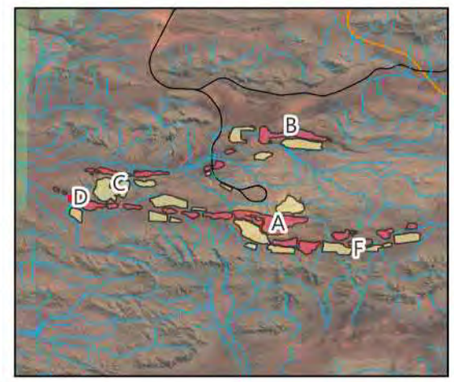
- <= 0.05
- 0.05 - 0.50
- 0.50 - 1.00
- 1.00 - 2.00
- 2.00 - 3.00
- 3.00 - 4.00
- > 4.00

Flow Velocity (m/s)

- 0.0
- 1.0
- 2.0
- 3.0
- 4.0

0 50 100 m

Date: 02/02/2022
Projection: GDA94 / MGA zone 50



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5.3.2.5 Pit D3 levee

The proposed closure concepts for the Pit D3 levee are consistent for all options and include upgrading operational levees consistent with the BoD (Section 4). Sheetflow runoff drains west towards Pit D3 where an existing operational diversion drain conveys flow along the northern edge of the pit and discharges southward towards the D1 diversion. The drain is constricted by haul and access roads on the northern side, concentrating the incoming sheetflow into a trapezoidal diversion channel.

The 1:1,000 AEP flood depth at the inlet of this diversion is approximately 3.5 m, reducing to between 1.7 m and 2.3 m near the outlet. Accordingly, velocities increase from 1.6 m/s at the inlet up to 3.2 m/s near the outlet (Figure 5-16 and Figure 5-17). The modelling results suggest a levee height increase is required along the upstream section for closure and existing operational levee rock protection should be reviewed (and upgraded as required) to protect from scour and erosion.

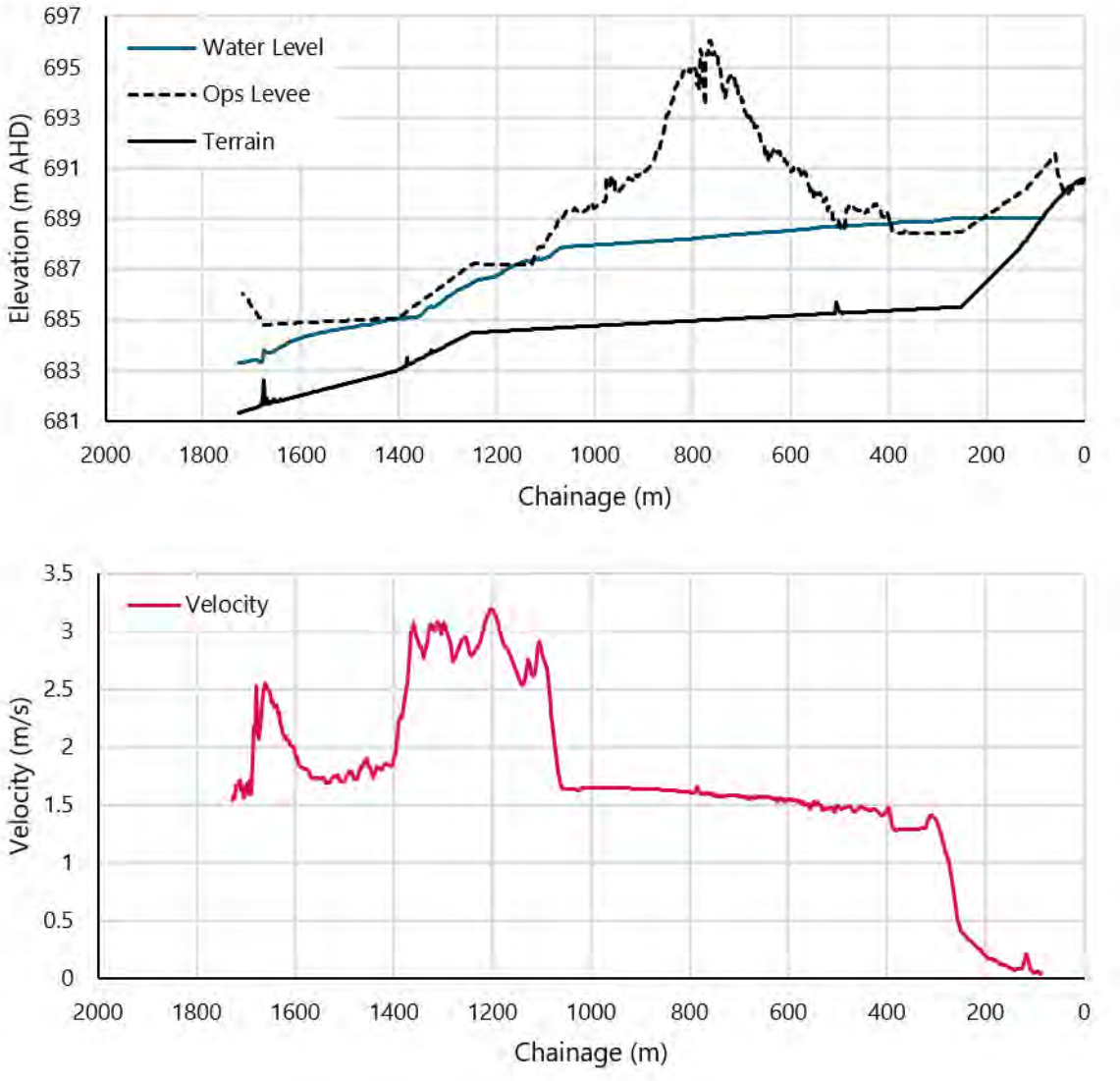
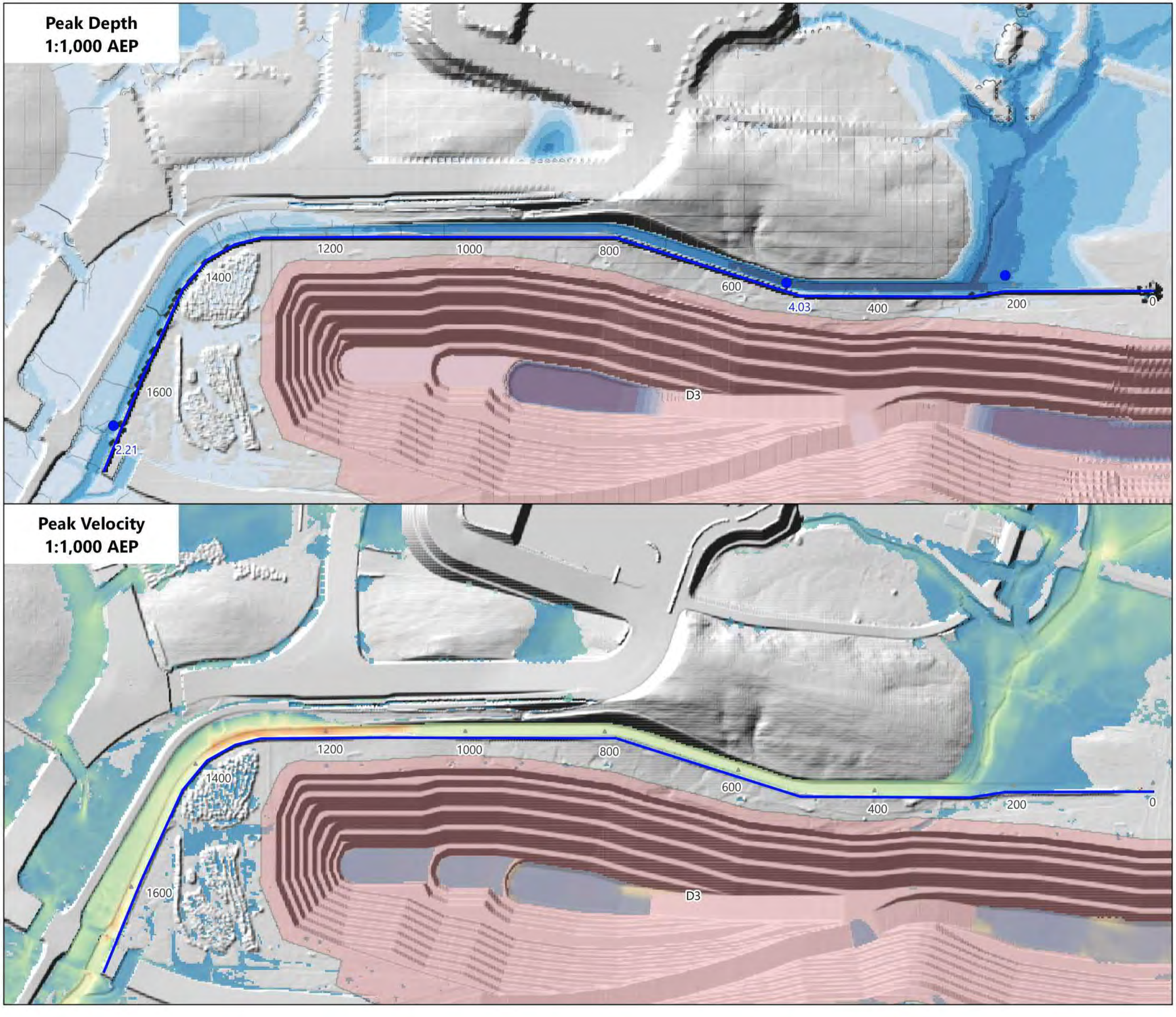


Figure 5-16 Flow depths (top) and velocities (bottom) along Pit D3 Levee

Surface Water Closure Strategy
West Angelas

Figure 5-17: Flood Depths and Velocities at Pit D3 Levee



Legend

- Key Flood Depth Location (m)
- Flood Levee Breaklines
- Chainage (m)
- LOM Pit Outlines

Flood Depth (m)

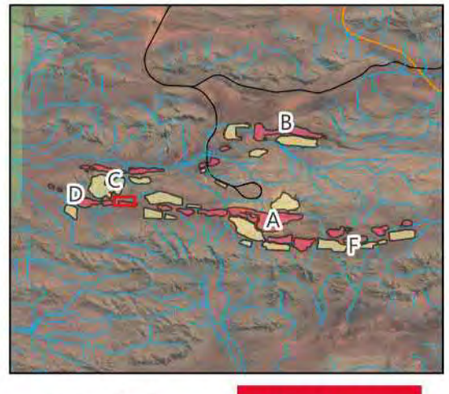
- <= 0.05
- 0.05 - 0.50
- 0.50 - 1.00
- 1.00 - 2.00
- 2.00 - 3.00
- 3.00 - 4.00
- > 4.00

Flow Velocity (m/s)

- 0.0
- 1.0
- 2.0
- 3.0
- 4.0

0 100 200 m

Date: 04/02/2022
Projection: GDA94 / MGA zone 50



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5.3.2.6 Deposit F diversion

Deposit F sits across the Turee Creek – Weeli Wolli catchment divide. Discharge from the ranges flows south then diverges over an alluvial fan into both Weeli Wolli Creek and the Turee Creek East tributary. The operational cut-off drain along the southern edge of the Deposit F landforms intersects the majority of this flow, directing it east into Weeli Wolli Creek. The operational diversion inlet diverts water at a right angle from the north into a flat straight reach.

The closure concept for the Deposit F diversion is consistent across all three options, with an upgrade of the operational levee to manage the 1:1,000 AEP design event. In the closure scenario, 1:10,000 AEP flows are between 2.0 m and 2.6 m deep in the diversion drain, with velocities typically between 1.5 and 2.4 m/s. Further east, the longitudinal slope of the diversion drain increases, with the average flood depth reducing to 1.5 m, and velocities increasing to between 2.0 and 3.4 m/s (presented in Figure 5-18 and Figure 5-19).

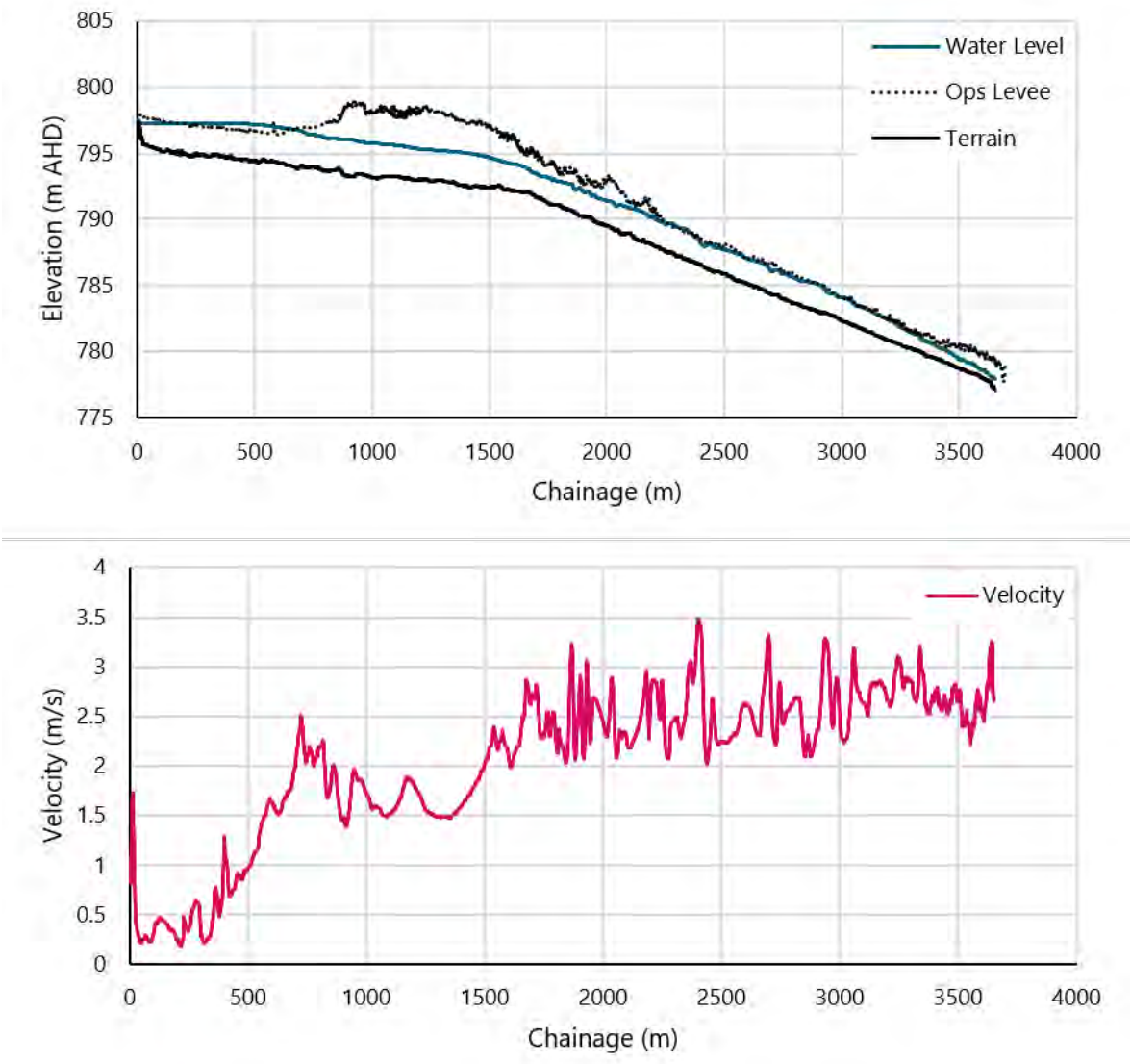
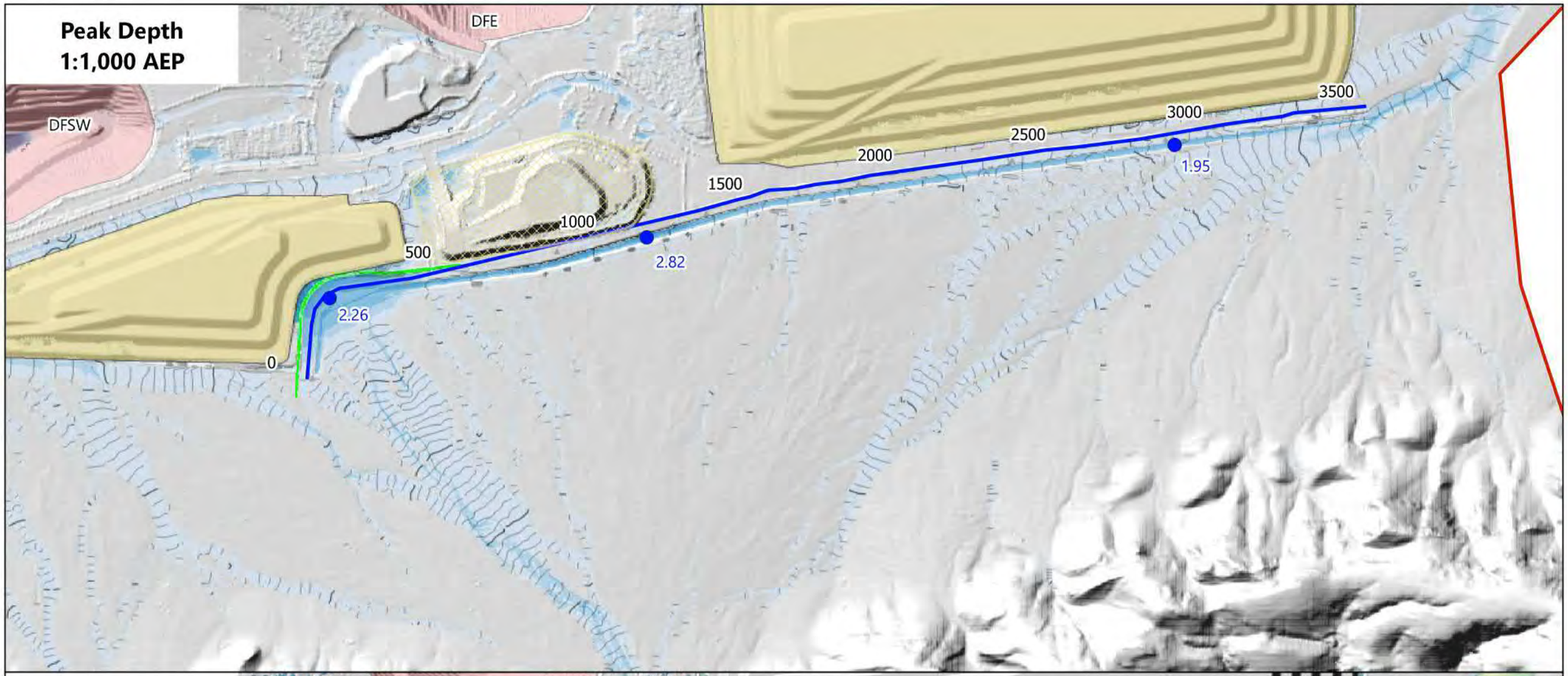
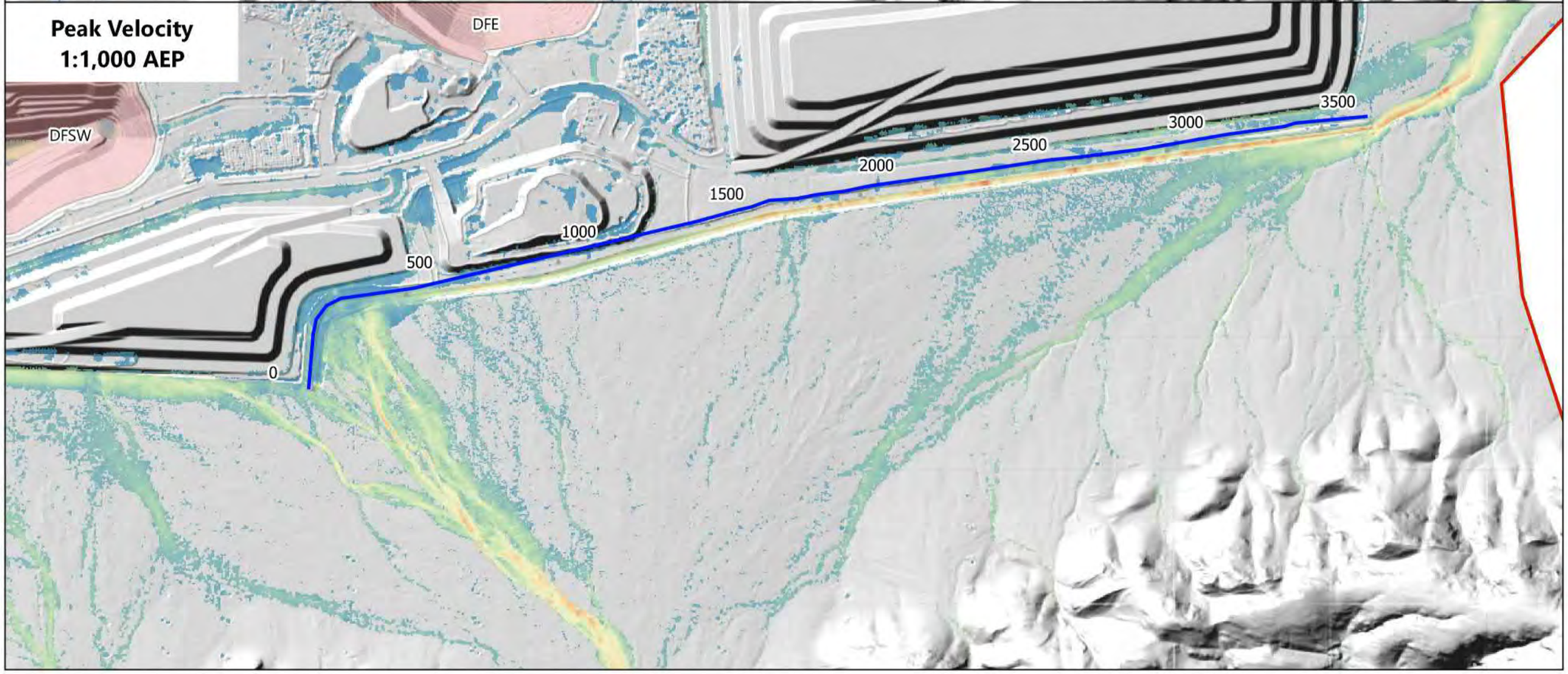


Figure 5-18 Flow velocities along Deposit F Levee

Surface Water Closure Strategy
West Angelas

Figure 5-19: Flood Depths and Velocities at F Diversion





Legend

- Key Flood Depth Locations (m)
- Chainage (m)
- Flood Levee Breaklines
- LOM Pit Outlines

Flood Depth (m)

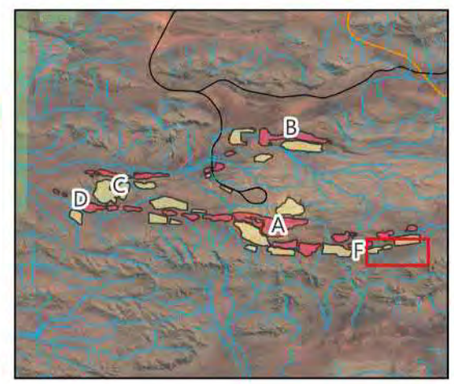
- <= 0.05
- 0.05 - 0.50
- 0.50 - 1.00
- 1.00 - 2.00
- 2.00 - 3.00
- 3.00 - 4.00
- > 4.00

Flow Velocity (m/s)

- 0.0
- 1.0
- 2.0
- 3.0
- 4.0

0 0.5 1 km

Date: 03/02/2022
Projection: GDA94 / MGA zone 50



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5.3.3 Summary of results

The 1:10,000 AEP mine closure modelling results for the three options were considered, suggest the following:

- ***Options 1 (operational levee upgrades)*** *and* ***Option 2 (floodplain reinstatement at Pit C3):*** both provide feasible hydraulic solutions at Deposit C.
- ***Option 3 (Spillway at Deposit B):*** offers limited benefits with regards to the engineering and construction efforts required to implement it.
- ***All Options:***
  - Closure landform assumptions, particularly removal of waste dump WD3 at Deposit D, increases floodplain capacity to contain the 1:10,000 AEP design event compared with previous assessments.
  - An additional diversion at Pit C3 was modelled to assist in reducing the flow velocities and flood depths at the Pit C3 closure levee (the highest risk area across the site). Optimisation of this diversion should occur in future stages.
  - Smaller levees at Pit D1 and Pit D3 and operational levees are sufficient for the 1:1,000 AEP flood depths (apart from minor raises at Pit D3). Both may require an upgrade to rock protection.

The flood modelling results are incorporated into the Options Selection Workshop described in Section 5.5. The option selection methodology considered the hydraulic modelling results above as well as the results from geotechnical assessments in Section 5.4. The construction and upgrade of closure levees will require rock protection sized to prevent scour and erosion in the design AEP event for closure in accordance with the BoD. This assessment was completed for the preferred conceptual closure design in Section 6.

5.4 Geotechnical assessments

A geotechnical assessment was undertaken for pits adjacent to major watercourses, to accomplish the following two key objectives needed to meet the design criteria in the basis of design:

- To identify where pit wall buttressing may be required, and
- To confirm the suitability of the levees and diversion designs with respect to pit wall stability.

Geotechnical stability modelling of pit walls was undertaken at selected locations using available geological data, based on the following criteria:

- Locations where the pits walls are in the close proximity to major creeks, and/or
- Locations that have an unfavourable geological structure in combination with a relatively deep final surface level.

The results of this selective modelling have been applied to all sections of mine pits with similar structures. This is a simplification of the real-world conditions, with additional geotechnical stability modelling recommended to occur in future design stages. At least one 2-dimensional analysis has been undertaken for Deposit B, Deposit C and Deposit D. The geotechnical stability of the flood levees that will form part of the permanent closure infrastructure has also been assessed. The results of the geotechnical assessment are provided in the following sections and are considered indicative only.

5.4.1 Mine pit cross-sectional geometry and analysis methodology

Geological cross-sections, detailing the internal geological unit distribution, were developed by Advisian using the geological DEMs provided by Rio Tinto. The geological DEMs were imported into the geological modelling software LeapFrog, with cross-sectional information then extracted from the LeapFrog model and imported to Slope/W, a geotechnical slope stability modelling package. A layout plan showing the location of cross-sections extracted from the LeapFrog model with respect to the layout of mine pits is provided on Figure 5-20.

The pre-mining groundwater table for each mine pit was provided or estimated by Rio Tinto. The pre-mining groundwater tables for each pit were used in the geotechnical stability models as the stable, post-closure groundwater level. Mine pits were modelled as backfilled to at least the level of the pre-mining groundwater table, using undifferentiated mine waste.

Where calculations indicated an unacceptably low factor of safety under a modelled scenario (FoS <1.5 under static conditions or <1.2 under seismic conditions), the pit backfill level was increased until design criteria were met. Any additional backfill material above the pre-mining groundwater table is considered a buttress and need not be placed across the entirety of the pit. There was no differentiation in the stability model for the geotechnical properties of backfill and buttress materials. This is a simplification and should be improved upon in future studies.

5.4.2 Flood levee cross-sectional geometry and analysis methodology

Flood protection levees that form part of the closure design and are in proximity to mine pit shells were assessed for geotechnical stability. The levees that were assessed are proposed to be constructed adjacent to Pit C3, Pit D1, Pit D3 and Pit F. Levees were assumed to have the following cross-sectional properties:

- Homogenous material composition (rock protection neglected for conservatism).
- Batter slopes of 2.5(H):1(V).
- Crest width of 5 m set at a minimum of 0.3 m above the greatest flood depth. Note that the height above the greatest flood depth is arbitrary (to prevent computational errors) and not reflective of a freeboard design.
- No cut-off into natural soils, and flat (horizontal) ground surface other than levee.
- Initial groundwater table at 3 m below ground surface.

5.4.3 Geotechnical parameters

Multiple design reports for mine pit shells at Deposits B, C and E were part of the data supplied by Rio Tinto (refer Section 2 for details). These reports, particularly those for Deposits B and C, were reviewed and data related to geotechnical strengths of units extracted for use in the pit wall geotechnical stability assessment. Properties for Deposit D could not be ascertained from the supplied information. Therefore, geological units identified on Deposit D cross sections were assigned the same geotechnical properties as Deposit C.

Table 5-5 to Table 5-8 contains the geotechnical strength information obtained from the mine pit shell design reports. Geotechnical properties for mine waste were estimated from Advisian experience with similar materials in Pilbara iron ore mines. Geotechnical properties for the flood levee analyses were estimated using limited available data on waste materials, which are summarised in Table 5-9.

Surface Water Closure Strategy
West Angelas

Figure 5-20: Geotechnical Cross-Section Locations

Legend

Mine Layout

- Geotechnical Cross-Sections
- Railway Centreline
- LoM Pit Extents
- LoM Waste Dump Extents

C XS4
C XS3
C XS2
C XS1
C1
C2
C3
D5
D4
D1
D2
D3
D XS1
D XS2
B
B XS1
A
DFW
DFN
DFE
DFEext
DFS
DFSW

0 2.5 5 km

Date: 09/11/2021
Projection: GDA94 / MGA zone 50

Advisian
RioTinto

Table 5-5 Geotechnical properties for Detritals

Strand	Lithology	Description	Unit weight (kN/m³)		Dep B Generalised Hoek-Brown Parameters			Dep C Generalised Hoek-Brown Parameters			Dep B Mohr-Coulomb Parameters		Dep C Mohr-Coulomb parameters	
			Dep B	Dep C	σ_{ci} (MPa)	GSI	m_i	σ_{ci} (MPa)	GSI	m_i	Φ (deg.)	c (kPa)	Φ (deg.)	c (kPa)
ALL	ALL, COL, SIT, SND, SOL	Undifferentiated, combined detritals	-	22.6	-	-	-	-	-	-	-	-	-	-
COL	ALL, COL, SIT, SND, SOL	Colluvial detritals	-	22.6	-	-	-	-	-	-	-	-	34	60
UDET		Uncemented detritals	-	22.6	-	-	-	-	-	-	-	-	38	175
CDET		Cemented detritals	-	25.5	-	-	-	-	-	-	-	-	33	75
LDET		Limonitic detritals	-	25.5	-	-	-	-	-	-	-	-	46	98
PDET	PIS	Pisolitic detritals	-	30.4	-	-	-	-	-	-	-	-	35	35
CAL	CAL	Calcrete	-	19.6	-	-	-	-	-	-	-	-	25	80
CLA	CLA	Clay	19.2	23.5	-	-	-	38	49	9	10	28	37	170
HYD-DET	n/a	Hydrated ore detritals	25.5	27.5	56.0	45	15	-	-	-	-	-	-	-
CAN	n/a	Canga	19.2	-	12.0	43	15	-	-	-	-	-	-	-
DI	n/a	*Unknown*	19.2	-	-	-	-	-	-	-	34	36	-	-

Table 5-6 Geotechnical properties for Wittenoom Formation and intrusives

Strand	Lithology	Description	Weathering	Unit weight (kN/m³)		Dep B Generalised Hoek-Brown Parameters			Dep C Generalised Hoek-Brown Parameters			Dep B Mohr-Coulomb Parameters		Dep C Mohr-Coulomb parameters	
				Dep B	Dep C	σ_{ci} (MPa)	GSI	m_i	σ_{ci} (MPa)	GSI	m_i	Φ (deg.)	c (kPa)	Φ (deg.)	c (kPa)
	BIF	Banded iron formation	Undifferentiated	26.2	-	37.5	39	15	-	-	-	-	-	-	-
	SHL	Shale	Weathered	-	19.6	-	-	-	-	-	-	-	-	28	90
	SHL	Shale	Undifferentiated	17.5	-	3.0	35	7	-	-	-	-	-	-	-
	MIN	Mineralised bedrock ore	Weathered	34.0	27.5	15.0	38	15	-	-	-	-	-	32	35
HYD		Hydrated bedrock ore	Weathered	-	31.4	38.5	15	44	38	5342	9	-	-	51	129
DOL	DOR	Intrusive dolerite	Undifferentiated	-	-	-	-	-	7.5	37.8	11	-	-	-	-
	DOR	Intrusive dolerite	Weathered	-	20.6	-	-	-	-	-	-	-	-	26	40
	DOR	Intrusive dolerite	Fresh	-	27.5	-	-	-	-	-	-	-	-	-	-

Table 5-7 Geotechnical properties for Marra Mamba Formation

Strand	Lithology	Description	Weathering	Unit weight (kN/m³)		Dep B Generalised Hoek-Brown Parameters			Dep C Generalised Hoek-Brown Parameters			Dep B Mohr-Coulomb Parameters		Dep C Mohr-Coulomb parameters	
				Dep B	Dep C	σ_{ci} (MPa)	GSI	m_i	σ_{ci} (MPa)	GSI	m_i	Φ (deg.)	c (kPa)	Φ (deg.)	c (kPa)
NEW	BIF	Banded Iron Formation	Weathered	-	-	70	20	15	55.9	45.2	15	-	-	-	-
	BIF	Banded Iron Formation	Fresh	-	-	70	20	175	75	64	35	-	-	-	-
	NS1, NS2, NS3	Shale	Weathered	29.0	-	-	-	-	-	-	-	30	10	-	-
	SHL	Shale	Weathered	29	-	-	-	-	-	-	-	30	10	-	-
	SHL&BIF	Undifferentiated, shale and/or BIF	Weathered	-	29.4	-	-	-	38	42	14	-	-	-	-
	SHL&BIF	Undifferentiated, shale and/or BIF	Fresh	-	29.4	-	-	-	38	42	18	-	-	-	-
	MIN	Mineralised bedrock ore	Weathered	34.0	31.4	25.0	38	15	15	35	12	-	-	-	-
	HYD	Hydration overprint of BIF or SHL	Weathered	-	31.4	-	-	-	38	42	9	-	-	-	-
	NE2	Newman 2 Strand BIF	Weathered	28.2	-	25.0	37	15	-	-	-	-	-	-	-
	NE2	Newman 2 Strand BIF	Fresh	31.2	-	n/a	n/a	n/a	-	-	-	-	-	-	-
	NE1	Newman 1 Strand BIF	Weathered	28.2	-	20.0	35	15	-	-	-	-	-	-	-
	NE1	Newman 1 Strand BIF	Fresh	31.2	-	75.0	44	15	-	-	-	-	-	-	-
MAC	BIF	Banded Iron Formation	Weathered	30.0	29	50.0	42	15	43.6	43.6	12.0	-	-	-	-
	BIF	Banded Iron Formation	Fresh	32.0	29	162.0	60	15	59.8	59.8	15.0	-	-	-	-
	SHL	Shale	Weathered	29.0	29	82.5	20	38	35.8	35.8	8.0	-	-	-	-
	SHL&BIF	Undifferentiated, shale and/or BIF	Weathered	-	24.5	-	-	-	49.0	35	12.0	-	-	-	-
	SHL&BIF	Undifferentiated, shale and/or BIF	Fresh	-	30.4	-	-	-	63.0	35	18.0	-	-	-	-
	MIN	Mineralised bedrock ore	Weathered	34.0	31.4	15.0	41	15	40.0	350	12.0	-	-	-	-
NAM	BIF	Banded Iron Formation	Weathered	30.0	29	64	45	15	50.8	46.0	15.0	-	-	-	-
	BIF	Banded Iron Formation	Fresh	32.0	31	140	68	15	169.5	71.2	15.0	-	-	-	-
	SHL&BIF	Undifferentiated, shale and/or BIF	Weathered	-	29.4	-	-	-	38	46	15.0	-	-	-	-
	SHL&BIF	Undifferentiated, shale and/or BIF	Fresh	-	29.4	-	-	-	175.0	82	18.0	-	-	-	-

Table 5-8 Geotechnical properties for fault zones and pit backfill material

Strand	Lithology	Description	Weathering	Unit weight (kN/m^3)		Dep B Generalised Hoek-Brown Parameters			Dep C Generalised Hoek-Brown Parameters			Dep B Mohr-Coulomb Parameters		Dep C Mohr-Coulomb parameters	
				Dep B	Dep C	σ_{ci} (MPa)	GSI	m_i	σ_{ci} (MPa)	GSI	m_i	Φ (deg.)	c (kPa)	Φ (deg.)	c (kPa)
FLT	FLT	Fault zone	n/a	-	30	-	-	-	-	-	-	-	-	38	175
FILL	BFL	Undifferentiated pit backfill	n/a	22	22	-	-	-	-	-	-	44	0	44	0

Table 5-9 Geotechnical properties for flood levee materials

Material	Unit weight (kN/m^3)	Φ (deg.)	c (kPa)	K_{sat} (m/s).)	D_{10} (mm)	D_{60} (mm)	Liquid Limit (%)	Anisotropy
Hydraulic barrier fill (sandy clay)	21	27	0	38	0.1	6	50	1.0
In-situ materials (clayey sandy gravel)	22	44	0	44	0.6	2	50	1.0

5.4.4 Seismic events

The Rio Tinto standard *D3 – Management of Slope Geotechnical Hazards* (Rio Tinto, 2019) does not provide guidance on the selection of Annual Exceedance Probabilities (AEP) for seismic events acting on slopes. Following discussions with Rio Tinto stakeholders and review of risk assessment documentation, a 1:500 AEP has been selected for seismic events acting on the closure pit slopes. This selection is reflected in the basis of design and design criteria (Section 4).

The 1:500 AEP seismic event results in a peak ground acceleration (PGA) of 0.08g according to the National Seismic Hazard Assessment public database (Geoscience Australia, 2021). In accordance with published literature and typical engineering practice in Western Australia, a pseudo-static analysis was performed alongside the static analysis, to model the slope behaviour under earthquake conditions. The pseudo-static analysis adopted a horizontal seismic load equal to 50% of the PGA, as recommended by Hynes-Griffin and Franklin (1984) in their paper *Rationalising the Seismic Coefficient Method*.

Seismic events and the associated pseudo-static analyses were not considered for the closure levees. Similarly, geohazards that can be triggered by seismic events, such as liquefaction, have not been considered for this assessment. Data provided for the project is insufficient to adequately understand and assess these types of geohazards, which should be considered in future works.

5.4.5 Pit wall and buttressing assessment

Table 5-10 contains the key results following geotechnical assessment of the pit walls at Deposit B, Deposit C and Deposit D under the closure conditions described in this report. The geotechnical assessment outputs are provided in Appendix C and described below.

In all cases, the static and pseudo-static analyses were undertaken with the pit geometry 'as-is' and with the pre-mining groundwater table present. This initial assessment allows us to understand the degree of instability that may result from the slope over the closure period. The slopes with a factor of safety below the design acceptance criteria (1.5 for static cases and 1.2 for pseudo-static cases) are highlighted with red text in Table 5-10.

After the 'as-is' assessment, the pit slope was analysed with backfill material placed to the same level as the pre-mining groundwater table, which is consistent with existing mine closure plans. Where the factor of safety was less than the design acceptance criteria, additional material was modelled above the backfill, against the slope. This additional material is referred to as a buttress, as it is not necessarily required to be placed across the full width of the pit void. A buttress geometry has been estimated and is presented in Table 5-11, however inter-bench heights and bench widths will be determined during the next stage of closure design, guided by existing waste dump designs.

The distance from the critical slip surface to the pit crest has been estimated in the horizontal plane and used to aid design decisions on the position of closure levees within PUPEZ for each mine pit. The conceptual closure design considers the position of each levee in proximity to the mine pit based on this assessment. The results presented in Table 5-10 indicate that the closure levees, including a 10 m buffer based on abandonment bund guidelines (DIR, 1997), are outside of the PUPEZ. Pit D3 is within the PUPEZ, however this is based on the geological cross-section for Pit D1 in the absence of Pit D3 data. Further investigations are required to confirm buttressing requirements, informed by geological information at this pit. There are limited opportunities to re-align this levee and therefore buttressing, based on Pit D1, is included in the design.

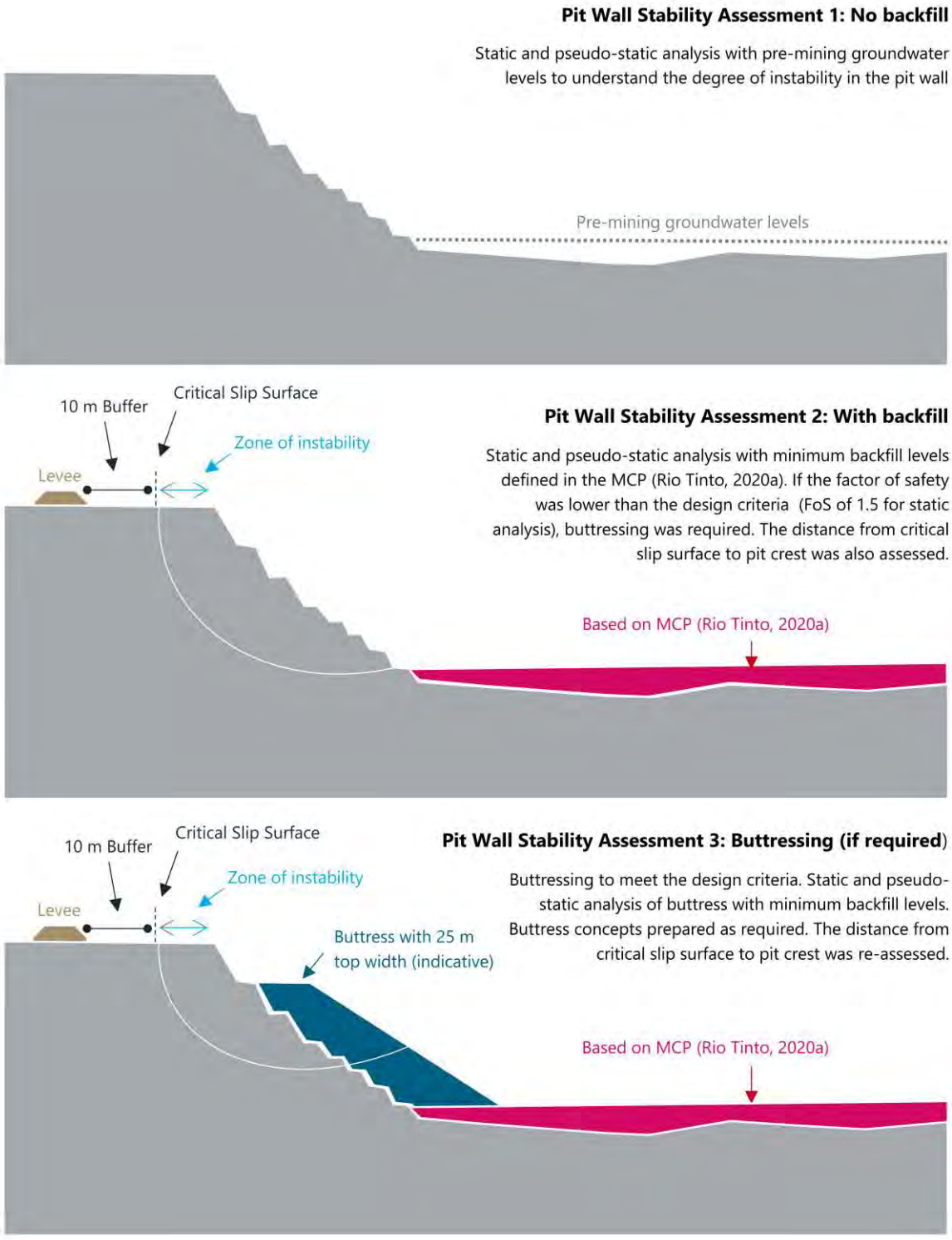


Figure 5-21 Pit wall stability sketch

Table 5-10 Geotechnical pit wall and backfill assessment summary

Deposit	Cross Section	Failure direction	Analysis Type	Stability Assessment #1 (No backfill)		Stability Assessment #2 (with MCP backfill)			Stability Assessment #3 (with buttressing – if required)		
				Factor of Safety with no backfill	Distance from Pit Crest to Critical Slip Surface (PUPEZ) (m)	MCP backfill level (mAHD)	FoS after backfilling	Buttressing requirement	Top of Buttress Level (mAHD)	Distance from Pit Crest to Critical Slip Surface (PUPEZ) (m)*	Distance from Levee buffer to Pit Crest (m)^
Deposit B	B XS1	n/a	Pseudo Static	1.48	13	n/a (no backfill required for geotechnical stability)		No	-	13	-
			Static	1.60	14	n/a (no backfill required for geotechnical stability)		No	-	14	-
Deposit C	C XS1 (Pit C3)	n/a	Pseudo Static	1.08	146	638	1.37	No	-	4	14
			Static	1.17	146	638	1.51	No	-	3	14
	C XS2 (Pit C3)	n/a	Pseudo Static	1.65	27	n/a (no backfill required for geotechnical stability)		No	-	27	130
			Static	1.83	28	n/a (no backfill required for geotechnical stability)		No	-	28	130
	C XS3 (Pit C2)	n/a	Pseudo Static	1.24	23	626	2.07	No	-	9	>200
			Static	1.35	34	626	2.21	No	-	8	>200
	C XS4 (Pit C2)	n/a	Pseudo Static	1.11	27	626	1.12	Yes	664	9	>200
			Static	1.19	33	626	1.20	Yes	664	12	>200
Deposit D	D XS1 (Pit D1)	North to South	Pseudo Static	1.20	85	626	1.57	No	-	5	7
			Static	1.32	95	626	1.66	No	-	3	7
		South to North	Pseudo Static	1.56	52	626	2.07	No	-	52	63
			Static	1.74	54	626	2.28	No	-	54	63
	D XS2 (Pit D1)	North to South	Pseudo Static	1.25	126	626	1.52	Yes	681	37	63
			Static	1.41	126	626	1.68	Yes	681	24	63
		South to North	Pseudo Static	1.33	12	626	2.45	No	-	11	63
			Static	1.43	12	626	2.65	No	-	12	63
	D XS2 (Pit D3 – Extrapolated ~1.2 km)	n/a	Pseudo Static	1.33	12	627	2.45	Yes	681	11	8
			Static	1.43	12	627	2.65	Yes	681	12	8

Note: Red text indicated FoS below design criteria (FoS >1.5 for static conditions, FoS >1.2 for pseudo-static conditions). Blue text indicates levees located within the PUPEZ.
** based on stability assessment #2 if no buttressing is required.*
^ Levee buffer of 10m
 # The geology was considered to be broadly similar to Pit D1, XS2 (the eastern bullnose), and the failure geometry calculated for Pit D1, XS2 was applied to the D3 pit.

Table 5-11 Pit buttressing requirements

Pit	Cross-section	Backfill level (mAHD)	Buttress top level (mAHD)	Buttress bottom level (mAHD)	Slope (H:V)
Pit C2	CXS4	626	664	Top of backfill	5:1
Pit D1	DXS2	626	681 (higher side of pit)	641 (lower side of pit)	5:1
Pit D2	DXS2	627	681 (higher side of pit)	641 (lower side of pit)	5:1
Pit D3	DXS2	627	681 (higher side of pit)	641 (lower side of pit)	5:1

5.4.6 Flood events

For each closure levee assessed for geotechnical stability, a hydrograph was developed for the design event at a minimum of three points along the levee. Each hydrograph was directly imported to Seep/W, a finite element seepage analysis software package, and a temporal analysis undertaken to understand pore pressure development during the design flood events. Pore pressure changes during the rising, peak and receding flood were considered.

The pore pressures developed within and below the levee as a result of the design flood events were then incorporated into a Slope/W (limit equilibrium) analysis, and the factor of safety against failure determined.

Table 5-12 summarises the factors of safety determined for the closure flood levees described in Section 5.4.2 subject to the flood events described above.

Table 5-12 Flood levee geotechnical stability assessment results

Levee/pit name	Levee height (m)	Flood design option	Factor of safety
Pit C3	3.9	Option 1	2.1
Pit C3	3.5	Option 2 (floodplain reinstatement)	2.1
Pit C3	3.9	Option 3 (Deposit B spillway)	2.1
Pit D1 South	4.4	Option 1	2.0
Pit D3	2.4	Option 1	1.7
Deposit F	2.1	Option 1	1.7

Review of the shape of the critical slip surfaces shows that they involve the entire downstream face of the closure levees, and typically 1-2 m of the foundation, exiting about 2 m downstream of the toe. This failure surface shape is typical of low levee heights on reasonably competent foundation materials. It does not present an additional risk to the closure design unless flood levees and pit shells are in very close proximity.

A sensitivity analysis was undertaken for the closure flood levees where the initial groundwater surface (prior to the design flood event) was at the ground surface. The factors of safety calculated were below the design criteria, typically less than 1.2 and sometimes less than 1.0. The installation of a 3 m deep cutoff/key below the levee crest did not increase the factors of safety to acceptable levels. Estimation of the likely initial groundwater surface (prior to the design flood event) should be undertaken during future studies.

5.4.7 Summary of results

The outcome of the geotechnical stability assessment for mine pit walls shows that a slope compliant with the design criteria can be obtained for the assessed pit walls. The critical factor of safety for determining backfill or buttress level appears to generally be the static load case, which implies that the seismic design case is not critical to the pit wall stability. However, the AEP for the seismic design case is considered relatively low (1:500 AEP) for closure and alternative design criteria may be considered in a site-wide risk assessment, as is recommended in Section 7.2.

The distance from the pit crest to the critical slip surface (measured in the horizontal plane and including the 10m buffer [DIR, 1997]) has been estimated using the geotechnical stability assessment results. This distance could be considered the PUPEZ for closure purposes if a pit is backfilled and buttressed as described in Section 5.4.5. Permanent infrastructure that is part of the closure design should be located outside the PUPEZ, including a 10 m buffer. The levee at Pit D3 is within this zone, and further assessments are required to confirm buttressing at this location to ensure a design that meets the BoD can be achieved in future phases.

The flood levee stability assessment was very sensitive to the starting groundwater level. Initial groundwater levels that may occur in the foundations of flood levees prior to a design flood event should be investigated in more detail during future design stages.

The competency of local material for spillway design has not been considered in the geotechnical assessment due to a lack of geotechnical data. As the spillway option is expected to provide little benefit for the cost and risk to construct it, further investigation of the geotechnical properties of this area is not recommended.

With regards to the option assessment, the significant surface water structure differences are near Deposit C. At Deposit C, the Pit C3 levee was assessed for all three closure design options, with negligible differences noted in the geotechnical stability assessment of the proposed levees for each closure design option.

5.5 Material quantity estimates

The selection of a preferred closure design was informed by the flood modelling (Section 5.3), geotechnical assessment (Section 5.4) and subsequent material quantity estimates for the associated infrastructure. The bulk material requirements for each option were estimated using the software package 12D and are provided in Table 5-13. The volumes have been measured using the surfaces provided by Rio Tinto as a baseline, including the LIDAR 2021 and LOM pit shells (Section 2.1).

Table 5-13. Bulk material estimates

Location	Cut / Fill	Option 1: Operational levee upgrades (m^3)	Option 2: Floodplain Reinstatement at Pit C3 (m^3)	Option 3: Spillway at Deposit B (m^3)
Deposit B				
Deposit B Spillway	Cut	-	-	1,052,515
Deposit C				
Pit C3 Levee	Fill	47,855	11,345	46,582
Pit C3 Backfill*	Fill	-	10,471,300	-
Deposit C Diversion	Cut	47,945	47,945	47,945
Pit C2 Buttress	Fill	370,295	370,295	370,295
Deposit D				
Pit D1 South Levee	Fill	49,885	49,885	49,885

Location	Cut / Fill	Option 1: Operational levee upgrades (m^3)	Option 2: Floodplain Reinstatement at Pit C3 (m^3)	Option 3: Spillway at Deposit B (m^3)
Pit D1 North Levee	Fill	-	-	-
Pit D1 Buttressing	Fill	2,353,685	2,353,685	2,353,685
Pit D2 Buttressing	Fill	2,897,380	2,897,380	2,897,380
Pit D3 Levee	Fill	2,420	2,420	2,420
Pit D3 Buttressing	Fill	5,785,820	5,785,820	5,785,820
Deposit F				
Deposit F Levee	Fill	22,550	22,550	22,550

**Above existing backfill commitments (Rio Tinto, 2020a).*

Table 5-13 shows a considerable difference in the material quantities between Option 1 and Option 2, suggesting that Option 1 is a clear preference. However, there is potential for the material required for the partial backfilling of Pit C3 to be sourced from within Deposit C or Deposit G without rehandling the material from a waste dump. For example, the planned WD1 at Deposit C has approximately 10 Mm^3 available, which is most of the material required to execute this option.

An outcome of the geotechnical stability assessment for the mine pits has been the determination that buttressing and backfilling requirements are mostly independent of the closure design option. To achieve the design criteria, a minimum level of backfill and buttress is required for each pit assessed. Only where a proposed closure levee is within, or near to, the estimated PUPEZ are additional buttress or backfill requirements identified. This has only affected the D3 Pit in the current study.

Owing to the early stage of the project, a limited selection of mine pits has been assessed, with a very limited number of cross-sections analysed for stability within the sub-set of mine pits assessed. As the closure design progresses, each mine pit should be assessed for geotechnical stability over the closure timeframe. Multiple cross-sections should be analysed for each mine pit, to better develop the influence of geological features on the pit wall stability.

One of the key materials required for closure levee construction is rock protection, to protect against scour and erosion. Scour of the adjacent creek beds, and erosion of levees banks, may lead to failure and creek capture if insufficient rock protection is provided. The size of rock required for protection is related to the flow velocity (and stream power) within the adjacent channel. Table 5-14 outlines a simple rock material classification (Austroads, 2019) for flow velocities that has been adopted for this assessment. A detailed scour assessment, considering creek material and flow directions, is recommended to refine the rock material estimates as design progresses. Suitable sources of competent rock protection also need to be identified and may not be readily available on site. This also requires further investigation.

Table 5-14. Rock material classification (Austroads, 2019)

Flow velocity (m/s)	Class of Rock Protection	Section Thickness (m)
< 2	None	-
2.0 – 2.6	Facing	0.50
2.6 – 2.9	Light	0.75
2.9 – 3.9	¼ Tonne	1.00
3.9 – 4.5	½ Tonne	1.25
4.5 – 5.1	1.0 Tonne	1.60
5.1 – 5.7	2.0 Tonne	2.00
5.7 – 6.4	4.0 Tonne	2.50
> 6.4	Special	-

Rock protection requirements were estimated in 12D based on Austroads classifications, using the peak flow velocities near the levee. An additional 2 m of rock protection was calculated beneath the closure levee to estimate protection required for scour and erosion. A detailed scour assessment should be considered to determine these depths. Note that consideration of the migration of low flow channels, and potential increase in rock protection requirements was considered in the conceptual design presented in Section 6.

As outlined in Table 5-15, the closure levees requires rock armour up to the ½ tonne size. Between the options considered, Option 2 shows a significant reduction in total rock armour requirements, associated with the decrease in levee length at Pit C3, in combination with the reduction in flow velocities from reinstating the floodplain at this location. The requirements at other locations are consistent amongst the options. Note that no rock protection was required at Deposit B, but this may be required following further design.

Table 5-15. Preliminary rock protection estimates

Rock armour class	Facing Rock (m^3)	Light Rock (m^3)	¼ Tonne Rock (m^3)	½ Tonne Rock (m^3)	Excavation for below ground for rock installation (m^3)
Option 1 – Operational levee upgrades / Option 3 – Spillway at Deposit B					
Pit C3 Levee	1,325	1,540	6,900	1,560	8,790
Pit D1 North Levee	565	n/a	195	n/a	1,390
Pit D1 South Levee	2,740	1,470	4,670	3,275	9,980
Pit D3 Levee	2,455	1,410	2,675	n/a	8,095
Deposit F Levee	11,010	4,830	1,000	n/a	19,290

Rock armour class	Facing Rock (m^3)	Light Rock (m^3)	¼ Tonne Rock (m^3)	½ Tonne Rock (m^3)	Excavation for below ground for rock installation (m^3)
Total	**18,095**	**9,250**	**15,440**	**4,835**	**47,545**
Option 2 – Floodplain reinstatement at Pit C3					
Pit C3 Levee	405	255	3,280	755	3,860
Pit D1 North Levee	565	n/a	195	n/a	1,390
Pit D1 South Levee	2,740	1,470	4,670	3,275	9,980
Pit D3 Levee	2,455	1,410	2,675	n/a	8,095
Deposit F Levee	11,010	4,830	1,000	n/a	19,290
Total	**17,175**	**7,965**	**11,820**	**4,030**	**42,615**

The various material estimates for each option are summarised in Table 5-16.

Table 5-16 Total material estimate for each option

Option	Compacted fill (m^3)	General backfill (m^3)	Semi-engineered backfill (m^3)	Excavation (m^3)	Rock protection (m^3)
Option 1: Operational levee upgrades	122,710	11,407,180	0	95,490	47,620
Option 2: Floodplain Reinstatement at Pit C3	86,200	11,407,180	10,471,300	90,560	40,990
Option 3: Spillway at Deposit B	121,437	11,407,180	0	1,148,005	47,620

5.6 Option Selection Workshop

The three selected options were assessed in an Options Selection Workshop, with reference to the basis of design and the results of hydraulic modelling, geotechnical assessments, material quantity estimates, to select the preferred closure concept. An additional qualitative assessment of the environmental, cultural and constructability risks and opportunities was also undertaken for each of the options.

The Options Selection Workshop was completed with Rio Tinto stakeholders on 28 September 2021. The outcomes of the workshop are summarised in Table 5-17 and in detail below:

- Option 3 (Deposit B Spillway) was identified as the least supported option. The benefits associated with the spillway, particularly at Pit C3 where the risk of creek capture is highest across the mine site, are low compared to the bulk excavation required to make the spillway functional. Flood modelling indicated a reduction in peak flood level at Pit C3 of less than 0.1 m, with no discernible

change in flow velocity (no change in rock protection), and no further environmental or cultural benefits. Further, there are significant uncertainties associated with the alignment and design of the spillway, including identification of competent rock material, which would require extensive geotechnical testing. These factors make a compelling case for not proceeding with a spillway at closure.

- There is a justifiable case for both Option 1 (Operational Levee Upgrade) or Option 2 (Floodplain Reinstatement at Pit C3) to be developed as the preferred closure outcome.
- Option 1 is a comparatively straight-forward design and construction undertaking that has been demonstrated to meet the basis of design. Option 2 also achieves the basis of design, whilst providing further environmental and cultural benefits associated with re-establishment of the pre-mining floodplain. Re-establishment of the floodplain may allow potential rehabilitation of Turee Creek East and establishment of a wider range of natural habitats.
- Option 2 carries a risk of long-term settlement and potential geotechnical stability issues, particularly if conventional paddock dumping is used for backfill of the C3 pit. A semi-engineered backfill is proposed to address these risks, which may require additional material for compaction in addition to compactive effort and water for moisture control. Settlement prediction and monitoring for a period after backfilling is recommended to confirm long-term suitability of the landform. There is also potential for the main channel to migrate towards, or into, the reinstated floodplain and cause creek capture. Further modelling, including confirmation of the design event (and frequency) of floodplain activation and consideration of small levees, is required to characterise and mitigate this risk.
- If successfully implemented, with consideration of the settlement risks, Option 2 eliminates the requirement for approximately 1.5 km of levee at the eastern end of Pit C3 which reduces the risk of creek capture associated with closure levee failure.
- The key difference between Option 1 and Option 2 is the material requirements at Pit C3. Option 2 requires approximately 10 Mm^3 of waste material for backfilling to the pre-mining surface levels. If mine planning is able to facilitate backfilling of Pit C3 during operations, there is the potential to reduce haul distances for Deposit C (currently planned to be deposited at WD1 and WD2) and have this option as either a cost neutral or net positive outcome. This outcome would be subject to further mine planning and Advisian recommend that Rio Tinto undertake this analysis, particularly with regards to the beneficial environmental and cultural outcomes outlined above.

5.7 Preferred closure option/s

The Options Selection Workshop identified two feasible options:

- ***Option 1: Upgrading Operational Levees, and***
- ***Option 2: Reinstating the Floodplain at Pit C3.***

Each option can achieve the design criteria and the preference can only be determined through further mining planning considerations. Therefore, a preferred option has not been selected, and should be reviewed at the completion of further investigations.

Option 1 (Operational Levee Upgrade) is considered to have lower uncertainty of the two feasible options as well as lower earthworks quantities so was progressed to conceptual design. These designs, including refinement from Rio Tinto feedback, are provided in Section 6.

Table 5-17. Option assessment

Option ID	Flood Protection	Geotechnical Assessment	Material Estimates	Environment	Heritage	Execution
Option 1: Operational levee upgrades	Flood protection meets the basis of design through closure levees and diversions.	Geotechnical assessment indicated levees have suitable factors of safety. The Pit D3 levee is within the PUPEZ.	This option required the least amount of bulk material movement. Rock (>1/4 tonne) protection requirements at Pit C3 were three times higher than Option 2	Minimal change to catchment connectivity (up to the design event), with only the local catchment south of Pit C3 blocked. Frequent flows are maintained across the catchment. No change to inflows into the Cracking Clays PEC in the 1:10,000 AEP event compared with operations.	No surface water structures are proposed near identified areas of heritage significance.	Upgrade of operational levees is comparatively straightforward.
Option 2: Floodplain Reinstatement at Pit C3	In addition to meeting the basis of design this option removes the eastern end of Pit C3, reducing the risk of pit capture.	Geotechnical assessment indicated levees have suitable factors of safety. There is a risk associated with settlement of C3 backfill, and with main channel migration into the backfill area. The Pit D3 levee is within the PUPEZ.	Significant volume required to partially reinstate the floodplain. Which is partially offset by the reduction in rock (>1/4 tonne) at Pit C3.	Provides the most favourable environmental outcomes with complete catchment connectivity and a lower risk of permanent creek capture from closure levee failure. No change to inflows into the Cracking Clays PEC in the 1:10,000 AEP event compared with operations.	As with Option 1, no direct impacts to heritage places. This option also re-instates a portion of the TCE floodplain that is otherwise left as a void.	Owing to the volume of material required for this option, planning is required to confirm the source of material and integration into mine planning and operation.

Option ID	Flood Protection	Geotechnical Assessment	Material Estimates	Environment	Heritage	Execution
Option 3: Spillway at Deposit B	The spillway facilitates a minor decrease in closure levee height at Pit C3.	Geotechnical assessment indicated levees have suitable factors of safety. Spillway itself not assessed for stability. The Pit D3 levee is within the PUPEZ.	Minimal reduction in levee and rock protection requirements compared with Option 1 however significant material movement required for spillway construction.	Minimal change to catchment connectivity with regards to frequent flows (spillway only activated >1:50 AEP event). As with Option 1, the local catchment south of Pit C3 is blocked. No change to inflows into the Cracking Clays PEC in the 1:10,000 AEP event compared with operations.	No surface water structures are proposed near identified areas of heritage significance.	Spillway design and construction requires competent material that has not yet been identified. Further geotechnical testing and assessment would be required to confirm if this option is feasible.

6 Conceptual closure design

A conceptual closure design was prepared for the selected / preferred option (Option 1, described in Section 5). This section documents the conceptual designs adopted.

6.1 Closure concept

The conceptual design was modified from the option presented in Section 5 following discussion with Rio Tinto stakeholders in the options analysis workshop, held on 28 September 2021. The following modifications were made:

- Adjustment of the closure levee alignment so that the increase in levee size is accommodated outside of the low flow channel on the pit-side.
- Closure levee alignments were assessed against the PUPEZ to ensure alignments were geotechnically stable.
- Refinement of rock protection estimates (presented in Section 6.3).

The revised closure concept is provided in Figure 6-1 and summarised in Table 6-1.

Table 6-1. Closure concept summary

Option ID	Operational levee upgrades
Deposit A	Retention of waste dumps, no additional closure infrastructure
Deposit B	Removal of haul road crossings, assessment of 1:10,000 AEP flows in drain
Deposit C	Closure levee and diversion for 1:10,000 AEP event, including blocking flows from the south and realignment of levee to the east. A diversion channel on TCE is included to reduce impinging flows.
Deposit D	Closure levee designed for the 1:10,000 AEP event, including partial backfilling of Pit D1 to ensure stability of pit wall. Levee at Pit D3 will be designed for the 1:1,000 AEP event.
Deposit F	Closure levee designed for the 1:1,000 AEP event
Rail	Existing formation is retained, but crossings are removed in flood modelling
Other infrastructure	Haul roads and LV crossings removed
Waste Dumps	Closure footprint (following removal of material for backfilling above pre-mining water table)

Supporting this, conceptual design drawings have been prepared for the following:

- General arrangement for the West Angelas site.
- Plan and profile drawings for deposits B, C, D, and F.
- Typical cross sections for deposits B, C, D, and F.
- Details drawing.

These drawings are provided in Appendix D.

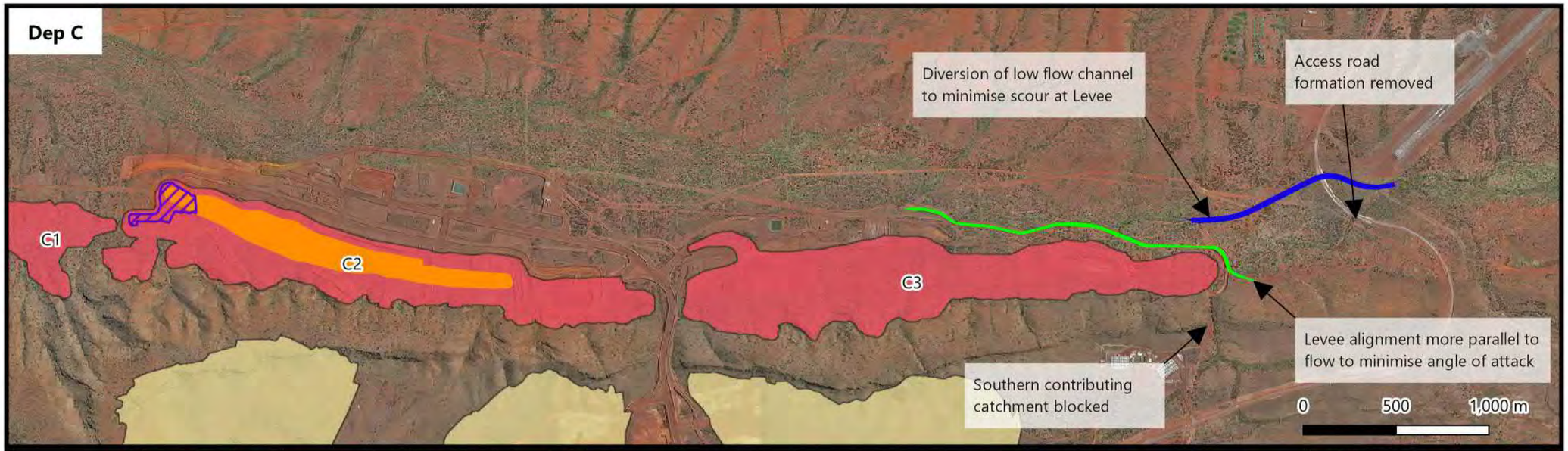
Surface Water Closure Strategy
West Angelas

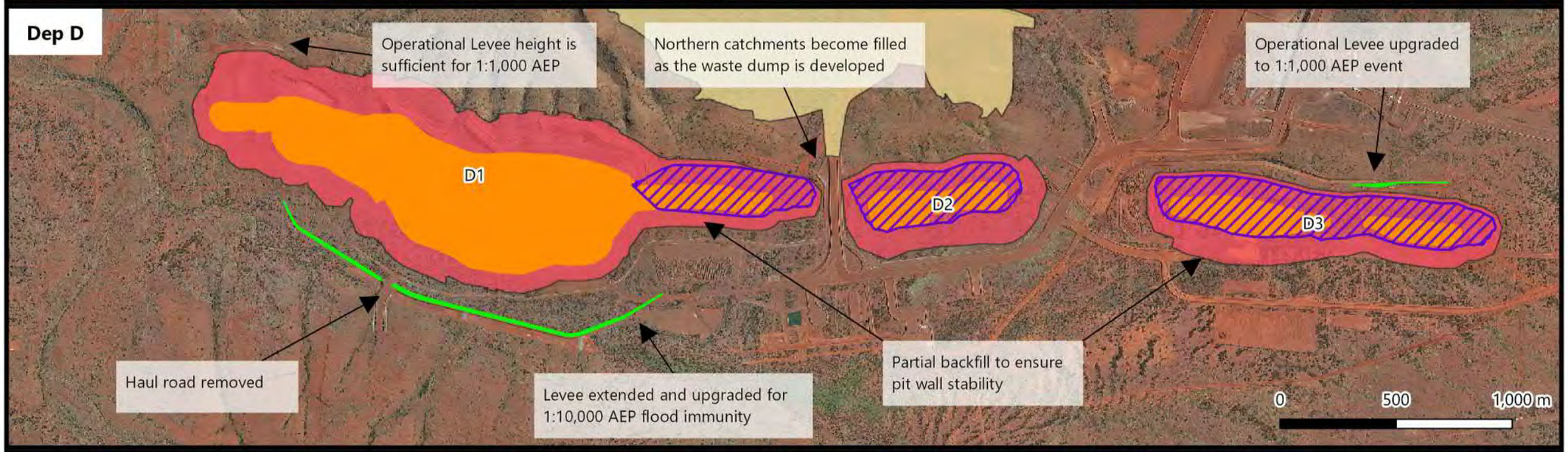
Figure 6-1: Closure Concept Layout

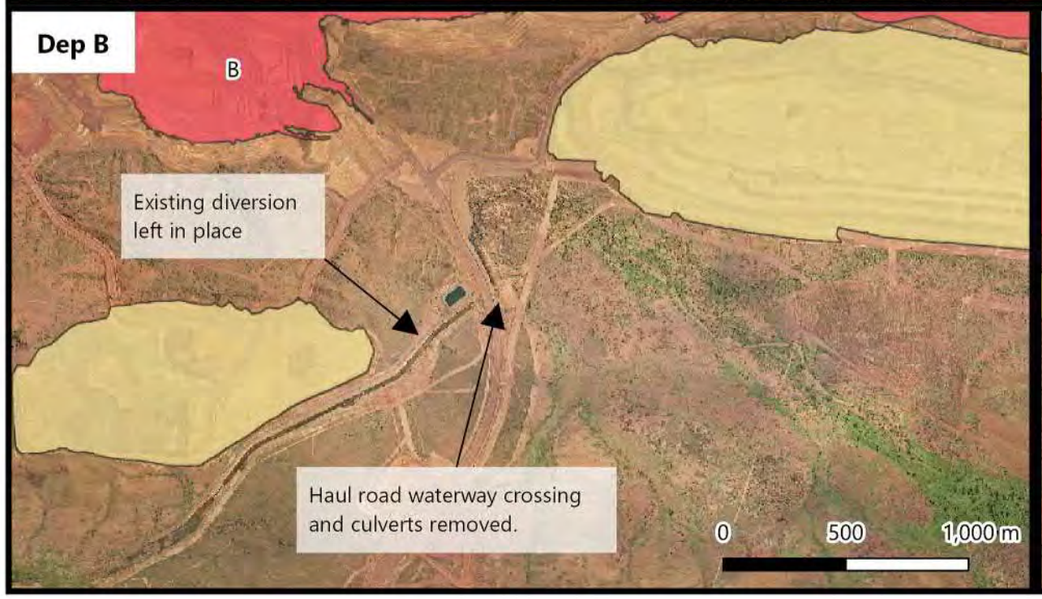
Legend

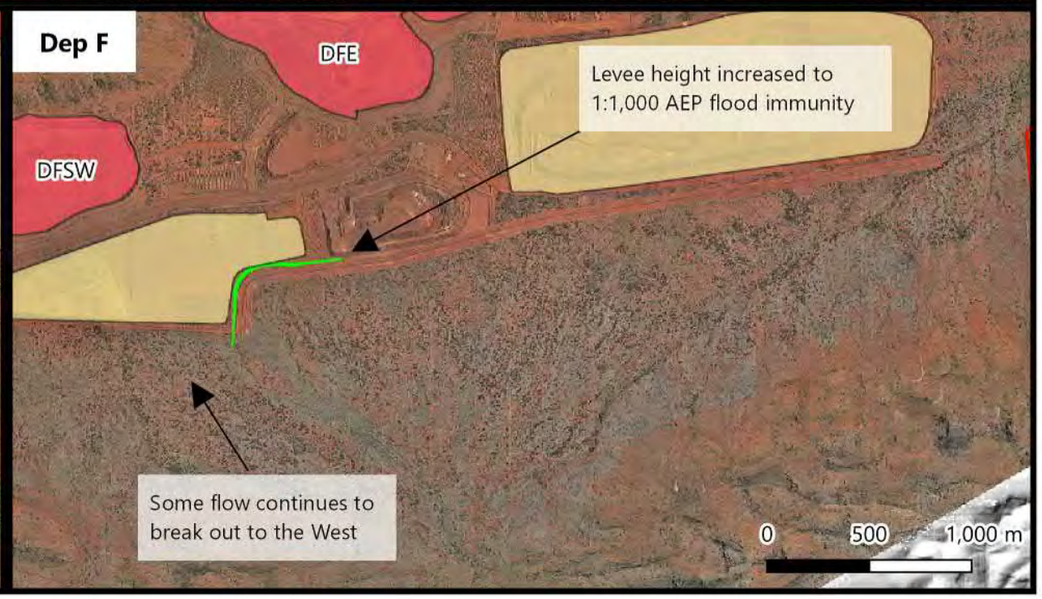
Mine Layout

- Concept Levee Upgrades
- Concept Diversion Design
- Buttress
- Pit Backfill Area
- In-Scope Pits
- In-Scope Waste Dumps









Closure Concept Notes:

- Use of levees as primary flood control measure.
- Deposit A: waste dumps retained, no additional closure infrastructure
- Pits to be backfilled to ensure pit wall stability at levee locations.
- Rail Formation is retained, with waterway crossings removed in flood modelling
- Haul road and LV road waterway crossings removed in flood modelling
- Waste Dump footprints assumed to be Life of Mine design footprints.

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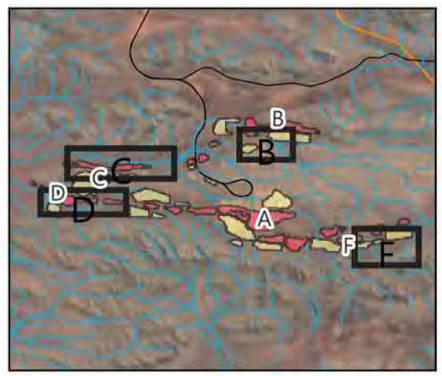

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In the concept designs, the closure levees were adjusted to ensure that the upgrades and extensions were located on the pit side, rather than the creek side. This adjustment removed any encroachment on the creek and floodplain to minimise increases in flood depths or flow velocities. These locations were modelled in TUFLOW, with results provided in Figure 6-2 and Figure 6-3 respectively.

Despite adjustment of these closure levees away from the creek, the levees (plus a nominal 10 m buffer width) have almost entirely been located outside the PUPEZ, as described in Section 5.4. The levee for Pit D3 is the only levee that has it's 10 m buffer overlapping with the D3 PUPEZ. Geotechnical assessment is required for Pit D3 to confirm buttressing requirements. Similarly, site specific investigation data would allow determination of the appropriate buffer width at this location, as it is not possible to realign this diversion and levee.

6.2 Bulk material estimates

The material estimates for the levee upgrades were estimated in 12D, incorporating changes from the options assessment. The dimensions are presented in Table 6-2 and Table 6-3. As discussed in Section 5.3.2.4, there are minimal upgrades required at the Pit D1 North levee (operational levee is suitable) and the Pit D3 levee (only a slight raise at the levee entrance).

Table 6-2. Material estimates for closure levee upgrades

Location	Existing Levee Length for Operations (m)	Length Upgraded for Closure (m)	Approx. Average Levee Crest Height (mAHD)		Slope (H:V)	Crest Width (m)	Cut (m^3)	Fill (m^3)
			Existing (Operations)	Closure^				
Pit C3 Levee	2,532	1,980	688.8	689.9	2.5:1	5	0	47,855
Pit D1 North Levee	315	0	n/a	n/a	n/a	n/a	n/a	n/a
Pit D1 South Levee	1,810	1,810	676.1	677.1	2.5:1	5	0	49,885
Pit D3 Levee	1,695	518	688.5	689.5	2.5:1	5	0	2,420
Deposit F Levee	3,828	759	796.9	797.8	2.5:1	5	0	22,550

^ *Raised section of levee*
* *Levee embankment slope*

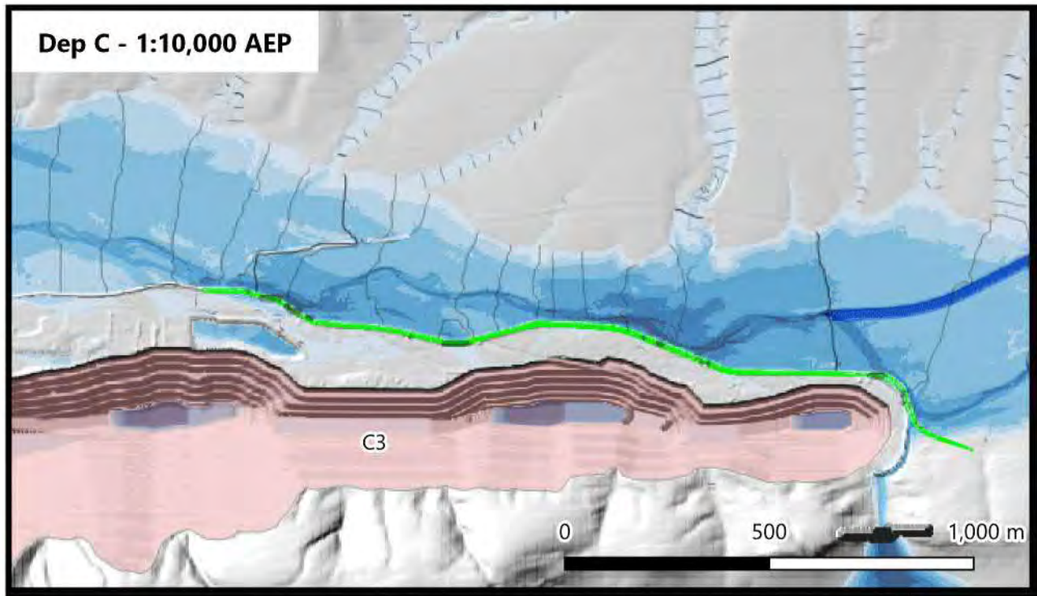
Table 6-3. Material estimates for diversion channel at closure

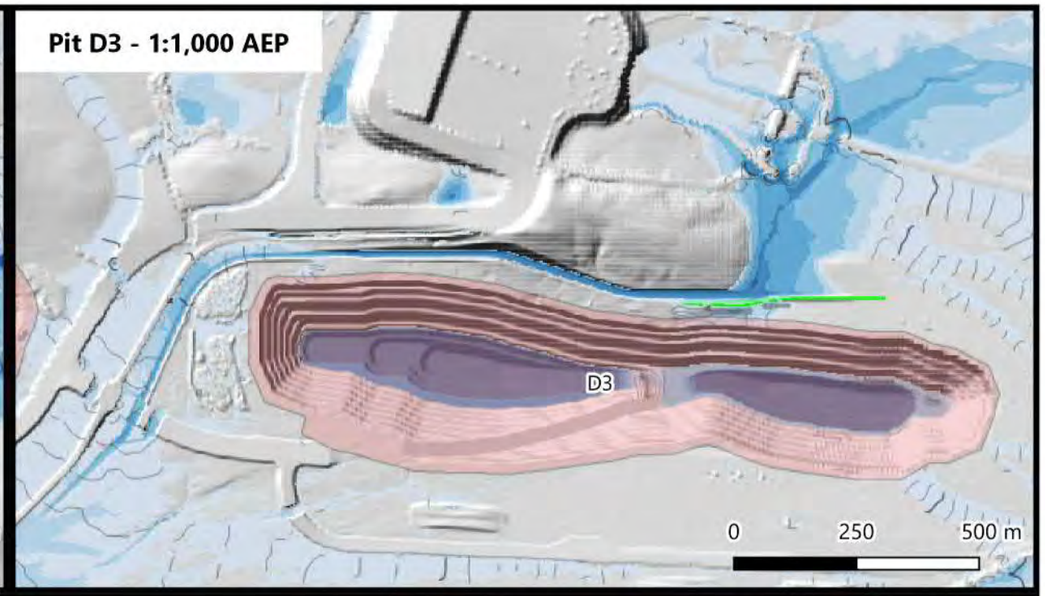
Location	Length (m)	Start RL (mAHD)	End RL (mAHD)	Bed Slope (%)	Bed Width (m)	Cut Volume (m^3)	Fill Volume (m^3)
Deposit C Diversion	1150	690.15	686.04	0.36%	20	47,945	0

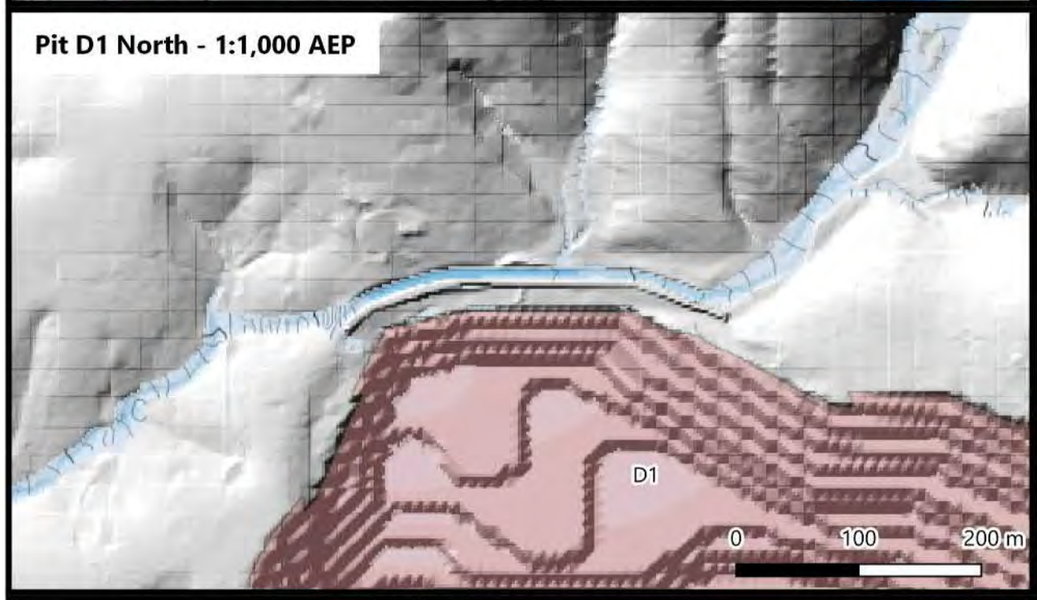
The buttressing requirements for the concept are provided in Table 6-4. These volumes were determined in 12D based on the geotechnical stability outlined in Section 5.4.5.

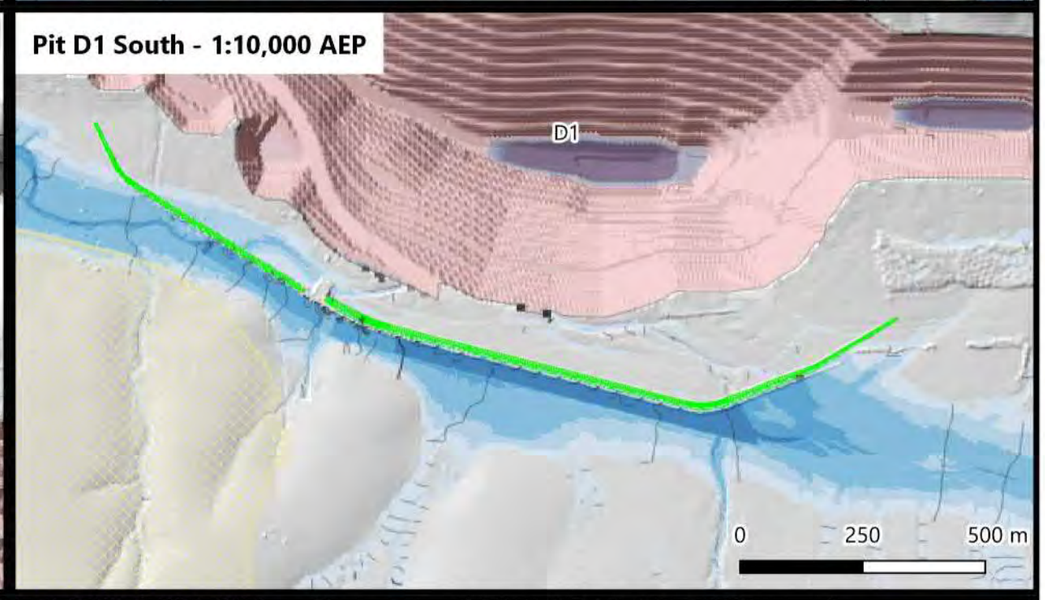
Surface Water Closure Strategy
West Angelas

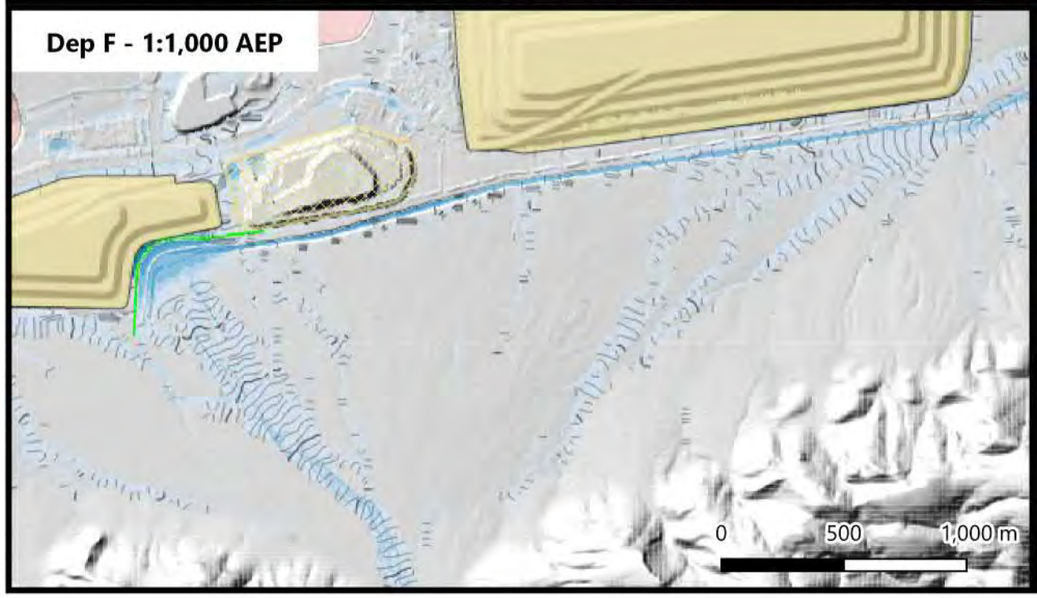
Figure 6-2: Conceptual Closure Design Flood Depth

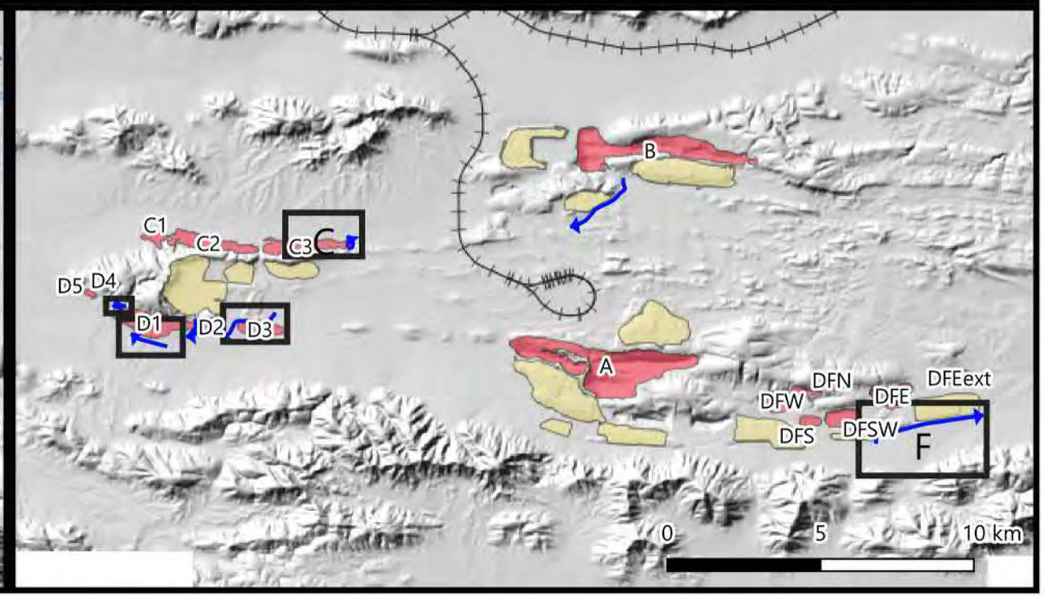












Legend

- Concept Levee Upgrades
- Concept Diversion Design

Water Surface Elevation Contours

- 0.5 m
- 5.0 m

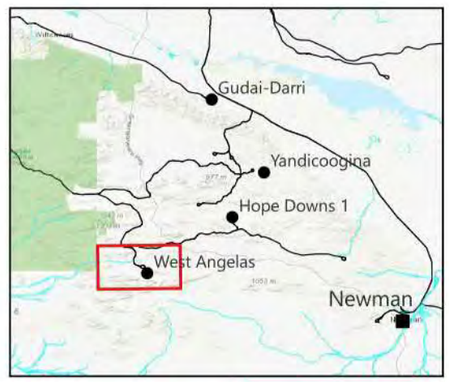
Flood Depth (m)

- 0.05 - 0.50
- 0.50 - 1.00
- 1.00 - 2.00
- 2.00 - 3.00
- 3.00 - 4.00
- > 4.00

Closure Landform Extents

- Pits
- Waste Dumps

Date: 22/11/2021
Projection: GDA94 / MGA zone 50



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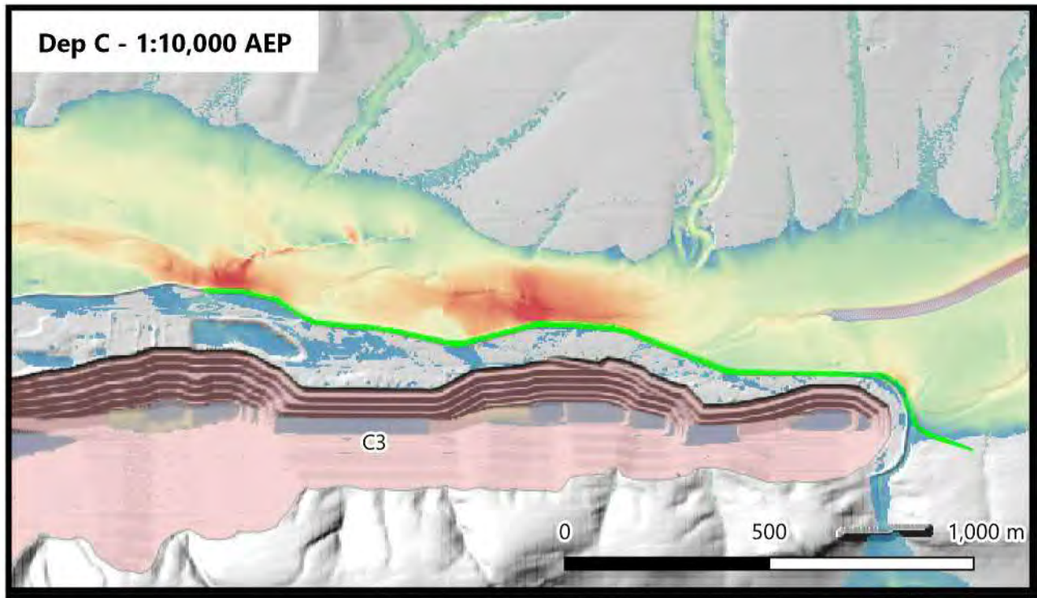
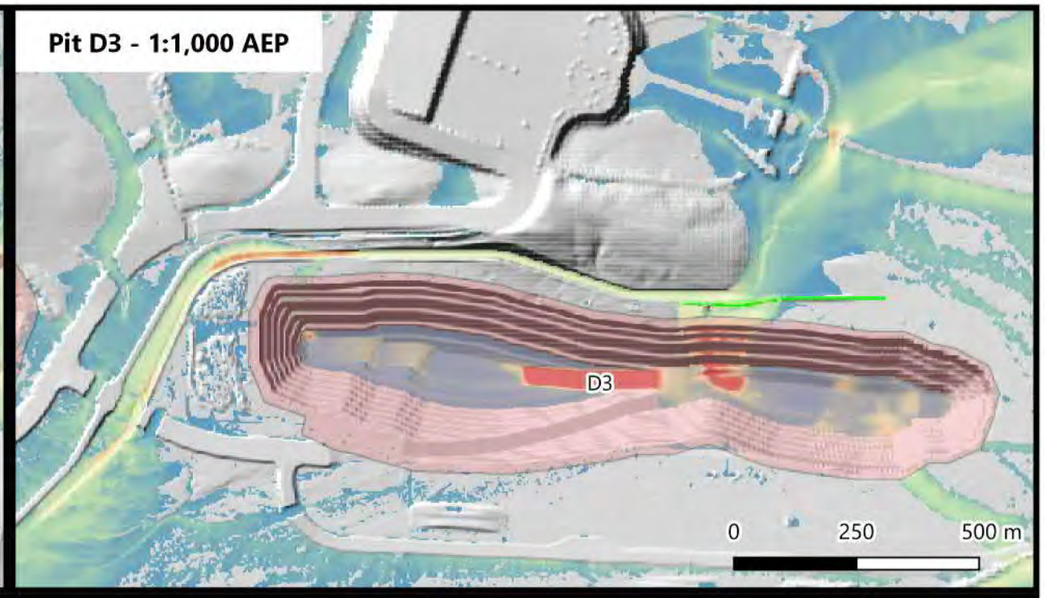
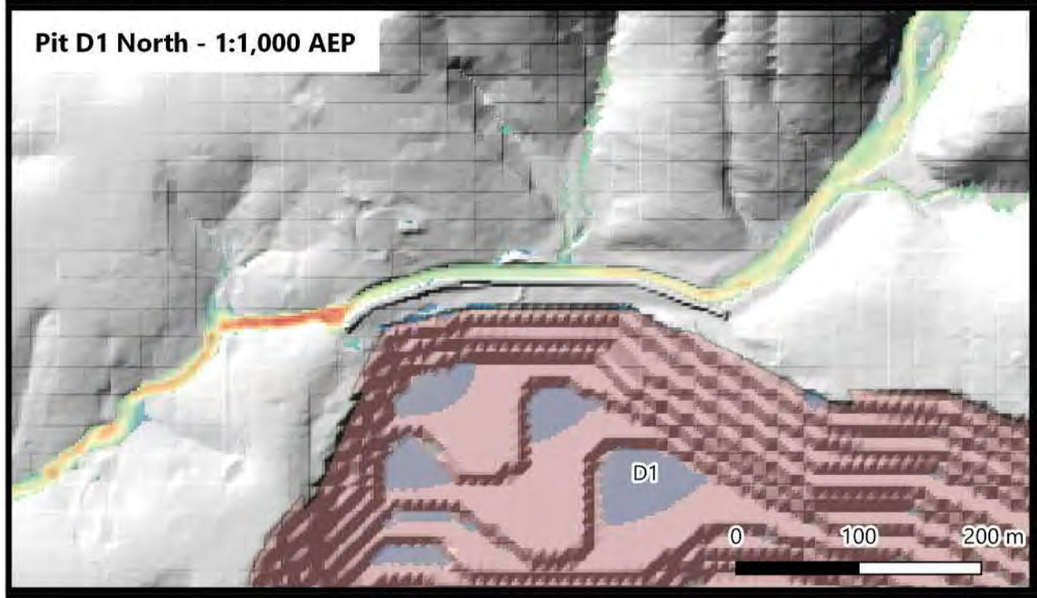
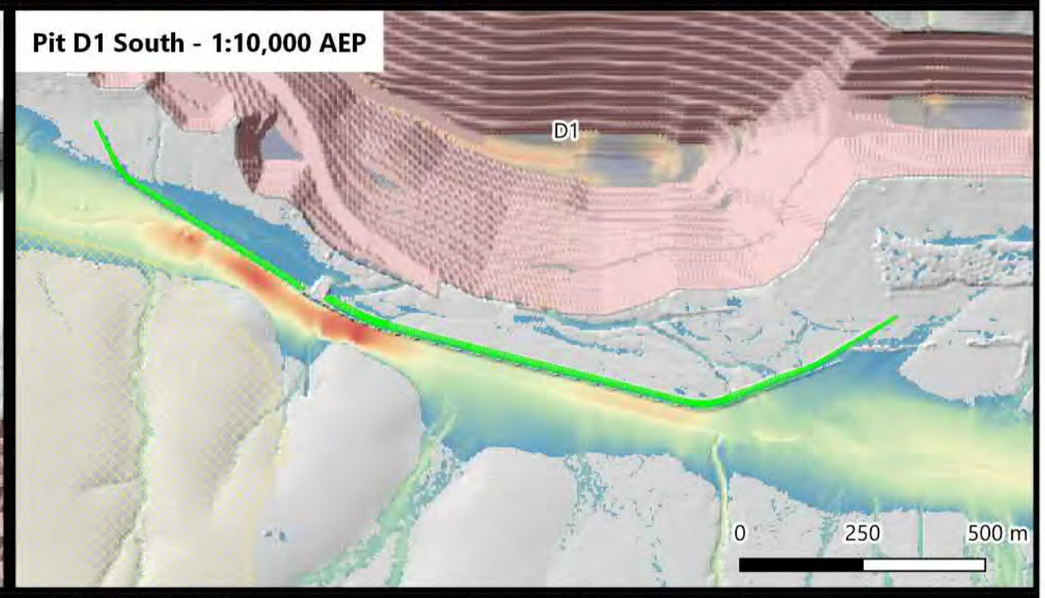
Surface Water Closure Strategy
West Angelas

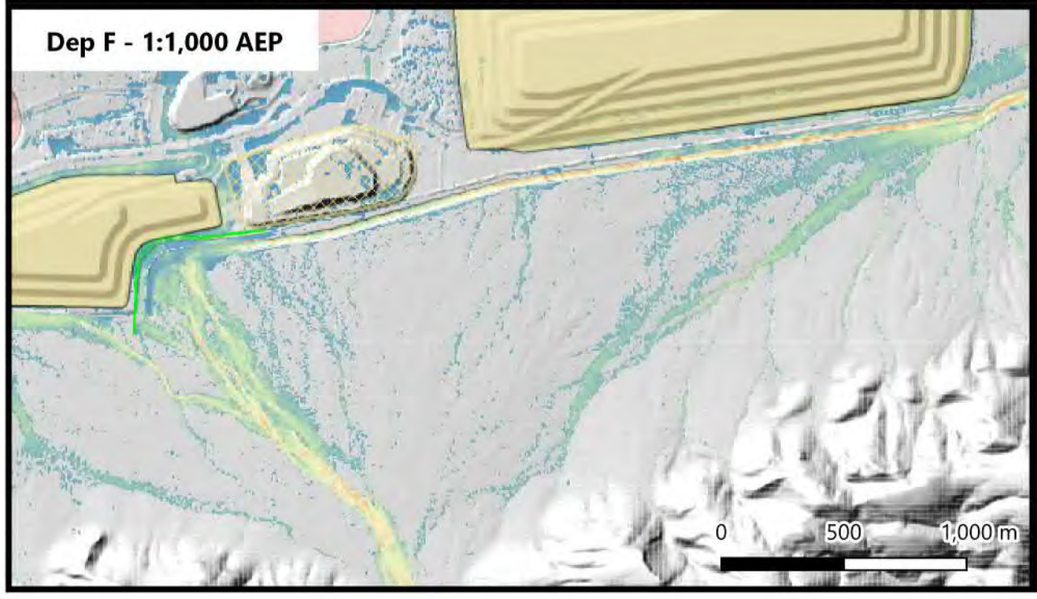
Figure 6-3: Conceptual Closure Design Flow Velocity

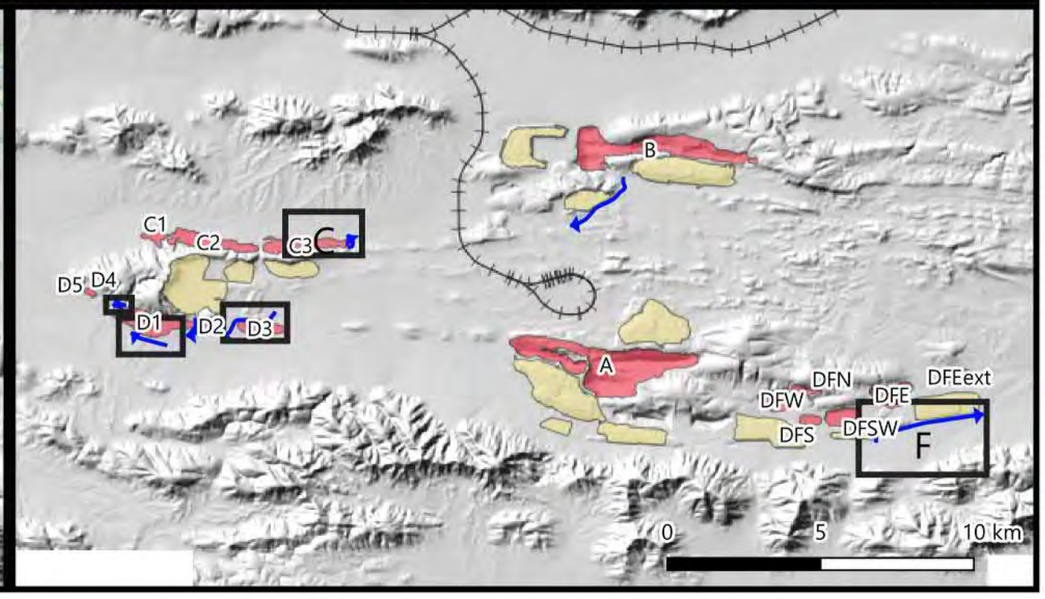












Legend

- Concept Levee Upgrades
- Concept Diversion Design

Flow Velocity (m/s)

4

0

Closure Landform Extents

- Pits
- Waste Dumps

Date: 22/11/2021
Projection: GDA94 / MGA zone 50

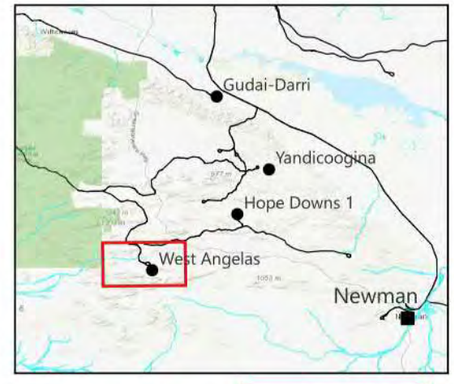


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Table 6-4. Material estimates for buttressing at identified pits

Location	Total Length (m)	Grade (H:V)	Width (m)	Fill (m^3)
Pit C2 Buttress	210	5:1	210	370,295
Pit D1 Buttress	195	5:1	740	2,353,685
Pit D2 Buttress	230	5:1	720	2,897,380
Pit D3 Buttress	240	5:1	1450	5,785,820

6.3 Rock protection estimates

To prevent scour and erosion damage to the closure levees, associated with high velocity flows, rock protection is required along the levee, and buried beneath the surface. For the former, rock sizes have been estimated from the flow velocity and Austroads (2019) rock classifications, accounting for lateral migration of the low flow channel, and potential changes in velocity distribution during closure. These estimates are therefore more conservative than those presented in Section 5.5. The distribution of the rock classes along the respective levees is presented in Figure 6-4.

Scour and erosion will occur in the creeks and diversions during the design flood events and there is a risk of migration of low flow channels towards the levees. In both scenarios, scour could lead to undercutting of the toe of the levee which could lead to failure, if insufficient rock protection is provided. In the absence of a detailed scour assessment, using a combination of geotechnical information and flood modelling, an assumed depth for rock protection was provided. This value was assumed to be 2 m beneath the surface at each closure levee.

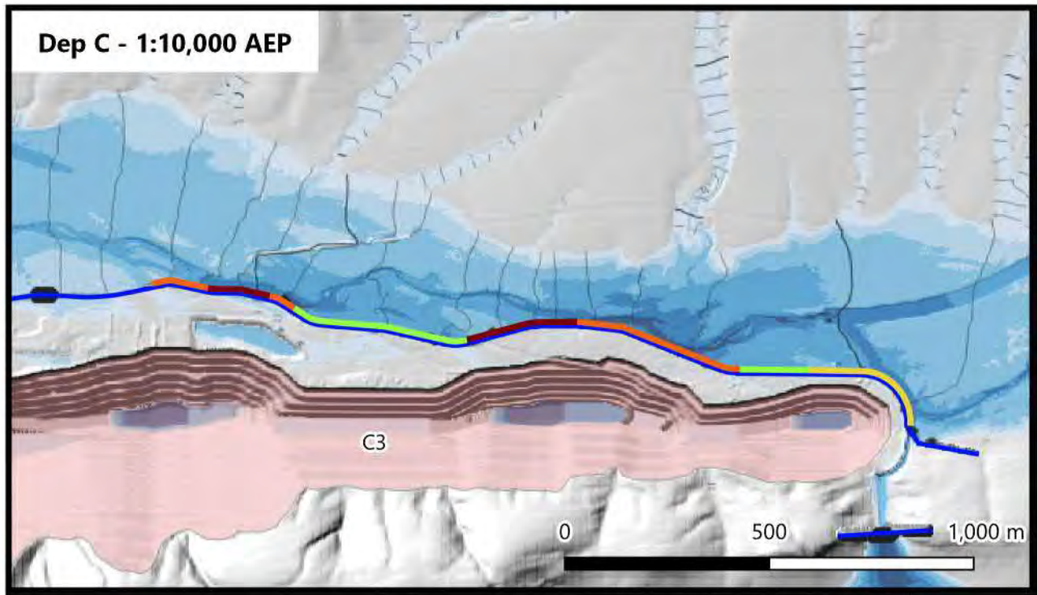
Based on the flow velocities, and assumed depth for scour protection, estimates for rock protection were made in 12D. The volumes of each rock class and cut required for rock protection beneath the surface is provided in Table 6-5. Note that if a source for competent rock onsite cannot be identified, costs for hauling rock from a nearby source (e.g. Newman) will need to be considered.

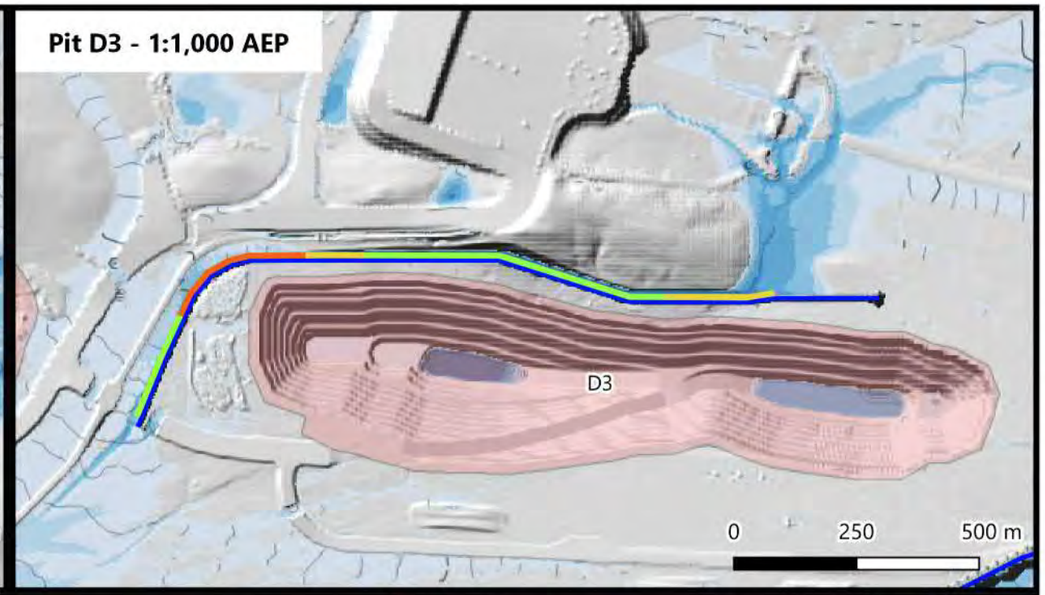
Table 6-5. Rock protection estimates for closure levee upgrades

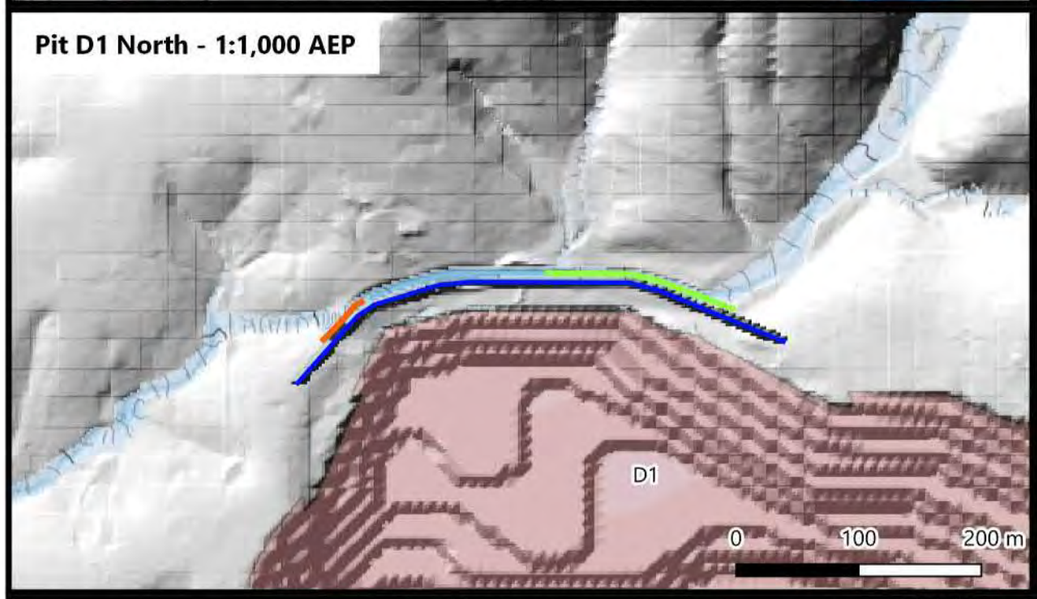
Location	Facing Class Rock (m^3)	Light Class Rock (m^3)	¼ Tonne Rock (m^3)	½ Tonne Rock (m^3)	Excavation for below ground for rock installation (m^3)
Pit C3 Levee	3,415	2,700	7,860	6,685	16,070
Pit D1 North Levee	770	n/a	345	n/a	2,045
Pit D1 South Levee	3,990	3,970	3,555	4,265	14,925
Pit D3 Levee	9,730	3,635	3,175	n/a	16,160
Deposit F Levee	9,180	7,470	1,475	n/a	19,365

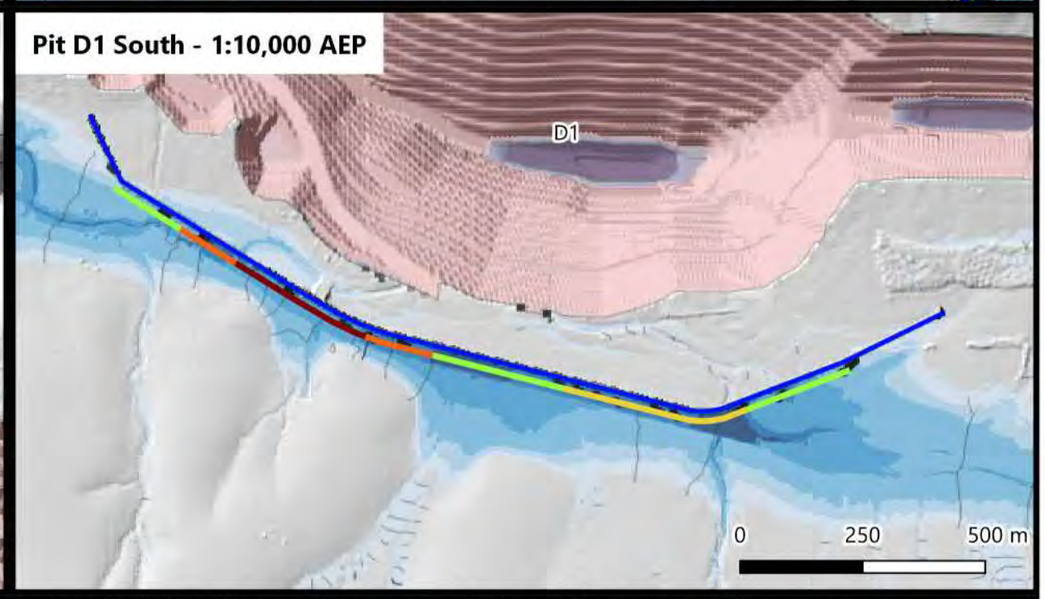
Surface Water Closure Strategy
West Angelas

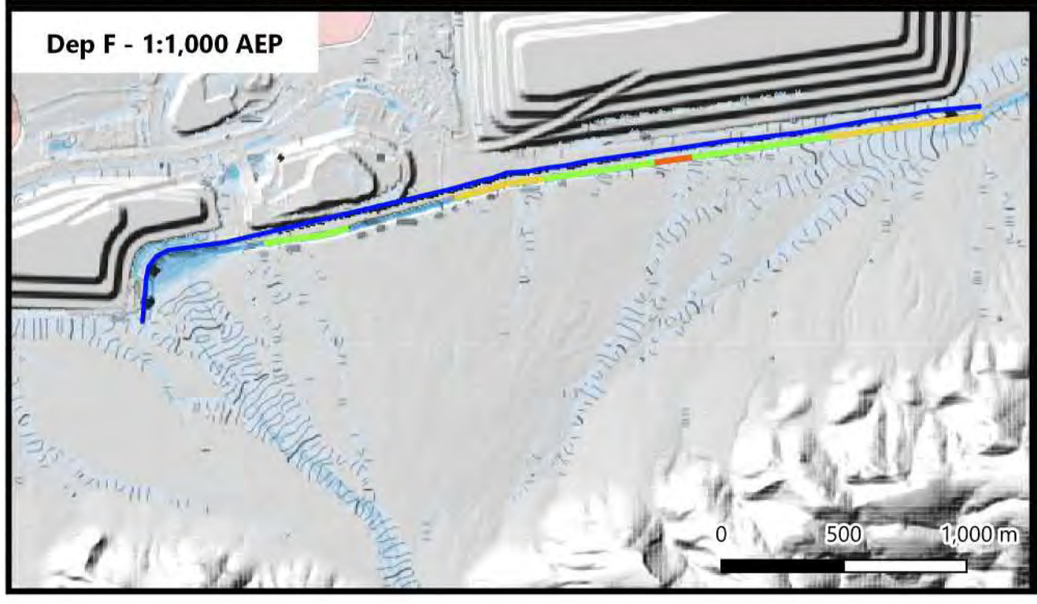
Figure 6-4: Rock Protection Classes

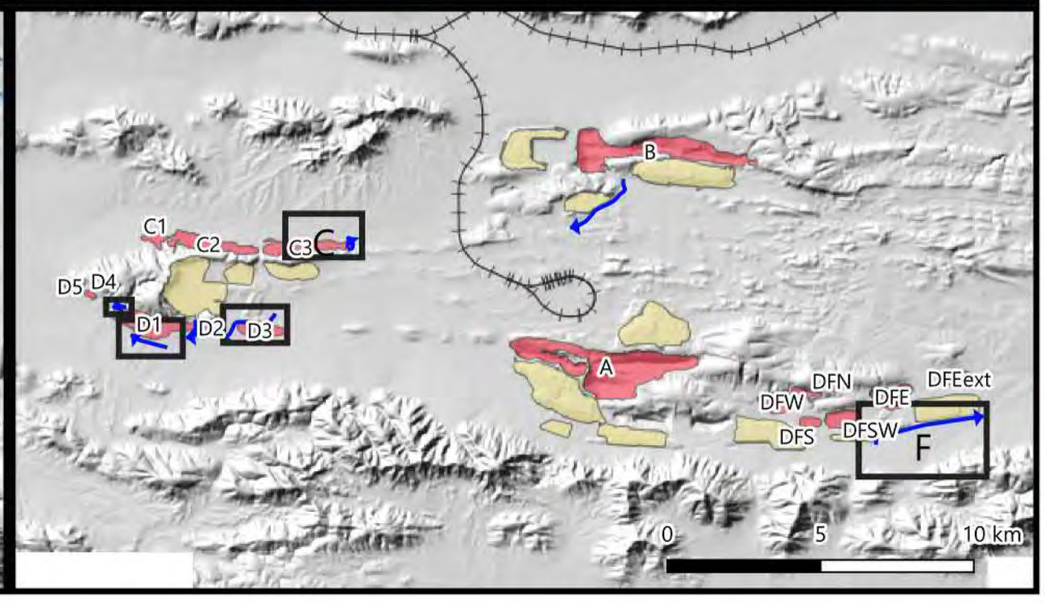












Legend

- Flood Levee Centrelines

Rock Protection Class

- 1/2 Tonne
- 1/4 Tonne
- Light
- Facing

Water Surface Elevation Contours

- 0.5 m
- 5.0 m

Flood Depth (m)

- 0.05 - 0.50
- 0.50 - 1.00
- 1.00 - 2.00
- 2.00 - 3.00
- 3.00 - 4.00
- > 4.00

Closure Landform Extents

- Pits
- Waste Dumps

Date: 22/11/2021
Projection: GDA94 / MGA zone 50

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6.4 Summary

Based on the revised designs, the material estimate for the concept design was refined, and is summarised in Table 6-6. This estimate is intended to represent the surface water infrastructure required above and beyond the backfilling that will occur to meet the minimum mine closure requirements (Rio Tinto, 2020a). This estimate is based on the information provided by Rio Tinto and within a ±50% accuracy.

Table 6-6 Material estimate for concept design

Location	Compacted Fill (m^3)	General Backfill (m^3)	Semi-engineered backfill (m^3)	Excavation (m^3)	Rock Protection (m^3)
Pit C3 Levee	47,855	-	-	16,070	20,660
Pit D1 North Levee	-	-	-	2,045	1,115
Pit D1 South Levee	49,885	-	-	14,925	15,780
Pit D3 Levee	2,420	-	-	16,160	16,540
Deposit F Levee	22,550	-	-	19,365	18,125
Deposit C Diversion	-	-	-	47,945	-
Pit C2 Buttress	-	370,295	-	-	-
Pit D1 Buttress	-	2,353,685	-	-	-
Pit D2 Buttress	-	2,897,380	-	-	-
Pit D3 Buttress	-	5,785,820	-	-	-
Total	**122,710**	**11,407,180**	**-**	**116,510**	**72,220**

Note that there is uncertainty around the types and availability of waste material onsite and further characterisation of this material is required.

7 Conclusions & recommendations

The surface water closure concepts have been assessed through a review of available data, flood modelling, geotechnical analysis, and material estimates. A summary of the project conclusions and recommendations for further assessment are provided below.

7.1 Conclusions

To meet the closure objectives at West Angelas, the surface water infrastructure at West Angelas is required to be designed to provide a safe, stable and non-polluting landform that protects the receiving environments. The hydrological and geotechnical investigations undertaken in this assessment demonstrate that this outcome will not be achieved by the operational infrastructure and current landform. Flood modelling of the operational infrastructure, initially by Rio Tinto (2020b) and updated by Advisian (this assessment), has identified that the high-risk areas during the closure design events are:

- Overtopping of the operational flood levees at Pit C3, Pit D3, and Deposit F.
- Bypass of the operational flood levee at Pit D1.
- High flow velocities at the eastern end of the Pit C3 levee, with high potential for scour and eventual creek capture.
- High flow velocities at the Pit D1 operational levee, and through the Deposit B diversion with potential for scour.

Three concept design options were identified as potentially feasible options for surface water management at closure: Option 1 (Operation Levee Upgrades), Option 2 (Reinstatement of Floodplains at Pit C3) and Option 3 (Spillway at Deposit B).

The closure options were tested to confirm compliance with the design criteria in the basis of design, then assessed in consultation with Rio Tinto to select the preferred option. The assessment compared earthworks quantities developed for each option using 12D civil design software and considered other criteria such as constructability, environmental and cultural/heritage risks and opportunities. The results of the option assessment are summarised below:

- Option 1 (*Operational Levee Upgrade*) requires less material and mine planning to implement but requires blocking a local catchment to reduce impinging flows on the closure levee, which presents a high risk of scour and erosion.
- Option 2 (*Floodplain Reinstatement at Pit C3*) removes approximately 1,500 m length of levee from the closure infrastructure, including the area of highest risk at Pit C3. Reinstating the floodplain also reduces flow velocities and provides additional catchment connectivity that improves environmental and cultural outcomes. The implementation of Option 2 requires considerable material volumes that, to be economical, would need to form part of operational backfilling to limit material movement, double handling and associated costs. There are also risks associated with long term settlement of backfill material which associated with floodplain activation or channel migration may lead to significant losses or creek capture.
- Option 3 (*Deposit B Spillway*) will be challenging to design and construct and the flood modelling results show only limited reductions in closure levee heights (<0.1 m) downstream at Pit C3. This option was the least preferred of the three options.

Option 1 and 2 both satisfy the basis of design and are considered potentially feasible options for closure. Option 1 was selected as the preferred for the following reasons:

- Option 1 is based on raising operational flood levees, which has fewer associated uncertainties and construction complexities when compared with reinstating a floodplain over a backfilled pit and has lower earthworks quantities.
- Option 2 requires assessment by Rio Tinto mine planners to determine if it is practical and offers suitable value with regards to closure outcomes. It also has complexities and uncertainties associated with the geotechnical and hydraulic design as well as the management of long-term settlement and stability risks. While potentially feasible and worth exploring further, more detailed assessments are required to confirm the feasibility of the concept.

Option 1 was subsequently progressed to conceptual design and design drawings and material estimates developed for all deposits.

7.2 Recommendations

This closure assessment has been undertaken with consideration of the data and information available at the time. As closure planning progresses, and prior to preparation of detailed designs, there are opportunities to improve the surface water closure concepts outlined in this assessment. Table 7-1 outlines the recommendations for investigations at West Angelas to assist with mine planning and closure designs, with a priority rating assigned.

Table 7-1. Recommendations

Item	Theme	Recommendation
1	Closure materials	A key data gap identified in this assessment is the lack of understanding of the waste material properties. The bulk material estimates assume a homogenous material without consideration of availability of different material for specific closure purposes (e.g. levees or buttressing). An inventory of the waste products should be prepared for the site, informed by testing of geotechnical parameters (including permeability, density and strength data). Classification of the respective erosion classes and dispersivity potential should also be undertaken. Establishing a material inventory/database, including the geographic location of material on site, will allow for detailed assessment of material use for closure. The database will be handed over to Operations to update as mining progresses.
2	Closure materials	The flood and geotechnical assessments identified the requirement for materials for surface water closure infrastructure (levee construction, pit buttressing, and rock protection). The establishment of a waste material inventory (Item 14) will allow for refinement of estimates of volumes (and types) of material required for this infrastructure and improvement of design (accounting for available material). Refiment of the designs should be undertaken and material requirements presented to Operations for identification and stockpiling of suitable material, particularly large and durable rocks, ahead of closure.
3	Geotechnical	Owing to the early stage of the project, a limited selection of mine pits was assessed, with a very limited number of geological cross-sections analysed for stability and seepage analysis within the sub-set of mine pits assessed.

Item	Theme	Recommendation
		Buttressing calculations should be refined through the analysis of multiple cross-sections at each pit to account for geological features on pit wall stability.
4	Mine Planning & Geotechnical	The assessment has identified two suitable options for closure: (1) upgrade of operational levees and (2) partial backfilling at Pit C3 and reinstating the creek floodplain over the backfill area. The latter would require geotechnical assessments and design of backfill to reinstate creek over C3 pit to address long term settlement and stability risk, and is reliant on mine planning to determine whether it is feasible to sequence backfilling during operations (either from Deposit C or G). This planning should also consider haulage distances for a cost/benefit analysis of the closure options and availability of suitable sources of competent rock protection.
5	Flood Modelling	Deposits (G) and Pits (AW1 – AW3) were not considered within this scope but should be assessed once pit design and operational surface water management is determined. Mining at Deposit G will impact Pit C3 and mining at Pits AW1-AW3 (and associated infrastructure) will impact Pit D1. These assessments should be considered prior to detailed design of the closure levees and future operational surface water infrastructure.
6	Levees	The geotechnical assessment indicates that the levee alignment at Pit D1 may be adjusted closer to the pit, widening the floodplain which may reduce the local flow velocity and depths. This optimisation should be considered in future project phases, alongside similar opportunities across the site, such as the downstream end of Pit C3.
7	Geotechnical	As outlined in Section 5.4.7, the levee at Pit D3 is within the PUPEZ, and further geotechnical and hydrological assessments are required to confirm buttressing at this location.
8	Diversions – Geomorphic design & geotechnical stability	The operational diversion at Deposit F is relatively straight and does not consider geomorphic design. All diversions at closure should be designed for analogue channel conditions, allowing for the channel to achieve a dynamic equilibrium which would minimise upstream, in-channel and upstream impacts. Geotechnical stability of cut slopes should also be considered. This should extend to consideration of shallow alluvial aquifers and provision of a substrate for vegetation establishment. A review of the site geomorphology should be undertaken to define pre-mining analogue conditions to guide the closure design of diversions and identify any areas of potential instability, which may require additional design controls.
9	Flood Modelling	The flood modelling undertaken in this assessment assumes no changes to waterways, however the diversion channel downstream of Deposit B presents a potential point of failure from blockage or erosion/scour. The consequence of a failure is unknown but is anticipated to affect Deposits C and G. Further modelling should be undertaken to assess failure scenarios and impacts.
10	Flood Modelling / Climate Change	Climate change impacts on the flood modelling and closure designs have not been considered in this assessment. As with the additional modelling scenarios outlined above, the sensitivity of the design to climate change should be considered where applicable through modelling of climate

Item	Theme	Recommendation
		scenarios with increased rainfall intensity in accordance with ARR (2019). Further assessment of the hydrology at infrastructure locations is required to determine the peak flow estimates (rather than relying on the existing site-wide assessment)
11	Geotechnical	With the improvement of material classification buttressing designs can be progressed to include shape, bench and inter-bench distances.
12	Geotechnical	There is limited earthquake (seismic) peak ground acceleration across different AEP. In consideration of the limited peak ground acceleration data, a simplified pseudo-static analysis was undertaken for the pit wall stability assessments. In future project phases a site-specific hazard assessment for earthquakes across a range of AEP should be prepared, including consideration of dampening and amplification factors.
13	Environment	The Cracking Clay Priority Ecological Community (PEC) is listed as a Priority One community and is noted as a key environmental feature at West Angelas. The PEC is dependent on sheetflow and additional TUFLOW modelling of frequent flows could be undertaken to confirm that closure assumptions do not disturb local catchment connectivity and ensure no direct or indirect disturbance to the PEC, consistent with the Ministerial Statement 1113.
14	Flood Modelling	The outcomes of this project are based on the closure assumptions, particularly with regards to rail, road, and conveyor infrastructure. Further flood modelling scenarios could be considered to assess retaining the infrastructure (and associated culverts) and/or complete removal. This assessment will inform decision-making over closure infrastructure by informing potential material requirements with each infrastructure scenario.
15	Flood Modelling	The focus of this assessment was prevention of pit capture during the design event (1:10,000 AEP for waterways and 1:1,000 AEP for local catchments). Frequent flows that support ecological functions have not been explicitly modelled to assess impacts on Karijini National Park (or other key sites). Assessment of frequent events in TUFLOW, or a long-term flow assessment (GOLDSIM) could be considered to confirm environmental flows are maintained, characterise any impacts and determine suitable closure strategies.
16	Flood Modelling	If Option 2 is identified as the preferred option, TUFLOW modelling of more frequent events should be undertaken to assess the activation of backfill areas. The more regular the activation, the higher degree of engineering controls, re-vegetation and over-tipping initial lifts (to allow settlement before completion of the final landform) will be required to reduce risks from scour, erosion, channel migration and settlement.
17	Mine Planning	Backfilling estimates and waste dump volumes are based on June 2021 data provided by Rio Tinto. Any significant changes to the backfilling strategies or waste dump volumes should be assessed against these surface water concepts.

Item	Theme	Recommendation
18	Mine Planning	Haulage distances have not been estimated in this assessment, owing to lack of information with respect to material characterisation. These distances should be considered to determine closure cost estimates.
19	Flood Modelling	The post-closure landform before riparian vegetation has been established should be considered. At this point in time, there is elevated risk of erosion as there is less channel roughness (therefore higher flow velocities). If riparian vegetation growth exceeds the channel roughness that has been modelled, flood levels may exceed the results. Therefore, further modelling to assess the result sensitivity to roughness should be undertaken. Similarly, consideration should be given to adjusting levee alignments to ensure that velocities and stream power are similar to natural reaches and allow vegetation to establish in alluvial (or similar blasted in-situ) material, at similar densities to pre-development conditions. Velocities and shear should not pose a risk of excessive erosion/loss of alluvium material from the channels which can pose long term stability risks within the channel as well as upstream/downstream.
20	Flood Modelling	The diversion channel upstream of Pit C3 was applied to all options to reduce flow velocities along the levee. Further TUFLOW modelling is required to confirm its effectiveness, optimise the design and include geomorphic features. There is also the opportunity to adjust the alignment of the levee at the downstream end of Pit C3 to widen the floodplain and improve the replication of natural geomorphic features of the creek.
21	Geotechnical	Geotechnical testing across the site is concentrated to pit areas, with limited information elsewhere. Additional testing should be undertaken, particularly near proposed levee locations to confirm levee construction requirements and long-term groundwater levels. Additional groundwater level modelling should also be undertaken in future studies to ensure stability assessments incorporate the latest data.
22	Levee Rock Protection	Rock protection estimates are based on a basic relationship between flow velocities and rock classification. These estimates should be refined though consideration of a multi-layered rock armour approach, with a combination of various rock classes (up face of the levee) to improve long term stability. Refined rock volumes may assist with identification of sources for various rock armour classes that may be available onsite at West Angelas.
23	Levee Rock Protection	The depth of rock protection extending down the face of the levee and beneath the surface is based on a uniform value across the site. Local conditions, including particle size distribution, low flow channel conditions and TUFLOW modelled velocity/depth results, influence the predicted scour and corresponding depth of rock protection. These parameters are used in empirical equations to predict scour depths. Additional data, not available in this assessment, would allow definition of subsurface rock protection requirements and improve the accuracy of volume estimates of respective rock classes required for closure designs.
24	Levee Stability	Other failure mechanisms for the levees, such as tree collapse / tree roots, meander migration, exposure to frequent events (wetting and drying),

Item	Theme	Recommendation
		piping and face erosion also require consideration in the final designs, particularly with regards to bank slopes and crest widths.
25	Safety	The identification of hazards of the proposed options has not been completed with Rio Tinto stakeholders. A hazard identification study (HAZID) workshop could be completed to identify key risks, uncertainties and opportunities associated with the preferred diversion options. Beyond safety considerations, the workshop may review issues like constructability and should include a wide range of Rio Tinto stakeholders. Potential actions and management measures could be incorporated into the design in future project phases.

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Appendix A
Design rainfalls

The 1,:10,000 AEP design rainfall depth is determined by interpolation of more frequent rainfall depths and the Probable Maximum Precipitation (PMP). The PMP estimate is a function of catchment area: that is, there is an Areal Reduction Factor (ARF) built into the method. Therefore, the more frequent design depths must also be areally reduced prior to the interpolation being undertaken. This is outlined in ARR2019 Book 8, Chapter 3.5 (Nathan and Weinmann, 2019).

The provided TUFLOW model design rainfall events had used point rainfall depths for the interpolation, resulting in an artificially high 1:10,000 AEP design depth. For this study, catchments reporting to the flood levees at Pit C3 and Pit D1 South were of interest for the 1:10,000 AEP design flood: the corresponding design depths are presented in Table B-1.

Table B-1. Comparison of point depths and adopted design rainfall depths.

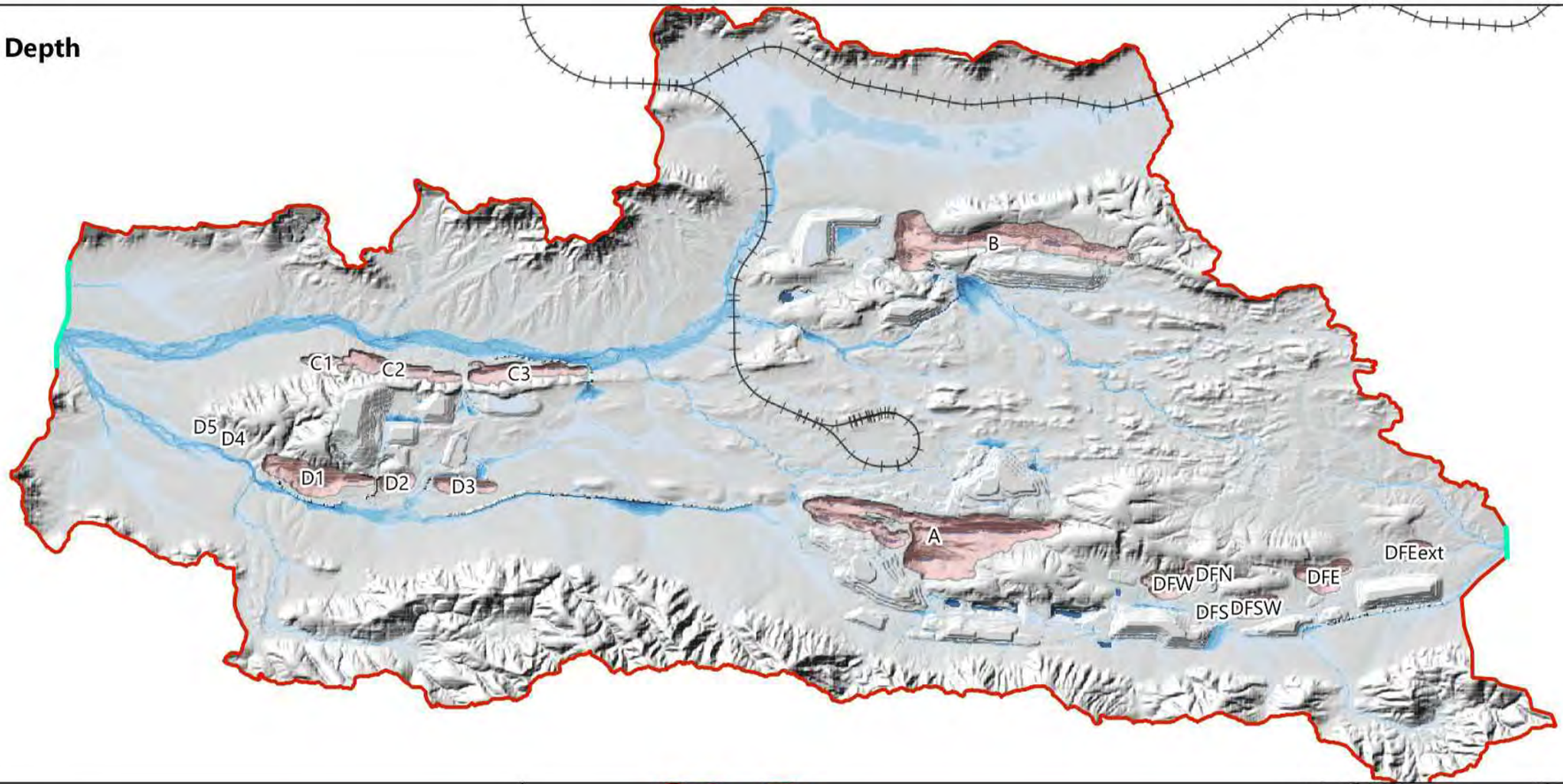
Catchment ID	Area (km^2)	Duration	Areally reduced Rainfall Depth (mm)			
			0.1% AEP	0.05% AEP	0.01% AEP	PMP
Provided (site-wide)	Point	6-hour	191	214	279	855
TCE at Pit C3	132	6-hour	160	178	226	673
TCE Trib at Pit D1	55.5	6-hour	168	186	238	713

For the minor design infrastructure, the 1:1,000 AEP event was adopted, with ARFs applied to each reporting catchment according to catchment area. These were calculated directly from the BoM point depth per ARR19 Book 2, Chapter 4 (Jordan et al 2019).

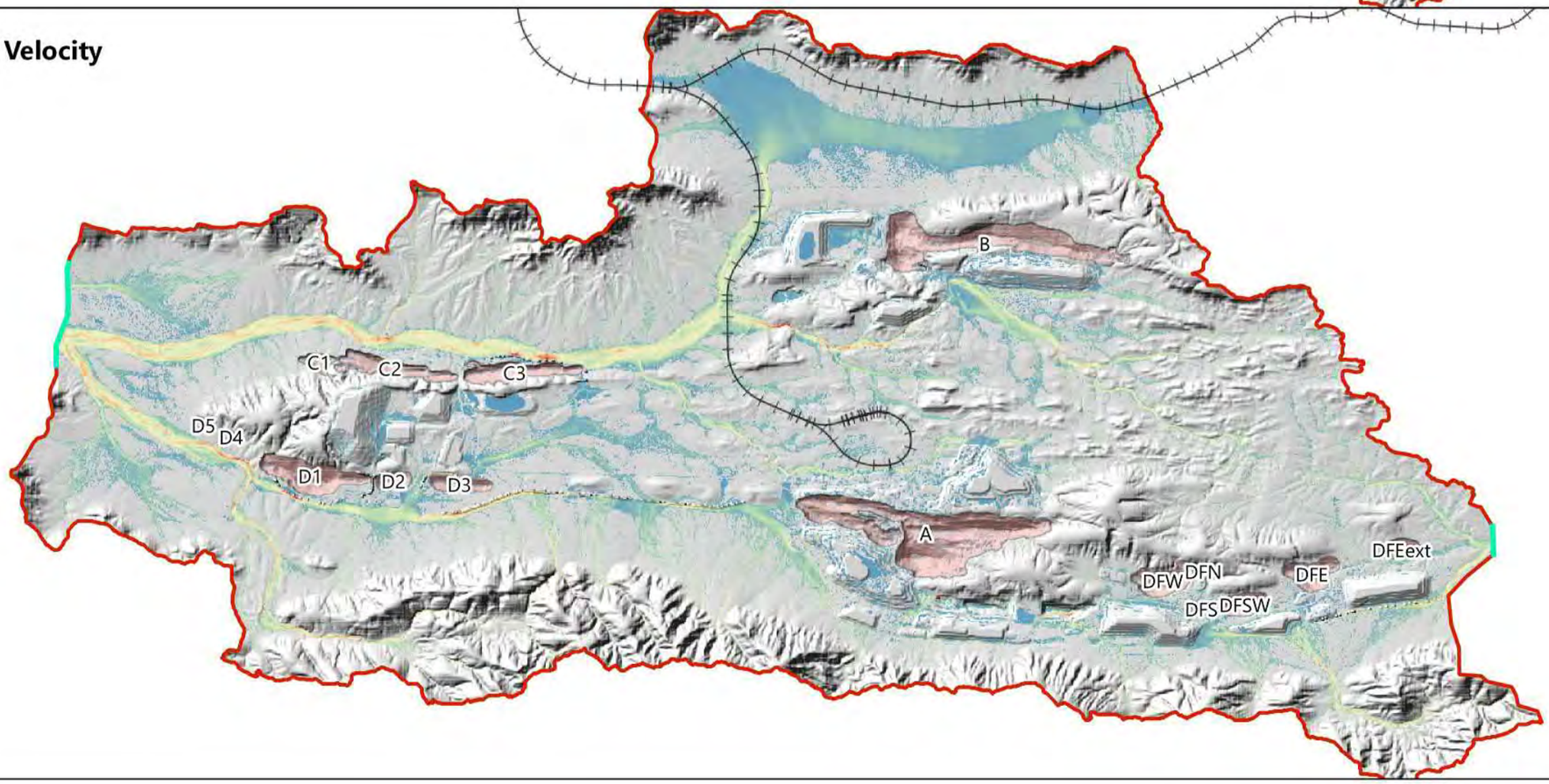
Temporal patterns and ILCL values were unchanged from the provided design hydrology as reported by Rio Tinto (2020b).

Appendix B
1:10,000 AEP floodplain mapping

Peak Depth



Peak Velocity



Surface Water Closure Strategy
West Angelas

Appendix B: Option 1 Flood Results - 1:10,000 AEP

Legend

- Rail Network
- LOM Pit Outlines
- Outflow Boundary
- 2D Model Domain

Flood Depth (m)

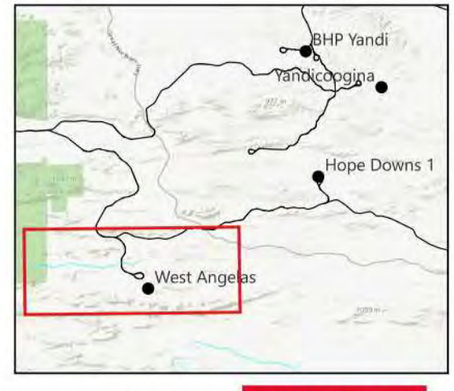
- 0.05 - 0.50
- 0.50 - 1.00
- 1.00 - 2.00
- 2.00 - 3.00
- 3.00 - 4.00
- > 4.00

Flood Velocity (m/s)

- 4
- 0

0 2.5 5 km

Date: 23/02/2022
Projection: GDA94 / MGA zone 50



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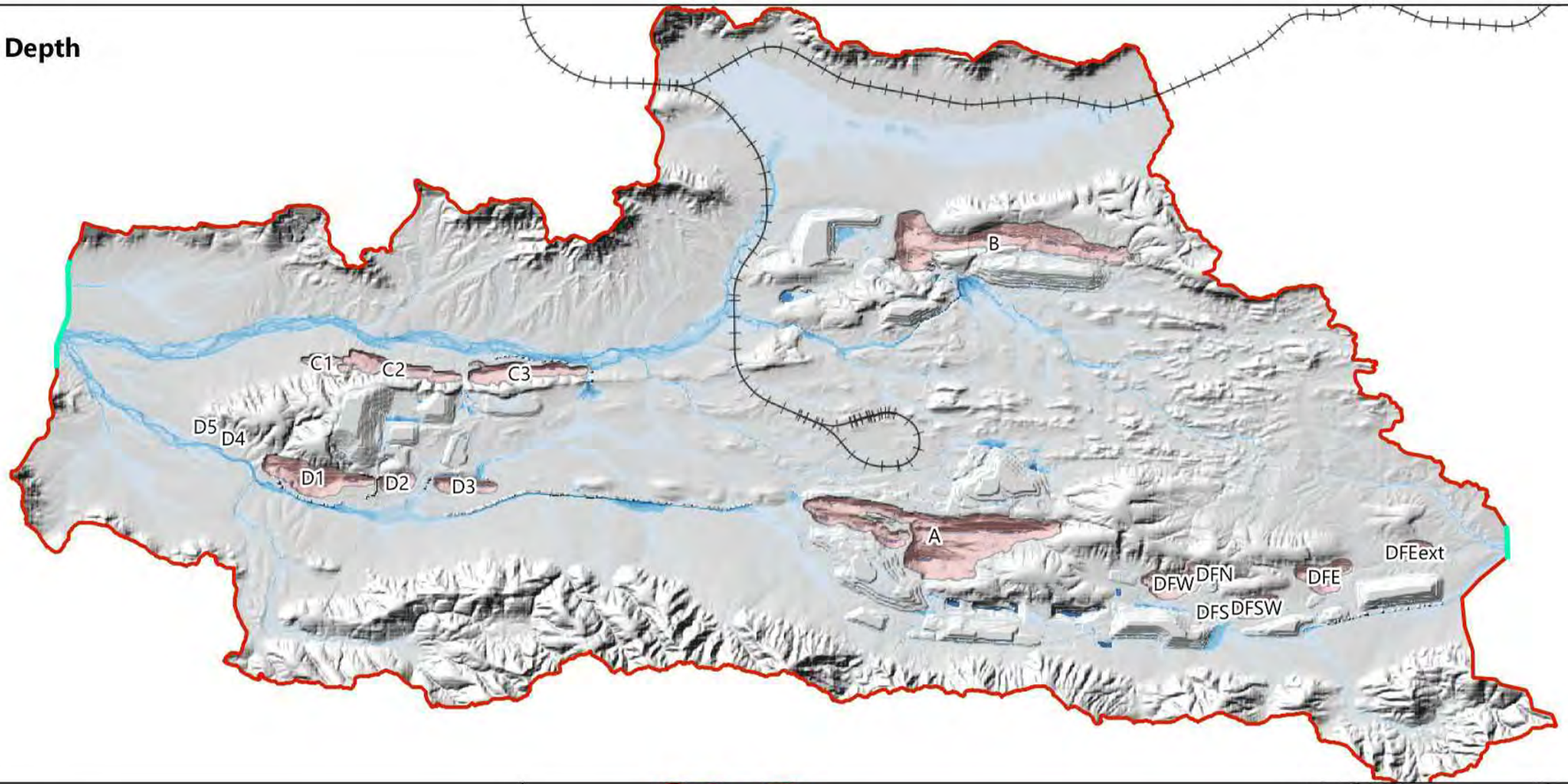
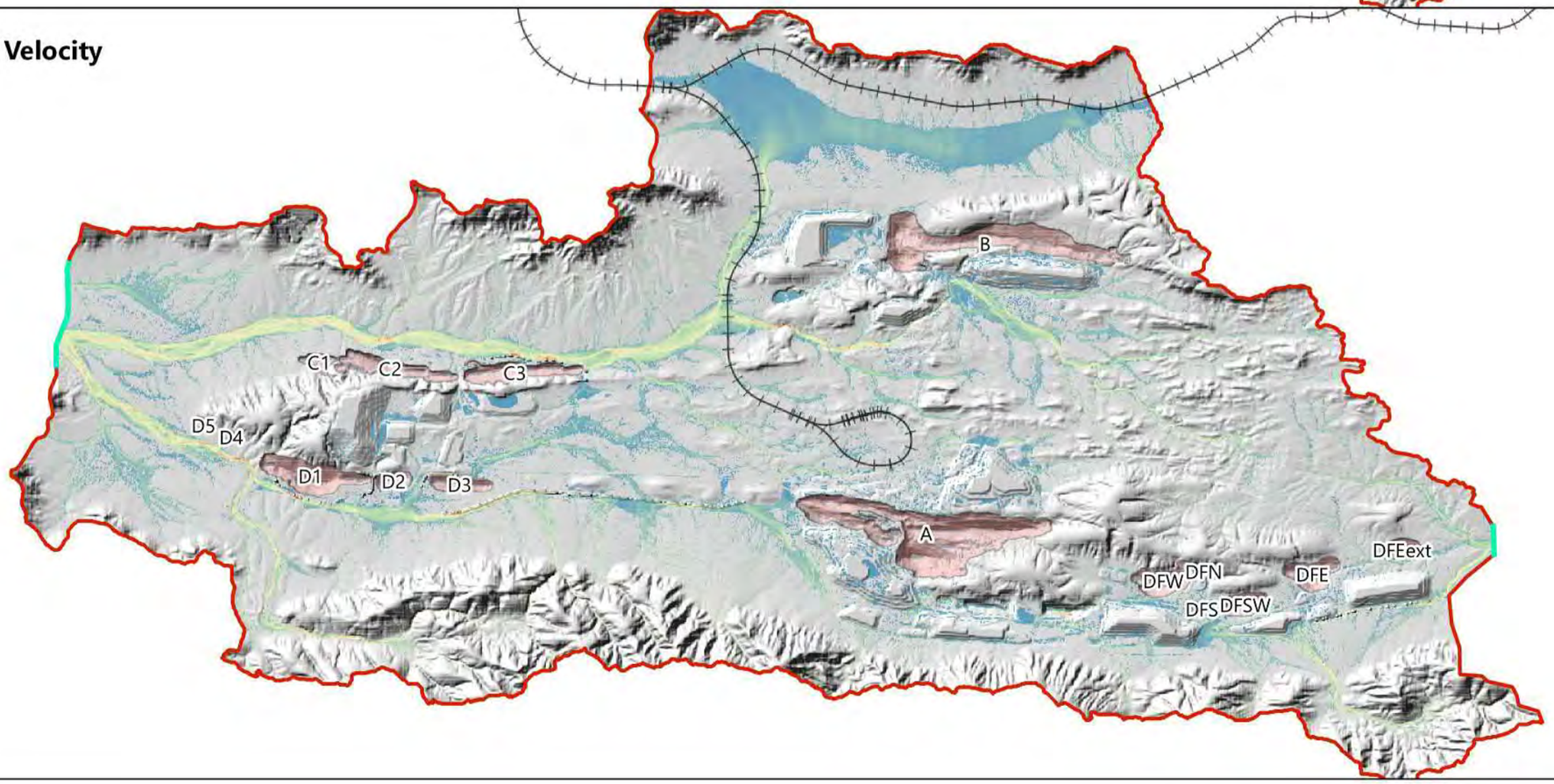
RioTinto

Peak Depth



Peak Velocity



Surface Water Closure Strategy
West Angelas

Appendix B: Option 1 Flood Results - 1:1,000 AEP

Legend

- Rail Network
- LOM Pit Outlines
- Outflow Boundary
- 2D Model Domain

Flood Depth (m)

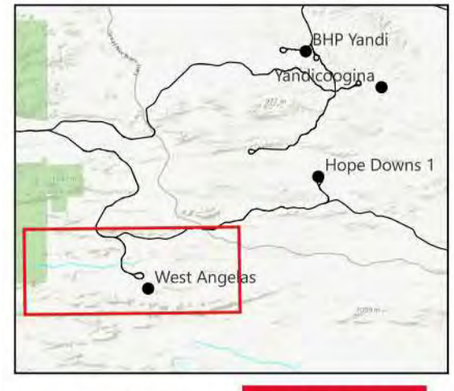
- 0.05 - 0.50
- 0.50 - 1.00
- 1.00 - 2.00
- 2.00 - 3.00
- 3.00 - 4.00
- > 4.00

Flow Velocity (m/s)

- 4
- 0

0 2.5 5 km

Date: 23/02/2022
Projection: GDA94 / MGA zone 50



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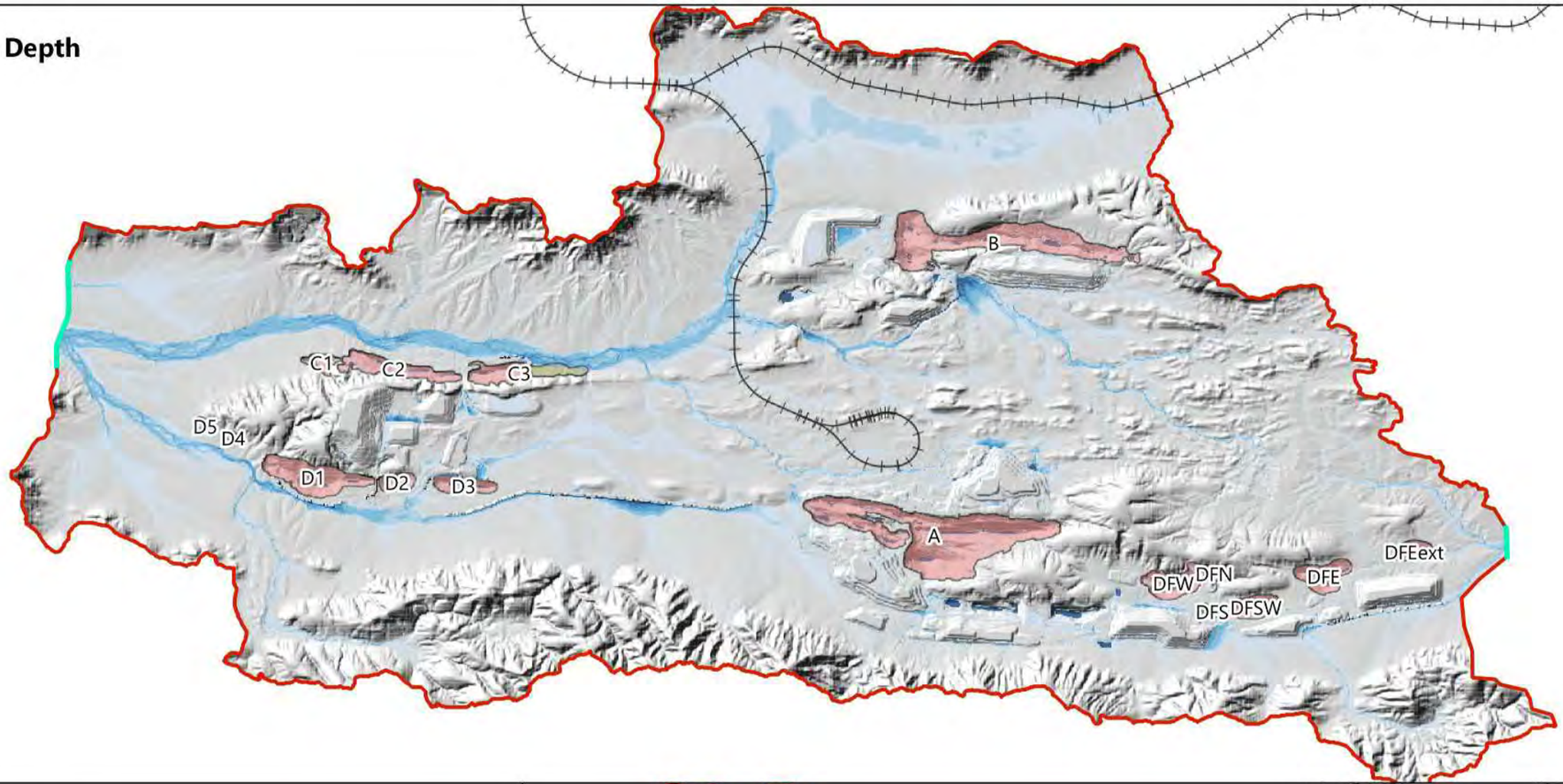
Peak Depth



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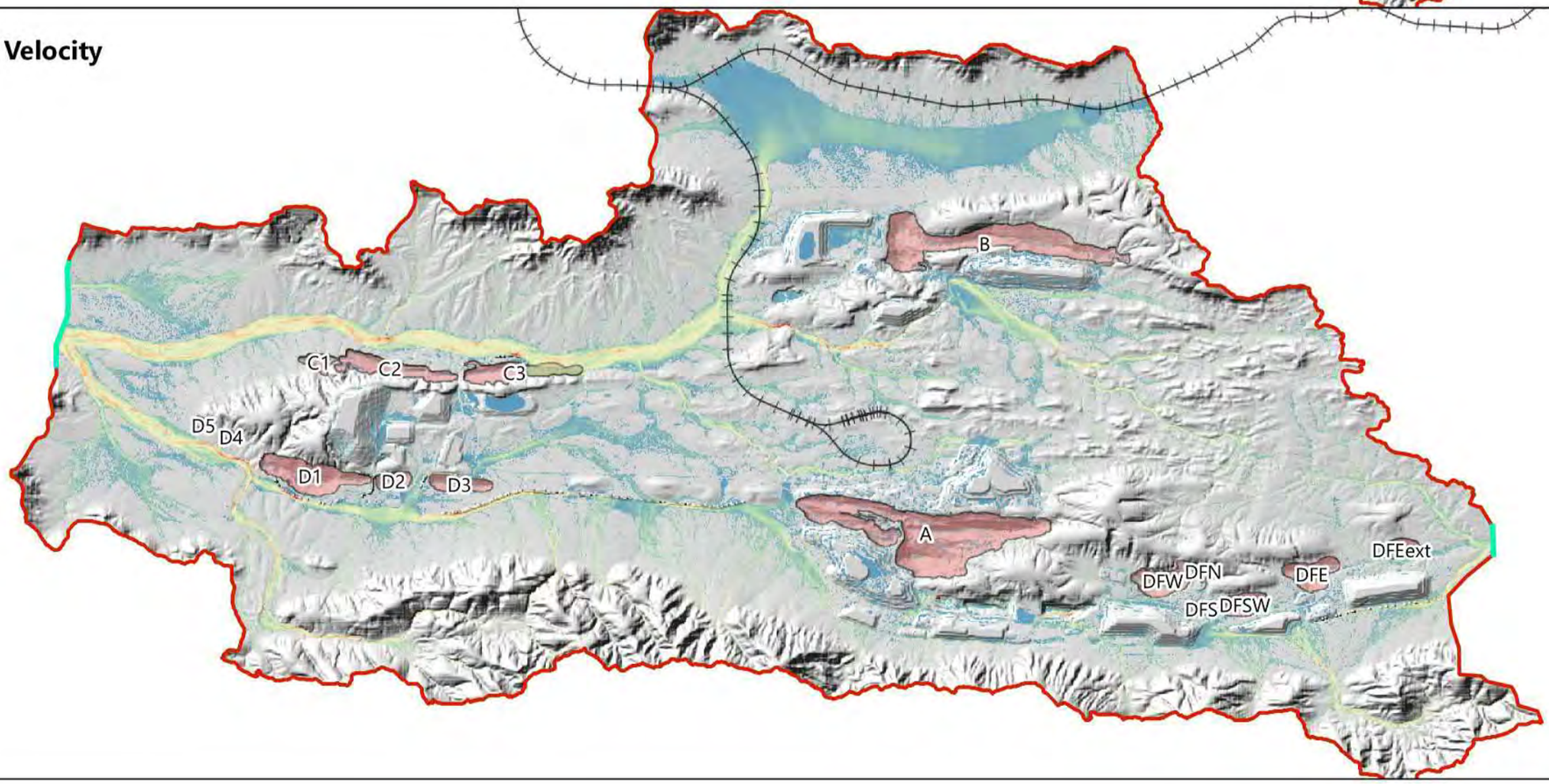


Surface Water Closure Strategy
West Angelas

Appendix B: Option 2 Flood Results - 1:10,000 AEP

Legend

- Rail Network
- LOM Pit Outlines
- Re-instated Floodplain
- Outflow Boundary
- 2D Model Domain

Flood Depth (m)

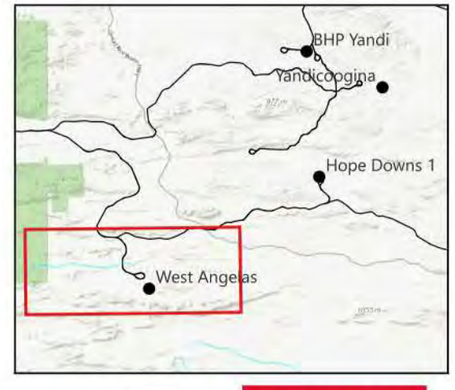
- 0.05 - 0.50
- 0.50 - 1.00
- 1.00 - 2.00
- 2.00 - 3.00
- 3.00 - 4.00
- > 4.00

Flow Velocity (m/s)

- 4
- 0

0 2.5 5 km

Date: 23/02/2022
Projection: GDA94 / MGA zone 50



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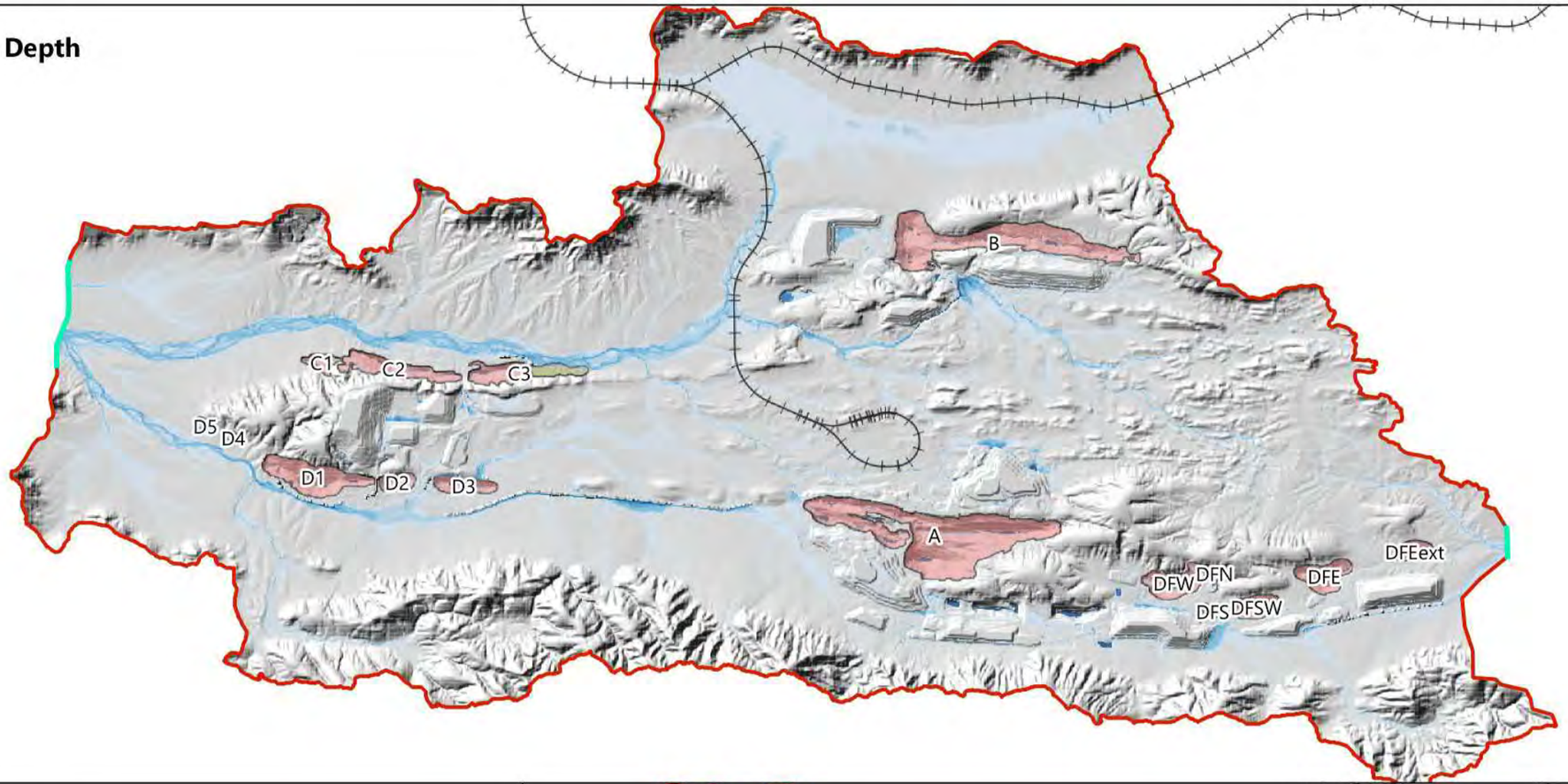
Peak Depth



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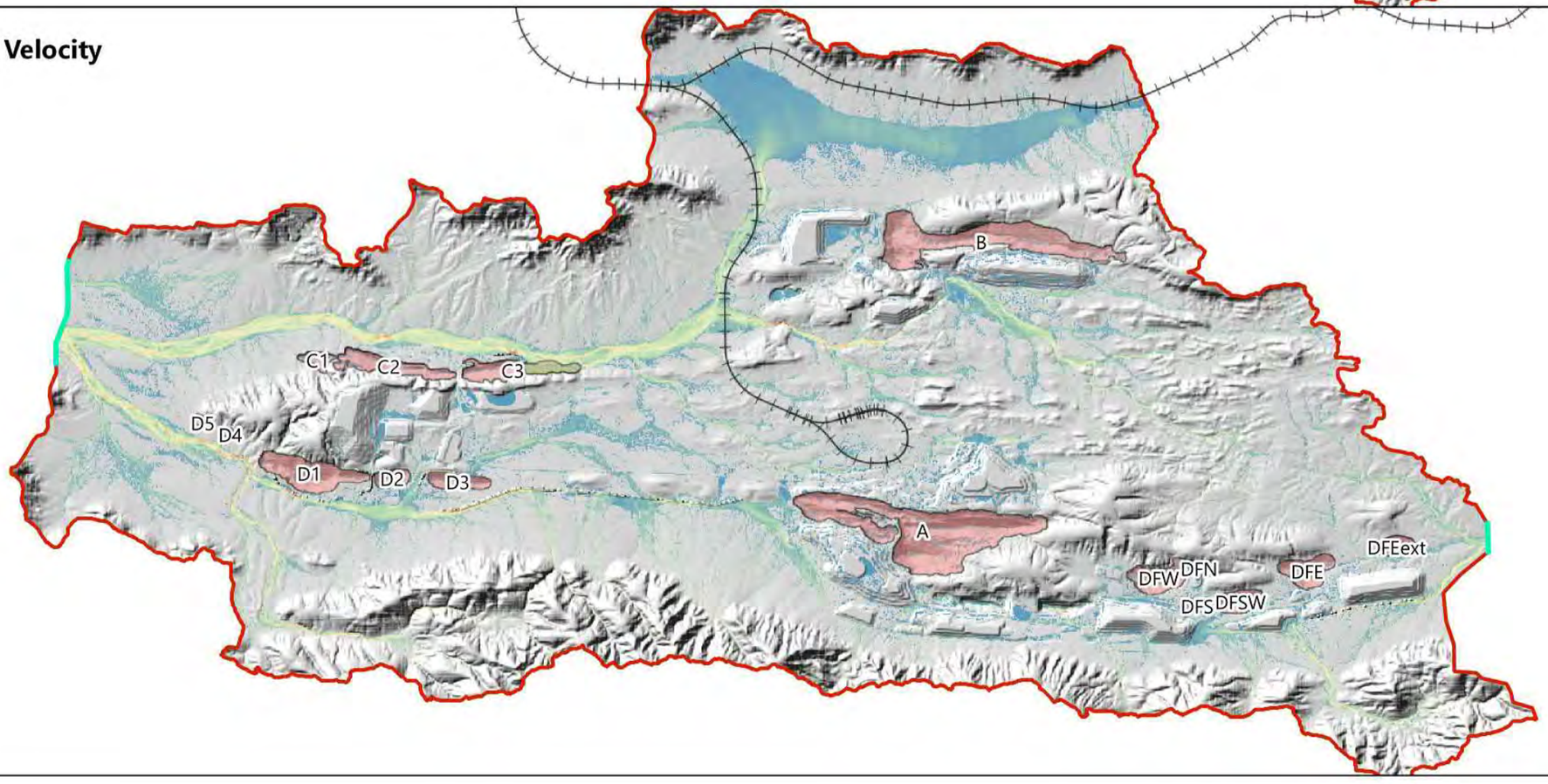


Surface Water Closure Strategy
West Angelas

Appendix B: Option 2 Flood Results - 1:1,000 AEP

Legend

- Rail Network
- LOM Pit Outlines
- Re-instated Floodplain
- Outflow Boundary
- 2D Model Domain

Flood Depth (m)

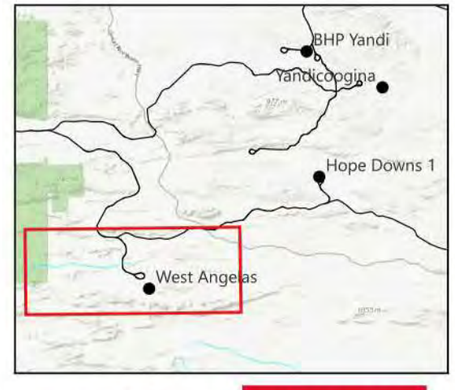
- 0.05 - 0.50
- 0.50 - 1.00
- 1.00 - 2.00
- 2.00 - 3.00
- 3.00 - 4.00
- > 4.00

Flow Velocity (m/s)

- 4
- 0

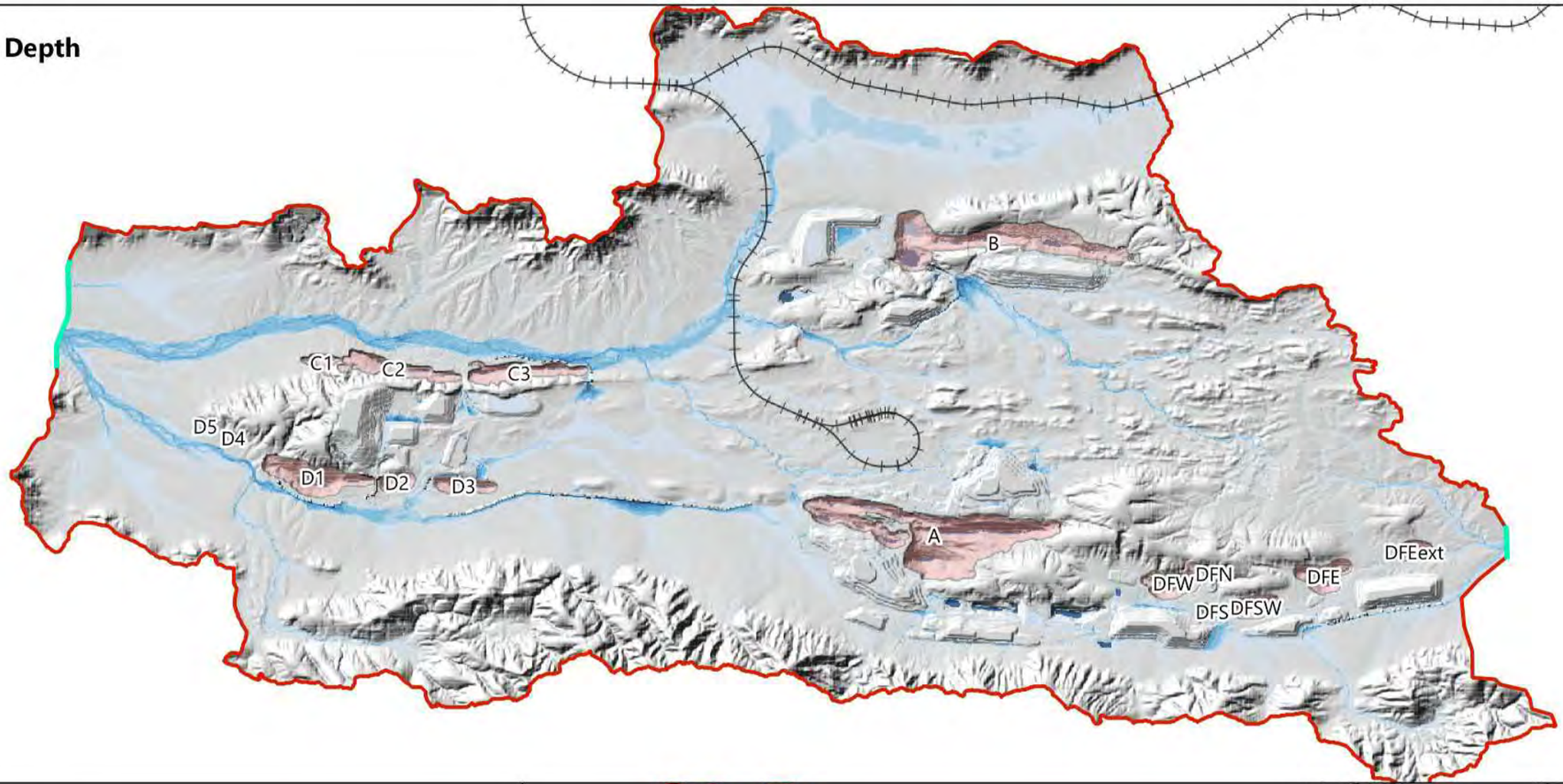
0 2.5 5 km

Date: 23/02/2022
Projection: GDA94 / MGA zone 50



Advisian RioTinto

Peak Depth



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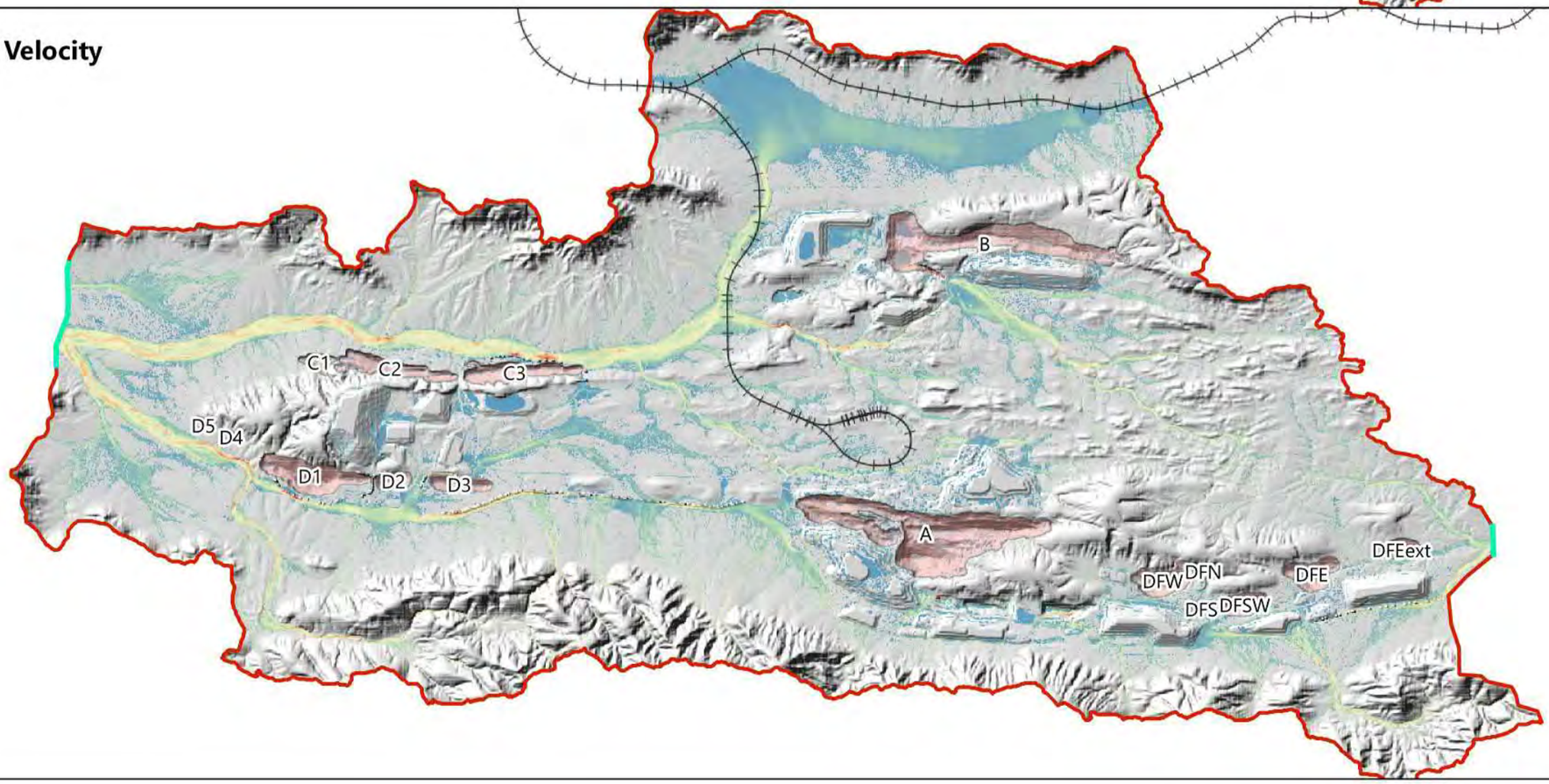


Surface Water Closure Strategy
West Angelas

Appendix B: Option 3 Flood Results - 1:10,000 AEP

Legend

- Rail Network
- LOM Pit Outlines
- Outflow Boundary
- 2D Model Domain

Flood Depth (m)

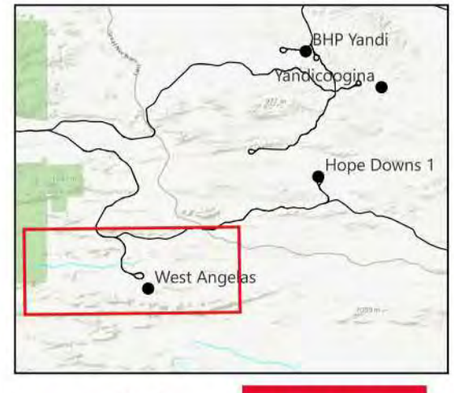
- 0.05 - 0.50
- 0.50 - 1.00
- 1.00 - 2.00
- 2.00 - 3.00
- 3.00 - 4.00
- > 4.00

Flow Velocity (m/s)

- 4
- 0

0 2.5 5 km

Date: 23/02/2022
Projection: GDA94 / MGA zone 50



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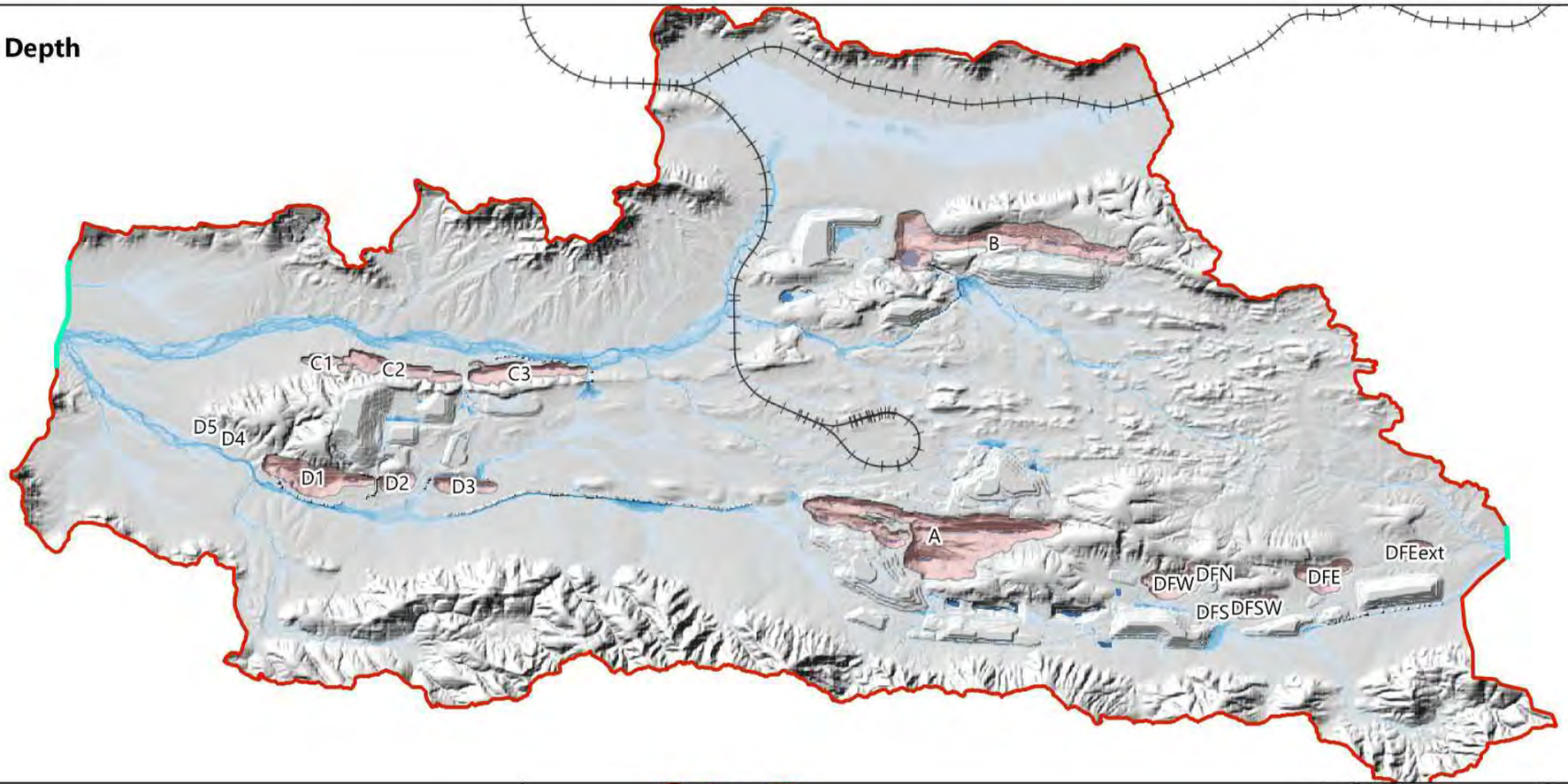
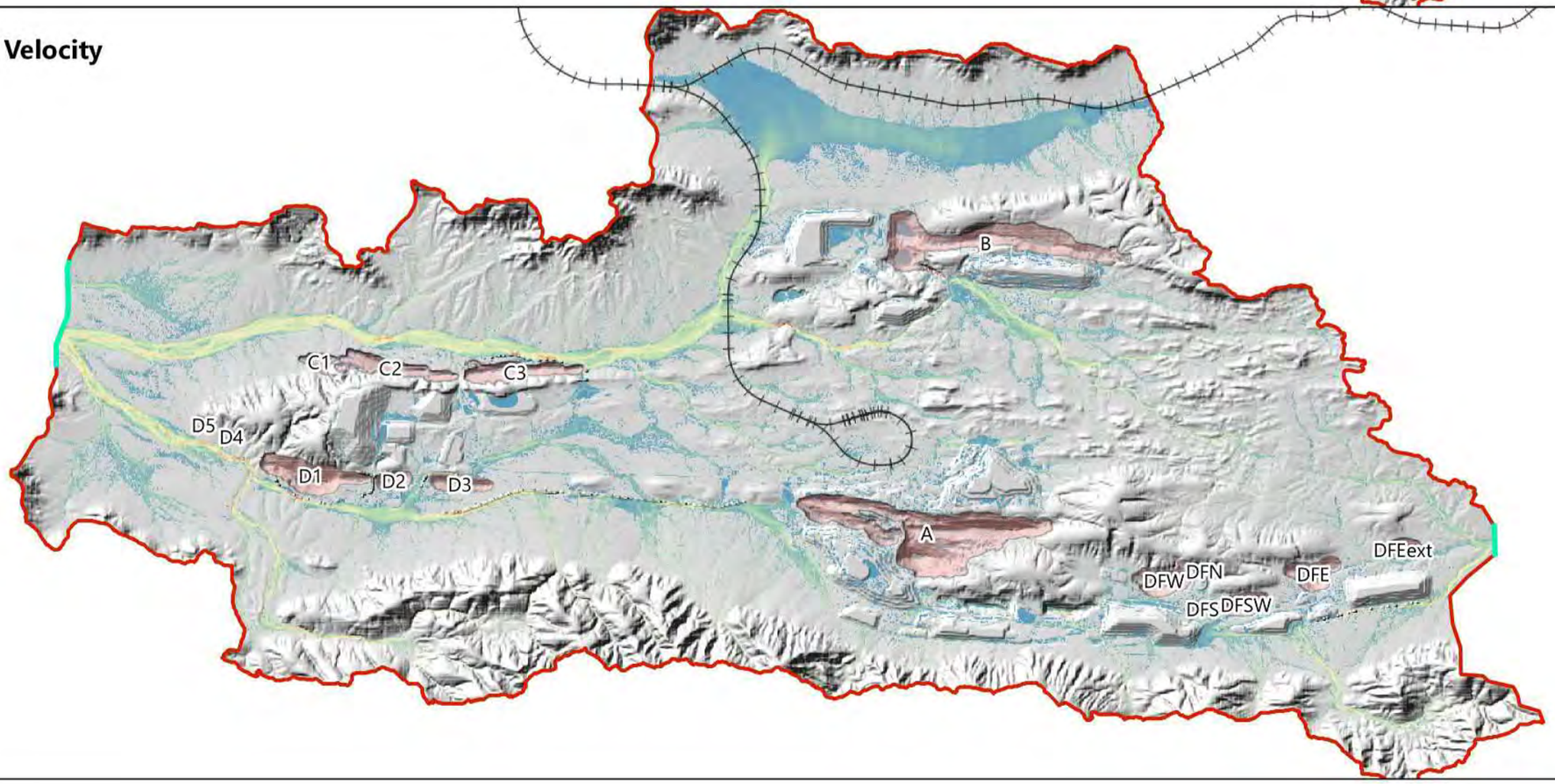
RioTinto

Peak Depth



Peak Velocity



Surface Water Closure Strategy
West Angelas

Appendix B: Option 3 Flood Results - 1:1,000 AEP

Legend

- Rail Network
- LOM Pit Outlines
- Outflow Boundary
- 2D Model Domain

Flood Depth (m)

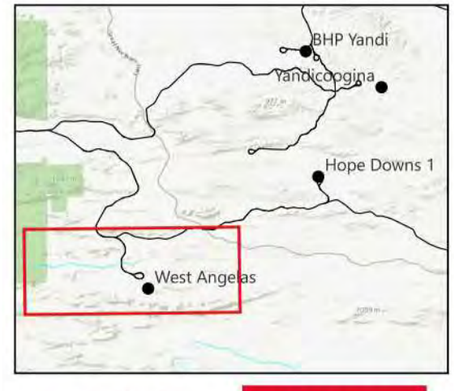
- 0.05 - 0.50
- 0.50 - 1.00
- 1.00 - 2.00
- 2.00 - 3.00
- 3.00 - 4.00
- > 4.00

Flow Velocity (m/s)

- 4
- 0

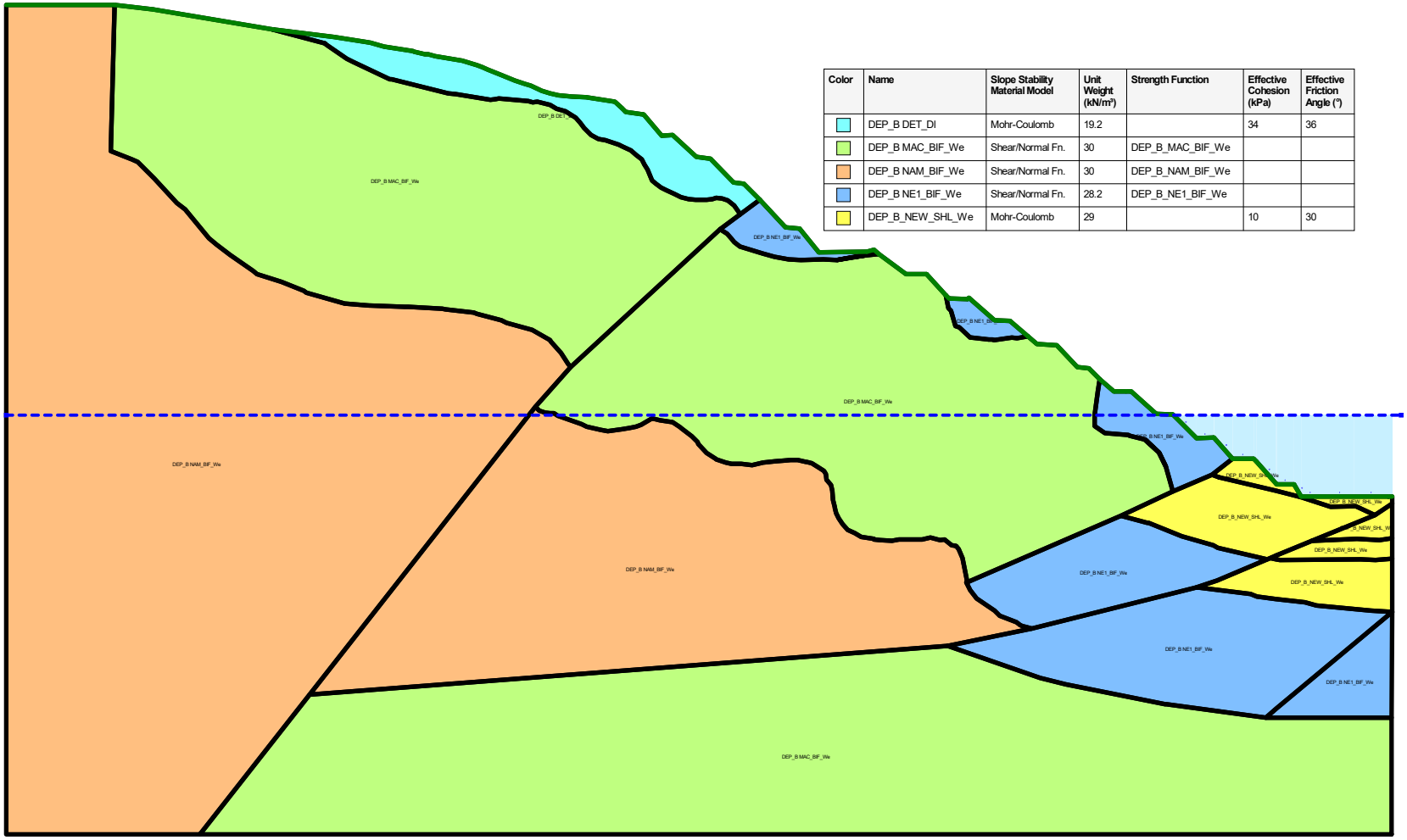
0 2.5 5 km

Date: 23/02/2022
Projection: GDA94 / MGA zone 50



Advisian
RioTinto

Appendix C
Pit wall and backfill assessment

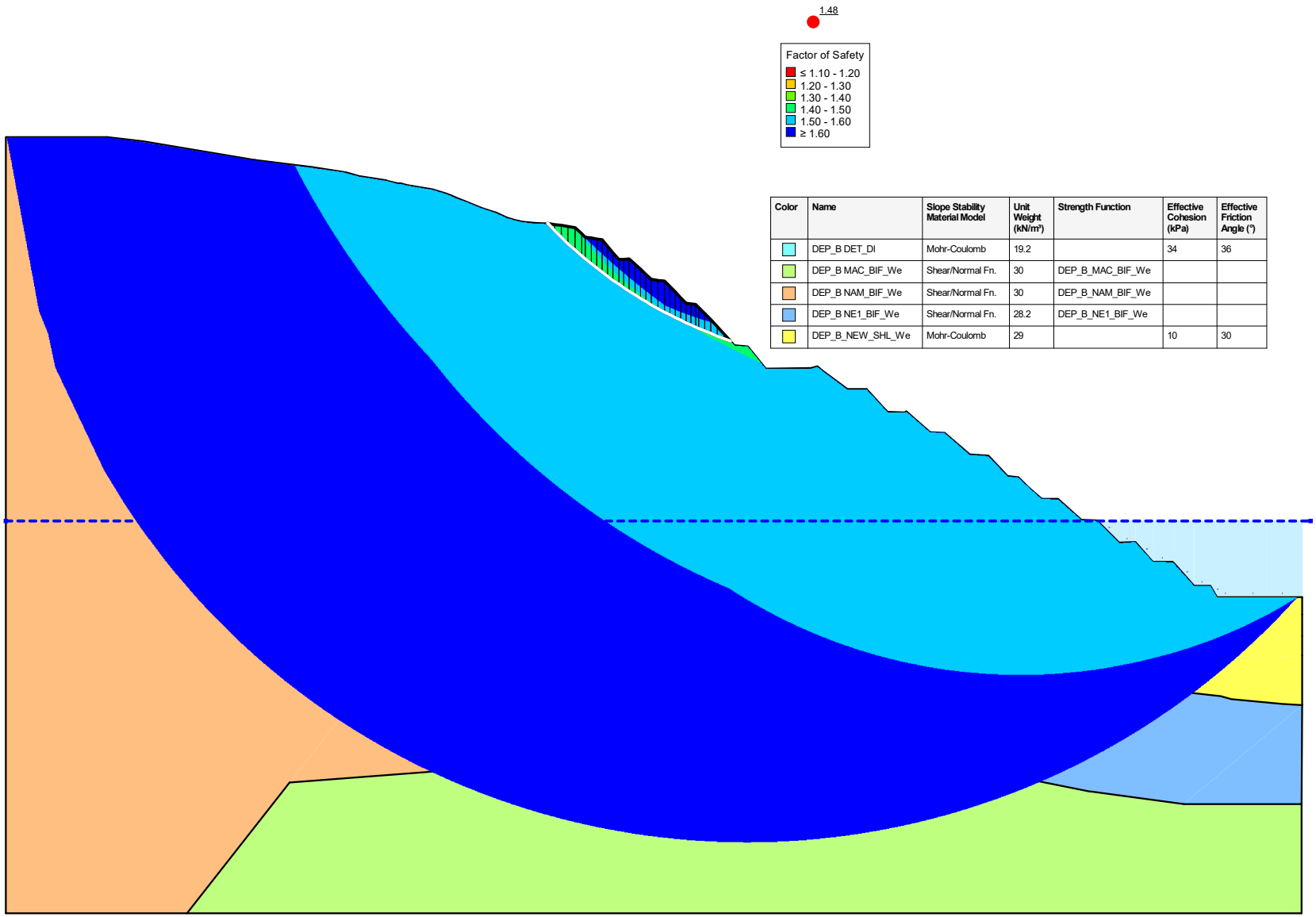


Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Strength Function	Effective Cohesion (kPa)	Effective Friction Angle (°)
	DEP_B DET_DI	Mohr-Coulomb	19.2		34	36
	DEP_B MAC_BIF_We	Shear/Normal Fn.	30	DEP_B_MAC_BIF_We		
	DEP_B NAM_BIF_We	Shear/Normal Fn.	30	DEP_B_NAM_BIF_We		
	DEP_B NE1_BIF_We	Shear/Normal Fn.	28.2	DEP_B_NE1_BIF_We		
	DEP_B_NEW_SHL_We	Mohr-Coulomb	29		10	30

Dep B XS1 - geometry

West Angelas

01/10/2021 1:2,750

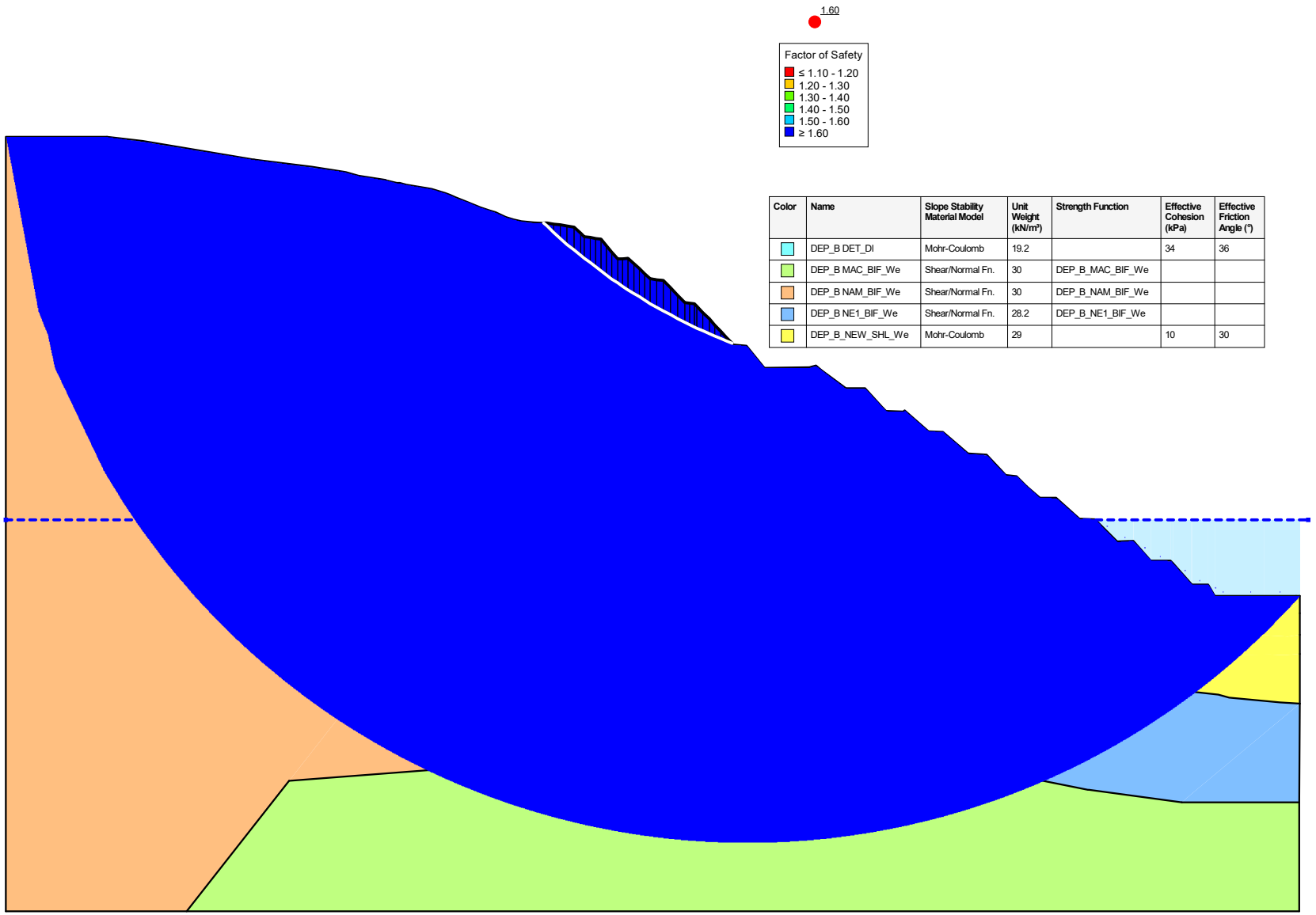


Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Strength Function	Effective Cohesion (kPa)	Effective Friction Angle (°)
	DEP_B DET_DI	Mohr-Coulomb	19.2		34	36
	DEP_B MAC_BIF_We	Shear/Normal Fn.	30	DEP_B_MAC_BIF_We		
	DEP_B NAM_BIF_We	Shear/Normal Fn.	30	DEP_B_NAM_BIF_We		
	DEP_B NE1_BIF_We	Shear/Normal Fn.	28.2	DEP_B_NE1_BIF_We		
	DEP_B_NEW_SHL_We	Mohr-Coulomb	29		10	30

Dep B XS1 pseudo-static

West Angelas

30/09/2021 1:2,750



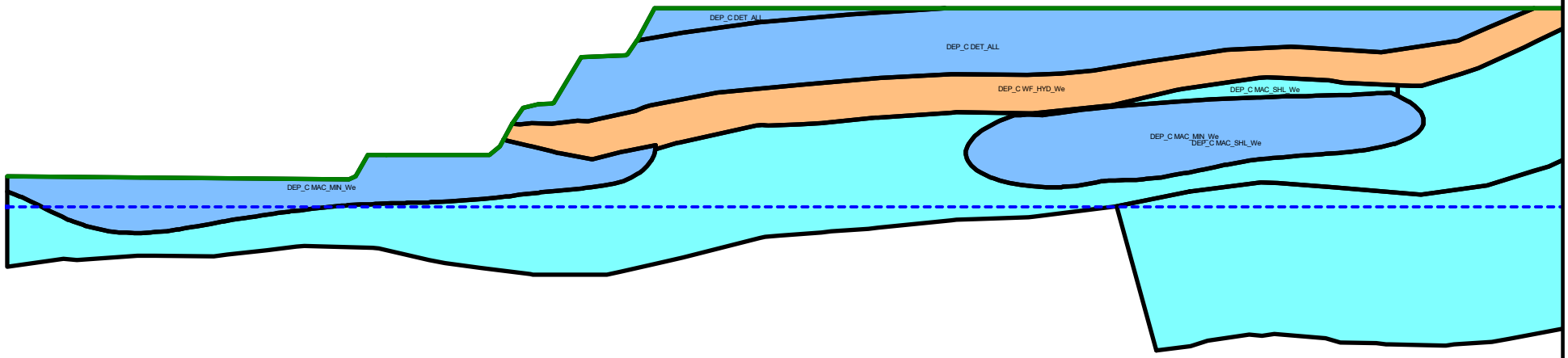
Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Strength Function	Effective Cohesion (kPa)	Effective Friction Angle (°)
	DEP_B DET_DI	Mohr-Coulomb	19.2		34	36
	DEP_B MAC_BIF_We	Shear/Normal Fn.	30	DEP_B_MAC_BIF_We		
	DEP_B NAM_BIF_We	Shear/Normal Fn.	30	DEP_B_NAM_BIF_We		
	DEP_B NE1_BIF_We	Shear/Normal Fn.	28.2	DEP_B_NE1_BIF_We		
	DEP_B_NEW_SHL_We	Mohr-Coulomb	29		10	30

Dep B XS1 static

West Angelas

30/09/2021 1:2,750

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Strength Function	Effective Cohesion (kPa)	Effective Friction Angle (°)
	DEP_C DET_ALL	Mohr-Coulomb	22.6		35	35
	DEP_C MAC_MIN_We	Shear/Normal Fn.	31.4	DEP_C_MAC_MIN_We		
	DEP_C MAC_SHL_We	Shear/Normal Fn.	29	DEP_C_MAC_SHL_We		
	DEP_C NE1_BIF_Fr	Shear/Normal Fn.	31.2	DEP_C_NE1_BIF_Fr		
	DEP_C WF_HYD_We	Shear/Normal Fn.	31.4	DEP_C WF_HYD_We		



Dep C XS1 - geometry

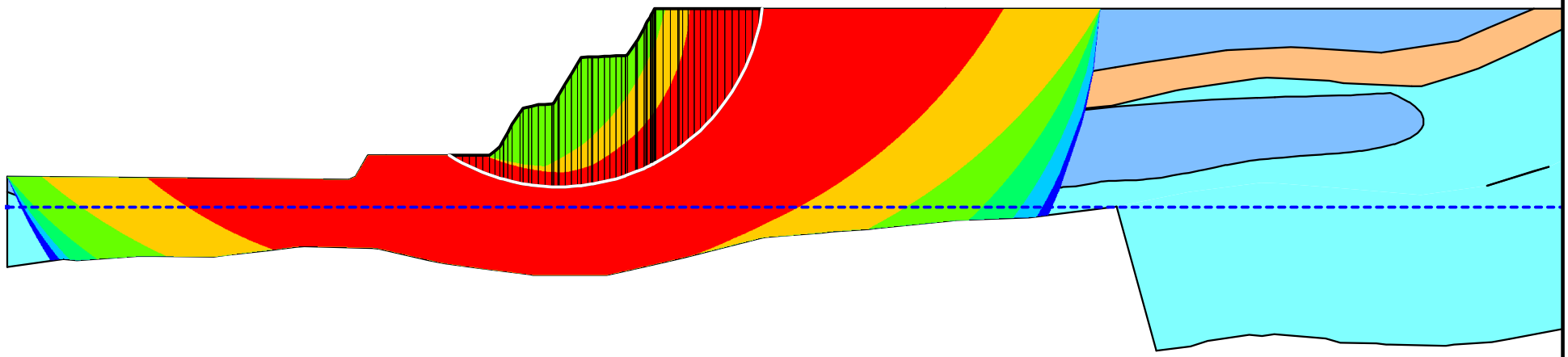
West Angelas

01/10/2021 1:2,000

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Strength Function	Effective Cohesion (kPa)	Effective Friction Angle (°)
	DEP_C DET_ALL	Mohr-Coulomb	22.6		35	35
	DEP_C MAC_MIN_We	Shear/Normal Fn.	31.4	DEP_C_MAC_MIN_We		
	DEP_C MAC_SHL_We	Shear/Normal Fn.	29	DEP_C_MAC_SHL_We		
	DEP_C NE1_BIF_Fr	Shear/Normal Fn.	31.2	DEP_C_NE1_BIF_Fr		
	DEP_C WF_HYD_We	Shear/Normal Fn.	31.4	DEP_C WF_HYD_We		

Factor of Safety
- ≤ 1.10 - 1.20
- 1.20 - 1.30
- 1.30 - 1.40
- 1.40 - 1.50
- 1.50 - 1.60
- ≥ 1.60

1.08



Dep C XS1 pseudo-static

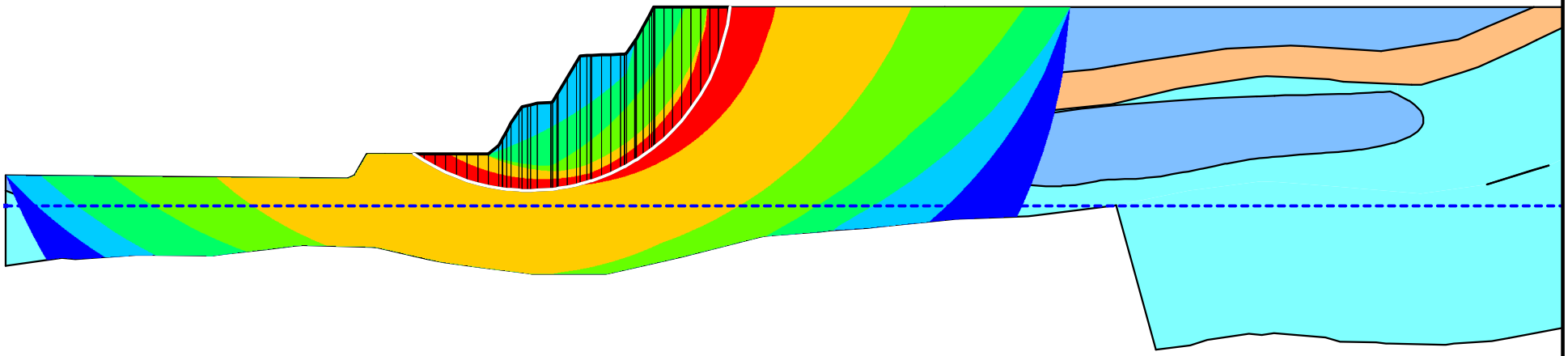
West Angelas

30/09/2021 1:2,000

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Strength Function	Effective Cohesion (kPa)	Effective Friction Angle (°)
	DEP_C DET_ALL	Mohr-Coulomb	22.6		35	35
	DEP_C MAC_MIN_We	Shear/Normal Fn.	31.4	DEP_C_MAC_MIN_We		
	DEP_C MAC_SHL_We	Shear/Normal Fn.	29	DEP_C_MAC_SHL_We		
	DEP_C NE1_BIF_Fr	Shear/Normal Fn.	31.2	DEP_C_NE1_BIF_Fr		
	DEP_C WF_HYD_We	Shear/Normal Fn.	31.4	DEP_C WF_HYD_We		

Factor of Safety
- ≤ 1.10 - 1.20
- 1.20 - 1.30
- 1.30 - 1.40
- 1.40 - 1.50
- 1.50 - 1.60
- ≥ 1.60

1.17

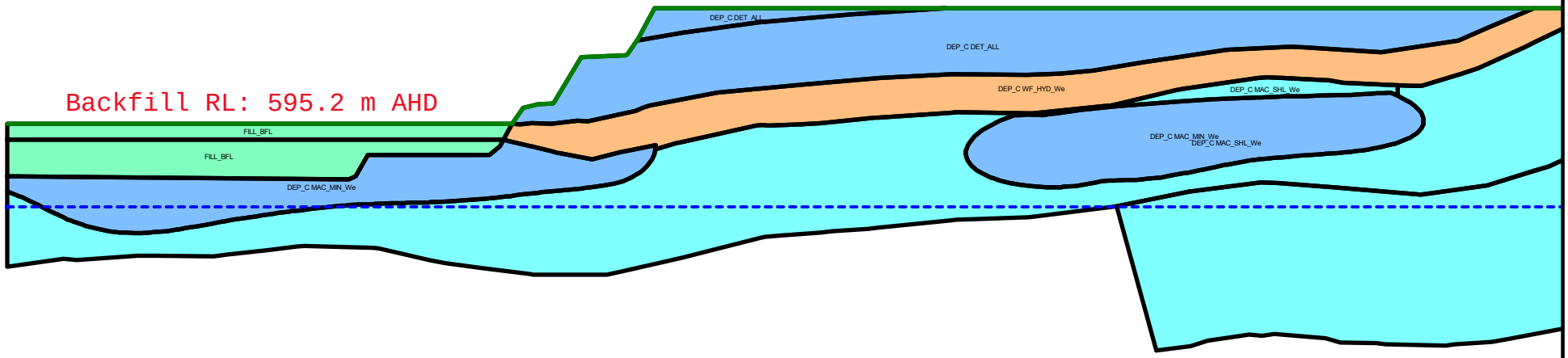


Dep C XS1 static

West Angelas

30/09/2021 1:2,000

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Strength Function	Effective Cohesion (kPa)	Effective Friction Angle (°)
	DEP_C DET_ALL	Mohr-Coulomb	22.6		35	35
	DEP_C MAC_MIN_We	Shear/Normal Fn.	31.4	DEP_C_MAC_MIN_We		
	DEP_C MAC_SHL_We	Shear/Normal Fn.	29	DEP_C_MAC_SHL_We		
	DEP_C NE1_BIF_Fr	Shear/Normal Fn.	31.2	DEP_C_NE1_BIF_Fr		
	DEP_C WF_HYD_We	Shear/Normal Fn.	31.4	DEP_C WF_HYD_We		
	FILL_BFL	Mohr-Coulomb	22		0	44



Dep C XS1 - backfilled geometry

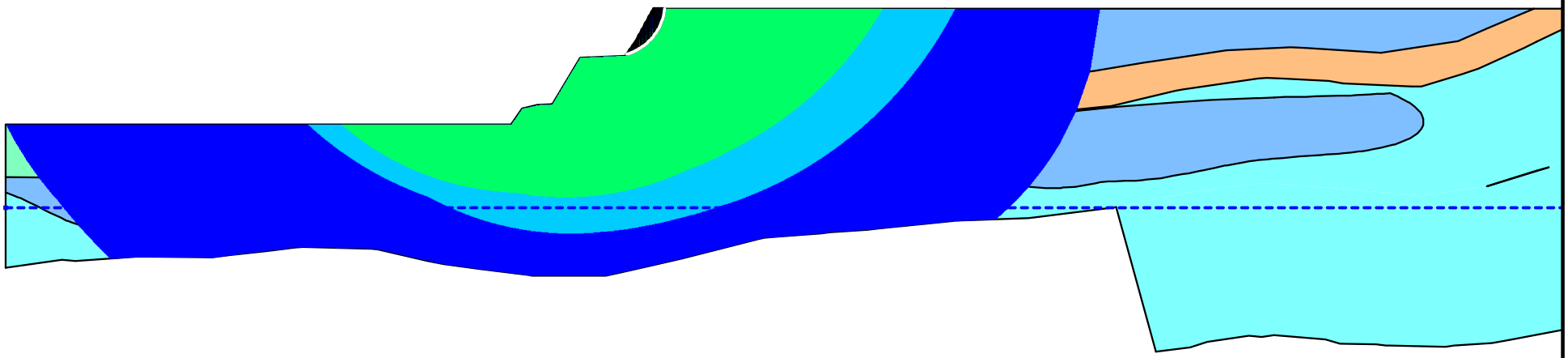
West Angelas

01/10/2021 1:2,000

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Strength Function	Effective Cohesion (kPa)	Effective Friction Angle (°)
	DEP_C DET_ALL	Mohr-Coulomb	22.6		35	35
	DEP_C MAC_MIN_We	Shear/Normal Fn.	31.4	DEP_C_MAC_MIN_We		
	DEP_C MAC_SHL_We	Shear/Normal Fn.	29	DEP_C_MAC_SHL_We		
	DEP_C NE1_BIF_Fr	Shear/Normal Fn.	31.2	DEP_C_NE1_BIF_Fr		
	DEP_C WF_HYD_We	Shear/Normal Fn.	31.4	DEP_C WF_HYD_We		
	FILL_BFL	Mohr-Coulomb	22		0	44

Factor of Safety
- ≤ 1.10 - 1.20
- 1.20 - 1.30
- 1.30 - 1.40
- 1.40 - 1.50
- 1.50 - 1.60
- ≥ 1.60

1.37



Dep C XS1 pseudo-static - backfilled

West Angelas

30/09/2021 1:2,000

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Strength Function	Effective Cohesion (kPa)	Effective Friction Angle (°)
	DEP_C DET_ALL	Mohr-Coulomb	22.6		35	35
	DEP_C MAC_MIN_We	Shear/Normal Fn.	31.4	DEP_C_MAC_MIN_We		
	DEP_C MAC_SHL_We	Shear/Normal Fn.	29	DEP_C_MAC_SHL_We		
	DEP_C NE1_BIF_Fr	Shear/Normal Fn.	31.2	DEP_C_NE1_BIF_Fr		
	DEP_C WF_HYD_We	Shear/Normal Fn.	31.4	DEP_C WF_HYD_We		
	FILL_BFL	Mohr-Coulomb	22		0	44

Factor of Safety
- ≤ 1.10 - 1.20
- 1.20 - 1.30
- 1.30 - 1.40
- 1.40 - 1.50
- 1.50 - 1.60
- ≥ 1.60

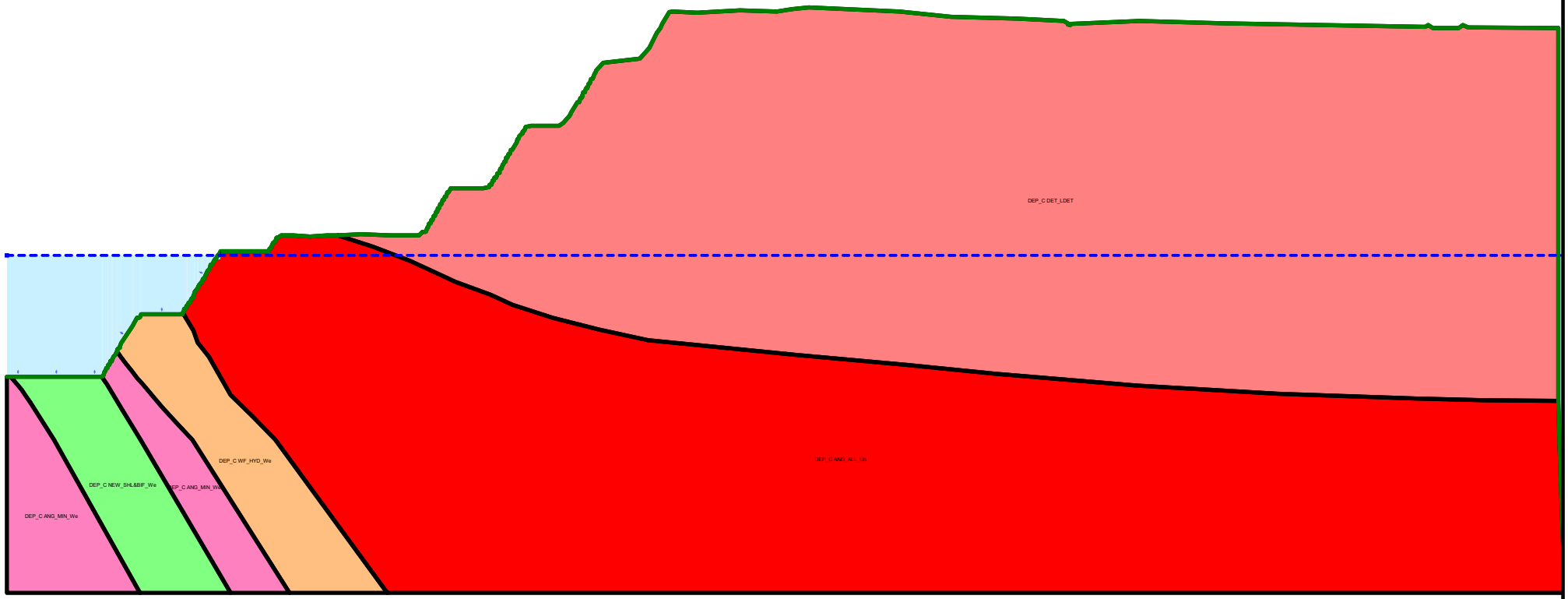
1.51

Dep C XS1 static - backfilled

West Angelas

30/09/2021 1:2,000

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)	Strength Function
	DEP_C ANG_ALL_Un	Shear/Normal Fn.	29			DEP_C_ANG_ALL_Un
	DEP_C ANG_MIN_We	Shear/Normal Fn.	27.5			DEP_C_ANG_MIN_We
	DEP_C DET_LDET	Mohr-Coulomb	25.5	98	46	
	DEP_C NEW_SHL&BIF_We	Shear/Normal Fn.	29.4			DEP_C_NEW_SHL&BIF_We
	DEP_C WF_HYD_We	Shear/Normal Fn.	31.4			DEP_C WF_HYD_We



Dep C XS2 pseudo-static

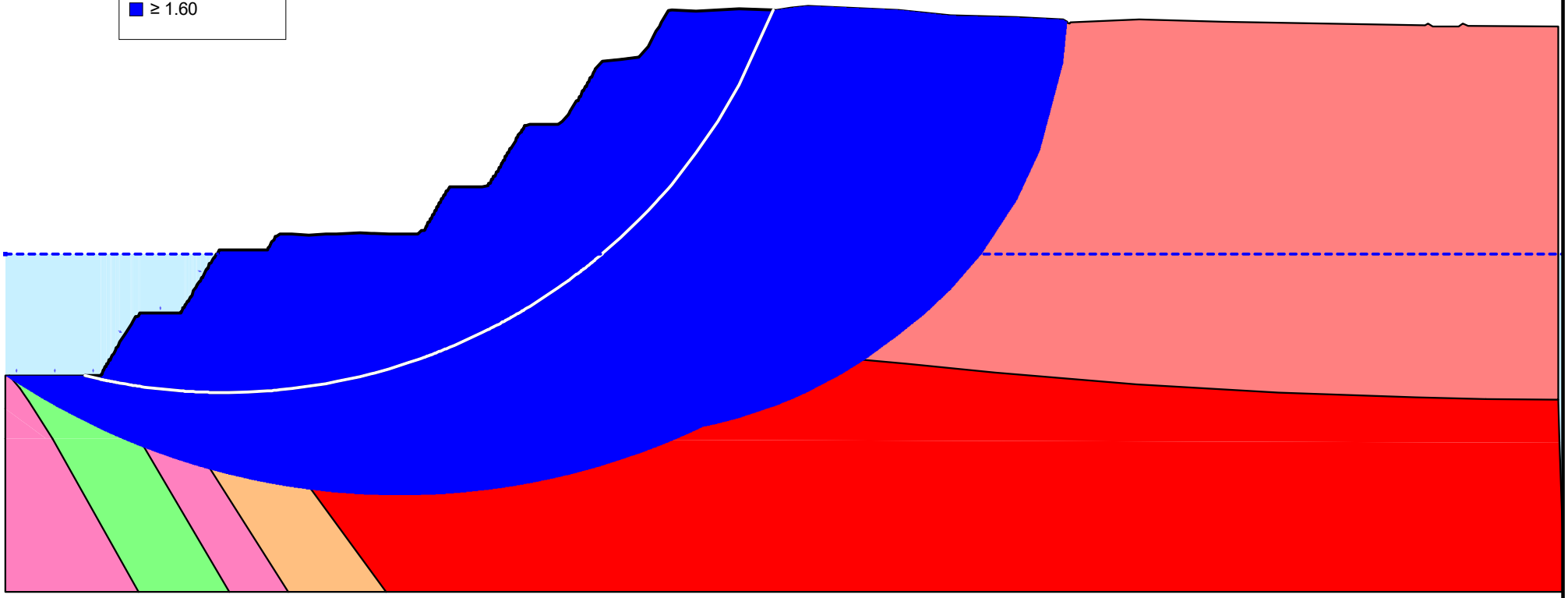
West Angelas

06/10/2021 1:1,500

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)	Strength Function
	DEP_C ANG_ALL_Un	Shear/Normal Fn.	29			DEP_C_ANG_ALL_Un
	DEP_C ANG_MIN_We	Shear/Normal Fn.	27.5			DEP_C_ANG_MIN_We
	DEP_C DET_LDET	Mohr-Coulomb	25.5	98	46	
	DEP_C NEW_SHL&BIF_We	Shear/Normal Fn.	29.4			DEP_C_NEW_SHL&BIF_We
	DEP_C WF_HYD_We	Shear/Normal Fn.	31.4			DEP_C WF_HYD_We

Factor of Safety
- ≤ 1.10 - 1.20
- 1.20 - 1.30
- 1.30 - 1.40
- 1.40 - 1.50
- 1.50 - 1.60
- ≥ 1.60

1.65

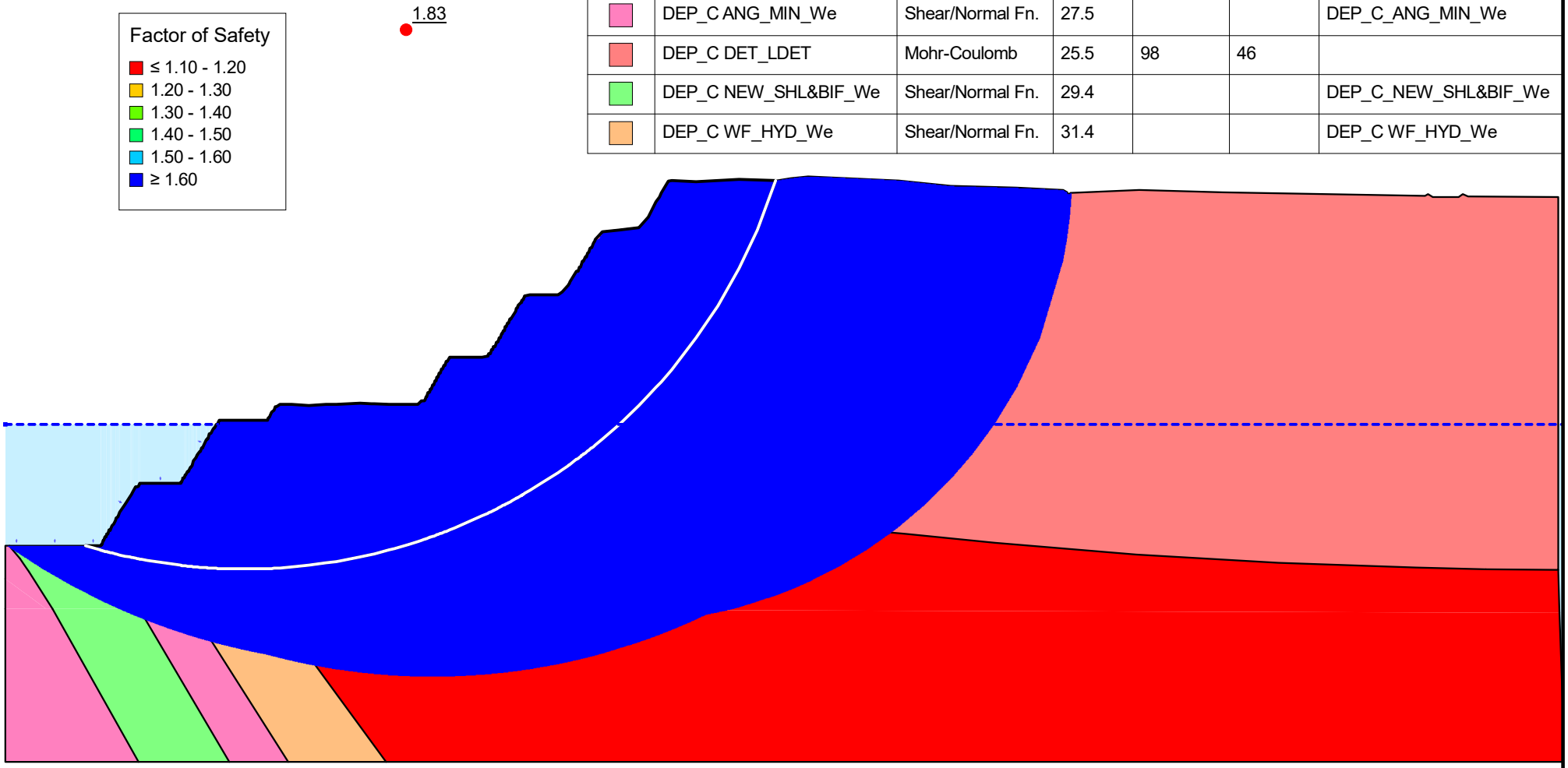


Dep C XS2 pseudo-static

West Angelas

06/10/2021 1:1,500

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)	Strength Function
	DEP_C ANG_ALL_Un	Shear/Normal Fn.	29			DEP_C_ANG_ALL_Un
	DEP_C ANG_MIN_We	Shear/Normal Fn.	27.5			DEP_C_ANG_MIN_We
	DEP_C DET_LDET	Mohr-Coulomb	25.5	98	46	
	DEP_C NEW_SHL&BIF_We	Shear/Normal Fn.	29.4			DEP_C_NEW_SHL&BIF_We
	DEP_C WF_HYD_We	Shear/Normal Fn.	31.4			DEP_C WF_HYD_We

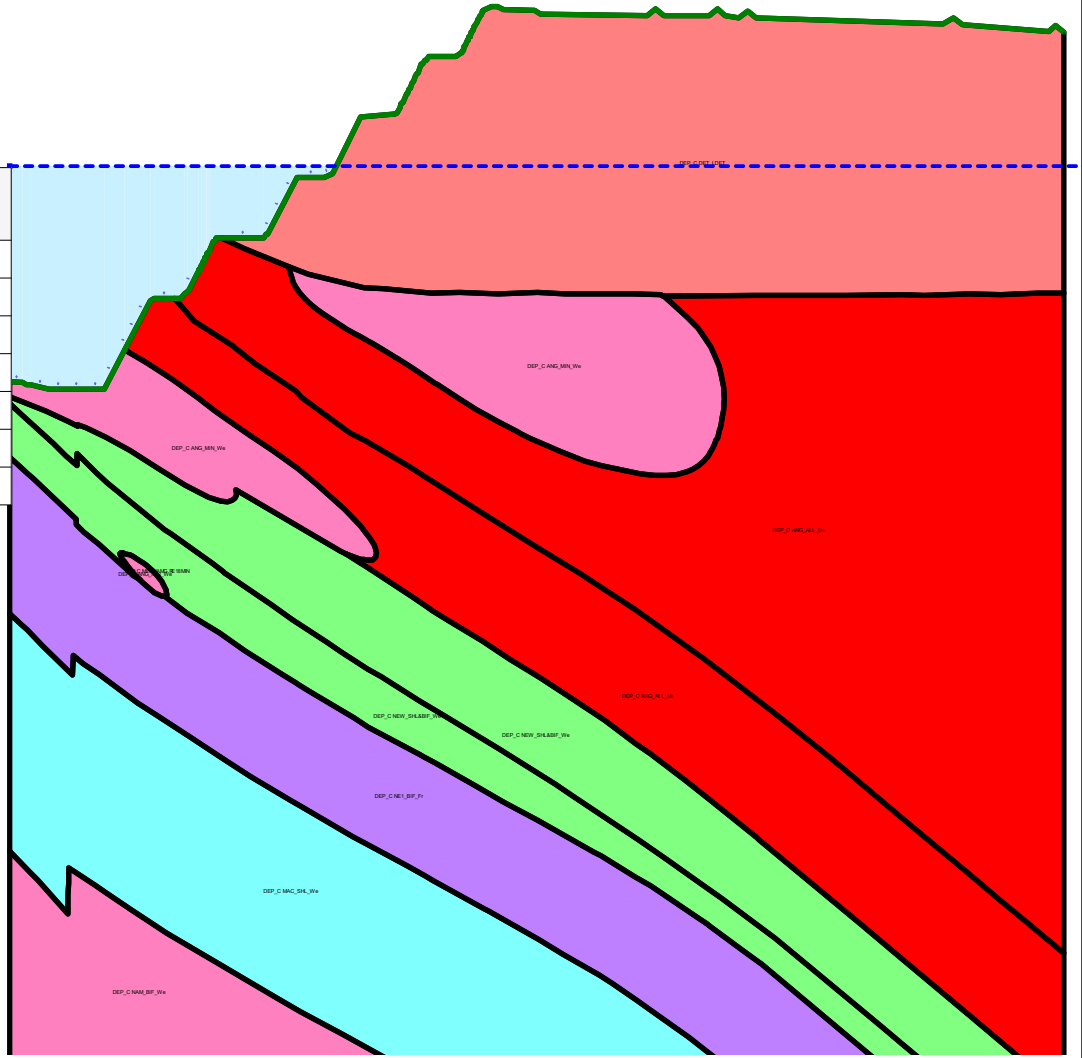


Dep C XS2 static

West Angelas

06/10/2021 1:1,500

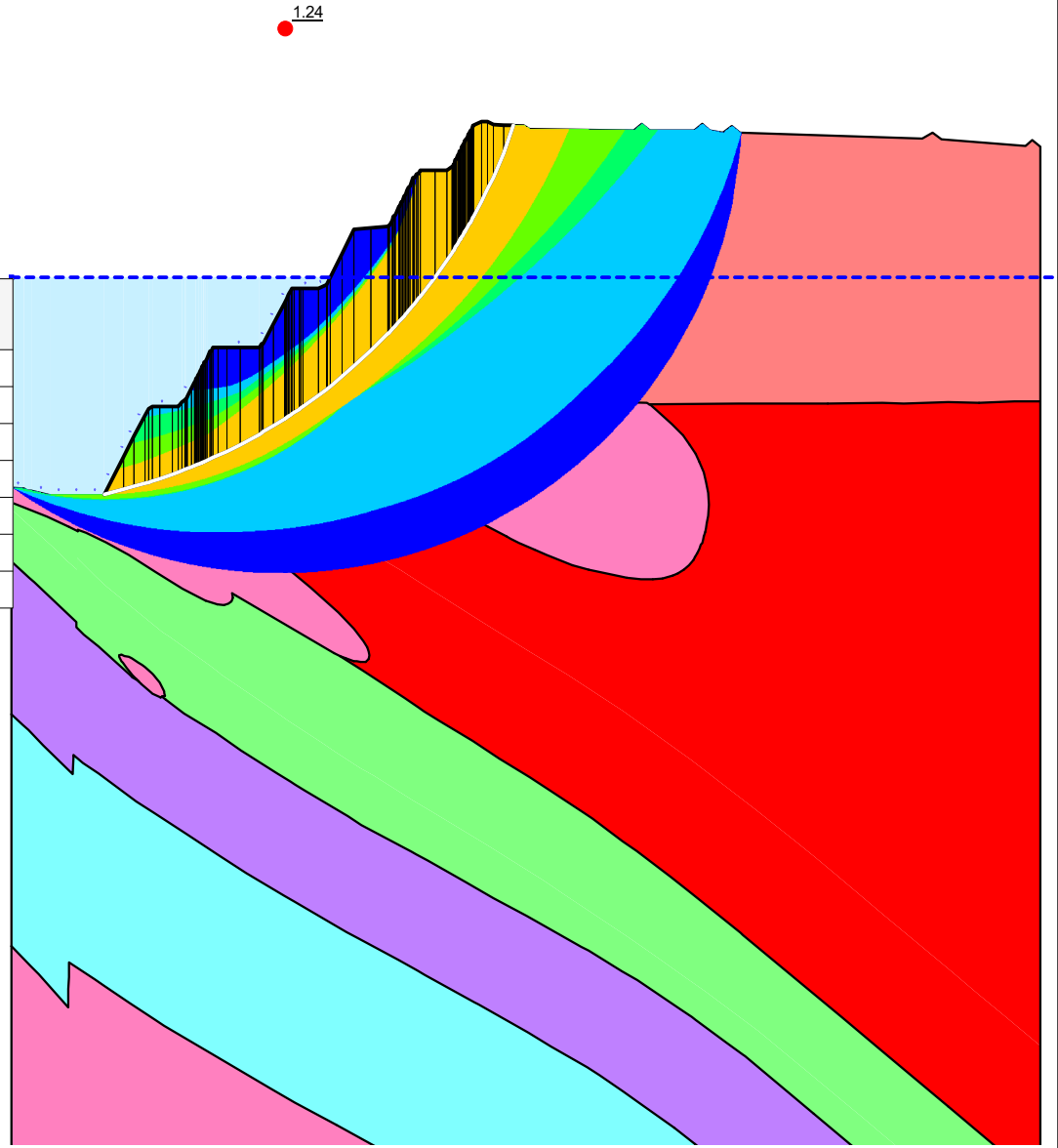
Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)	Strength Function
	DEP_C ANG_ALL_Un	Shear/Normal Fn.	29			DEP_C_ANG_ALL_Un
	DEP_C ANG_MIN_We	Shear/Normal Fn.	27.5			DEP_C_ANG_MIN_We
	DEP_C DET_LDET	Mohr-Coulomb	25.5	98	46	
	DEP_C MAC_SHL_We	Shear/Normal Fn.	29			DEP_C_MAC_SHL_We
	DEP_C NAM_BIF_We	Shear/Normal Fn.	29			DEP_C_NAM_BIF_We
	DEP_C NE1_BIF_Fr	Shear/Normal Fn.	31.2			DEP_C_NE1_BIF_Fr
	DEP_C NEW_SHL&BIF_We	Shear/Normal Fn.	29.4			DEP_C_NEW_SHL&BIF_We



Dep C XS3 - geometry

West Angelas

01/10/2021 1:2,000

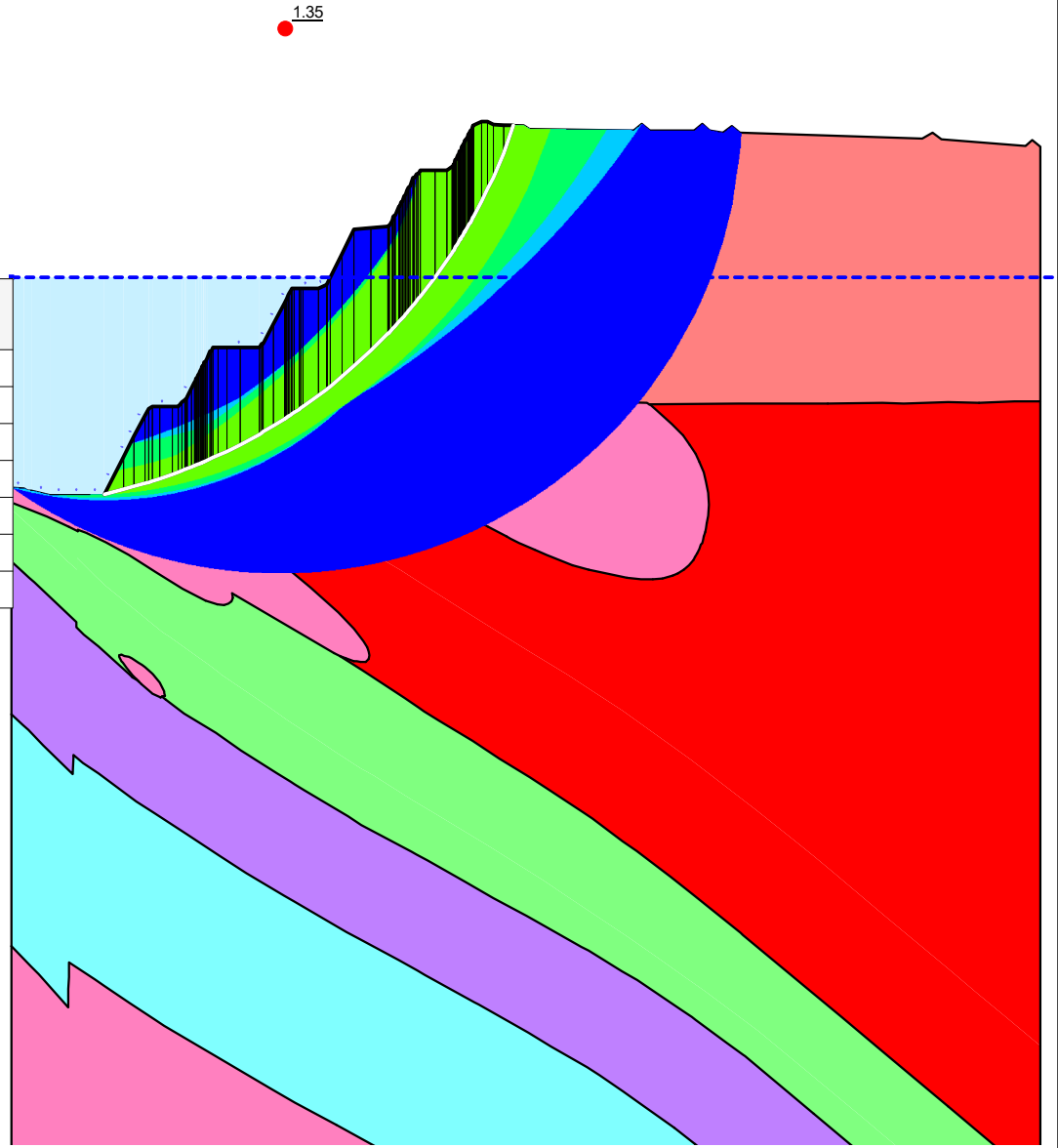


Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)	Strength Function
	DEP_C ANG_ALL_Un	Shear/Normal Fn.	29			DEP_C_ANG_ALL_Un
	DEP_C ANG_MIN_We	Shear/Normal Fn.	27.5			DEP_C_ANG_MIN_We
	DEP_C DET_LDET	Mohr-Coulomb	25.5	98	46	
	DEP_C MAC_SHL_We	Shear/Normal Fn.	29			DEP_C_MAC_SHL_We
	DEP_C NAM_BIF_We	Shear/Normal Fn.	29			DEP_C_NAM_BIF_We
	DEP_C NE1_BIF_Fr	Shear/Normal Fn.	31.2			DEP_C_NE1_BIF_Fr
	DEP_C NEW_SHL&BIF_We	Shear/Normal Fn.	29.4			DEP_C_NEW_SHL&BIF_We

Dep C XS3 pseudo-static

West Angelas

30/09/2021 1:2,000



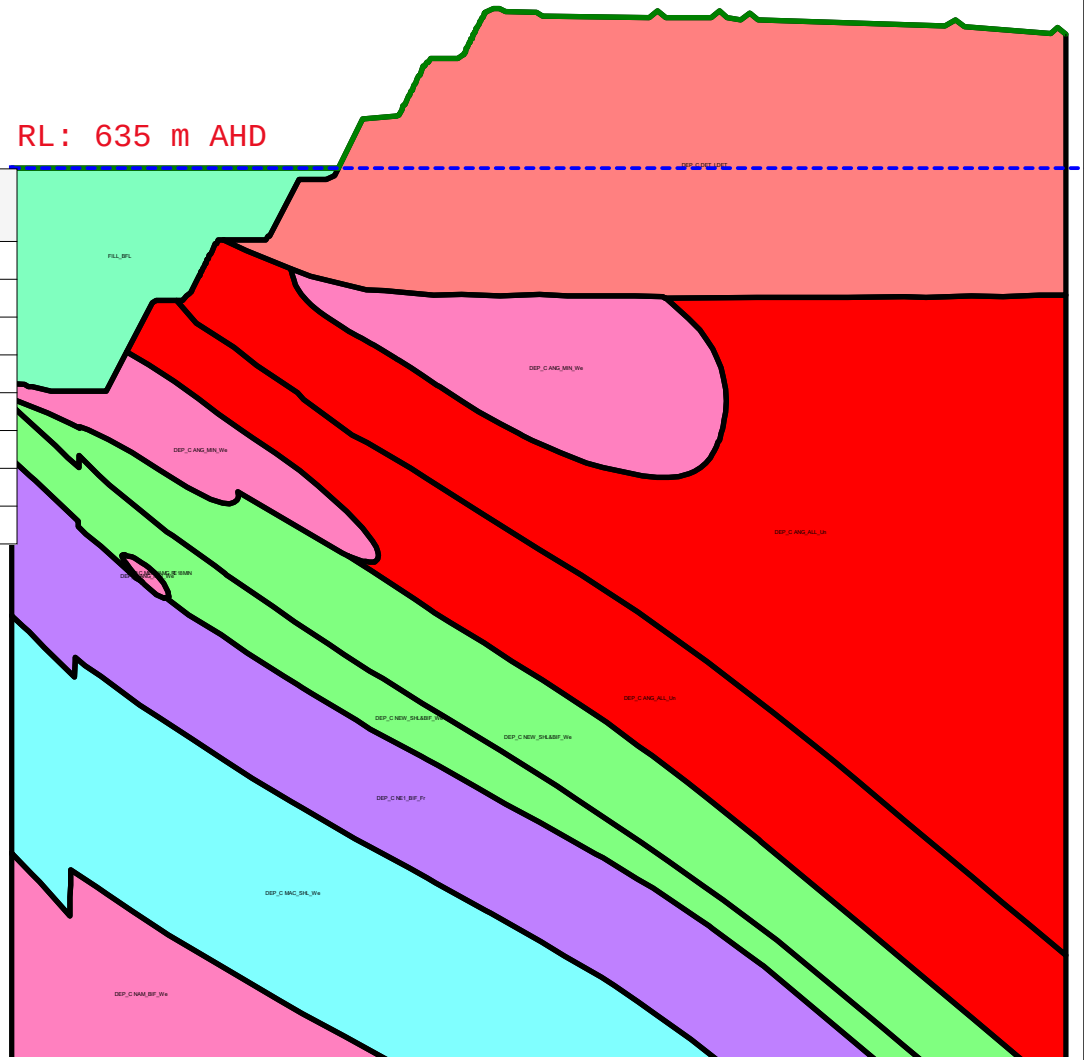
Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)	Strength Function
	DEP_C ANG_ALL_Un	Shear/Normal Fn.	29			DEP_C_ANG_ALL_Un
	DEP_C ANG_MIN_We	Shear/Normal Fn.	27.5			DEP_C_ANG_MIN_We
	DEP_C DET_LDET	Mohr-Coulomb	25.5	98	46	
	DEP_C MAC_SHL_We	Shear/Normal Fn.	29			DEP_C_MAC_SHL_We
	DEP_C NAM_BIF_We	Shear/Normal Fn.	29			DEP_C_NAM_BIF_We
	DEP_C NE1_BIF_Fr	Shear/Normal Fn.	31.2			DEP_C_NE1_BIF_Fr
	DEP_C NEW_SHL&BIF_We	Shear/Normal Fn.	29.4			DEP_C_NEW_SHL&BIF_We

Dep C XS3 static

West Angelas

30/09/2021 1:2,000

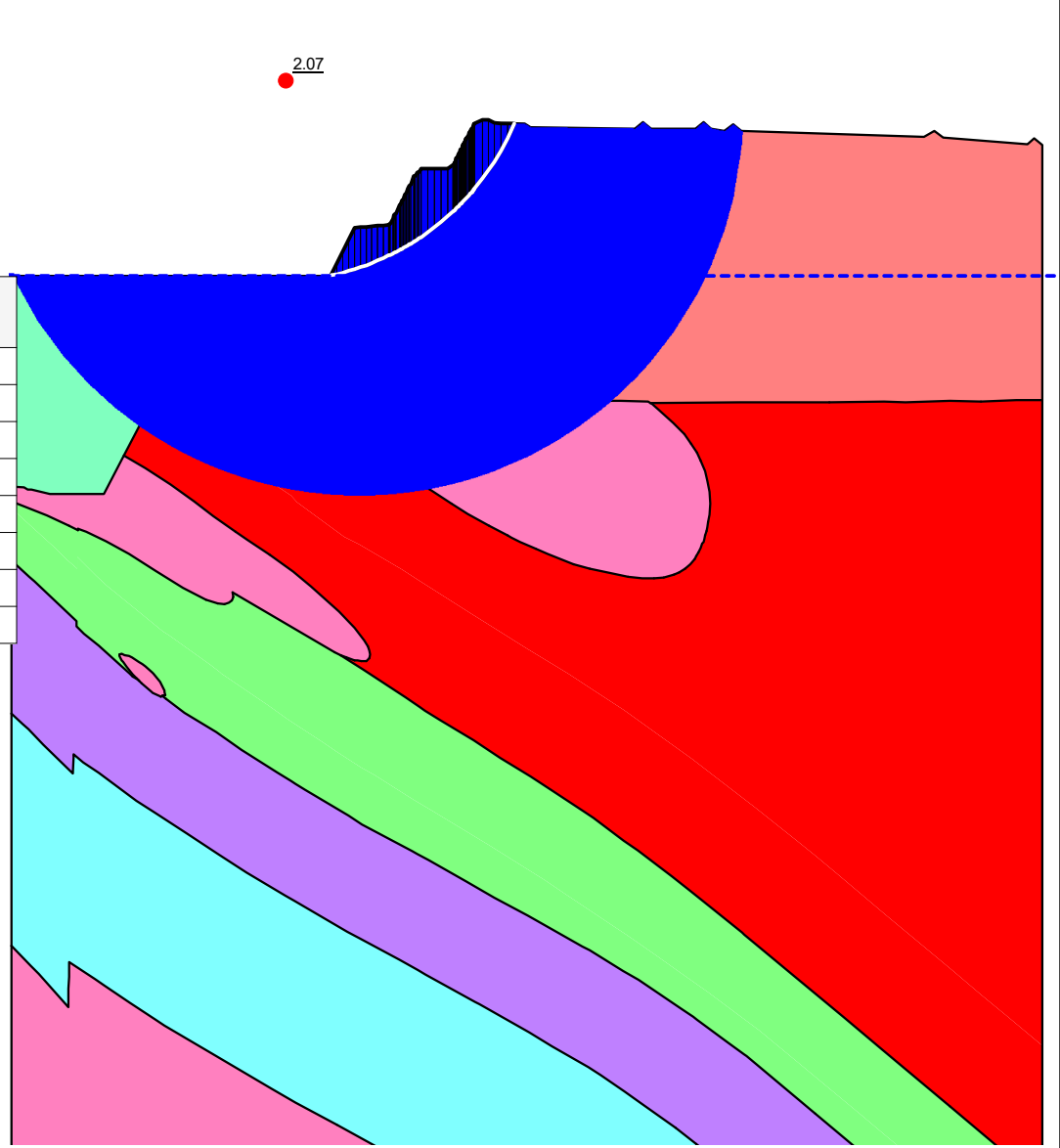
Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)	Strength Function
	DEP_C ANG_ALL_Un	Shear/Normal Fn.	29			DEP_C_ANG_ALL_Un
	DEP_C ANG_MIN_We	Shear/Normal Fn.	27.5			DEP_C_ANG_MIN_We
	DEP_C DET_LDET	Mohr-Coulomb	25.5	98	46	
	DEP_C MAC_SHL_We	Shear/Normal Fn.	29			DEP_C_MAC_SHL_We
	DEP_C NAM_BIF_We	Shear/Normal Fn.	29			DEP_C_NAM_BIF_We
	DEP_C NE1_BIF_Fr	Shear/Normal Fn.	31.2			DEP_C_NE1_BIF_Fr
	DEP_C NEW_SHL&BIF_We	Shear/Normal Fn.	29.4			DEP_C_NEW_SHL&BIF_We
	FILL_BFL	Mohr-Coulomb	22	0	44	



Dep C XS3 - backfilled geometry

West Angelas

01/10/2021 1:2,000

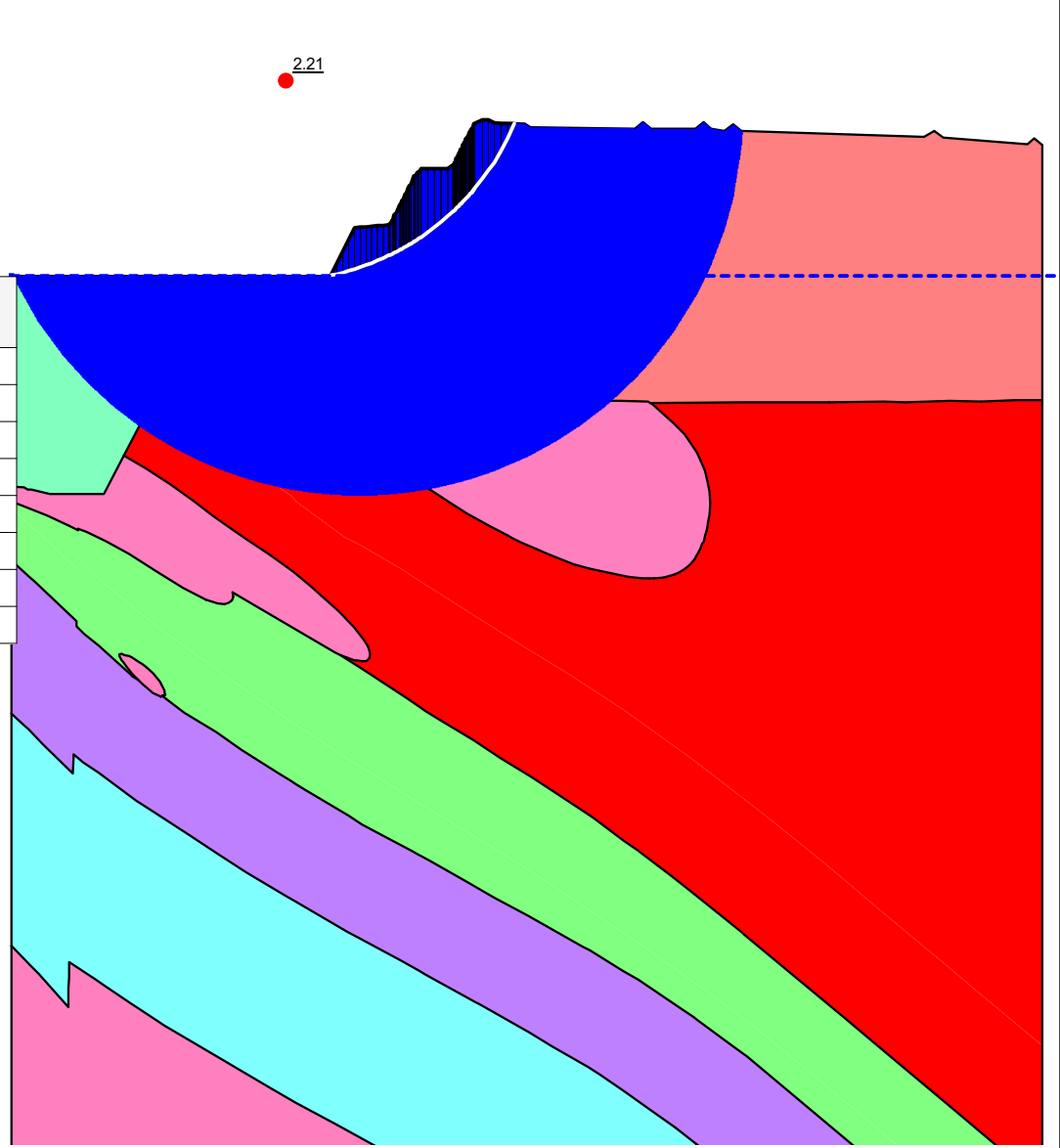


Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)	Strength Function
	DEP_C ANG_ALL_Un	Shear/Normal Fn.	29			DEP_C_ANG_ALL_Un
	DEP_C ANG_MIN_We	Shear/Normal Fn.	27.5			DEP_C_ANG_MIN_We
	DEP_C DET_LDET	Mohr-Coulomb	25.5	98	46	
	DEP_C MAC_SHL_We	Shear/Normal Fn.	29			DEP_C_MAC_SHL_We
	DEP_C NAM_BIF_We	Shear/Normal Fn.	29			DEP_C_NAM_BIF_We
	DEP_C NE1_BIF_Fr	Shear/Normal Fn.	31.2			DEP_C_NE1_BIF_Fr
	DEP_C NEW_SHL&BIF_We	Shear/Normal Fn.	29.4			DEP_C_NEW_SHL&BIF_We
	FILL_BFL	Mohr-Coulomb	22	0	44	

Dep C XS3 pseudo-static - backfilled

West Angelas

30/09/2021 1:2,000



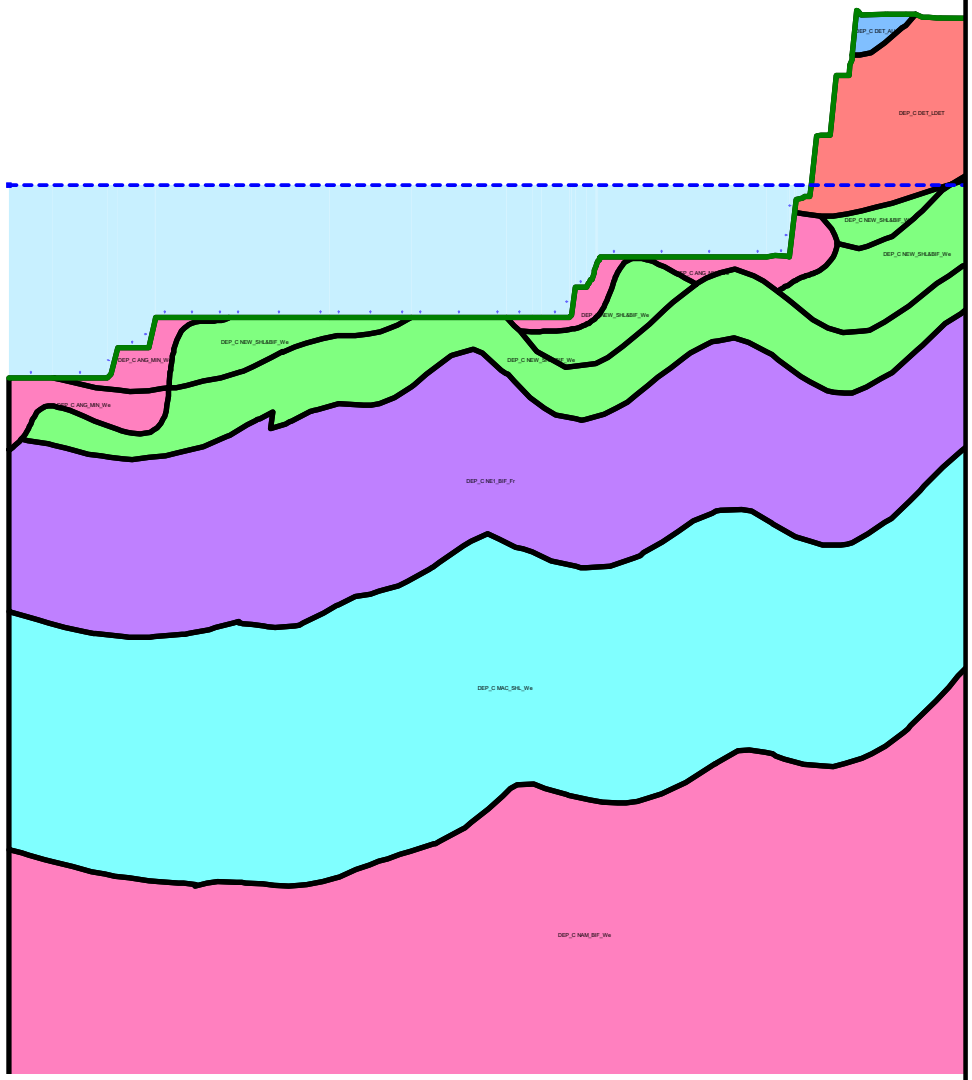
Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)	Strength Function
	DEP_C ANG_ALL_Un	Shear/Normal Fn.	29			DEP_C_ANG_ALL_Un
	DEP_C ANG_MIN_We	Shear/Normal Fn.	27.5			DEP_C_ANG_MIN_We
	DEP_C DET_LDET	Mohr-Coulomb	25.5	98	46	
	DEP_C MAC_SHL_We	Shear/Normal Fn.	29			DEP_C_MAC_SHL_We
	DEP_C NAM_BIF_We	Shear/Normal Fn.	29			DEP_C_NAM_BIF_We
	DEP_C NE1_BIF_Fr	Shear/Normal Fn.	31.2			DEP_C_NE1_BIF_Fr
	DEP_C NEW_SHL&BIF_We	Shear/Normal Fn.	29.4			DEP_C_NEW_SHL&BIF_We
	FILL_BFL	Mohr-Coulomb	22	0	44	

Dep C XS3 static - backfilled

West Angelas

30/09/2021 1:2,000

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)	Strength Function
	DEP_C ANG_MIN_We	Shear/Normal Fn.	27.5			DEP_C_ANG_MIN_We
	DEP_C DET_ALL	Mohr-Coulomb	22.6	35	35	
	DEP_C DET_LDET	Mohr-Coulomb	25.5	98	46	
	DEP_C MAC_SHL_We	Shear/Normal Fn.	29			DEP_C_MAC_SHL_We
	DEP_C NAM_BIF_We	Shear/Normal Fn.	29			DEP_C_NAM_BIF_We
	DEP_C NE1_BIF_Fr	Shear/Normal Fn.	31.2			DEP_C_NE1_BIF_Fr
	DEP_C NEW_SHL&BIF_We	Shear/Normal Fn.	29.4			DEP_C_NEW_SHL&BIF_We

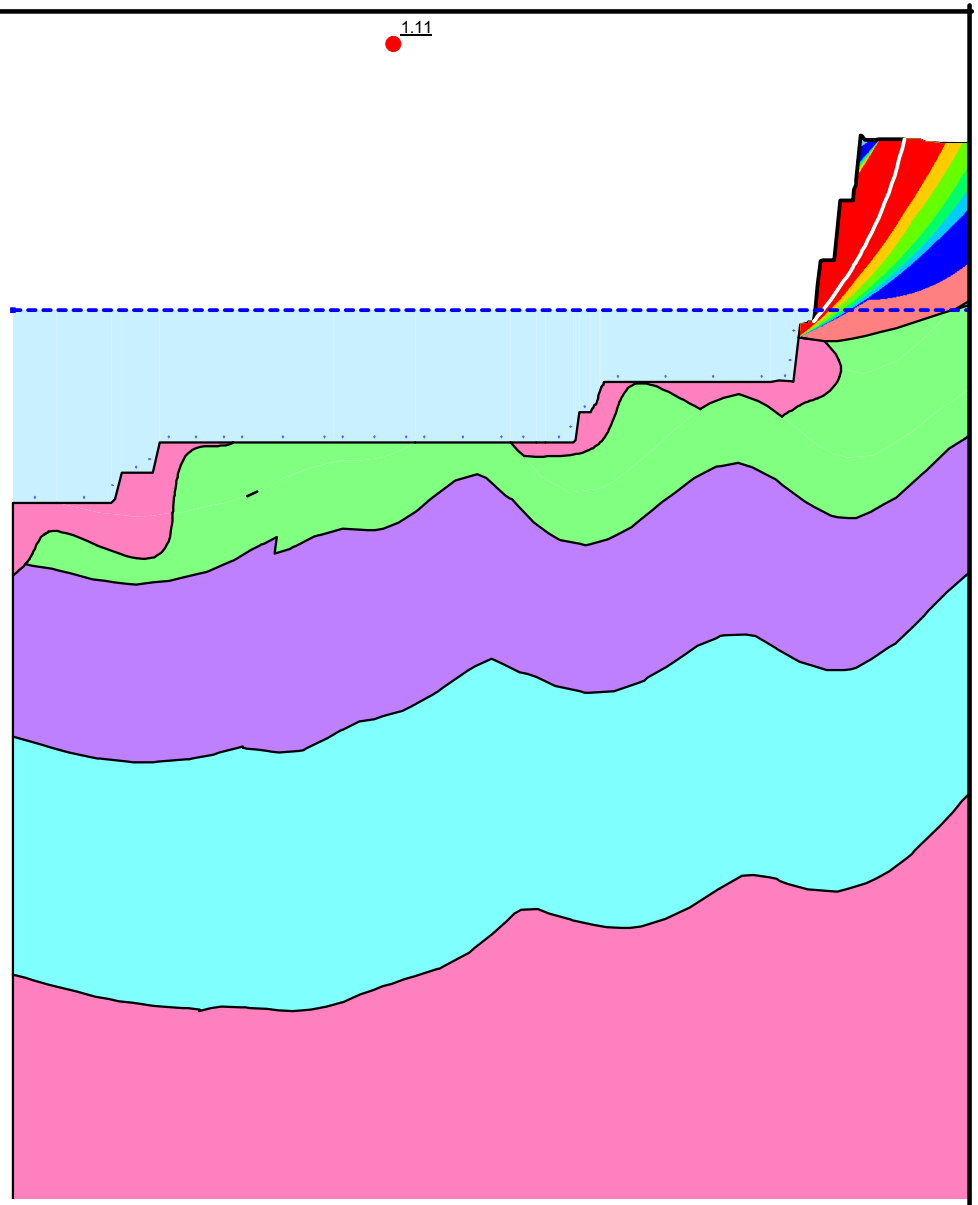


Dep C XS4 static

West Angelas

06/10/2021 1:2,000

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)	Strength Function
	DEP_C ANG_MIN_We	Shear/Normal Fn.	27.5			DEP_C_ANG_MIN_We
	DEP_C DET_ALL	Mohr-Coulomb	22.6	35	35	
	DEP_C DET_LDET	Mohr-Coulomb	25.5	98	46	
	DEP_C MAC_SHL_We	Shear/Normal Fn.	29			DEP_C_MAC_SHL_We
	DEP_C NAM_BIF_We	Shear/Normal Fn.	29			DEP_C_NAM_BIF_We
	DEP_C NE1_BIF_Fr	Shear/Normal Fn.	31.2			DEP_C_NE1_BIF_Fr
	DEP_C NEW_SHL&BIF_We	Shear/Normal Fn.	29.4			DEP_C_NEW_SHL&BIF_We

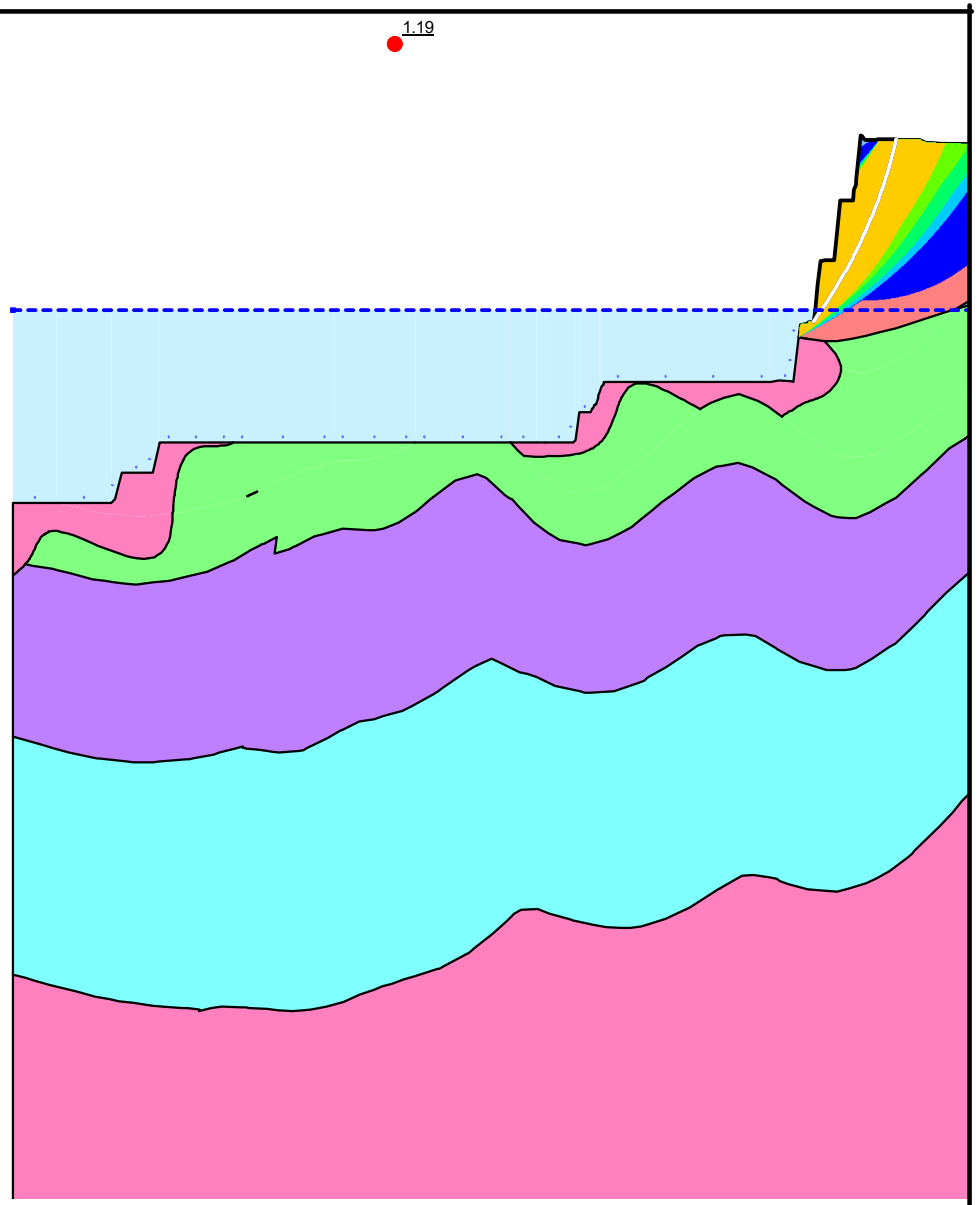


Dep C XS4 pseudo-static

West Angelas

06/10/2021 1:2,000

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)	Strength Function
	DEP_C ANG_MIN_We	Shear/Normal Fn.	27.5			DEP_C_ANG_MIN_We
	DEP_C DET_ALL	Mohr-Coulomb	22.6	35	35	
	DEP_C DET_LDET	Mohr-Coulomb	25.5	98	46	
	DEP_C MAC_SHL_We	Shear/Normal Fn.	29			DEP_C_MAC_SHL_We
	DEP_C NAM_BIF_We	Shear/Normal Fn.	29			DEP_C_NAM_BIF_We
	DEP_C NE1_BIF_Fr	Shear/Normal Fn.	31.2			DEP_C_NE1_BIF_Fr
	DEP_C NEW_SHL&BIF_We	Shear/Normal Fn.	29.4			DEP_C_NEW_SHL&BIF_We

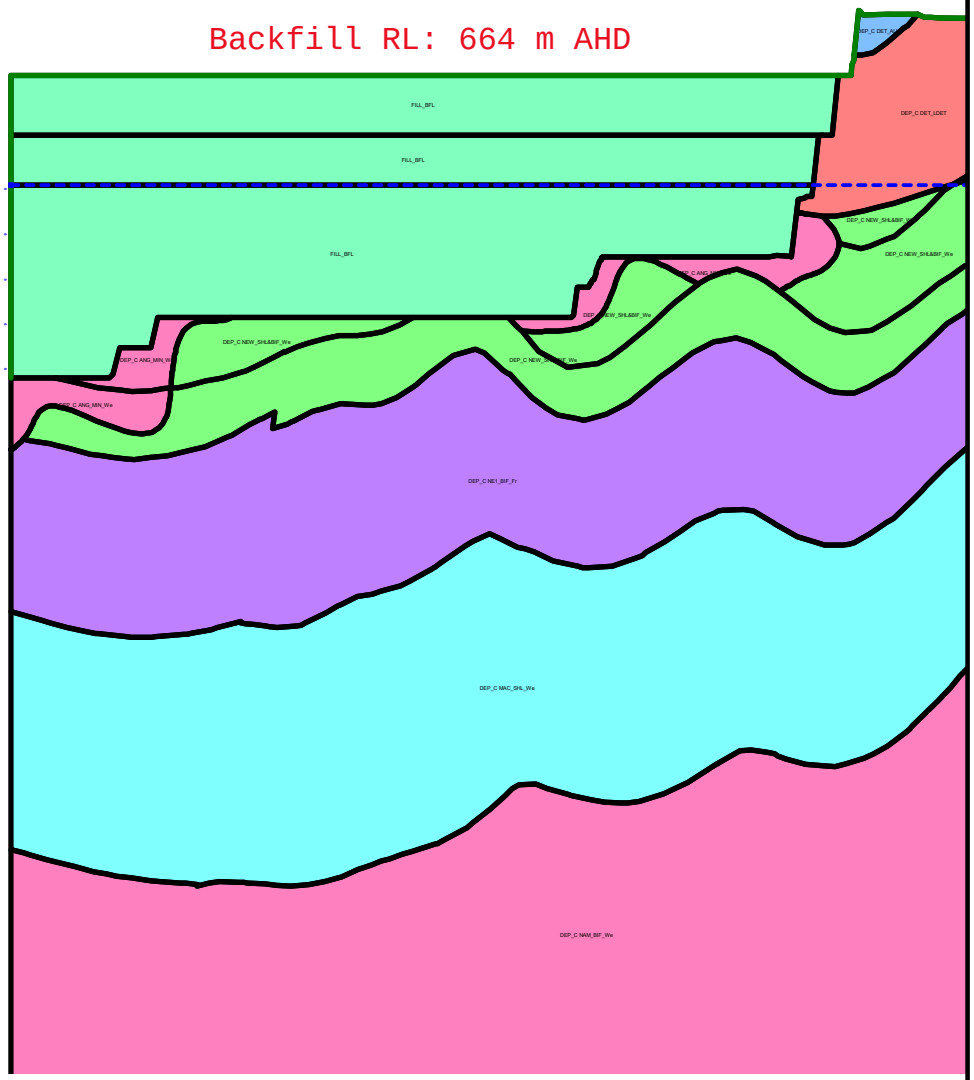


Dep C XS4 static

West Angelas

06/10/2021 1:2,000

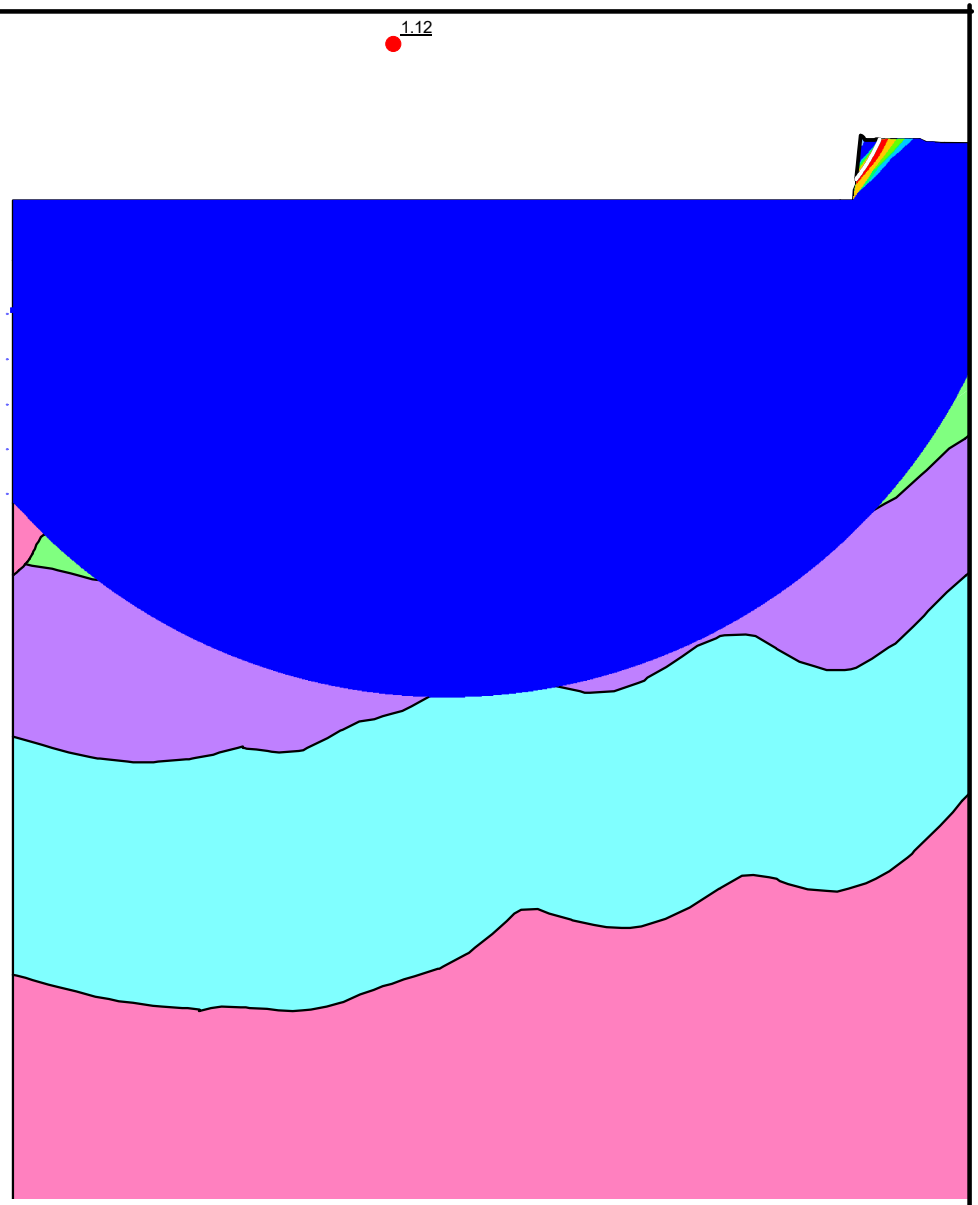
Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)	Strength Function
	DEP_C ANG_MIN_We	Shear/Normal Fn.	27.5			DEP_C_ANG_MIN_We
	DEP_C DET_ALL	Mohr-Coulomb	22.6	35	35	
	DEP_C DET_LDET	Mohr-Coulomb	25.5	98	46	
	DEP_C MAC_SHL_We	Shear/Normal Fn.	29			DEP_C_MAC_SHL_We
	DEP_C NAM_BIF_We	Shear/Normal Fn.	29			DEP_C_NAM_BIF_We
	DEP_C NE1_BIF_Fr	Shear/Normal Fn.	31.2			DEP_C_NE1_BIF_Fr
	DEP_C NEW_SHL&BIF_We	Shear/Normal Fn.	29.4			DEP_C_NEW_SHL&BIF_We
	FILL_BFL	Mohr-Coulomb	22	0	44	



Dep C XS4 static - backfilled

West Angelas

06/10/2021 1:2,000



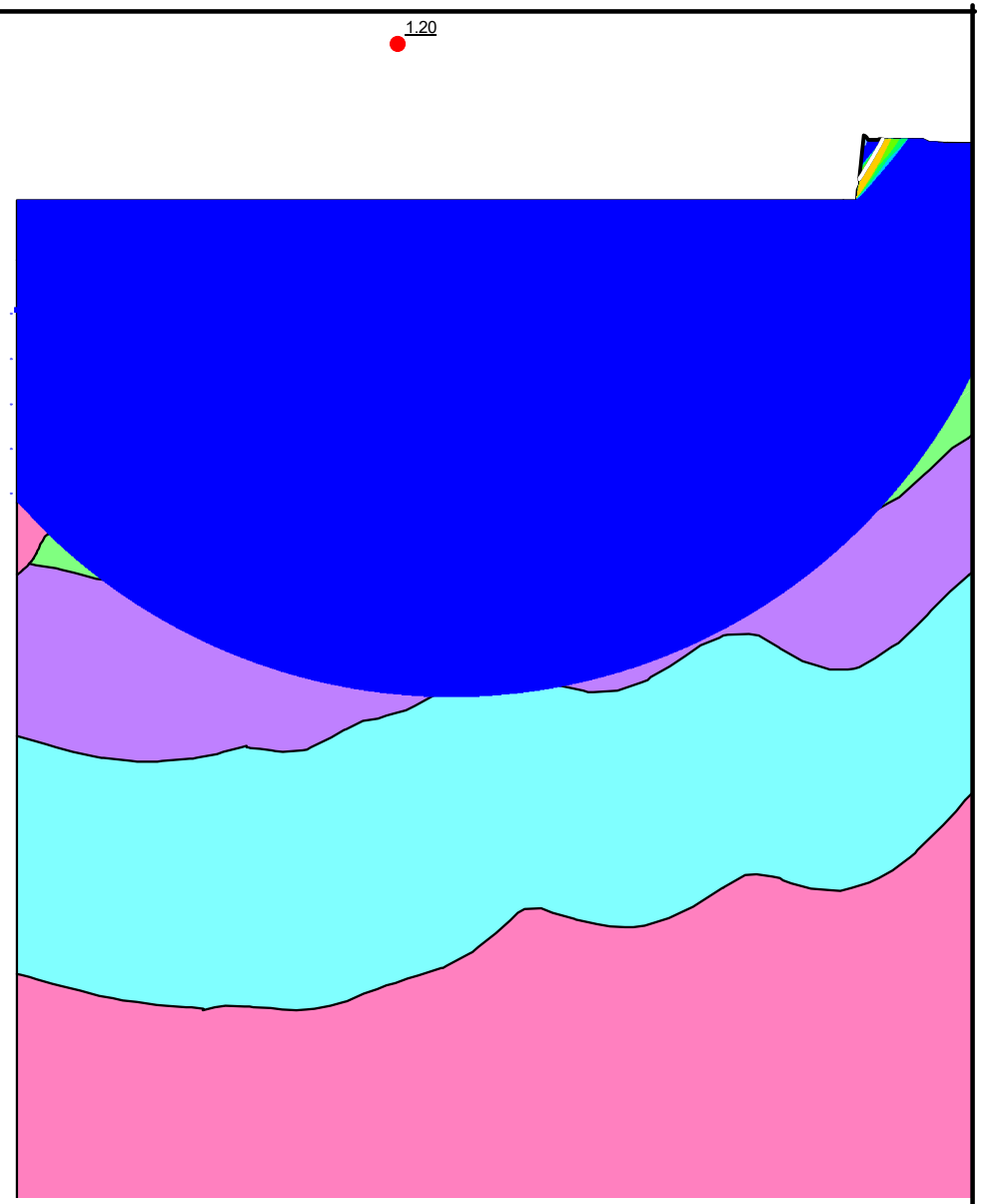
Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)	Strength Function
	DEP_C ANG_MIN_We	Shear/Normal Fn.	27.5			DEP_C_ANG_MIN_We
	DEP_C DET_ALL	Mohr-Coulomb	22.6	35	35	
	DEP_C DET_LDET	Mohr-Coulomb	25.5	98	46	
	DEP_C MAC_SHL_We	Shear/Normal Fn.	29			DEP_C_MAC_SHL_We
	DEP_C NAM_BIF_We	Shear/Normal Fn.	29			DEP_C_NAM_BIF_We
	DEP_C NE1_BIF_Fr	Shear/Normal Fn.	31.2			DEP_C_NE1_BIF_Fr
	DEP_C NEW_SHL&BIF_We	Shear/Normal Fn.	29.4			DEP_C_NEW_SHL&BIF_We
	FILL_BFL	Mohr-Coulomb	22	0	44	

Dep C XS4 pseudo-static - backfilled

West Angelas

06/10/2021 1:2,000

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)	Strength Function
	DEP_C ANG_MIN_We	Shear/Normal Fn.	27.5			DEP_C_ANG_MIN_We
	DEP_C DET_ALL	Mohr-Coulomb	22.6	35	35	
	DEP_C DET_LDET	Mohr-Coulomb	25.5	98	46	
	DEP_C MAC_SHL_We	Shear/Normal Fn.	29			DEP_C_MAC_SHL_We
	DEP_C NAM_BIF_We	Shear/Normal Fn.	29			DEP_C_NAM_BIF_We
	DEP_C NE1_BIF_Fr	Shear/Normal Fn.	31.2			DEP_C_NE1_BIF_Fr
	DEP_C NEW_SHL&BIF_We	Shear/Normal Fn.	29.4			DEP_C_NEW_SHL&BIF_We
	FILL_BFL	Mohr-Coulomb	22	0	44	

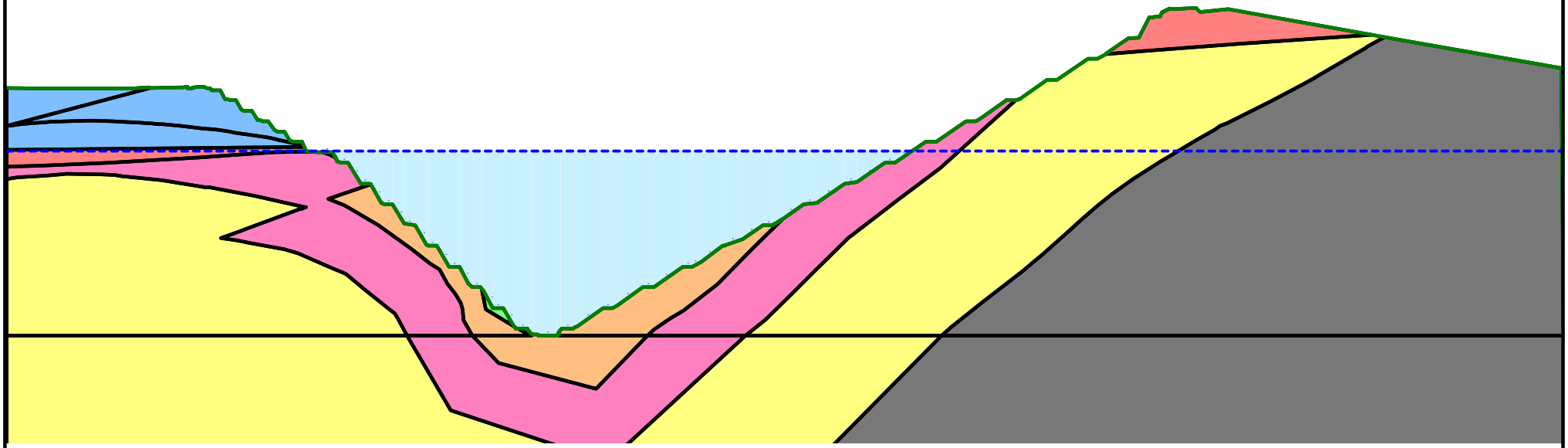


Dep C XS4 static - backfilled

West Angelas

06/10/2021 1:2,000

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	UCS Intact (kPa)	Parameter mb	Parameter s	Parameter a	Calculated from	Intact Rock Parameter mi	Geological Strength Index GSI	Disturbance Factor D	Max Confining Stress Sigma 3 (kPa)	Effective Cohesion (kPa)	Effective Friction Angle (°)	Strength Function
	DEP_C ANG_HYD _Un	Shear/Normal Fn.	29												DEP_C WF_HYD_We
	DEP_C DET_ALL	Mohr-Coulomb	22.6										35	35	
	DEP_C MAC_SHL&BIF_We (2)	Hoek-Brown	24.5	15,000	0.31412933	0.00020346837	0.50614345	Yes	12	49	1	2,000,000			
	DEP_C NAM_SHL&BIF_We	Shear/Normal Fn.	29.4												DEP_C_NAM_SHL&BIF_We
	DEP_C NEW_BIF_We	Shear/Normal Fn.	29												DEP_C_NEW_MIN_We
	DEP_C NEW_SHL&BIF_We	Shear/Normal Fn.	29.4												DEP_C_NEW_SHL&BIF_We
	FOUNDATION	Shear/Normal Fn.	29.4												DEP_C_NAM_SHL&BIF_We



Dep D XS1 Right pseudo-static

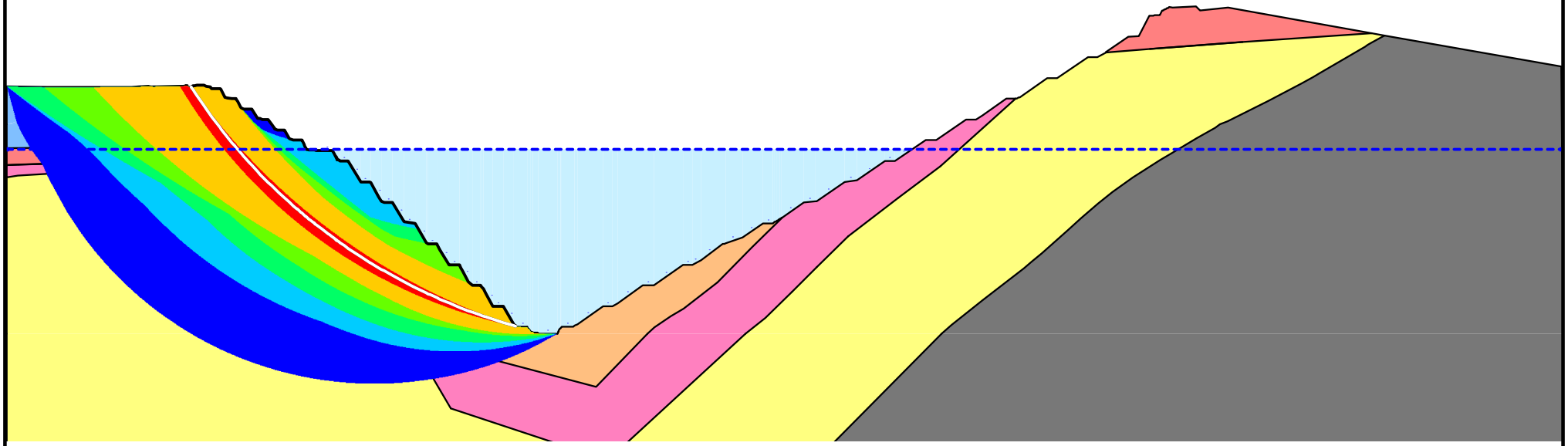
West Angelas

07/10/2021 1:4,500

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	UCS Intact (kPa)	Parameter mb	Parameter s	Parameter a	Calculated from	Intact Rock Parameter mi	Geological Strength Index GSI	Disturbance Factor D	Max Confining Stress Sigma 3 (kPa)	Effective Cohesion (kPa)	Effective Friction Angle (°)	Strength Function
	DEP_C ANG_HYD_Un	Shear/Normal Fn.	29												DEP_C WF_HYD_We
	DEP_C DET_ALL	Mohr-Coulomb	22.6										35	35	
	DEP_C MAC_SHL&BIF_We (2)	Hoek-Brown	24.5	15,000	0.31412933	0.00020346837	0.50614345	Yes	12	49	1	2,000,000			
	DEP_C NAM_SHL&BIF_We	Shear/Normal Fn.	29.4												DEP_C_NAM_SHL&BIF_We
	DEP_C NEW_BF_We	Shear/Normal Fn.	29												DEP_C_NEW_MIN_We
	DEP_C NEW_SHL&BIF_We	Shear/Normal Fn.	29.4												DEP_C_NEW_SHL&BIF_We
	FOUNDATION	Shear/Normal Fn.	29.4												DEP_C_NAM_SHL&BIF_We

1.20

Factor of Safety
- ≤ 1.10 - 1.20
- 1.20 - 1.30
- 1.30 - 1.40
- 1.40 - 1.50
- 1.50 - 1.60
- ≥ 1.60



Dep D XS1 Left pseudo-static

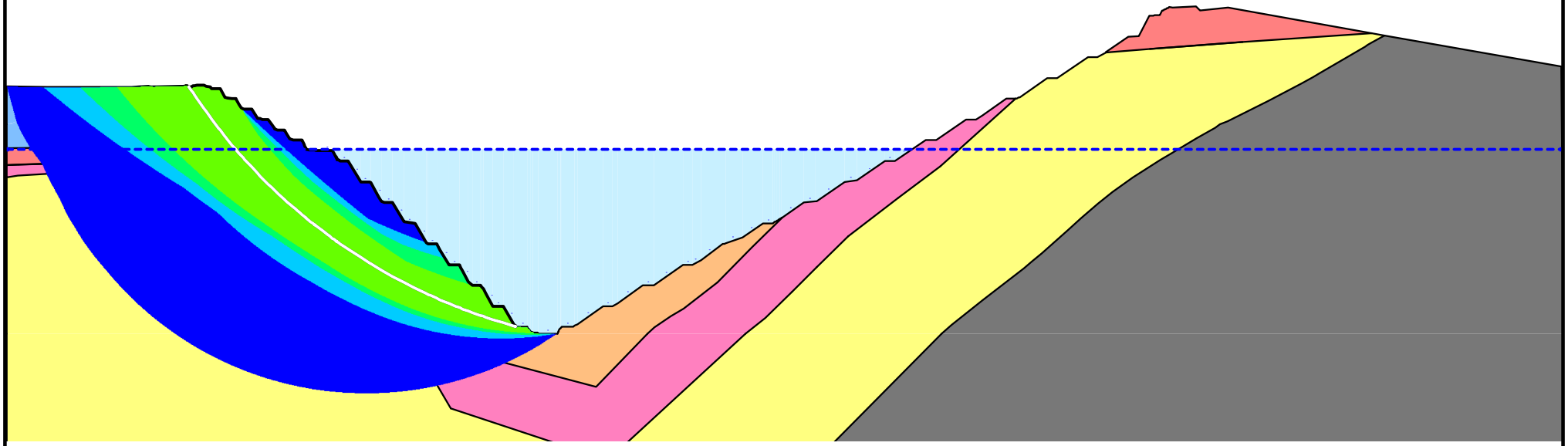
West Angelas

07/10/2021 1:4,500

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	UCS Intact (kPa)	Parameter mb	Parameter s	Parameter a	Calculated from	Intact Rock Parameter mi	Geological Strength Index GSI	Disturbance Factor D	Max Confining Stress Sigma 3 (kPa)	Effective Cohesion (kPa)	Effective Friction Angle (°)	Strength Function
	DEP_C ANG_HYD_Un	Shear/Normal Fn.	29												DEP_C WF_HYD_We
	DEP_C DET_ALL	Mohr-Coulomb	22.6										35	35	
	DEP_C MAC_SHL&BIF_We (2)	Hoek-Brown	24.5	15,000	0.31412933	0.00020346837	0.50614345	Yes	12	49	1	2,000,000			
	DEP_C NAM_SHL&BIF_We	Shear/Normal Fn.	29.4												DEP_C_NAM_SHL&BIF_We
	DEP_C NEW_BF_We	Shear/Normal Fn.	29												DEP_C_NEW_MIN_We
	DEP_C NEW_SHL&BIF_We	Shear/Normal Fn.	29.4												DEP_C_NEW_SHL&BIF_We
	FOUNDATION	Shear/Normal Fn.	29.4												DEP_C_NAM_SHL&BIF_We

1.32

Factor of Safety
- ≤ 1.10 - 1.20
- 1.20 - 1.30
- 1.30 - 1.40
- 1.40 - 1.50
- 1.50 - 1.60
- ≥ 1.60

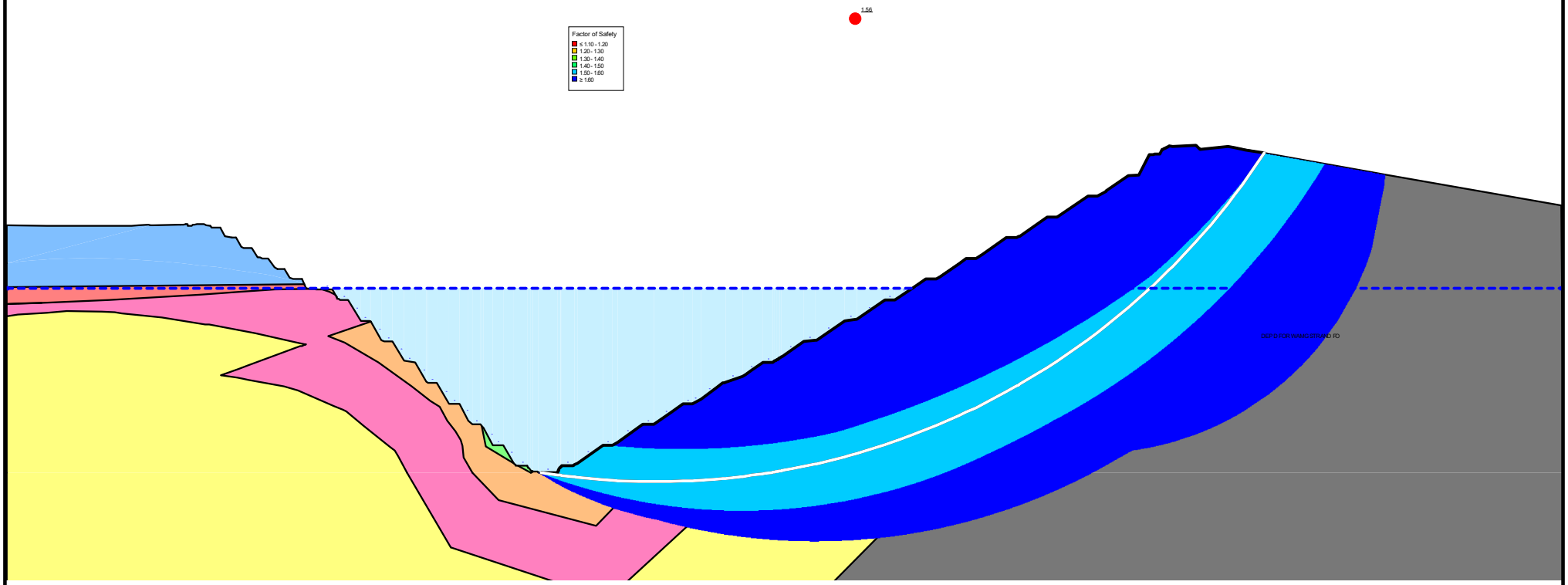


Dep D XS1 Left static

West Angelas

07/10/2021 1:4,500

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	UCS Intact (kPa)	Parameter mb	Parameter s	Parameter a	Calculated from	Intact Rock Parameter mi	Geological Strength Index GSI	Disturbance Factor D	Max Confining Stress Sigma 3 (kPa)	Effective Cohesion (kPa)	Effective Friction Angle (°)	Strength Function
	DEP_C ANG_HYD _Un	Shear/Normal Fn.	29												DEP_C WF_HYD_We
	DEP_C DET_ALL	Mohr-Coulomb	22.6										35	35	
	DEP_C MAC_SHL&BIF_We (2)	Hoek-Brown	24.5	15,000	0.31412933	0.00020346837	0.50614345	Yes	12	49	1	2,000,000			
	DEP_C NAM_SHL&BIF_We	Shear/Normal Fn.	29.4												DEP_C_NAM_SHL&BIF_We
	DEP_C NEW_BIF_We	Shear/Normal Fn.	29												DEP_C_NEW_MIN_We
	DEP_C NEW_SHL&BIF_We	Shear/Normal Fn.	29.4												DEP_C_NEW_SHL&BIF_We
	FOUNDATION	Shear/Normal Fn.	29.4												DEP_C_NAM_SHL&BIF_We

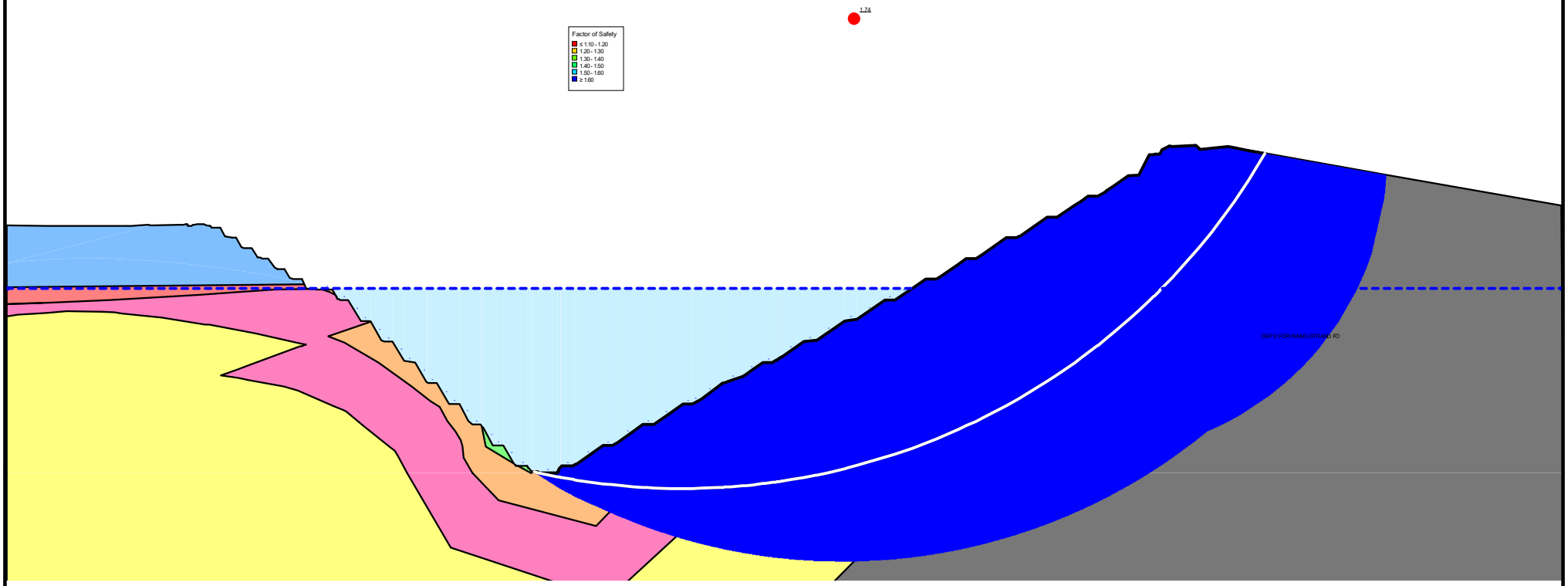


Dep D XS1 Right pseudo-static

West Angelas

07/10/2021 1:4,500

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	UCS Intact (kPa)	Parameter mb	Parameter s	Parameter a	Calculated from	Intact Rock Parameter mi	Geological Strength Index GSI	Disturbance Factor D	Max Confining Stress Sigma 3 (kPa)	Effective Cohesion (kPa)	Effective Friction Angle (°)	Strength Function
	DEP_C ANG_HYD _Un	Shear/Normal Fn.	29												DEP_C WF_HYD_We
	DEP_C DET_ALL	Mohr-Coulomb	22.6										35	35	
	DEP_C MAC_SHL&BIF_We (2)	Hoek-Brown	24.5	15,000	0.31412933	0.00020346837	0.50614345	Yes	12	49	1	2,000,000			
	DEP_C NAM_SHL&BIF_We	Shear/Normal Fn.	29.4												DEP_C_NAM_SHL&BIF_We
	DEP_C NEW_BIF_We	Shear/Normal Fn.	29												DEP_C_NEW_MIN_We
	DEP_C NEW_SHL&BIF_We	Shear/Normal Fn.	29.4												DEP_C_NEW_SHL&BIF_We
	FOUNDATION	Shear/Normal Fn.	29.4												DEP_C_NAM_SHL&BIF_We

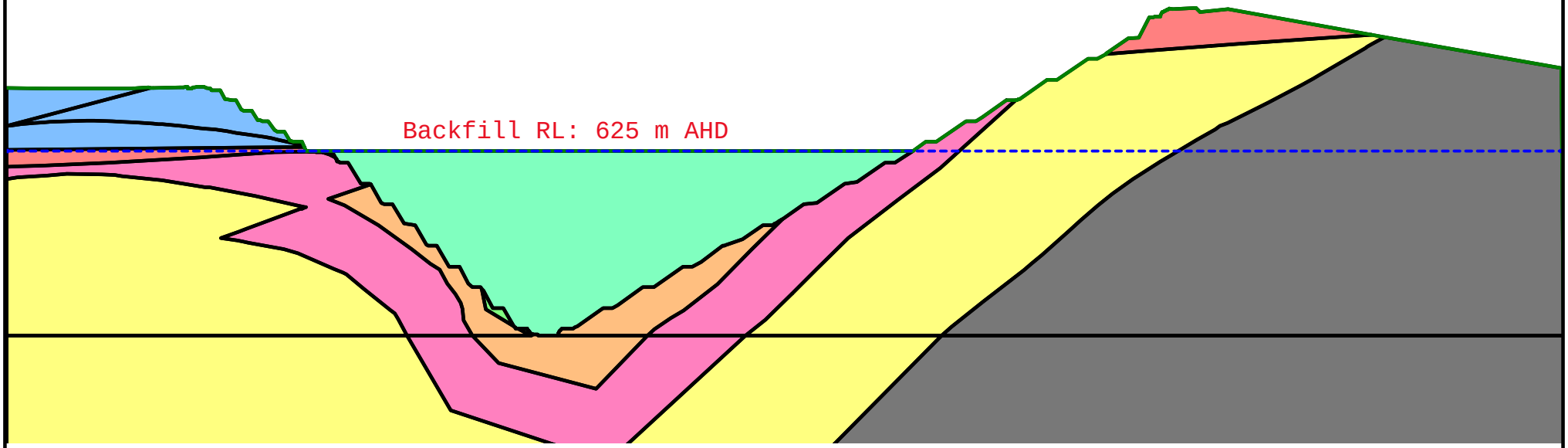


Dep D XS1 Right static

West Angelas

07/10/2021 1:4,500

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	UCS Intact (kPa)	Parameter mb	Parameter s	Parameter a	Calculated from	Intact Rock Parameter mi	Geological Strength Index GSI	Disturbance Factor D	Max Confining Stress Sigma 3 (kPa)	Effective Cohesion (kPa)	Effective Friction Angle (°)	Strength Function
	DEP_C ANG_HYD_Un	Shear/Normal Fn.	29												DEP_C WF_HYD_We
	DEP_C DET_ALL	Mohr-Coulomb	22.6										35	35	
	DEP_C MAC_SHL&BF_We (2)	Hoek-Brown	24.5	15,000	0.31412933	0.00020346837	0.50614345	Yes	12	49	1	2,000,000			
	DEP_C NAM_SHL&BF_We	Shear/Normal Fn.	29.4												DEP_C_NAM_SHL&BF_We
	DEP_C NEW_BF_We	Shear/Normal Fn.	29												DEP_C_NEW_MIN_We
	DEP_C NEW_SHL&BF_We	Shear/Normal Fn.	29.4												DEP_C_NEW_SHL&BF_We
	FILL_BFL	Mohr-Coulomb	22										0	44	
	FOUNDATION	Shear/Normal Fn.	29.4												DEP_C_NAM_SHL&BF_We



Dep D XS1 Right pseudo-static - backfilled

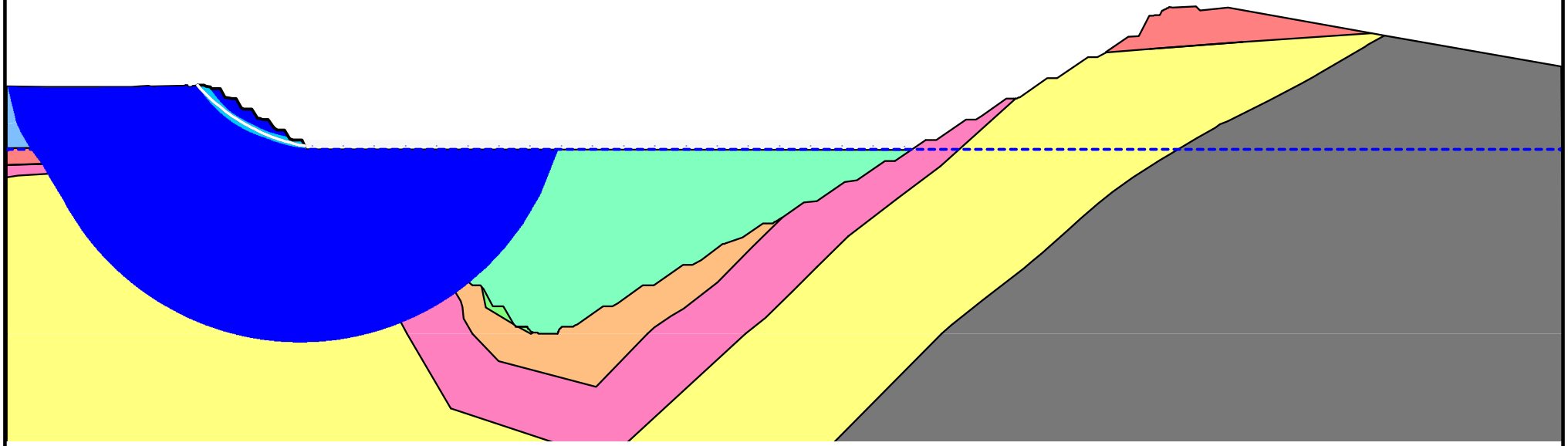
West Angelas

07/10/2021 1:4,500

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	UCS Intact (kPa)	Parameter mb	Parameter s	Parameter a	Calculated from	Intact Rock Parameter mi	Geological Strength Index GSI	Disturbance Factor D	Max Confining Stress Sigma 3 (kPa)	Effective Cohesion (kPa)	Effective Friction Angle (°)	Strength Function
	DEP_C ANG_HVD_Un	Shear/Normal Fn.	29												DEP_C WF_HYD_We
	DEP_C DET_ALL	Mohr-Coulomb	22.6										35	35	
	DEP_C MAC_SHL&BIF_We (2)	Hoek-Brown	24.5	15,000	0.31412933	0.00020346837	0.50614345	Yes	12	49	1	2,000,000			
	DEP_C NAM_SHL&BIF_We	Shear/Normal Fn.	29.4												DEP_C_NAM_SHL&BIF_We
	DEP_C NEW_BF_We	Shear/Normal Fn.	29												DEP_C_NEW_MIN_We
	DEP_C NEW_SHL&BIF_We	Shear/Normal Fn.	29.4												DEP_C_NEW_SHL&BIF_We
	FILL_BFL	Mohr-Coulomb	22										0	44	
	FOUNDATION	Shear/Normal Fn.	29.4												DEP_C_NAM_SHL&BIF_We

1.57

Factor of Safety
- ≤ 1.10 - 1.20
- 1.20 - 1.30
- 1.30 - 1.40
- 1.40 - 1.50
- 1.50 - 1.60
- ≥ 1.60



Dep D XS1 Left pseudo-static - backfilled

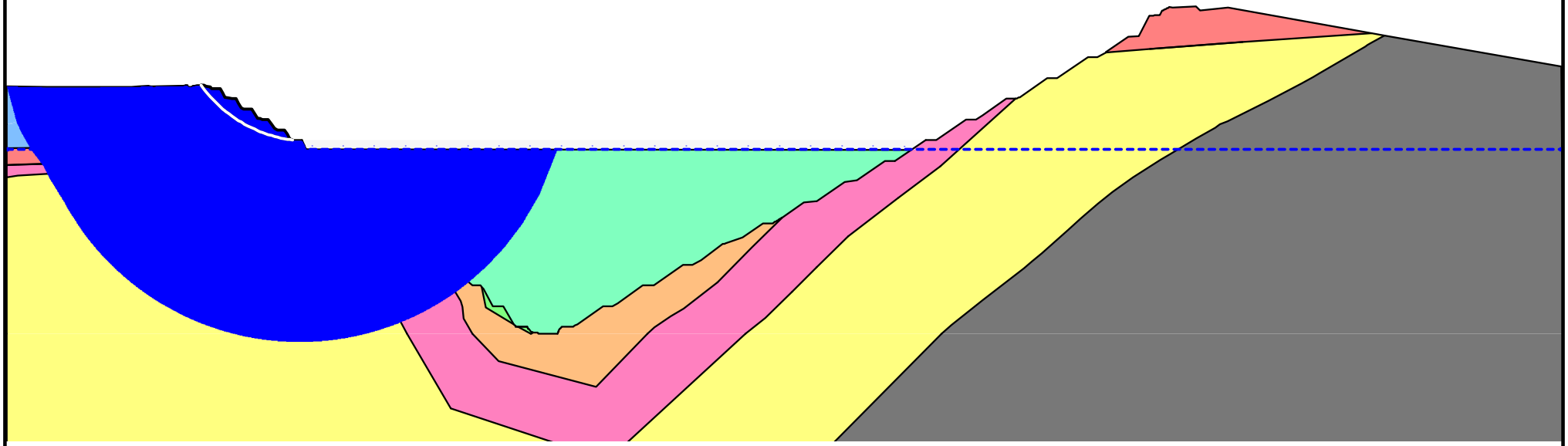
West Angelas

07/10/2021 1:4,500

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	UCS Intact (kPa)	Parameter mb	Parameter s	Parameter a	Calculated from	Intact Rock Parameter mi	Geological Strength Index GSI	Disturbance Factor D	Max Confining Stress Sigma 3 (kPa)	Effective Cohesion (kPa)	Effective Friction Angle (°)	Strength Function
	DEP_C ANG_HVD_Un	Shear/Normal Fn.	29												DEP_C WF_HYD_We
	DEP_C DET_ALL	Mohr-Coulomb	22.6										35	35	
	DEP_C MAC_SHL&BIF_We (2)	Hoek-Brown	24.5	15,000	0.31412933	0.00020346837	0.50614345	Yes	12	49	1	2,000,000			
	DEP_C NAM_SHL&BIF_We	Shear/Normal Fn.	29.4												DEP_C_NAM_SHL&BIF_We
	DEP_C NEW_BF_We	Shear/Normal Fn.	29												DEP_C_NEW_MIN_We
	DEP_C NEW_SHL&BIF_We	Shear/Normal Fn.	29.4												DEP_C_NEW_SHL&BIF_We
	FILL_BFL	Mohr-Coulomb	22										0	44	
	FOUNDATION	Shear/Normal Fn.	29.4												DEP_C_NAM_SHL&BIF_We

1.66

Factor of Safety
- ≤ 1.10 - 1.20
- 1.20 - 1.30
- 1.30 - 1.40
- 1.40 - 1.50
- 1.50 - 1.60
- ≥ 1.60



Dep D XS1 Left static - backfilled

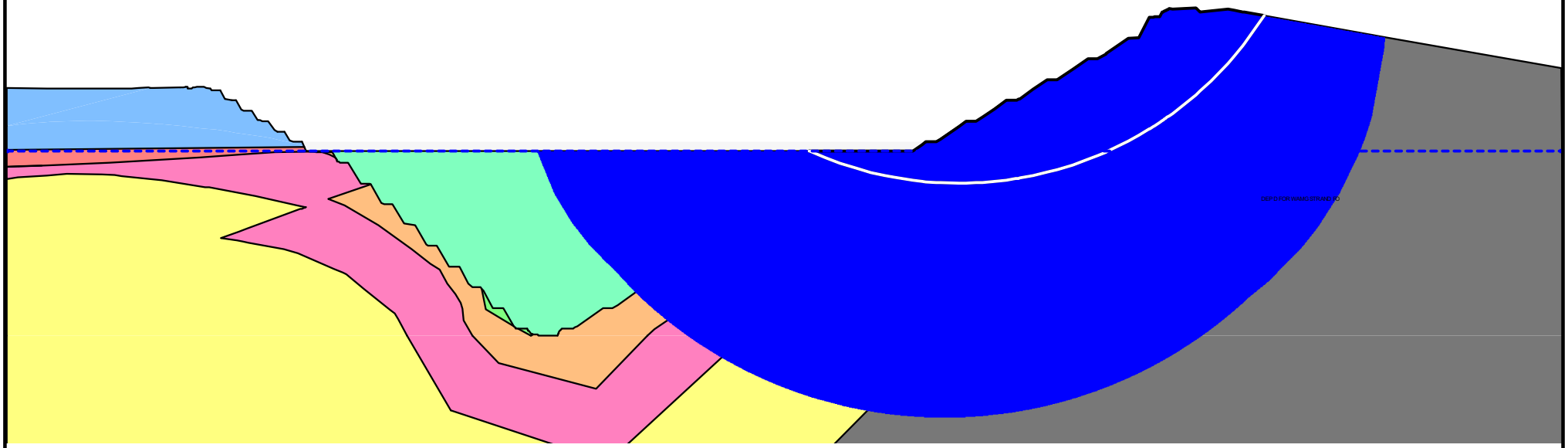
West Angelas

07/10/2021 1:4,500

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	UCS Intact (kPa)	Parameter mb	Parameter s	Parameter a	Calculated from	Intact Rock Parameter mi	Geological Strength Index GSI	Disturbance Factor D	Max Confining Stress Sigma 3 (kPa)	Effective Cohesion (kPa)	Effective Friction Angle (°)	Strength Function
	DEP_C ANG_HYD_Un	Shear/Normal Fn.	29												DEP_C WF_HYD_We
	DEP_C DET_ALL	Mohr-Coulomb	22.6										35	35	
	DEP_C MAC_SHL&BF_We (2)	Hoek-Brown	24.5	15,000	0.31412933	0.00020346837	0.50614345	Yes	12	49	1	2,000,000			
	DEP_C NAM_SHL&BF_We	Shear/Normal Fn.	29.4												DEP_C_NAM_SHL&BF_We
	DEP_C NEW_BF_We	Shear/Normal Fn.	29												DEP_C_NEW_MIN_We
	DEP_C NEW_SHL&BF_We	Shear/Normal Fn.	29.4												DEP_C_NEW_SHL&BF_We
	FILL_BFL	Mohr-Coulomb	22										0	44	
	FOUNDATION	Shear/Normal Fn.	29.4												DEP_C_NAM_SHL&BF_We

2.07

Factor of Safety
- ≤ 1.10 - 1.20
- 1.20 - 1.30
- 1.30 - 1.40
- 1.40 - 1.50
- 1.50 - 1.60
- ≥ 1.60



Dep D XS1 Right pseudo-static - backfilled

West Angelas

07/10/2021 1:4,500

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	UCS Intact (kPa)	Parameter mb	Parameter s	Parameter a	Calculated from	Intact Rock Parameter mi	Geological Strength Index GSI	Disturbance Factor D	Max Confining Stress Sigma 3 (kPa)	Effective Cohesion (kPa)	Effective Friction Angle (°)	Strength Function
	DEP_C ANG_HYD_Un	Shear/Normal Fn.	29												DEP_C WF_HYD_We
	DEP_C DET_ALL	Mohr-Coulomb	22.6										35	35	
	DEP_C MAC_SHL&BF_We (2)	Hoek-Brown	24.5	15,000	0.31412933	0.00020346837	0.50614345	Yes	12	49	1	2,000,000			
	DEP_C NAM_SHL&BF_We	Shear/Normal Fn.	29.4												DEP_C_NAM_SHL&BF_We
	DEP_C NEW_BF_We	Shear/Normal Fn.	29												DEP_C_NEW_MIN_We
	DEP_C NEW_SHL&BF_We	Shear/Normal Fn.	29.4												DEP_C_NEW_SHL&BF_We
	FILL_BFL	Mohr-Coulomb	22										0	44	
	FOUNDATION	Shear/Normal Fn.	29.4												DEP_C_NAM_SHL&BF_We

2.28

Factor of Safety
- ≤ 1.10 - 1.20
- 1.20 - 1.30
- 1.30 - 1.40
- 1.40 - 1.50
- 1.50 - 1.60
- ≥ 1.60

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West Angelas

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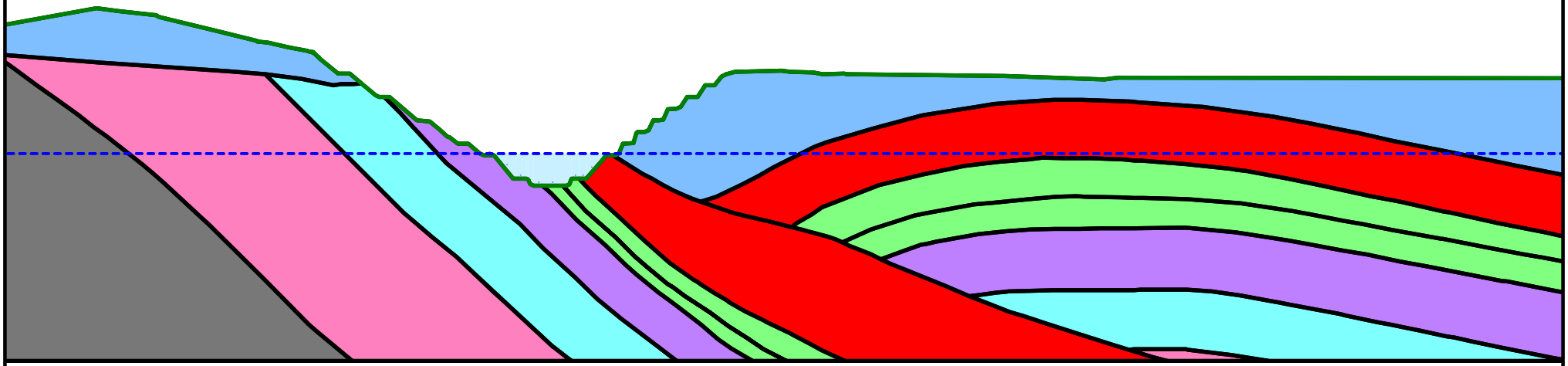
Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)	Strength Function
	DEP_C ANG_ALL_Un	Shear/Normal Fn.	29			DEP_C_ANG_ALL_Un
	DEP_C DET_ALL	Mohr-Coulomb	22.6	35	35	
	DEP_C MAC_SHL_We	Shear/Normal Fn.	29			DEP_C_MAC_SHL_We
	DEP_C NAM_BIF_We	Shear/Normal Fn.	29			DEP_C_NAM_BIF_We
	DEP_C NE1_BIF_We	Shear/Normal Fn.	28.2			DEP_B_NE1_BIF_We
	DEP_C NEW_SHL&BIF_We	Shear/Normal Fn.	29.4			DEP_C_NEW_SHL&BIF_We
	FOUNDATION	Shear/Normal Fn.	29.4			DEP_C_NAM_SHL&BIF_We



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West Angelas

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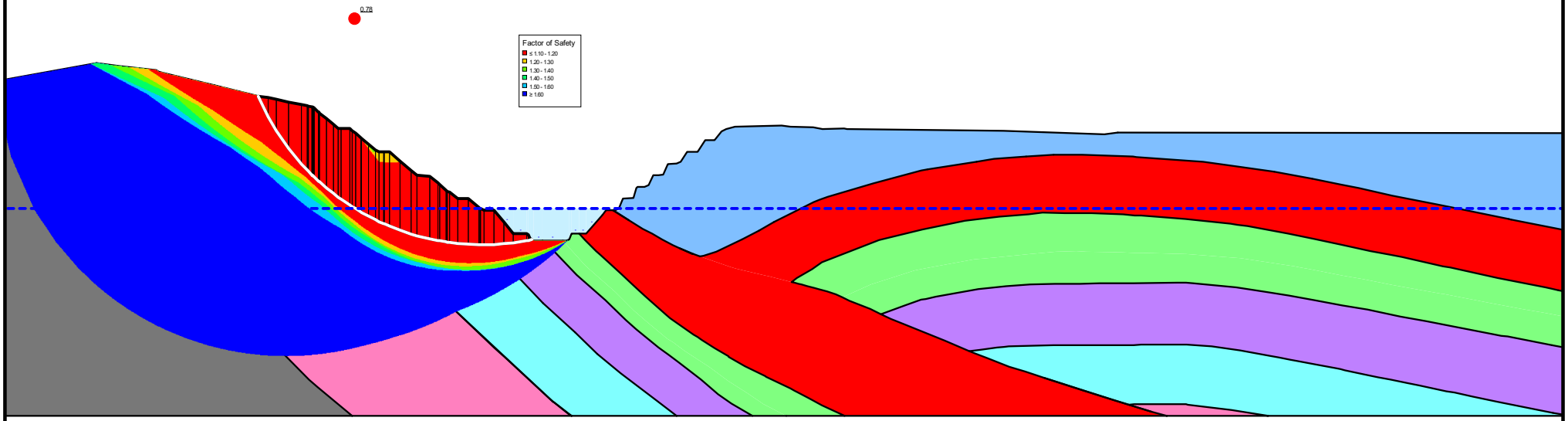
	DEP_C ANG_ALL_Un	Shear/Normal Fn.	29			DEP_C_ANG_ALL_Un
	DEP_C DET_ALL	Mohr-Coulomb	22.6	35	35	
	DEP_C MAC_SHL_We	Shear/Normal Fn.	29			DEP_C_MAC_SHL_We
	DEP_C NAM_BIF_We	Shear/Normal Fn.	29			DEP_C_NAM_BIF_We
	DEP_C NE1_BIF_We	Shear/Normal Fn.	28.2			DEP_B_NE1_BIF_We
	DEP_C NEW_SHL&BIF_We	Shear/Normal Fn.	29.4			DEP_C_NEW_SHL&BIF_We
	FOUNDATION	Shear/Normal Fn.	29.4			DEP_C_NAM_SHL&BIF_We



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West Angelas

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	DEP_CDET_ALL	Mohr-Coulomb	22.6	35	35	
	DEP_CMAC_SHL_We	Shear/Normal Fn.	29			DEP_C_MAC_SHL_We
	DEP_CNAM_BIF_We	Shear/Normal Fn.	29			DEP_C_NAM_BIF_We
	DEP_CNE1_BIF_We	Shear/Normal Fn.	28.2			DEP_B_NE1_BIF_We
	DEP_CNEW_SHL&BIF_We	Shear/Normal Fn.	29.4			DEP_C_NEW_SHL&BIF_We
	FOUNDATION	Shear/Normal Fn.	29.4			DEP_C_NAM_SHL&BIF_We

0.84

Factor of Safety
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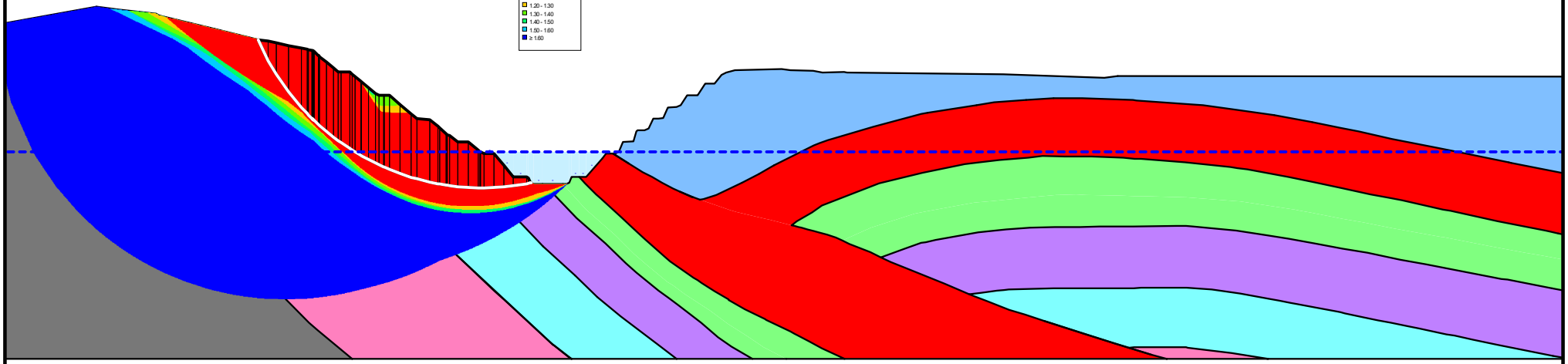
- 1.20 - 1.30
- 1.30 - 1.40
- 1.40 - 1.50
- 1.50 - 1.60
- ≥ 1.60



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West Angelas	
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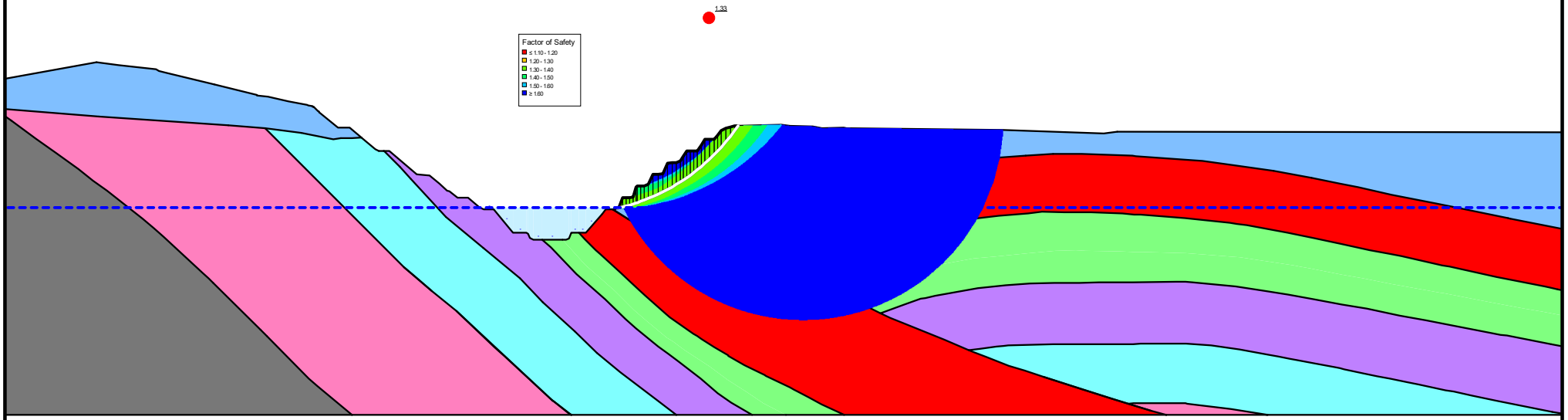
	DEP_CDET_ALL	Mohr-Coulomb	22.6	35	35	
	DEP_CMAC_SHL_We	Shear/Normal Fn.	29			DEP_C_MAC_SHL_We
	DEP_CNAM_BIF_We	Shear/Normal Fn.	29			DEP_C_NAM_BIF_We
	DEP_CNE1_BIF_We	Shear/Normal Fn.	28.2			DEP_B_NE1_BIF_We
	DEP_CNEW_SHL&BIF_We	Shear/Normal Fn.	29.4			DEP_C_NEW_SHL&BIF_We
	FOUNDATION	Shear/Normal Fn.	29.4			DEP_C_NAM_SHL&BIF_We



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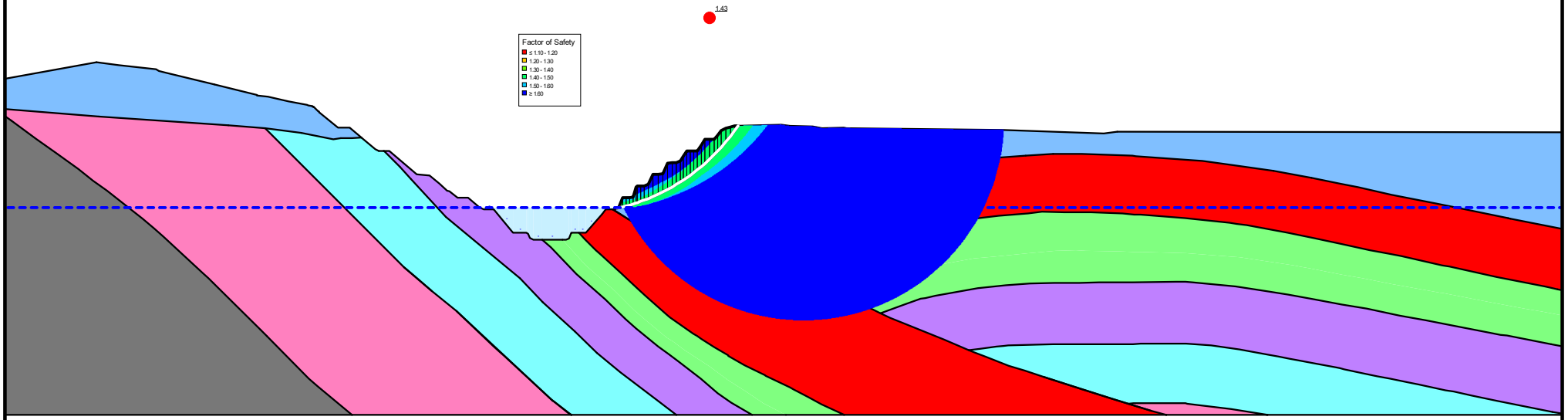
	DEP_CANG_ALL_Un	Shear/Normal Fn.	29			DEP_C_ANG_ALL_Un
	DEP_CDET_ALL	Mohr-Coulomb	22.6	35	35	
	DEP_CMAC_SHL_We	Shear/Normal Fn.	29			DEP_C_MAC_SHL_We
	DEP_CNAM_BIF_We	Shear/Normal Fn.	29			DEP_C_NAM_BIF_We
	DEP_CNE1_BIF_We	Shear/Normal Fn.	28.2			DEP_B_NE1_BIF_We
	DEP_CNEW_SHL&BIF_We	Shear/Normal Fn.	29.4			DEP_C_NEW_SHL&BIF_We
	FOUNDATION	Shear/Normal Fn.	29.4			DEP_C_NAM_SHL&BIF_We



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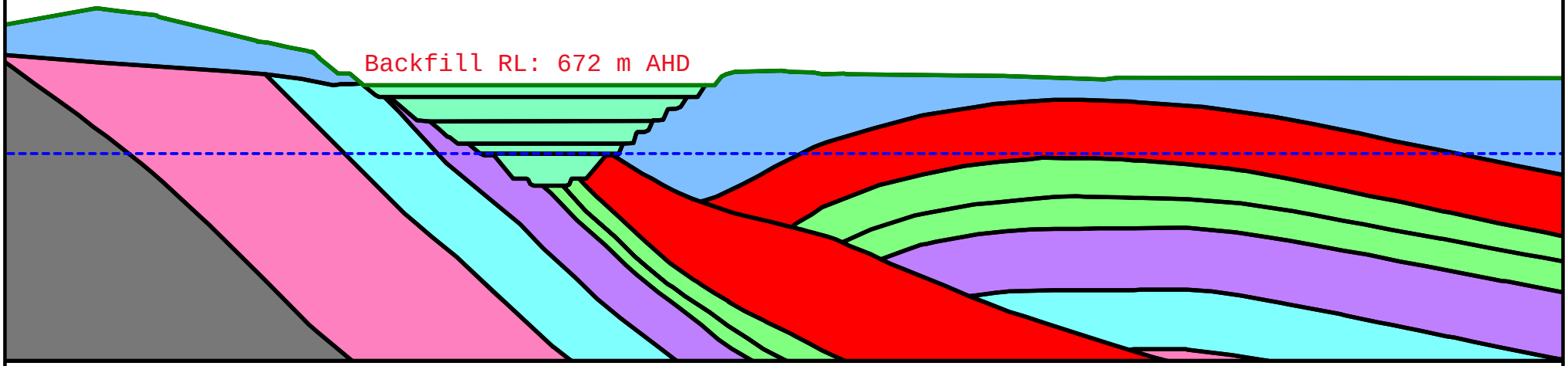
	DEP_C DET_ALL	Mohr-Coulomb	22.6	35	35	
	DEP_C MAC_SHL_We	Shear/Normal Fn.	29			DEP_C_MAC_SHL_We
	DEP_C NAM_BIF_We	Shear/Normal Fn.	29			DEP_C_NAM_BIF_We
	DEP_C NE1_BIF_We	Shear/Normal Fn.	28.2			DEP_B_NE1_BIF_We
	DEP_C NEW_SHL&BIF_We	Shear/Normal Fn.	29.4			DEP_C_NEW_SHL&BIF_We
	FILL_BFL	Mohr-Coulomb	22	0	44	
	FOUNDATION	Shear/Normal Fn.	29.4			DEP_C_NAM_SHL&BIF_We



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	DEP_C DET_ALL	Mohr-Coulomb	22.6	35	35	
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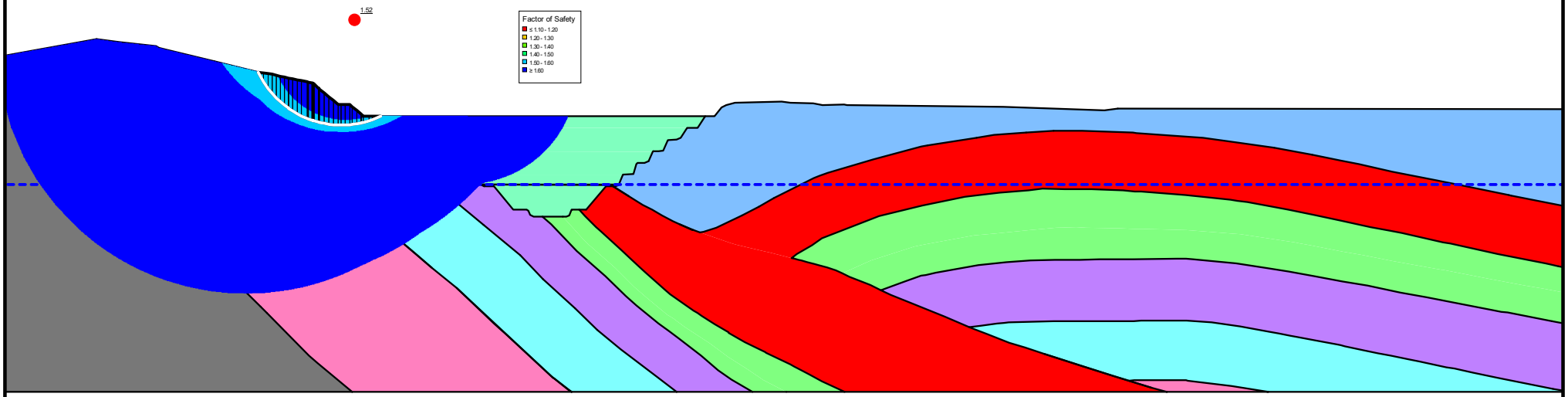
	DEP_C NAM_BIF_We	Shear/Normal Fn.	29			DEP_C_NAM_BIF_We
	DEP_C NE1_BIF_We	Shear/Normal Fn.	28.2			DEP_B_NE1_BIF_We
	DEP_C NEW_SHL&BIF_We	Shear/Normal Fn.	29.4			DEP_C_NEW_SHL&BIF_We
	FILL_BFL	Mohr-Coulomb	22	0	44	
	FOUNDATION	Shear/Normal Fn.	29.4			DEP_C_NAM_SHL&BIF_We



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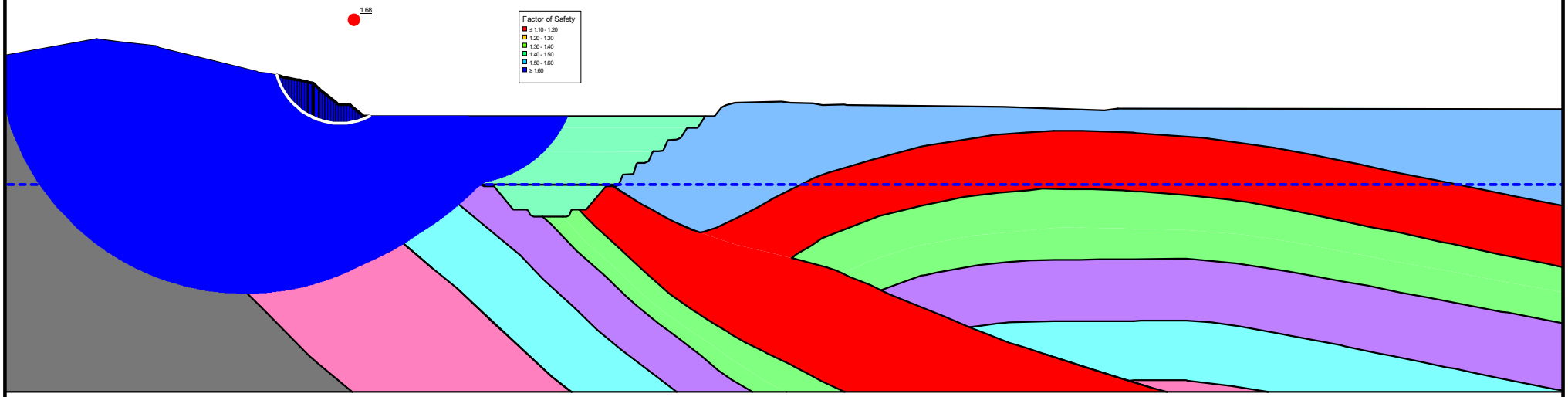
	FOUNDATION	Shear/Normal Fn.	29.4			DEP_C_NAM_SHL&BIF_We



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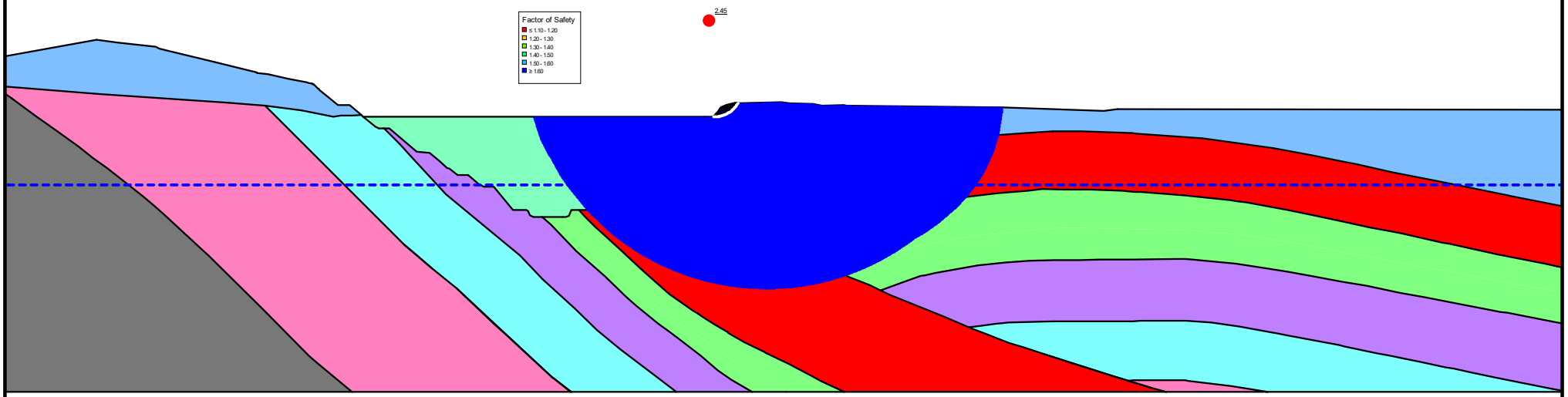
	DEP_CDET_ALL	Mohr-Coulomb	22.6	35	35	
	DEP_CMAC_SHL_We	ShearNormal Fn.	29			DEP_C_MAC_SHL_We
	DEP_CNAM_BIF_We	ShearNormal Fn.	29			DEP_C_NAM_BIF_We
	DEP_CNE1_BIF_We	ShearNormal Fn.	28.2			DEP_B_NE1_BIF_We
	DEP_CNEW_SHL&BIF_We	ShearNormal Fn.	29.4			DEP_C_NEW_SHL&BIF_We
	FILL_BFL	Mohr-Coulomb	22	0	44	
	FOUNDATION	ShearNormal Fn.	29.4			DEP_C_NAM_SHL&BIF_We



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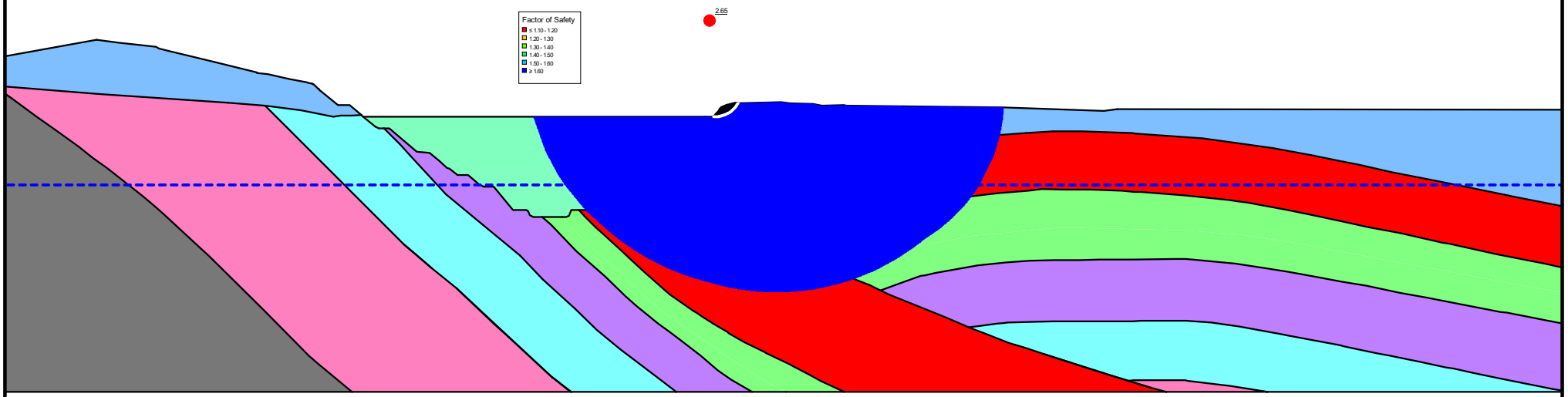
	DEP_CANG_ALL_Un	ShearNormal Fn.	29			DEP_C_ANG_ALL_Un
	DEP_CDET_ALL	Mohr-Coulomb	22.6	35	35	
	DEP_CMAC_SHL_We	ShearNormal Fn.	29			DEP_C_MAC_SHL_We
	DEP_CNAM_BIF_We	ShearNormal Fn.	29			DEP_C_NAM_BIF_We
	DEP_CNE1_BIF_We	ShearNormal Fn.	28.2			DEP_B_NE1_BIF_We
	DEP_CNEW_SHL&BIF_We	ShearNormal Fn.	29.4			DEP_C_NEW_SHL&BIF_We
	FILL_BFL	Mohr-Coulomb	22	0	44	
	FOUNDATION	ShearNormal Fn.	29.4			DEP_C_NAM_SHL&BIF_We



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Appendix D
Conceptual design drawings

Appendix 10: Biological Knowledge Database

Appendix 10 – Biological Knowledge Database

West Angelas

Biological Knowledge Database

November 2023

Disclaimer and Limitation

This report has been prepared by Rio Tinto's Iron Ore Group (Rio Tinto), on behalf of Hamersley Iron Pty Limited (the Proponent), specifically for the West Angelas Mine Closure Plan. Neither the report nor its contents may be referred to without the express approval of Rio Tinto.

Document Status		
Rev	Author	Date
0	N. Oakley	December 2022
A	S. Robinson	January 2023
B	L. Nelson	November 2023

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1 PURPOSE

This document presents the current knowledge for biological baseline information relevant to the West Angelas Iron Ore Project. Information supporting this document has been sourced from baseline surveys completed to support the following environmental approvals and proposed activities:

- West Angelas – approved via Ministerial Statement (MS) 1113
- West Angelas Revised Proposal

This database will be reviewed in support of every Mine Closure Plan (MCP) update to ensure that the biological knowledge remains current.

2 BIOREGION

Bioregions for the Australian continent have been created as part of a national classification of ecosystems and is known as the Interim Biogeographic Regionalisation for Australia (IBRA) (Thackway and Cresswell, 1995). There are currently 89 bioregions and 419 sub-regions under this classification. Each region is based on similarities in climate, geology, landform, native vegetation and species information.

West Angelas lies within bioregion 68 or the Pilbara (PIL), a bioregion characterised by vast coastal plains and inland mountain ranges with cliffs and deep gorges. Vegetation is predominantly mulga low woodlands or snappy gum over bunch and hummock grasses. The Pilbara bioregion covers an area of 17,823,126 ha and is divided into four subregions: Chichester (PIL01), Fortescue Plains (PIL02), Hamersley (PIL03) and Roebourne Plains (PIL04).

West Angelas lies within the Hamersley (PIL03) subregion, occupying an area of 5,634,727 ha with features (Kendrick 2001) including:

- Mountainous areas of Proterozoic sedimentary ranges and plateaux, dissected by gorges (basalt, shale and dolerite).
- Mulga low woodland over bunch grasses on fine textured soils in valley floors, and *Eucalyptus leucophloia* over *Triodia brizoides* on skeletal soils of the ranges.
- Gorges of Hamersley Range, particularly those of Karijini National Park. Deeply incised gorges, up to 100m deep, containing extensive permanent spring fed streams and pools (Duck creek and Palm Springs).
- Major land uses such as unoccupied Crown Land, Crown Reserves pastoralism, intensive rural freehold blocks, horticulture, mining and indigenous freehold, and
- Major population centres at Tom Price, Paraburdoo and Newman.

3 FLORA AND VEGETATION

The Key Flora and Vegetation values identified in the Revised Development Envelope include:

- 28, 907ha of native vegetation in good to excellent condition
- ~ 433 ha of Priority 1 PEC –- ‘West Angelas Cracking-Clays’ PEC (Vegetation Type P15)
- Three vegetation types (D11, H15 and P8) are considered to be highly locally significant as the types are either habitat for Priority 2 and 3 flora, and/or represents riparian habitat.
- Presence of a potential GDV (D2 vegetation type near Turee Creek). Four vegetation features were identified as ‘low- moderate’ to ‘moderate’ likelihood of groundwater dependence. Five vegetation types were classed as riparian vegetation.
- Twenty- eight (28) Priority flora species (seven P2, seventeen P3 and four P4) predominantly hosted within three relatively widespread vegetation types

- West Angelas MCP – Biological Knowledge Database

This section describes the flora and vegetation that occurs within the West Angelas Revised Development Envelope and regionally, through using the data collected for the *West Angelas Revised Proposal – Environmental Review Document* (Rio Tinto 2023).

- West Angelas MCP – Biological Knowledge Database

3.1 Studies and Survey Effort

Table 3-1 summarises the relevant regional surveys and studies undertaken for Flora and Vegetation. Survey coverage is shown in **Figure 3-1**.

Table 3-1: Summary of technical studies for flora and vegetation

Studies/Survey/Prepared for	Study Area, Type and Timing	Consistency with Guidance
West Angelas Beyond 2020 Infrastructure Corridors Reconnaissance and Targeted Survey (Biologic 2022a) **Prepared for Rio Tinto**	**Survey Area: Proposed infrastructure corridors within existing Development Envelope.** **Type: Desktop assessment, reconnaissance and targeted flora and vegetation survey.** **Timing: February & April 2022.**	**The survey was conducted in accordance with:** • Statement of Environmental Principles, Factors and Objectives (EPA, 2021a). • Technical Guidance – Flora and Vegetation Surveys for Environmental Impact Assessment (EPA 2016a) • Environmental Factor Guideline: Flora and Vegetation (EPA 2016b).
West Angelas Beyond 2020 Mt Ella East and Dep J Detailed and Targeted Survey (Biologic 2022b) **Prepared for Rio Tinto**	**Survey Area: Proposed Mt Ella East and Deposit J previously unsurveyed areas. Mt Ella East (East) and Deposit J have been removed from the scope of the proposal. Data is used as a reference and to support impact assessment.** **Type: Desktop assessment, detailed and targeted flora and vegetation survey.** **Timing: February & April 2022.**	**The survey was conducted in accordance with:** • Statement of Environmental Principles, Factors and Objectives (EPA, 2021a). • Technical Guidance – Flora and Vegetation Surveys for Environmental Impact Assessment (EPA 2016a) • Environmental Factor Guideline: Flora and Vegetation (EPA 2016b).
West Angelas Beyond 2020 Dep H and Dep F North Reconnaissance Survey (Rio Tinto 2022)	**Survey Area: Identified field survey coverage gap, eastern extent of Development Envelope at Dep H and northern extent of Development Envelope at Dep F North**	**The survey was conducted in accordance with:** • Statement of Environmental Principles, Factors and Objectives (EPA, 2021a).

- West Angelas MCP – Biological Knowledge Database

Studies/Survey/Prepared for	Study Area, Type and Timing	Consistency with Guidance
Internal survey by Rio Tinto	**Type: Desktop assessment and single-phase reconnaissance flora and vegetation survey.** **Timing: February & April 2022.**	• Technical Guidance – Flora and Vegetation Surveys for Environmental Impact Assessment (EPA 2016a) • Environmental Factor Guideline: Flora and Vegetation (EPA 2016b).
Biologic Environmental Survey Pty Ltd (Biologic) 2022c . **Targeted Flora and Fauna Survey Mt Ella East and Deposit J pit and waste dump footprints** **Prepared for Rio Tinto**	**Survey Area: Mt Ella East and Deposit J covering approximately 237.9 ha of the WAN Development Envelope. Mt Ella East (East) and Deposit J have been removed from the scope of the proposal. Data is used as a reference and to support impact assessment.** **Type: A single season targeted survey for conservation significant flora and fauna.** **Survey Methods: Habitat assessment, targeted searches, water feature and cave assessments, Ultrasonic recordings and opportunistic observations.** **Timing: February 2021.**	**Survey meets relevant EPA and EPBC Act policy and guidance.**
West Angelas: Baseline Groundwater Dependent Ecosystem Assessment for the Greater West Angelas Areas (SLR 2022) **Prepared for Rio Tinto**	**Survey Area: The greater West Angelas area, encompassing the Development Envelope.** **Type: Assessment of potential GDE features based on desktop data sources and analysis of remotely sensed vegetation indices.** **Timing: Field work conducted in 2018 and 2021**	**The EPA has no developed guidance specific to this type of study. Based on relevant EPA guidance, the study has drawn on hydrogeological and hydrological studies undertaken for the Proposal.** **The classification of GDEs in this ERD is based on the results of this report as the most in-depth investigation conducted to identify and assess GDEs. It is noted that this work builds on previous vegetation**

Studies/Survey/Prepared for	Study Area, Type and Timing	Consistency with Guidance
		survey data and supersedes the general identification of potential GDEs in Biologic (2021) Consolidated Vegetation Mapping report.
West Angelas Development Envelope Vegetation Condition Assessment (Biologic 2022e) **Prepared for Rio Tinto**	**Survey Area: West Angelas Revised Development Envelope.** **Type: Vegetation mapping condition assessment.** **Timing: September 2022.**	**N/A - desktop assessment to assign condition ratings to the vegetation units mapped across the West Angelas Project Envelope.** **The condition of the vegetation within the Study Area was mapped based on a desktop assessment and limited on-ground observations. The existing consolidated vegetation mapping and the recent revisions formed the basis of the condition assessment, with the existing vegetation unit polygons assigned a condition rating.**
West Angelas Development Envelope Vegetation Significance Assessment (Biologic 2022f) **Prepared for Rio Tinto**	**Survey Area: West Angelas Revised Development Envelope.** **Type: Vegetation mapping significance assessment.** **Timing: September 2022.**	**N/A - The consolidated vegetation units mapped and described within the Study Area were assessed against a Biological Significance Guidance table. The Biological Significance Guidance table ranks vegetation units based on whether the unit supports significance environmental values.**
West Angelas Beyond 2020 Deposit G Reconnaissance and Targeted Survey (Biologic 2022g) **Prepared for Rio Tinto**	**Survey Area: Previously unsurveyed riparian area within existing Development Envelope.** **Type: Desktop assessment, reconnaissance and targeted flora and vegetation survey.** **Timing: February & April 2022.**	The survey was conducted in accordance with: • Statement of Environmental Principles, Factors and Objectives (EPA 2021a). • Technical Guidance – Flora and Vegetation Surveys for Environmental Impact Assessment (EPA 2016a) • Environmental Factor Guideline: Flora and Vegetation (EPA 2016b).
West Angelas Development Envelope Vegetation Mapping (Biologic 2021a)	**Survey Area: West Angelas Revised Development Envelope.**	**N/A Vegetation mapping has previously been undertaken for the Proposal Development Envelope as part of the West Angelas Revised Proposal flora and vegetation survey completed in 2019 (Biota, 2020).**

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Studies/Survey/Prepared for	Study Area, Type and Timing	Consistency with Guidance
Prepared for Rio Tinto	**Type: Vegetation mapping consolidation and extrapolation.** **Timing: August 2021.**	**Additionally, vegetation mapping also exists for sections of the Development Envelope from numerous surveys, ranging from detailed (formerly Level 2), reconnaissance (Level 1) and native vegetation clearing permit (NVCP) surveys. Combined, previous vegetation mapping has been completed over approximately 98% (40,547.87 hectare (ha)) of the Development Envelope (Biologic 2021a).** **Vegetation mapping (Biologic 2021a) is a consolidation of previous mapping and extrapolation of mapping across areas where mapping has not previously occurred to produce a single consolidated mapping layer of vegetation types present** **All the studies used for consolidation and extrapolation were conducted per EPA guidance, as listed in the following part of this table.**
West Angelas Development Envelope Consolidated Vegetation Mapping (Angelo River) (Biologic 2022d) **Prepared for Rio Tinto**	**Survey Area: Southern section of Proposed Mt Ella East and Deposit J previously unsurveyed areas. Mt Ella East (East) and Deposit J have been removed from the scope of the proposal. Data is used as a reference and to support impact assessment.** **Type: Desktop assessment, detailed and targeted flora and vegetation survey from recent survey to support future project.** **Timing: February & April 2022.**	**Survey meets relevant EPA and EPBC Act policy and guidance.**
West Angelas Beyond 2020 Detailed Flora and Vegetation	**Survey Area: Western Hill, Deposit F North, Deposit H, Deposit J and Mt Ella East.**	**The survey was conducted in accordance with:**

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Studies/Survey/Prepared for	Study Area, Type and Timing	Consistency with Guidance
Survey: Phases 1 and 2 (Biota 2020) **Prepared for Rio Tinto**	**Type: Desktop assessment and two-phase detailed flora and vegetation survey.** **Timing: August/September 2018 and April 2019.**	• Technical Guidance – Flora and Vegetation Surveys for Environmental Impact Assessment (EPA 2016a[G5]) • Environmental Factor Guideline: Flora and Vegetation (EPA 2016b[G7]). No limitations or constraints have been identified.
West Angelas Targeted *Tetratheca fordiana* Survey (Astron 2018) **Prepared for Rio Tinto**	**Survey Area: 263,186 ha to the south, west and north-west of the West Angelas operations.** **Type: Targeted flora survey.** **Timing: November 2018.**	**The survey was conducted in accordance with:** • Terrestrial Biological Surveys as an Element of Biodiversity Protection: Position Statement No. 3 (EPA 2002) • Guidance Statement 51: Terrestrial Flora and Vegetation Surveys for Environmental Impact Assessments in Western Australia (EPA 2004a) • Technical Guidance – Flora and Vegetation Surveys for Environmental Impact Assessment (EPA 2016a) The following limitations and constraints have been identified: • Areas of moderate to the low likelihood of supporting the presence of *Tetratheca fordiana* were unable to be surveyed. • Access was considered a minor limiting factor of this survey as it restricted where ground surveys and specimen collections could take place.
Rio Tinto Greater West Angelas Vegetation and Flora Assessment (Ecologia 2013a) **Prepared for Rio Tinto**	**Survey Area: Greater West Angelas study area (Deposits C, D, D extension, G, F, H and Mt Ella).** **Type: Two-Phase Detailed Flora and Vegetation survey.** **Timing: July 2012 and August 2013.**	**The survey was conducted in accordance with:** • Terrestrial Biological Surveys as an Element of Biodiversity Protection: Position Statement No. 3 (EPA 2002)

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Studies/Survey/Prepared for	Study Area, Type and Timing	Consistency with Guidance
		• Guidance Statement 51: Terrestrial Flora and Vegetation Surveys for Environmental Impact Assessments in Western Australia (EPA 2004a) **The following limitations and constraints have been identified:** **Access limitations in some areas may have reduced total flora inventory to a minor degree.** **Some tussock grasses collected were dry and lacked reproductive material, which resulted in identification difficulties.**
Ngarlawangga Traditional Ecological Knowledge (TEK) – Ethnobotanical Survey (Vicki Long and Associates (2021) **Prepared for Ngarlawangga Aboriginal Corporation**	**Area: Ngarlawangga Native Title Determination Area** **Type: Consultation including on-country assessment** **Timing: August 2021**	**NAC with the support of the Proponent has begun to record the TEK associated with flora in the Revised Development Envelope and surrounding region. Ngarlawangga wish to continue to develop these TEK projects and consider it essential that this knowledge be incorporated into mine design and rehabilitation. The primary purpose of the TEK survey is to develop a written record of existing knowledge and known language names of plants as provided by the Ngarlawangga people, for use within their community and ranger programme. The secondary purpose was to gain an understanding of plants that are traditionally and culturally important to the past and current lives of the Ngarlawangga people, and how these plants may be impacted by both singular and cumulative mining developments in order that these mat be mitigated to some extent.** **Yinhawangka also have expressed desire to conduct these types of flora surveys**
Report of an Yinhawangka Ethnobotanical Survey of the Deposits C and D at West Angelas (2018_31_WACD Project)	**Survey Area: West Angelas Deposits C and D** **Type: Consultation including on-country assessment** **Timing: 31st March – 4th April 2019**	**N/A – Ethnobotany is a cross-disciplinary endeavour, involving traditional knowledge and botanises, and often social scientists. This survey team comprises traditional knowledge holders, an experienced botanist, and experienced heritage professionals. The work draws on traditional knowledge of useful or culturally significant plants and on botanical knowledge for plant identification. The ethnobotanical field team visited 42 locations, and recorded a sample**

Studies/Survey/Prepared for	Study Area, Type and Timing	Consistency with Guidance
Prepared for: Rio Tinto Iron Ore and Yinhawangka Aboriginal Corporation.		**name (archaeological site and control samples), coordinates and vegetation unit identified by Ecologia (2013).** **The team travelled together to various points, including 42 botanical samples areas, around Deposits C and D at West Angelas. The entire field team assisted each other in the tasks that each researcher considered practical.**
Vegetation and Flora survey of West Angelas Deposits E and F (Biota 2005a) **Prepared for Rio Tinto**	**Survey Area: Deposits E and F.** **Type: Two-Phase Detailed Flora and Vegetation survey.** **Timing: 2004-05.**	**Not assessed due to age of survey; survey results used for contextual information and to inform consolidated vegetation mapping by Biologic.**
Flora and vegetation surveys of Orebody A and Orebody B in the West Angela Hill area (Trudgen and EcAus 1998) **Prepared for Rio Tinto**	**Survey Area: Greater West Angelas study area (Deposits C, D, D extension, G, F, H and Mt Ella).** **Type: Two-Phase Detailed Flora and Vegetation survey.** **Timing: 1995; April – July/Sep 1997; 1998.**	**Not assessed due to age of survey; survey results used for contextual information and to inform consolidated vegetation mapping by Biologic.**

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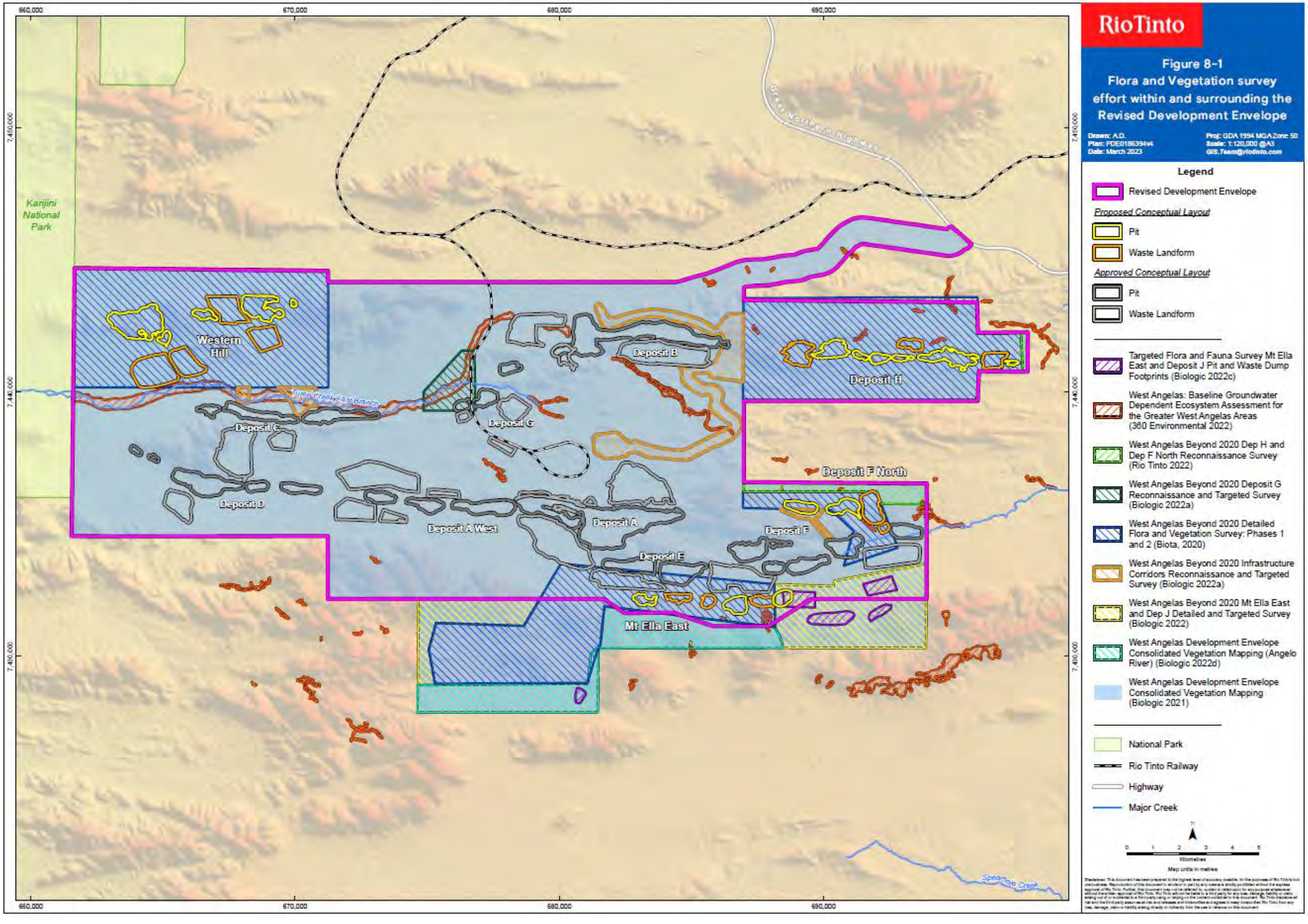

Figure 3-1 Flora and Vegetation survey effort within and surrounding the Development Envelope

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3.2 Vegetation

3.2.1 Vegetation Types

Forty-seven (47) vegetation types have been described within the Development Envelope (Biologic 2021a). The most widespread vegetation types are:

- **M1:** *Acacia aneura*, *Acacia pruinocarpa* low open woodland/ *A. aneura*, *A. catenulata* subsp. *occidentalis* and/or *A. pruinocarpa* low woodland to low open forest - *Eremophila forrestii* subsp. *forrestii* open shrubland *Triodia pungens* open hummock grassland/*T. pungens* very open hummock grassland (occupying 5,352 ha (15%) of the Development Envelope). This type is a mosaic of P3 and P6 vegetation types, of which a further 665 ha (P3) and 80 ha (P6) have been mapped within the Development Envelope
- **H4:** *Acacia inaequilatera* scattered tall shrubs *Triodia wiseana* open hummock grassland (occupying 3,755 ha (10%) of the Development Envelope)
- **H7:** *Eucalyptus leucophloia* subsp. *leucophloia* scattered low trees *Acacia maitlandii* scattered shrubs *Triodia vanleeuwenii*, *T. pungens* open hummock grassland (occupying 2,283 ha (6%) of the Development Envelope).

Of the vegetation types recorded in the Development Envelope, 45 were broadly associated with four major landforms: Drainage Lines (11 vegetation types); Gullies/Gorges (three vegetation types); Stony Hillslopes, Hill Crests and Foothills (15 vegetation types); and Stony Plains, Sand Plains and Clay Plains (16 vegetation types). The remaining two vegetation types are considered a mosaic of the others (Biologic 2021a).

The extent of all vegetation types within the Revised Development Envelope is presented in Table 3-2 and Figure 3-2.

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Table 3-2: Vegetation types

Vegetation Type	Description	Extent within the (ha)*	Total Extent within Development Envelope (ha)*	Total % of Development Envelope
Drainage Lines				
D2	*Eucalyptus victrix* low open woodland *Acacia citrinoviridis* tall open shrubland over *Tephrosia rosea* var. Fortescue Creeks (M.I.H. Brooker 2186) scattered low shrubs *Themeda triandra* very open tussock grassland over *Triodia pungens* scattered hummock grasses to very open hummock grassland.	160	160	0.4
D3	*Eucalyptus xerothermica* and/or *Corymbia hamersleyana* low open woodland *Petalostylis labicheoides*, *Acacia pyrifolia* tall open shrubland over *Tephrosia rosea* var. Fortescue Creeks (M.I.H. Brooker 2186) low open shrubland *Themeda triandra* very open tussock grassland over *Triodia pungens* very open hummock grassland to scattered hummock grasses.	178	70	0.2
D4	Acacia 'aneura', A. catenulata subsp. occidentalis, A. pruinocarpa low woodland Triodia pungens very open hummock grassland.	6	6	0.0
D5	*Corymbia hamersleyana* low open woodland *Petalostylis labicheoides, Acacia monticola* tall shrubland over *Tephrosia rosea* var. Fortescue Creeks (M.I.H. Brooker 2186) low open shrubland *Themeda triandra* very open tussock grassland over *Triodia pungens* very open hummock grassland.	18	18	0.0
D6	Corymbia hamersleyana and/or Corymbia deserticola subsp. deserticola low open woodland Acacia 'aneura', Petalostylis labicheoides tall open shrubland Triodia pungens open hummock grassland.	312	312	0.8

Vegetation Type	Description	Extent within the (ha)*	Total Extent within Development Envelope (ha)*	Total % of Development Envelope
D7	*Corymbia hamersleyana* low open woodland *Acacia monticola* tall shrubland *Themeda triandra* very open tussock grassland over *Triodia pungens* very open hummock grassland.	70	45	0.1
D8	Eucalyptus leucophloia subsp. leucophloia, Corymbia hamersleyana low open woodland Petalostylis labicheoides, Gossypium robinsonii, Acacia monticola open shrubland Themeda triandra tussock grassland over Triodia pungens open hummock grassland.	5	5	0.0
D9	*Eucalyptus trivalva* low mallee woodland *Triodia pungens* very open hummock grassland.	27	27	0.1
D10*	*Eucalyptus xerothermica, Acacia 'aneura'* low woodland *Androcalva luteiflora* open shrubland over *Isotropis iophyta* (formally *Isotropis* sp. Arid zone (G. Byrne 2775)) low open shrubland *Themeda triandra* tussock grassland.	4	4	0.0
D11	Eucalyptus xerothermica and/or Acacia 'aneura' low open woodland over E. trivalva low open mallee woodland Petalostylis labicheoides, Androcalva luteiflora open shrubland Eulalia symonii and/or Themeda triandra very open tussock grassland with Triodia pungens very open hummock grassland.	153	153	0.4
D12	Eucalyptus xerothermica and/or E. victrix scattered low trees to low open woodland Melaleuca bracteata, (M. glomerata) tall open shrubland over Androcalva luteiflora open shrubland Themeda triandra tussock grassland over Triodia longiceps, T. pungens very open hummock grassland.	5	5	0.0
D13*	Acacia 'aneura', Callitris columellaris and/or Corymbia ferriticola low woodland Capparis mitchellii scattered tall shrubs over Ptilotus obovatus low open shrubland Eriachne mucronata and/or Aristida burbidgeae very open tussock grassland with Triodia pungens scattered hummock grasses.	72	0	0

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Vegetation Type	Description	Extent within the (ha)*	Total Extent within Development Envelope (ha)*	Total % of Development Envelope
D14	Acacia. pyrifolia var. pyrifolia, Petalostylis labicheoides tall sparse to tall open shrubland over Indigofera georgei, Ptilotus obovatus, Solanum lasiophyllum low isolated to low open shrubland	646	646	1.8
Gullies and Gorges				
G1*	Acacia 'aneura', A. pruinocarpa, Corymbia ferriticola low open forest Dodonaea pachyneura tall open shrubland over Harnieria kempeana subsp. muelleri, (Ptilotus obovatus) low shrubland Triodia pungens very open hummock grassland.	5	5	0.0
G2	Acacia 'aneura', Callitris columellaris and/or Corymbia ferriticola low woodland Capparis mitchellii scattered tall shrubs over Ptilotus obovatus low open shrubland Eriachne mucronata and/or Aristida burbidgeae very open tussock grassland with Triodia pungens scattered hummock grasses.	111	45	0.1
G3	*Corymbia ferriticola* low open woodland *Acacia monticola* tall open shrubland *Themeda triandra* very open tussock grassland over *Triodia pungens* scattered hummock grasses.	27	27	0.1
Stony Hillslopes, Hillcrests and Foothills				
H1	Acacia 'aneura' and/or A. ayersiana, (Eucalyptus leucophloia subsp. leucophloia) low woodland Eremophila forrestii subsp. forrestii, E. latrobei subsp. latrobei scattered shrubs Triodia pungens, T. wiseana very open hummock grassland.	100	100	0.3
H2	Acacia 'aneura' low woodland Eremophila jucunda subsp. pulcherrima, E. phyllopoda subsp. obliqua, (E. cuneifolia, E. oppositifolia subsp. angustifolia) open shrubland Triodia pungens very open hummock grassland.	457	457	1.2

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Vegetation Type	Description	Extent within the (ha)*	Total Extent within Development Envelope (ha)*	Total % of Development Envelope
H3	Acacia catenulata subsp. occidentalis, (Eucalyptus leucophloia subsp. leucophloia, A. 'aneura') low open forest Triodia pungens open hummock grassland.	179	54	0.1
H4	*Acacia inaequilatera* scattered tall shrubs *Triodia wiseana* open hummock grassland.	3,755	3,755	10.2
H5*	Corymbia hamersleyana, Eucalyptus leucophloia subsp. leucophloia low open woodland Acacia maitlandii open heath over Halgania gustafsenii var. Mid-West (G. Perry 370) low open shrubland Triodia pungens, T. wiseana hummock grassland.	326	0	0.0
H6	Eucalyptus leucophloia subsp. leucophloia low open woodland Acacia bivenosa open shrubland Triodia pungens open hummock grassland.	152	152	0.4
H7	Eucalyptus leucophloia subsp. leucophloia scattered low trees Acacia maitlandii scattered shrubs Triodia vanleeuwenii, T. pungens open hummock grassland.	2,283	2,283	6.2
H8	Eucalyptus leucophloia subsp. leucophloia and/or Corymbia deserticola subsp. deserticola low open woodland Acacia pruinocarpa scattered tall shrubs Triodia vanleeuwenii and/or T. pungens open hummock grassland.	2,074	2,074	4.6
H9	Eucalyptus leucophloia subsp. leucophloia and/or Corymbia deserticola subsp. deserticola low open woodland over E. gamophylla low open mallee woodland Triodia vanleeuwenii open hummock grassland.	1,543	318	0.9
H10	Eucalyptus leucophloia subsp. leucophloia scattered low trees over E. gamophylla low open mallee woodland Acacia maitlandii, Petalostylis labicheoides open shrubland Triodia vanleeuwenii, T. wiseana open hummock grassland.	1,532	1,532	4.2

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Vegetation Type	Description	Extent within the (ha)*	Total Extent within Development Envelope (ha)*	Total % of Development Envelope
H11	Eucalyptus leucophloia subsp. leucophloia scattered low trees over E. kingsmillii low open mallee woodland Acacia hamersleyensis scattered tall shrubs Triodia vanleeuwenii, T. wiseana open hummock grassland.	76	76	0.2
H12	Eucalyptus leucophloia subsp. leucophloia scattered low trees Eremophila fraseri subsp. fraseri low open shrubland Triodia pungens and/or T. wiseana open hummock grassland.	27	27	0.1
H13	*Eucalyptus leucophloia* subsp. *leucophloia* low open woodland over *Eucalyptus* spp. low open mallee woodland *Triodia wiseana, T.* sp. Mt Ella (M.E. Trudgen 12739) open hummock grassland.	320	9	0.1
H14	Eucalyptus leucophloia subsp. leucophloia scattered low trees Triodia brizoides, (T. wiseana) open hummock grassland.	293	293	0.8
H15	Eucalyptus leucophloia subsp. leucophloia low open woodland Triodia pungens and/or T. wiseana open hummock grassland.	3,426	1,729	4.7
H16	*Eucalyptus leucophloia* subsp. *leucophloia* low open woodland *Triodia vanleeuwenii*, *T. pungens* and/or *T.* sp. Mt Ella (M.E. Trudgen 12739) open hummock grassland.	1,885	1,885	5.1
Mosaics				
M1	Acacia 'aneura', Acacia pruinocarpa low open woodland/Acacia 'aneura', A. catenulata subsp. occidentalis and/or Acacia pruinocarpa low woodland to low open forest - / Eremophila forrestii subsp. forrestii open shrubland Triodia pungens open hummock grassland/Triodia pungens very open hummock grassland.	5,352	5,352	14.6

Vegetation Type	Description	Extent within the (ha)*	Total Extent within Development Envelope (ha)*	Total % of Development Envelope
M2	Eucalyptus trivalva, E. repullulans, E. socialis subsp. eucentrica low open mallee woodland Acacia inaequilatera scattered tall shrubs/- Triodia wiseana open hummock grassland/Triodia wiseana, (T. angusta, T. pungens, T. longiceps) open hummock grassland.	242	242	0.7
Stony Plains, Sand Plains and Clay Plains				
P1	Acacia 'aneura', A. ayersiana, A. pruinocarpa low open woodland Triodia vanleeuwenii, T. pungens open hummock grassland.	156	156	0.4
P2	Acacia 'aneura', A. ayersiana low open woodland Eremophila forrestii subsp. forrestii open shrubland Triodia melvillei open hummock grassland.	391	391	1.1
P3	Acacia 'aneura', A. catenulata subsp. occidentalis and/or Acacia pruinocarpa low woodland to low open forest Eremophila forrestii subsp. forrestii open shrubland Triodia pungens very open hummock grassland	610	610	1.7
P4	Acacia 'aneura', A. pruinocarpa, A. ayersiana woodland Triodia pungens open hummock grassland.	328	275	0.7
P5	*Acacia 'aneura'* and/or *A. pruinocarpa* low woodland to low open forest *Eremophila forrestii* subsp. *forrestii* open shrubland *Triodia pungens* very open hummock grassland.	356	336	0.9
P6	Acacia 'aneura', A. pruinocarpa low open woodland Triodia pungens open hummock grassland.	79	79	0.2
P7	Acacia 'aneura', Eucalyptus xerothermica scattered low trees to low open woodland Eremophila forrestii subsp. forrestii and/or E. longifolia very open shrubland Themeda	1,207	1,207	3.3

Vegetation Type	Description	Extent within the (ha)*	Total Extent within Development Envelope (ha)*	Total % of Development Envelope
	triandra scattered tussock grasses over Triodia wiseana and/or T. pungens open hummock grassland.			
P8	*Acacia 'aneura'* scattered tall shrubs *Themeda triandra* scattered tussock grasses to tussock grassland with *Aristida contorta* scattered bunch grasses to bunch grassland over *Triodia pungens* scattered hummock grasses.	159	159	0.4
P9	*Acacia pruinocarpa* scattered tall shrubs over *A. wanyu* open shrubland *Triodia vanleeuwenii* and/or *T. pungens* open hummock grassland.	224	224	0.6
P10	Eucalyptus leucophloia subsp. leucophloia low open woodland Acacia tenuissima, A. dictyophleba, A. maitlandii open shrubland Triodia wiseana hummock grassland.	33	33	0.1
P11	Eucalyptus leucophloia subsp. leucophloia low open woodland Triodia longiceps and/or T. wiseana, T. pungens open hummock grassland.	663	663	1.8
P12	*Eucalyptus gamophylla* low open mallee woodland *Triodia pungens* and/or *T. vanleeuwenii* open hummock grassland.	1,585	1,410	3.8
P13	Eucalyptus repullulans, E. socialis subsp. eucentrica low open mallee woodland Melaleuca eleuterostachya low open shrubland Triodia wiseana, T. angusta very open hummock grassland.	41	41	0.1
P14	Eucalyptus trivalva, E. repullulans, E. socialis subsp. eucentrica low open mallee woodland Triodia wiseana, (T. angusta, T. pungens, T. longiceps) open hummock grassland.	1,367	928	2.5
P15	Astrebla pectinata, Astrebla elymoides and Aristida latifolia open tussock grassland	433	433	1.2

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Vegetation Type	Description	Extent within the (ha)*	Total Extent within Development Envelope (ha)*	Total % of Development Envelope
P16	Acacia 'aneura' tall open shrubland Eremophila forrestii subsp. forrestii, Rhagodia eremaea open shrubland Chrysopogon fallax scattered tussock grasses	112	112	0.3
Disturbed				
Cleared	Native vegetation cleared and disturbed	7,931	7,857	21.4
Total		41,483	36,779	100

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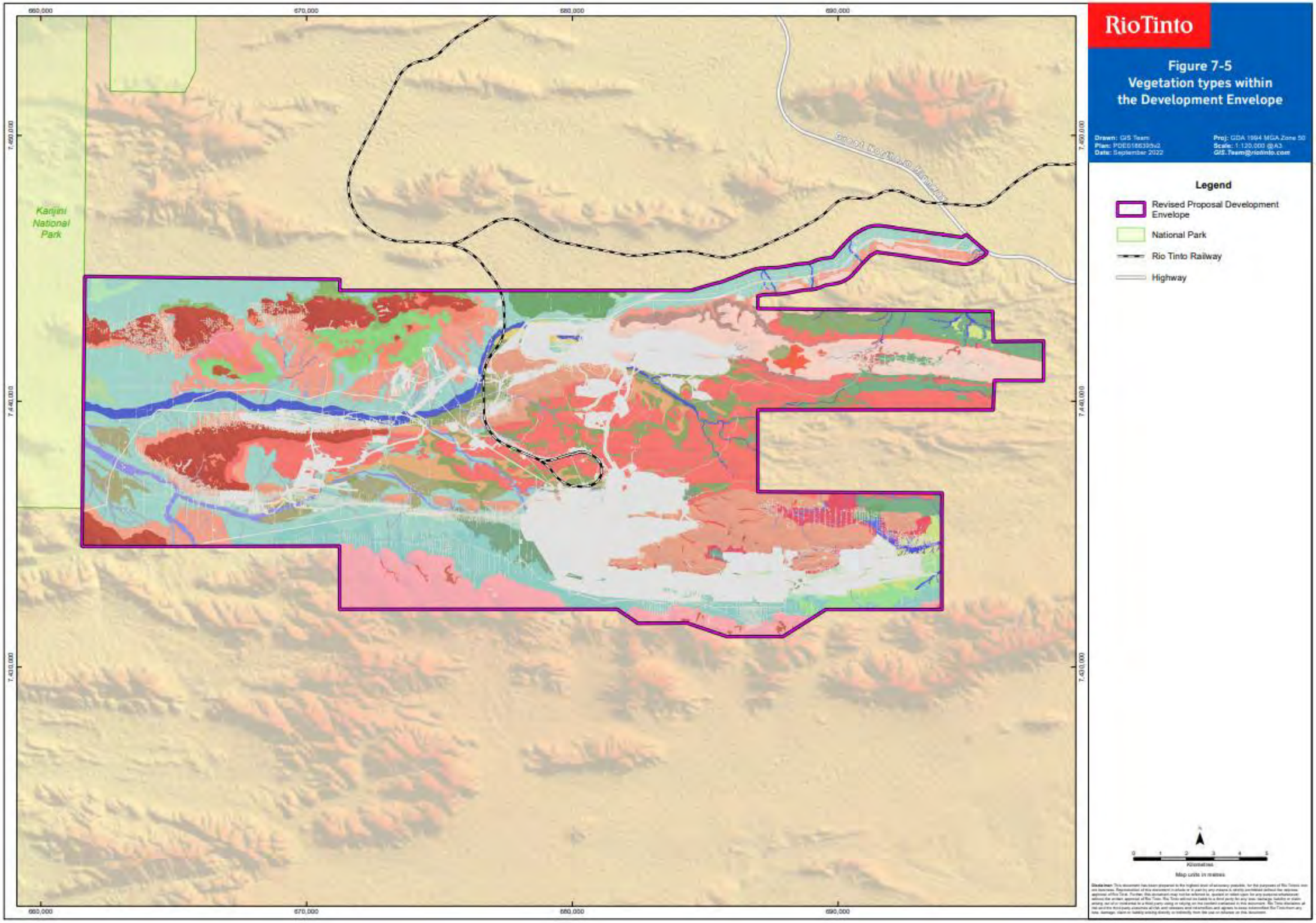

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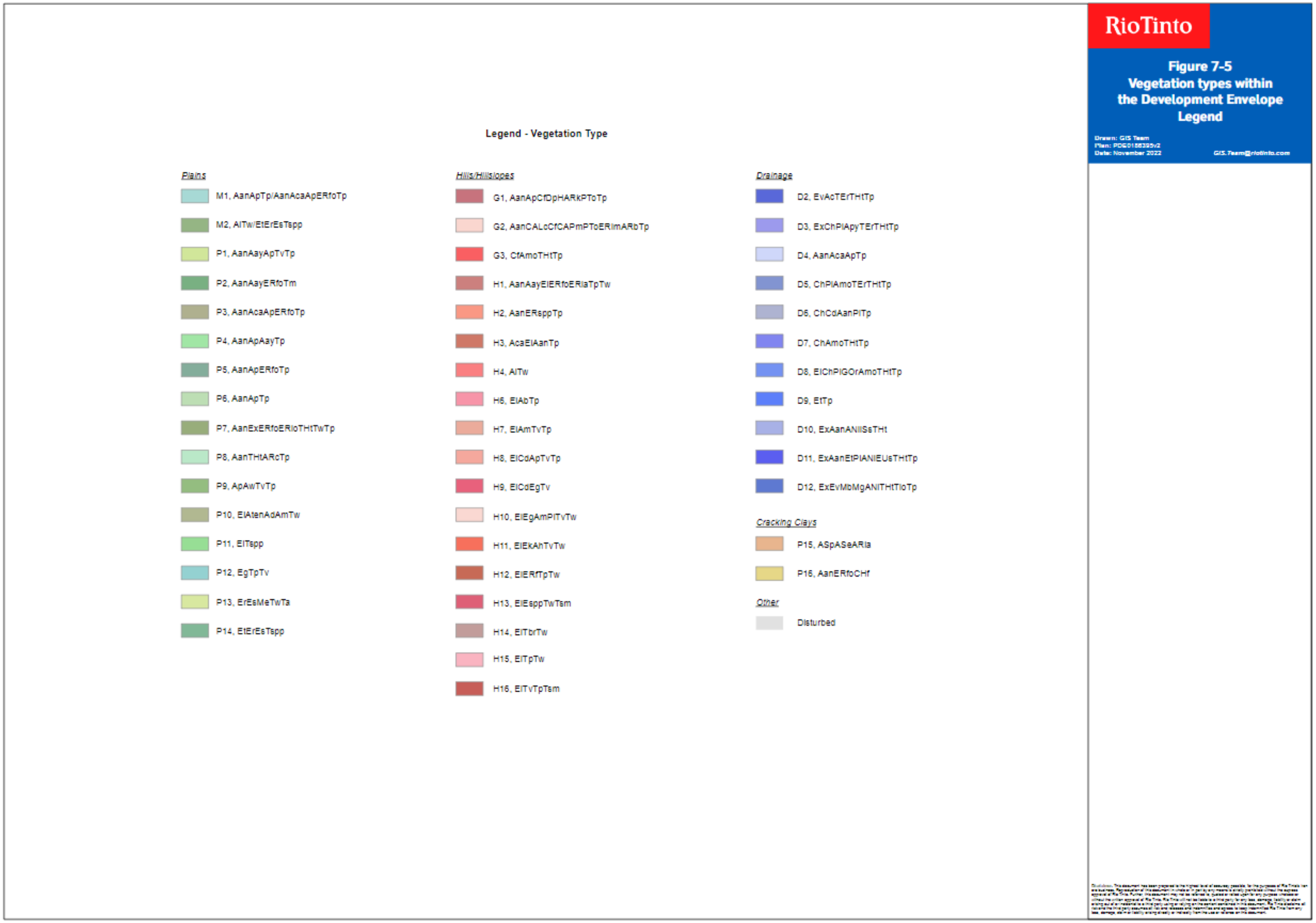

Figure 3-2: Vegetation types within the Development Envelope

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3.2.2 Vegetation Condition

Vegetation condition within the Revised Development Envelope ranges from excellent to completely degraded, with the majority classified as being in either excellent (15,571 ha) or very good (11,612 ha) condition. Native vegetation within the Development Envelope is largely considered to be in better condition than other areas of the Pilbara, based on the lack of historical pastoral activities and associated disturbance (Biota 2020). Approximately 7,857 ha of the Development Envelope is classified as being completely degraded due to impacts from existing operations, including clearing undertaken for mining exploration activities for the Proposal (**Table 3-3**).

Table 3-3: Vegetation condition for remanent vegetation in the Revised Development Envelope

Condition	
Units	**Area (ha)***
Excellent	**15,571**
Very good	**11,612**
Good	**1,724**
Poor	**15**
Completely degraded	**7,857**
Total	**36,779**

3.2.3 Significant Vegetation

Threatened Ecological Communities

No TECs as defined by the BC or EPBC Act occur within the Revised Development Envelope. The closest TEC is the Ethel Gorge Aquifer Stygobiont Community, located approximately 110 km east of the Revised Development Envelope.

Priority Ecological Communities

The Revised Development Envelope includes mapped areas of the 'West Angelas Cracking-Clays' P1 Priority Ecological Communities(PEC) (**Figure 3-2**), represented by the vegetation type P15 (Table 8 4). This PEC is restricted to the West Angelas area. It is described as 'Open tussock grasslands of *Astrebla pectinata, A. elymoides*, *Aristida latifolia*, in combination with low scattered shrubs of *Sida fibulifera*, on basalt (Jerrinah formation) derived cracking clay loam depressions and flow lines'. Approximately 433 ha of the Priority 1 'West Angelas Cracking Clays' PEC is mapped within the Revised Development Envelope.

Other locally significant vegetation

Vegetation that is locally significant due to the habitat is forms for Priority flora is described below. Three vegetation types (including D11, classified as riparian) within the Revised Development Envelope are considered to have high local significance due to their role as habitat for Priority (P2-3) flora. 17 of the 45 vegetation types identified in the Revised Development Envelope are considered to have moderate local significance due to the presence and supporting habitat for Priority 2 and 3 species.

High Locally Significant Vegetation Types Within the Revised Development Envelope include:

- D11: ExAanEtPlANlEUsTHtTp (included in Riparian vegetation)

Supports an extensive population of the P2 *Aristida lazaridis* within one of the mapped polygons.

A single specimen of the P3 flora *Vittadinia* sp. Coondewanna Flats (S. van Leeuwen 4684) was found on red clays described in this vegetation type in 2014 but has not been recorded since.

- H15: ElTpTw

Supports an extensive record of P2 taxa *Tetratheca fordiana*, *Hibiscus* sp. Gurinbiddy Range (M.E. Trudgen MET 15708) and Oxalis sp. Pilbara (M.E. Trudgen 12725) as well as the extensive records of P3 taxa *Eremophila naaykensii, Triodia* sp. Mt Ella (M.E. Trudgen 12739), *Indigofera gilesii*, *Solanum kentrocaule*, *Acacia subtiliformis* and Pilbara *trudgenii*.

- P8: AanTHtARcTp

Extensive records of *Eremophila pusilliflora* (P2) in this unit northwest within the Revised Development Envelope

Moderate Locally Significant Vegetation Types Within the Revised Development Envelope include:

- D14

Numerous occurrences of *Aristida lazaridis* (P2) and a single occurrence of *Eremophila pusilliflora* (P2). Numerous occurrences of P3 taxa *Rhagodia* sp. Hamersley (M. Trudgen 17794), *Themeda* sp. Hamersley Station (M.E. Trudgen 11431).

- G1

Two occurrences of P2 *Hibiscus* sp. Gurinbiddy Range (M.E. Trudgen MET 15708) occurs along the boundary of the unit. Three P3 taxa occur, *Eremophila naaykensii* (numerous occurrences), *Solanum kentrocaule*, *Rhagodia* sp. Hamersley (M. Trudgen 17794).

- G2

Two P2 taxa, *Oxalis* sp. Pilbara (M.E. Trudgen 12725), *Hibiscus* sp. Gurinbiddy Range (M.E. Trudgen MET 15708). Five P3 taxa, *Pilbara trudgenii*, *Eremophila naaykensii*, *Solanum kentrocaule*, *Triodia* sp. Mt Ella (M.E. Trudgen 12739), *Grevillea saxicola*.

- G3

Two P2 taxa, *Tetratheca fordiana* and *Hibiscus* sp. Gurinbiddy Range (M.E. Trudgen MET 15708). Two P3 taxa, *Indigofera gilesii* and *Triodia* sp. Mt Ella (M.E. Trudgen 12739)

- H1

Isolated occurrences of two P3 taxa: *Aristida jerichoensis* subsp. *subspinulifera* and *Rhagodia* sp. Hamersley (M. Trudgen 17794), and one P4 taxa: *Sida* sp. Barlee Range (S. van Leeuwen 1642)

- H2

Supports the only population of the P2 *Eremophila* sp. West Angelas (S. van Leeuwen 4068) in the DE. Two P2 taxa, *Oxalis* sp. Pilbara (M.E. Trudgen 12725) and *Hibiscus* sp. Gurinbiddy Range (M.E. Trudgen MET 15708). Five P3 taxa, *Grevillea saxicola*, *Rhagodia* sp. Hamersley (M. Trudgen 17794), *Aristida jerichoensis* subsp. *subspinulifera*, *Eremophila naaykensii*, *Triodia* sp. Mt Ella (M.E. Trudgen 12739).

- H5

Three occurrences of the P2 *Hibiscus* sp. Gurinbiddy Range (M.E. Trudgen MET 15708). Two P3 taxa, *Indigofera gilesii* and *Triodia* sp. Mt Ella (M.E. Trudgen 12739) One occurrence of P4 taxon *Acacia bromilowiana*.

- H6

One occurrence of the P2 *Hibiscus* sp. Gurinbiddy Range (M.E. Trudgen MET 15708) along the boundary of the unit. Four P3 taxa, *Grevillea saxicola*, *Rhagodia* sp. Hamersl

- H7

Two P3 taxa, *Triodia* sp. Mt Ella (M.E. Trudgen 12739), *Indigofera gilesii*, One P4 taxon, *Acacia bromilowiana*.

- H8

One P2 taxa *Eremophila pusilliflora*, with a second (*Hibiscus* sp. Gurinbiddy Range (M.E. Trudgen MET 15708)) occurring as one location on the boundary. Six P3 taxa: *Themeda* sp. Hamersley Station (M.E. Trudgen 11431), *Rhagodia* sp. Hamersley (M. Trudgen 17794), *Solanum kentrocaule*, *Eremophila naaykensii*, *Triodia* sp. Mt Ella (M.E. Trudgen 12739) and *Isotropis parviflora*.

- H9

Five P3 taxa, *Indigofera gilesii*, *Triodia* sp. Mt Ella (M.E. Trudgen 12739), *Rhagodia* sp. Hamersley (M. Trudgen 17794), *Isotropis parviflora* and *Aristida jerichoensis* subsp. *subspinulifera* One P4 taxa, *Acacia bromilowiana*.

- H13

Numerous occurrences of the P2 Hibiscus sp. Gurinbiddy Range (M.E. Trudgen MET 15708). Two P3 taxa, *Solanum kentrocaule*, *Triodia* sp. Mt Ella (M.E. Trudgen 12739)

- H14

Several occurrences of P2 *Hibiscus* sp. Gurinbiddy Range (M.E. Trudgen MET 15708). Three P3 taxa, *Triodia* sp. Mt Ella (M.E. Trudgen 12739), *Rhagodia* sp. Hamersley (M. Trudgen 17794) and *Aristida jerichoensis* subsp. *subspinulifera* (and others adjacent to the boundary).

- H16

Three P2 taxa, *Eremophila* sp. West Angelas (S. van Leeuwen 4068), Oxalis sp. Pilbara (M.E. Trudgen 12725), *Hibiscus* sp. Gurinbiddy Range (M.E. Trudgen MET 15708) Extensive records of P3 taxa, *Triodia* sp. Mt Ella (M.E. Trudgen 12739), , *Eremophila naaykensii*, *Indigofera gilesii*, *Rhagodia* sp. Hamersley (M. Trudgen 17794), *Grevillea saxicola*, *Solanum kentrocaule*, *Pilbara trudgenii*. Two P4 taxa, *Sida* sp. Barlee Range (S. van Leeuwen 1642), *Lepidium catapycnon*.

- M1

Occurrences of P2 taxa *Eremophila pusilliflora*, and *Aristida lazaridis*. Extensive occurrences of P3 taxon *Rhagodia* sp. Hamersley (M. Trudgen 17794), with isolated (or on boundaries) occurrences of *Aristida jerichoensis* subsp. *subspinulifera*, *Eremophila naaykensii*, *Isotropis parviflora* and *Themeda* sp. Hamersley Station (M.E. Trudgen 11431)

- P2

One occurrence of P2 *Aristida lazaridis*. Several occurrences of *Rhagodia* sp. Hamersley (M. Trudgen 17794) (P3).

- P3

One occurrence of P2 *Eremophila pusilliflora*. Occasional occurrences of two P3 taxa, *Aristida jerichoensis* subsp. *subspinulifera* and *Rhagodia* sp. Hamersley (M. Trudgen 17794). One occurrence of P4 *Goodenia nuda*

High local significance vegetation types are shown in **Figure 3-3**.

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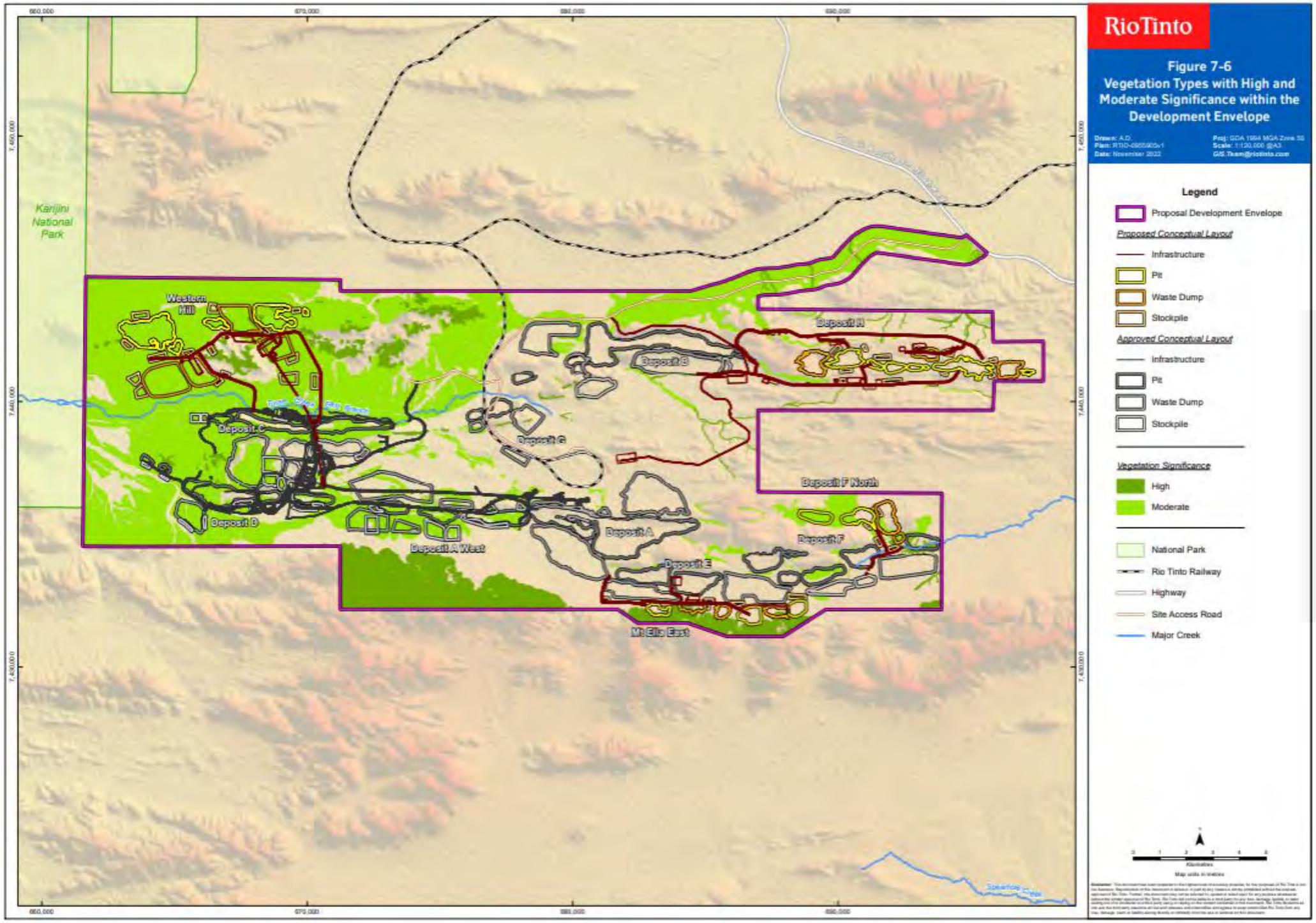

Figure 3-3: High and moderate local significance vegetation ratings

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3.2.4 Riparian Vegetation

Eleven local vegetation types within the Development Envelope are associated with drainage lines however, not all types supported riparian flora, particularly those associated with minor creek lines that were considered to only experience occasional flows. In the Pilbara, riparian vegetation is typically represented by increasingly dense vegetation, which establishes surrounding the low flow channel of moderate to major sized drainage systems. Of the eleven vegetation types, five represent riparian vegetation Table 3-4. The overstorey typically comprises keystone tree species such as Eucalyptus *camaldulensis*, E. *victrix* and to a lesser extent other common riparian tree species such as E. *xerothermica* (Rio Tinto 2020a, Lyons 2015).

Vegetation type D10 (Deposit H) is restricted in extent and supports a low woodland of *E*. *xerothermica* and *A*. *aneura*, over a middle stratum dominated by Isotropis iophyta (formally Isotropis sp. Arid zone (G. Byrne 2775)) and a dense cover of *Themeda triandra* at ground level. Vegetation type D12 is also restricted, possesses the perennial mesophyte *Melaleuca bracteata* and was only recorded at Deposit H in minor drainage lines with a calcareous component in their substrates (Biota 2020). The other riparian vegetation types are not restricted within the Revised Development Envelope.

Table 3-4: Vegetation types that support riparian vegetation

Vegetation Type and Species Code	Riparian Species Present	Drainage System
D2: EvAcTErTHtTp	Eucalyptus victrix and Eragrostis tenella	Major/ Moderate
D3: ExChPlApyTErTHtTp	Eucalyptus xerothermica	Major
D10: ExAanANllSsTHt	Eucalyptus xerothermica	Minor/ Moderate
D11: ExAanEtPlANlEUsTHtTp	Eucalyptus xerothermica	Minor
D12: ExEvMbMgANlTHtTloTp	Eucalyptus victrix, Melaleuca glomerata, M. bracteate, Cyprus vaginatus and Abutilon amplum	Minor

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3.2.5 Groundwater Dependent Ecosystems

GDEs are terrestrial, aquatic or subterranean ecosystems that require access to groundwater to persist in the landscape (Biologic 2021c) and, therefore only occur where the water table is shallow. Subterranean ecosystems dependent on groundwater are addressed in relation to stygofauna in Section 4.6. This section focuses on groundwater dependent vegetation (GDV) and the ecosystems they support.

Terrestrial GDEs rely on shallow groundwater typified by GDV species, called phreatophytes. Phreatophytes may be classified as either obligate or facultative depending on their reliance on groundwater (Eamus et al. 2016 cited in Biologic 2021c). Obligate phreatophytes are confined to habitats with access to, and are highly dependent on, groundwater. Facultative phreatophytes will use groundwater where it is available but can also exist in environments without access to groundwater. Not all riparian vegetation is groundwater dependent; vadophytes are commonly associated with drainage lines and rely on moisture in the soil profile, independent of groundwater [Biologic 2020b; 2021a).

Within the Development Envelope, only one potential example of GDV (Vegetation type D2) was identified as part of the detailed flora and vegetation survey, predominantly due to its association with Turee Creek and the presence of E. victrix. A subsequent GDE assessment was commissioned, using multiple lines of biological evidence (including remote sensing) and basic hydrologic evidence to determine likelihood of groundwater dependence (SLR 2022).

The GDE assessment identified four vegetation features within and around the Proposal exhibiting either a 'Low-moderate' or 'Moderate' likelihood of groundwater dependence based on the utilised biological and hydrological evidence:

- Feature 1a 'Low-moderate' groundwater dependence likelihood. E. camaldulensis woodland over E. xerothermica low open woodland associated with an upper tributary of Turee Creek between Western Hill and Deposit H Thought to be accessing a relatively small scale perched (potentially seasonally) groundwater source located in a local clay feature; inferred depth to regional groundwater >45 m.
- Feature 12 ('Turtle Pool') 'Low-moderate' groundwater dependence likelihood. Woodland of E. victrix and E. camaldulensis co-dominant, E. xerothermica also common over Acacia shrublands; located outside of the Development Envelope to the east of Deposit H; inferred depth to groundwater >50 m so considered to be accessing a perched resource that is surface water fed
- Feature 14 'Low-moderate' groundwater dependence likelihood. Woodland of E. victrix and E. camaldulensis co-dominant, E. xerothermica also common over Acacia shrublands; located outside of the Development Envelope to the north of Deposit H where the inferred depth to groundwater is >50 m; vegetation appears severely water limited for 5 – 6 months of the year, indicating association with an ephemeral water resource, probably a local perched aquifer
- Feature 22 'Moderate' groundwater dependence likelihood. This is the previously described potential GDE located outside the Development Envelope to the west within Karijini National Park and associated with Turee Creek East.

None of these features are considered to be reliant to any extent on the regional groundwater resource (Wittenoom Formation) or local groundwater formations.

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3.3 Flora

A total of 812 taxa have been recorded within the Development Envelope. These taxa represent a total of 62 families and 221 genera, with dominant families recorded as *Fabaceae*, *Poaceae* and *Malvaceae.*

3.3.1 Threatened and Priority Flora

Significant flora includes species listed under the EPBC Act, the BC Act, or Priority species identified by DBCA as requiring further protection. Significant flora can also include species that are locally endemic or associated with a restricted habitat type, occur as range extensions, are a new species or have anomalous features that indicate a potential new species, represent a restricted subspecies, varieties or hybrids, or are relictual representatives of taxonomic groups that no longer occur widely in the broader landscape.

No Threatened flora species currently listed under the EP Act or EPBC Act have been recorded within the Revised Development Envelope, owing to the lack of suitable habitat (Biota 2020).

No Priority(P) 1 have been recorded within the Development Envelope from the most recent flora assessment (Biologic 2022). Twenty eight Priority taxa; P2 (7), P3 (17) and P4 (4) taxa have been recorded within the Development Envelope, and are shown in Table 3-5 and Figure 3-4. Another five species have been classed as likely to occur or possibly occurring.

Another four species were found to be undescribed/unresolved taxa and a possible range extension. None were found to be likely of conservation significance.

Table 3-5: Significant flora species recorded in the Development Envelope

Taxon	Recorded	Likely to Occur	Possibly Occuring
Priority 2			
Aristida lazaridis	**x**		
***Eremophila* sp. West Angelas (S. van Leeuwen 4068)**	**x**		
Eremophila pusilliflora	**x**		
Euphorbia inappendiculata* var. *inappendiculata	**x**		
***Hibiscus* sp. Gurinbiddy Range (M.E. Trudgen MET15708)**	**x**		
***Oxalis* sp. Pilbara (M.E. Trudgen 12725)**	**x**		
Rhodanthe ascendens			**x**
Tetratheca fordiana	**x**		

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Taxon	Recorded	Likely to Occur	Possibly Occuring
Priority 3			
Acacia effusa	**x**		
Acacia subtiliformis	**x**		
Aristida jerichoensis* var. *subspinulifera	**x**		
***Dolichocarpa* sp. Hamersley Station (A.A. Mitchell PRP 1479)**	**x**		
***Eremophila naaykensii* (A.L. Curtis & K.R. Thiele)**	**x**		
Euphorbia clementii	**x**		
Euphorbia stevenii			**x**
Geijera salicifolia			**x**
Grevillea saxicola	**x**		
Indigofera gilesii	**x**		
Isotropis parviflora	**x**		
Olearia mucronata	**x**		
Pilbara trudgenii	**x**		
***Rhagodia* sp. Hamersley (M. Trudgen 17794)**	**x**		
Solanum kentrocaule	**x**		
Swainsona thompsoniana			**x**
***Themeda* sp. Hamersley Station (M.E. Trudgen 11431)**	**x**		
***Triodia* sp. Mt Ella (M.E. Trudgen 12739)**	**x**		

Taxon	Recorded	Likely to Occur	Possibly Occuring
***Vittadinia* sp. Coondewanna Flats (S. van Leeuwen 3835)**	**x**		
Priority 4			
Acacia bromilowiana	**x**		
Lepidium catapycnon	**x**		
Eremophila magnifica* subsp. *magnifica	**x**		
***Sida* sp. Barlee Range (S. van Leeuwen 1642)**	**x**		

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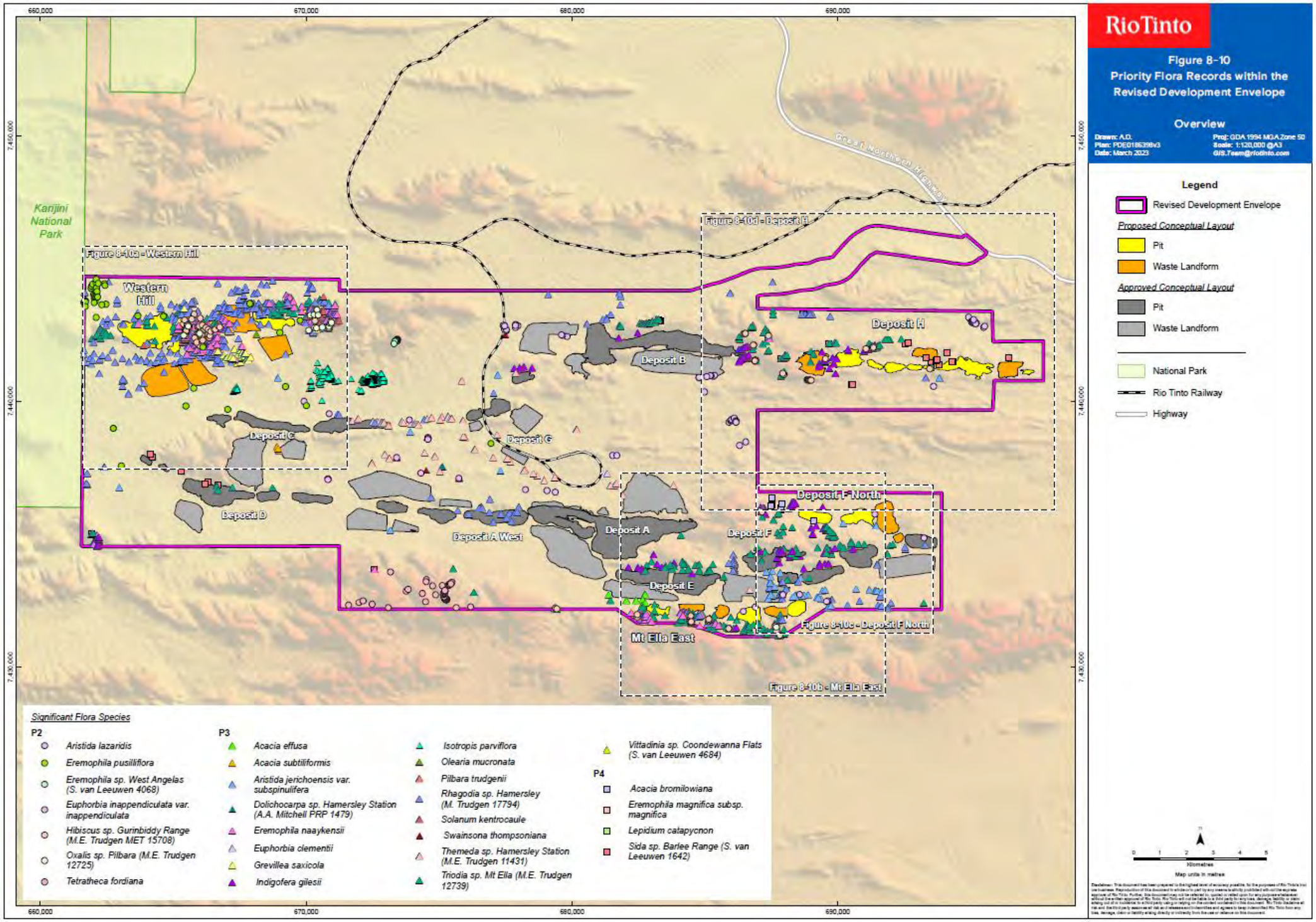

Figure 3-4: Priority Flora records within the Revised Development Envelope

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3.4 Introduced Flora (Weeds)

A total of 24 weed species have been recorded within the Revised Development Envelope of which 12 were recorded within the Extension Areas (Biota 2020, Biota 2021 and ecologia 2013). None of the recorded species are listed as declared pests under the WA *Biosecurity and Agriculture Management Act 2007* (BAM Act) or a Weed of National Significance (WoNS) on the Western Australian Organism List database. The most common species recorded were **Bidens bipinnata* (Bippinnate Beggartick), **Setaria verticillata* (Whorled Pigeon Grass) and **Malvastrum americanum* (Spiked Malvastrum). Weed records, indicative locations and abundance are provided in the key flora and vegetation surveys and are shown in Figure 3-5.

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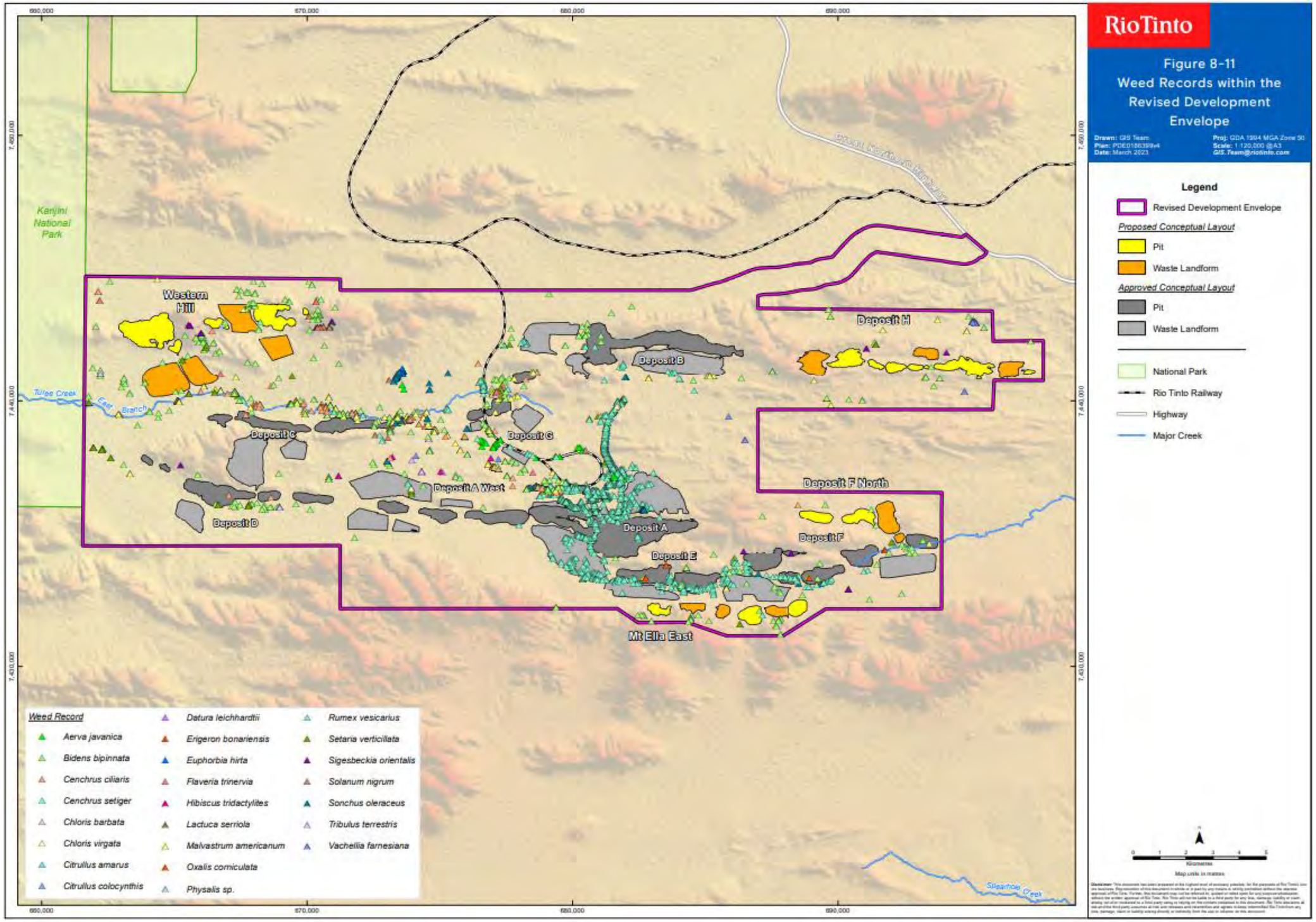

Figure 3-5: Weed Records within the Revised Development Envelope

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4 TERRESTRIAL FAUNA

The key terrestrial fauna values identified in the Revised Development Envelope include:

- Seven significant fauna species have been recorded in the Development Envelope, including Northern Quoll (Endangered), Ghost Bat (Vulnerable), Pilbara Leaf-nosed Bat (Vulnerable), Pilbara Olive Python (Vulnerable), Fork-tailed Swift (Migratory), Western Pebble-mound Mouse (P4) and Pilbara Barking Gecko (P2)
- Five significant fauna species that are likely or possible to occur, including Grey Falcon (Vulnerable), Pilbara Flat-headed Blind-snake (P1), Short-tailed Mouse (P4), Brush-tailed Mulgara (P4) and the Peregrine Falcon (OS)
- Approximately 627 ha of Gorge/Gully habitat within the Development Envelope considered to be critical denning, roosting, breeding/shelter and foraging habitat for Northern Quoll, Ghost Bat and Pilbara Olive Python and supporting habitat for Pilbara Leaf-nosed Bat
- Approximately 12,202 ha of Hillcrest/Hillslope habitat within the Development Envelope considered to be critical roosting and foraging habitat for Ghost Bat. This habitat supports foraging and dispersal habitat for Northern Quoll, Pilbara Olive Python and Pilbara Leaf-nosed Bat
- Approximately 378 ha of Drainage Line habitat within the Development Envelope considered to be a supporting habitat for Northern Quoll, Ghost Bat, Pilbara Leaf-nosed Bat and Pilbara Olive Python (within species range from critical habitat)
- Approximately 15,715 ha of Mixed Acacia Woodland, Foot slopes and Plain and Cracking Clay habitat within the Development Envelope considered to be supporting habitat for Ghost Bat (within 12 km from critical habitat)
- Suitable habitat for Grey Falcon (VU), Peregrine Falcon, Pilbara Flat-headed Blind-snake, Pilbara Barking Gecko, Western Pebble-mound Mouse, Short-tailed Mouse, and Brush-tailed Mulgara
- Forty-one (41) category 4 caves (non-critical) for the Pilbara Leaf-nosed Bat
- Seven category 2 caves, fourteen category 3 caves, 20 category 4 caves for the Ghost Bat
- Eighteen potential SRE species were recorded only within the Development Envelope
- Approximately 627 ha of Gorge/Gully habitat within the Development Envelope considered to be of high significance to potential SRE species.

This section describes the terrestrial fauna that occurs within the Development Envelope and regionally.

4.1 Studies and Survey Effort

Table 4-1 summarises the Proposal-specific and other relevant regional surveys and studies undertaken for Terrestrial Fauna. Figure 4-1 represents the survey coverage.

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Table 4-1: Summary of Technical Studies for Terrestrial Fauna Environmental Factor

Studies/Survey/Prepared for	Study Area, Type and Timing	Consistency with Guidance
Key Studies and Surveys		
Targeted Flora and Fauna Survey Mt Ella East and Deposit J pit and waste dump footprints (Biologic Environmental Survey Pty Ltd (Biologic) 2022c) **Prepared for Rio Tinto**	**Survey Area:** Mt Ella East and Deposit J covering approximately 237.9 ha of the WAN Development Envelope **Type:** A single season targeted survey for conservation significant flora and fauna **Survey Methods:** Habitat assessment, targeted searches, water feature and cave assessments, ultrasonic recordings and opportunistic observations **Timing:** February 2021	Survey meets relevant EPA and EPBC Act policy and guidance. Survey approach and method undertook with consideration of the following: • Environmental Factor Guideline: Terrestrial Fauna (EPA 2016c) • Technical Guidance: Terrestrial vertebrate fauna surveys for environmental impact assessment (EPA 2020) • Survey guidelines for Australia's threatened bats (DEWHA 2010a) • Survey guidelines for Australia's threatened birds (DEWHA 2010b) • Survey guidelines for Australia's threatened mammals (DSEWPaC 2011a) • Survey guidelines for Australia's threatened reptiles (DSEWPaC 2011b). • Interim guideline for preliminary surveys of Night Parrot (*Pezoporus occidentalis*) in Western Australia (DPaW 2017) • EPBC Act referral guideline for the endangered Northern Quoll (*Dasyurus hallucatus*) (DoE 2016).
West Angelas Beyond 2020 Infrastructure Corridors Reconnaissance and Targeted Survey (Biologic 2022a) **Prepared for Rio Tinto**	**Survey Area**: Proposed infrastructure corridors within existing Development Envelope	The survey was conducted in accordance with: • Technical Guidance: Terrestrial vertebrate fauna surveys for environmental impact assessment (EPA 2020) • Environmental Factor Guideline: Terrestrial Fauna (EPA 2016c)

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Studies/Survey/Prepared for	Study Area, Type and Timing	Consistency with Guidance
	Type: Desktop assessment, reconnaissance and targeted terrestrial fauna survey **Survey Method:** Habitat assessment, active searches, bird census, targeted searches, water feature and cave assessments, ultrasonic recordings and opportunistic observations **Timing:** February 2022	• Survey guidelines for Australia's threatened bats (DEWHA 2010a) • Survey guidelines for Australia's threatened birds (DEWHA 2010b) • Survey guidelines for Australia's threatened mammals (DSEWPaC 2011a) • Survey guidelines for Australia's threatened reptiles (DSEWPaC 2011b) • EPBC Act referral guideline for the endangered Northern Quoll (*Dasyurus hallucatus*) (DoE 2016).
West Angelas Beyond 2020 Mt Ella East and Dep J Detailed and Targeted Survey (Biologic 2022b) **Prepared for Rio Tinto**	**Survey Area**: Proposed Mt Ella East and Deposit J previously unsurveyed areas **Type:** Desktop assessment, detailed and targeted terrestrial fauna survey **Survey Method:** Methods included targeted searches, cave searches and assessments, dusk surveys, ultrasonic bat recordings, motion cameras, opportunistic observations and acoustic bird recordings **Timing:** July 2022	**The survey was conducted in accordance with:** • Statement of Environmental Principles, Factors and Objectives (EPA 2021a) • Technical Guidance: Terrestrial vertebrate fauna surveys for environmental impact assessment (EPA 2020) • Environmental Factor Guideline: Terrestrial Fauna (EPA 2016c) • Survey guidelines for Australia's threatened bats (DEWHA 2010a) • Survey guidelines for Australia's threatened birds (DEWHA 2010b) • Survey guidelines for Australia's threatened mammals (DSEWPaC 2011a) • Survey guidelines for Australia's threatened reptiles (DSEWPaC 2011b) • Guidelines for surveys to detect the presence of bilbies and assess the importance of habitat in Western Australia (DBCA 2017)

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Studies/Survey/Prepared for	Study Area, Type and Timing	Consistency with Guidance
West Angelas Beyond 2020 Deposit H and F North Reconnaissance Survey (Biologic 2022h)	**Survey Area**: Identified field survey coverage gap, eastern extent of Revised Development Envelope at Deposit H and northern extent of Revised Development Envelope at Deposit F North **Type:** Desktop assessment and single phase reconnaissance terrestrial fauna survey **Survey Method:** Methods included targeted searches, cave searches and assessments, dusk surveys, ultrasonic bat recordings, motion cameras, opportunistic observations and acoustic bird recordings **Timing:** February & April 2022.	The survey was conducted in accordance with: • Statement of Environmental Principles, Factors and Objectives (EPA 2021a). • Technical Guidance: Terrestrial vertebrate fauna surveys for environmental impact assessment (EPA 2020) • Environmental Factor Guideline: Terrestrial Fauna (EPA 2016c)
West Angelas Fauna Habitat Mapping (Biologic 2021b).	**Survey Area:** West Angelas Revised Proposal Development Envelope and 20 km radius around the Development Envelope (herein the Regional Extrapolated Mapping Area) **Type:** Desktop assessment to review and consolidate fauna habitats previously mapped within the Development Envelope and extrapolate mapping in regional areas within a 20 km radius of the Development Envelope **Timing:** August 2021	The source materials used in the consolidation of historical mapping were generally prepared in accordance with EPA guidance relevant at the time of the original survey.

Studies/Survey/Prepared for	Study Area, Type and Timing	Consistency with Guidance
West Angelas Beyond 2020: Targeted Vertebrate Fauna Survey (Biologic 2021d).	**Survey Area:** Five iron ore deposits: Western Hill, Deposit J and Mt Ella East, Deposit F North and Deposit H, covering 11,762 ha of the WAN Development Envelope **Type:** Targeted vertebrate fauna survey for MNES species including Northern Quoll, Night Parrot, Greater Bilby, Pilbara Leaf-nosed Bat, Ghost Bat, Pilbara Olive Python and Northern Brushtail Possum **Survey Methods:** Methods included targeted searches, cave searches and assessments, dusk surveys, ultrasonic bat recordings, motion cameras, opportunistic observations and acoustic bird recordings **Timing:** June and July 2019	Survey meets relevant EPA and EPBC Act policy and guidance. Survey approach and method undertook with consideration of the following: • Environmental Factor Guideline: Terrestrial Fauna (EPA 2016c) • Technical Guidance: Terrestrial vertebrate fauna surveys for environmental impact assessment (EPA 2020) • Survey guidelines for Australia's threatened bats (DEWHA 2010a) • Survey guidelines for Australia's threatened birds (DEWHA 2010b) • Survey guidelines for Australia's threatened mammals (DSEWPaC 2011a) • Survey guidelines for Australia's threatened reptiles (DSEWPaC 2011b) • Interim guideline for preliminary surveys of Night Parrot (*Pezoporus occidentalis*) in Western Australia (DPaW 2017) • EPBC Act referral guideline for the endangered Northern Quoll (*Dasyurus hallucatus*) (DoE 2016).
West Angelas Beyond 2020: Level 2 Vertebrate and SRE Invertebrate Fauna Assessment Phase 1 and 2 (Biologic 2021e)	**Survey Area:** Five iron ore deposits: Western Hill, Deposit J and Mt Ella East. Deposit F North and Deposit H, covering 11,762 ha of the WAN Development Envelope **Type:** Two phase Level 2 vertebrate and short-range endemic (SRE) invertebrate fauna survey	Survey meets relevant EPA and EPBC Act policy and guidance. Survey approach and method undertook with consideration of the following: • Environmental Factor Guideline: Terrestrial Fauna (EPA 2016c) • Technical Guidance: Terrestrial vertebrate fauna surveys for environmental impact assessment (EPA 2020) • Technical Guidance: Sampling of Short-Range Endemic Invertebrate Fauna (EPA 2016f)

Studies/Survey/Prepared for	Study Area, Type and Timing	Consistency with Guidance
	Survey Methods: 10 systematic sampling sites, including pitfall trapping, funnel traps, Elliot traps and cage traps, and avifauna census. Targeted sampling included targeted searches, ultrasonic bat recording using SongMeters, acoustic recordings, motion cameras and scat recording sheets. **Timing:** October 2018 and March 2019	• Survey guidelines for Australia's threatened bats (DEWHA 2010a) • Survey guidelines for Australia's threatened birds (DEWHA 2010b) • Survey guidelines for Australia's threatened mammals (DSEWPaC 2011a) • Survey guidelines for Australia's threatened reptiles (DSEWPaC 2011b) • Interim guideline for preliminary surveys of Night Parrot (*Pezoporus occidentalis*) in Western Australia (DPaW 2017) • EPBC Act referral guideline for the endangered Northern Quoll (*Dasyurus hallucatus*) (DoE 2016).
Targeted Flora and Fauna Survey for the West Angelas Managed Aquifer Recharge (MAR) Area (Biologic 2021f)	Survey Area: MAR Area **Type:** Targeted flora and fauna survey for species of conservation significance, including Northern Quoll, Pilbara Leaf-nosed Bat, Ghost Bat, Pilbara Olive Python and Western Pebble-mound Mouse **Survey Methods:** Habitat assessments, targeted searches, cave assessments, ultrasonic recorded and opportunistic recordings **Timing**: February 2021	Survey meets relevant EPA and EPBC Act policy and guidance. Survey approach and methods undertaken with consideration of the following: • Environmental Factor Guideline: Terrestrial Fauna (EPA 2016c) • Technical Guidance: Terrestrial vertebrate fauna surveys for environmental impact assessment (EPA 2020) • Survey guidelines for Australia's threatened bats (DEWHA 2010a) • Survey guidelines for Australia's threatened birds (DEWHA 2010b) • Survey guidelines for Australia's threatened mammals (DSEWPaC 2011a) • Survey guidelines for Australia's threatened reptiles (DSEWPaC 2011b)

Studies/Survey/Prepared for	Study Area, Type and Timing	Consistency with Guidance
		• Guidelines for surveys to detect the presence of bilbies and assess the importance of habitat in Western Australia (DBCA 2017).
West Angelas Revised Proposal Short-Range Endemic Invertebrate Fauna Environmental Impact Assessment (Biologic 2022i)	**Survey Area:** Development Envelope **Type:** Desktop- EIA **Timing:** October 2022	The source materials used in the EIA were generally prepared in accordance with EPA guidance relevant at the time of the original survey.
West Angelas: Short-Range Endemic Invertebrate Fauna Risk Assessment (Biologic 2022j)	**Survey Area:** Development Envelope **Type:** Risk assessment **Timing:** October 2022	The source materials used in the risk assessment were generally prepared in accordance with EPA guidance relevant at the time of the original survey.
Supporting Studies and Surveys		
West Angelas Deposits C, D & G Targeted Fauna Survey (Biologic 2018) **and** **Addendum to West Angelas C, D & G Targeted Fauna Survey (Biologic 2019)**	**Survey Area:** Deposits C, D and G, covering approximately 26,689 ha of the Approved Development Envelope **Type:** Targeted fauna survey for Northern Quoll, Pilbara Olive Python, Ghost Bat and Pilbara Leaf-nosed Bat **Survey Methods:** Targeted searches, motion cameras, ultrasonic recordings and acoustic recordings **Timing**: October 2018	Survey meets relevant EPA and EPBC Act policy and guidance. Survey approach and method undertook with consideration of the following: • Environmental Factor Guideline: Terrestrial Fauna (EPA 2016c) • Technical Guidance: Terrestrial vertebrate fauna surveys for environmental impact assessment (EPA 2020) • Survey guidelines for Australia's threatened bats (DEWHA 2010a) • Survey guidelines for Australia's threatened birds (DEWHA 2010b) • Survey guidelines for Australia's threatened mammals (DSEWPaC 2011a)

Studies/Survey/Prepared for	Study Area, Type and Timing	Consistency with Guidance
		• Survey guidelines for Australia's threatened reptiles (DSEWPaC 2011b) • Interim guideline for preliminary surveys of Night Parrot (*Pezoporus occidentalis*) in Western Australia (DPaW 2017) • EPBC Act referral guideline for the endangered Northern Quoll (*Dasyurus hallucatus*) (DoE 2016).
Karijini/Upper Turee Creek Targeted Pilbara Leaf-nosed Bat Survey (Bat Call WA 2018)	**Survey Area:** Karijini National Park **Type:** Targeted Pilbara Leaf-nosed Bat survey **Survey Methods:** Analysis of acoustic recordings **Timing:** November 2018	Survey meets relevant EPA and EPBC Act policy and guidance. Survey approach and method undertook with consideration of the following: • Environmental Factor Guideline: Terrestrial Fauna (EPA 2016c) • Technical Guidance: Terrestrial vertebrate fauna surveys for environmental impact assessment (EPA 2020) • Survey guidelines for Australia's threatened bats (DEWHA 2010a)
Rio Tinto Iron Ore Greater West Angelas Terrestrial Fauna Assessment (ecologia 2014)	**Survey Area:** Deposits C, D, D extension, G, F, H and Mt Ella **Type:** Two-phase vertebrate fauna and SRE survey **Survey Methods:** Systemic sampling, acoustic recorders, SRE leaf litter collection, opportunistic searches and motion camera trapping **Timing:** Spring 2012 and Autumn 2013	Survey meets relevant EPA and EPBC Act policy and guidance in place at the time. Survey approach and method undertaken in consideration of the following: • Terrestrial Fauna Surveys for Environmental Impact Assessment in Western Australia (EPA 2004b) • Terrestrial Biological Surveys as an Element of Biodiversity Protection: Position Statement No. 3 (EPA 2002) • Technical Guide – Terrestrial Vertebrate Fauna Surveys for Environmental Impact Assessment (EPA 2010) • Guidance Statement 20: Sampling of Short Range Endemic Invertebrate Fauna for Environmental Impact Assessment in Western Australia (EPA 2009).

Studies/Survey/Prepared for	Study Area, Type and Timing	Consistency with Guidance
Fauna Habitats and Fauna Assemblage of Deposits E and F at West Angelas (Biota 2005b)	**Survey Area:** Deposits E and F **Type:** Systematic survey of fauna habitat and fauna assemblage **Survey Methods:** Systematic surveys, echolocation recordings, habitat searches for conservation significant species, opportunistic sightings **Timing:** May 2004	Survey approach and method undertaken in consideration of the following: • Terrestrial Fauna Surveys for Environmental Impact Assessment in Western Australia (EPA 2004b) • Terrestrial Biological Surveys as an Element of Biodiversity Protection: Position Statement No. 3 (EPA 2002)
Ghost Bats at West Angelas: 2002 Survey, Data Review and Future Directions (Biota 2002)	**Survey Area**: Caves adjacent to Deposits B and F **Type**: Targeted survey for Ghost Bats **Survey Methods**: Survey of caves for evidence of Ghost Bat presence **Timing**: November 2002	The survey was undertaken per the relevant State and Commonwealth guidelines in place at the time of the survey.
West Angelas Iron Ore Project Vertebrate Fauna Assessment Survey (ecologia 1998a)	**Survey Area**: Mine and rail corridor **Type**: Detailed vertebrate fauna assessment **Survey Methods**: Systemic and opportunistic sampling **Timing**: June-October 1997	The survey was undertaken in accordance with the relevant EPA and DCCEEW (formerly CALM) guidelines in place at the time of the survey.

Studies/Survey/Prepared for	Study Area, Type and Timing	Consistency with Guidance
West Angelas Project Ghost Bat *Macroderma gigas* Assessment Survey (ecologia 1998b) **Prepared for Robe River Mining Co.**	**Survey Area:** Gullies and hills adjacent to Deposits A, B, E and F **Type:** Targeted survey for Ghost Bats **Survey Methods:** Systematic surveys of caves **Timing:** August to September 1998	The survey was undertaken in accordance with the relevant EPA and DCCEEW (formerly CALM) guidelines in place at the time of the survey.

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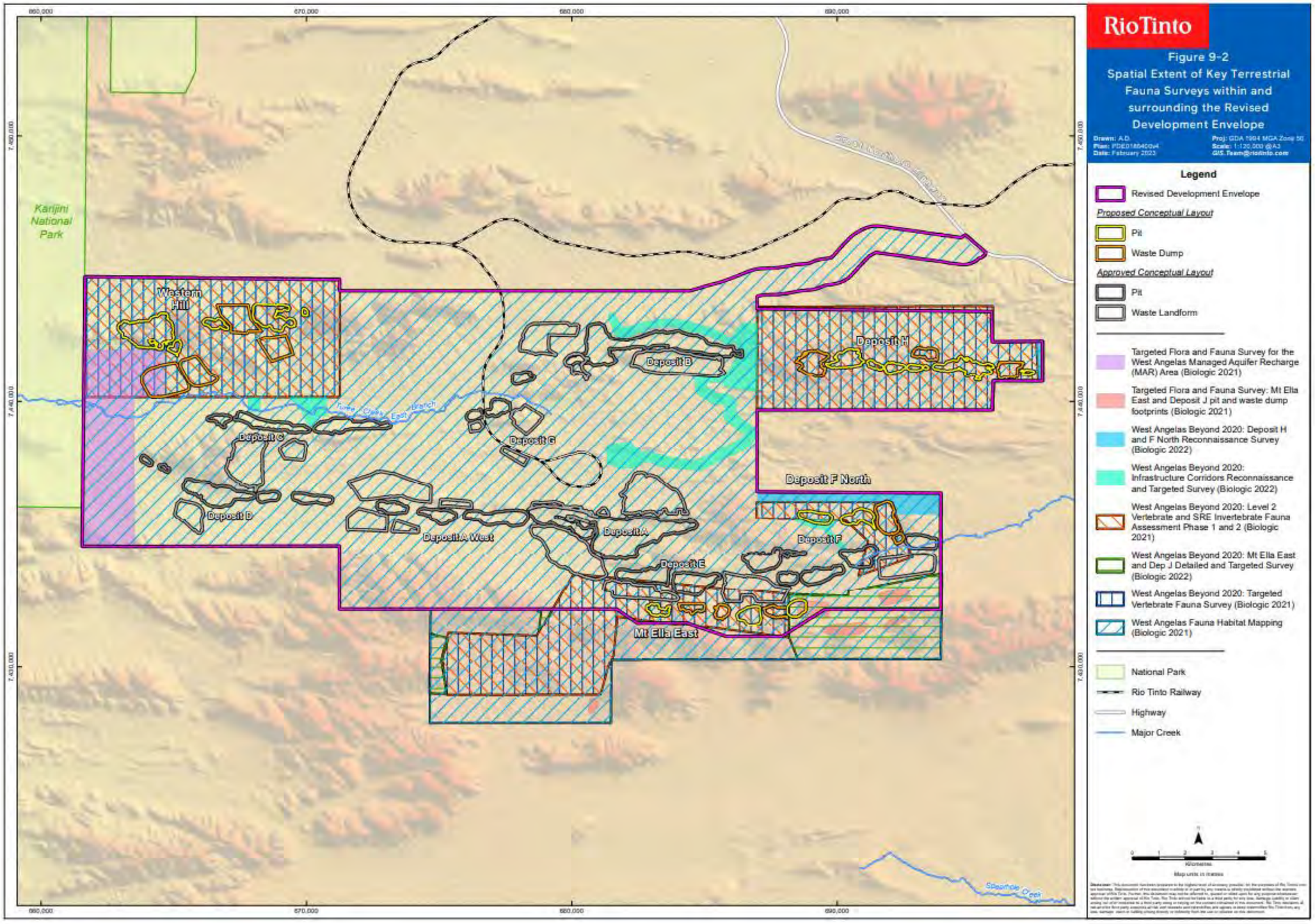

Figure 4-1: Fauna Survey Effort within and surrounding the Revised Development Envelope

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4.2 Regional Context

The Pilbara bioregion is an area of high biodiversity value within WA and provides unique fauna habitat types. This appears to be related to the diversity of geological, altitudinal and climatic elements in the region and is a function of its location. The Development Envelope lies within the Hamersley subregion. Due to the vast scale of the Pilbara bioregion, only Projects within the Hamersley subregion

Temperature extremes are characteristic of the region. Many water features are ephemeral, reflecting the seasonal and temporary water availability; however, endemic species are adapted to this environment.

4.3 Fauna Habitat

Six broad fauna habitat types were mapped across the Development Envelope: Gorge/Gully; Drainage Line; Hillcrest/Hillslope; Mixed Acacia Woodland; Foot slopes and Plain; and Cracking Clay.

Extensive Pilbara fauna species datasets have been used to inform a detailed understanding and assessment of the significance of habitats and impacts at a local and regional level. The detailed understanding of local species occurrence and habitat use in the Revised Development Envelope has been used to assign habitat significance ratings based on their value to threatened fauna species listed under the EPBC Act or BC Act (Biologic 2021b). Table 4-2 describes the criteria used to inform each significance rating in this assessment.

Table 4-2: Fauna habitat significance assessment criteria for Threatened Species

Significance Score	Criteria
High	**Provides core breeding/refugia/shelter sites (i.e., denning, roosting or water sources) for significant fauna species. These habitats are considered critical to the survival of MNES* fauna species within the Revised Development Envelope.**
Moderate	**Provides foraging and dispersal habitat for significant fauna species. For MNES fauna species, these habitats are considered supporting habitats when they are within the species' home range* but are not considered critical to their survival. These habitats are more widespread and of lower importance than the high significance (critical) habitats.**
Low	**Habitat does not directly support any significant fauna species but may represent limited foraging and dispersal habitat. Significant fauna species are not dependent on this habitat. This habitat is widespread in the local and regional areas.**
Nil	**Disturbed or cleared areas that do not provide any fauna habitat.**

Source: Biologic 2021b,c *Threatened species – listed under EPBC Act.

a. "critical habitat" is defined as denning, roosting and/or shelter and water sources for MNES fauna species.
b. "Supporting habitat" is foraging and dispersal habitat within a fauna species' range.

Six broad fauna habitat types were mapped within the Development Envelope (Figure 4-2 and Table 4-3).

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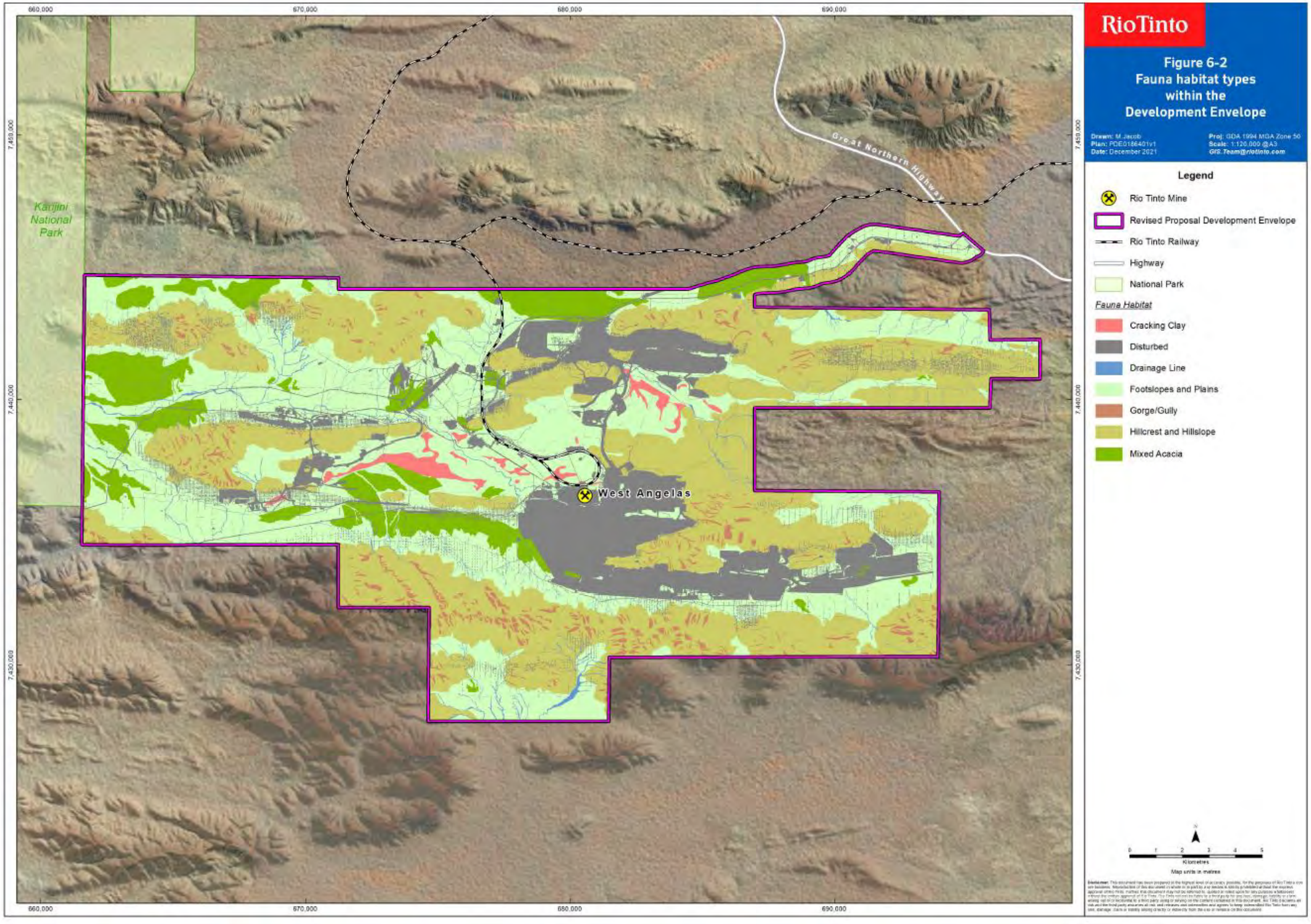

Figure 4-2: Fauna habitat within the Development Envelope

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Table 4-3: Fauna habitat types within the Development Envelope

Fauna Habitat Type	Fauna Habitat Description	Microhabitats within the Revised Development Envelope	Value for Significant Fauna[1]	Mapped Extent*		Representative Photograph
				Extent within West Angelas Area**	Extent within Revised Development Envelope	
High Significance						
Gorge/Gully	Gorges and gullies are rugged, steep-sided valleys incised into the surrounding landscape. Gorges tend to be deeply incised, with vertical cliff faces, while gullies are more open (but not as open as Drainage Line habitat or valleys). Caves and deep, rocky crevices are most often encountered in this habitat type, as are water pools. Vegetation can vary and can be dense and complex in areas of soil deposition or sparse and simple where exposed outcropping or erosion has occurred. Limited extent within the Revised Development Envelope and widely distributed across the Pilbara.	Contains caves and deep, rocky crevices and ephemeral pools.	Critical for: • Northern Quoll • Ghost Bat • Pilbara Olive Python Supporting for: • Pilbara Leaf-nosed Bat Suitable for: • Pilbara Flat-headed Blind-Snake • Pilbara Barking Gecko.	1082 ha (2.6%)	• 627 ha (1.7%)	
Hillcrest/Hillslope	Hillcrest/Hillslope habitat tends to be more open and structurally simple than other fauna habitats. A common feature of this habitat is a rocky substrate, often with exposed bedrock, and skeletal red soils. These can contain cracks and crevices, but not to the same extent as within rocky upland areas of Gorge/Gully habitat. This habitat is usually dominated by open Eucalyptus woodlands, Acacia and Grevillea scrublands and Triodia low hummock grasslands. Widespread within Revised Development Envelope and wider region. Significance rating presumes presence of caves considered critical for survival of Ghost Bat populations.	May contain caves and crevices, but not to the same extent as Gorge or Gully.	Critical for: • Ghost Bat Supporting for: • Northern Quoll • Pilbara Leaf-nosed Bat • Pilbara Olive Python Suitable for: • Peregrine Falcon • Western Pebble-mound Mouse • Pilbara Barking Gecko	15,015 ha (36.2%)	12,202 ha (33.2%)	

[1] For the purposes of this assessment, “critical habitat” is defined as denning, roosting and/or shelter and water sources for significant species. “Supporting habitat” is foraging and dispersal habitat within a significant species’ range.

Fauna Habitat Type	Fauna Habitat Description	Microhabitats within the Revised Development Envelope	Value for Significant Fauna[1]	Mapped Extent*		Representative Photograph
				Extent within West Angelas Area**	Extent within Revised Development Envelope	
Moderate Significance						
Drainage Line	Drainage Line habitat is variable in structure and condition. Temporary, semi-permanent – permanent water pools can occur within this habitat, usually after rainfall events. Vegetation within this habitat is often dominated by Eucalyptus or Melaleuca species over a variable understory comprising mixed small to medium shrubs (*Acacia* sp.) and tussock grasses over sandy creek beds. Vegetation adjacent to the main channel or channels is denser, taller and more diverse than adjacent terrain. The structure and condition of vegetation often varies seasonally, particularly following rainfall events. Vegetation condition often subject to heavy cattle grazing. Limited extent within the Revised Development Envelope but widespread in the surrounding region.	Contains leaf litter and woody debris and small hollows.	Supporting for: • Northern Quoll • Ghost Bat • Pilbara Leaf-nosed Bat • Pilbara Olive Python • Grey Falcon Suitable for: • Peregrine Falcon	493 ha (1.2%)	378 ha (1.0%)	
Mixed Acacia Woodland	Mixed Acacia Woodland habitat comprises areas where vegetation is a dense mix of Acacia, with a mixture of mulga (*Acacia aneura*), *Acacia maitlandii* and *Acacia pruinocarpa* over a mixture of sparse small shrubs and grasses, such a Triodia and Senna species and *Ptilotus* sp. Dense leaf litter, and woody debris is a common feature of this habitat type. The soils consist of loam clay with continuous layers of small ironstone pebbles on the surface. The habitat is mostly flat with no or very small drainage channels. Limited extent within the Revised Development Envelope but widespread through the Pilbara region.	Contains leaf litter and woody debris and small hollows	Supporting for: • Ghost Bat • Grey Falcon Suitable for: • Peregrine Falcon • Short-tailed Mouse	3,240 ha (7.8%)	3,229 ha (8.8%)	

Fauna Habitat Type	Fauna Habitat Description	Microhabitats within the Revised Development Envelope	Value for Significant Fauna[1]	Mapped Extent*		Representative Photograph
				Extent within West Angelas Area**	Extent within Revised Development Envelope	
Footslopes and Plain	Footslopes and Plain habitat comprises low-lying open plains and the rolling hills below upland areas. Vegetation within this habitat varies in composition; however, is generally dominated by scattered mulga and *Acacia pruinocarpa* forming an over-storey, with a mid-storey comprising *Eremophila* and *Ptilotus* spp., over low hummock grasslands of *Triodia wiseana*, *T. basedowii*, *T. longifolia* and *T. pungens*. Scattered *Corymbia hamersleyana*, *Eucalyptus leucophloia* and *E. gamophylla* were also present. Widespread within Revised Development Envelope and wider region.		Supporting for: • Ghost Bat • Grey Falcon Suitable for: • Western Pebble-mound Mouse • Brush-tailed Mulgara • Short-tailed Mouse • Peregrine Falcon	13,287 ha (32.0%)	12,051 ha (32.8%)	
Cracking clay	Cracking clay habitat is characterised by open and sparse low vegetation with approximately half of its area being bare ground. Isolated shrubs of *Salsola australis*, *Boerhavia paludosa* and *Ptilotus nobilis* subsp. *nobilis* occur over open tussock grassland of *Aristida* sp., *Brachyachne* sp. and *Astrebla pectinata*. The soil is often dark orange sand-clay to clay with an undulating surface caused by crabholes and gilgai. Rocks and pebbles are often very rare and when present, the rock type is consistently ironstone. Limited extent within Revised Development Envelope.		Supporting for: • Ghost Bat Suitable for: • Short-tailed Mouse	435 ha (1.0%)	435 ha (1.2%)	
Total Fauna Habitat				33,553	28,922	
Disturbed/Cleared Areas	Cleared areas, or areas devoid of any vegetation	No value for fauna	N/A	7,931 (19.1%)	7,857 (21.4%)	
Total Area				41,483	36,779	

*Extent rounded to nearest ha **West Angelas Area includes the Revised Development Envelope, All Survey Areas and any References Sites

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Of the six habitat types identified within the Development Envelope, two fauna habitat types are considered to provide high significance habitat:

- **Gorge/Gully habitat:** This type of habitat occurs across 627 ha (2%) of the Development Envelope and is considered high significance due to the microhabitats it provides, such as caves, deep rocky crevices and ephemeral pools (Biologic 2021b). The rocky shelter provides opportunities for denning, shelter, roosting and foraging for significant fauna species such as the Northern Quoll (*Dasyurus hallucatus*), Ghost Bat (*Macroderma gigas*), and Pilbara Olive Python (*Liasis olivaceus barroni*).
- **Hillcrest/Hillslope:** This habitat occurs across 12,202 ha (34%) of the Development Envelope and is considered high significance due to its microhabitats, such as caves and crevices. As with the Gorge/Gully habitat, this habitat (to a lesser extent) provides suitable habitat for denning, shelter, roosting and foraging for significant fauna species, such as Northern Quoll, Ghost Bat, Pilbara Leaf-nosed Bat and Pilbara Olive Python.

The remaining four fauna habitats within the Revised Development Envelope (Drainage Line; Mixed Acacia Woodland; Footslopes and Plain; and Cracking Clay) are considered moderate significance. None of the broad terrestrial fauna habitats are confined to the Revised Development Envelope and are widespread throughout the wider Hamersley subregion. No fauna habitats of low significance for terrestrial vertebrate fauna were recorded within the Revised Development Envelope.

4.3.1 Habitat Features and Resources

Significant habitat features are elements within a broader fauna habitat that provide important microhabitats that support significant fauna species or have a highly diverse or abundant faunal assemblage. In the Pilbara, significant habitat features typically include caves and surface water expressions in the form of pools in drainage lines or gorges each of which is discussed in detail below.

Caves

Caves are considered important ecological habitat features in the Pilbara due to the stable microclimate and shelter they provide to a range of fauna including the significant species Northern Quoll, Ghost Bat, Pilbara Leaf-nosed Bat and Pilbara Olive Python. A total of 41 caves have been recorded within the Development Envelope. These caves provide potential roosting and foraging habitats for two significant bat species: Ghost Bat and Pilbara Leaf-nosed Bat. For Ghost Bats, this includes two confirmed maternity roosts (category 2), six potential maternity roosts (category 2), two confirmed diurnal roosts (category 2), ten potential diurnal roosts (category 3), 12 night roosts (category 4), and eight potential night roosts (category 4) across the Development Envelope for Ghost Bat (Bat Call WA 2021a). There are no Category 1, 2 or 3 roosts for the Pilbara Leaf-nosed Bat within the Development Envelope, with all 41 caves providing potential nocturnal refuges (category 4) for the Pilbara Leaf-nosed Bat (Bat Call WA 2021b). Nineteen caves occur within the Gorge/Gully habitat type, with the remaining 22 caves occurring in the Hillcrest/Hillslope habitat.

Ghost Bats were confirmed within 21 of the 41 caves, eight of which occur within Western Hill, two at Mount Ella East, one at Deposit H, and one at Deposit F. The Pilbara Leaf-nosed Bat has not been confirmed in any of the caves.

Water Features

The Development Envelope does not contain any permanent water features such as pools and springs. It does contain five ephemeral pools: Two within the current Approved Development Envelope and three within the Proposal Area. Of the three features within the Proposal Area two of which occur at Mt Ella East (WB-WAJ1 and WB-WAJ2) and one at Deposit H (WB-WAH1). All pools occur within Gorge/Gully fauna habitat. These pools were recorded in October following a typical dry season (Biologic 2021a). The water in these pools likely came from the high rainfall in June 2018, three months prior. Following the lack of rainfall between June and the survey, the pools were drying up, indicating that they provide only temporary sources of water following periods of rain.

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Water feature WB-WAH1 (Deposit H Pool) was initially documented in August 2018 and by the time of the October survey, it had dried up substantially. A motion camera and ultrasonic bat recorder were installed at the site for four nights in October 2018 as part of targeted sampling efforts; however, no bat species of significance were recorded here during this time. One Pilbara Olive Python has been recorded at this pool (Biologic 2021d).

Water features WB-WAJ1 and WB-WAJ2 were located in the same rocky gully. Ten motion cameras were deployed at these sites during October 2018 (Biologic 2021e). No species of significance were recorded on these cameras. When the cameras were retrieved, recent rain had created a series of small, interconnected pools within the gully.

These pools may provide drinking and foraging resources for part of the year (after rainfall) for various fauna species, including Northern Quoll, Pilbara Leaf-nosed Bat and Pilbara Olive Python.

4.4 Species Diversity and Fauna Assemblage

The fauna assemblage in the Revised Development Envelope is considered typical of the Hamersley subregion. A total of 214 vertebrate species have been recorded within the Development (including two amphibian, 103 bird, 29 mammal and 80 reptile species (including 41 native and eight introduced mammals).

4.5 Conservation Significant Fauna

Seven have been recorded within the Proposal Area and Revised Development Envelope including:

- Northern Quoll – Endangered (EPBC and BC Acts)
- Ghost Bat – Vulnerable (EPBC and BC Acts)
- Pilbara Leaf-nosed Bat – Vulnerable (EPBC and BC Acts)
- Pilbara Olive Python – Vulnerable (EPBC and BC Acts)
- Fork-tailed Swift – Migratory Species (EPBC Act)
- Pilbara Barking Gecko – P2 (DBCA)
- Western Pebble Mound Mouse – P4 (DBCA).

Feral Cats were recorded within the Revised Development Envelope and are known from the surrounding area. The Cane Toad (*Rhinella marina*) is yet to establish in the Pilbara.

Information on conservation significant fauna (State only) is presented in Table 4-4.

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Table 4-4: Significant Fauna Recorded or Considered to Likely or Possibly Occur within the Development Envelope

Species	Conservation Status	Broad Habitat Type	Presence within Development Envelope
Birds			
Fork-tailed Swift (*Apus pacificus*)	Migratory (EPBC Act and BC Act)	Variety of habitats This species is an aerial forager with no specific habitat requirements within the Development Envelope.	Recorded Twenty individuals were recorded flying over the Development Envelope at the Western Hill deposit. However, given that the species is largely aerial, it would not depend on any of the habitats present within the Development Envelope.
Grey Falcon (Falco hypoleucos)	Vulnerable (EPBC Act and BC Act)	Timbered lowland plains, particularly Acacia shrublands that are near tree-lined watercourses. It has been observed in treeless areas and tussock grassland, open woodland.	Likely The species has not been recorded within the Development Envelope; however, it was recorded within 3 km of the Development Envelope in 1997 and 10 km in 2008. Suitable foraging habitat may occur within Drainage Line, Mixed Acacia Woodland, Foot slopes and Plain habitat types. Suitable nesting habitat may occur where other birds have constructed nests in large trees or other structures within the Development Envelope.
Peregrine Falcon (Falco peregrinus)	Other Specially Protected Fauna (OS; BC Act)	It is most often encountered in arid areas along cliffs above rivers, ranges and wooded watercourses where it hunts birds (Johnstone & Storr, 1998). It typically nests on rocky ledges on tall, vertical cliff faces between 25 m and 50 m high (Olsen *et al.*, 2004; Olsen & Olsen, 1989).	Likely This species can utilise a wide variety of habitats and has been recorded within 10 km of the Development Envelope. Suitable nesting habitat occurs within the Gorge/Gully and Hillcrest/Hillslope habitats, and suitable foraging habitat occurs within Drainage Line, Mixed Acacia Woodland and Foot slopes and Plain habitats.
Mammals			
Northern Quoll (Dasyurus hallucatus)	Endangered (EPBC Act and BC Act)	Rocky habitats which provide protection from predators and are productive with regards to the availability of resources (Braithwaite and Griffiths 1994[P43]; Oakwood 2000[P109]). Den sites include caves and rocky crevices, particularly near water sources (Woinarski et al. 2008[P110]).	Recorded Scats observed in a cave at Western Hill deposit within Gorge/Gully habitat. Suitable denning habitat occurs within the Gorge/Gully habitat type, and suitable foraging and dispersal habitat occur within Gorge/Gully, Hillcrest/Hillslope and Drainage Line habitats.
Pilbara Leaf-nosed Bat (*Rhinonicteris aurantia*)	Vulnerable (EPBC Act and BC Act)	Roosting sites include caves, deep fissures or abandoned mine shafts with warm and humid climates (Armstrong, 2000[P112], 2001[P66]; Baudinette et al. 2000[P111]). Foraging occurs widely across almost all productive and semi-productive habitats (Bat Call WA 2021b[G164]).	Recorded Echolocation calls have been recorded at two locations within the Development Envelope at the Western Hill deposit. Three calls were recorded in a cave (CWAN-04) located within Hillcrest/Hillslope habitat, and one was recorded in the Foot slopes and Plain habitat type (VWAW 87). Nocturnal roosting habitat occurs within Gorge/Gully habitat. Foraging and dispersal habitat occurs within Hillcrest/Hillslope and Drainage Line habitat types.
Ghost Bat (Macrotis lagotis)	Vulnerable (EPBC Act and BC Act)	Rocky gorges and outcrops with caves and crevices which are used as nocturnal, diurnal and maternity roosts. Foraging typically occurs up to 12 km from a diurnal roost (Bat Call WA 2021a[G163]).	Recorded Evidence recorded in 19 caves (CWAN-01, 03, 04, 06, 07, 08, 09, 11, 28, 29 and 32; CMAR-01 to 04; A1, A2, L3 and AA1) throughout the Development Envelope, within Gorge/Gully and Hillcrest/Hillslope habitat types. Echolocation calls have been recorded at four of these caves, and secondary evidence (scats) have been recorded at 18 caves. Two caves contained the remains of Ghost Bat pups, and a live Ghost Bat was sighted at two caves. Roosting habitat occurs within Gorge/Gully and Hillcrest/Hillslope habitat types. Foraging and dispersal habitat occurs in Drainage Line, Mixed Acacia Woodland, Foot slopes and Plain and Cracking Clay habitat types.

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Species	Conservation Status	Broad Habitat Type	Presence within Development Envelope
Western Pebble-mound Mouse **(Pseudomys chapmani)**	Priority 4 (DBCA)	Occurs on gentle slopes of rocky ranges where the ground is covered with a stony mantle and vegetated by hard spinifex, often with a sparse overstorey of eucalypts and scattered shrubs (Biologic 2021d[P21]).	Recorded 288 records from across the entire Development Envelope. Suitable habitat occurs within stony slopes of Foot slopes and Plain and Hillcrest/Hillslope habitats, and the species may also utilise stony areas within other habitats.
Short-tailed Mouse **(Leggadina lakedownensis)**	Priority 4 (DBCA)	The species occupies a diverse range of habitats, including spinifex and tussock grasslands, samphire and sedgelands, Acacia shrublands, tropical eucalypt and Melaleuca woodlands and stony ranges; however, the species is most commonly found in seasonally inundated habitats on red or white sandy-clay soils (Moro & Kutt 2008[P113]).	Possible Marginally suitable habitat occurs within the Foot slopes and Plain habitat and Mixed Acacia Woodland habitats. In addition, there are species records within 5 km of the Development Envelope. Given the proximity of recent records and suitable habitat is only marginal, it is possible this species occurs.
Brush-tailed Mulgara **(Dasycercus blythi)**	Priority 4 (DBCA)	Prefers spinifex Triodia spp. grasslands on sand plains and the swales between low dunes (Pavey et al. 2012[P114]; Woolley 2006[P115]). Mature spinifex hummocks appear to be important for protection from introduced predators (Körtner et al. 2007[P116]).	Possible Marginally suitable habitat occurs in the form of sandy plains within the Foot slopes and Plain habitat types. In addition, there are 12 records within 35 km of the Development Envelope. Given the proximity of recent records and suitable habitat is only marginal, it is possible that this species occurs.
Reptiles			
Pilbara Olive Python (*Liasis olivaceus barroni*)	Vulnerable (EPBC Act and BC Act)	Escarpments, deep gorges, water holes and rock piles associated with permanent pools in rocky areas.	Recorded Recorded on a motion camera at a water feature in Gorge/Gully habitat (WB-WAH1) at Deposit H. Scats were recorded in cave CWAN-04 within Western Hill deposit in Hillcrest/Hillslope habitat. Gorge/Gully habitat within the Development Envelope provides breeding, shelter and foraging habitat. Foraging and dispersal habitat occurs in the Hillcrest/Hillslope and Drainage Line habitat types.
Pilbara Flat-headed Blind-snake **(Anilios ganei)**	Priority 1 (DBCA)	Little is known about the ecology of the Pilbara Flat-headed Blind-snake, but the species is possibly associated with moist soils and leaf litter within gorges and gullies and potentially within a wide range of other stony habitats (Wilson & Swan 2014[P117]). The species has been recorded from numerous habitats but is most likely to be present in rocky terrain and along drainage lines (DBCA 2018[P118]).	Likely This species has been recorded approximately 2.3 km south of the Development Envelope in Drainage Line habitat (Biologic 2021[P21]). Suitable habitat occurs in Gorge/Gully habitat (where moist soil is present) and in rocky terrain within Drainage Line habitat.
Pilbara Barking Gecko **(Underwoodisaurus seorsus)**	Priority 2 (DBCA)	Little is known about the ecology of the Pilbara Barking Gecko, but the species is thought to prefer rocky areas with spinifex and low tree cover habitats (Wilson & Swan 2014[P117]).	Recorded Recorded in 2014 from Deposit H in Hillcrest/Hillslope habitat type and approximately 2 km southwest of Deposit H. Suitable habitat occurs within Gorge/Gully and Hillcrest/Hillslope habitats.

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4.6 Short range endemic fauna

4.6.1 SRE invertebrate Fauna Habitat

Of the six habitat types mapped within the Revised Development Envelope, one habitat type (Gorge/Gully) is considered high significance for SRE invertebrate fauna due to high levels of shade and stable detrital microhabitats (**Table 4-5**). The Drainage Line, Hillcrest/Hillslope and Mixed Acacia Woodland habitat type have moderate significance to SRE invertebrate fauna as they provide shelter and microhabitats, such as leaf litter and woody debris. Still, they tend to be less isolated and have lower stability in areas seasonally disturbed by rain events (**Table 4-5**). The Footslopes and Plain and Cracking Clay habitat types are low significance for SRE invertebrate fauna as suitable microhabitats, shade, and shelter are scarce (**Table 4-5**; Biologic 2021e). The SRE habitats and their extent within the Revised Development Envelope are summarised in **Table 4-5**.

Most of the SRE fauna habitats are well represented within the Revised Development Envelope, except for Gorge/Gully and Mixed Acacia Woodland habitats which both have a limited extent within the Revised Development Envelope. All habitats are common throughout the Pilbara region (Biologic 2021b, 2021d).

Table 4-5: Suitability of SRE and Potential SRE habitat within the Development Envelope

Habitat Type	Extent within the Development Envelope (ha)	SRE Habitat Description
High Significance		
Gorge/Gully	627	The Gorge/Gully habitat provides consistent shade and complex microhabitats, offering shelter and fire protection. Dense pockets of vegetation with stable detrital microhabitats occur in areas where water can be retained long after rainfall. Where these landform and vegetation factors combine, particularly when highly fragmented or isolated, they often provide the most suitable habitats for SRE invertebrate fauna.
Moderate Significance		
Mixed Acacia Woodland	3,229	The dense patches of vegetation are structurally distinct from the surrounding landscape and provide a high degree of shelter, detrital microhabitats (such as leaf litter and woody debris), and deep clay-loam soils. However, some areas are more open and have a lower vegetation complexity, which lowers the value from high to moderate.
Drainage Line	378	Similar in structure and complexity to the Mixed Acacia Woodland habitat, however, it is generally less isolated due to connectivity with other drainage habitats, facilitating the dispersal of many SRE invertebrate groups. The detrital microhabitats and surface soil structure of drainage habitats

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Habitat Type	Extent within the Development Envelope (ha)	SRE Habitat Description
		tend to be less stable in the long-term due to being seasonally inundated or disturbed, which reduces the value for SREs, particularly for long-lived species such as trapdoor spiders.
Hillcrest/Hillslope	12,202	Rocky habitats within this habitat type, such as outcroppings, ridges and gullies, can provide moderate-value microhabitats; however, the slopes and crests of skeletal soils and open vegetation are less suitable as they are mostly devoid of microhabitats that provide shade and shelter.
Low Significance		
Footslopes and Plains	12,051	This habitat has low value for SRE species as, typically, microhabitats are scarce, and the habitat is not restricted or isolated.
Cracking Clay	435	This habitat has low value for SRE species as it is typically open bare ground and microhabitats are scarce.

4.6.2 SRE Invertebrate Fauna Assemblage and Species Diversity

A total of 328 invertebrate specimens have been collected within the Revised Development Envelope, including 42 mygalomorph spiders, one selenopid spider, 74 pseudoscorpions, 56 scorpions, 24 myriapods, 31 gastropods and 100 isopods (Biologic 2021e). Of these, 199 were collected within the Extension Areas across all four deposits, comprising 26 mygalomorph spiders, 60 pseudoscorpions, 25 scorpions, 21 myriapods, 22 gastropods, and 45 isopods.

In total, 75 unique taxa have been recorded within the Revised Development Envelope (31 of which were recorded within the Extension Areas). No confirmed SRE invertebrate taxa were collected from the Revised Development Envelope. Thirty eight (38) of these taxa are considered Potential SREs (**Table 4-6**; Biologic 2021e). An additional 19 potential SRE taxa were recorded within the Revised Development Envelope that could not be identified to species or subspecies level. All of these specimens were collected in multiple or widespread habitats and are not considered further in this assessment. The remaining 18 taxa are widespread species (Biologic 2021e). The widespread taxa are not described further.

4.6.3 Significant SRE Invertebrate Fauna Records

None of the potential SRE species recorded are listed under State or Commonwealth legislation or as Priority species by the DBCA.

The majority of potential SRE species recorded are considered unlikely to be restricted to the Revised Development Envelope as they were recorded from multiple sites and in habitats that are widespread or have low suitability for SREs. This indicates that they are likely to have larger distributions than the sample area and are unlikely to be habitat specialists (Biologic 2021e). However, 19 potential SRE

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species have only been recorded within the Revised Development Envelope and of these, 13 have been recorded within the Proposal Area only (Biologic 2022i; **Table 4-6**).

Table 4-6: Potential SRE Species Recorded

Taxon	Habitat type	Deposit
Spiders		
Aname **`sp. Biologic-ARAN050`**	Footslopes and Plain	Deposit F
Kwonkan **`MYG197`**	Footslopes and Plain	Deposit D
Kwonkan **`MYG380`**	Footslopes and Plain	Western Hill
Conothele `MYG002`	Footslopes and Plain, Mixed Acacia Woodland	Deposit B, D and G
Pseudoscorpions		
Austrochthonius **`sp. Biologic-PSEU101`**	Hillcrest/Hillslope	Deposit H*
Tyrannochthonius **`sp. Biologic-PSEU104`**	Hillcrest/Hillslope	Deposit H*
Tyrannochthonius **`sp. Biologic-PSEU107`**	Hillcrest/Hillslope	Mt Ella East*
Austrohorus **`sp. Biologic-PSEU103`**	Gorge/Gully	Deposit H*
Beierolpium `sp. 8/3`	Hillcrest/Hillslope	Deposit F North and H
Beierolpium `sp. 8/4`	Hillcrest/Hillslope	Deposit H
Beierolpium **`sp. Biologic-PSEU087`**	Gorge/Gully	Deposit H*
Beierolpium **`sp. Biologic-PSEU088`**	Hillcrest/Hillslope	Deposit H*
Beierolpium **`sp. Biologic-PSEU092`**	Footslopes and Plains	Deposit F North
Euryolpium **`sp. Biologic-PSEU086`**	Gorge/Gully	Deposit H
Euryolpium **`sp. Biologic-PSEU093`**	Footslopes and Plains	Deposit F North and Western Hill
Euryolpium **`sp. Biologic-PSEU102`**	Gorge/Gully	Deposit F

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Taxon	Habitat type	Deposit
***Indolpium* `sp. Biologic-PSEU017`**	Various	Deposit F North, Mt Ella East and Deposit C
***Indolpium* `sp. WAM-PSE118`**	Various	Deposit H and Mt Ella East
***Olpiidae* `sp. Biologic-PSEU072`**	Hillcrest/Hillslope	Mt Ella East
***Olpiidae* `sp. Biologic-PSEU084`**	Footslopes and Plains	Western Hill
***Olpiidae* `sp. Biologic-PSEU085`**	Hillcrest/Hillslope	Western Hill*
***Xenolpium* `sp. Biologic-PSEU091`**	Hillcrest/Hillslope	Deposit F North
Scorpions		
***Lychas* `bituberculatus complex`**	Footslopes and Plains	Deposit D and F North
***Lychas* `hairy tail complex`**	Hillcrest/Hillslope	Deposit H
***Lychas* `harveyi complex`**	Various	Western Hill, Deposits C and F
Isopods		
***Armadillidae* Gen. nov. `sp. nov. 1`**	Footslopes and Plains, Cracking Clay, Mixed Acacia Woodland	Deposit C
***Buddelundia* `sp. 10 1458A`**	Footslopes and Plains, Hillcrest and Hillslope, Mixed Acacia Woodland	Deposits C, D, E, F and H
***Buddelundia* `sp. 10 1458B`**	Hillcrest and Hillslope, Footslopes and Plains, Mixed Acacia Woodland	Deposits A and H
***Buddelundia* `sp. 10 1458C`**	Hillcrest/Hillslope	Deposit H*
***Buddelundia* `sp. 10 1458D`**	Hillcrest/Hillslope	Deposit H*
Buddelundia `sp. 47`	Gorge/Gully	Western Hill
***Buddelundia* `sp. 68WA`**	Footslopes and Plains,	Deposits B and D
Buddelundia `sp. 77`	Hillcrest/Hillslope	Deposit H

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Taxon	Habitat type	Deposit
***Buddelundia* `sp. Biologic-ISOP081`**	Hillcrest/Hillslope	Deposit H
***Buddelundia* `sp. Biologic-ISOP082`**	Hillcrest/Hillslope	Deposit H
Diplopods		
***Austrostrophus* `sp. clade E`**	Gorge/Gully	Western Hill
***Austrostrophus* `sp. clade F`**	Hillcrest/Hillslope	Deposit F North, Mt Ella East
Snails		
Sinumeloninae nr. `Mt. Robinson`	Gorge/Gully	Mt Ella East

5 SUBTERRANEAN FAUNA

Subterranean fauna includes troglofauna (terrestrial subterranean fauna) and stygofauna (aquatic subterranean fauna).

The main geological/ hydrogeological formations which provide habitat for subterranean fauna comprise:

- Weathered/ fractured bedrock habitats of the hills and ranges, including: Dales Gorge and Joffre Members of the Brockman Iron Formation, Mt Newman Member of the Marra Mamba Formation, and Wittenoom Dolomite in the valleys (typically BWT).
- Detrital habitats on the lower flanks and valleys, including: Unconsolidated or porous alluvium/ colluvium and weathered/ fractured calcrete within the synclinal valley.

The Key Subterannean fauna values recorded

- 42 troglofauna taxa representing 12 orders comprising Araneae (5 taxa), Blattodea (2 taxa), Symphyla (4 taxa), Diplura (2 taxa), Diptera (1 taxon), Hemiptera (2 taxa), Isopoda (2 taxa), Palpigradi (5 taxa), Pauropoda (6 taxa), Pseudoscorpiones (7 taxa), Scolopendrida (1 taxon) and Zygentoma (5 taxa).
- 12 stygofauna taxa representing six (6) taxonomic orders comprising Amphipoda (4 taxa), Bathynellacea (2 taxa), Harpacticoida (1 taxon), Podocopida (1 taxon), Tubificida (3 taxa), and Isopoda (1 taxon).

5.1 Studies and Survey Effort

Table 5-1 summarises the relevant regional surveys and studies undertaken for Subterranean Fauna.

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Table 5-1 : Summary of Technical Studies for Subterranean Fauna

Study	Study area, type and timing	Consistency with Guidelines
West Angelas Iron Ore Project Stygofauna Assessment Survey (Ecologia 1998c) Prepared for Rio Tinto	**Study area:** Dep. A, B, C, CP, Turee Creek Borefield (TCBF) **Type:** Baseline stygofauna sampling – net hauling, baited traps – 44 bores **Timing:** October 1998	Survey completion pre-dates EPA consideration of subterranean fauna.
West Angelas Iron Ore Project Stygofauna Assessment Survey (Ecologia 2002) Prepared for Rio Tinto	**Study area:** Dep. A, B, CP, TCBF **Type:** Stygofauna monitoring survey – net hauling, no baited traps – 20 bores(12 successfully sampled) **Timing:** 20 March to 22 March 2002	Survey completion pre-dates EPA consideration of subterranean fauna.
West Angelas Stygofauna Survey (Biota 2003) Prepared for Rio Tinto	**Study area:** Dep. A, B, CWB, TCBF **Type:** Stygofauna sampling – net hauling – 30 bores (24 successfully sampled) **Timing:** 28 November to 1 December 2002	Survey completion pre-dates EPA consideration of subterranean fauna.
West Angelas Expansion Deposits E and F Subterranean Fauna Survey (Biota 2004)	Study area: Dep. E, F **Type:** Stygofauna – net hauling – 28 bores (15 successfully sampled) **Timing:** 5 December and 6 December 2003	Survey meets relevant EPA policy and guidance. Survey approach and methodology undertaken with consideration of the following: • Guidance Statement No. 54 (EPA, 2003)

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Study	Study area, type and timing	Consistency with Guidelines
West Angelas Stygofauna Monitoring Programme Report (Ecologia 2005)	**Study area:** Dep. A, B, CWB, TCBF **Type:** Stygofauna monitoring survey via net hauling – 16 bores (14 successfully sampled) **Timing:** 28 to 30 January 2005	Survey approach and methodology undertaken with consideration of the following: • Groundwater Extraction Management Plan (GEMP) for West Angelas (commitments 8, 11,12, 13 and 14)
West Angelas and Deposit A Stygofauna Survey (Biota 2008a)	Study area: Dep. A **Type:** Stygofauna survey via net hauling - 19 bores (15 successfully sampled) **Timing:** 4 to 5 March 2008	Survey approach and methodology undertaken with consideration of the following: • MS514 (commitments 7, 10 and 11 in particular)
West Angelas Operations Stygofauna Requirements (Biota 2008b) Compliance Review	**Study area:** West Angelas Operations **Type:** Desktop compliance review Timing: 2008	Survey approach and methodology undertaken with consideration of the following: • MS514 (commitments 7, 10 and 11 in particular)
West Angelas Stygofauna Survey 2012 (Biota 2012)	**Study area:** Dep. A, TCBF **Type:** Stygofauna – net hauling – 12 bores (12 bores successfully sampled) **Timing:** 9 to 11 July 2012	Survey approach and methodology undertaken with consideration of the following: • MS 514 • Environmental Review and Management Programme (ERMP) for West Angelas • Groundwater Extraction Management Plan (GEMP) for West Angelas

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Study	Study area, type and timing	Consistency with Guidelines
Greater West Angelas Subterranean Fauna Assessment (Ecologia 2013b)	**Study area:** Dep. C, D, G, F, H **Type:** Single phase subterranean fauna survey (troglofauna and stygofauna) Stygofauna (4 accessible bores in Deposit F) & Troglofauna – net hauling, scraping, trapping - 91 bores (38 successfully sampled for troglofauna and 4 successfully sampled for stygofauna) **Timing:** 9 July to 5 October 2012	Survey did not meet relevant EPA policy and guidance. Survey approach and methodology undertaken with consideration of the following : • EPA Guidance Statement No. 54 (EPA, 2003) • EPA Guidance Statement No. 54a (EPA, 2007)
Rio Tinto Iron Ore Regional Troglofauna Sampling (Biota 2013) Rio Tinto Regional Troglobitic Fauna Study Integration Report (Biota 2014)	**Study area:** Dep. Western Hill and, Mt Ella East **Type:** Troglofauna – trapping and scraping - 25 bores at Western Hill Deposit and 28 bores at Mt Ella East **Timing:** 28 January to 13 October 2010	Survey meets relevant EPA policy and guidance. Survey approach and methodology undertaken with consideration of the following : • EPA Guidance Statement No. 54 (EPA, 2003) • EPA Guidance Statement No. 54a (EPA, 2007)
West Angelas Deposit B Stygofauna Assessment (Ecologia 2015)	Study area: Dep. B **Type:** Single phase stygofauna assessment– net hauling – 8 bores (7 successfully sampled in the Central Water bores area to the south of Deposit B) **Timing:** 6 to 8 October 2015	Survey meets relevant EPA policy and guidance. Survey approach and methodology undertaken with consideration of the following : • EPA Guidance Statement No. 54 (EPA, 2003) • EPA Guidance Statement No. 54a (EPA, 2007)

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Study	Study area, type and timing	Consistency with Guidelines
West Angelas Subterranean Fauna Assessment - Report Excerpt (Eco Logical 2015)	**Study area:** Desktop greater West Angelas Study Area **Type:** Desktop report prepared as an excerpt from the Greater West Angelas Subterranean Fauna Assessment (ecologia 2013) Timing: n/a	Desktop review meets relevant EPA policy and guidance. Desktop review approach and methodology undertaken with consideration of the following: • EPA Guidance Statement No. 54 (EPA, 2003) • EPA Guidance Statement No. 54a (EPA, 2007)
West Angelas Deposits C, D & G Subterranean Fauna Survey 2016 (Biologic 2016a)	**Study area:** Dep. C, D, G **Type:** Stygofauna & Troglofauna — (92 bores sampled over two field trips; 43 troglofauna traps, 71 troglofauna scrapes, 29 stygofauna net hauls) **Timing:** 15 to 23 March 2016 and 10 to 12 May 2016	Survey meets relevant EPA policy and guidance. Survey approach and methodology undertaken with consideration of the following : • EPA Guidance Statement No. 54 (EPA, 2003) • EPA Guidance Statement No. 54a (EPA, 2007)
West Angelas Deposit F Stygofauna Monitoring 2016 (Biologic 2016b)	Study area: Dep. F **Type:** Stygofauna - net hauling – 28 bores (9 successfully sampled) Timing: 2016	Survey meets relevant EPA policy and guidance. Survey approach and methodology undertaken with consideration of the following : • EPA Guidance Statement No. 54 (EPA, 2003) • EPA Guidance Statement No. 54a (EPA, 2007)
West Angelas: Subterranean fauna survey (Biologic 2022j)	**Study area:** Dep H, J, F North, Western Hill & Mt Ella East **Type:** Two season Level 2 Subterranean Fauna Survey: Stygofauna & Troglofauna – trapping, net hauling, scrapes – 331 bores (278 successfully sampled) Timing (8 x sampling episodes): 6 to 14 September 2018	Survey meets relevant EPA Act policy and guidance. Survey approach and methodology undertaken with consideration of the following: • Environmental Factor Guideline: Subterranean Fauna (EPA, 2016d) • Technical Guidance: Sampling methods for subterranean fauna (EPA, 2016e)

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Study	Study area, type and timing	Consistency with Guidelines
	4 to 9 November 2018 11 to 18 March 2019 29 March to 10 May 2019 4 to 12 March 2020 24 – 30 June 2020 30 July to 7 August 2020 30 September to 7 October 2020	• Technical Guidance: Subterranean fauna surveys for environmental impact assessment (EPA, 2021b)
Habitat Assessment and Modelling Report (Biologic 2022k)	**Study area**: Greater West Angelas area (comprised 36,779 ha) **Type:** Desktop assessment and integration of: 2D surface geology 3D habitat modelling from drill hole information AWT and BWT. **Timing**: 2021 to 2022	No specific guidance

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5.2 Subterranean Fauna Habitat

The Revised Development Envelope encompasses the Wonmunna Anticline. This anticline-syncline structure dominates the topography of the Revised Development Envelope, comprising a low, east-west striking, rounded range extending from the west of the Revised Development Envelope to the north-eastern and south-eastern parts (i.e. splitting into a northern and a southern limb in the area of Deposits C and D). The major geological formations of the Wonmunna Anticline (predominantly the Brockman Iron Formation and Marra Mamba Formation) are broadly continuous beyond the Revised Development Envelope, occurring throughout the Hamersley subregion.

The four sections of the Revised Development Envelope (Western Hill, Mt Ella East, Deposits H, and F North) each have different combinations of geological and hydrogeological factors that have contributed to the extent, thickness, and connectivity of subterranean fauna habitats AWT and BWT as described in Table 5-2. The main geological and hydrogeological formations which provide habitat for subterranean fauna comprise:

- Weathered/ fractured and/ or mineralized bedrock, including:
    - Dales Gorge, Whaleback Shale, and Joffre Members of the Brockman Iron Formation (occurring on hills and ridges such as Western Hill and Mt Ella East)
    - Mt Newman Member of the Marra Mamba Formation (occurring on low hills and plateaus such as Deposit H and Deposit F North)
    - Wittenoom Dolomite (typically BWT, in the synclinal valley surrounding the Wonmunna anticline and Western Hill, also extending west beyond the Revised Development Envelope)
- Detrital habitats AWT and BWT, including:
    - Poorly consolidated and porous alluvium and colluvium, occurring along the flanks of hills and ranges, throughout the valleys, and along drainage lines
    - Weathered/ fractured calcrete and pisolitic channel-iron deposits occurring as lenses within the synclinal valley surrounding the tip of the Wonmunna Anticline and extending west beyond the Revised Development Envelope (Biologic 2022k).

At Western Hill, thick AWT habitats are hosted within mineralised and weathered/fractured Brockman Iron Formation, which occurs as a series of steep hills and ridges (Table 5-2) Pisolitic duricrust pods on the crests and flanks of the hills provides highly suitable habitat associated with hydrated mineralisation. Poorly consolidated colluvium on the lower flanks provides medium suitability habitat that is well connected between the hills and extensive AWT detrital habitats throughout the synclinal valley.

At Deposit H, high to medium suitability AWT habitats are hosted within mineralised and weathered/ fractured Marra Mamba Iron Formations, occurring as low hills and plateaus (Table 5-2). Pisolitic duricrust on the crests and flanks provides highly suitable habitat, and the Mt Newman Member is highly fractured and faulted. The surrounding Fortescue Group geologies (low suitability) constrain the wider occurrence of AWT habitat, except to the west, towards Deposit B.

At Deposit F North, high to medium suitability AWT habitats are hosted within the Marra Mamba Iron Formation, which occurs as a large, rounded range striking east-west. Poorly consolidated colluvium on the lower flanks and in the valleys provides wider connectivity of medium suitability AWT habitats. A fault (striking SSE) cross-cuts the mineralisation above the water table and results in the MacLeod Member being offset over a small portion of the mineralisation, potentially limiting AWT habitat connectivity in that area. Several dolerite dykes occur at Deposit F North, however, at present it is unclear whether they affect AWT habitat connectivity (Table 5-2).

At Mt Ella East, thick, high to medium suitability AWT habitats are hosted throughout the Brockman Iron Formation. The Mt Ella range is regionally extensive beyond the Revised Development Envelope to the south, west, and east (Table 5-2). Poorly consolidated colluvium on the northern flank and AWT in the valley to the north provides further connectivity with Marra Mamba Iron Formation habitats at Deposit F.

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Table 5-2: Subterranean Fauna Habitat Values at each Revised Development Envelope Section

Section of the Revised Development Envelope	Geological Setting	Key Habitat Values for Troglofauna (AWT)	Value Extent- Pre-impact Suitable Habitat AWT (million m^3)*	Key Habitat Values for Stygofauna (BWT)	Value Extent - Pre-impact Suitable Habitat BWT (million m^3) *
Western Hill and regional synclinal aquifer	Brockman Iron Formation (hills and ranges). Detritals, calcrete/ CID, and Wittenoom Dolomite in the valley.	Extensive, thick habitats AWT (fractured/ weathered/ mineralised Dales Gorge & Whaleback Shale). Thick detritals (poorly consolidated colluvium) AWT in the valley and hill slopes. Broad habitat connectivity between hills and throughout valley.	845,580	Western Hill mineralised orebody aquifer, Dales Gorge Member. Mt McRae Shales layer separates orebody aquifer from regional synclinal aquifer. Regional synclinal valley aquifer hosting Wittenoom Dolomite, detritals, calcrete. Extensive surrounding central anticline, Western Hill, and beyond Revised Development Envelope to the west. Dykes do not impede connectivity due to faulting, detritals BWT.	Western Hill orebody aquifer: 409,281 (3D 'vein' modelling) Synclinal aquifer: 15,025,691 (Stratigraphic habitat modelling)
Deposit H	Marra Mamba Iron Formation (hills and plateau). Thin detritals atop plateau.	Thick suitable habitats AWT (weathered/ mineralised Mt Newman Member). Major faulting/ fracturing. Thin detritals, no known dykes. Fortescue Group geologies (low suitability) surround the Deposit. Potential connectivity to the west.	189,173	Deep mineralised orebody aquifer in Mt Newman Member. Surrounding Fortescue Group geologies constrain the aquifer (closed, 'basin-type' system). No wider BWT habitat connectivity beyond Deposit H/ MMIF.	598,930

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Section of the Revised Development Envelope	Geological Setting	Key Habitat Values for Troglofauna (AWT)	Value Extent- Pre-impact Suitable Habitat AWT (million m^3)*	Key Habitat Values for Stygofauna (BWT)	Value Extent - Pre-impact Suitable Habitat BWT (million m^3) *
Deposit F North	Marra Mamba Iron Formation (hill tops and upper flanks). Detritals (lower flanks and valley).	Thick suitable habitats AWT (weathered/ mineralised Mt Newman Member). Fault potentially affecting AWT connectivity. Dolerite dykes known to occur but their effects on habitat connectivity unknown. Thick detrital habitats extending north/ west/ south.	727,330	No significant aquifer or BWT habitat within MMIF. Small, constrained groundwater patch, deep below surface (~78m). Low suitability for stygofauna.	Negligible
Mt Ella East	Brockman Iron Formation (hills and ranges). Deep detritals in the valley to the north.	Regionally extensive, thick habitats AWT (fractured/ weathered/ mineralised Dales Gorge & Whaleback Shale). Thick detritals AWT in the valley to the north - broad connectivity between and beyond deposits.	1,163,720	No significant aquifer or BWT habitat within Brockman Iron Formation. Adjacent northern valley groundwater very deep (>100 m), low suitability. Mt Ella East pits entirely AWT, Proposal will not impact groundwater.	Negligible

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5.3 Subterranean Fauna Values

Consolidation of the results from all the subterranean fauna surveys undertaken within and surrounding the Revised Development Envelope (refer to **Table 5-1**) identified 165 troglofauna individuals representing 77 troglofauna taxa, and 490 stygofauna individuals representing 23 stygofauna taxa.

Indeterminate subterranean fauna records (i.e. those that could not be identified to a species-equivalent level) were not included in the above. For the most part, these records represented residual specimens that were left over from sub-sampling for molecular analysis, poor-quality damaged specimens, juveniles, and legacy records from historical surveys (pre-2012) that were unfit for further taxonomic work.

Of the total 77 troglofauna taxa and 23 stygofauna taxa recorded in the West Angelas Region, 42 troglofauna taxa and 12 stygofauna taxa were considered relevant to the assessment (Biologic 2022m). These taxa are described as troglofauna and stygofauna species values in sections 5.3.1 and 5.3.2 below.

The remaining 35 troglofauna taxa and 11 stygofauna taxa were excluded from further consideration in this assessment, based on their:

- Records occurring exclusively outside of direct/ indirect/ combined impact areas (unlikely to be impacted)
- Regionally widespread occurrence (linear ranges >100 km; therefore impacts expected to be negligible)
- Widely occurring regional genetic matches (linear ranges >50 km beyond the Revised Development Envelope; therefore, impacts expected to be negligible)
- Records occurring exclusively within approved impact areas (*i.e.* already assessed).

5.3.1 Troglofauna Values

The 42 troglofauna taxa relevant to the assessment represented 12 orders comprising Araneae (5 taxa), Blattodea (2 taxa), Symphyla (4 taxa), Diplura (2 taxa), Diptera (1 taxon), Hemiptera (2 taxa), Isopoda (2 taxa), Palpigradi (5 taxa), Pauropoda (6 taxa), Pseudoscorpiones (7 taxa), Scolopendrida (1 taxon) and Zygentoma (5 taxa) (Table 5-3). Western Hill and Mt Ella East both recorded 14 troglofauna taxa, 13 taxa were recorded at Deposit H and 9 taxa at Deposit F North (Table 5-3). Important details for troglofauna are shown in Table 5-3.

Conservation Significance of Troglofauna

No TECs or PECs relevant to troglofauna have been recorded from the Revised Development Envelope or wider West Angelas Region. None of the troglofauna taxa recorded within the West Angelas Region are listed as threatened or priority species. None of the troglofauna species are recognised as confirmed SRE species, which may be influenced by a lack of taxonomic certainty and formal description at the species level.

Following the WAM categorisation,18 troglofauna taxa have been identified as being troglobitic (or potentially troglobitic), potential SRE species (Table 5-3). These taxa were identified as new species recorded only from the Revised Development Envelope, which are likely to occur in locally restricted geological habitats. These 18 troglobitic (and potentially troglobitic) taxa have therefore conservatively been treated as putative SREs for the purpose of the impact assessment.

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Table 5-3: Troglofauna Species Values Relevant to the Proposal, and Ecological/Distribution Attributes

Shaded rows indicate species known only from the proposed mining pits.

Taxonomy	Occurrence in Revised Development. Envelope	Identification / Match	Subterranean Status	Local/ Regional Linear Range	Distribution*
Araneae					
Araneae `sp. Biologic-ARAN008`	Deposit F North	Genetics, unique	Troglobite, Potential SRE	-	Single site, outside impacts
Araneae `sp. Biologic-ARAN030`	Western Hill	Genetics, unique	Troglobite, Potential SRE	-	Single site, inside impacts. Habitat extends beyond impacts.
Oonopidae `sp. Biologic-ARAN018`	Mt Ella East	Genetic match, regional sequence	Potential Troglobite, Potential SRE	7.6 km	Locally widespread, external genetic match, outside impacts
Prethopalpus `sp. Biologic-ARAN012`	Deposit H	Genetics, unique	Troglobite, Potential SRE	-	Single site, indirect impacts. Habitat extends beyond impacts.
Theridiidae `sp. Biologic-ARAN010`	Deposit H, Mt Ella East	Genetic match, regional sequence	Troglophile/ xene, Uncertain SRE	13.8 km/ 17.6 km	Locally widespread, external match, outside impacts.

Taxonomy	Occurrence in Revised Development. Envelope	Identification / Match	Subterranean Status	Local/ Regional Linear Range	Distribution*
Palpigradi					
Palpigradi `sp. Biologic-PALP016`	Western Hill	Genetics, unique	Troglobite, Potential SRE	-	Single site, inside impacts. Habitat extends beyond impacts.
Palpigradi `sp. Biologic-PALP017`	Deposit H	Genetics, unique	Troglobite, Potential SRE	-	Single site, inside impacts. Habitat extends beyond impacts.
Palpigradi `sp. Biologic-PALP018`	Deposit F North, Mt Ella East	Genetics, unique	Potential Troglobite, Potential SRE	8.7 km	Locally widespread, inside & outside impacts.
Palpigradi `sp. Biologic-PALP019`	Mt Ella East	Genetics, unique	Troglobite, Potential SRE	-	Single site, inside impacts. Habitat extends beyond impacts.
Palpigradi `sp. Biologic-PALP020`	Deposit H	Genetics, unique	Troglobite, Potential SRE	-	Single site, inside impacts. Habitat extends beyond impacts.
Pseudoscorpiones					

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Taxonomy	Occurrence in Revised Development. Envelope	Identification / Match	Subterranean Status	Local/ Regional Linear Range	Distribution*
Indohya `sp. Biologic-PSEU016`	Deposit H	Genetics, unique	Troglobite, Potential SRE	-	Single site, indirect impacts only.
Indolpium `sp. Biologic-PSEU017`	Mt Ella East	Genetic match, regional sequence	Troglophile/ xene, Uncertain SRE	23.2 km	Locally widespread, external match, outside impacts.
Tyrannochthonius `sp. Biologic-PSEU011`	Mt Ella East	Genetics, unique	Troglobite, Potential SRE	0.3 km	Localised range, inside & outside impacts.
Tyrannochthonius `sp. Biologic-PSEU012`	Mt Ella East	Genetics, unique	Troglobite, Potential SRE	3.5 km	Localised range, inside & outside impacts.
Tyrannochthonius `sp. Biologic-PSEU013`	Deposit H	Genetics, unique	Troglobite, Potential SRE	-	Single site, inside impacts. Habitat extends beyond impacts.
Tyrannochthonius `sp. Biologic-PSEU014`	Deposit H	Genetics, unique	Troglobite, Potential SRE	0.7 km	Localised range, indirect & outside impacts.
Tyrannochthonius `sp. Biologic-PSEU015`	Western Hill	Genetics, unique	Troglobite, Potential SRE	-	Single site, inside impacts. Habitat

Taxonomy	Occurrence in Revised Development. Envelope	Identification / Match	Subterranean Status	Local/ Regional Linear Range	Distribution*
					extends beyond impacts.
Scolopendrida					
Cryptops `sp. WAWH`	Western Hill	Morphological, putatively unique	Uncertain troglobite/ trogloxene. Potential SRE	-	Single site, outside impacts
Pauropoda					
Pauropoda `sp. Biologic-PAUR014`	Western Hill	Genetics, unique	Uncertain troglobite/ trogloxene. Potential SRE	-	Single site, inside impacts. Habitat extends beyond impacts.
Pauropoda `sp. Biologic-PAUR016`	Western Hill	Genetic match, regional sequence	Uncertain troglobite/ trogloxene. Potential SRE	37.2 km	Locally widespread, regional match, outside impacts.
Pauropoda `sp. Biologic-PAUR017`	Deposit H	Genetics, unique	Uncertain troglobite/ trogloxene. Potential SRE	-	Single site, indirect impacts
Pauropoda `sp. Biologic-PAUR018`	Western Hill	Genetics, unique	Uncertain troglobite/ trogloxene. Potential SRE	-	Single site, inside impacts. Habitat extends beyond impacts.

Taxonomy	Occurrence in Revised Development. Envelope	Identification / Match	Subterranean Status	Local/ Regional Linear Range	Distribution*
Pauropoda `sp. Biologic-PAUR019`	Deposit F North	Genetics, unique	Uncertain troglobite/ trogloxene. Potential SRE	-	Single site, outside impacts. Habitat extends beyond impacts.
Pauropoda `sp. Biologic-PAUR020`	Western Hill	Genetics, unique	Uncertain troglobite/ trogloxene. Potential SRE	-	Single site, inside impacts. Habitat extends beyond impacts.
Symphyla					
Hanseniella `sp. Biologic-SYMP018`	Mt Ella East	Genetics, unique	Uncertain troglobite/ trogloxene. Potential SRE	-	Single site, outside impacts
Scutigerellidae `sp. Biologic-SYMP011`	Deposit H, Deposit F North, synclinal valley	Genetic match, local sequence	Uncertain troglobite/ trogloxene. Potential SRE	24.1 km	Locally widespread, inside & outside impacts.
Scolopendrellidae `sp. Biologic-SYMP012`	Western Hill	Genetics, unique	Uncertain troglobite/ trogloxene. Potential SRE	-	Single site, inside impacts. Habitat extends beyond impacts.
Scutigerellidae sp. `Helix-SYM027`	Deposit F North	Genetics, unique	Uncertain troglobite/ trogloxene. Potential SRE	-	Single site, indirect and outside impacts

Taxonomy	Occurrence in Revised Development. Envelope	Identification / Match	Subterranean Status	Local/ Regional Linear Range	Distribution*
Diplura					
Parajapygidae `sp. Biologic-DIPL016`	Deposit H	Genetics, unique	Uncertain troglobite/ trogloxene. Potential SRE	-	Single site, outside impacts
Japygidae `sp. Biologic-DIPL017`	Deposit F North	Genetic match, regional sequence	Troglophile/ trogloxene. Potential SRE	29.4 km	Locally widespread, regional match, inside & outside impacts.
Blattodea					
Nocticola `sp. Biologic-BLAT014`	Western Hill, Deposit F North, Mt Ella East	Genetic match, regional sequence	Potential troglophile/ trogloxene. Unlikely SRE	50.9 km	Locally widespread, regional match, inside & outside impacts.
Nocticola `sp. Biologic-BLAT015`	Deposit H	Genetics, unique	Uncertain troglobite/ trogloxene. Unlikely SRE	-	Single site, inside impacts. Habitat extends beyond impacts.
Diptera					
Sciaridae `sp. Biologic-DIPT001`	Western Hill	Genetic match, regional sequence	Potential troglophile/ trogloxene Unlikely SRE	38.4 km	Locally widespread, regional match, inside & outside impacts.
Hemiptera					

Taxonomy	Occurrence in Revised Development. Envelope	Identification / Match	Subterranean Status	Local/ Regional Linear Range	Distribution*
Meenoplidae `sp. Biologic-HEMI010`	Western Hill	Genetics, unique	Troglophile/ trogloxene. Unlikely SRE	28.4 km	Locally widespread, outside impacts.
Phaconeura `sp. Biologic-HEMI003`	Deposit H, Deposit F North	Genetic match, regional sequence	Troglophile/ trogloxene. Unlikely SRE	67 km	Locally widespread, external match. Inside and outside impacts
Zygentoma					
Dodecastyla `sp. Biologic-ZYGE011`	Deposit F North, Mt Ella East	Genetic match, regional sequence	Troglophile/ trogloxene. Unlikely SRE	9.1 km/ 20.9 km	Locally widespread, regional match, inside & outside impacts.
Atelurinae `sp. Biologic-ZYGE012`	Western Hill	Genetics, unique	Troglophile/ trogloxene. Unlikely SRE	-	Single site, inside impacts. Habitat extends beyond impacts.
Atelurinae `sp. Biologic-ZYGE014`	Mt Ella East	Genetics, unique	Troglophile/ trogloxene. Unlikely SRE	4.0 km	Locally widespread, inside & outside impacts.
Trinemura `sp. Biologic-ZYGE013`	Western Hill	Genetics, unique	Potential Troglobite, Potential SRE	-	Single site, inside impacts. Habitat extends beyond impacts.

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Taxonomy	Occurrence in Revised Development. Envelope	Identification / Match	Subterranean Status	Local/ Regional Linear Range	Distribution*
Trinemura `sp. Biologic-ZYGE017`	Mt Ella East	Genetics, unique	Potential Troglobite, Potential SRE	-	Single site, outside impacts
Isopoda					
Philosciidae `sp. Biologic ISOP015`	Mt Ella East	Genetics, unique	Potential troglophile/ trogloxene. Potential SRE	-	Single site, outside impacts
Pseudodiploexochus `sp. WAH`	Deposit H	Morphological, putatively unique	Potential Troglobite. Potential SRE	0.8 km	Localised range, outside impacts.
Total species/ taxa	**42**				

**Distribution is discussed relative to direct (pit locations) and indirect (waste/infrastructure locations) impact areas.*

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5.3.2 Stygofauna Values

The 12 stygofauna taxa relevant to the assessment represented six (6) taxonomic Orders: Amphipoda (4 taxa), Bathynellacea (2 taxa), Harpacticoida (1 taxon), Podocopida (1 taxon), Tubificida (3 taxa), and Isopoda (1 taxon).

Most of the stygofauna taxa were recorded from the regional synclinal aquifer, two taxa were recorded from Western Hill orebody aquifer, and no stygofauna taxa relevant to the assessment were recorded from Deposits H, F North and Mt Ella East. Details for each stygofauna species, SRE status, distribution and known area of occurrence are shown in Table 5-4

The overall richness and capture rates for stygofauna throughout the West Angelas Region (total 23 taxa from 141 samples, 0.16 species per sample) was considered to be relatively low in comparison with other regional surveys (Biologic 2022l). The availability of bores and drill holes intercepting groundwater in some areas, and legacy taxonomic issues limited the ability to compare historically collected specimens. Nevertheless, the overall sampling and taxonomic effort was considered to have met the minimum requirements throughout the West Angelas Region (Biologic 2022m).

Conservation Significance of Stygofauna

No TECs or PECs relevant to stygofauna have been recorded from the Revised Development Envelope or wider West Angelas Region. None of the recorded stygofauna taxa are listed as threatened or priority species. None of the stygofauna species are recognised as confirmed SREs, which may be influenced by a lack of taxonomic certainty and formal description.

Following the WAM categorisation system, seven stygofauna taxa were identified as stygobitic, potential SRE species (Table 5-4). These taxa were identified as new species recorded only from distinct hydrogeological habitats within the Revised Development Envelope (Biologic 2022k). These seven stygobitic taxa have therefore conservatively been treated as putative SREs for the purpose of the impact assessment.

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Table 5-4: Stygofauna Species Values Relevant to the Proposal, and Ecological/Distribution Attributes

Taxonomy	Occurrence in Revised Development Envelope	Identification	Subterranean Status	Linear Range (km)	Distribution*
Tubificida					
Enchytraeidae `sp. Biologic-OLIG008`	Western Hill OB	Genetic match, regional sequence	Amphibious, unlikely SRE	21	Locally widespread, regional match, outside predicted direct impacts
Enchytraeidae `sp. Helix-OLE028`	Synclinal aquifer	Genetics, unique	Amphibious, unlikely SRE	-	Singleton within synclinal aquifer. Habitat extends beyond predicted direct impacts
Enchytraeidae `sp. Helix-OLE029`	Synclinal aquifer	Genetics, unique	Amphibious, unlikely SRE	-	Singleton within synclinal aquifer. Habitat extends beyond predicted direct impacts
Podocopida					
Candonidae `sp. WAN`	Synclinal aquifer	Morphological	Stygobite. Uncertain SRE	-	Single site within synclinal aquifer. Habitat extends beyond predicted direct impacts.
Harpacticoida					
Australocamptus `sp. B13`	Synclinal aquifer	Morphological	Stygobite, Potential SRE	2.1	Localised range within synclinal aquifer. Habitat extends beyond predicted direct impacts.
Syncarida					

Taxonomy	Occurrence in Revised Development Envelope	Identification	Subterranean Status	Linear Range (km)	Distribution*
Atopobathynella `sp. Helix-BAP027_WA`	Synclinal aquifer	Genetics, unique	Stygobite, Potential SRE	2.1	Localised range within synclinal aquifer. Habitat extends beyond predicted direct impacts.
Bathynellidae `sp. Helix-BAB018`	Synclinal aquifer	Genetics, unique	Stygobite, Potential SRE	2.1	Localised range within synclinal aquifer. Habitat extends beyond predicted direct impacts.
Amphipoda					
Kruptus `sp. Helix-AMP035`	Western Hill OB, Synclinal aquifer	Genetics, unique	Stygobite, Potential SRE	6.2	Localised range within synclinal aquifer. Habitat extends beyond predicted direct impacts.
Maarrka `sp. Helix-AMP037`	Synclinal aquifer	Genetics, unique	Stygobite, Potential SRE	2.4	Localised range within synclinal aquifer. Habitat extends beyond predicted direct impacts.
Paramelitidae `sp. Biologic-AMPH018`	Synclinal aquifer	Genetics, unique	Stygobite, Potential SRE	1.1	Localised range within synclinal aquifer. Habitat extends beyond predicted direct impacts.
Paramelitidae `sp. Helix-AMP036`	Synclinal aquifer	Genetics, unique	Stygobite, Potential SRE	8.9	Occurs widely within synclinal aquifer. Habitat extends beyond predicted direct impacts.
Isopoda					

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Taxonomy	Occurrence in Revised Development Envelope	Identification	Subterranean Status	Linear Range (km)	Distribution*
Pygolabis `sp. WAN`	Synclinal aquifer	Morphological	Stygobite, Uncertain SRE	1.1	Localised range within synclinal aquifer. Habitat extends beyond predicted direct impacts.
Total species/ taxa	**12**				

* Distribution is discussed relative to predicted direct impacts - pit locations and predicted drawdown extents.

- West Angelas MCP – Biological Knowledge Database

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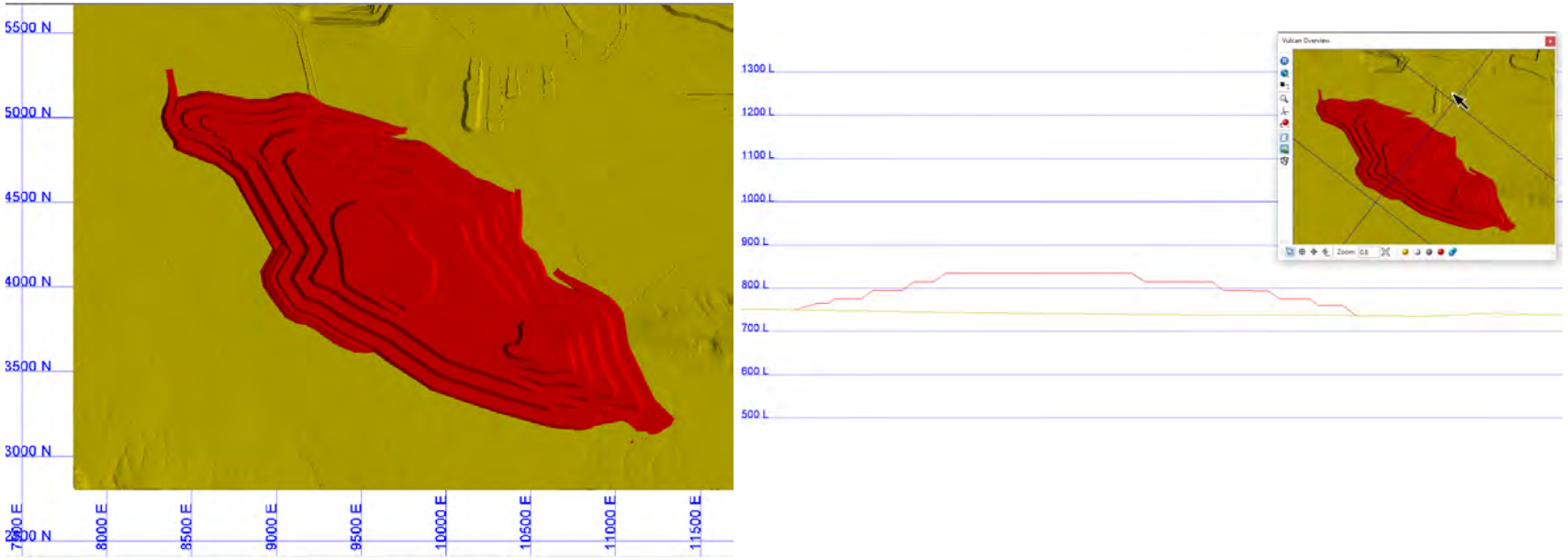
Appendix 11: Primary Landform Designs

Appendix 11 – Primary Landform Designs

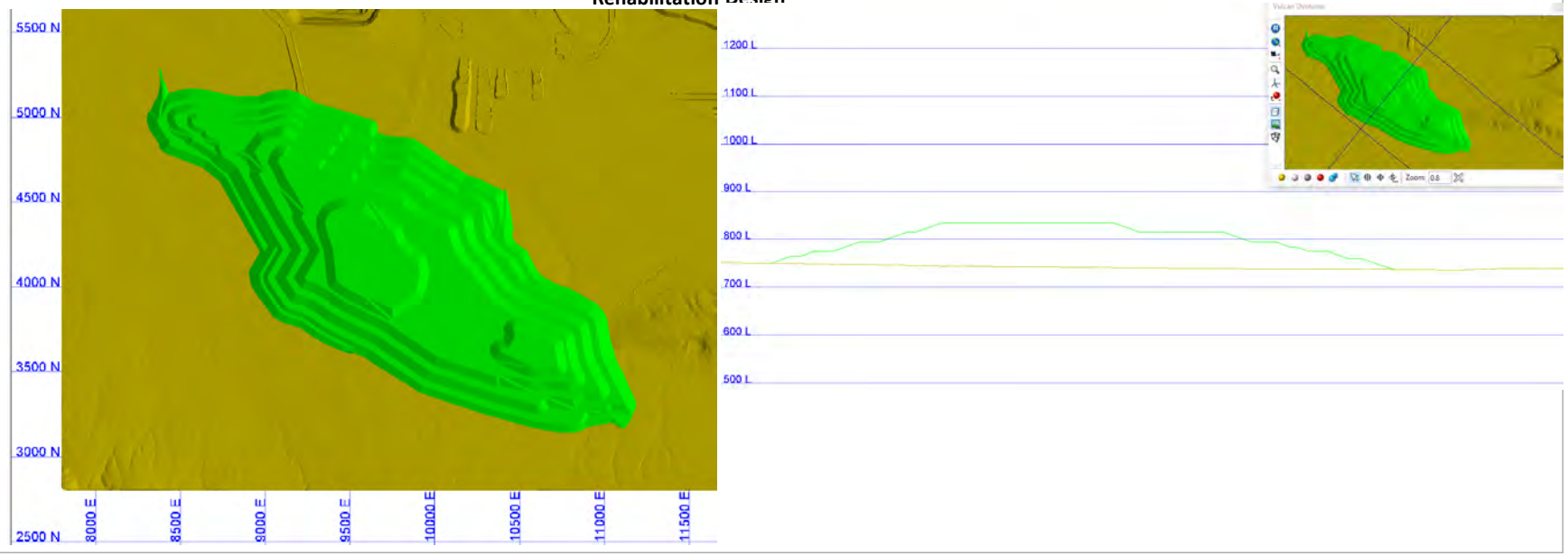
Deposit A South WD

Waste volume	145.2 Mm3	
Erodibility ranking	Low/Medium or High	
	Low	46%
	Medium	0%
	High	54%
Classification	Inert ☒	Capping required at closure:
	PAF ☐	-
	Fibrous minerals ☐	Mm^3
	WFSF ☐	-
Overall height (m)	105	
Topsoil required (Mm^3)	0.619 Mm^3	

Construction Design



Rehabilitation Design



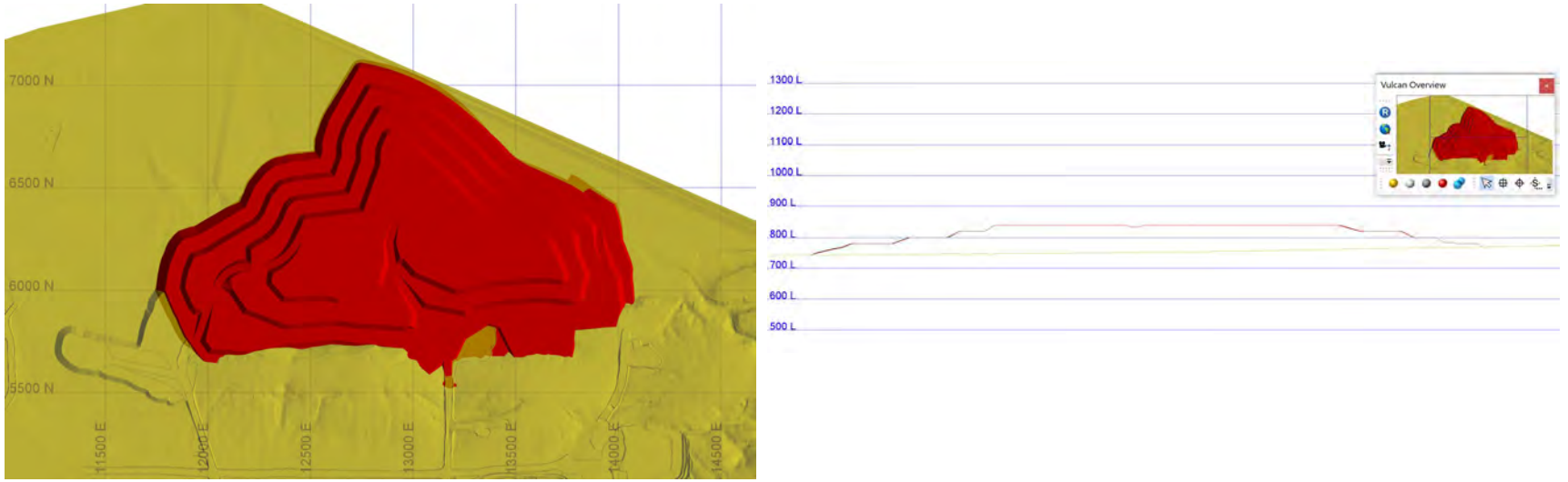
	Construction Specifications	Rehabilitation Specifications
Slope angle (deg)	37	20
Lift height (m)	10/15/20	10/15/20
Berm width (m)	34.2/51.4/68.4	20.0/30.0/40.0
Berm slope (deg)	0	0
Footprint (ha)	301	300

Comments:

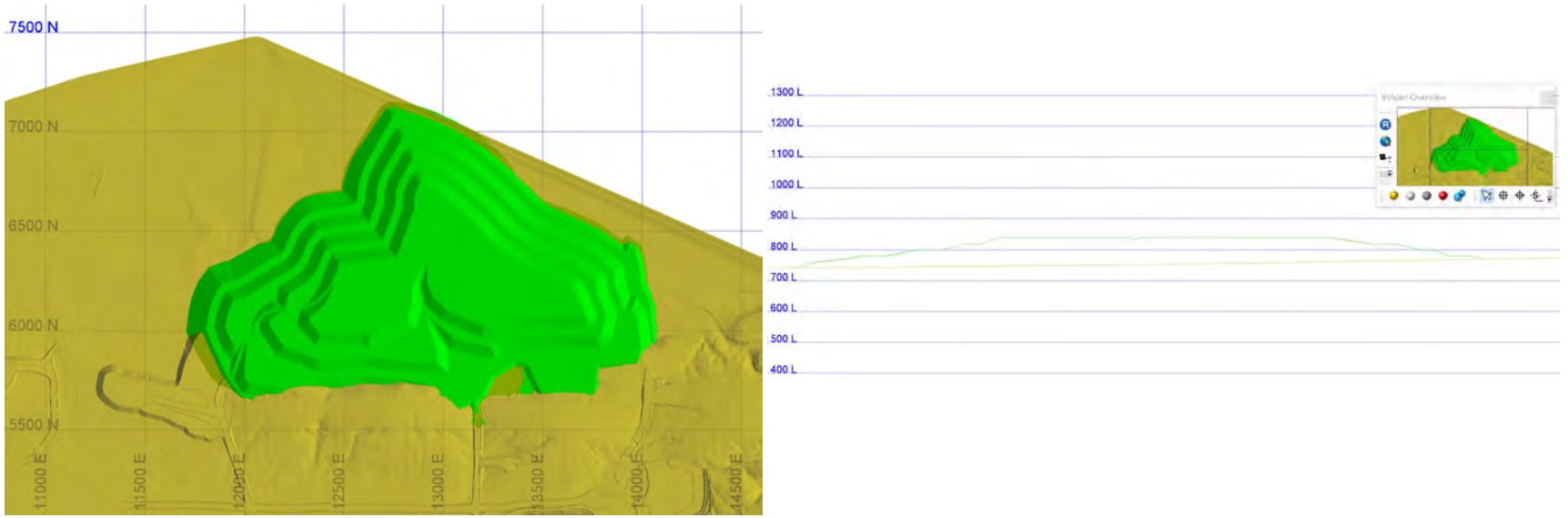
Deposit A North WD

Waste volume	106.5 Mm3	
Erodibility ranking	Low/Medium or High	
	Low	51%
	Medium	0%
	High	49%
Classification	Inert ☒	Capping required at closure:
	PAF ☐	-
	Fibrous minerals ☒	Mm^3
	WFSF ☐	-
Overall height (m)	90	
Topsoil required (Mm^3)	0.478 Mm^3	

Construction Design



Rehabilitation Design



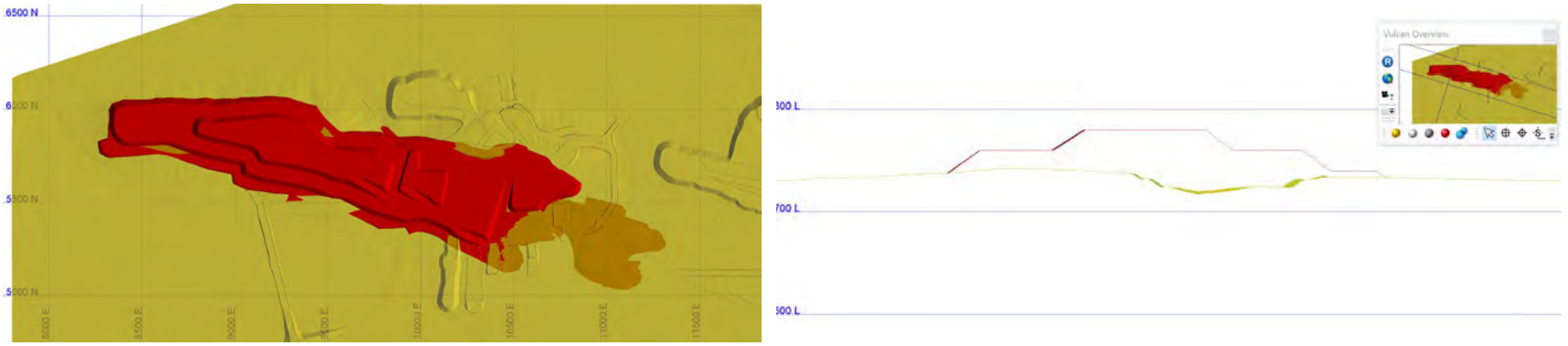
	Construction Specifications	Rehabilitation Specifications
Slope angle (deg)	37°	20
Lift height (m)	20	20
Berm width (m)	68.4	40
Berm slope (deg)	0	0
Footprint (ha)	225.3	232.7

Comments:

Deposit A West Pit North backfill

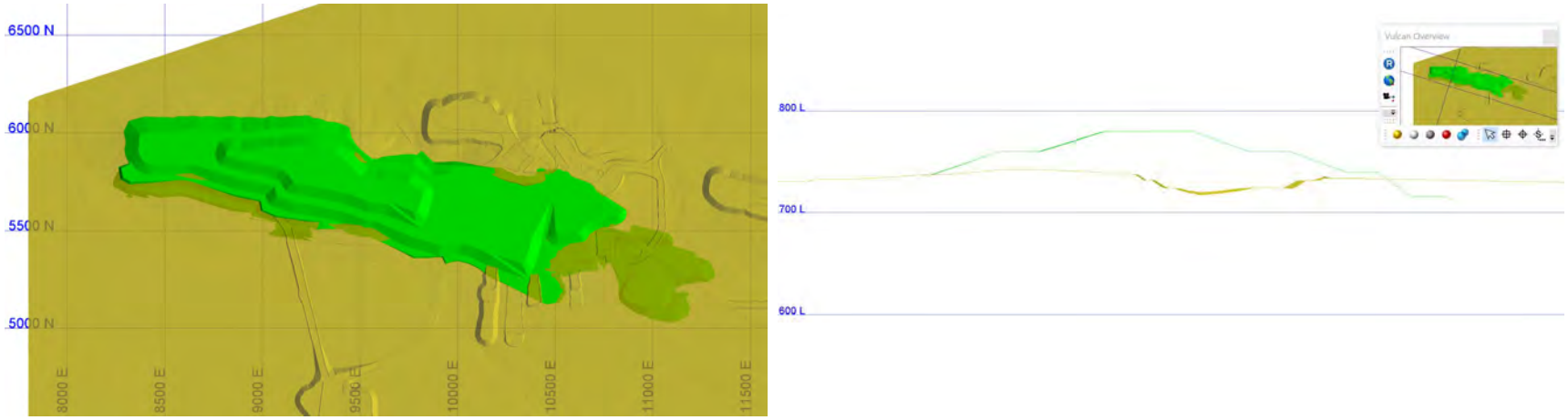
Waste volume	49.6 Mm3	
Erodibility ranking	Low/Medium or High	
	Low	77%
	Medium	0%
	High	23%
Classification	Inert ☒	Capping required at closure:
	PAF ☐	-
	Fibrous minerals ☐	Mm^3
	WFSF ☐	-
Overall height (m)	40m Above pre mining topography	
Topsoil required (Mm^3)	Mm^3	

Construction Design



	Construction Specifications	Rehabilitation Specifications
Slope angle (deg)	37	20
Lift height (m)	20	20
Berm width (m)	68.4/45	40
Berm slope (deg)	0	0
Footprint (ha)	144.1	146.8

Rehabilitation Design

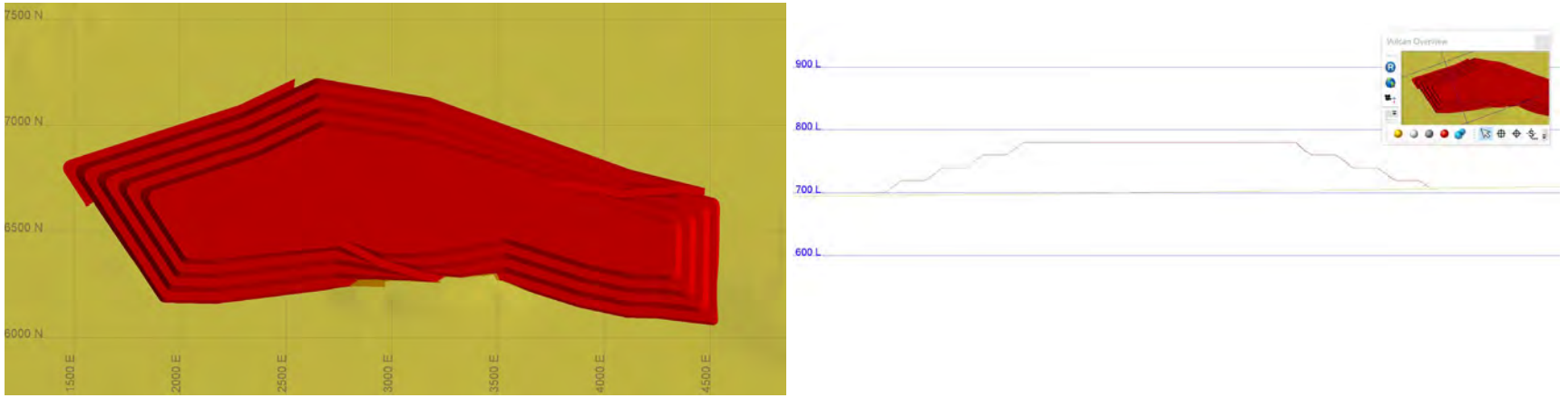


Comments:

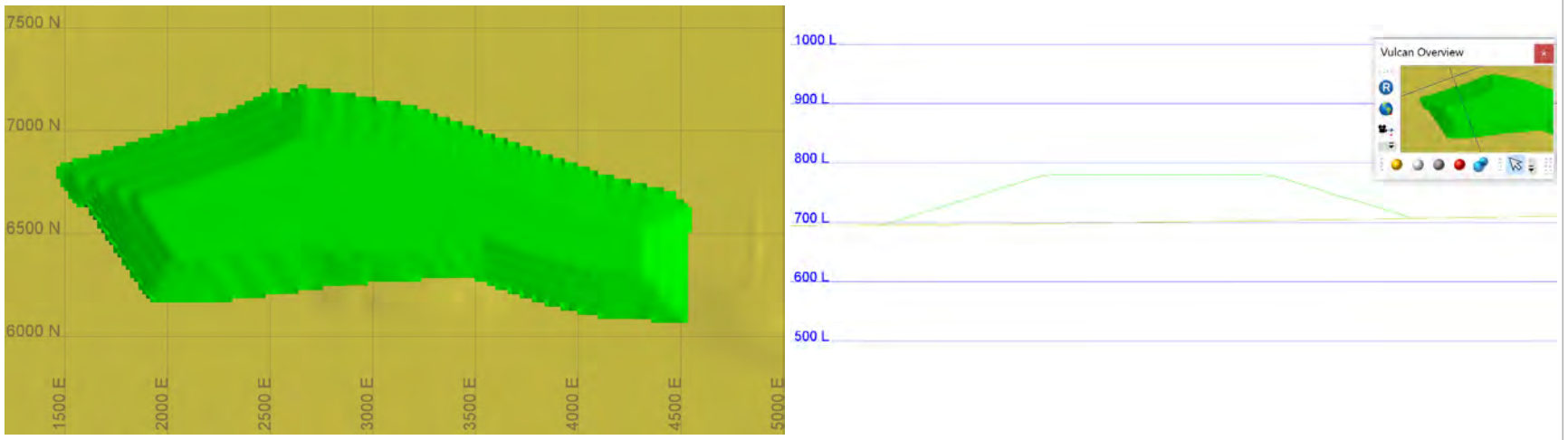
Deposit A West WD1

Waste volume	126.0 Mm3	
Erodibility ranking	Low/Medium or High	
	Low	11%
	Medium	0%
	High	89%
Classification	Inert ☒	Capping required at closure:
	PAF ☐	-
	Fibrous minerals ☐	Mm^3
	WFSF ☐	-
Overall height (m)	80m	
Topsoil required (Mm^3)	0.482 Mm^3	

Construction Design



Rehabilitation Design



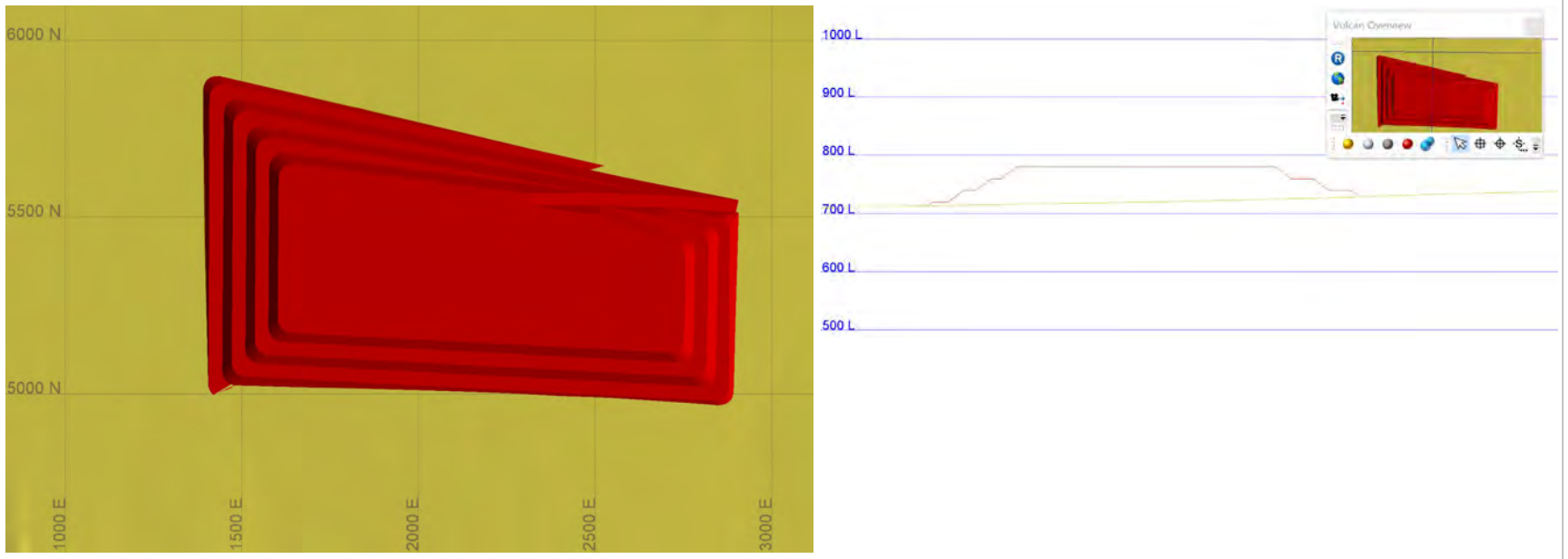
	Construction Specifications	Rehabilitation Specifications
Slope angle (deg)	37	20
Lift height (m)	20	5
Berm width (m)	38.4	10
Berm slope (deg)	0	3
Footprint (ha)	234.7	233.8

Comments:

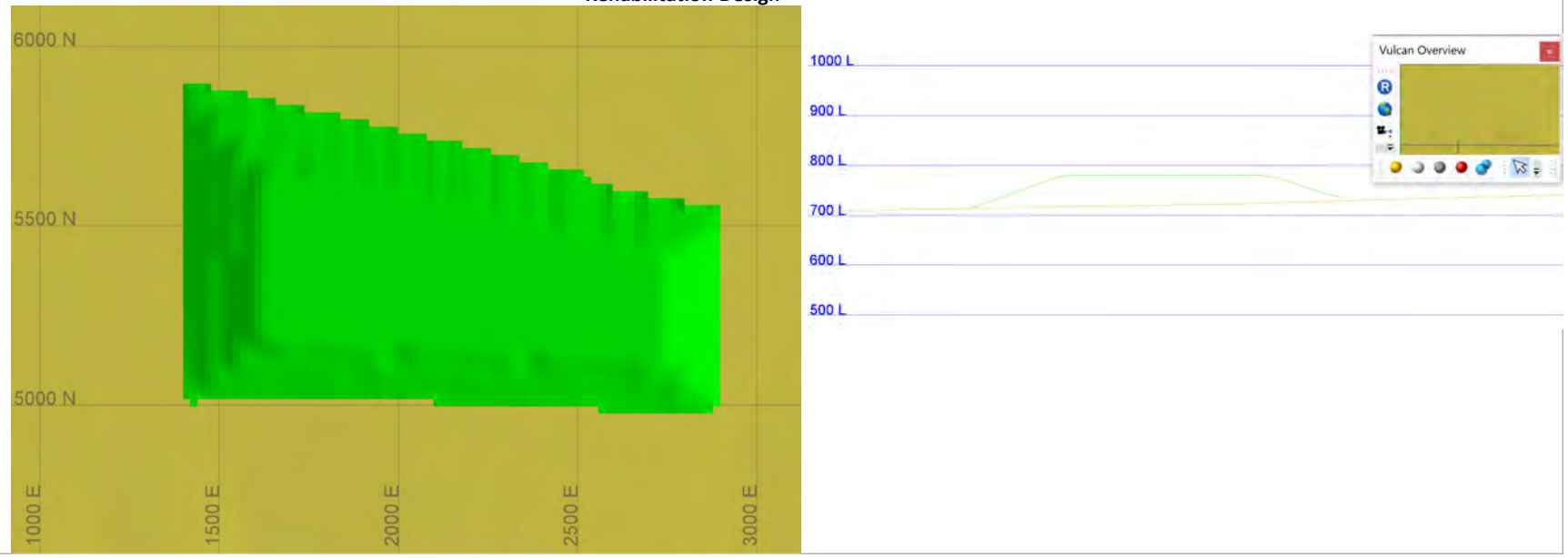
Deposit A West LG Stockpile

Waste volume	44.9 Mm3	
Erodibility ranking	Low/Medium or High	
	Low	48%
	Medium	0%
	High	52%
Classification	Inert ☒	Capping required at closure:
	PAF ☐	-
	Fibrous minerals ☐	Mm^3
	WFSF ☐	-
Overall height (m)	60m	
Topsoil required (Mm^3)	0.225 Mm^3	

Construction Design



Rehabilitation Design



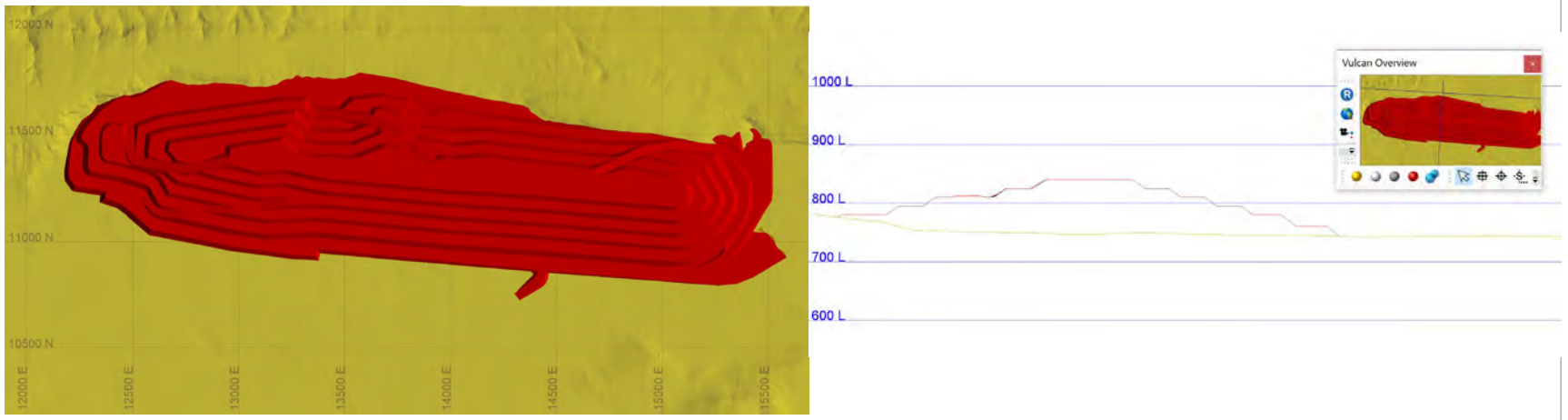
	Construction Specifications	Rehabilitation Specifications
Slope angle (deg)	37	20
Lift height (m)	20	5
Berm width (m)	38.4	10
Berm slope (deg)	0	3
Footprint (ha)	109.2	109.0

Comments:

Deposit B East WD

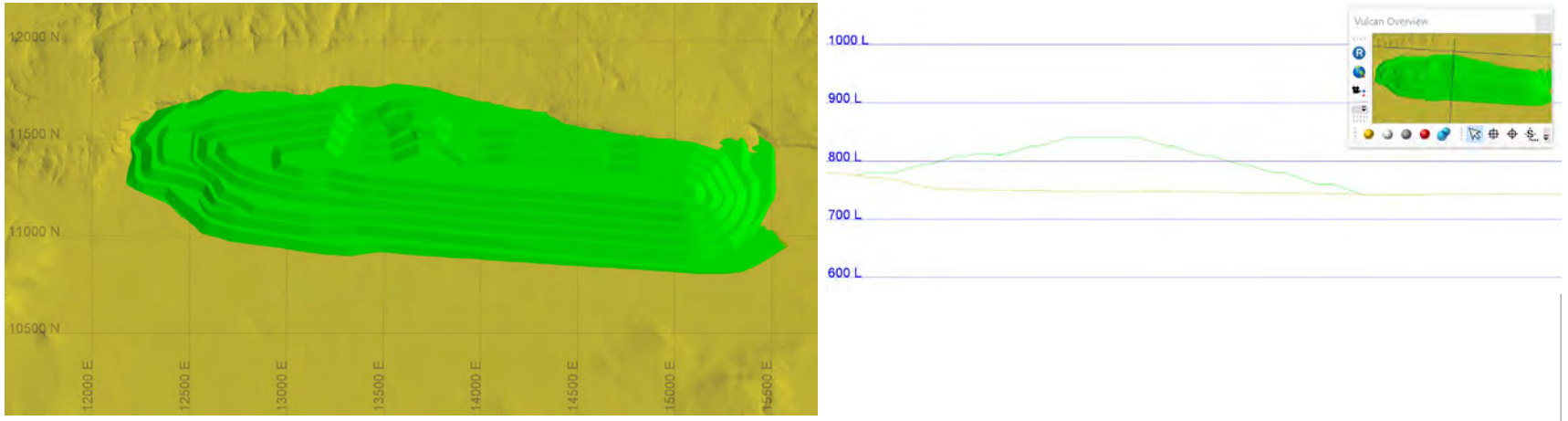
Waste volume	112.4 Mm3	
Erodibility ranking	Low/Medium or High	
	Low	42%
	Medium	0%
	High	58%
Classification	Inert ☒	Capping required at closure:
	PAF ☐	-
	Fibrous minerals ☒	Mm^3
	WFSF ☐	-
Overall height (m)	100	
Topsoil required (Mm^3)	0.503 Mm^3	

Construction Design



	Construction Specifications	Rehabilitation Specifications
Slope angle (deg)	37	20
Lift height (m)	20/15	20/15
Berm width (m)	48.4/41	20/11
Berm slope (deg)	0	0
Footprint (ha)	243.5	244.7

Rehabilitation Design

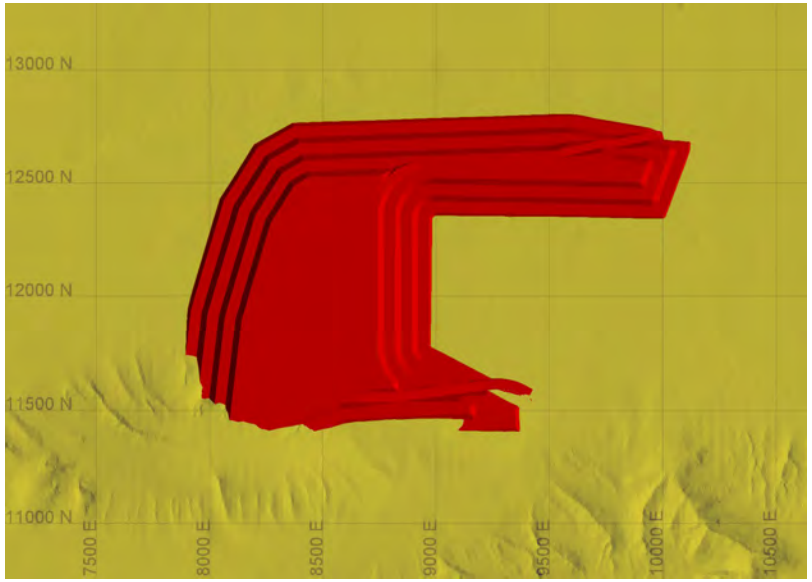


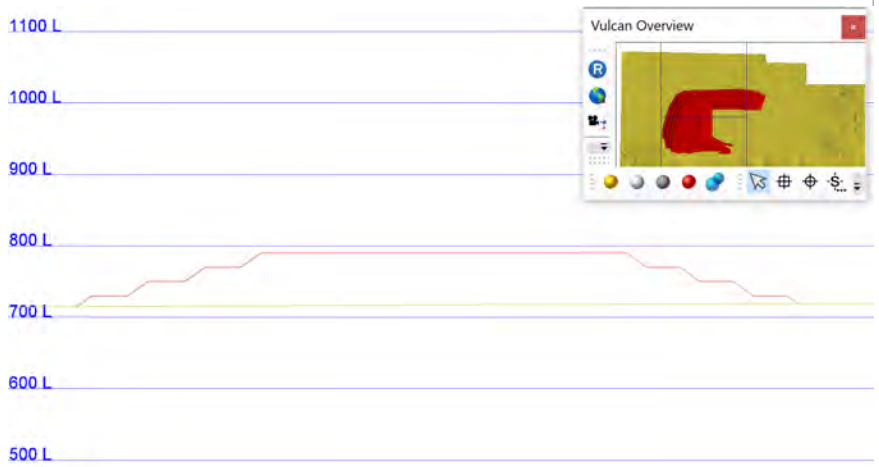
Comments:

Deposit B West WD

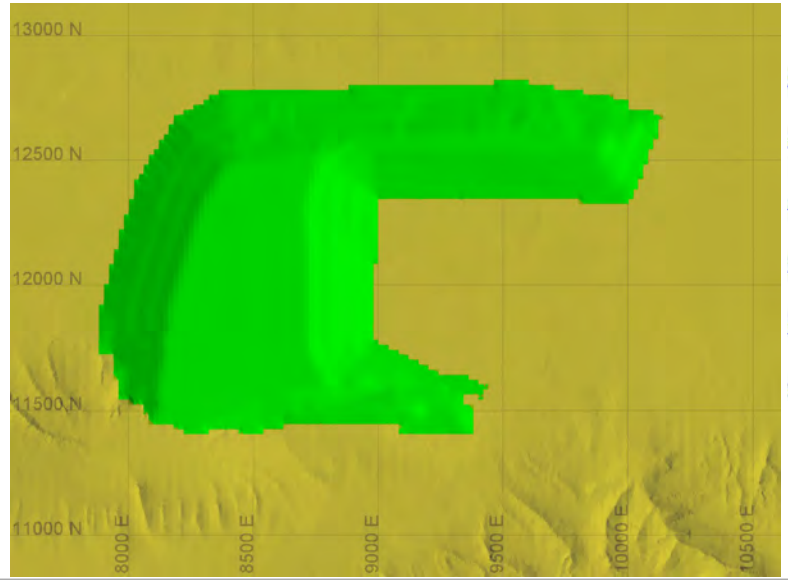
Waste volume	73.3 Mm3	
Erodibility ranking	Low/Medium or High	
	Low	63%
	Medium	0%
	High	37%
Classification	Inert ☒	Capping required at closure:
	PAF ☐	-
	Fibrous minerals ☐	Mm^3
	WFSF ☐	-
Overall height (m)	75	
Topsoil required (Mm^3)	0.394 Mm^3	

Construction Design





Rehabilitation Design



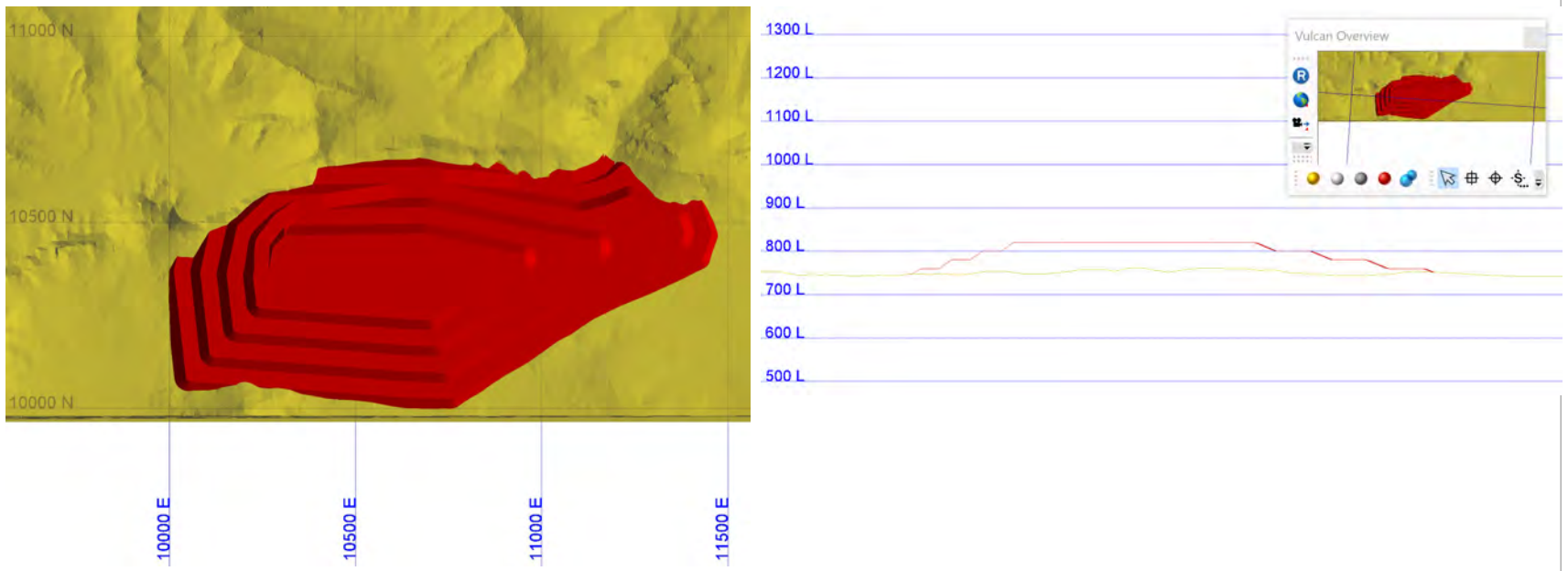
	Construction Specifications	Rehabilitation Specifications
Slope angle (deg)	37	16
Lift height (m)	20	17
Berm width (m)	48.4	12
Berm slope (deg)	0	11
Footprint (ha)	186.5	193.0

Comments:

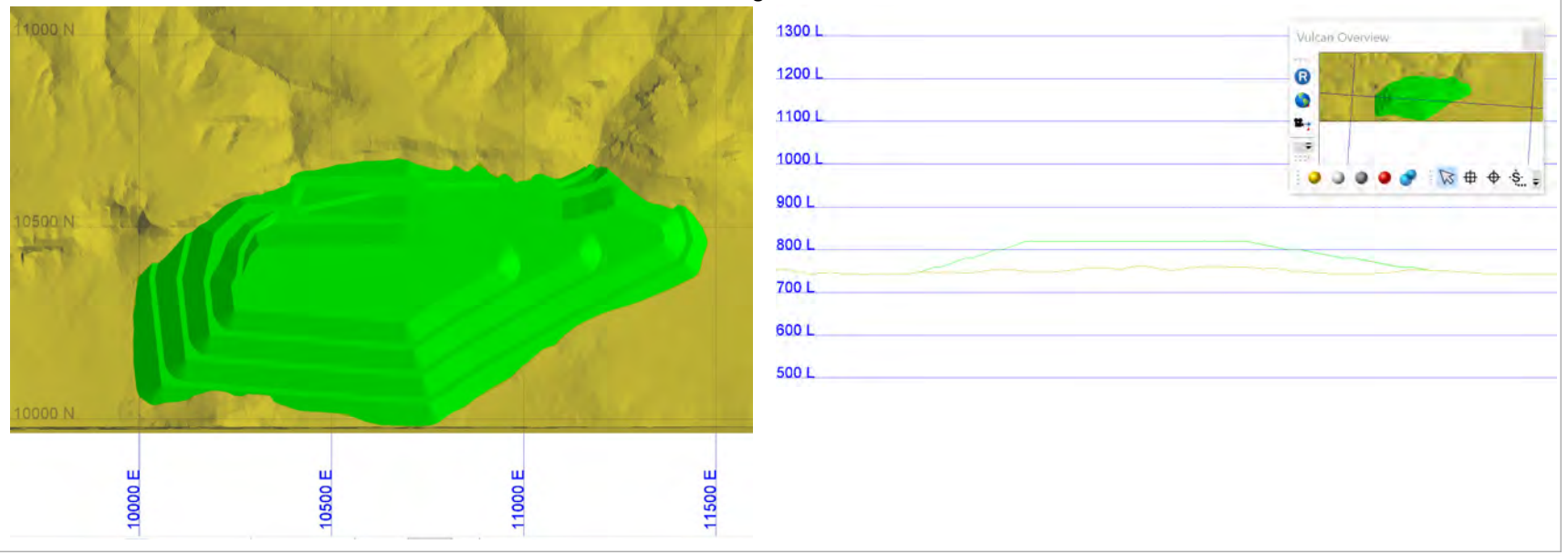
Deposit B LG Stockpile

Waste volume	25.4 Mm3	
Erodibility ranking	Low/Medium or High	
	Low	87%
	Medium	0%
	High	13%
Classification	Inert ☒	Capping required at closure:
	PAF ☐	-
	Fibrous minerals ☐	Mm^3
	WFSF ☐	-
Overall height (m)	80	
Topsoil required (Mm^3)	0.151 Mm^3	

Construction Design



Rehabilitation Design



	Construction Specifications	Rehabilitation Specifications
Slope angle (deg)	37	20
Lift height (m)	20	20
Berm width (m)	43.4	15
Berm slope (deg)	0	0
Footprint (ha)	71.6	72.9

Comments:
Some of the material from this stockpile has been used in the latest LOM to be fed into the crusher.

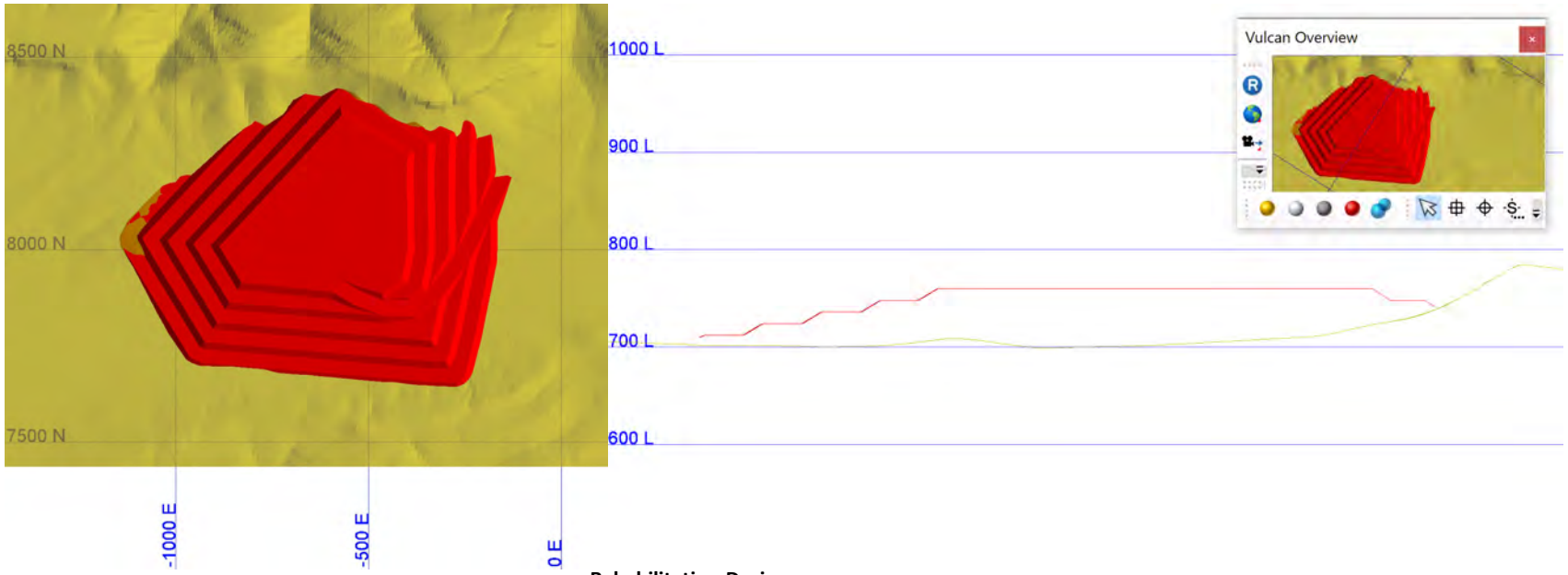
Deposit C WD1

Waste volume	31.9 Mm3	
Erodibility ranking	Low/Medium or High	
	Low	21%
	Medium	0%
	High	79%
Classification	Inert ☒	Capping required at closure:
	PAF ☐	
	Fibrous minerals ☐	Mm^3
	WFSF ☐	-
Overall height (m)	48 m	
Topsoil required (Mm^3)	0.119 Mm^3	

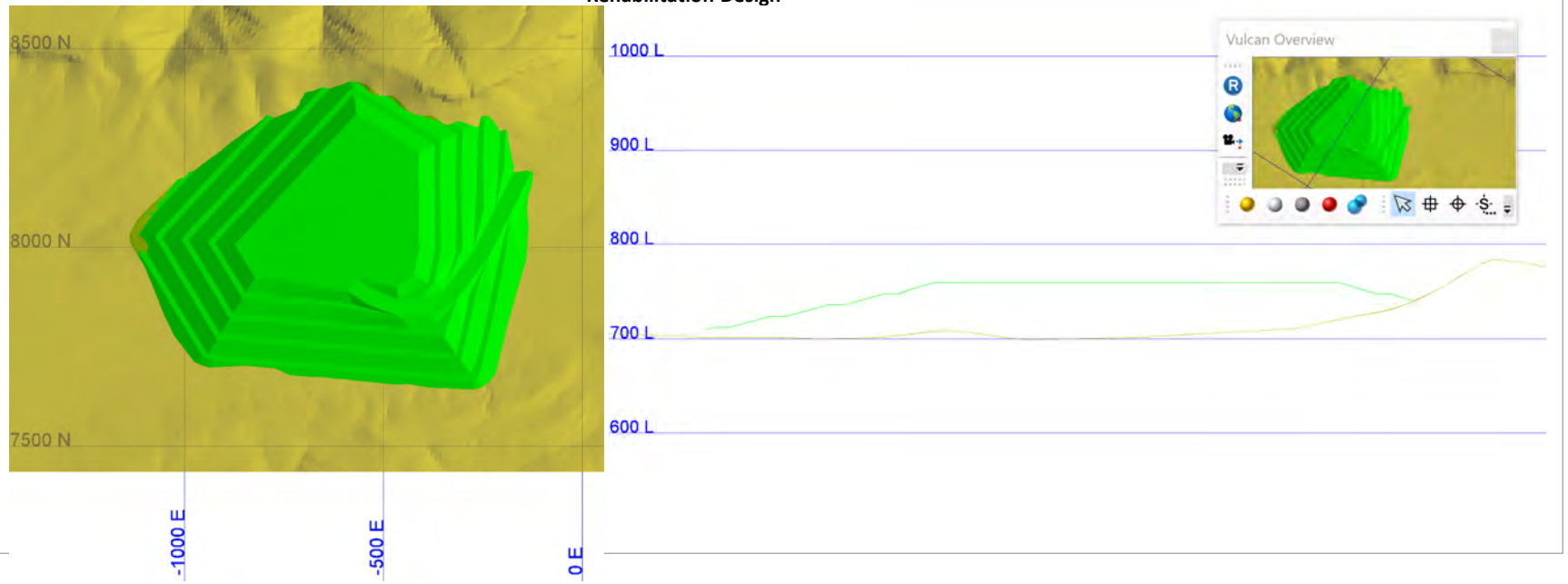
	Construction Specifications	Rehabilitation Specifications
Slope angle (deg)	35	17
Lift height (m)	12	12
Berm width (m)	36	10
Berm slope (deg)	0	0
Footprint (ha)	57.5	58.2

Comments:

Construction Design

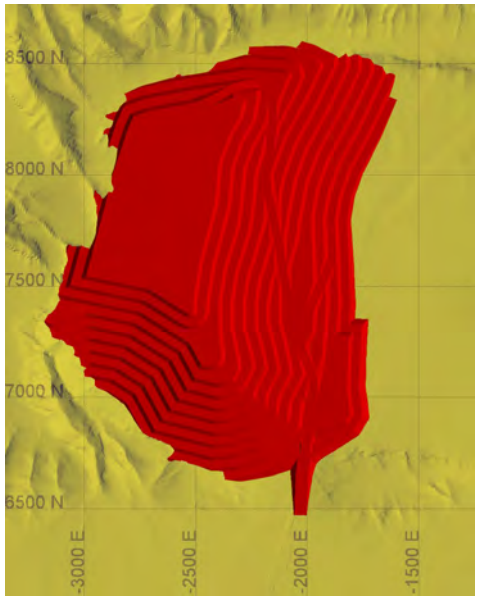


Rehabilitation Design

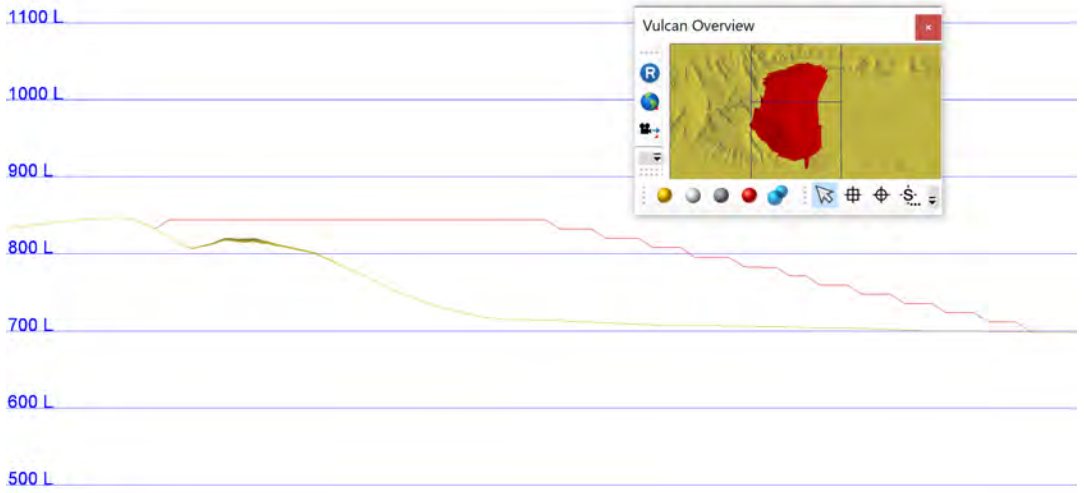


Deposit C&D WD2

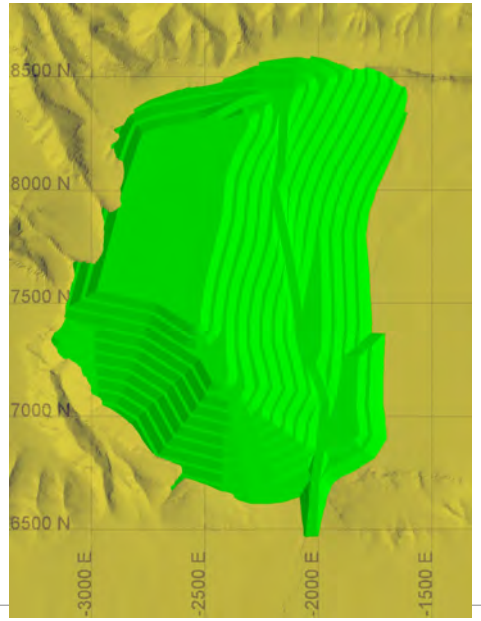
Waste volume	196.0 Mm3	
Erodibility ranking	Low/Medium or High	
	Low	27%
	Medium	0%
	High	73%
Classification	Inert ☒	Capping required at closure:
	PAF ☐	
	Fibrous minerals ☒	Mm^3
	WFSF ☐	-
Overall height (m)	132 m	
Topsoil required (Mm^3)	0.456 Mm^3	



Construction Design



	Construction Specifications	Rehabilitation Specifications
Slope angle (deg)	35	17
Lift height (m)	12	12
Berm width (m)	36	10
Berm slope (deg)	0	0
Footprint (ha)	220.6	224.0



Rehabilitation Design

Comments:

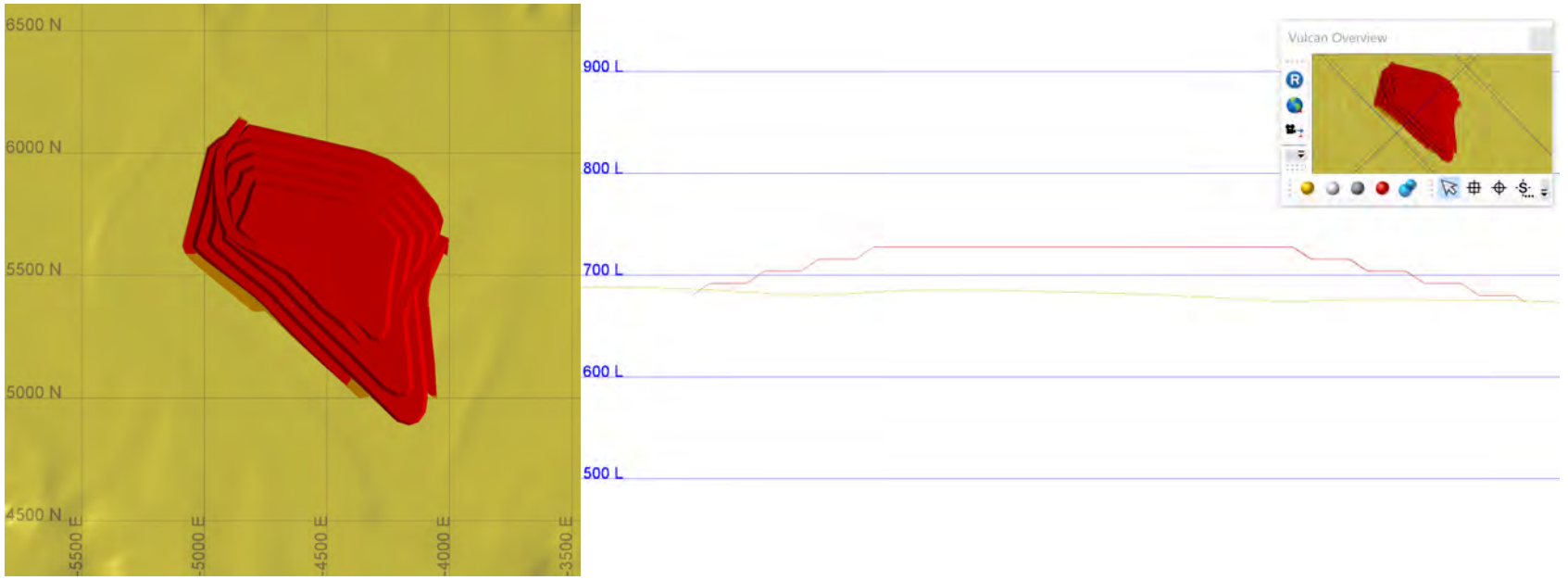
Deposit D WD3

Waste volume	17.4 Mm3	
Erodibility ranking	Low/Medium or High	
	Low	33%
	Medium	0%
	High	67%
Classification	Inert ☒	Capping required at closure:
	PAF ☐	
	Fibrous minerals ☐	Mm^3
	WFSF ☐	-
Overall height (m)	48 m	
Topsoil required (Mm^3)	0.175 Mm^3	

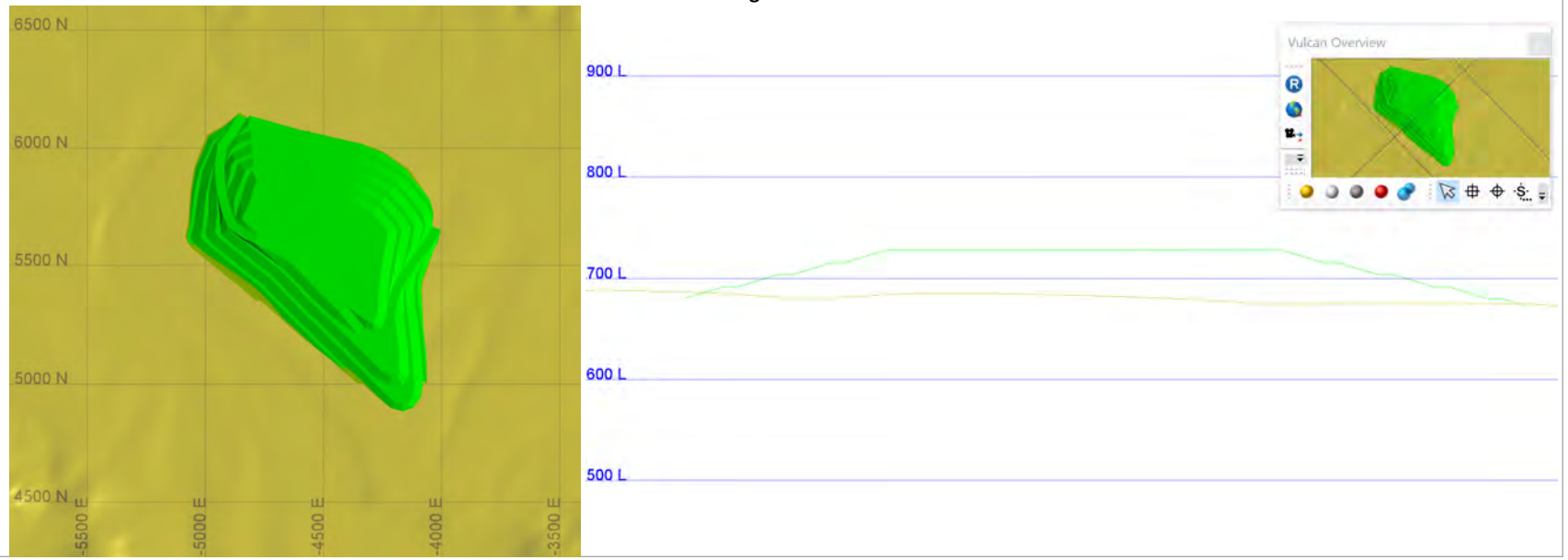
	Construction Specifications	**Rehabilitation Specifications**
Slope angle (deg)	35	17
Lift height (m)	12	12
Berm width (m)	36	10
Berm slope (deg)	0	0
Footprint (ha)	84.2	85.1

Comments:

Construction Design



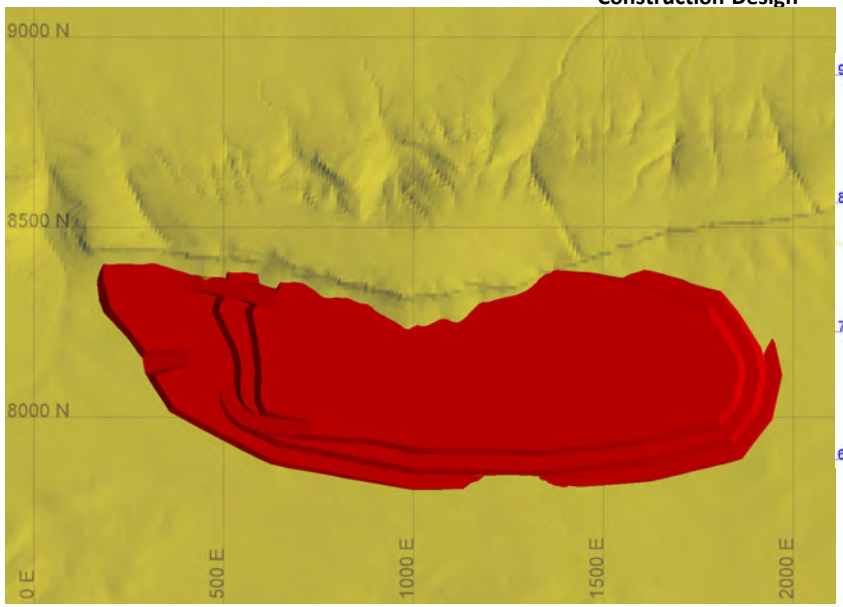
Rehabilitation Design

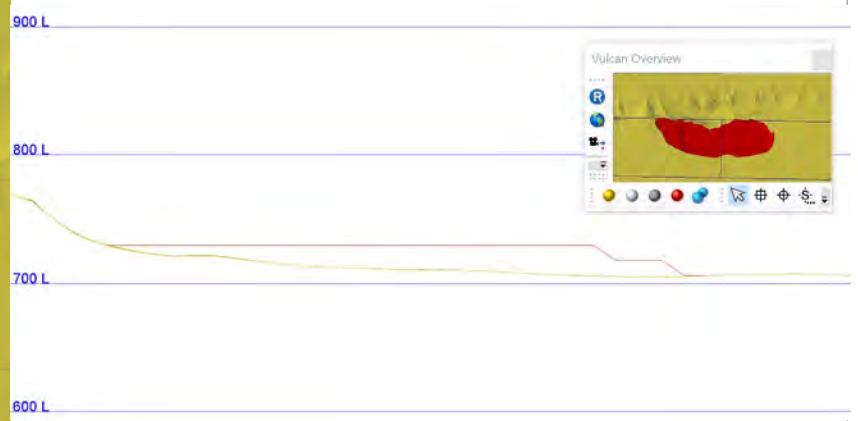


Deposit C LG Stockpile

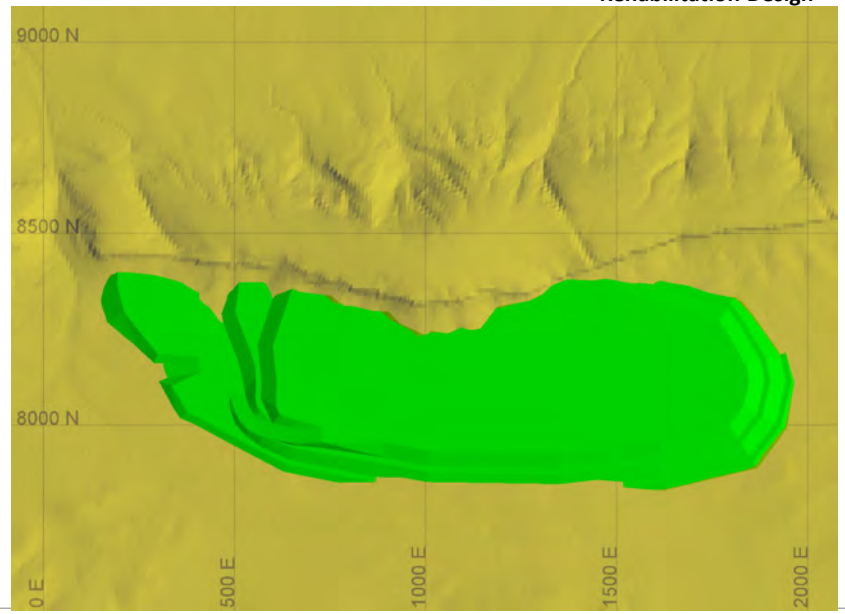
Waste volume	12.1 Mm3	
Erodibility ranking	Low/Medium or High	
	Low	48%
	Medium	0%
	High	52%
Classification	Inert ☒	Capping required at closure:
	PAF ☐	
	Fibrous minerals ☐	Mm^3
	WFSF ☐	-
Overall height (m)	24 m	
Topsoil required (Mm^3)	0.153 Mm^3	

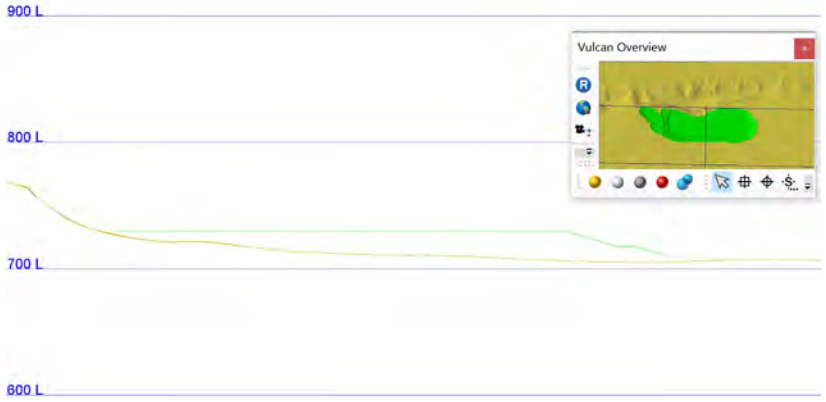
Construction Design





Rehabilitation Design





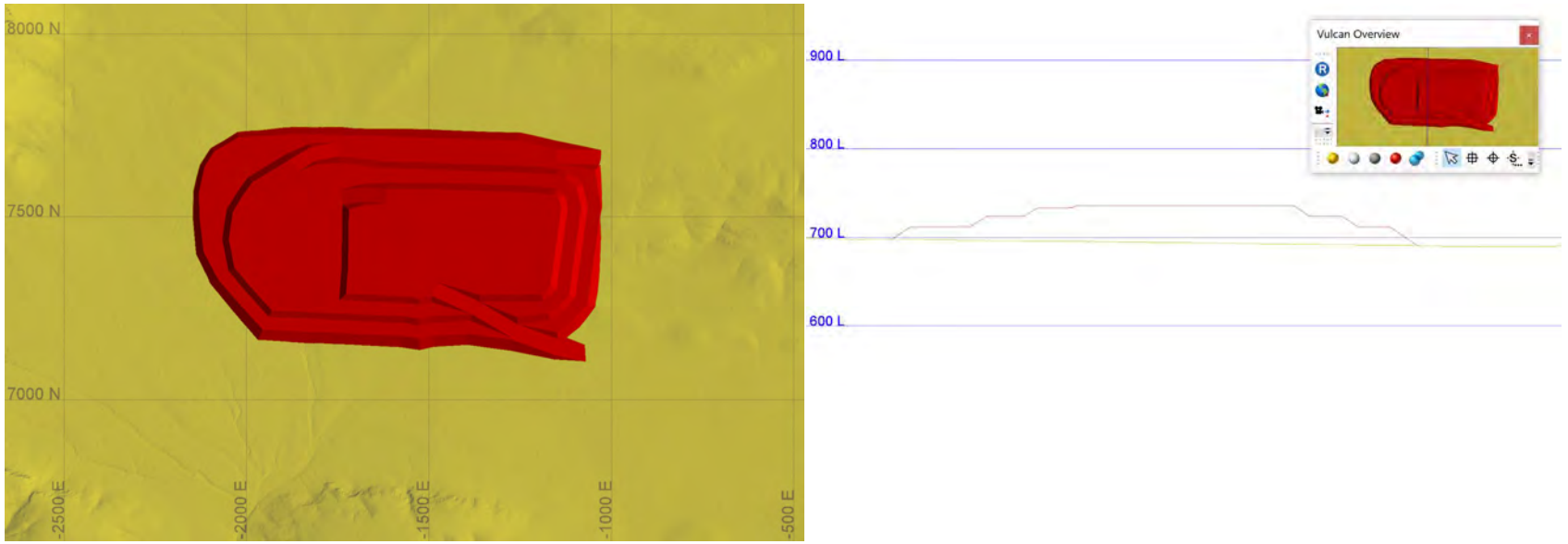
	Construction Specifications	Rehabilitation Specifications
Slope angle (deg)	35	17
Lift height (m)	12	12
Berm width (m)	36	10
Berm slope (deg)	0	0
Footprint (ha)	79.3	75.8

Comments:

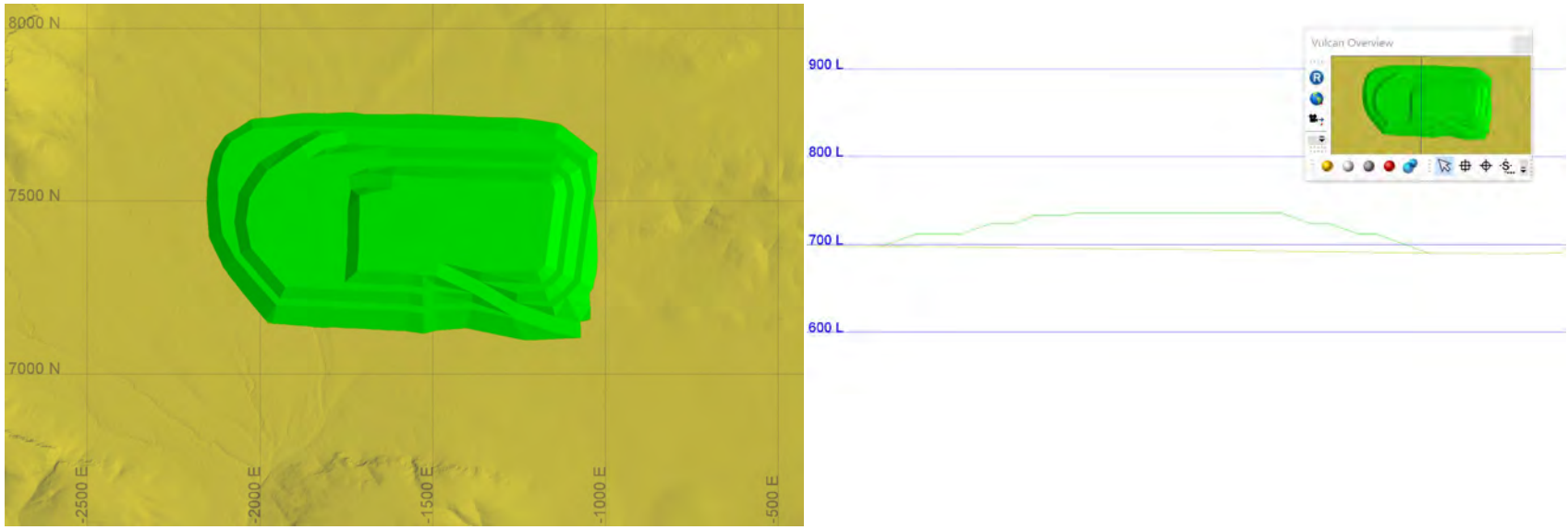
Deposit D LGA Stockpile

Waste volume	16.2 Mm3	
Erodibility ranking	Low/Medium or High	
	Low	34%
	Medium	0%
	High	66%
Classification	Inert ☒	Capping required at closure:
	PAF ☐	
	Fibrous minerals ☐	Mm^3
	WFSF ☐	-
Overall height (m)	41 m	
Topsoil required (Mm^3)	0.131 Mm^3	

Construction Design



Rehabilitation Design



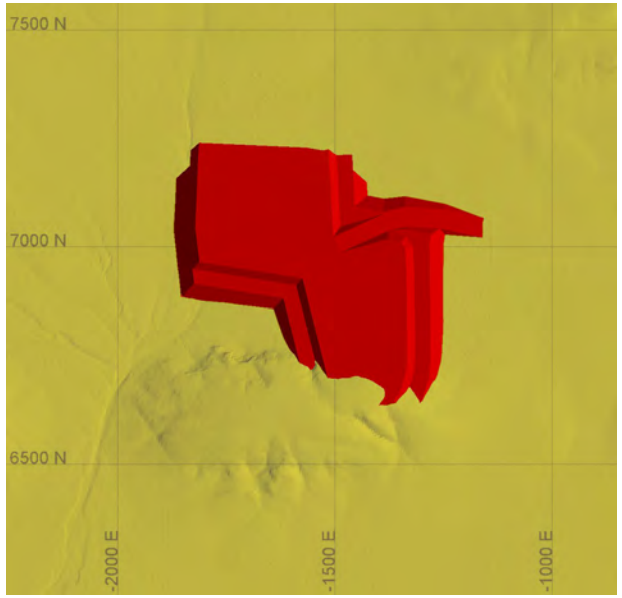
	Construction Specifications	Rehabilitation Specifications
Slope angle (deg)	35	17
Lift height (m)	12	12
Berm width (m)	36	10
Berm slope (deg)	0	0
Footprint (ha)	62.6	66.3

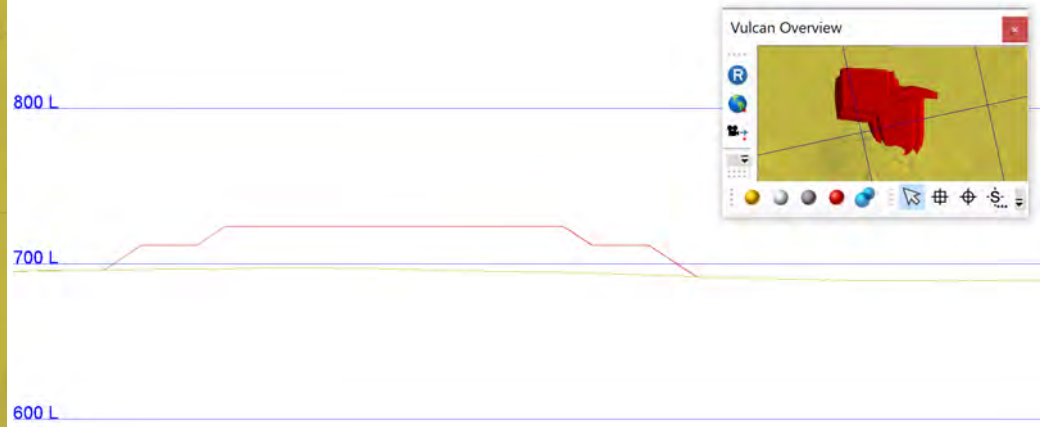
Comments:

Deposit D LGS Stockpile

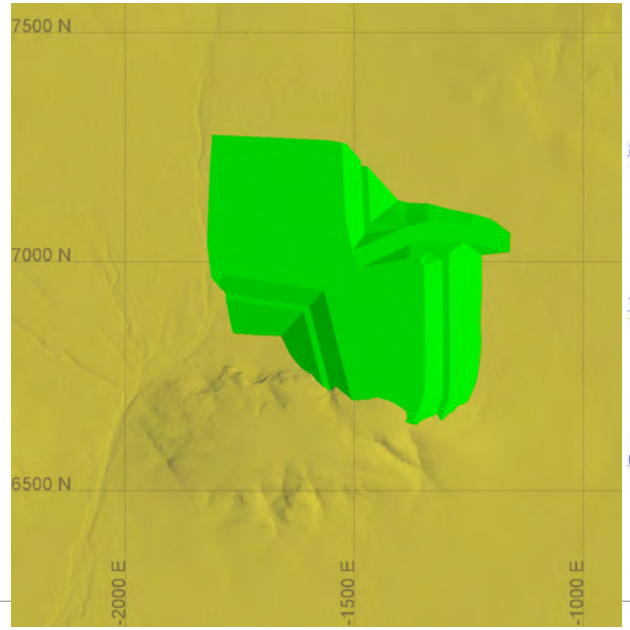
Waste volume	6.4 Mm3	
Erodibility ranking	Low/Medium or High	
	Low	34%
	Medium	0%
	High	66%
Classification	Inert ☒	Capping required at closure:
	PAF ☐	
	Fibrous minerals ☐	Mm^3
	WFSF ☐	-
Overall height (m)	29 m	
Topsoil required (Mm^3)	0.056 Mm^3	

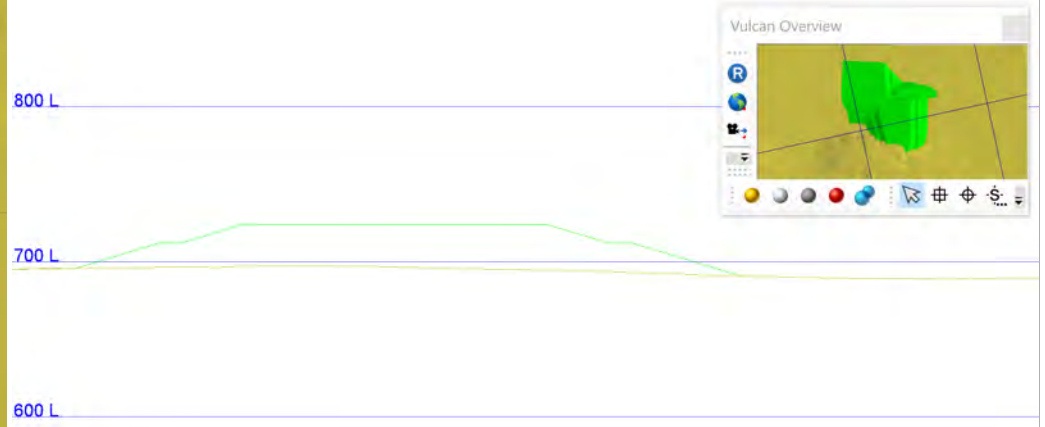
Construction Design





Rehabilitation Design





	Construction Specifications	Rehabilitation Specifications
Slope angle (deg)	35	17
Lift height (m)	12	12
Berm width (m)	36	10
Berm slope (deg)	0	0
Footprint (ha)	27.0	28.0

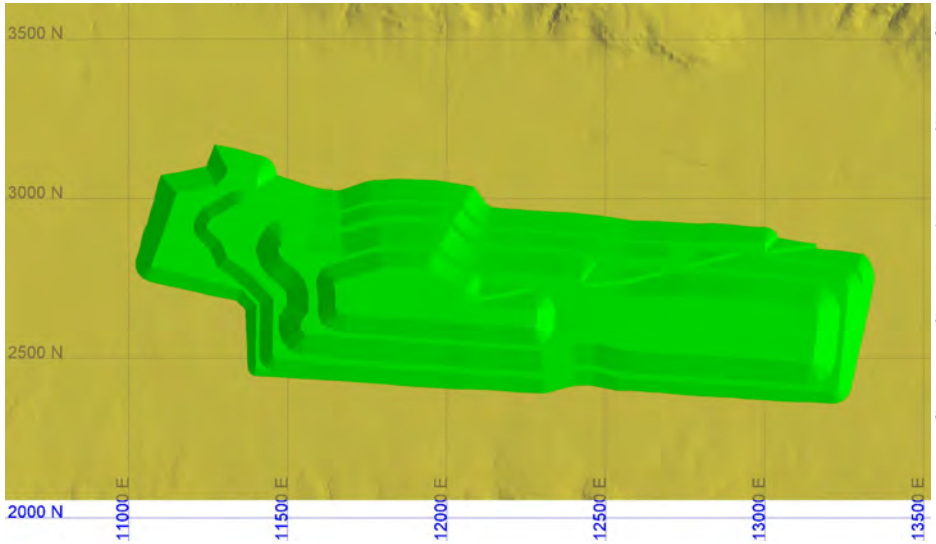
Comments:

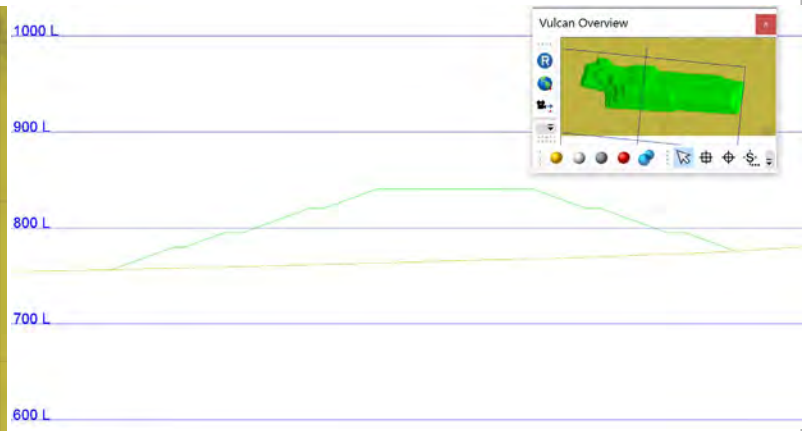
Deposit E South WD

Waste volume	42.5 Mm3	
Erodibility ranking	Low/Medium or High	
	Low	55%
	Medium	0%
	High	45%
Classification	Inert ☒	Capping required at closure:
	PAF ☐	1.29
	Fibrous minerals ☒	Mm^3
	WFSF ☐	-
Overall height (m)	80m	
Topsoil required (Mm^3)	0.258 Mm^3	

Construction Design

Rehabilitation Design





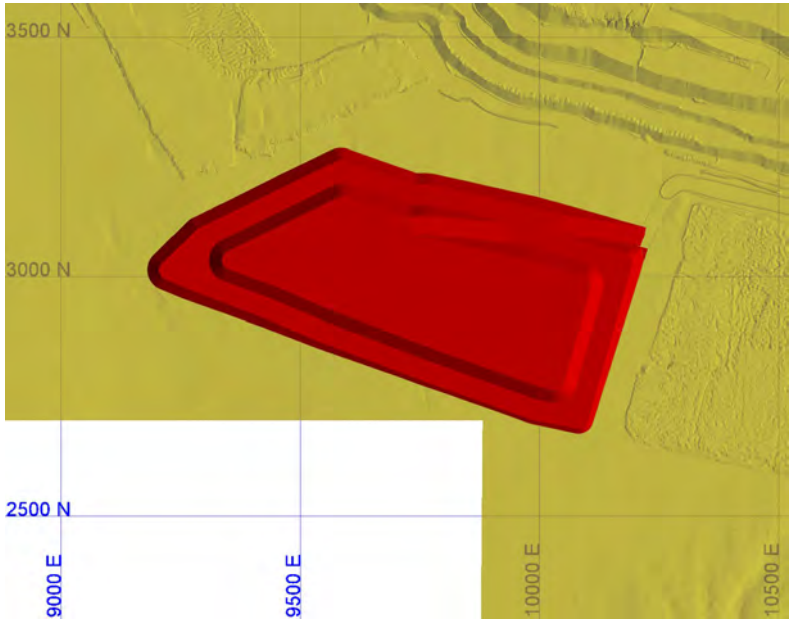
	Construction Specifications	Rehabilitation Specifications
Slope angle (deg)	37	20
Lift height (m)	20	15/20/25
Berm width (m)	43.4	11.25/15/18.75
Berm slope (deg)	0	0
Footprint (ha)	116.4	124.1

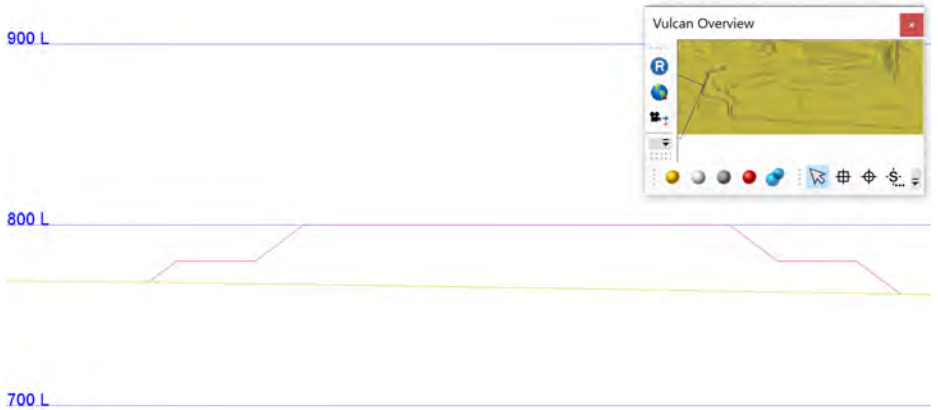
Comments:

Deposit E West WD

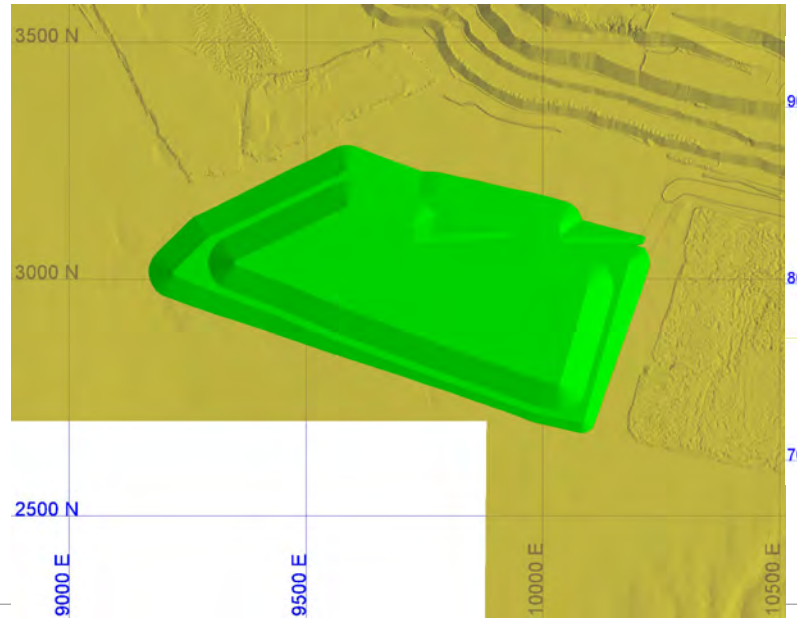
Waste volume	8.5 Mm3	
Erodibility ranking	Low/Medium or High	
	Low	44%
	Medium	0%
	High	56%
Classification	Inert ☒	Capping required at closure:
	PAF ☐	0.4
	Fibrous minerals ☐	Mm^3
	WFSF ☐	-
Overall height (m)	40m	
Topsoil required (Mm^3)	0.080 Mm^3	

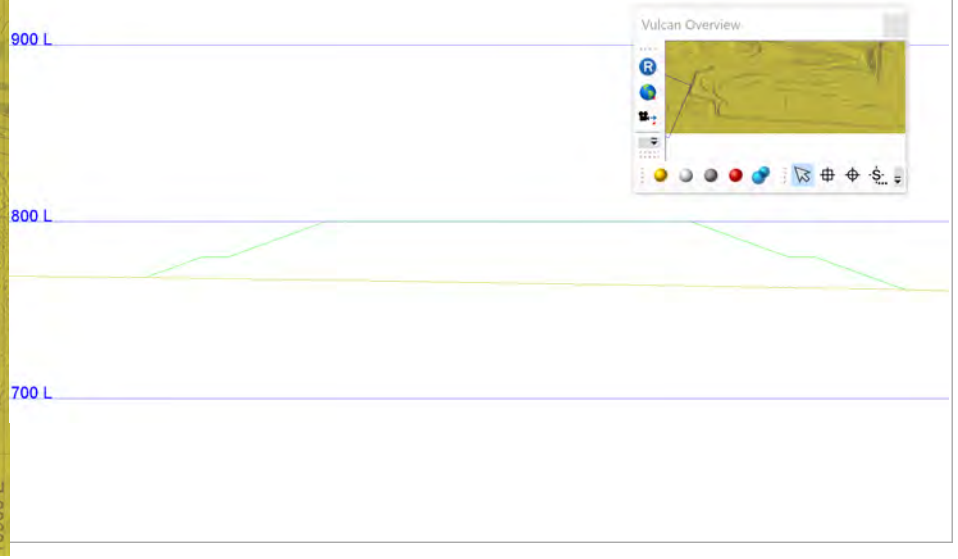
Construction Design





Rehabilitation Design





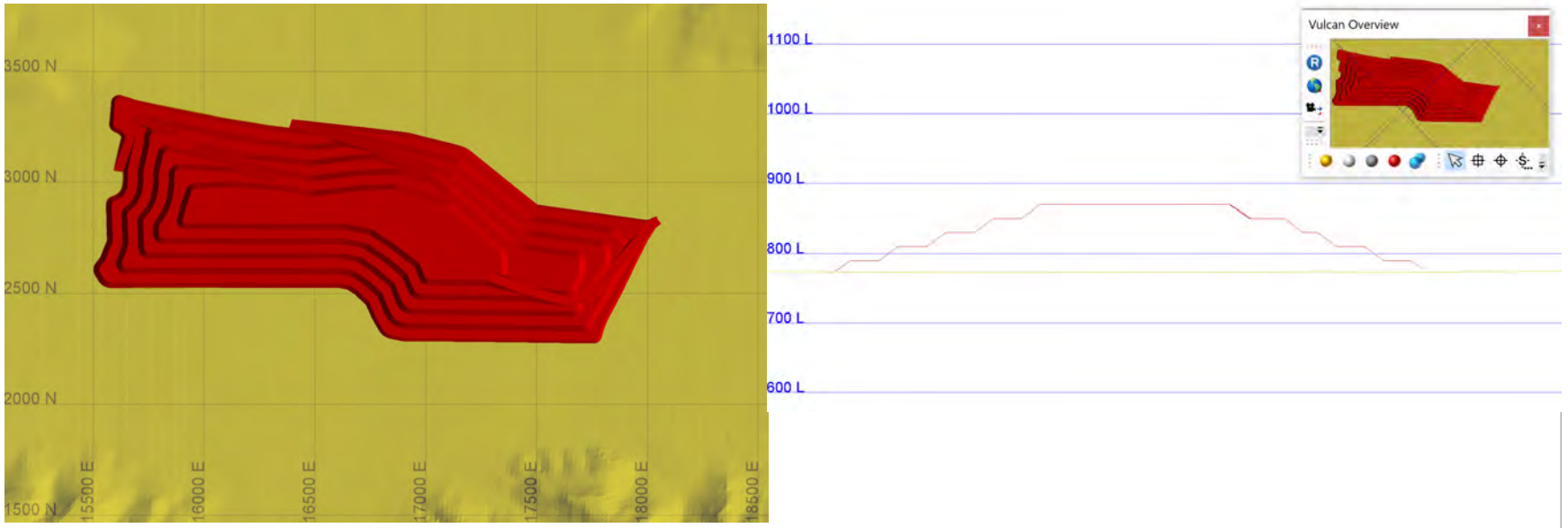
	Construction Specifications	Rehabilitation Specifications
Slope angle (deg)	37	20
Lift height (m)	20	20
Berm width (m)	43.4	15
Berm slope (deg)	0	0
Footprint (ha)	37.4	38.7

Comments:

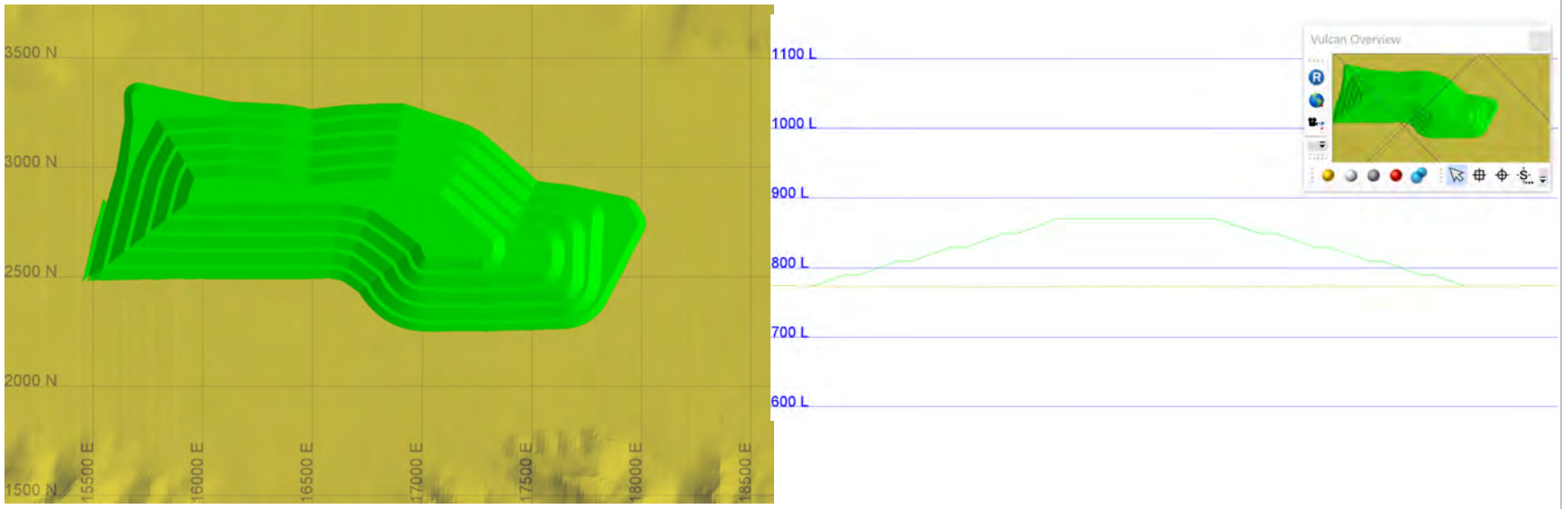
Deposit F West WD

Waste volume	94.1 Mm3	
Erodibility ranking	Low/Medium or High	
	Low	27%
	Medium	0%
	High	73%
Classification	Inert ☒	Capping required at closure:
	PAF ☐	2.0
	Fibrous minerals ☐	Mm^3
	WFSF ☐	-
Overall height (m)	100 m	
Topsoil required (Mm^3)	0.407 Mm^3	

Construction Design



Rehabilitation Design



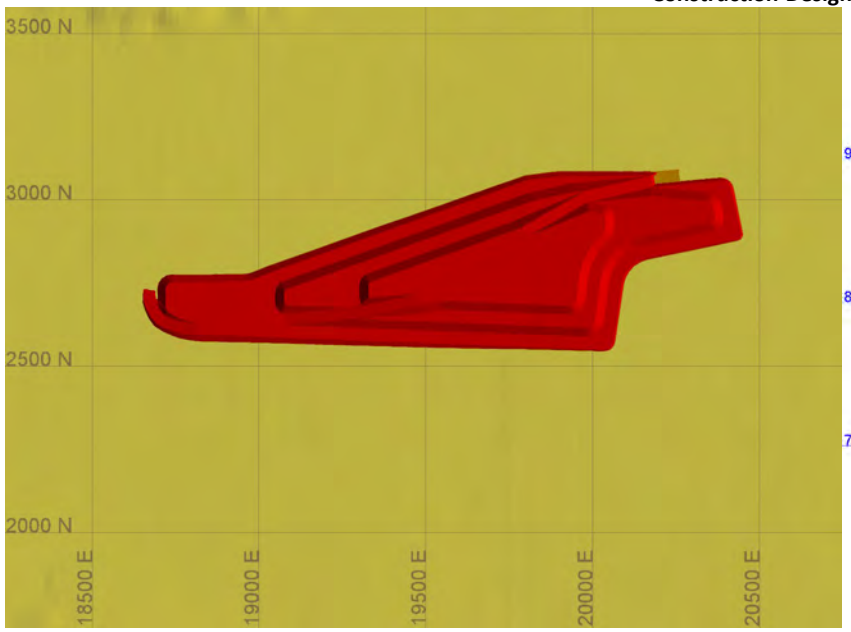
	Construction Specifications	Rehabilitation Specifications
Slope angle (deg)	37	20
Lift height (m)	20	20
Berm width (m)	38	20
Berm slope (deg)	0	0
Footprint (ha)	179.8	195.4

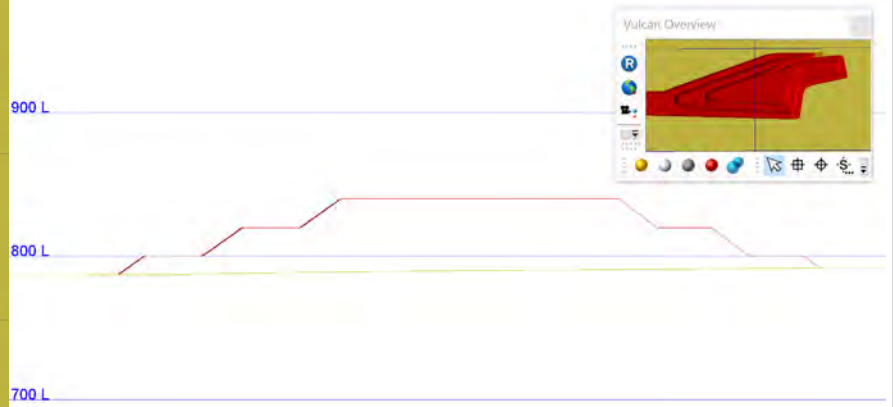
Comments: Will be capped with hydrated waste to enable less conservative parameters

Deposit F LG Stockpile

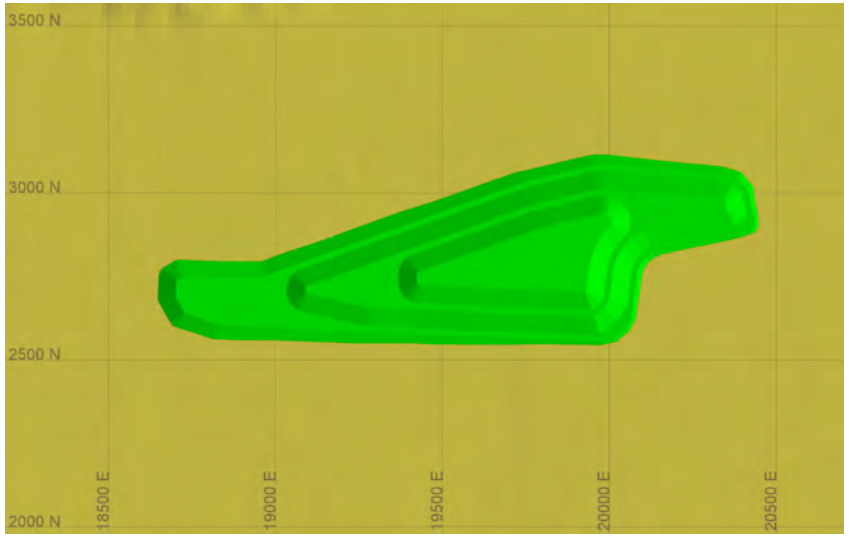
Waste volume	15.4 Mm3	
Erodibility ranking	Low/Medium or High	
	Low	85%
	Medium	0%
	High	15%
Classification	Inert ☒	Capping required at closure:
	PAF ☐	0.7
	Fibrous minerals ☐	Mm^3
	WFSF ☐	-
Overall height (m)	80 m	
Topsoil required (Mm^3)	0.134 Mm^3	

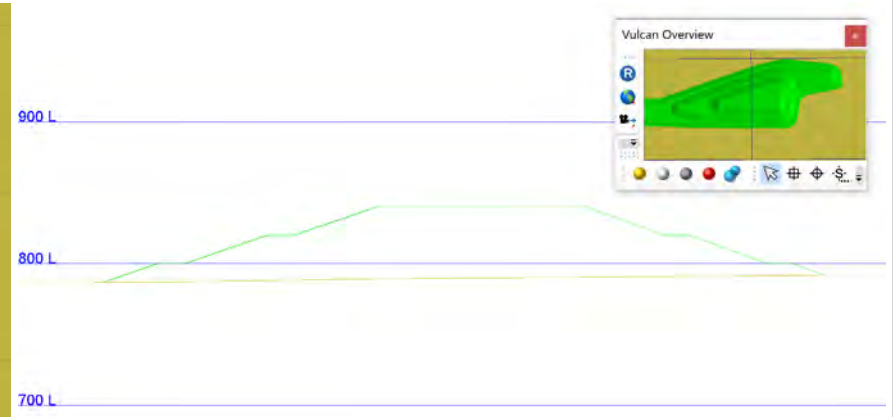
Construction Design





Rehabilitation Design





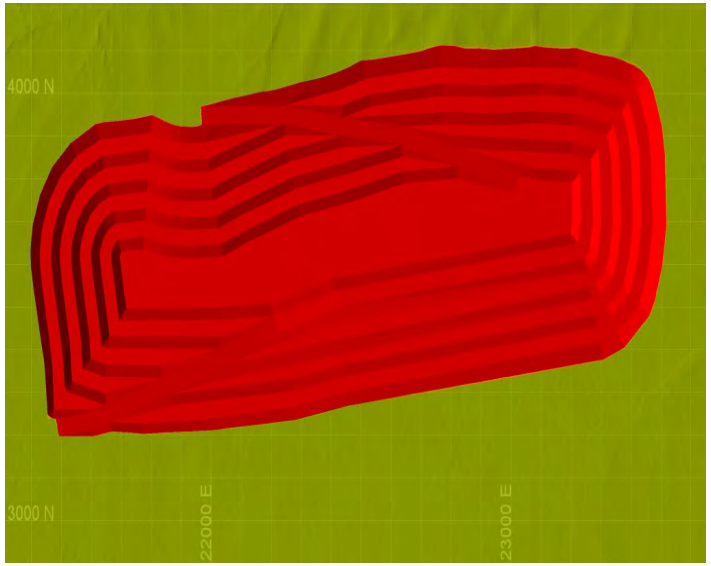
	Construction Specifications	Rehabilitation Specifications
Slope angle (deg)	37	20
Lift height (m)	20	20
Berm width (m)	38	18
Berm slope (deg)	0	0
Footprint (ha)	60.0	64.4

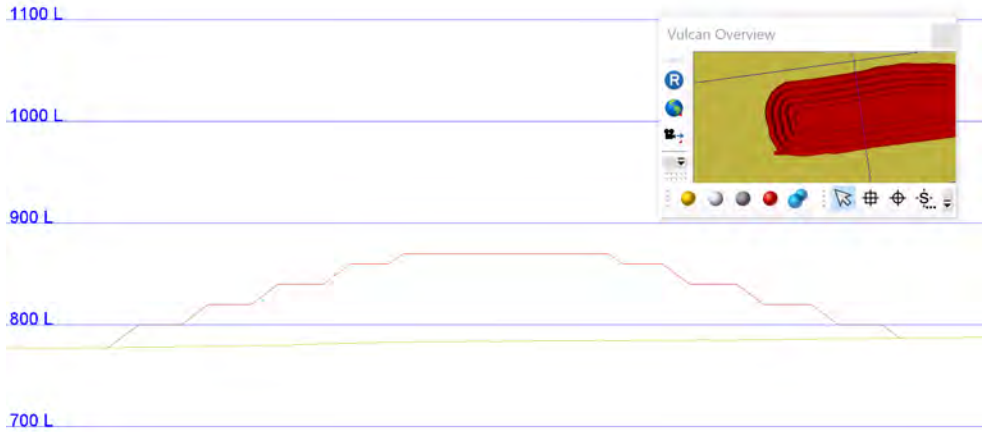
Comments:
Material from this stockpile has been used in the latest LOM to feed the crusher.

Deposit F East WD

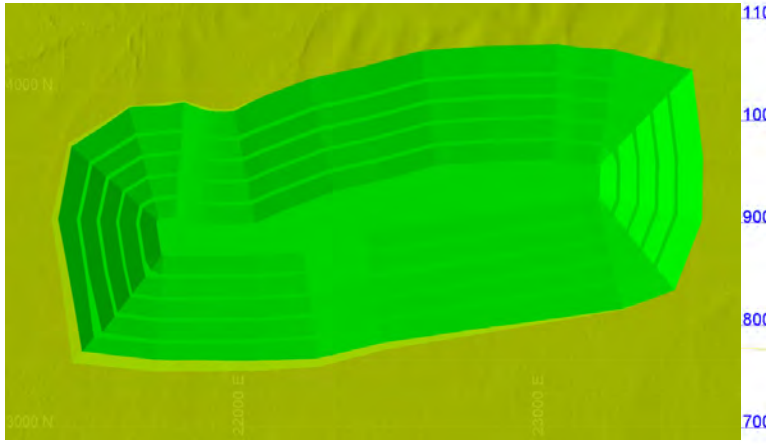
Waste volume	92.2 Mm3	
Erodibility ranking	Low/Medium or High	
	Low	28%
	Medium	0%
	High	72%
Classification	Inert ☒	Capping required at closure:
	PAF ☐	1.7
	Fibrous minerals ☐	Mm^3
	WFSF ☐	-
Overall height (m)	80 m	
Topsoil required (Mm^3)	0.339 Mm^3	

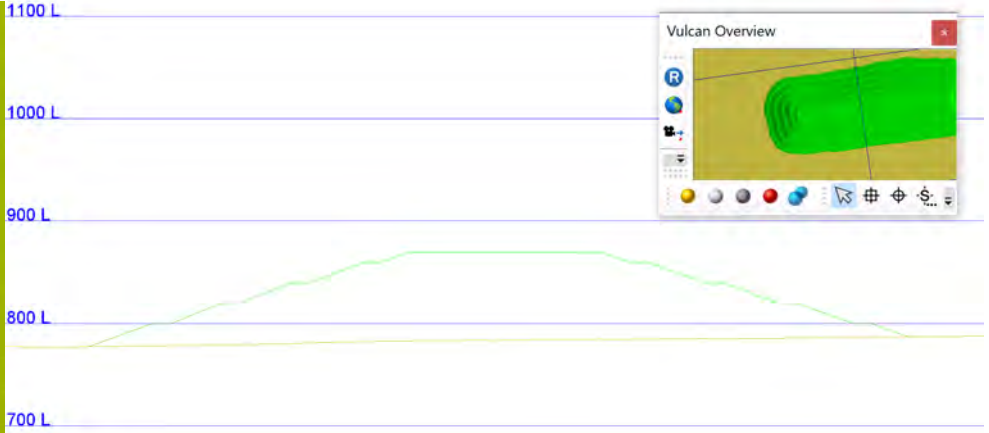
Construction Design





Rehabilitation Design





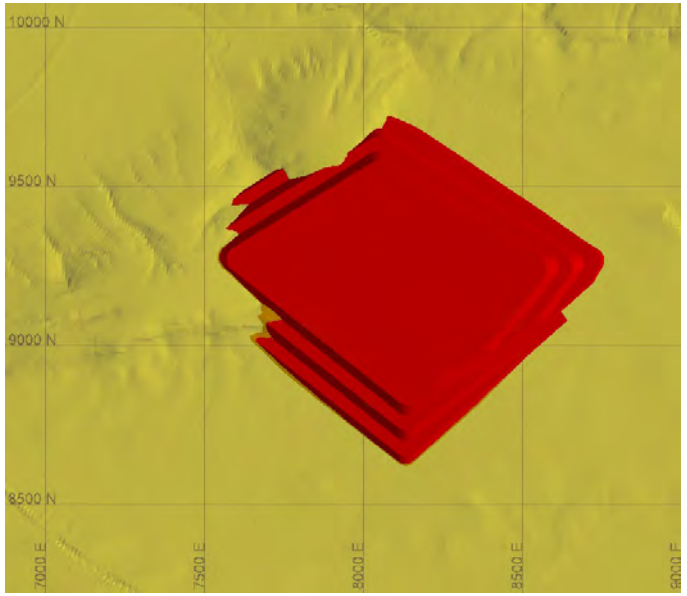
	Construction Specifications	Rehabilitation Specifications
Slope angle (deg)	37	20
Lift height (m)	20	20
Berm width (m)	38	18
Berm slope (deg)	0	0
Footprint (ha)	155.8	162.4

Comments: Will be capped with hydrated waste to enable less conservative parameters

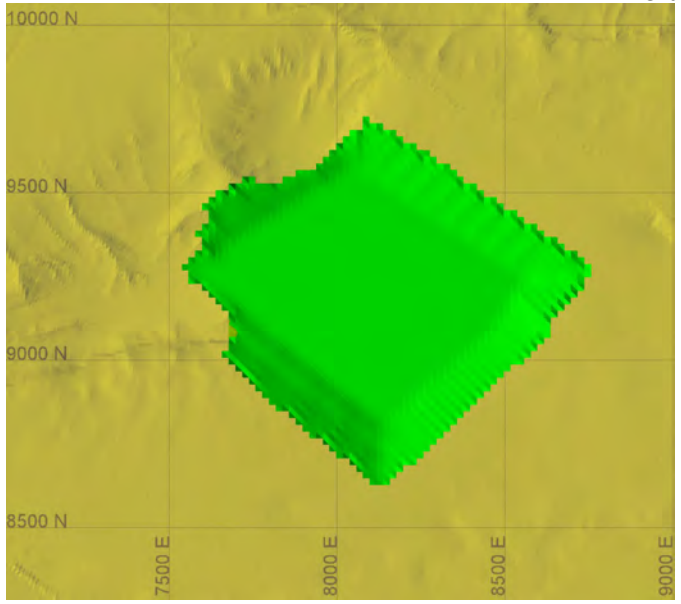
Deposit G South WD1

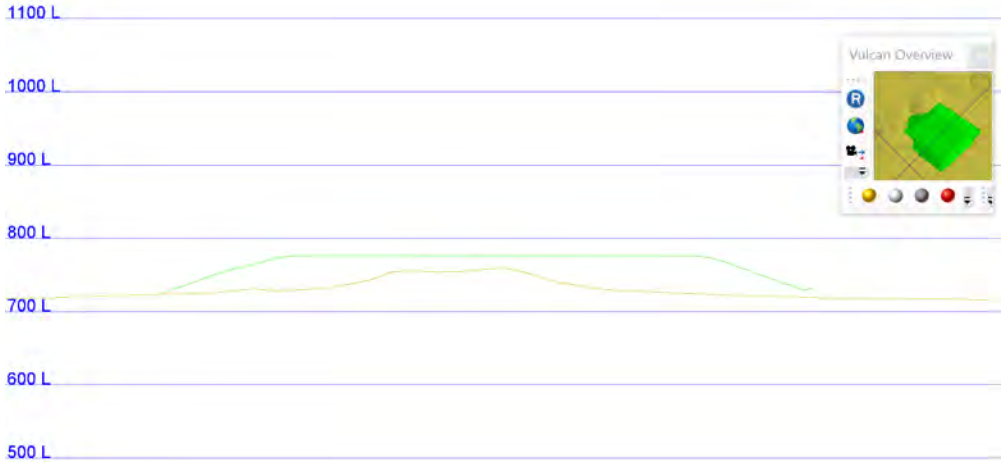
Waste volume	23.5 Mm3	
Erodibility ranking	Low/Medium or High	
	Low	16%
	Medium	0%
	High	84%
Classification	Inert ☒	Capping required at closure:
	PAF ☐	
	Fibrous minerals ☐	Mm^3
	WFSF ☐	-
Overall height (m)	60 m	
Topsoil required (Mm^3)	0.156 Mm^3	

Construction Design



Rehabilitation Design





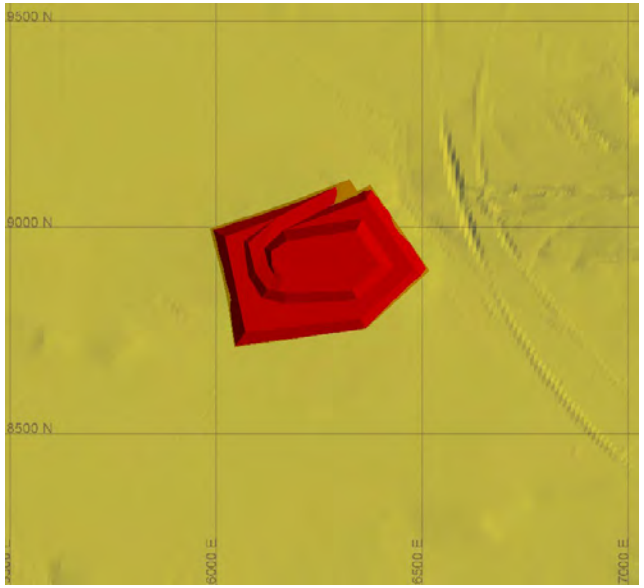
	Construction Specifications	Rehabilitation Specifications
Slope angle (deg)	37	20
Lift height (m)	20	5
Berm width (m)	40	10
Berm slope (deg)	0	3
Footprint (ha)	77.5	76.0

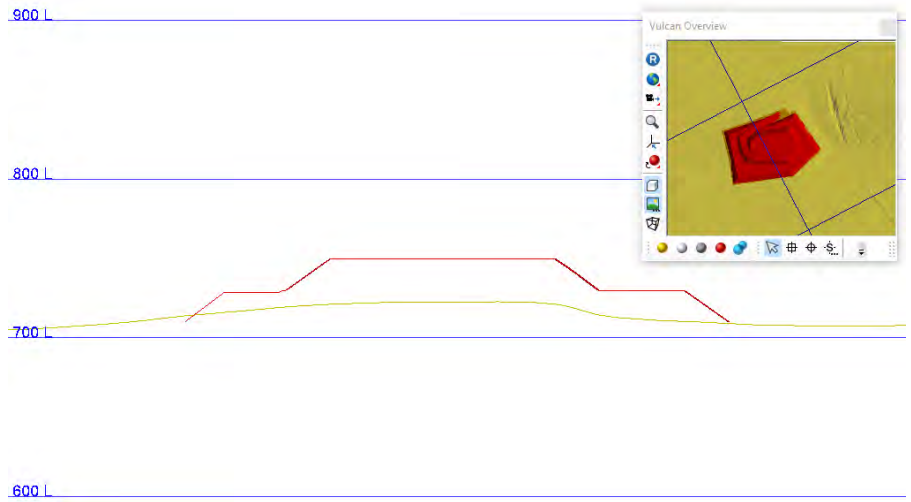
Comments:

Deposit G South WD2

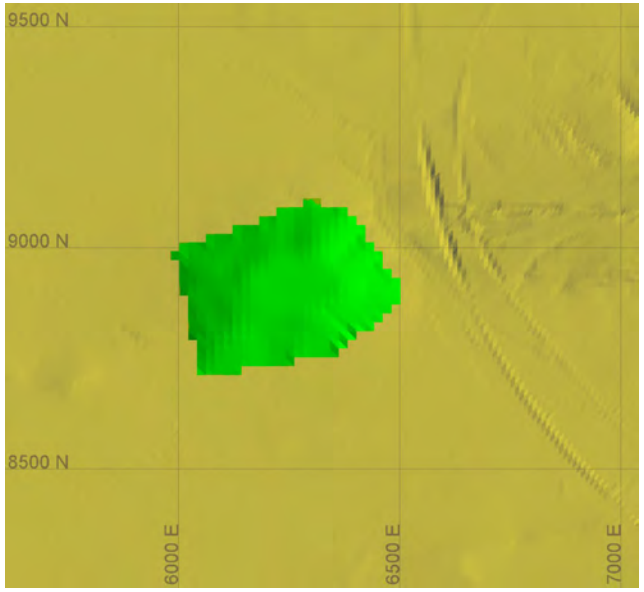
Waste volume	2.4 Mm3	
Erodibility ranking	Low/Medium or High	
	Low	16%
	Medium	0%
	High	84%
Classification	Inert ☒	Capping required at closure:
	PAF ☐	
	Fibrous minerals ☐	Mm^3
	WFSF ☐	-
Overall height (m)	40 m	
Topsoil required (Mm^3)	0.030 Mm^3	

Construction Design





Rehabilitation Design



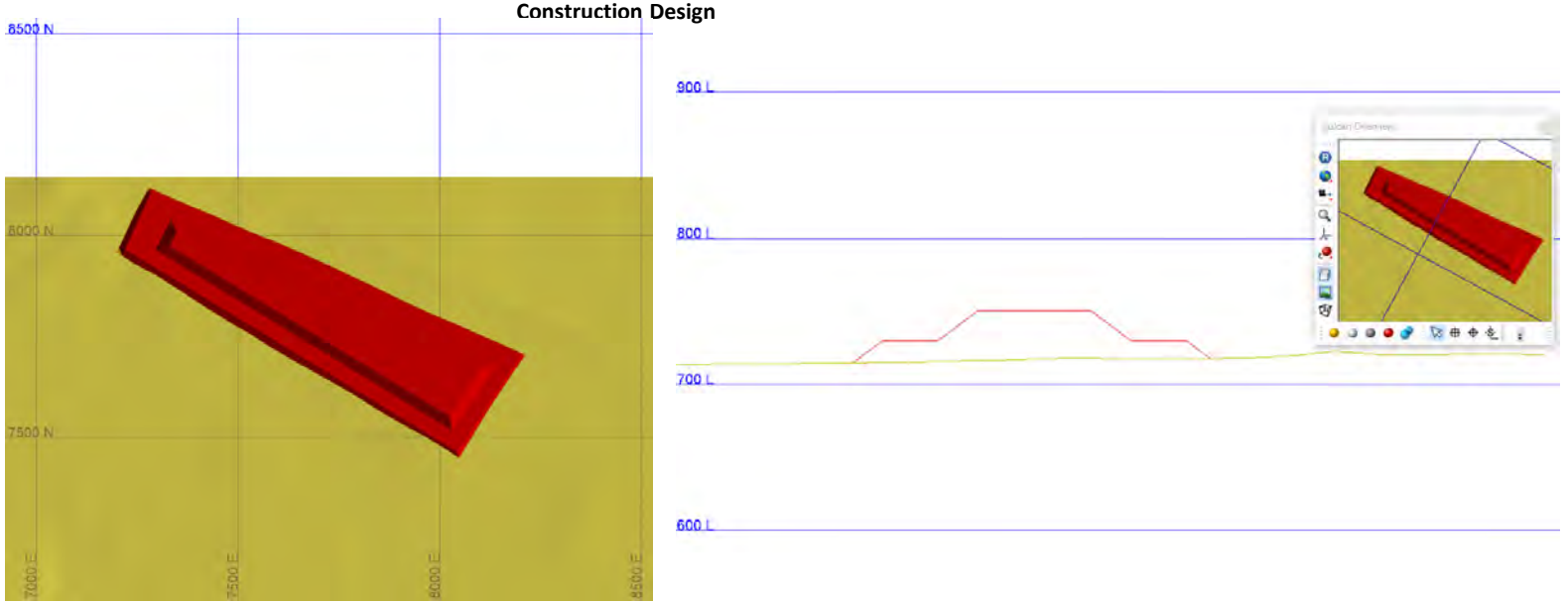
	Construction Specifications	Rehabilitation Specifications
Slope angle (deg)	37	20
Lift height (m)	20	5
Berm width (m)	40	10
Berm slope (deg)	0	3
Footprint (ha)	14.4	14.2

Comments:

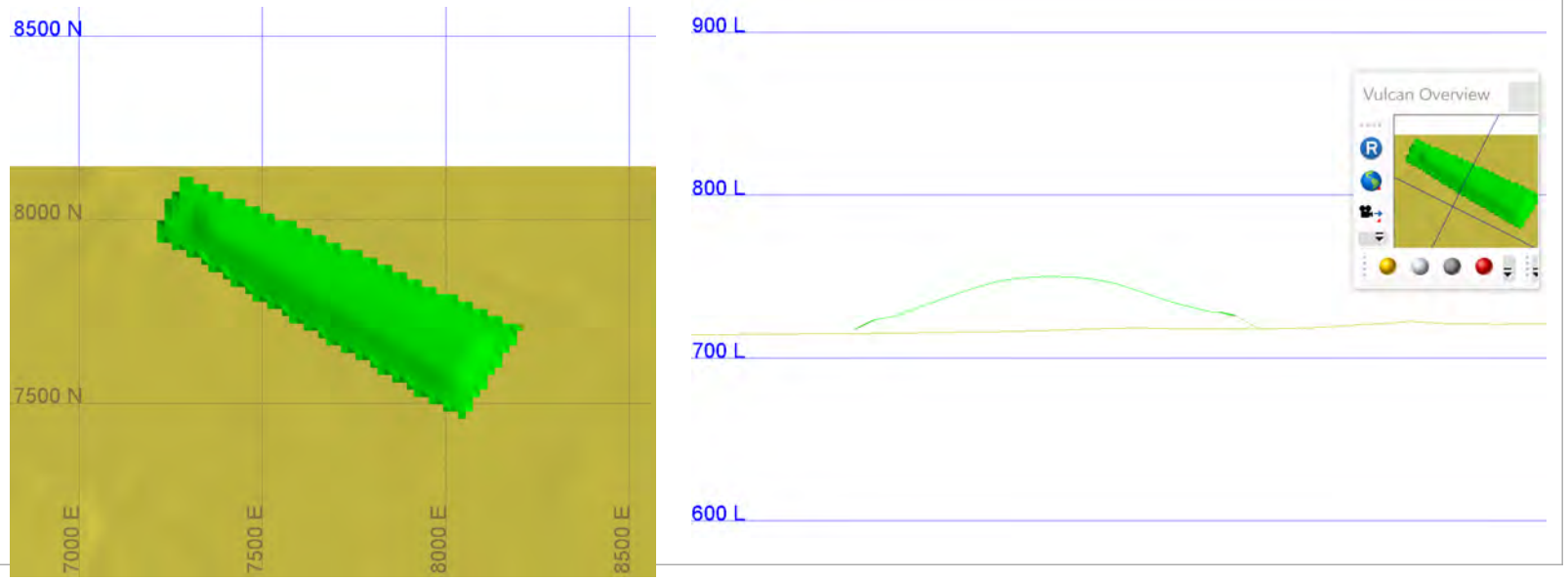
Deposit G South WD3

Waste volume	4.3 Mm3	
Erodibility ranking	Low/Medium or High	
	Low	16%
	Medium	0%
	High	84%
Classification	Inert ☒	Capping required at closure:
	PAF ☐	
	Fibrous minerals ☐	Mm^3
	WFSF ☐	-
Overall height (m)	30 m	
Topsoil required (Mm^3)	0.050 Mm^3	

Construction Design



Rehabilitation Design

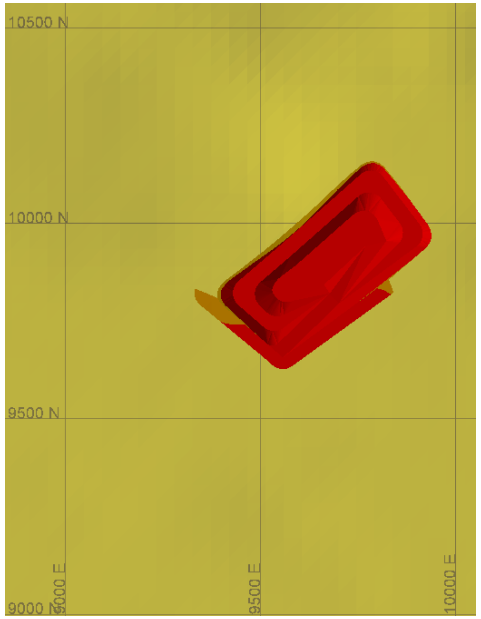


	Construction Specifications	Rehabilitation Specifications
Slope angle (deg)	37	20
Lift height (m)	20	5
Berm width (m)	40	10
Berm slope (deg)	0	3
Footprint (ha)	24.7	24.2

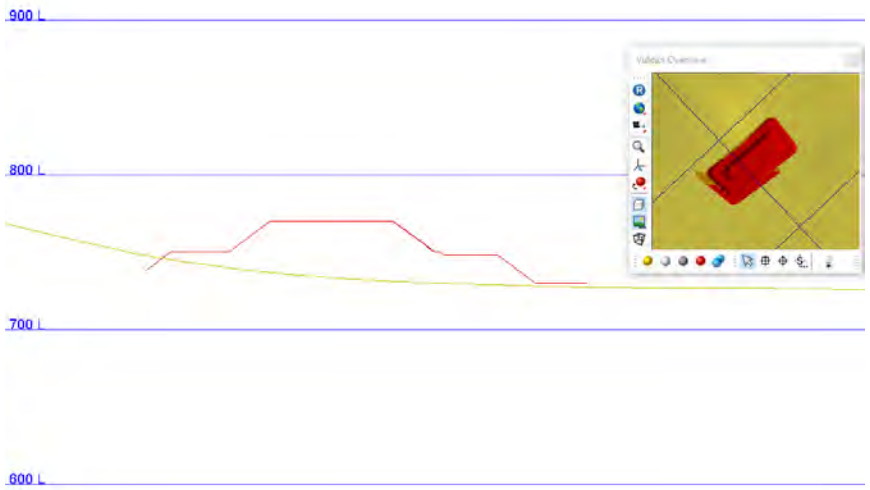
Comments:

Deposit G South LG Stockpile

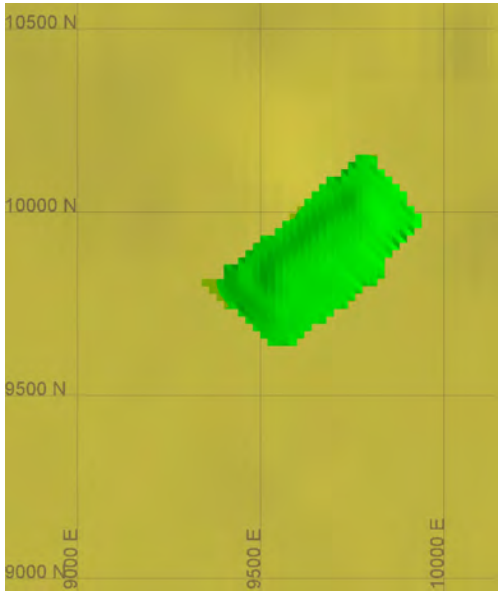
Waste volume	2.6 Mm3	
Erodibility ranking	Low/Medium or High	
	Low	68%
	Medium	0%
	High	32%
Classification	Inert ☒	Capping required at closure:
	PAF ☐	
	Fibrous minerals ☐	Mm^3
	WFSF ☐	-
Overall height (m)	40 m	
Topsoil required (Mm^3)	0.031 Mm^3	



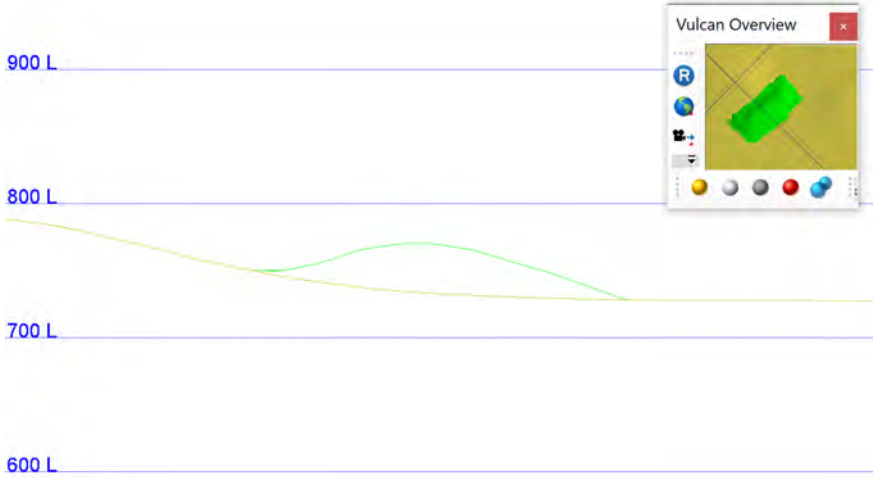
Construction Design



	Construction Specifications	Rehabilitation Specifications
Slope angle (deg)	37	20
Lift height (m)	20	5
Berm width (m)	40	10
Berm slope (deg)	0	3
Footprint (ha)	15.6	15.2



Rehabilitation Design

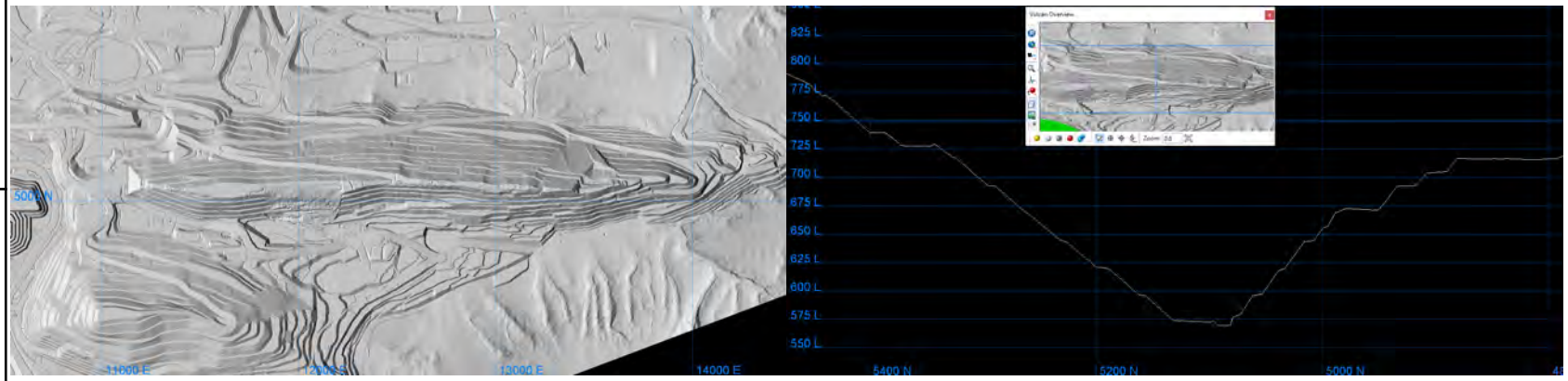


Comments:

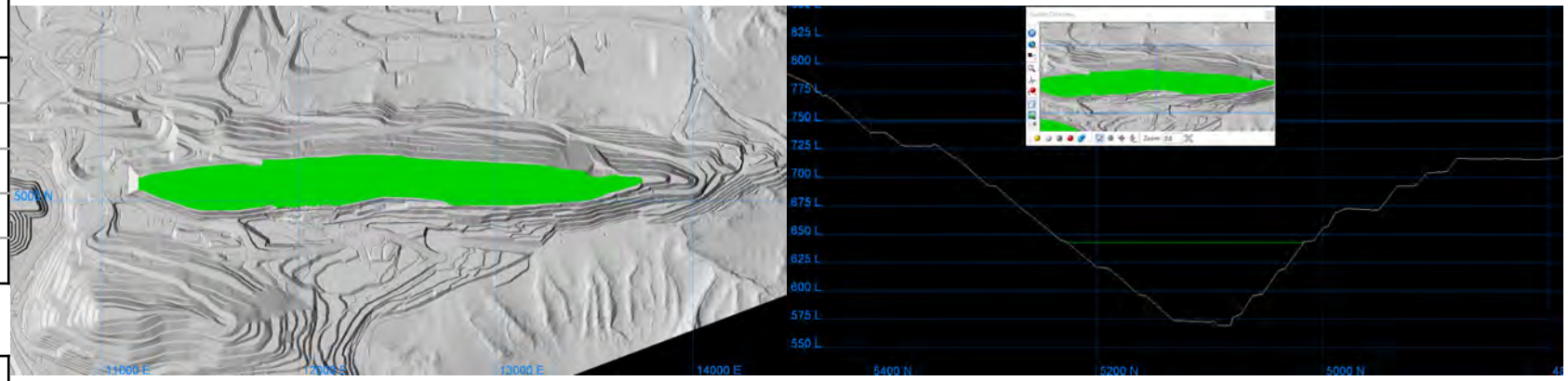
Deposit A CEPN Pit

Waste volume	19.3 Mm3	
Erodibility ranking	Low/Medium or High Low Medium High	
Classification	Inert ☒ PAF ☐ Fibrous minerals ☐ WFSF ☐	Capping required at closure: Mm^3 -
Overall height (m)	83 m	
Topsoil required (Mm^3)		

Construction Design



Rehabilitation Design



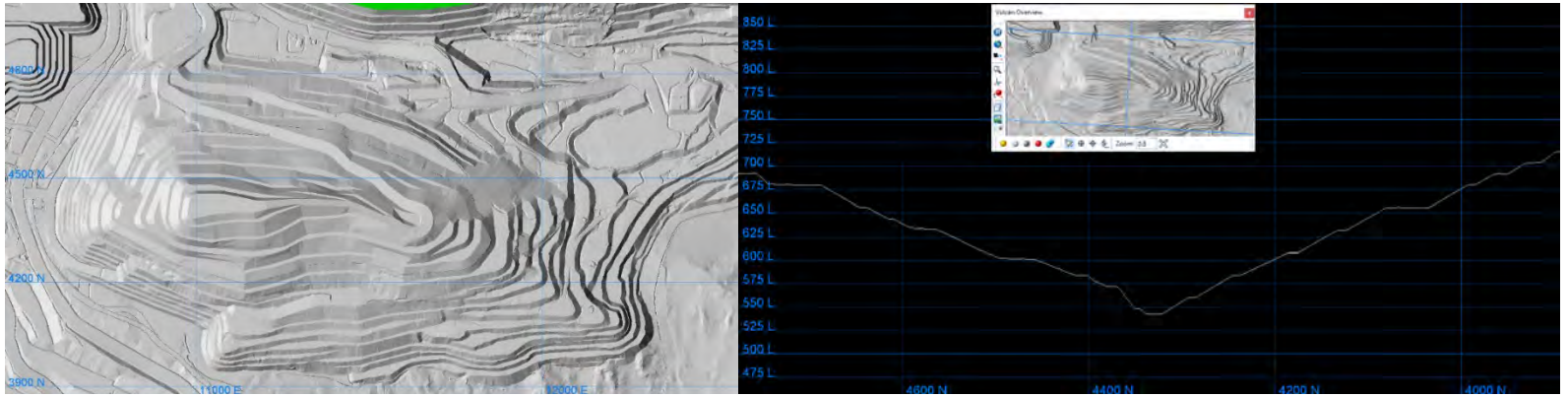
	Construction Specifications	Rehabilitation Specifications
Slope angle (deg)		
Lift height (m)		
Berm width (m)		
Berm slope (deg)		
Footprint (ha)		

Comments:

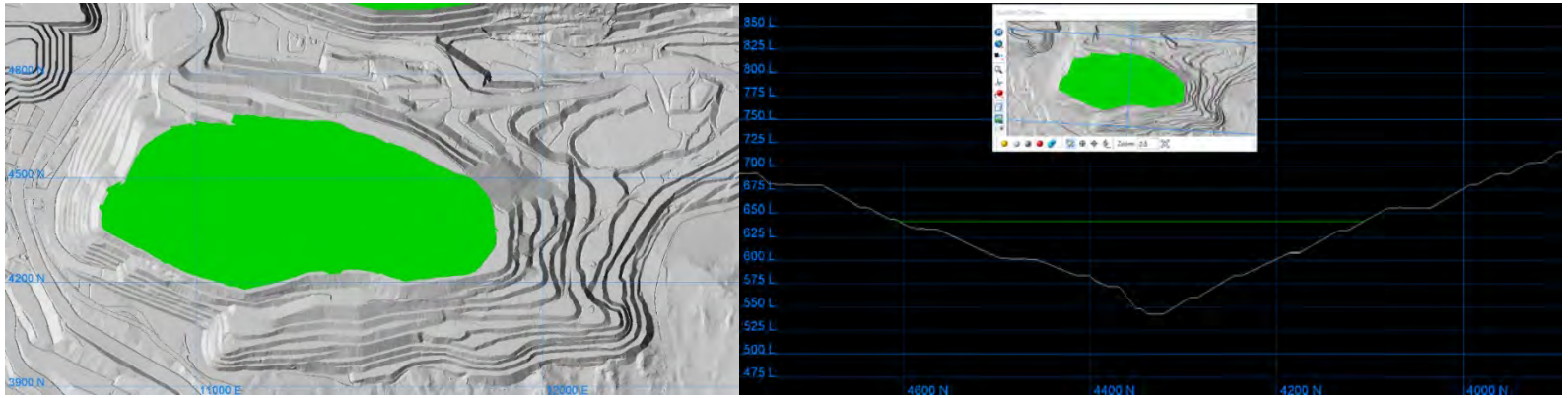
Deposit A CEPS Pit

Waste volume	17.9 Mm3	
Erodibility ranking	Low/Medium or High Low Medium High	
Classification	Inert ☒ PAF ☐ Fibrous minerals ☐ WFSF ☐	Capping required at closure: Mm^3 -
Overall height (m)	118 m	
Topsoil required (Mm^3)		

Construction Design



Rehabilitation Design



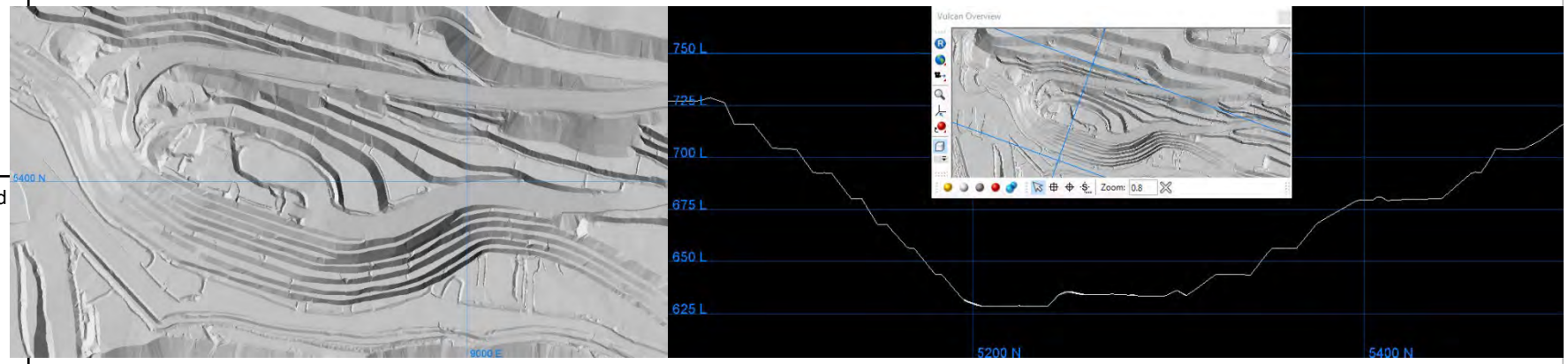
	Construction Specifications	Rehabilitation Specifications
Slope angle (deg)		
Lift height (m)		
Berm width (m)		
Berm slope (deg)		
Footprint (ha)		

Comments:

Deposit A WEPS Pit

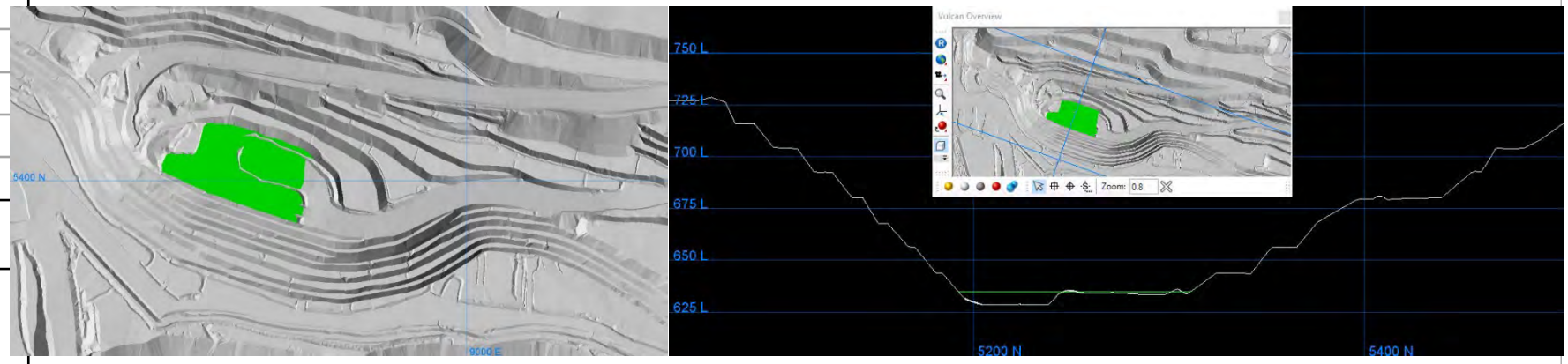
Waste volume	0.1 Mm3	
Erodibility ranking	Low/Medium or High	
	Low	
	Medium	
	High	
Classification	Inert ☒	Capping required at closure:
	PAF ☐	
	Fibrous minerals ☐	Mm^3
	WFSF ☐	-
Overall height (m)	7 m	
Topsoil required (Mm^3)		

Construction Design



Rehabilitation Design

	Construction Specifications	Rehabilitation Specifications
Slope angle (deg)		
Lift height (m)		
Berm width (m)		
Berm slope (deg)		
Footprint (ha)		

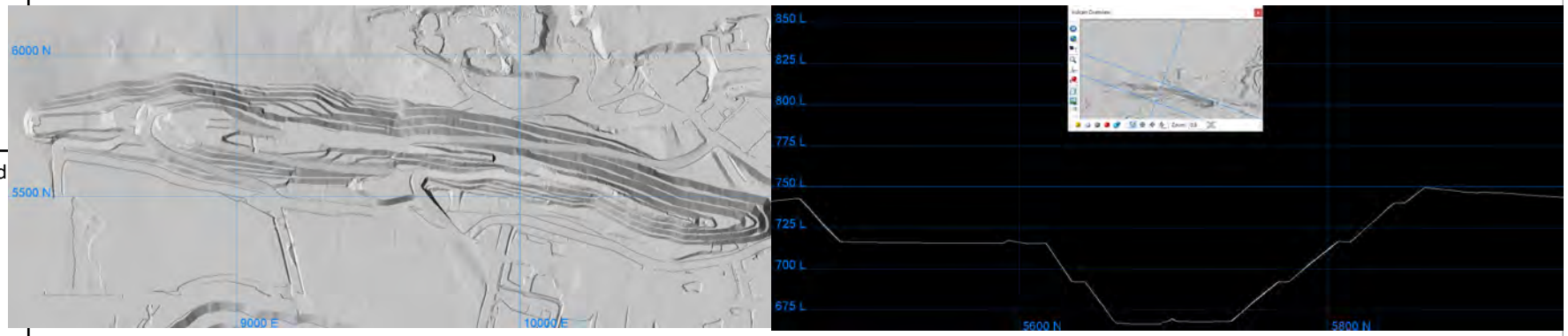


Comments:

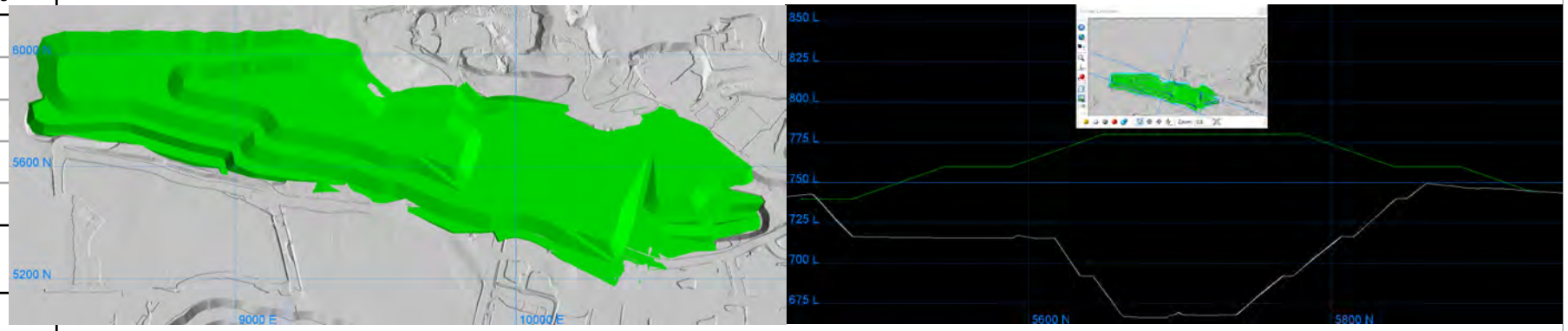
Deposit A WEPN Pit (backfilled)

Waste volume	49.6 Mm3	
Erodibility ranking	Low/Medium or High	
	Low	
	Medium	
	High	
Classification	Inert ☒	Capping required at closure:
	PAF ☐	
	Fibrous minerals ☐	Mm^3
	WFSF ☐	-
Overall height (m)	40m above pre mining topography	
Topsoil required (Mm^3)		

Construction Design



Rehabilitation Design



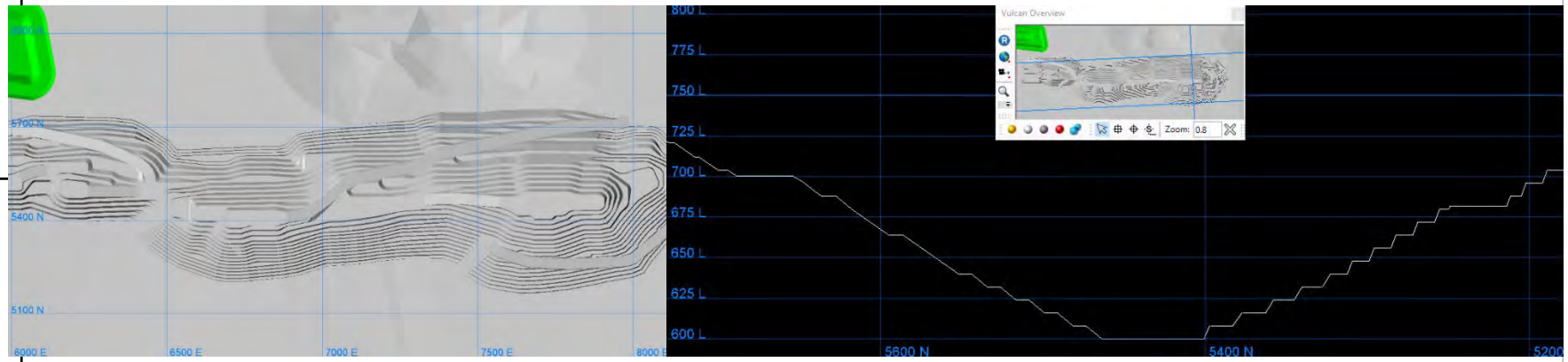
	Construction Specifications	Rehabilitation Specifications
Slope angle (deg)		
Lift height (m)		
Berm width (m)		
Berm slope (deg)		
Footprint (ha)		

Comments:

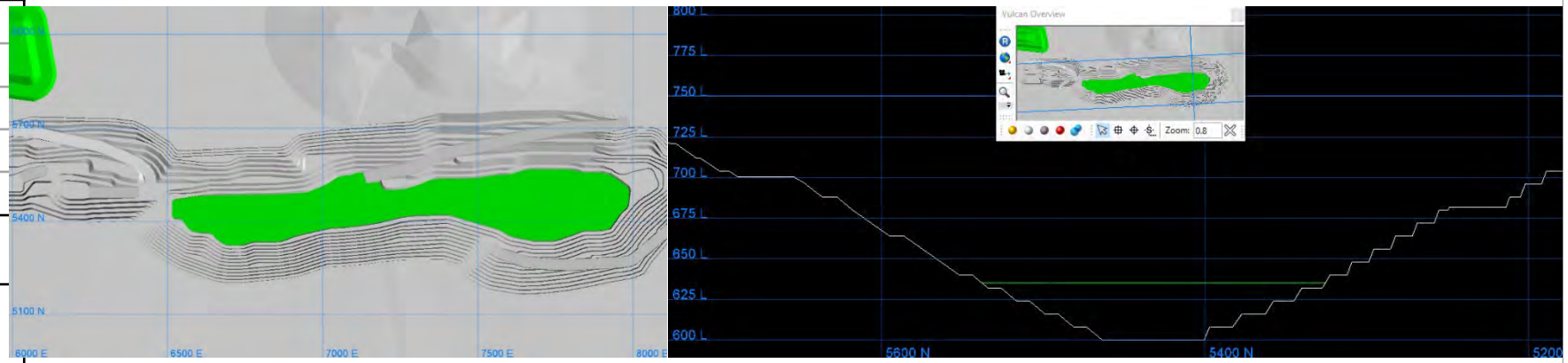
Deposit A West AW1 Pit

Waste volume	2.2 Mm3	
Erodibility ranking	Low/Medium or High Low Medium High	
Classification	Inert ☒ PAF ☐ Fibrous minerals ☐ WFSF ☐	Capping required at closure: Mm^3 -
Overall height (m)	29 m	
Topsoil required (Mm^3)		

Construction Design



Rehabilitation Design



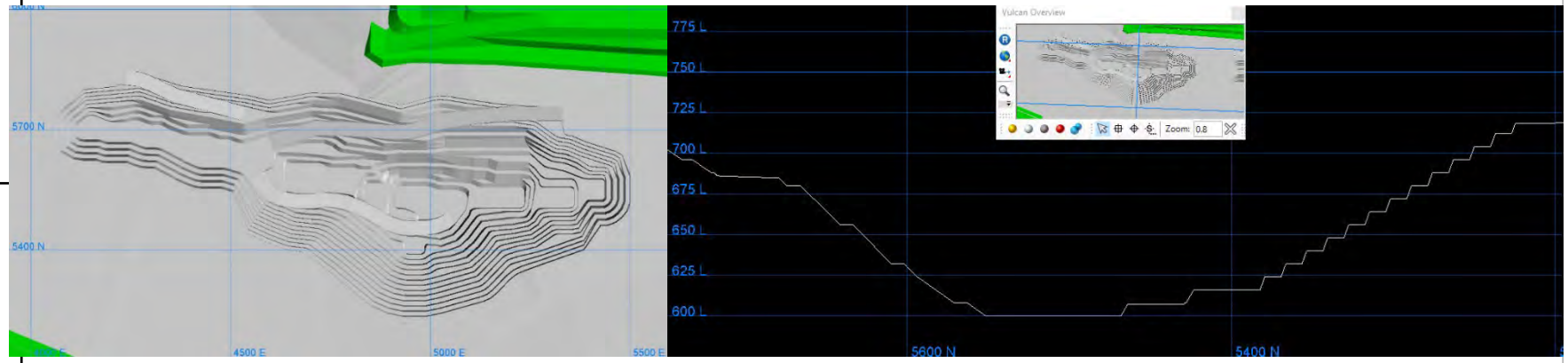
	Construction Specifications	Rehabilitation Specifications
Slope angle (deg)		
Lift height (m)		
Berm width (m)		
Berm slope (deg)		
Footprint (ha)		

Comments:

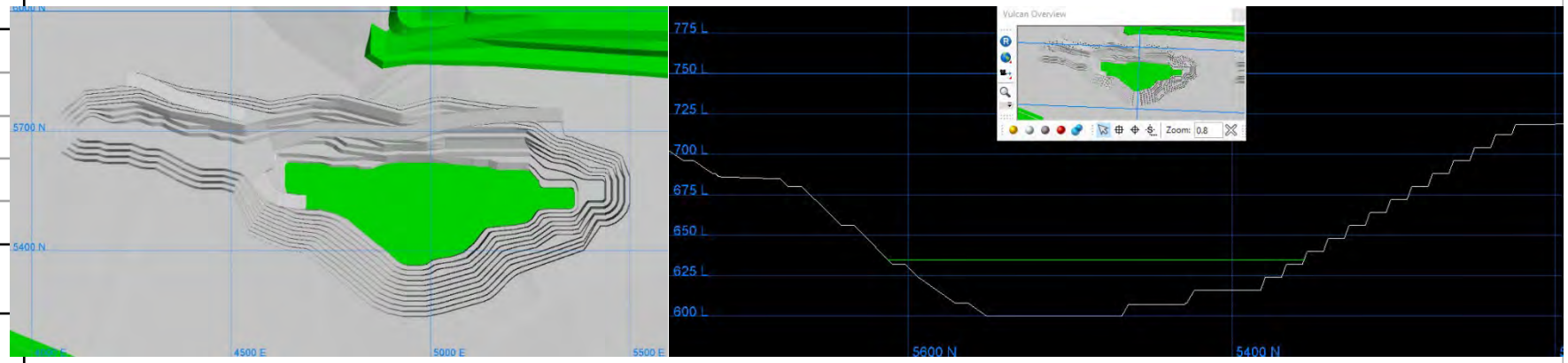
Deposit A West AW2 Pit

Waste volume	1.2 Mm3	
Erodibility ranking	Low/Medium or High Low Medium High	
Classification	Inert ☒ PAF ☐ Fibrous minerals ☐ WFSF ☐	Capping required at closure: Mm^3 -
Overall height (m)	29 m	
Topsoil required (Mm^3)		

Construction Design



Rehabilitation Design



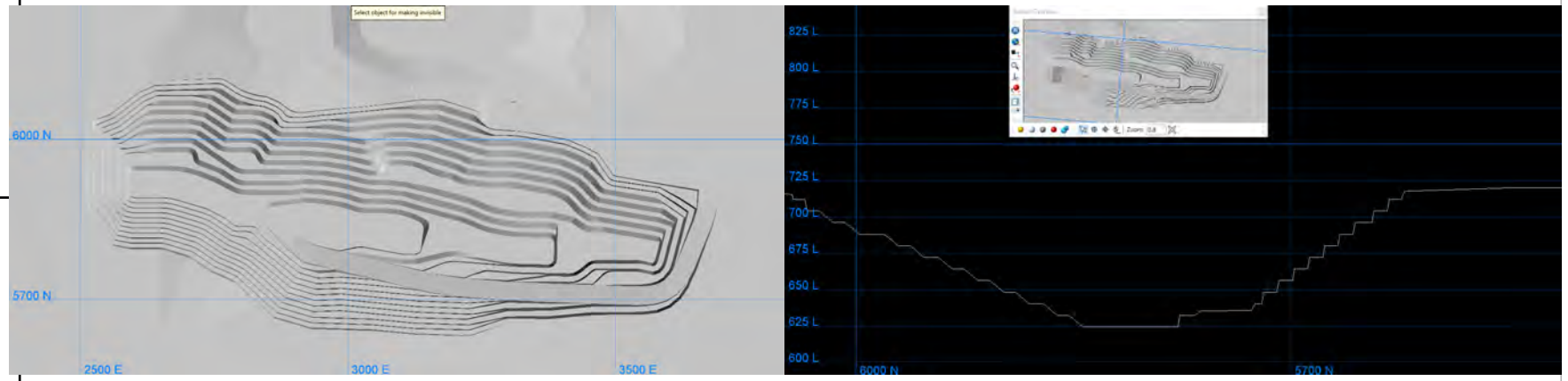
	Construction Specifications	Rehabilitation Specifications
Slope angle (deg)		
Lift height (m)		
Berm width (m)		
Berm slope (deg)		
Footprint (ha)		

Comments:

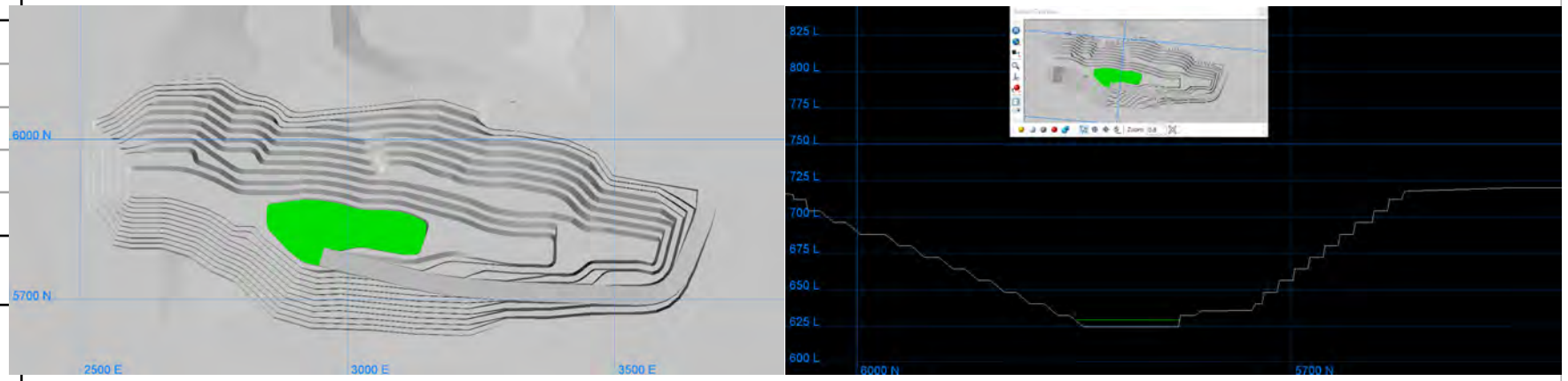
Deposit A West AW3 Pit

Waste volume	0.1 Mm3	
Erodibility ranking	Low/Medium or High Low Medium High	
Classification	Inert ☒ PAF ☐ Fibrous minerals ☐ WFSF ☐	Capping required at closure: Mm^3 -
Overall height (m)	5 m	
Topsoil required (Mm^3)		

Construction Design



Rehabilitation Design



	Construction Specifications	Rehabilitation Specifications
Slope angle (deg)		
Lift height (m)		
Berm width (m)		
Berm slope (deg)		
Footprint (ha)		

Comments:

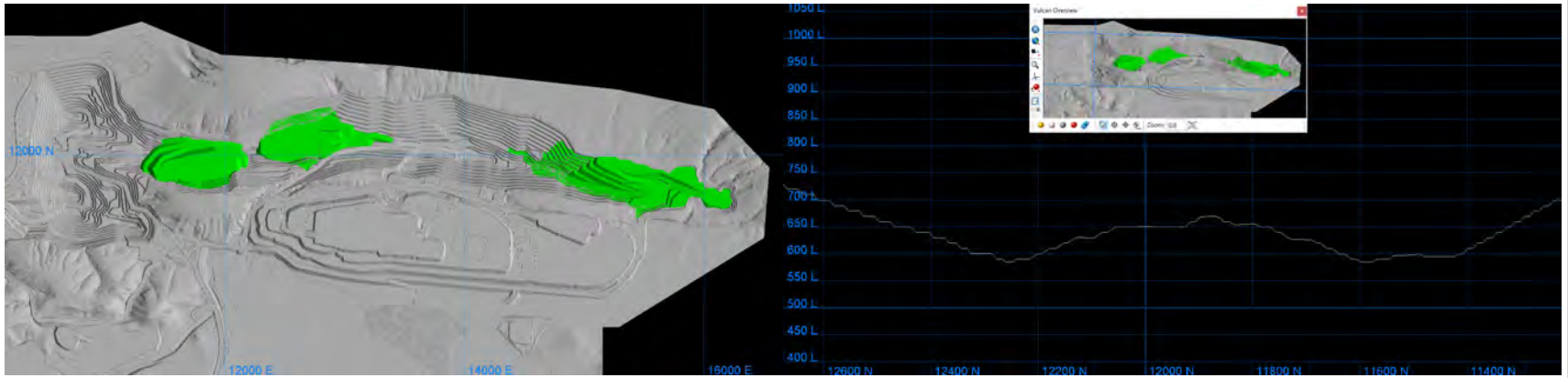
Deposit B DBC4, DBC5 Pits

Waste volume	4.0 Mm3	
Erodibility ranking	Low/Medium or High Low Medium High	
Classification	Inert ☒ PAF ☐ Fibrous minerals ☐ WFSF ☐	Capping required at closure: Mm^3 -
Overall height (m)	52 m	
Topsoil required (Mm^3)		

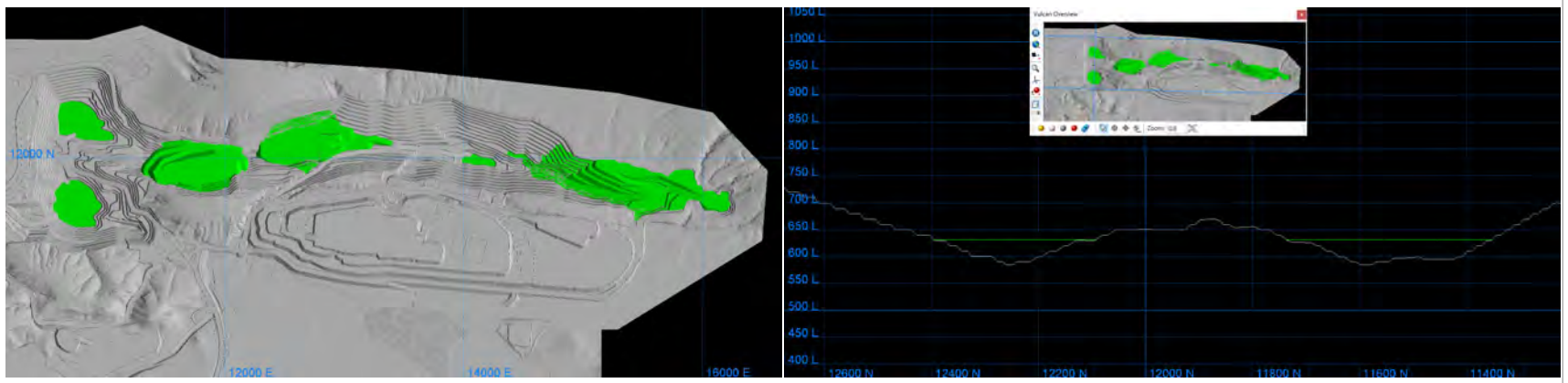
	Construction Specifications	Rehabilitation Specifications
Slope angle (deg)		
Lift height (m)		
Berm width (m)		
Berm slope (deg)		
Footprint (ha)		

Comments:

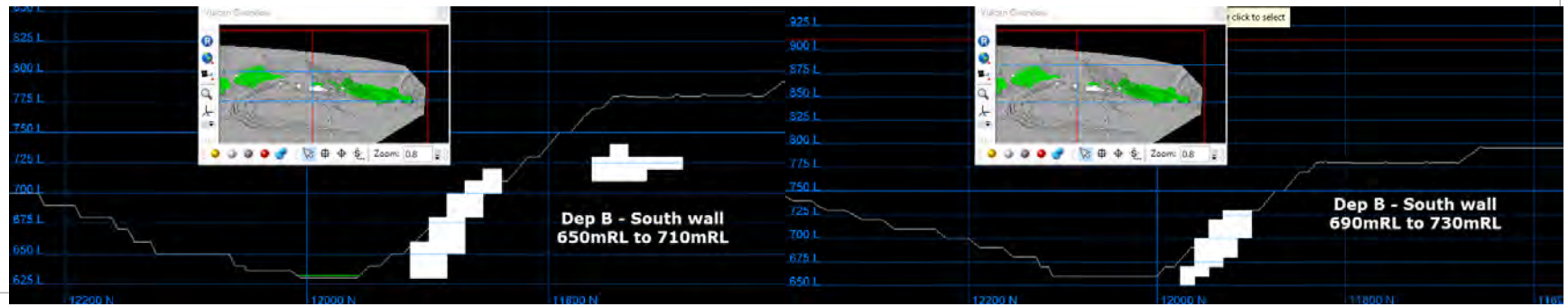
Construction Design



Rehabilitation Design



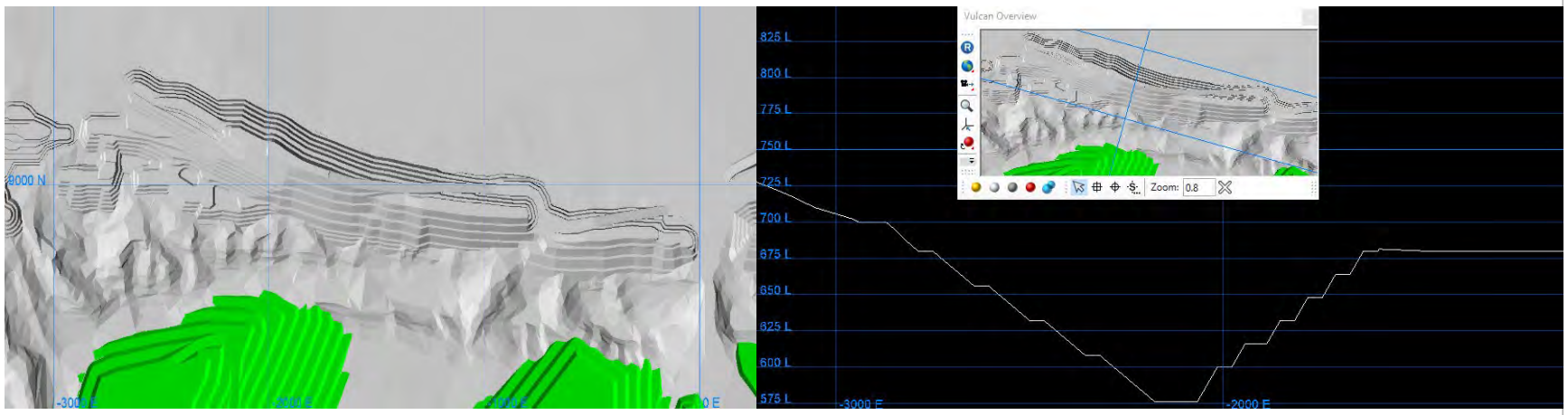
Fibrous exposure



Deposit C C2 Pit

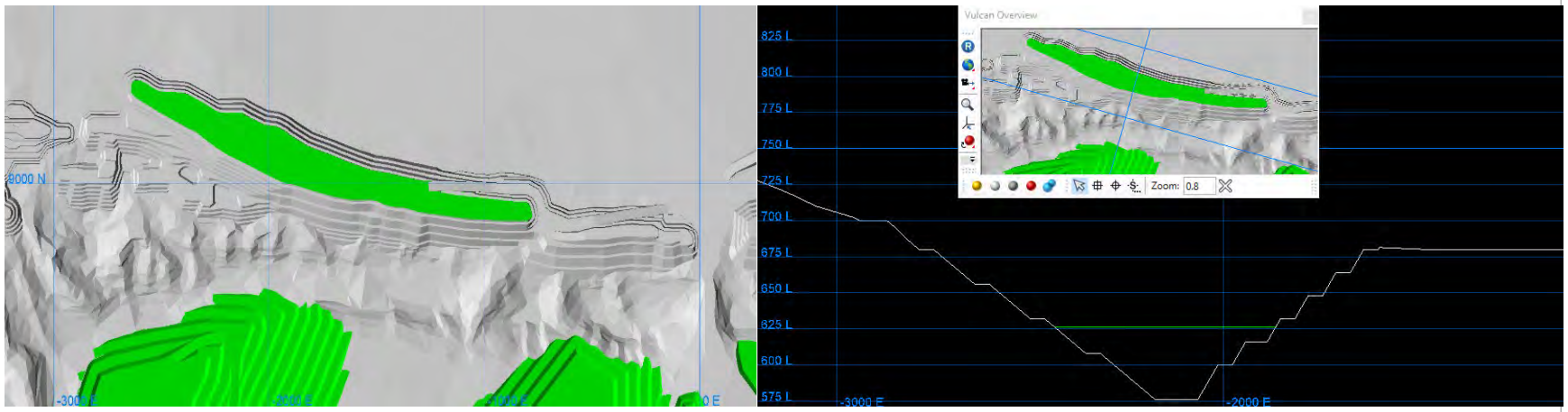
Waste volume	4.5 Mm3	
Erodibility ranking	Low/Medium or High Low Medium High	
Classification	Inert ☒ PAF ☐ Fibrous minerals ☐ WFSF ☐	Capping required at closure: Mm^3 -
Overall height (m)	50 m	
Topsoil required (Mm^3)		

Construction Design



	Construction Specifications	Rehabilitation Specifications
Slope angle (deg)		
Lift height (m)		
Berm width (m)		
Berm slope (deg)		
Footprint (ha)		

Rehabilitation Design

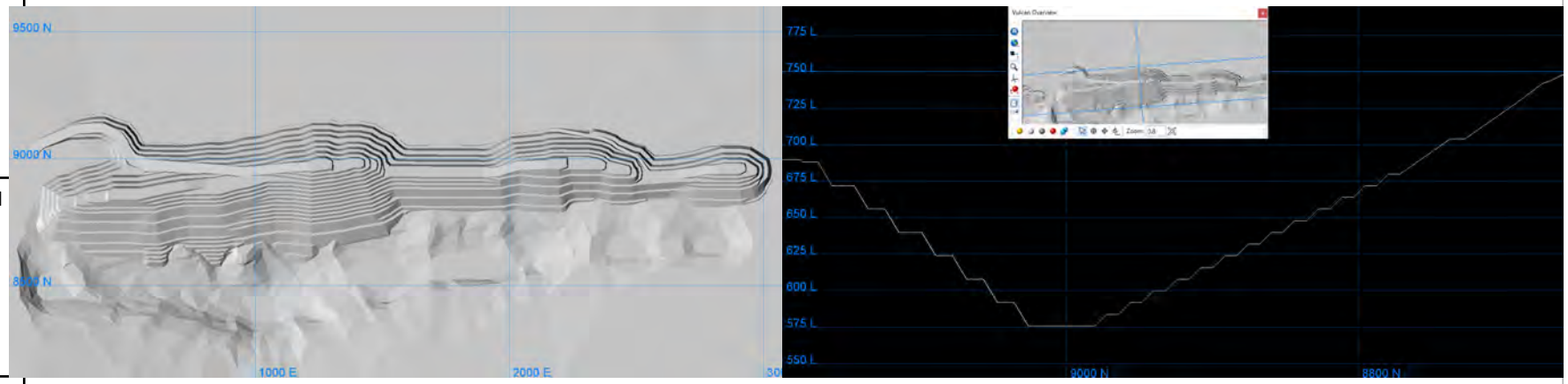


Comments:

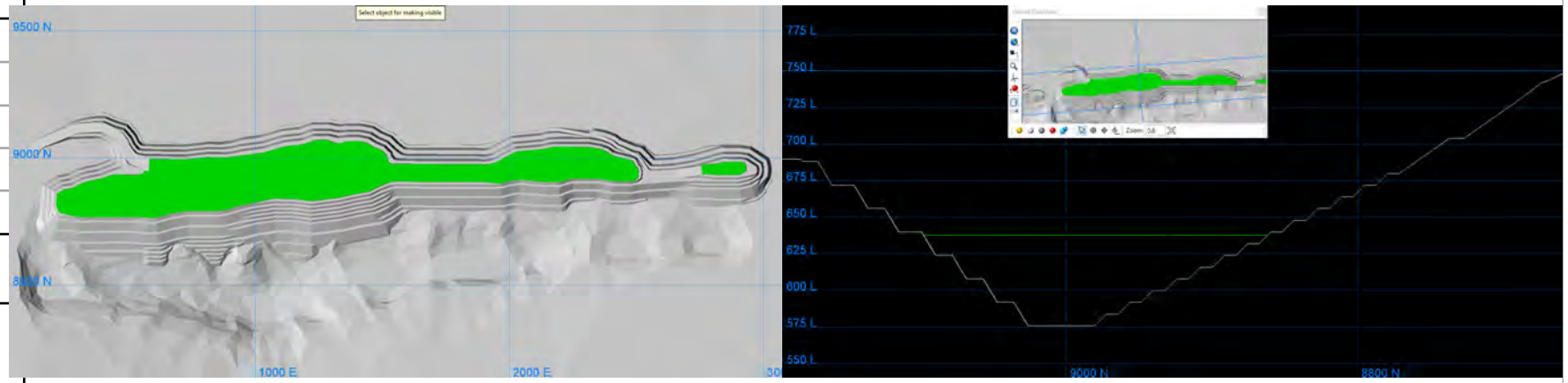
Deposit C C3 Pit

Waste volume	8.4 Mm3	
Erodibility ranking	Low/Medium or High	
	Low	
	Medium	
	High	
Classification	Inert ☒	Capping required at closure:
	PAF ☐	
	Fibrous minerals ☐	Mm^3
	WFSF ☐	-
Overall height (m)	62 m	
Topsoil required (Mm^3)		

Construction Design



Rehabilitation Design



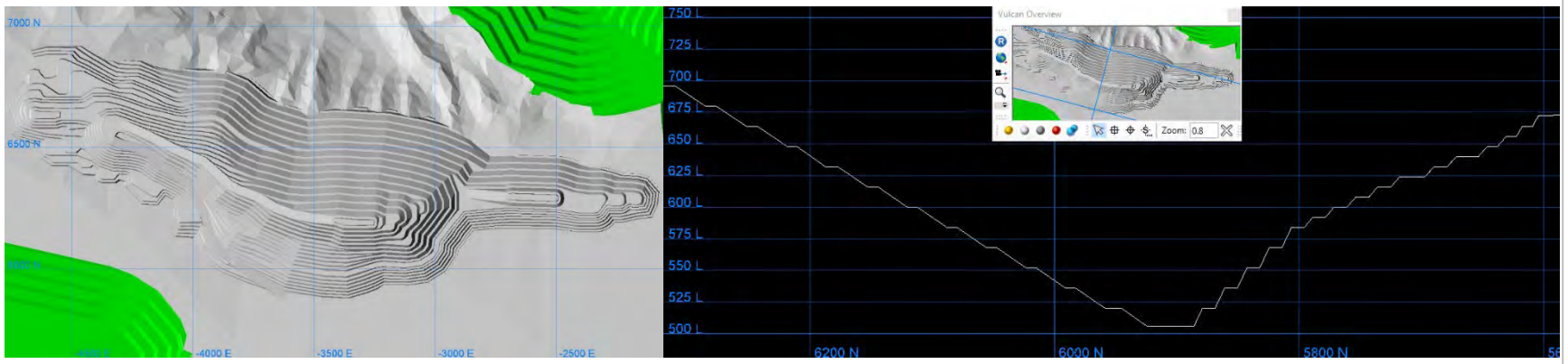
	Construction Specifications	Rehabilitation Specifications
Slope angle (deg)		
Lift height (m)		
Berm width (m)		
Berm slope (deg)		
Footprint (ha)		

Comments:

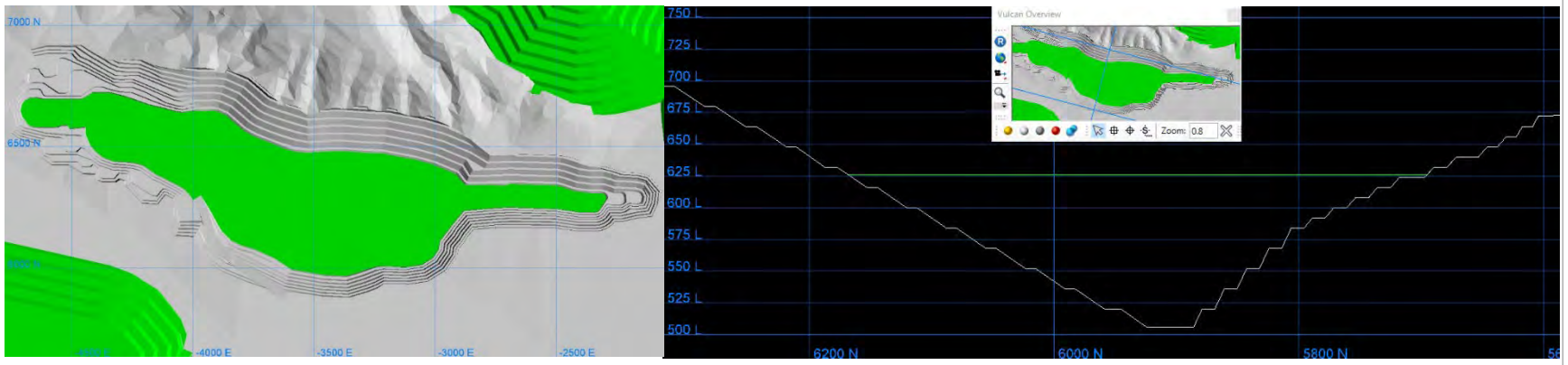
Deposit D D1 Pit

Waste volume	31.4 Mm3	
Erodibility ranking	Low/Medium or High Low Medium High	
Classification	Inert ☒ PAF ☐ Fibrous minerals ☐ WFSF ☐	Capping required at closure: Mm^3 -
Overall height (m)	146 m	
Topsoil required (Mm^3)		

Construction Design



Rehabilitation Design



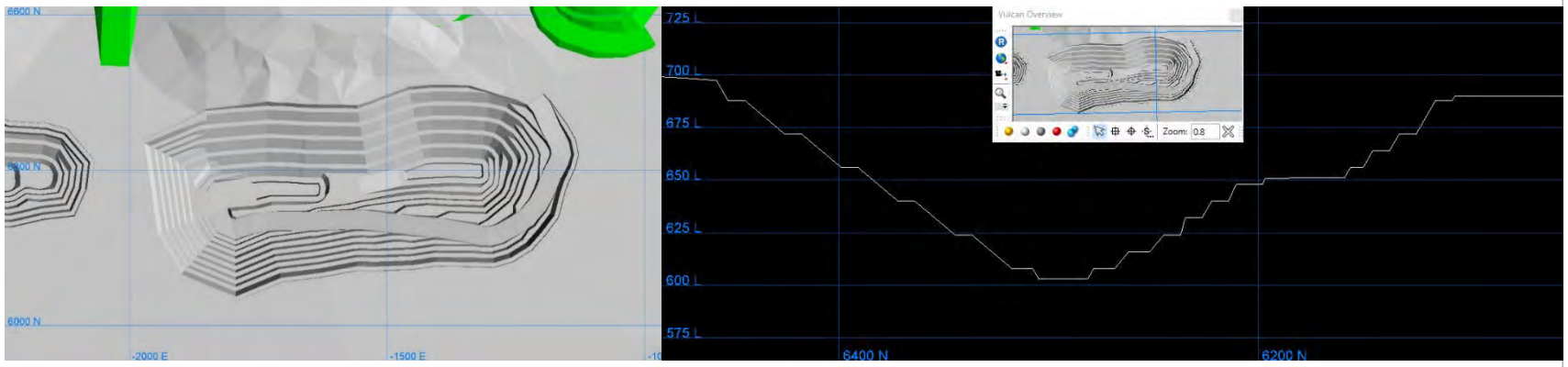
	Construction Specifications	Rehabilitation Specifications
Slope angle (deg)		
Lift height (m)		
Berm width (m)		
Berm slope (deg)		
Footprint (ha)		

Comments:

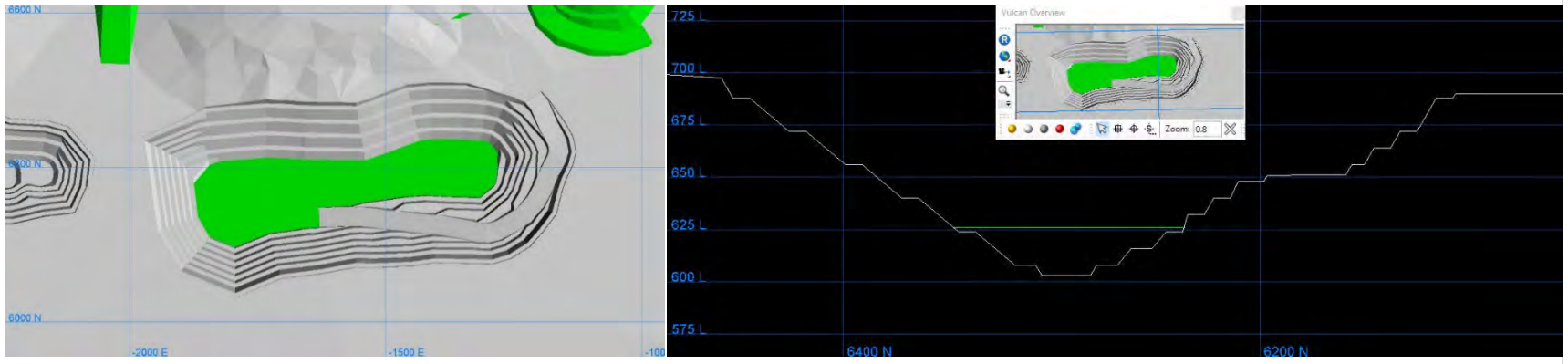
Deposit D D2 Pit

Waste volume	0.8 Mm3	
Erodibility ranking	Low/Medium or High Low Medium High	
Classification	Inert ☒ PAF ☐ Fibrous minerals ☐ WFSF ☐	Capping required at closure: Mm^3 -
Overall height (m)	26 m	
Topsoil required (Mm^3)		

Construction Design



Rehabilitation Design



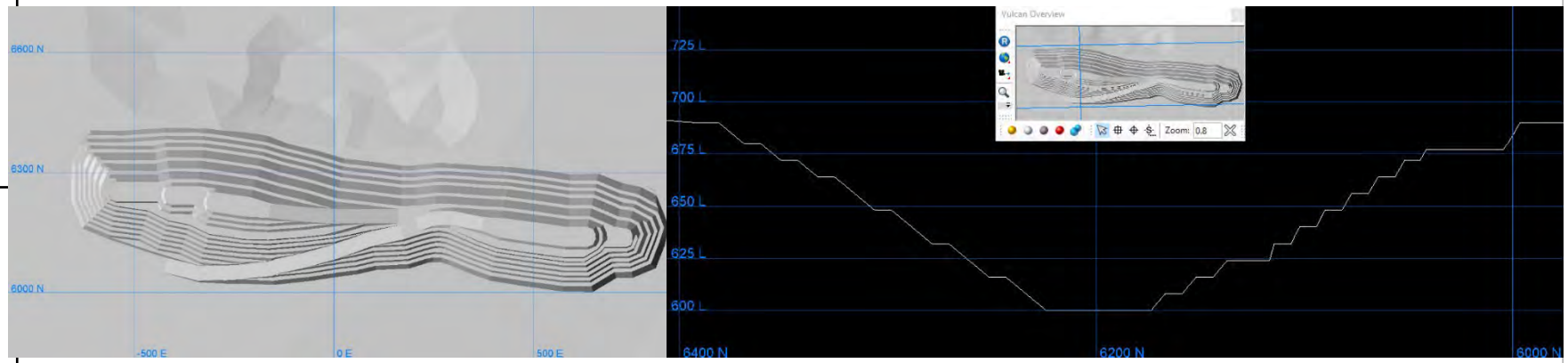
	Construction Specifications	Rehabilitation Specifications
Slope angle (deg)		
Lift height (m)		
Berm width (m)		
Berm slope (deg)		
Footprint (ha)		

Comments:

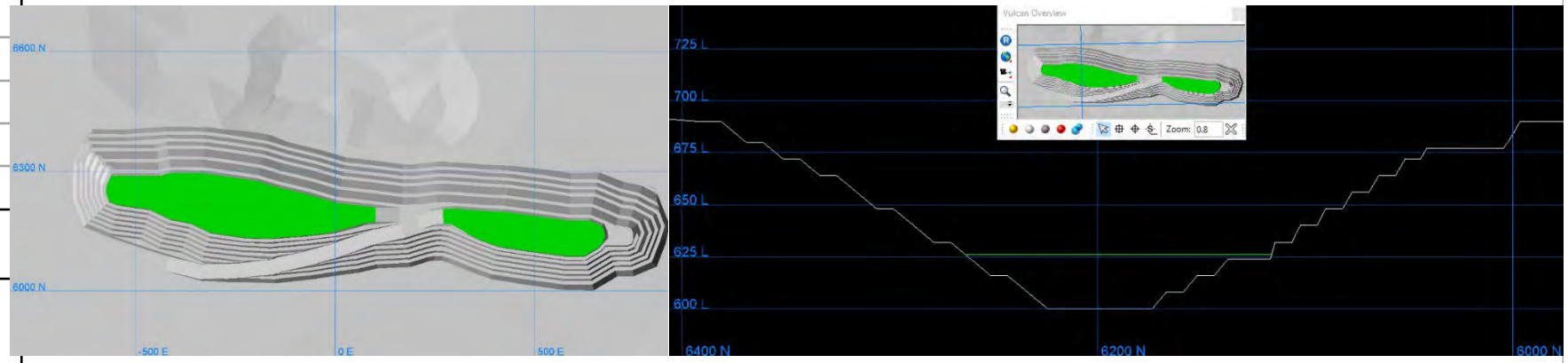
Deposit D D3 Pit

Waste volume	1.0 Mm3	
Erodibility ranking	Low/Medium or High Low Medium High	
Classification	Inert ☒ PAF ☐ Fibrous minerals ☐ WFSF ☐	Capping required at closure: Mm^3 -
Overall height (m)	26 m	
Topsoil required (Mm^3)		

Construction Design



Rehabilitation Design



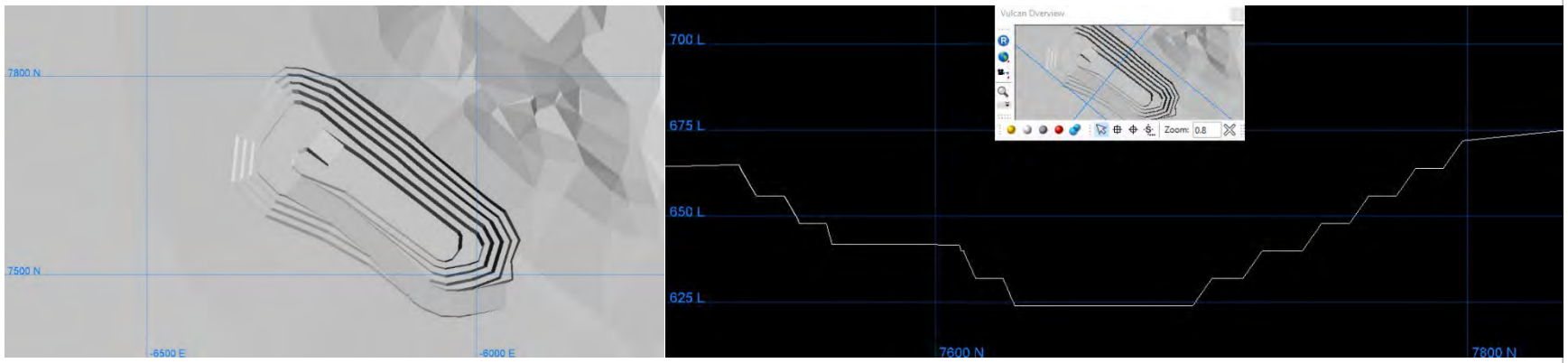
	Construction Specifications	Rehabilitation Specifications
Slope angle (deg)		
Lift height (m)		
Berm width (m)		
Berm slope (deg)		
Footprint (ha)		

Comments:

Deposit D D5 Pit

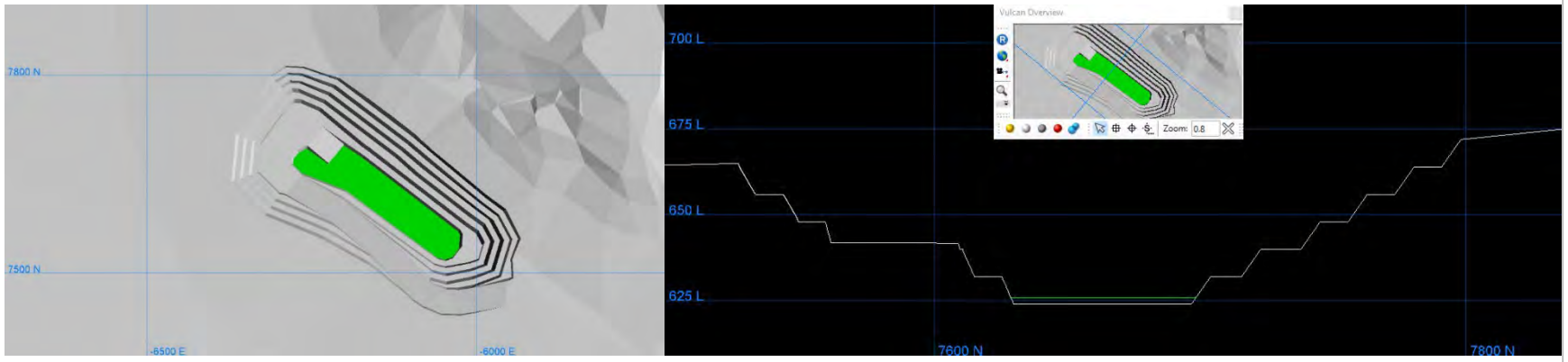
Waste volume	0.05 Mm3	
Erodibility ranking	Low/Medium or High Low Medium High	
Classification	Inert ☒ PAF ☐ Fibrous minerals ☐ WFSF ☐	Capping required at closure: Mm^3 -
Overall height (m)	3 m	
Topsoil required (Mm^3)		

Construction Design



	Construction Specifications	Rehabilitation Specifications
Slope angle (deg)		
Lift height (m)		
Berm width (m)		
Berm slope (deg)		
Footprint (ha)		

Rehabilitation Design

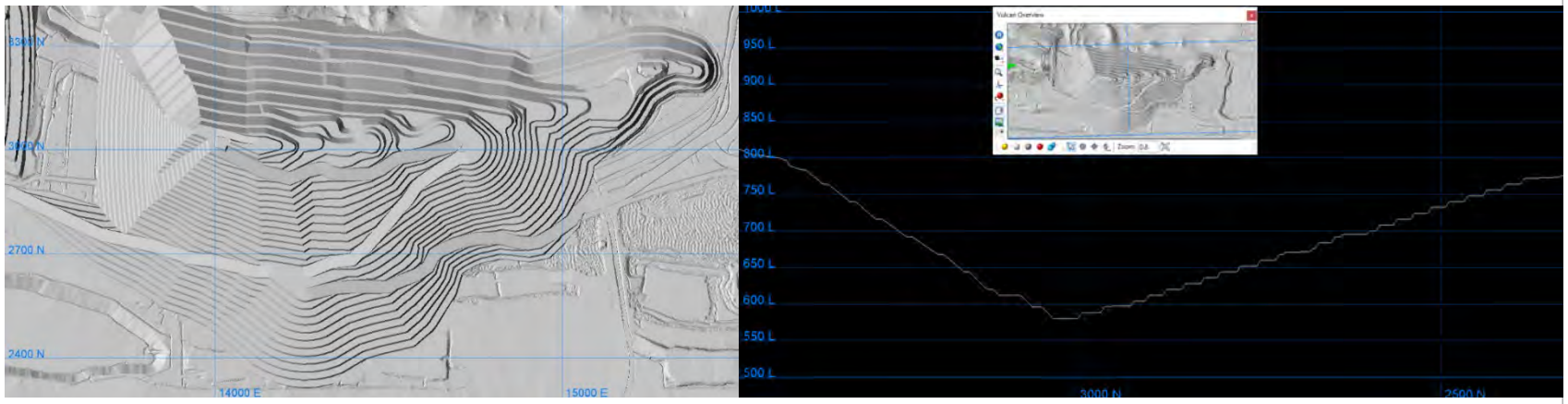


Comments:

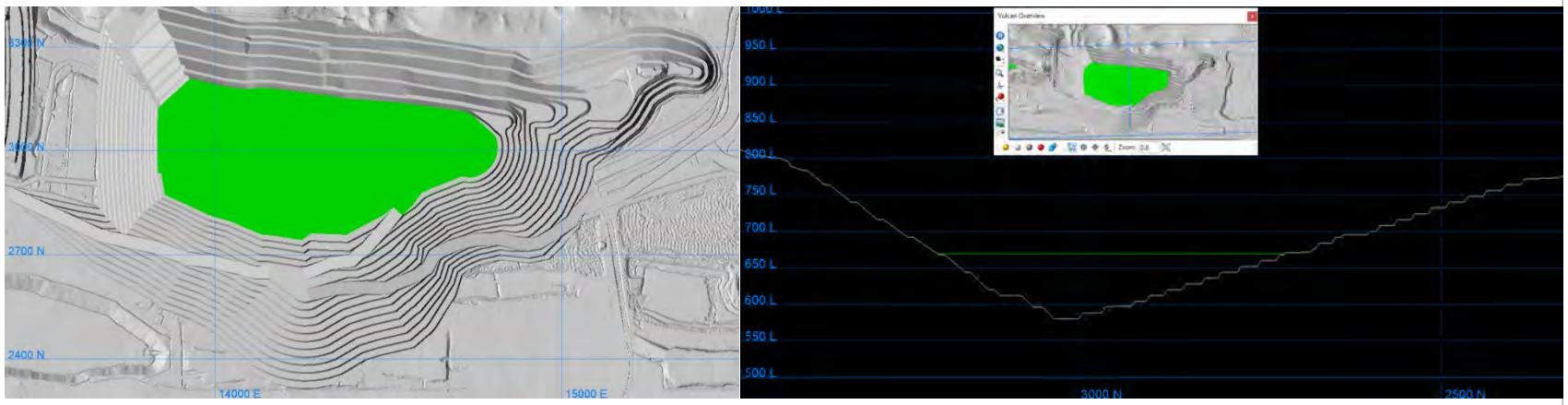
Deposit E East Pit

Waste volume	19.9 Mm3	
Erodibility ranking	Low/Medium or High Low Medium High	
Classification	Inert ☒ PAF ☐ Fibrous minerals ☐ WFSF ☐	Capping required at closure: Mm^3 -
Overall height (m)	122 m	
Topsoil required (Mm^3)		

Construction Design



Rehabilitation Design



	Construction Specifications	Rehabilitation Specifications
Slope angle (deg)		
Lift height (m)		
Berm width (m)		
Berm slope (deg)		
Footprint (ha)		

Comments:

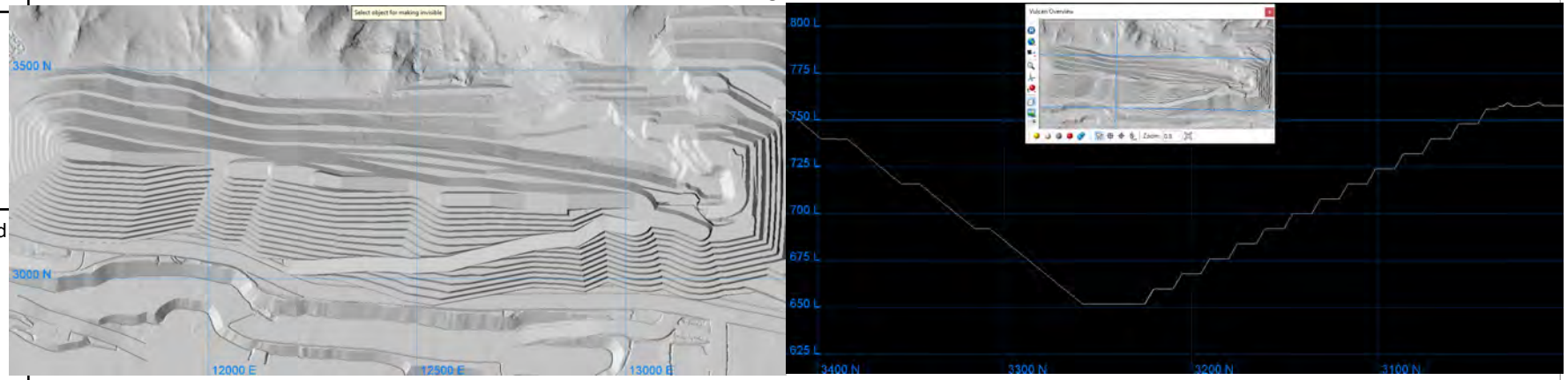
Deposit E West Pit

Waste volume	1.1 Mm3	
Erodibility ranking	Low/Medium or High	
	Low	
	Medium	
	High	
Classification	Inert ☒	Capping required at closure:
	PAF ☐	
	Fibrous minerals ☐	Mm^3
	WFSF ☐	-
Overall height (m)	26 m	
Topsoil required (Mm^3)		

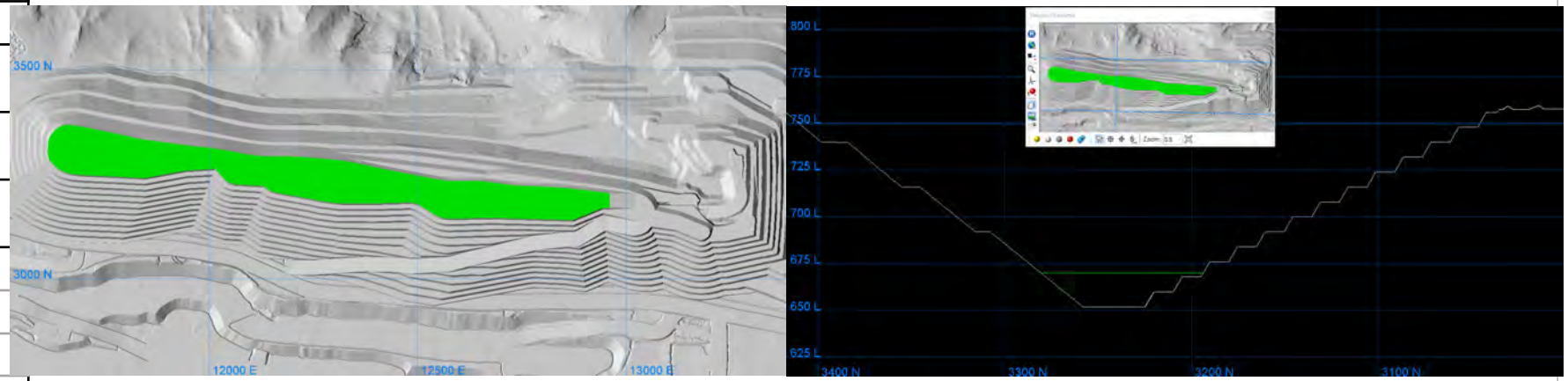
	Construction Specifications	Rehabilitation Specifications
Slope angle (deg)		
Lift height (m)		
Berm width (m)		
Berm slope (deg)		
Footprint (ha)		

Comments:

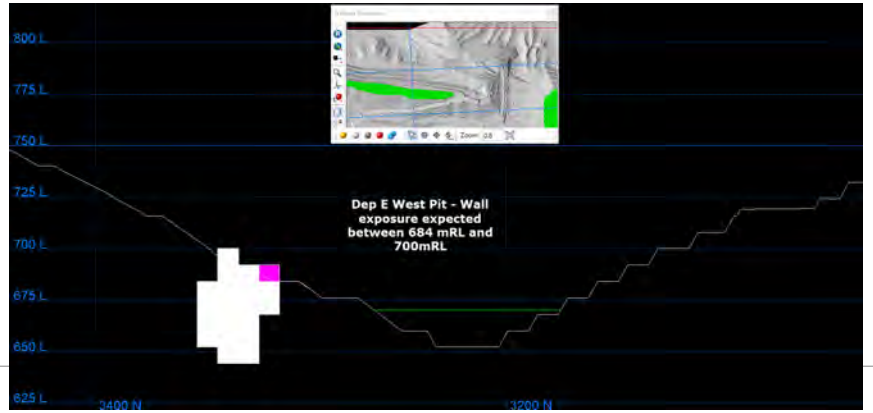
Construction Design



Rehabilitation Design



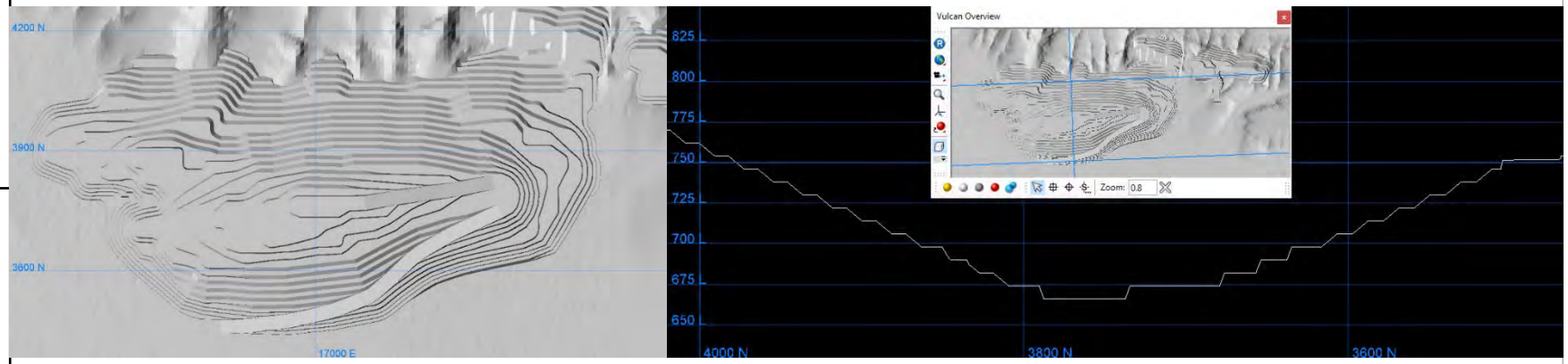
Fibrous exposures



Deposit F DFW Pit

Waste volume	0.8 Mm3	
Erodibility ranking	Low/Medium or High Low Medium High	
Classification	Inert ☒ PAF ☐ Fibrous minerals ☐ WFSF ☐	Capping required at closure: Mm^3 -
Overall height (m)	22 m	
Topsoil required (Mm^3)		

Construction Design



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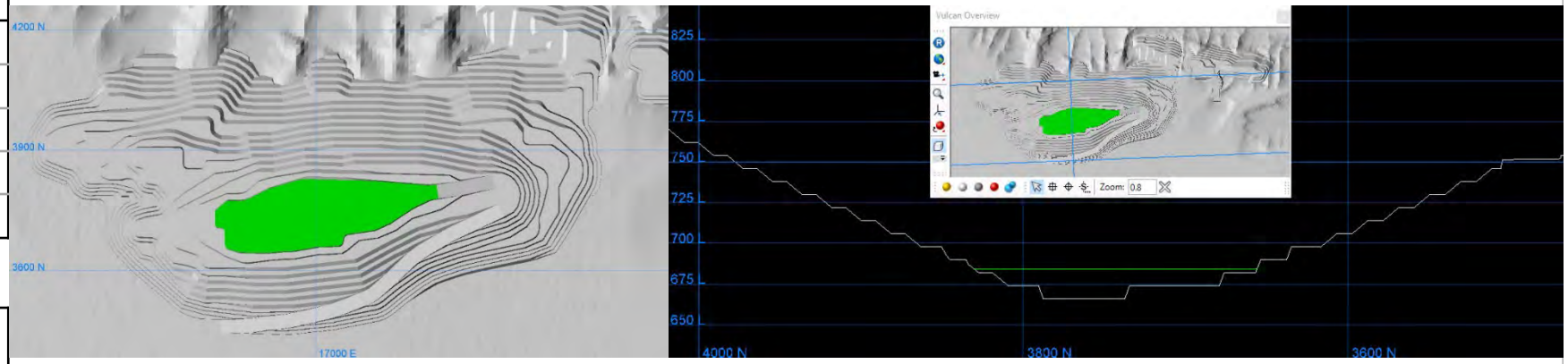


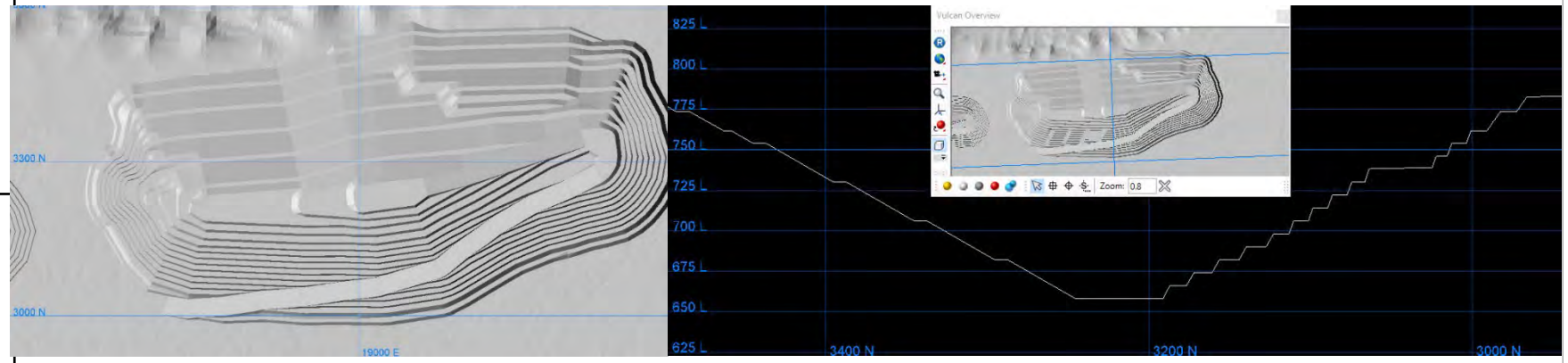
	Construction Specifications	Rehabilitation Specifications
Slope angle (deg)		
Lift height (m)		
Berm width (m)		
Berm slope (deg)		
Footprint (ha)		

Comments:

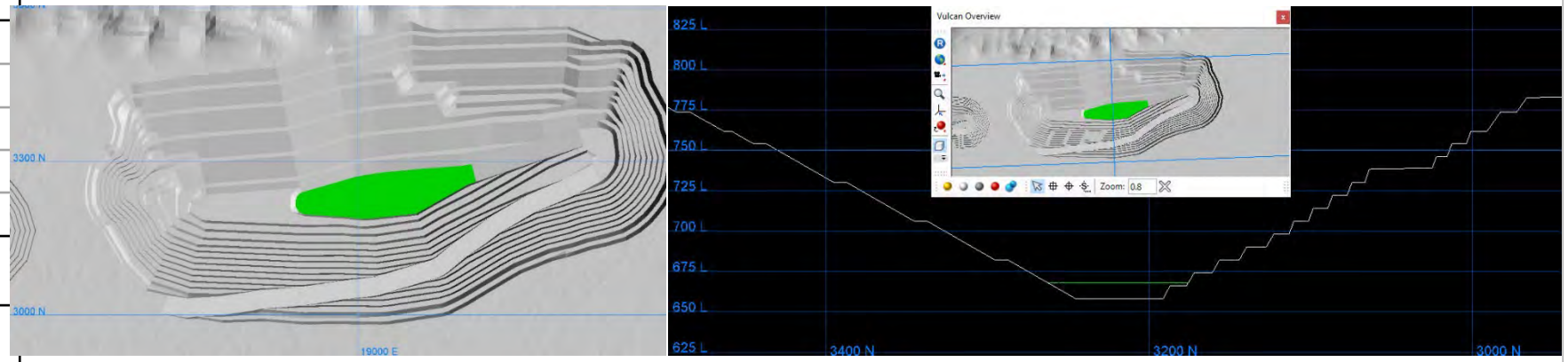
Deposit F DFS1 Pit

Waste volume	0.2 Mm3	
Erodibility ranking	Low/Medium or High Low Medium High	
Classification	Inert ☒ PAF ☐ Fibrous minerals ☐ WFSF ☐	Capping required at closure: Mm^3 -
Overall height (m)	14 m	
Topsoil required (Mm^3)		

Construction Design



Rehabilitation Design



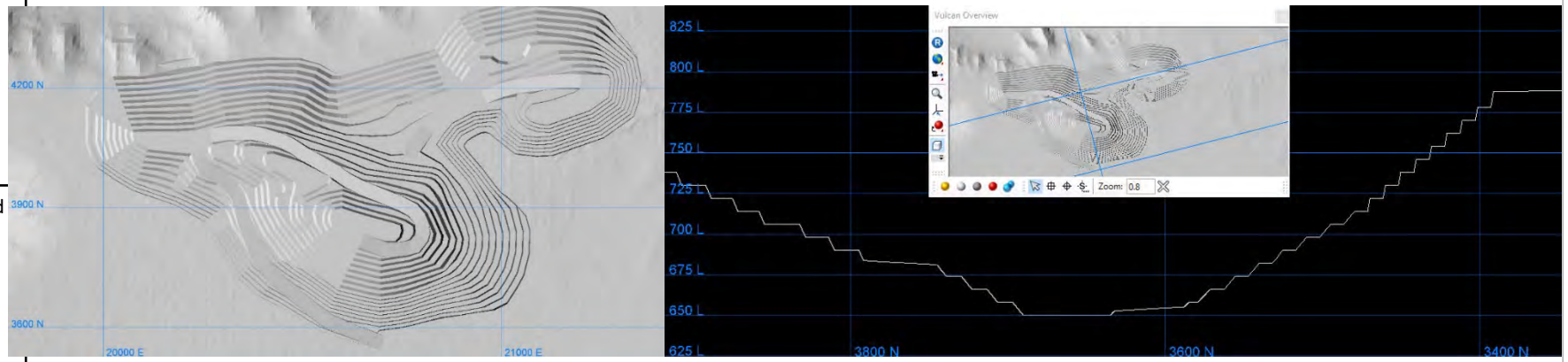
	Construction Specifications	Rehabilitation Specifications
Slope angle (deg)		
Lift height (m)		
Berm width (m)		
Berm slope (deg)		
Footprint (ha)		

Comments:

Deposit F DFE Pit

Waste volume	0.5 Mm3	
Erodibility ranking	Low/Medium or High Low Medium High	
Classification	Inert ☒ PAF ☐ Fibrous minerals ☐ WFSF ☐	Capping required at closure: Mm^3 -
Overall height (m)	22 m	
Topsoil required (Mm^3)		

Construction Design



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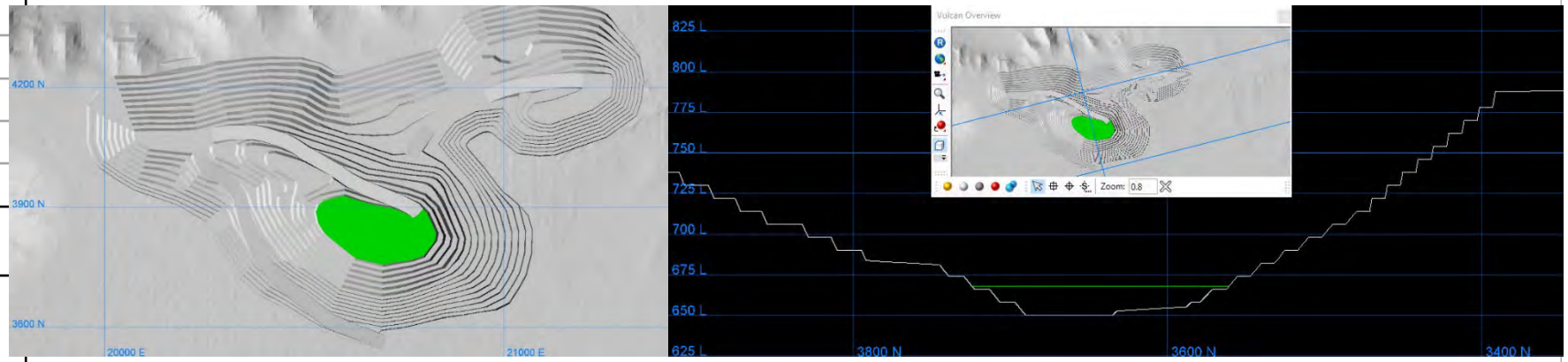


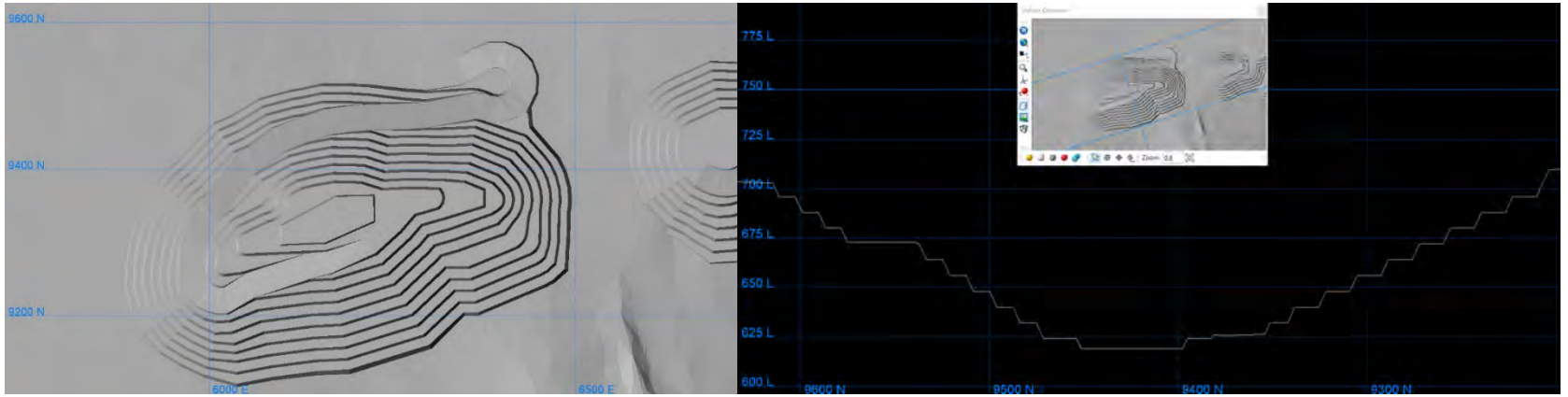
	Construction Specifications	Rehabilitation Specifications
Slope angle (deg)		
Lift height (m)		
Berm width (m)		
Berm slope (deg)		
Footprint (ha)		

Comments:

Deposit G G1 Pit

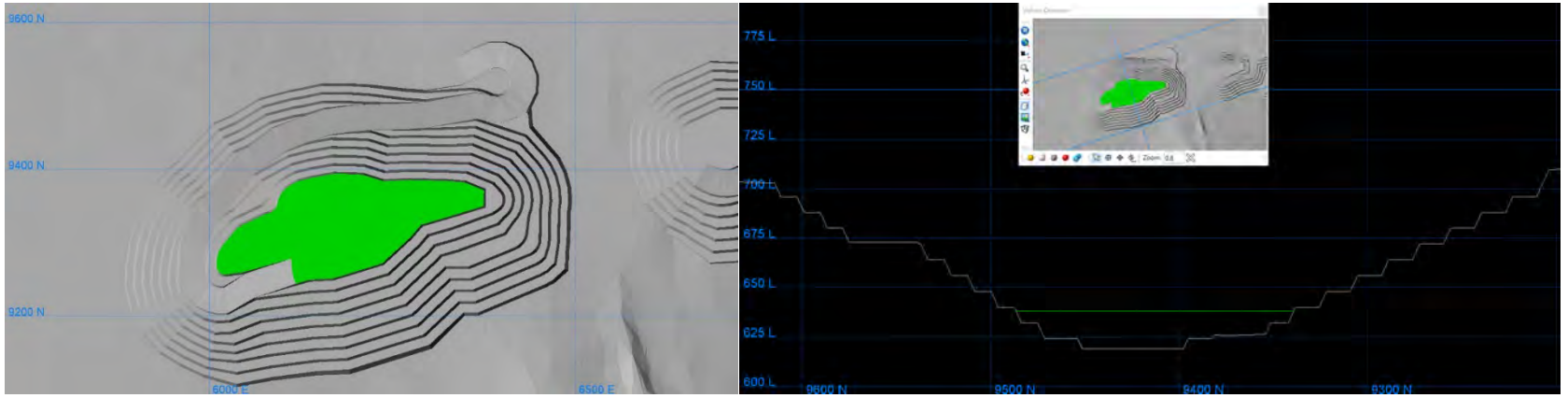
Waste volume	0.2 Mm3	
Erodibility ranking	Low/Medium or High Low Medium High	
Classification	Inert ☒ PAF ☐ Fibrous minerals ☐ WFSF ☐	Capping required at closure: Mm^3 -
Overall height (m)	19 m	
Topsoil required (Mm^3)		

Construction Design



	Construction Specifications	Rehabilitation Specifications
Slope angle (deg)		
Lift height (m)		
Berm width (m)		
Berm slope (deg)		
Footprint (ha)		

Rehabilitation Design

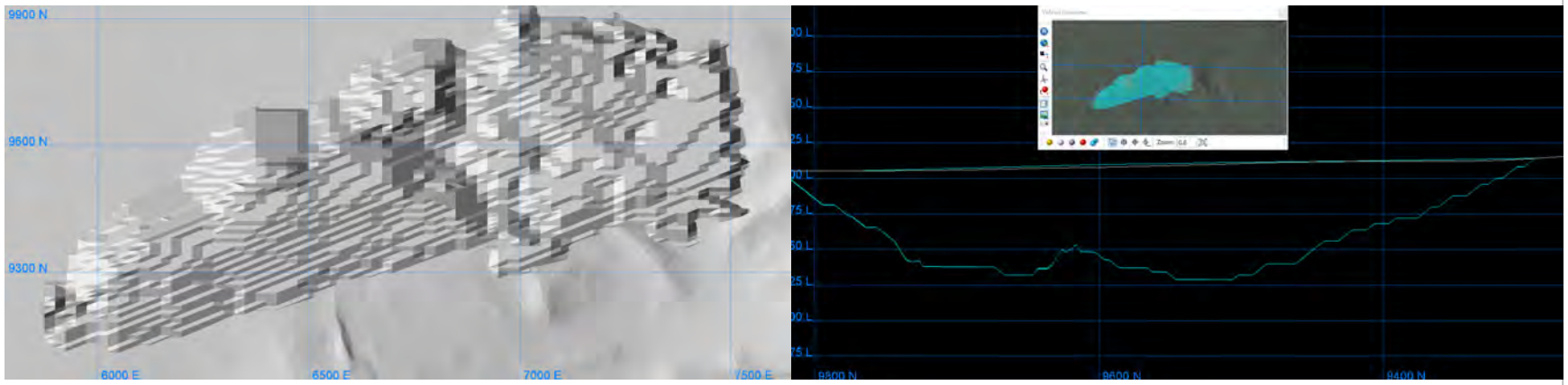


Comments:

Deposit G G4 Pit

Waste volume	2.8 Mm3	
Erodibility ranking	Low/Medium or High Low Medium High	
Classification	Inert ☒ PAF ☐ Fibrous minerals ☐ WFSF ☐	Capping required at closure: Mm^3 -
Overall height (m)	63 m	
Topsoil required (Mm^3)		

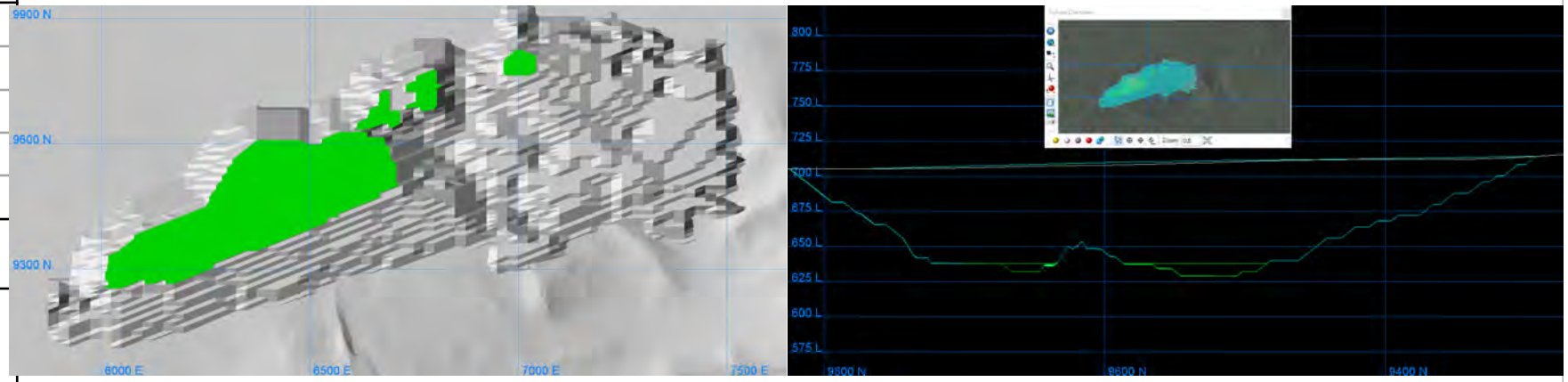
Construction Design



	Construction Specifications	Rehabilitation Specifications
Slope angle (deg)		
Lift height (m)		
Berm width (m)		
Berm slope (deg)		
Footprint (ha)		

Comments:

Rehabilitation Design



Appendix 12: Progressive Rehabilitation and Monitoring Summary

RioTinto

Rio Tinto Iron Ore Rehabilitation and Closure

West Angelas Proposal

Progressive Rehabilitation Performance Summary

January 2023

RioTinto

Disclaimer and Limitation

This report has been prepared by Rio Tinto's Iron Ore Group (Rio Tinto), on behalf of Hamersley Iron Pty Limited (the Proponent), specifically for the West Angelas Iron Ore Project. Neither the report nor its contents may be referred to without the express approval of Rio Tinto, unless the report has been released for referral and assessment of proposals.

Document Status					
Rev	Author	Reviewer/s	Date	Approved for Issue	
				To Whom	Date
A	TK, MB	MB	23/10/2022		
B	TK	MB	25/10/2022		
0	TK	MB	05/01/2023		

Executive Summary

This Progressive Rehabilitation Performance Summary (Summary) has been prepared primarily to support the update and submission of the West Angelas 2023 Mine Closure Plan (MCP), developed in accordance with the Environmental Protection Authority (EPA)'s decision to assess the West Angelas Proposal under Part IV s38 of the Environmental Protection Act 1986. Evidence obtained from analyses of outcomes at these sites will inform rehabilitation strategies for current and future projects and will also provide evidence that current and future rehabilitation activities will be successful in establishing a self-sustaining functional native ecosystem. Rio Tinto has a dedicated Rehabilitation and Closure team responsible for closure planning, progressive rehabilitation, ongoing development of closure knowledge, and closure cost estimation. This team is supported by a robust internal governance framework and embedded partnerships with multi-disciplinary technical experts.

Rio Tinto undertakes progressive rehabilitation across its network of Pilbara iron ore operations to actively reduce closure liability. A key driver for completion of progressive rehabilitation is growth in confidence in the ability to deliver quality rehabilitation and reduce associated closure liabilities. Lessons learnt, and information gathered, from progressive rehabilitation will be used to indicate the likely success of future rehabilitation and inform the development of final closure criteria. Local undisturbed vegetation is used as a reference to guide rehabilitation activities such as seed list development and rehabilitation quality assessment.

To date, the success of the Rio Tinto rehabilitation in the Pilbara has been variable, with some poor to moderately successful rehabilitation outcomes observed across historical and recent rehabilitation areas. Significant improvements have been made recently in mineral waste characterisation, landform design and earthwork conformance to design practices, leading to closure designs with reduced erosion rates and related impacts and improved outcomes for rehabilitated areas.

Broad outcomes observed in rehabilitation performance at the West Angelas Mine, and other Pilbara assets, include:

- Rainfall is integral to the success of rehabilitation. Good results in plant density and spinifex cover are achieved if rainfall is received soon after seeding i.e. soil moisture assists in germination and establishment of seedlings. However, if the quantity of rainfall after seeding is too high, detrimental impacts upon rehabilitation success may occur. This makes the timing of seeding an important factor in the success of rehabilitation.
- Generally, the addition of topsoil as a growth medium provides better revegetation results than those achieved at sites where no topsoil was available. However, there has been some successful revegetation at sites where no topsoil was utilised. Direct return of topsoil provides the highest rehabilitation performance in trials, to date.
- Higher species richness values can be observed at the seeded sites, suggesting a potential correlation. Similarly, higher numbers of flowering / fruiting species appear to be associated with the application of seed.
- Knowledge of vegetation parameter dynamics in post-fire communities is highly valuable for rehabilitation understanding. The parallels observed between vegetation parameter trends at early rehabilitation sites and at burnt sites are also cause for furthering the current knowledge base on fire-affected communities.
- Selection and monitoring of a range of appropriate reference sites is critical in understanding rehabilitation performance towards achieving closure completion criteria.

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TABLE OF ABBREVIATIONS

AGM	Alternative growth media
ANFO	Ammonium Nitrate Fuel Oil
BWT	Below water table
DAWE	Commonwealth Department of Agriculture, Water and the Environment
DJTSI	Department of Jobs, Tourism, Science and Innovation
DMIRS	Department of Mines, Industry Regulation and Safety
EPA	Environmental Protection Authority
ESD	Environmental Scoping Document
HV	Heavy Vehicle
LOM	Life of Mine
MCP	Mine closure plan
PAF	Potentially acid forming
PRG	Pilbara Rehabilitation Group
RQA	Rehabilitation Quality Assessment
Rio Tinto	Rio Tinto Iron Ore
SMART	Specific, Measurable, Achievable, Relevant and Time-Bound
UWA	University of Western Australia
WABSI	Western Australian Biodiversity Science Institute
WAN	West Angelas
WFSF	Waste Fines Storage Facility

1. SCOPE AND PURPOSE

This Progressive Rehabilitation Performance Summary (Summary) has been prepared primarily to support the update and submission of the West Angelas 2023 Mine Closure Plan (MCP). The MCP has been developed in accordance with the Environmental Protection Authority (EPA)'s decision to assess the West Angelas Proposal under Part IV s38 of the Environmental Protection Act 1986 (EP Act). Table 1 sets out the environmental scoping requirements prescribed by the EPA) relevant to this Summary and for which it has been developed to accomplish.

This Summary is aligned with the Department of Mines, Industry Regulation and Safety (DMIRS) statutory requirements for MCP content and structure (DMIRS 2020a & b). This summary may also be used to support the submission of:

- Native Vegetation Clearing Permits; and
- Annual Environment Reports requirements for:
    - *Iron Ore (Hamersley Range) State Agreement Act 1963* and Annual Compliance assessment reporting for Ministerial Statements to the Department of Jobs, Tourism, Science and Innovation (JTSI); or
    - Mining Act tenure to DMIRS; or
    - Native Vegetation Clearing Permits (to DMIRS).

The outcomes of rehabilitation undertaken, to date, at the West Angelas Mine are discussed within this Summary, including details of relevant rehabilitation trials installed at other sites (Section 6). Evidence obtained from analyses of rehabilitation performance at West Angelas sites and supporting data from the various trials will help inform rehabilitation strategies for current and future projects, giving increasing confidence that current and future rehabilitation activities can successfully establish a self-sustaining functional native ecosystem.

Table 1: West Angelas Proposal scoping document requirements relevant to this Summary

ESD WORK ITEM NO.	REQUIRED WORK		SUMMARY SECTION
8 (flora and vegetation) **23 (terrestrial fauna)** **40 (subterranean fauna)**	Prepare a Mine Closure Plan, consistent with DMIRS Mine Closure Plan Guidance – How to Prepare in Accordance with Part 1 of the Statutory Guidelines (March 2020) and DMIRS Statutory Guidelines for Mine Closure Plans (March 2020), which:	Includes methodologies to ensure progressive rehabilitation of disturbed land	Sections 2.3. Section 3
		Meets closure objectives, including vegetation composed of native species of local provenance	Section 4.2.1
		Includes consideration of backfilling mine pits, final landforms and rehabilitation of disturbed areas.	Section 2
9 (flora and vegetation) 24 (terrestrial fauna)	Provide a report that details the likely success of future rehabilitation activities in establishing self-sustaining areas of rehabilitation, taking into account	Evidence of success of rehabilitation undertaken to date in the region	Section 5
		Relevant contemporary scientific evidence	Section 5 Section 5.6
		The types of area to be rehabilitated	Section 3

2. GENERAL OVERVIEW OF PILBARA REHABILITATION

2.1. Progressive rehabilitation planning

Rio Tinto has a dedicated Rehabilitation and Closure team responsible for closure planning, progressive rehabilitation, ongoing development of closure knowledge, and closure cost estimation. This team is supported by a robust internal governance framework and embedded partnerships with multi-disciplinary technical experts.

Rio Tinto undertakes progressive rehabilitation across its network of Pilbara iron ore operations to actively reduce the closure liability, and to demonstrate legislatively required compensation for losses of native vegetation. However, as the Rio Tinto Pilbara operations are typically large scale and long-lived, with multiple pits being mined simultaneously to meet grade and product requirements, the disturbance areas are usually active for long periods. Consequently, the pace of progressive rehabilitation is not always commensurate with the associated pace of clearing, and long periods of time may elapse between the construction and mining and the commencement of rehabilitation.

A key component of progressive rehabilitation is the assessment of outcomes, undertaken for the purposes of facilitating an increased confidence in the ability to deliver quality rehabilitation and thereby reduce associated closure liabilities. Local, undisturbed vegetation is used as a reference to assess rehabilitation performance and guides rehabilitation methodology such as seed list development. Due to the nature of the mining activity undertaken, and the cumulative impacts the Pilbara region has experienced, it must be recognised that rehabilitation cannot feasibly reflect the pre-mining environment (i.e. as compared to 'restoration', as defined in SERA, 2021). Instead, the objective of progressive rehabilitation is to reinstate a self-sustaining native ecosystem that can assimilate in the surrounding

natural vegetation, as exhibited by designated reference sites. This objective aligns with the desired closure outcome of 'Vegetation on rehabilitated land is self-sustaining and compatible with the post-mining land use(s)'.

To date, the performance of the Rio Tinto rehabilitation in the Pilbara has been inconsistent, with variations observed both between different mine sites and within single sites. Monitoring data to date has indicated some instances of poor rehabilitation performance, where little to no improvement in vegetation parameters occurs; whilst contrary successful outcomes have also been reflected by monitoring data across a range of historical and recent rehabilitation areas. Despite considerable fluctuations, vegetation parameter trends at long-term rehabilitation sites generally show progression toward corresponding reference values, with exceedance of reference values at some sites.

Significant improvements have been made recently in mineral waste characterisation and conformance of landform design earthworks to best practices. These advances have resulted in closure designs with reduced erosion rates and mitigation of related impacts, subsequently leading to improved rehabilitation outcomes. Lessons learnt, and information gathered, from progressive rehabilitation will continue to be used to indicate the likely success of future rehabilitation and inform the development of final closure criteria.

2.2. Definition of land disturbance types

The following categories are applied to disturbance features at Rio Tinto operations.

2.2.1. Low impact disturbance

Low impact disturbance areas are defined as areas where vegetation has been cleared and there has been minimal disturbance to the soil profile. Examples include laydowns; above surface linear infrastructure corridors (dirt roads, tracks etc.); topsoil stockpile footprints; and exploration disturbance. Rehabilitation of such areas includes backfilling sumps, contour ripping and spreading of topsoil (if available). Seed may also be spread, if required.

2.2.2. Moderate impact disturbance

Moderate impact disturbance areas are defined as those which require minor earthworks to either return the area to natural relief or create a compatible landform consistent with the surrounding natural relief and landforms. Examples include airstrips; buildings (other than accommodation camps); infrastructure including pipelines and powerlines mine access roads; and borrow pits. Typically, rehabilitation of such areas involves removal of infrastructure, services and road surfaces, deep ripping of compacted areas if required, re-contouring, spreading of topsoil, contour ripping and seeding.

2.2.3. High impact disturbance

High impact disturbance areas are defined based on their requirement for extensive earthworks to either approximate surrounding natural relief or create a compatible landform consistent with the surrounding natural relief and landforms. Typically, such areas contain concrete footings that require cracking and covering with fill, voids that need to be filled with waste rock, and/or significant reshaping and contouring to create the required relief. All concrete and buried services are required to be removed to at least one metre below final surface. Examples of high disturbance areas include accommodation camps; fuel farm facilities; haul roads; bridges; dams; power stations; and processing plants. Constructed landforms, such as waste dumps and waste fines storage facilities, are also highly disturbed areas that require significant earthworks to achieve stable rehabilitation designs.

2.3. Rehabilitation methodology

Key learnings from the progressive rehabilitation undertaken to date across a range of Rio Tinto operational locations facilitate continual improvement within rehabilitation methodology. Examples relevant to the West Angelas Proposal are provided in Table 2.

Table 2: Key learnings from Pilbara mine site progressive rehabilitation

LEARNING	OPERATIONAL CONTROL	FURTHER DISCUSSION WITHIN THE SUMMARY
Rainfall is integral to the success of rehabilitation. Good results in plant density and *Triodia* **(spinifex grass)** cover are achieved if rainfall is received soon after seeding i.e., soil moisture assists in germination and establishment of seedlings. However, if the quantity of rainfall after seeding is too high, detrimental impacts upon rehabilitation success may occur.	Schedule seeding before the onset of wet season where practical Planned trials to determine effect of timing of seeding.	2.3.2 Seed management 5 Summary of rehabilitation outcomes 6.1 Eco-engineering solutions to improve mine site rehabilitation outcomes
Ongoing intermittent rainfall is required through time to ensure that revegetation continues to develop on the desired trajectory to achieve closure criteria. In alignment, weed density generally decreases over periods of low rainfall.	Monitoring of reference sites to determine the effect of rainfall on natural systems Weed monitoring and management.	2.3.2 Seed management 5 Summary of rehabilitation outcomes 6.1 Eco-engineering solutions to improve mine site rehabilitation outcomes
The presence of weeds significantly impedes overall rehabilitation outcomes particularly within parameters native perennial species richness / density and native perennial cover.	Regular monitoring of weeds and prompt implementation of weed management actions when required.	5 Summary of rehabilitation outcomes
Generally, the addition of topsoil as a growth medium provides better revegetation results than those achieved at sites where no topsoil was available. However, there has been some successful revegetation at sites where no topsoil was utilised. Direct return of topsoil provides better rehabilitation outcomes than stockpiled topsoil.	Ongoing review of topsoil management and monitoring of trials	2.3.1 Growth mediums 5 Summary of rehabilitation outcomes 6.5 Growth media trials
Current results indicate that waste materials with soil-like properties, collectively termed 'Alternate Growth Media' (AGM) can act as effective germination beds and be used as longer-term growth mediums.	Ongoing characterisation of potential AGM and monitoring of trials.	2.3.1 Growth mediums 6.5 Growth media trials
With the limited trials to date, application of fertiliser did not improve revegetation results.	Ongoing investigation of soil ameliorants to improve success of AGM, and of germination and survivability results for native species	2.3.1 Growth mediums 6.5 Growth media trials
Triodia cover is closely associated with total plant cover and density values.	Ongoing monitoring to determine if association continues through time and with differing seed mixes.	5 Summary of rehabilitation outcomes

2.3.1. Growth medium

There may also be a shortfall of topsoil and subsoil available for rehabilitation due to topsoil being naturally thin or absent on topography such as hillslopes and ridge lines, or steep underlying topography presenting safety risks preventing the collection of topsoil. Where a topsoil deficit exists at a site, consideration is given to the use of subsoil and alternative growth media in rehabilitation.

Throughout the Pilbara, there is an ongoing opportunity to utilise mineral waste as topsoil substitutes or supplements for rehabilitation activities. The waste materials with soil-like properties are referred to as 'alternative growth media' (AGM). It is anticipated that AGM will provide a suitable growth medium in rehabilitation areas where topsoil is unavailable or limited in quantity. Research trials are underway to determine if the revegetation success in areas rehabilitated with alternative growth media will be acceptable, and early indications are promising (Section 6.5). Waste types which are identified as potentially suitable are laboratory tested for key soil chemical and physical parameters. If the characterisation results are favourable, the material is stockpiled with the location recorded on mine site survey records.

Alternative growth media material was identified and tested from several Rio Tinto sites in the Pilbara including: Marandoo; Tom Price; Western Turner Syncline; and Channar (Outback Ecology 2010, Stantec 2017, and Landloch 2018). Stockpiling of suitable material commenced, with additional investigations to incorporate materials into the mine plans for future recovery underway.

Results from ongoing monitoring of these trials will be used to inform future closure strategies. If required, seeding rates may be increased in areas receiving alternative growth media or subsoil material to compensate for the lack of a topsoil seedbank. The application of fertiliser, or other ameliorants, will also be considered for materials that have low nutrient status, although recent evidence suggests the addition of fertiliser is not always beneficial and can promote weed establishment (Stantec 2020).

2.3.2. Seed management

Locally collected seed assists in the revegetation and creation of a self-sustaining ecosystem. Over time, the viability of the seed within stockpiled topsoil may decrease, particularly if stored for long periods or if the stockpile does not become vegetated. In addition, as topsoil is not always used in rehabilitation of areas it was salvaged from, the salvaged topsoil may not contain seeds of all the target species of its new location/habitat.

Seed mixes used during rehabilitation are of local provenance. Specific seed mixes are selected to provide a range of species appropriate to the landscape position and slope. Local colonising species are included in the mix to aid in quick vegetation establishment, and to thus compete with weed species that may establish from wind-blown seed. Rio Tinto is working towards ensuring culturally significant species are also considered in the selection of species and determination of proportion of seed numbers for each species in the mix.

Rio Tinto purchases seeds from commercial seed suppliers, with emphasis on ensuring that there are adequate seed of appropriate quantity and local provenance species available for planned rehabilitation at each of the mine sites or other assets. Stringent controls on seed quality, provenance and seed storage are in place and seed pre-treatments are used for a proportion of the seed of some species to maximise the potential of applied seed to germinate under field conditions. Seeds are stored in purpose-built, climate-controlled storage facilities to maximise long-term viability. Viability testing and species-specific pre-treatments occur prior to seeds being spread onto rehabilitation areas. Increasing revegetation success through ongoing improvement projects and research partnerships in seed biology and seeding technologies is a key factor in the ability to successfully rehabilitate across all Pilbara mining operations.

As the opportunity to utilise rare and threatened species in rehabilitation programs is limited by various factors such as availability, the focus of rehabilitation programs is to restore vegetation complexes that include the more common species present in the habitat type, and to achieve a suitable range of strata

considering the desired post-mining land use. Seed mixes may include species of conservation significance if available, but presence of these species in rehabilitation areas is more likely to result from natural recruitment from surrounding areas.

Legislative requirements regarding seed provenance are often included as conditions within Native Vegetation Clearing Permits obtained under the EP Act. A review of all legislative requirements for seed provenance is conducted as part of the planning process for rehabilitation programs to ensure seed provenance conditions are met. All legal obligations related to rehabilitation and seed provenance for the West Angelas mine site are summarised in the Legal Obligations Register appended to the 2022 MCP.

3. PROGRESSIVE REHABILITATION OVERVIEW

This progressive rehabilitation Summary provides a synopses of Rio Tinto's internal completion reports and of the annual rehabilitation monitoring program results for the West Angelas mine site. The objective of the progressive rehabilitation program is to evaluate successional development of the rehabilitation and thereby provide feedback for the improvement of rehabilitation techniques, and to help assess progress towards long term rehabilitation goals.

3.1. Disturbance areas and progressive rehabilitation

Within the proposed West Angelas closure boundary, all disturbed areas that can be accessed safely, with the exception of pit floors (unless backfilled to within 10m of the final surface), will be rehabilitated, either progressively through operations or at closure.

Figure 1 shows the total area of disturbance within the West Angelas closure boundary, illustrating the amount of rehabilitation already undertaken and the area still requiring rehabilitation. At the time of writing this Summary, 617.7 ha of disturbed land has been rehabilitated, ranging from low disturbance areas to highly disturbed waste landforms (see Table 3).

Implementation of progressive rehabilitation at the West Angelas site will occur during the operational phase when disturbed areas become available. Completed and planned rehabilitation areas (as of 2021) within the associated closure boundary are presented in Figure 2 and Figure 3.

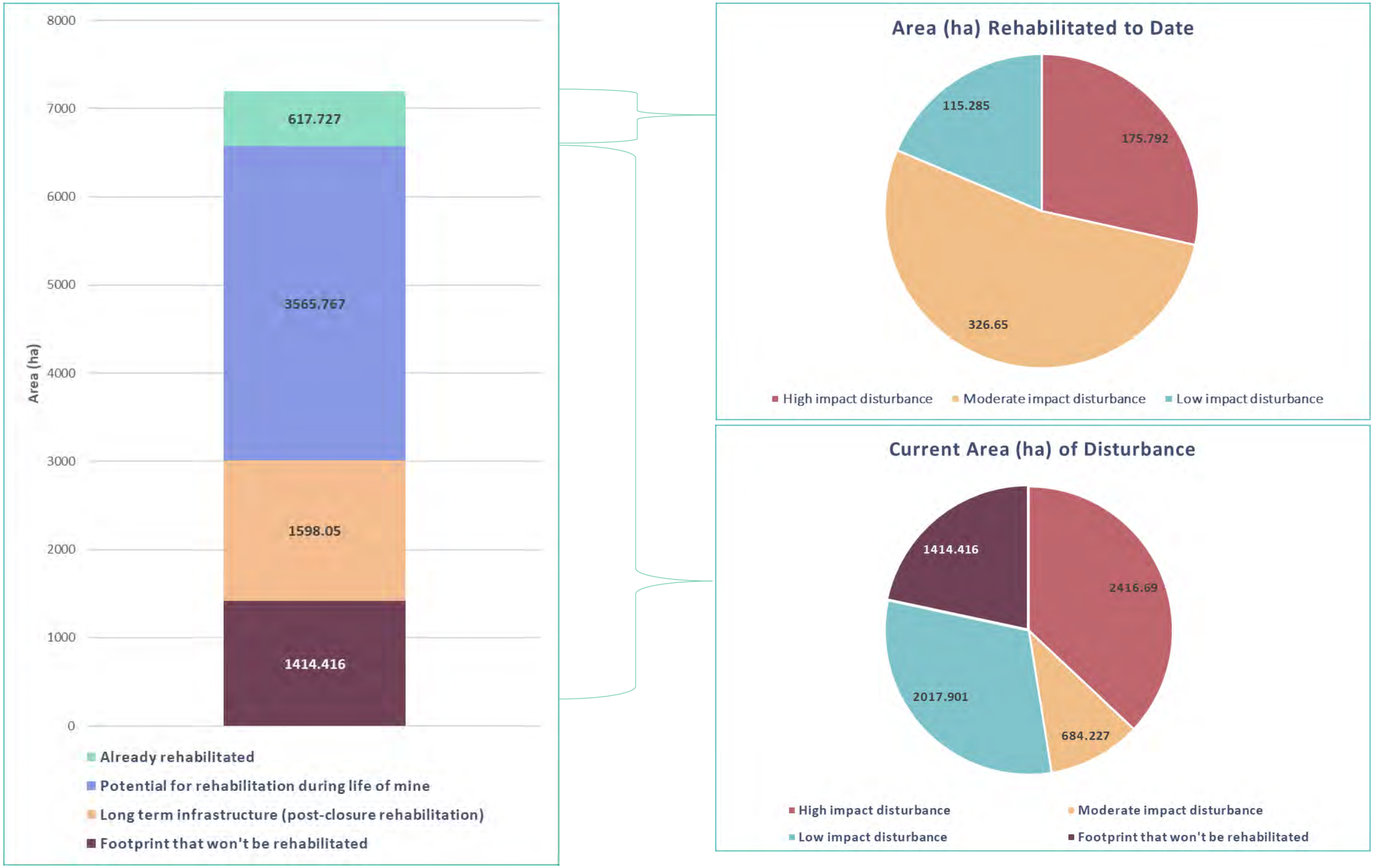

Figure 1: West Angelas type and scale of rehabilitation completed and remaining (data captured in December 2021)

Table 3: Completed progressive rehabilitation within the West Angelas closure boundary.

IMPACT DISTURBANCE CATEGORY	DOMAIN	REHABILITATION SITES[1]	SITE AREA (HA)	ACTIVE TRANSECTS *(INACTIVE TRANSECTS ITALICISED)*	SUMMARY SECTION
Low	Various	N/A	N/A	N/A	5.3
Moderate	Borrow pit	West Angelas Access Road	Unknown	WAN_HwyAccessRoad_T1_2010 WAN_HwyAccessRoad_T2_2010 WAN_HwyAccessRoad_T3_2010 WAN_HwyAccessRoad_T4_2010 WAN_HwyAccessRoad_T5_2010	5.4.2
		Highway Access Road		WAN_Access_Rd_Upgrade_BP_T1_2016 WAN_Access_Rd_Upgrade_BP_T2_2016 WAN_Access_Rd_Upgrade_BP_T3_2016	5.4.1
		Railway Loop		*WAN_RailwayLoop_T1a_2010* *WAN_RailwayLoop_T1b_2010* *WAN_RailwayLoop_T2_2010* WAN_RailwayLoop_T3_2010	5.4.3
		Airstrip		WAN_Airstrip_T2_2010 WAN_Airstrip_T3_2010	5.4.4
	Infrastructure	Gas Pipeline		WAN_GasPL_T1_2015 WAN_GasPL_T2_2015 WAN_GasPL_T3_2015 WAN_GasPL_T4_2015 WAN_GasPL_T5_2015	5.4.5

[1] Rehabilitation sites are presented as examples of rehabilitation completed within the closure boundary and do not reflect the full area (ha) of disturbance that has been rehabilitated.

IMPACT DISTURBANCE CATEGORY	DOMAIN	REHABILITATION SITES[1]	SITE AREA (HA)	ACTIVE TRANSECTS *(INACTIVE TRANSECTS ITALICISED)*	SUMMARY SECTION
High	Waste dump	East and South Waste Dump	7.3 / 7.5	WAN_EastWD_T1_2013 WAN_EastWD_T2_2013 *WAN_SouthWD_T1_2013* *WAN_SouthWD_T2_2013*	5.5.1
		Deposit A South-Western Waste Dump	78.1	WAN_SW_WD_T1_2021 WAN_SW_WD_T10_2021 WAN_SW_WD_T11_2021 WAN_SW_WD_T12_2021 WAN_SW_WD_T2_2021 WAN_SW_WD_T3_2021 WAN_SW_WD_T4_2021 WAN_SW_WD_T5_2021 WAN_SW_WD_T6_2021 WAN_SW_WD_T7_2021 WAN_SW_WD_T8_2021 WAN_SW_WD_T9_2021 2022_WA_SWWD_T1 2022_WA_SWWD_T2 2022_WA_SWWD_T3 2022_WA_SWWD_T4 2022_WA_SWWD_T5 2022_WA_SWWD_T6 2022_WA_SWWD_T7 2022_WA_SWWD_T8 2022_WA_SWWD_T9	5.5.2

IMPACT DISTURBANCE CATEGORY	DOMAIN	REHABILITATION SITES[1]	SITE AREA (HA)	ACTIVE TRANSECTS *(INACTIVE TRANSECTS ITALICISED)*	SUMMARY SECTION
		Deposit A Northern Waste Dump	54.5 (2022)	2022_WA_NWD_S1_T1 2022_WA_NWD_S1_T2 2022_WA_NWD_S1_T3 2022_WA_NWD_S1_T4 2022_WA_NWD_S1_T5 2022_WA_NWD_S1_T6 2022_WA_NWD_S1_T7 2022_WA_NWD_S1_T8 2022_WA_NWD_S1_T9 2022_WA_NWD_S1_T10 2022_WA_NWD_S2_T1 2022_WA_NWD_S2_T2 2022_WA_NWD_S2_T3 2022_WA_NWD_S2_T4 2022_WA_NWD_S2_T5 2022_WA_NWD_S2_T6 2022_WA_NWD_S2_T7 2022_WA_NWD_S2_T8	
		Deposit B Western Waste Dump (Boeing Dump)	28.1	WAN_Westdump_WD_T1_2021 WAN_Westdump_WD_T2_2021 WAN_Westdump_WD_T3_2021 WAN_Westdump_WD_T4_2021	5.5.3

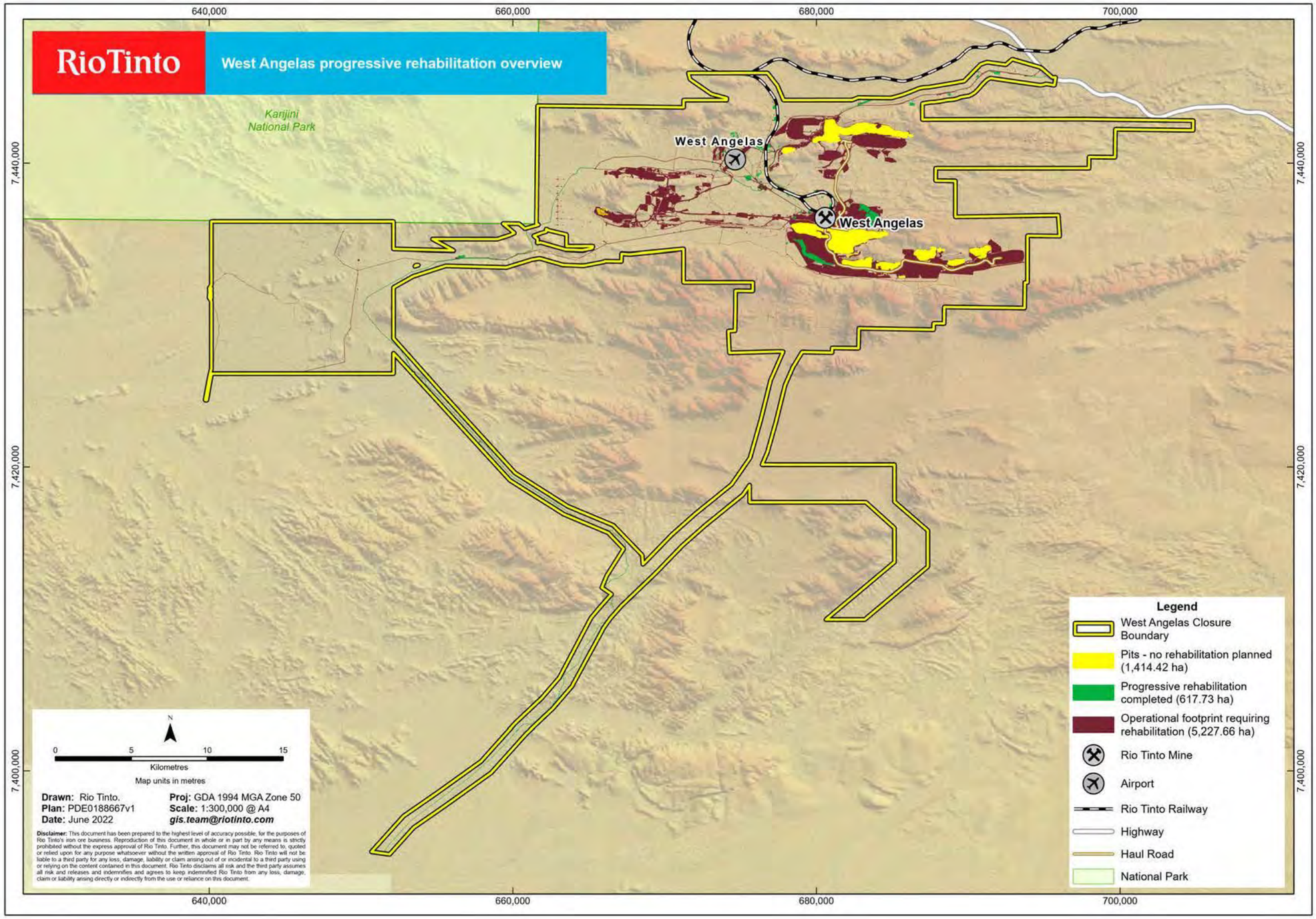

Figure 2: Overview of progressive rehabilitation within the West Angelas closure boundary.

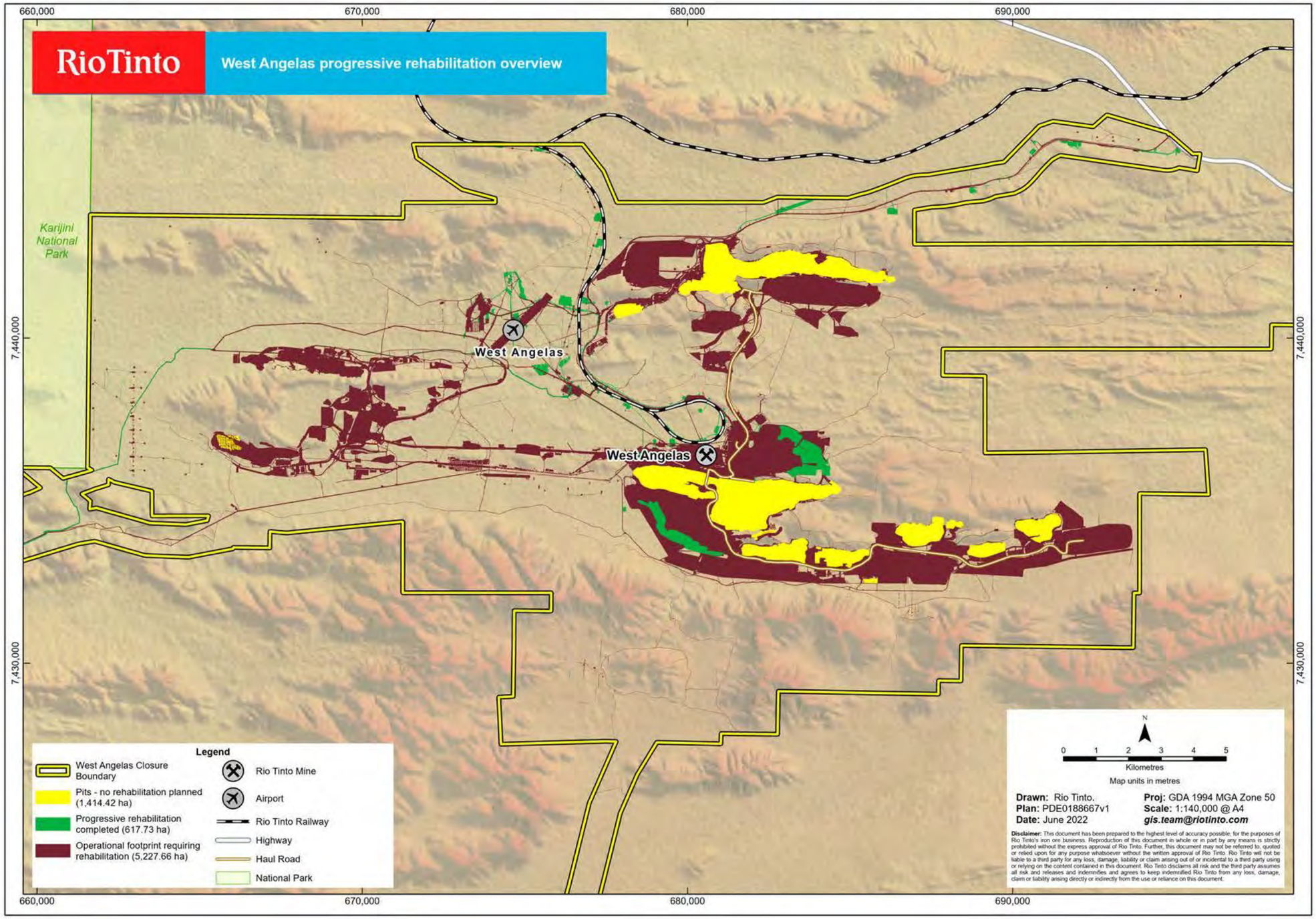

Figure 3: West Angelas progressive rehabilitation areas within operational footprint.

4. MONITORING PROGRAMME

Rio Tinto monitors rehabilitated areas across its Pilbara operations with the objective of obtaining data that will be used to evaluate the success of rehabilitation against biological and erosion completion criteria, as well as supporting adaptive management and continuous improvement of rehabilitation techniques as described in the Rio Tinto Rehabilitation Monitoring Procedure (Rio Tinto 2019b).

Analysis of monitoring results provides information to inform the development of Specific, Measurable, Achievable, Relevant and Time-Bound (SMART) completion criteria, by examining changes in key parameters over time and comparing results from the rehabilitation with those from corresponding reference sites in undisturbed areas. Such analysis of monitoring results will also be used to indicate the likely success of progressive rehabilitation in achieving completion criteria and whether any areas of rehabilitation require rework due to poor performance.

4.1. Monitoring schedule and design factors

Rehabilitation monitoring is scheduled using a risk-based approach to determine the appropriate monitoring technique and frequency. Where possible, monitoring is completed annually for the first three years following rehabilitation, then in years 5, 7, 9, 12 and 15, and then every third year thereafter. Frequency of monitoring may be altered depending on the condition of the rehabilitated site and the availability of resources.

Rehabilitation monitoring is completed in the cooler months (May to September) of each year, noting that COVID restrictions modified the program in 2020 and 2021. The monitoring program design (i.e., monitoring technique and frequency) for each rehabilitated site considers the following factors:

- The level of complexity of the rehabilitation and subsequent risk to rehabilitation quality outcomes (e.g. waste dumps are a high risk whilst low disturbance areas represent a lower risk for achieving desired rehabilitation outcomes).
- The regulatory requirements for rehabilitation monitoring.
- The age of the rehabilitation.
- The overall area of the rehabilitation (i.e., the larger the size, the higher the number of monitoring locations required).
- If there is a trial implemented on some of the rehabilitation, there will be the requirement to monitor each trial plot to record replication data. Also, targeted early monitoring to ensure the collection of germination results of seeded species, rather than only survivability information, will be especially important in the analysis of many trial results).
- Natural disturbance such as fire or cyclonic rainfall (may reset the timing of monitoring to year 1).
- Safe access for monitoring personnel.

4.2. Rehabilitation monitoring methods

Monitoring methods utilised by Rio Tinto include:

- **Rehabilitation Quality Assessments (RQAs) and photo point monitoring**: These observational assessments are used on low to moderate disturbance areas, historical rehabilitation with no monitoring history, or on areas too small for transects. They can also be used in combination with the above transect methods on large rehabilitation areas to manage monitoring resources efficiently. The purpose is to gain an overview of the rehabilitation quality including erosion, growth medium, vegetation cover, species richness, vegetation structure, plant density, weed presence and general condition. Each characteristic is compared between the rehabilitation and local undisturbed native vegetation and given a score according to the RQA

field book guidelines. A representative photograph is taken of both the rehabilitation and reference areas.

- **Vegetation, fauna habitat and erosion monitoring**: Vegetation monitoring involves establishing quadrats (2 m x 2 m) at 5 m intervals along a 50 m or 100 m transect. Within each quadrat, numbers of all native perennial plant species and weeds are counted, and individual percent cover estimated. The number of bare areas is assessed by dividing the edge of each quadrat on the transect baseline into eight x 25 cm sections and recording the number that has no perennial plant species cover. A subjective assessment of total native perennial plant cover (%) is also recorded for each quadrat. Notes are taken of the general condition of the rehabilitation, including new disturbance and fire damage. The term 'spinifex' in this report refers to *Triodia* species.

  Fauna and habitat monitoring comprises estimating litter cover, noting rocks and logs in each quadrat, and a whole-of-transect assessment of grazing extent, native animal scats, ant numbers, and other indicators of animal activity.

  Erosion monitoring entails an examination of a permanent vegetation transect to identify the presence and number of gullies that are greater than 30 cm in depth. Gully locations and associated measurements of total width and depth at the deepest point are recorded. Comparisons of data collected over time can determine if a landform has stabilised or if it is exhibiting rates of erosion which require intervention. Eroded areas that may require intervention are then investigated for potential rework opportunities.

4.2.1. Revegetation completion criteria

Vegetation on rehabilitated land has been identified as a key outcome in evaluating the site condition at closure and compatibility with the post-mining land use. All progressive rehabilitation undertaken during operations is required to meet the closure outcomes / completion criteria described within the associated MCP. Broadly, the desired closure outcomes help align the rehabilitation methodology with the objectives of establishing a safe, stable, and non-polluting landscape vegetated with native species of local provenance, and ensuring the site is compatible with proposed post-mining land use.

Based on recent work undertaken by Rio Tinto and Stantec (Stantec 2020) on potential biological completion criteria for the Channar mine site, the following key parameters were selected to develop quantitative targets which are applicable across all rehabilitation areas and reference sites:

- **Native perennial species richness and species density**: Species richness is the total number of species in a defined area. This differs from the more comprehensive measurement of species diversity which incorporates relative abundances.

  Species density was calculated as the mean number of species per quadrat and is a valuable measure for monitoring vegetation changes over the long-term. Although not significantly different to species richness, species density can better detect plant responses to a given management action, and unlike species richness, comparative analyses can still be made when transect lengths differ.

- **Native perennial plant density**: Plant density refers to the mean number of plants per unit area. Total counts of native plants were documented for each quadrat and averaged for entire transect values.

- **Native perennial plant cover**: Values for this parameter were obtained with visual assessments for each quadrat of the percentage of surface area with vegetation (i.e. percentage that is not bare). Final values were calculated for each transect as the mean percentage of cover across all quadrats. Due to the subjectivity involved in visually assessing percentage cover, final values are considered estimates only.

The analysis of these parameters is standardised across all Rio Tinto operational sites and is considered appropriate in the development of a consistent approach to determining success of rehabilitation over

time. Rio Tinto is undertaking further work on this approach and will also incorporate feedback when received from stakeholders on the preliminary Channar monitoring strategy present in the MCP (2020). Further refinements of completion criteria will be presented in future updates to closure plans and progressive rehabilitation performance summaries.

The preliminary completion criteria for West Angelas closure are presented in Table 4 below, with the associated monitoring methods and means of verification (vegetation parameters). These will be refined further as mining progresses to ensure they are SMART, as defined by Young *et al* (2019). Application of the SMART principle facilitates a systematic and comprehensive framework for goal formation. Any refinements of parameter targets will be presented in future updates of the West Angelas MCP and this Summary.

Table 4: West Angelas preliminary completion criteria.

CLOSURE OUTCOME	PRELIMINARY COMPLETION CRITERIA	UNIT AND METHOD(S) OF VERIFICATION
Vegetation on rehabilitated land is self-sustaining and compatible with the post-mining land use	• Seed used in rehabilitation works is of local[1] provenance.	• Seed management plan. • Analysis of historical monitoring data
	• Recruitment of native perennial plants is observed.	• Rehabilitation monitoring/site inspections. • Number of native perennial plants per m^2
	• Native plants within rehabilitated areas are observed to flower and/or fruit.	• Rehabilitation monitoring/site inspections. • Reproductive activity • Species flowering/fruiting
	• Species richness of native perennial plants within rehabilitated areas is not less than reference sites.	• Rehabilitation monitoring/site inspections. • Number of perennial plants species per m^2
	• Diversity and abundance of weed species recorded within rehabilitation areas will be no higher than within established reference sites.	• Rehabilitation monitoring/site inspections. • Weed cover (%) • Proportion of weed cover to total perennial cover • Weed species count
The final landform is stable, and its design considers hydrological factors.	• No erosion features that compromise landform integrity or stability are present. • Erosion from landforms does not threaten the health of surrounding natural ecosystems	• Depth and width and length of rills/gullies. • Erosion monitoring to quantitatively evaluate behaviour of rills and gullies over time (increasing depth width or length may indicate need for further management)

[1] Local is defined as Pilbara IBRA and/or as defined in NVCPs

CLOSURE OUTCOME	PRELIMINARY COMPLETION CRITERIA	UNIT AND METHOD(S) OF VERIFICATION
	• The final landform has been designed and constructed with consideration given to its stability during intense rainfall and large flood events. • Final landforms are outside pit crest zones of instability	• Post-construction review by competent person to ensure landforms were built in accordance with plan, including QA/QC checks. • Analysis of aerial imagery to provide qualitative analysis of landform stability

4.2.2. Rehabilitation monitoring reference sites

Overview

To obtain meaningful information on rehabilitation outcomes, suitable reference sites are required for comparative purposes. The location, topography and vegetative structure of the rehabilitated area are the key considerations when selecting a reference site, which will ideally represent the natural landscape surrounding the operational area. Additional factors and potential limitations that are also considered during reference site selection include approval boundaries, exclusion areas, final landform designs, mine planning, accessibility and safety factors. Consequently, the distance between rehabilitation and reference sites can vary.

Reference sites are positioned within undisturbed native vegetation representative of the local area where the rehabilitation is to be conducted. Appropriately positioned monitoring reference sites will encompass the target vegetation community to provide the baseline vegetation criteria used for assessing rehabilitation progress and outcomes and, where possible, enable a comparison to similar undisturbed areas. Reference sites are located on different topography types (upper slopes / hilltops, mid-slopes and lower slopes and flats) to account for spatial variations of mined landforms and their influencing factors.

The monitoring of reference sites provides a temporal record of natural variations in established vegetation through time which can offer valuable insights into the influence of non-mining related variables such as climate or fire events. Monitoring data obtained from reference sites also assists in the planning of rehabilitation by informing methodology, such as the development of seed lists. Using a range of reference sites is endorsed to better facilitate a comprehensive assessment of rehabilitation progress.

West Angelas reference sites

Nine control sites were established and first monitored at West Angelas in 2009 (C1 – C9), although four sites (C1, C2, C5 and C6) were not included in any subsequent monitoring events and have been classified as inactive. Reference data was obtained in varying years from the remaining five control sites, all of which were burnt at some point between 2010 and 2021 (see Table 5 for further details).

Ideally, rehabilitation data is compared to reference sites monitored in the same years to account for variations in climatic conditions (such as above or below average rainfall) that may influence vegetation parameters. However, several West Angelas reference sites historically used for comparison were either not monitored frequently enough to provide appropriate reference data or were destroyed. As such, West Angelas reference site selection is inconsistent and often resulted in the inclusion of inappropriate reference sites as comparison to rehabilitation. Reference site selection and establishment is currently under review to develop an appropriate methodology which ensures such issues are avoided.

Reference sites C8 and C9 are the only two located on flat terrain thus have been utilised within this Summary for all corresponding flat borrow pit rehabilitation sites. Reference site selection for borrow pit

rehabilitation was inconsistent between monitoring assessments, with C7 used in four, non-consecutive years, and two assessments included use of less suitable sloped reference sites, C3 and C4. Reference site C7 is topographically categorised as lower slope, however field notes recommend disregarding the site, declaring it an inappropriate analogue due to its location on a creek line resulting in a vegetation complex unreflective of the rehabilitation target community *(Jeffry Cargill, Rehabilitation Monitoring Schedule_v1.8.1*). Although C7 was included in the 2018 monitoring assessment, based on the field notes, C7 has not been included for rehabilitation performance analyses within this Summary.

The sloped topography of reference sites C3 and C4 is appropriate for evaluating rehabilitation performance of the East and South Waste Dumps, although neither aligns with the mid-slope classification for three of the four rehabilitation transects. The only mid-slope reference site established at West Angelas is no longer active, having only been monitored once in 2009. As with borrow pits, East and South Waste Dump monitoring assessments are inconsistent in their selection of controls, with ad-hoc inclusions of C7, C8 and C9 in one or more monitoring report.

Due to the same fire affecting reference sites C3 and C4, this Summary has included C8 and C9 for evaluating rehabilitation performance at the East and South WD sites. Although the flat topography of C8 and C9 theoretically renders them inappropriate analogues for waste dump sites, the lower slope location of EastWD_T1 is in fact flat terrain (*West Angelas - Rehabilitation Monitoring Report – 2017)*, thus C8 / C9 suitability is retained.

Monitoring reports refer to C8 as the “unburnt reference site”. The designation of C8 as an ‘unburnt reference’ is questionable due to reports documenting up to 45% of the site was burnt in 2011/12 (Table 5).

Five control sites were established and first monitored at the Gas Pipeline rehabilitation in 2015, with all five also monitored the following year. Three sites were inaccessible in 2017 so monitoring was only conducted at two reference transects, GasPL_C1 and GasPL_C5, the former of which had been entirely burnt prior to the 2016 survey.

Reference sites at West Angelas are shown in Figure 4 below.

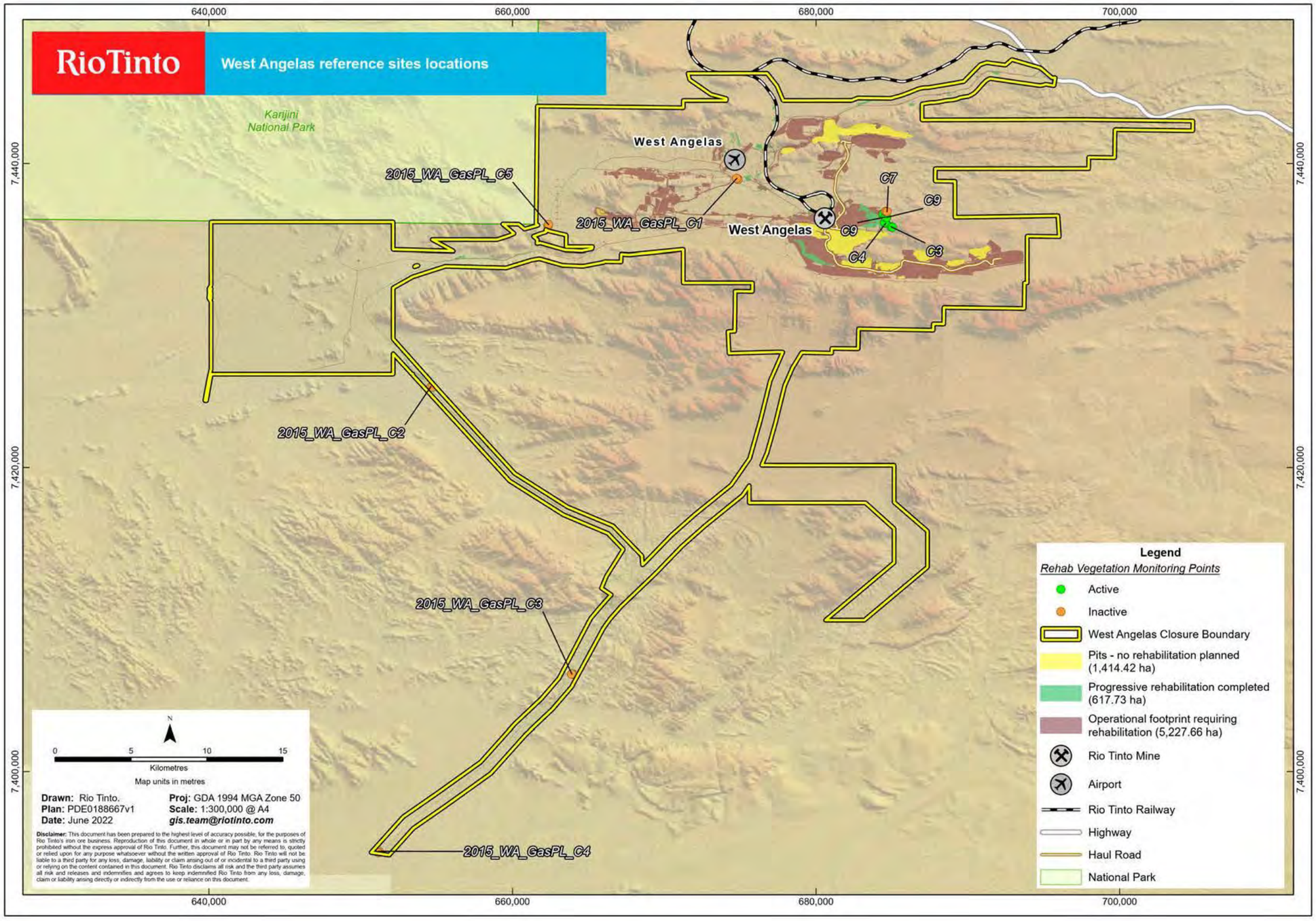

Figure 4: West Angelas reference sites location

4.2.3. Climate data

Sources of climate data

Rainfall and temperature data utilised for the progressive rehabilitation monitoring program is sourced from nearby Bureau of Meteorology (BOM) certified weather stations which provide long-term data. Where applicable, Rio weather stations located in adequate proximity to the relevant mine closure boundary are used to provide monthly localised data.

Rio Tinto maintains an automatic weather station at West Angelas but presently there is insufficient data for inclusion in this Summary thus climatic data has been obtained from the nearest certified meteorological station – the Newman Aerodrome BOM Station 007176 which lies approximately 107 km to the East of West Angelas. Climatic data gathered from Station 007176 is considered representative of that experienced at West Angelas and is thus appropriate for utilisation within this Summary.

Local climatic conditions

West Angelas is in the Pilbara region of Western Australia which has an arid climate and experiences regular cyclonic activity during November to March. Characteristic climatic features of the region include seasonally low rainfall with high temperatures, high evaporation rates and high daily temperature range.

Rainfall occurs predominantly in the summer months as low- pressure troughs descend into the region, with resultant tropical cyclones bringing heavy rain to inland areas. The resulting frequent summer thunderstorm activity and occasional protracted rainfall are characteristic to the Pilbara region.

The rainfall distribution typically experienced at West Angelas is bi-modal, peaking in December to February and May to June, resulting from the influence by two main climatic systems:

- the northern rainfall system of tropical origin; and
- the southern winter rainfall associated with low-pressure frontal systems.

Rainfall and temperature data (reflective of that experienced at West Angelas) obtained from Station 007176 is presented in Figure 5, and demonstrates the following general trends:

- A long-term annual average rainfall (1971 to 2021) of 324.4 mm/year.
- Rainfall during December to February ranges from 35-72 mm per month
- September to November rainfall ranges between 4-12 mm per month.
- Maximum average temperatures generally occur from November to March, during the season of peak rainfall.
- Mean daily maximum temperatures range from 40°C in summer to 23°C in winter.
- The coolest months occur between June and August.

Annual evaporation rates across Australia are depicted in Figure 6, illustrating a rate of 3400 mm for the West Angelas region (BOM, 2021), which vastly exceeds the areas' annual average rainfall. Maximum evaporation rates generally occur in January with approximately 400 mm anticipated in the seasonal peak. These rates can reduce to approximately 125 mm in June.

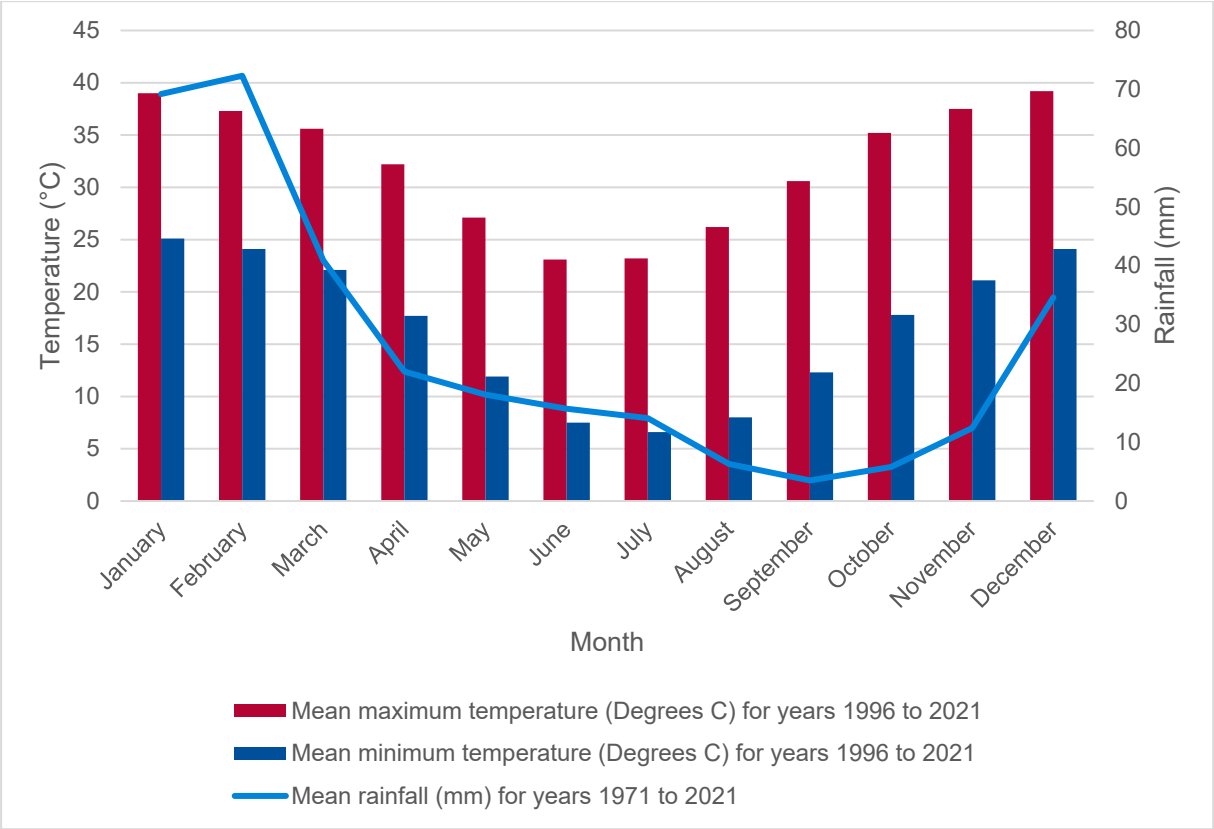

Figure 5: **Long term average mean and maximum rainfall and temperature for Station 007176**

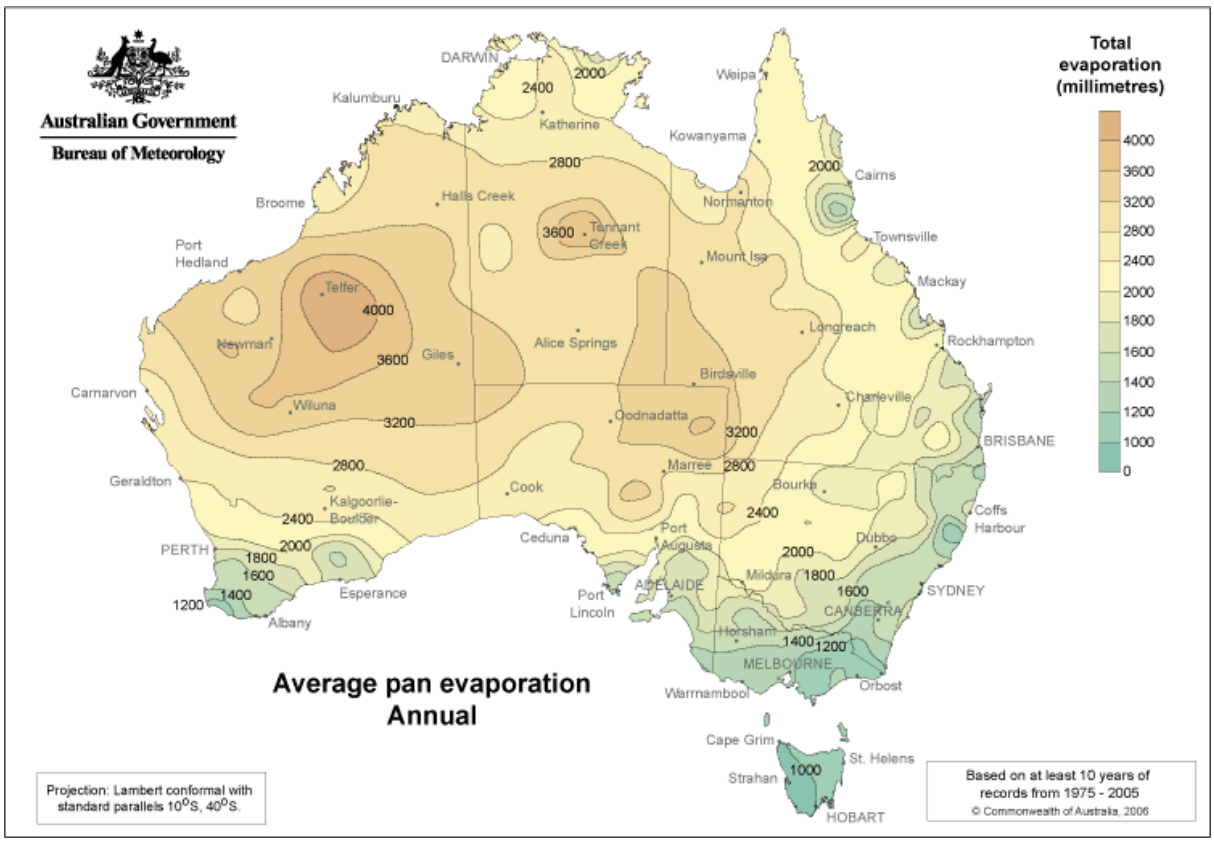

Figure 6: **Average annual evaporation rates across Australia (BOM 2021)**

Implications of this climatic data to the mine closure process include:

- Regional climatic conditions must be considered when scheduling and implementing rehabilitation works to enhance rehabilitation success (i.e. Ensuring adequate access for the covering of Waste Fines Storage Facility (WFSF) surfaces and ripping/seeding scheduling);
- Regional climatic conditions must be considered during waste landform design, in particular the high intensity nature of rainfall during thunderstorms and cyclonic events which is responsible for elevated erosion potential on newly constructed landforms and rehabilitated areas; and
- Regional evaporation rates exceeding annual rainfall will have a significant impact on surface water and soil cover water balances.

Climate change

Rio Tinto accepts the current view of the Intergovernmental Panel on Climate Change (IPCC) that global warming is unequivocal, human influence is clear and physical impacts are unavoidable (IPCC, 2021). Rio Tinto understands that climate change will amplify existing risks in mining, port and rail operations in the Pilbara region.

Rio Tinto recognises a responsibility to act by focusing on a reduction in greenhouse gas emissions (particularly with the use of low emissions technology) and increasing resilience to physical climate change impacts.

Based on the outputs of 40 global climate models (Watterson et al., 2015), climate projections for the Pilbara predict that

- Mean, maximum and minimum temperatures will continue to increase (above the climate of 1986–2005) by 0.6-1.4 °C by 2030 and by 1.3-5.3 °C by 2090.
- There will be a substantial increase in the maximum temperature and frequency of hot days and the duration of hot spells.
- Natural climate variability will continue to drive rainfall variability but an increase in the intensity of heavy rainfall events is projected.
- At Port Hedland, sea level will continue to rise by 0.07-0.17m (above the 1986-2005 level) by 2030 and by 0.28-0.84m by 2090.
- Tropical cyclones may become less frequent, but the proportion of the most intense storms will increase.

Implications of these data and long-term predictions for the mine closure process include:

- Regional climatic conditions must be considered when scheduling and implementing rehabilitation works to enhance rehabilitation success (for example, through ensuring adequate access for the covering of tailings surfaces and ripping/seeding scheduling).
- Regional climatic conditions must be considered during waste landform design, particularly the high intensity of rainfall during thunderstorms and cyclonic events which are responsible for elevated erosion potential on newly constructed landforms and rehabilitated areas.
- Regional evaporation rates exceeding annual rainfall resulting in a significant impact on surface water and soil cover water balances.

Climate change is a complex issue, with inherent uncertainty about the timing, pace and severity of possible impacts. Risks from climate change have been considered in closure planning and include stability of landforms, mobilisation of contaminants and success of revegetation.

Based on climate change projections (Watterson et al., 2015) the reduction in rainfall in the Pilbara over time will be relatively small. However, sensitivity of hydrological processes to small changes in rainfall,

coupled with the expected rise in temperatures and potential evaporation, will have a significant impact on the hydrology of the Pilbara region (Charles et al., 2015). The materialisation of these climate projections is likely to make successful rehabilitation in the Pilbara more challenging.

Climate change resilience

Rio Tinto accepts the climate science assessed by the IPCC which unequivocally shows that human influence has warmed the atmosphere, ocean and land and that widespread and rapid changes in the atmosphere, ocean, cryosphere and biosphere have occurred (IPCC, 2021). Rio Tinto understands that climate change will amplify existing risks in mining, port and rail operations in the Pilbara region and recognises a responsibility to act by focusing on a reduction in greenhouse gas emissions (particularly with the use of low emissions technology); and increasing resilience to physical climate change impacts.

As part of addressing the business, social and environmental risks associated with climate change, Rio Tinto have undertaken the following:

- Established emission reductions targets: 15% reduction by 2025, 50% reduction by 2030 and net zero emissions by 2050.
- Development of a Physical Climate Change Analysis Guidance Note (Rio Tinto, 2022) which sets out:
    - The physical climate change risk analysis process for identification and evaluation of material risks from climate change on our assets and communities.
    - The key requirements to be utilised in all climate modelling for Rio Tinto assets, including future time horizons; climate scenarios; climate variables; time steps and spatial resolution.
- Engaged a climate data service provider to provide Rio Tinto with high-quality and site-specific climate change projections using the latest generation Coupled Modelled Intercomparison Project Phase 6 (CMIP6) modelling.
- Conducted the Pilbara physical risk assessment workshops between June and August 2022 which identified priority risks for evaluation and future inclusion in the relevant mine risk registers, including the closure risk register.
- As a signatory to the Global Industry Standard for Tailings Management (GISTM), uncertainty and impacts associated with climate change will be considered in all TSF closure designs through the six specific requirements of GISTM relating to climate change.

5. SUMMARY OF REHABILITATION PERFORMANCE

Examples of monitoring outcomes of key rehabilitation areas at within the West Angelas closure boundary provide contemporary scientific evidence of the success of rehabilitation undertaken to date in the area. Summaries of key rehabilitation areas within the West Angelas closure boundary are outlined in the associated MCP.

Interpretations and analyses of rehabilitation monitoring results were limited to a moderate extent by deficiencies in pre-2010 records of rehabilitation methodology. For example, the use of ameliorant was rarely documented so any potential correlation with successful rehabilitation outcomes will not be evident. Data and document management is currently undergoing a significant upgrade to alleviate the issue. Detailed close-out reports will be completed for all future rehabilitation works, following a standardised approach which utilises up-to-date databases and document control methods.

5.1. Rainfall and temperature

Rainfall was above average in July 2004, prior to rehabilitation of the Highway Access Road, Railway Loop and Airstrip. However ensuing rainfall was below average until July 2005, with high rainfall not received until summer 2005/06. As monitoring did not commence at these sites until 2010, it is unknown whether the establishing vegetation was affected by these rainfall conditions.

Rainfall in 2009 and 2010 was well below-average and the prolonged dry conditions from April 2009 to July 2010 may have hindered plant growth and establishment at sites rehabilitated prior to 2009 (Highway Access Road, Railway Loop, and Airstrip). It is unlikely that initial germination rates would have been affected at these three sites, due to rehabilitation being completed five to six years prior. Impacts to vegetation were most evident within species and plant density trends, with low values consistently recorded across all three sites in 2010, reflecting how the extensive dry conditions limited further growth, potentially preventing the sustained presence of already established plants.

Since the 2012 completion of East and South waste dump rehabilitation, West Angelas monthly rainfall has been consistent with the long-term trend of higher rainfall over the summer months (December to February) and lower rainfall during the rest of the year. Yearly rainfall totals have been consistently above the long-term average of 253 mm, which would have generally aided seed germination and plant establishment. High rainfall events (double the average monthly rainfall) were recorded in December and January 2014, March 2015, and January and February 2017, facilitating further growth of establishing plants at the East and South WD site.

Additionally, the high rainfall in January 2014 and March 2015 likely provided adequate conditions for seed germination at the West Angelas Access Road, and Gas Pipeline rehabilitation sites, where works were completed in 2015 and 2014 respectively. Despite small rainfall events occurring over the subsequent months, potentially hindering seedling establishment, the period from October 2014 through to July 2015 was generally wetter than normal, including large peak rainfall events. Furthermore, sufficient rainfall was received during summer and winter of 2016, and in early 2017, further enhancing favourable conditions for continued establishment of existing vegetation and may have initiated additional seed germination.

Little rainfall was received in the latter half of 2017, with dry conditions sustained throughout 2018 and 2019. Negligible rainfall was received prior to the 2019 assessment, with West Angelas recording levels well below the long term annual and summer averages. A nominal 90 mm of rain fell during the twelve months prior to the 2019 assessment which may be considered as the impetus for post-2017 declining trends (in density parameters), such as those observed at the Airstrip, Highway Access Road and East and South waste dumps.

Below average rainfall continued into early 2020, which may have inhibited initial seed germination and survival on the newly (2020) rehabilitated Deposit A South waste dump. However, the substantial, above average rainfall, received in February 2020 should have counteracted any detrimental effects at this site as well as providing favourable conditions for seed germination at the 2021 rehabilitated Deposit B North waste dump. Conversely, atypically high rainfall has the potential to increase erosion at newly rehabilitated waste dumps, resulting in the formation of gullies, which will be assessed throughout monitoring of the waste dump sites.

Annual temperatures were consistently in line with the average expected across West Angelas rehabilitation sites.

5.2. Fire

Obtaining a comprehensive understanding of vegetation parameter dynamics in post-fire communities is highly valuable for rehabilitation in Western Australia due to the climate-induced, increasing prevalence of fire. The parallels observed between vegetation parameter trends at early rehabilitation sites and at burnt sites are also cause for furthering the current knowledge base on fire-affected communities, and to facilitate this, exploring the potential for undertaking additional monitoring at burnt sites.

As fire is a natural and common occurrence in Pilbara ecosystems, vegetation quadrat data obtained from burnt reference sites can still facilitate meaningful comparisons on the premise that the trends observed reflect a vegetation community in post-fire recovery, and do not represent the target community for rehabilitation. Monitoring data may also be valuable to anticipate post-fire recovery trajectories at burnt rehabilitation transects.

Details of burnt sites within the West Angelas closure boundary are provided in Table 5 and Table 6.

Table 5: Overview of burnt reference sites.

REFERENCE SITE	MONITORING YEARS BETWEEN WHICH BURNING OCCURRED	PERCENTAGE OF QUADRATS BURNT
WAN_C3	2015 and 2017	100%
WAN_C4	2015 and 2017	100%
WAN_C7	2016 and 2018	95%
WAN_C8	2010 and 2012	45%
WAN_C9	2016 and 2017	90%
GasPL_C1	2015 and 2016	100%

Table 6: Overview of burnt rehabilitation sites

REHABILITATION SITE	MONITORING YEARS BETWEEN WHICH BURNING OCCURRED	PERCENTAGE OF QUADRATS BURNT
Airstrip_T3	2014 and 2017	65%
Highway_T3	2014 and 2017	20%
Highway_T5	2014 and 2017	63%
GasPL_T1	2015 and 2016	85%

5.3. Low impact disturbance areas

West Angelas low impact disturbance areas include infrastructure construction areas and a landfill site.

Low impact disturbance areas designated for rehabilitation are monitored with the RQA method. This Summary focuses on vegetation quadrat monitoring data (typically used for moderate and high disturbance) as it provides greater analytic value for informing rehabilitation methodology. For this reason, no low impact disturbance areas have been included in this Summary.

5.4. Monitoring results – Moderate impact disturbance areas

Areas disturbed by moderate impacts at West Angelas comprise infrastructure and borrow pit sites. Borrow pits are an inevitable disturbance consequence of mining so to gain a comprehensive understanding of outcomes at these sites, West Angelas borrow pit monitoring data has been collectively analysed (Table 8), with available rehabilitation methodology information for the borrow pit sites presented in Table 7.

By developing a baseline catalogue of borrow pit rehabilitation outcomes, emergent patterns and trends can be clarified to better inform future rehabilitation of borrow pits. Evaluating outcomes in this collective manner will better inform future rehabilitation methodology and design parameters, and ultimately facilitate an increasing assurance in successful outcomes. Strategies and design parameters can be refined with the continual input of new data, resulting in, for example, an enhanced risk management process and less requirements for rework.

Table 7: West Angelas borrow pits rehabilitation overview.

REHABILITATION PARAMETER	SITE			
	West Angelas Access Road	**Highway Access Road**	**Railway Loop**	**Airstrip**
# Active transects (monitored)	3	5	2	2
Area (ha)	N/A	N/A	N/A	N/A
Closure domain	Borrow pit	Borrow pit	Borrow pit	Borrow pit
Year of rehab	2015	2004	2004 / 2005	2004
Growth medium	Topsoil	Topsoil	Unknown	Unknown
Depth of growth medium application (mm)	200 mm	200 mm	Unknown	Unknown
Time of storage of growth medium (yr)	Unknown	Unknown	Unknown	Unknown
Seeding mix	N/A	N/A	N/A	N/A
Seeding rate (kg/ha)	0 kg/ha	0 kg/ha	N/A	N/A
Soil ameliorant (type)	N/A	Unknown	Unknown	Unknown
Rate of application of ameliorant (kg/ha)	N/A	Unknown	Unknown	Unknown
Contour ripping (depth)	Yes (depth not recorded, assumed <1m)	Yes (depth unknown)	Yes (depth unknown)	Yes (depth unknown)
Ripping technique	Dozer Tyne assumption Unknown	Unknown	Unknown	Unknown

Table 8: West Angelas borrow pit rehabilitation and reference sites monitoring overview.

MONITORING	SITE					TOTAL / RANGE
	West Angelas Access Road	**Highway Access Road**	**Railway Loop**	**Airstrip**	***WAN_C8*** ***WAN_C9***	
Year rehabilitation completed / year reference site established	2015	2004	2004 / 2005	2004	2009	
Year of monitoring data	2017					
Number of transects monitored	3	5	1	3	2	14
Range of species richness values	24 to 38	3 to 21	3	7 to 16	20 to 26	3 to 38
Range of species density values	5.2 to 7.1	0.8 to 5.9	0.5	1.6 to 2.5	2.4 to 4.7	0.5 to 7.1
Range of plant density values	9.5 to 12.9	2.6 to 70.9	0.5	2.7 to 13	6.4 to 202.3	0.5 to 202.3
Range of spinifex density values	1.3 to 3.8	0.2 to 44.3	0	2.7 to 13.0	2.9 to 187.4	0 to 187.4
Range of total cover values (%)	26.2 to 36.5 %	29.6 to 60.8 %	2.5 %	20.1 to 53.5 %	14.3 to 27.9 %	2.5 to 60.8 %
Range of spinifex cover values (%)	1.5 to 3.6 %	5.0 to 51.5 %	0 %	3.8 to 29.1 %	9.2 %	0 to 51.5 %

MONITORING	SITE					TOTAL / RANGE
	West Angelas Access Road	**Highway Access Road**	**Railway Loop**	**Airstrip**	***WAN_C8*** ***WAN_C9***	
Range of weed cover values (%)	0 %	0 %	20.8 % (*C. ciliaris)* 43.5 %(*C. setiger)*	0 to 1.4 % (*B.bipinnata)*	0 %	0 to 43.5 %
Range of weed density values	0	0	9.2 (*C. ciliaris)* 14.5 (*C. setiger)*	0 to 1.2 (*B.bipinnata)*	0	0 to 14.5
Range of percentages of quadrats with weeds present	0 %	0 %	100 %	0 to 30 %	0 %	0 to 100 %
Range of percentages of quadrats with annuals present	5 to 75 %	0 to 80 %	0 %	40 to 100 %	70 to 100 %	0 to 100 %
Range of # of species flowering / fruiting (inc. walkaround assessment)	-	-	-	-	-	-
Erosion (number of gullies)	0 gullies	0 gullies	0 gullies	0 gullies	0 gullies	0 gullies

5.4.1. West Angelas Access Road

Encouraging results in species richness and density were observed at the West Angelas Access Road rehabilitation site, two years since completion of works. It should be noted that the high species richness values may be partially due to the 100 m length of the transects, compared to, the 40-50 m Highway Access Road transects where less species were recorded. Considering the relatively young age of the rehabilitation, each transect exhibited improvement in total plant cover, most apparent within AccessRd_T1, as evidenced by Figure 7 and Figure 8 below.

Species density and plant density trends observed in 2018 (two years post rehabilitation) are characteristic of early-stage rehabilitation, where colonising species establish quickly in the preliminary years, and the short-lived species senesce shortly after.

The rehabilitation exhibited some key species associated with the target vegetation community and which were present at reference sites. However, the extent of *Triodia* cover across the rehabilitation was unsatisfactory, and the transects did not share floristic similarity with the reference transects. There was considerable variation between the rehabilitation transects and burnt reference C9, whilst no significant differences were found in comparison to C8.

Figure 7: WAN_Access_Rd_Upgrade_BP_T1 (end) 2016

Figure 8: WAN_Access_Rd_Upgrade_BP_T1 (end) 2018

Native perennial species density

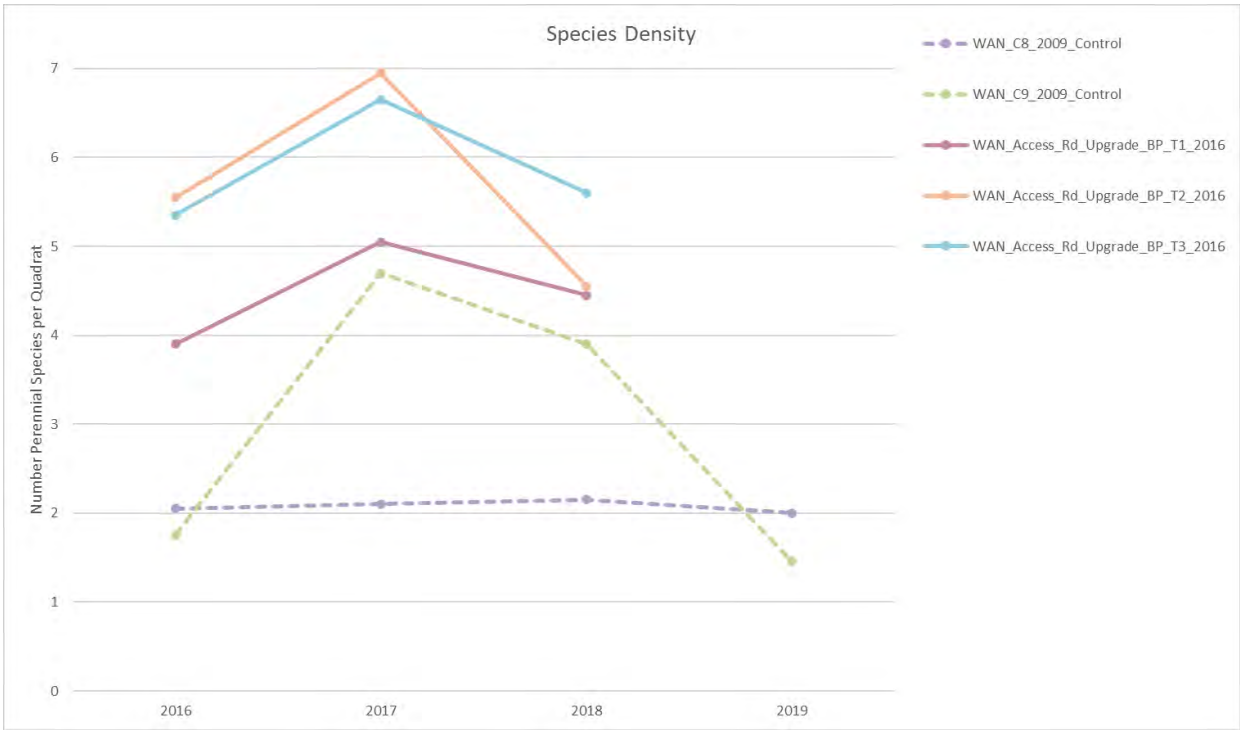

Figure 9: Native perennial species density (species/ quadrat) for the West Angelas Access Road rehabilitation and reference sites over time

The number of species per quadrat recorded in the first year of monitoring (2016) was higher at all rehabilitation transects compared to the reference sites, with similar trends observed across the rehabilitation over the three monitoring years (Figure 9). Species density increased at the rehabilitation between 2016 and 2017, with higher resultant values at each rehabilitation transect than the reference sites (Table 8).

Inverse trends were observed the following year, with AccessRd_T2 declining at the highest rate, from 7 species per quadrat (the highest value recorded for any transect throughout entire monitoring period) to 4.6. Despite declines being recorded across the rehabilitation during the last monitoring event, species density at all three transects in 2018 was comparable to or higher than the reference site range, indicating an overall successful outcome for species establishment in early rehabilitation. Furthermore, the declines recorded at the rehabilitation transects can be largely attributed to natural succession processes, where short-lived colonising species, such as *Ptilotus calostachyus*, senesce.

Similar trends were observed at reference site C9, demonstrating potential comparability between post-fire recovery sites and early rehabilitation. The rate of change was notably higher at C9, indicating that fire disturbance has a greater influence on vegetation parameters than that of early rehabilitation.

A variety of native *Acacia, Senna and Triodia* species were observed throughout the rehabilitation, and species present in both the reference and rehabilitated communities included *Corchorus lasiocarpus*, *Indigofera monophylla*, *Paraneurachne muelleri* and *Themeda triandra.*

Native perennial plant density

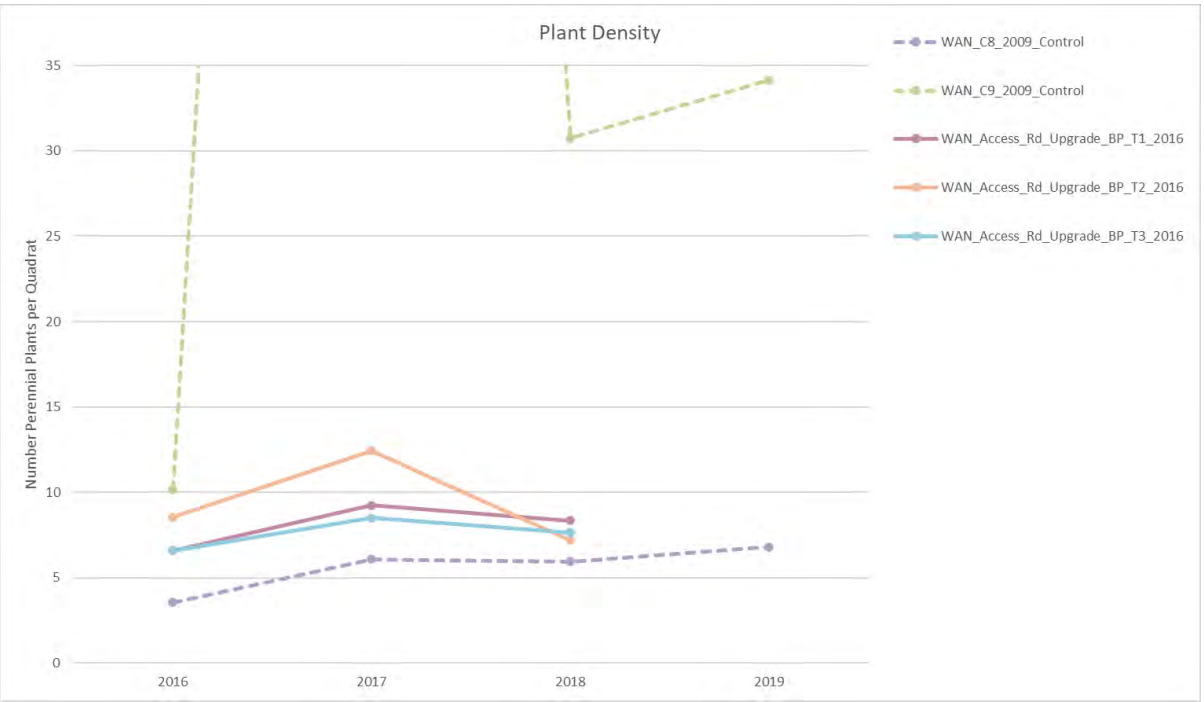

Figure 10: Native perennial plant density (plants/ quadrat) for the West Angelas Access Road rehabilitation and reference sites over time[2]

Initial numbers of plants per quadrat recorded at the rehabilitation transects ranged from 6.7 to 8.6, whilst 4 to 11 were observed at the reference sites. Subsequent statistical analyses of these values indicated comparability of each rehabilitation transect to at least two reference transects. Inclining trends were observed at the rehabilitation transects between 2016 and 2017 with AccessRd_T2 showing the highest rate, increasing by 4.3 plants per quadrat. The following year saw plant density decrease across all rehabilitation transects, revealing similar overall trajectories to those observed for species density. The overall rehabilitation trajectories were most comparable to reference site C8, with no monitoring assessment recording statistically significant variations between this reference and any rehabilitation transect.

The considerable influence of fire disturbance on plant density was evident at reference site C9, where 202 plants per quadrat were documented in 2017, comprising mostly of juvenile *Triodia*. To maintain clarity of rehabilitation trends within Figure 10, the scale used for plant density values does not encompass the 2017 C9 value. Prior to 2017, plant density at C9 was relatively low and stable, like that of other reference sites.

2

Native perennial plant cover

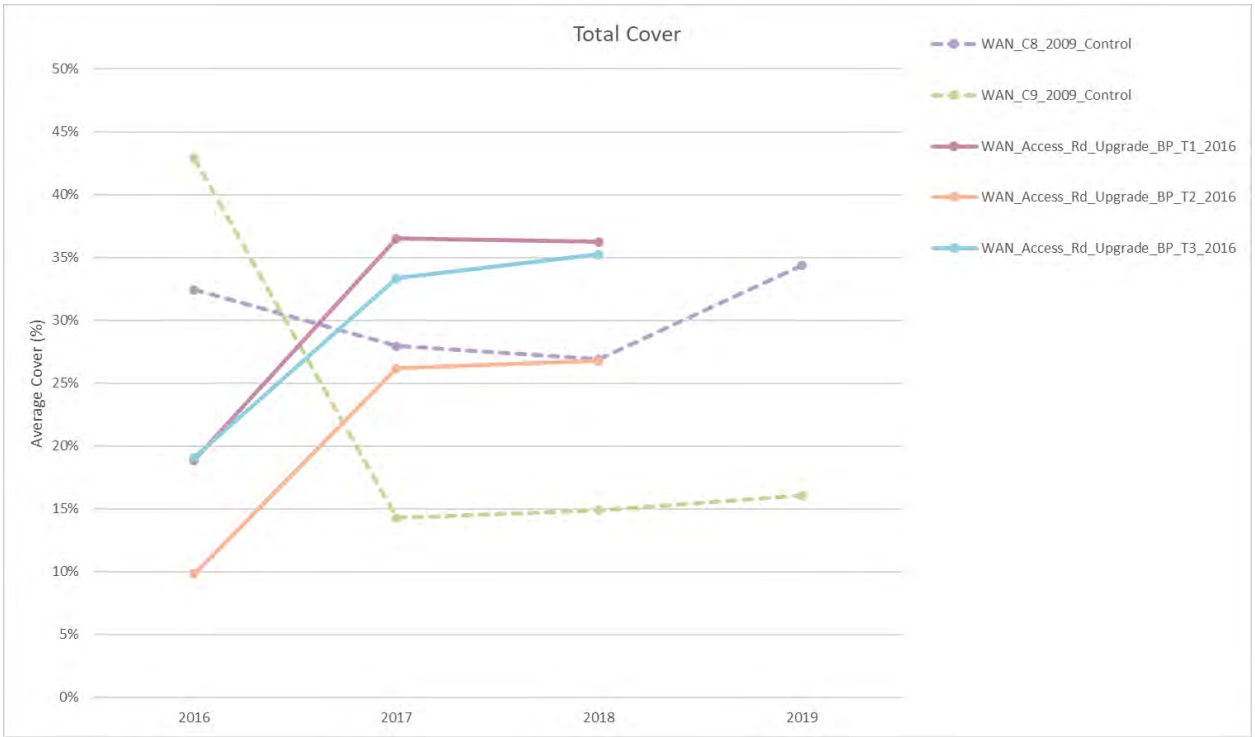

Figure 11: Native perennial total plant cover (%) for the West Angelas Access Road rehabilitation and reference sites over time

Perennial plant cover increased by approximately 15 % at each rehabilitation transect between the first two monitoring assessments, with no or minimal change observed the following year (Figure 11). Significant differences were found in 2016, with all rehabilitation transects having significantly less cover than reference site C9, whilst only AccessRd_T2 was significantly lower than reference site C8. Total perennial cover at all three rehabilitated sites in 2018 was statistically similar to the unburnt reference site (C8) and higher than plant cover at reference site C9.

5.4.2. Highway Access Road

After 13 years, the Highway Access Road had rehabilitated well (Figure 12 and Figure 13). No erosion or weeds were recorded and native vegetation had developed well. Total cover was high and included considerable shrub and/or tree cover, as well as substantial amounts of *Triodia* at most transects. A wide range of native species was recorded, but the floristic composition of the rehabilitation transects was dissimilar to the reference transects. Overall, the Highway Access Road rehabilitation areas were developing well, with the vegetation providing an array of structural and species diversity, which should continue to be self-sustaining.

Characteristic post-fire species density and plant density trajectories were observed at T3 and T5, with greater inclining and declining rates observed at T5, consistent with fire impacting a larger proportion of the transect. The results of the analyses of variation were impeded by the low values observed at C8 across all parameters. Trends derived from vegetation quadrat data at the Highway Access Road rehabilitation are discussed below.

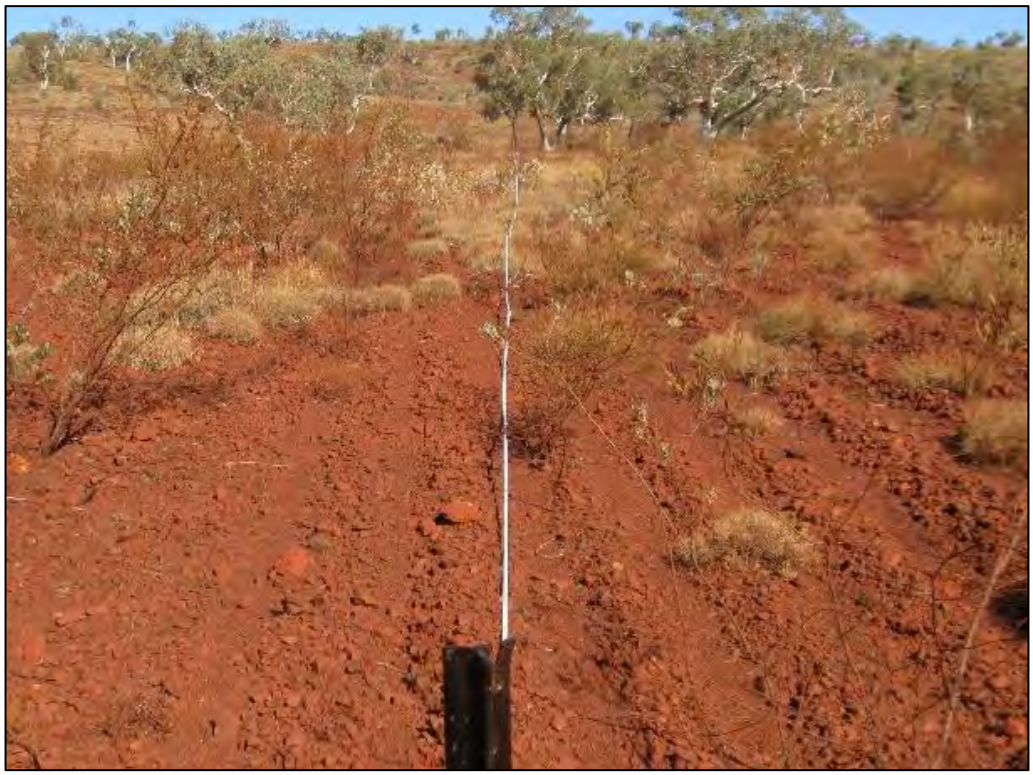

Figure 12: WAN_HwyAccessRoad _T4 (start) 2010

Figure 13: WAN_HwyAccessRoad _T4 (start) 2017

Native perennial species density

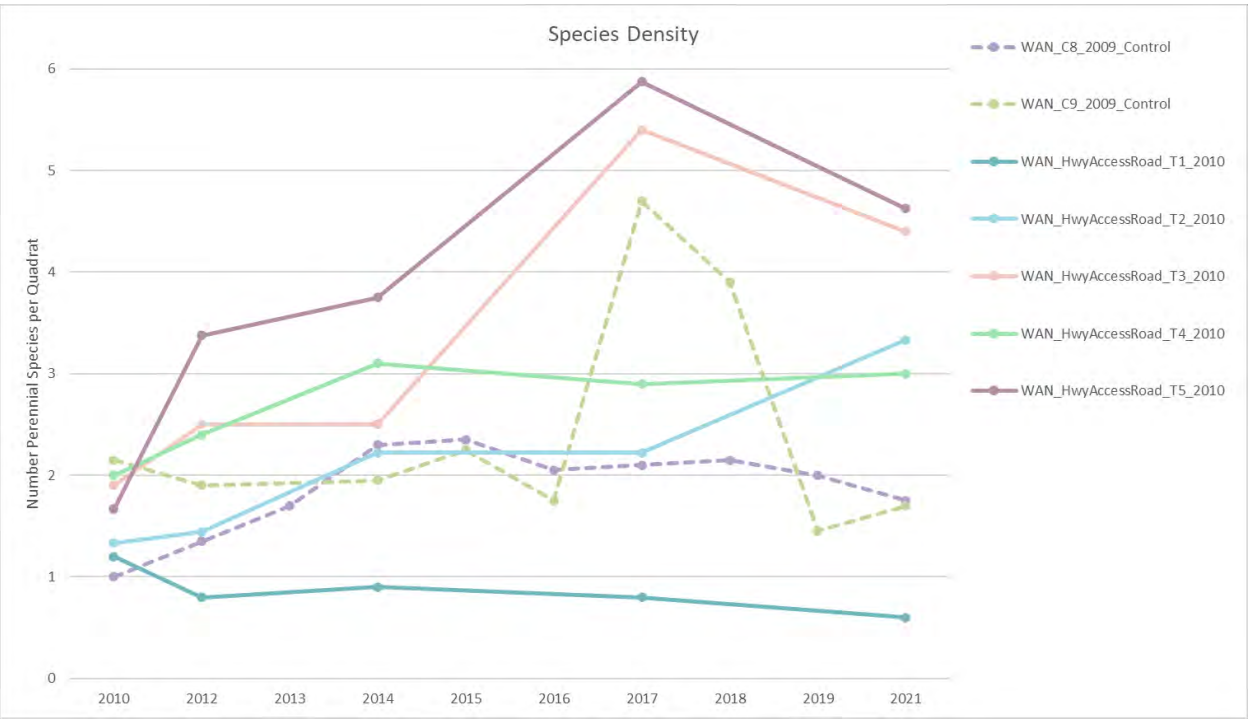

Figure 14: Native perennial species density (species/ quadrat) for the Highway Access Road rehabilitation and reference sites over time

Initial numbers of species per quadrat recorded across the rehabilitation were within the reference range, as both the highest and lowest value was recorded at a control site in 2010 (Figure 14).

Both declining and inclining trends were observed between 2010 and 2012, with losses in species density observed at reference site C9, and rehabilitated sites T1 and T2, whilst gains occurred at all other sites. Excluding HwyAccessRd_T1 which recorded the least number of species per quadrat each year from 2012, species density across the rehabilitation was within the range of values recorded at the reference sites in both 2012 and 2014.

Highway rehabilitation transects T2 and T4 follow parallel trajectories from 2012 to 2017, showing steady inclines until 2014 when species density values stabilize. Trajectories of considerable similarity were also observed at HwyAccessRd_T3 and T5, maintaining comparability from 2012 through to 2021. The 2012 and 2014 assessments recorded relatively constant species density values at T3 and T5, with an increase, consistent with early post-fire establishment, recorded in 2017. As expected in post-fire environments, an ensuing decrease was recorded in 2021.

The unburnt Highway transects had relatively few species per quadrat in 2017, ranging from 0.8 at T1 to 2.9 at T4. The three unburnt rehabilitation transects were most comparable to reference transect C8, where the lowest reference value of 2.1 species per quadrat was observed.

Native perennial plant density

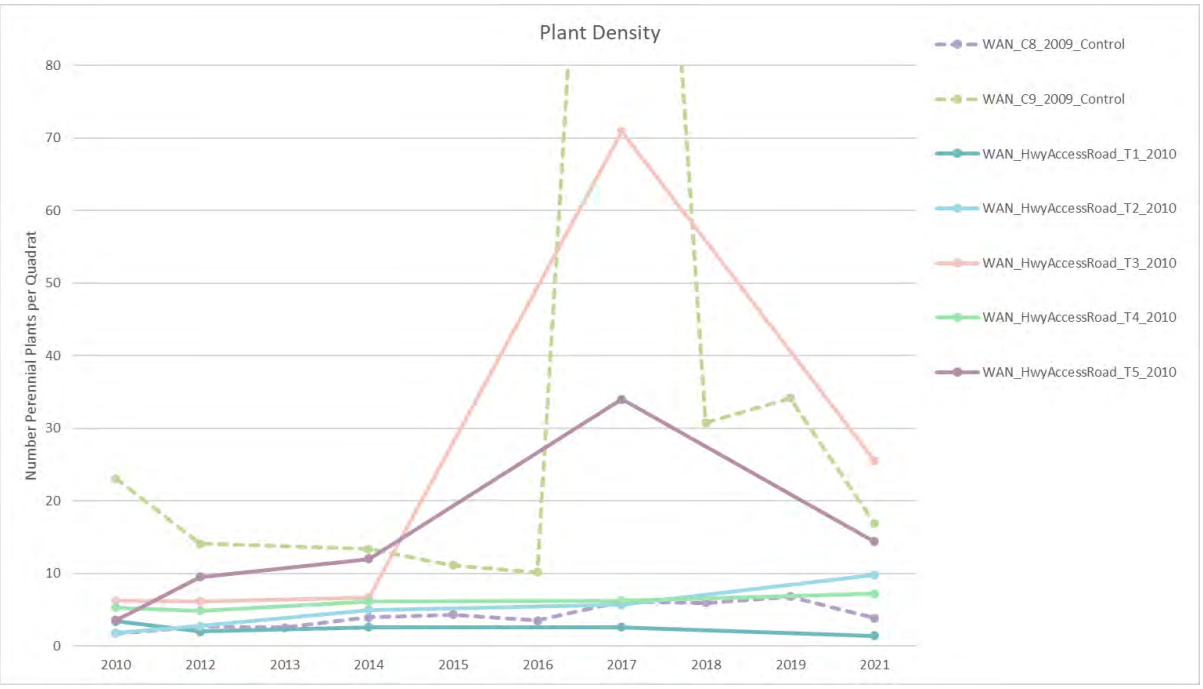

Figure 15: Native perennial plant density (plants/ quadrat) for the Highway Access Road rehabilitation and reference sites over time

The number of plants per quadrat recorded across the rehabilitation in the first year of monitoring ranged from 1.8 at HwyAccessRd_T2 to 6.3 at HwyAccessRd_T3, showing most comparability to reference site C8 (Figure 15). Reference plant densities were significantly higher at C9 with 14.1 plants per quadrat, largely attributed to atypically high numbers of a single species – *Triodia wiseana.* The 2010 and 2012 monitoring assessments documented *Triodia* as the most abundant plant at three rehabilitated transects, and an unidentified native grass at the other two.

Declining trends were observed across all transects between 2010 and 2012, except C8 and HwyAccessRd_T5, with ensuing increases recorded at all transects in 2014.The highest rates of decline were observed at reference site C9 and at rehabilitation transect HwyAccessRd_T2, where an unidentified grass species decreased from 119 plants per quadrat to zero. Highest plant density in 2021 was recorded at C9, with HwyAccessRd_T3 and T5 being the most comparable.

Increases in the number of plants per quadrat observed between 2012 and 2014 were likely facilitated by the good rainfall received between 2012 and 2014. The largest increases occurred at rehabilitation transects HwyAccessRd_T2 and HwyAccessRd_T5, predominately attributed to increasing numbers of *Eriachne mucronata* (at T2) and *Themida trianda* (at T5).

All rehabilitation transects except HwyAccessRd_T1 recorded plant density values within the reference site range for each monitoring year, however this is not the case if C8 is omitted. Statistical analyses found no significant difference between the rehabilitated and reference sites in 2010, 2012 or 2014, although this was strongly influenced by the low density (uncharacteristic of the target vegetation community) recorded in reference site C8.

All Highway Access Road rehabilitation transects except T1 showed an increase in plant density from the first to last monitoring assessment (2010 to 2021). Relatively stable overall trajectories of low plant density were observed at T1, T2 and T4, whilst the influence of fire on plant density was reflected by the post-2014 trajectories of T3 and T5. The number of plants per quadrat post-fire at the two transects increased initially, with a proportionate declining trend observed in subsequent years.

Trends observed at reference site C9 were also indicative of impacts from fire, with plant density increasing and decreasing at a higher rate due to more of the site being burnt. The overall highest plant density value was documented at C9 in 2017, reflecting the early post-fire successional stage of the site. The 202.3 plants per quadrat recorded was mostly comprised by juvenile *Triodia*, as post-fire conditions facilitate increased establishment of perennial grass species.

Native perennial plant cover

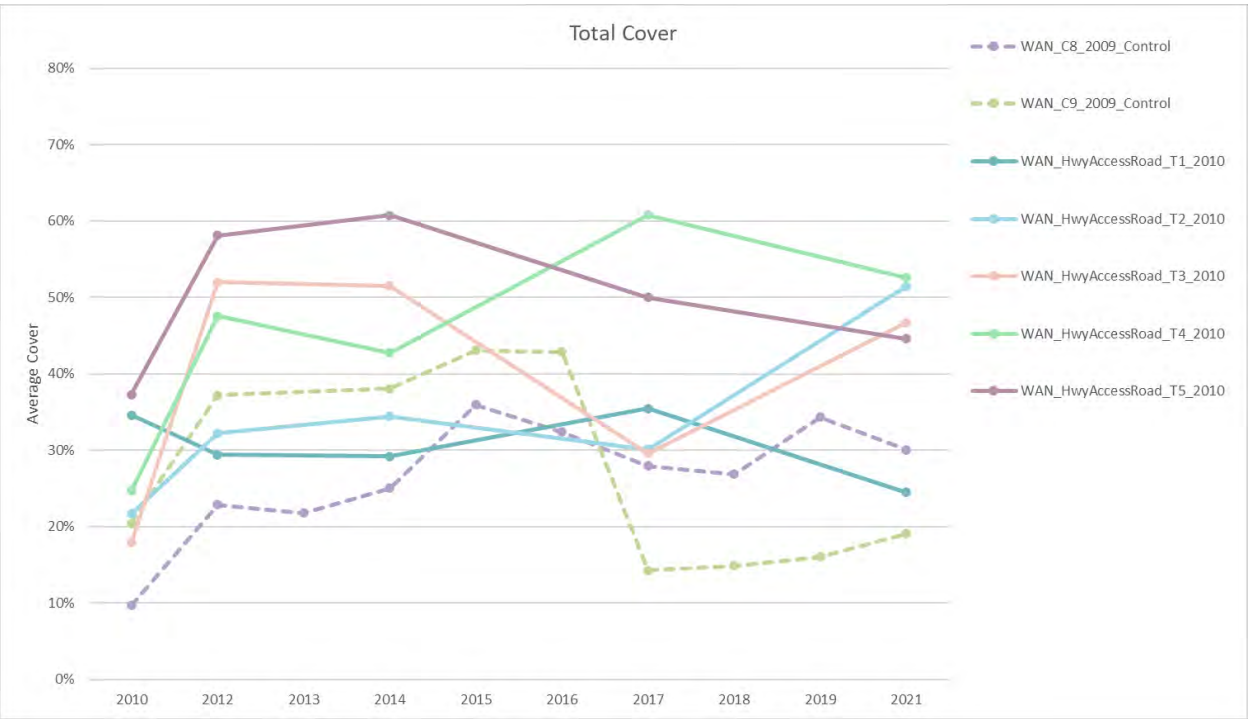

Figure 16: Native perennial total plant cover (%) for the Highway Access Road rehabilitation and reference sites over time

Cover percentages recorded across the rehabilitation in the first year of monitoring ranged from just under 20% at HwyAccessRd_T3 to 37% at HwyAccessRd_T5 (Figure 16). The following assessment recorded inclining trends at all rehabilitation transects except HwyAccessRd_T1, which also had the least amount of perennial cover at the time of the last assessment. Despite the transect gaining cover between 2014 and 2017, it is one of the three rehabilitation transects where considerably low cover was observed in 2017 (T1, T2 and T3). The largest decrease in cover from the previous assessment occurred at T3, where the loss of 22% was attributed to fire. A considerable loss of perennial plant cover between 2014 and 2017 was also evident at the other burnt rehabilitation transect T5. T3 had begun to recover in this parameter as of the 2021 monitoring assessment, whilst cover continued to decline at T5 but at a lower rate. These differing rates of post-fire recovery reflect the differing burnt proportions of each transect (Table 6).

A notable increase in cover was observed at HwyAccessRd_T4 between 2014 and 2017, predominately attributed to high *Triodia* recruitment and resulting in a significantly higher cover value than that of reference transect C8.

An overall increase in cover (from the first to last monitoring event) occurred at all rehabilitation transects, with the smallest increase of 1% observed at HwyAccessRd_T1. Variation between all sites was found to be statistically significant in all years, however there was no overall significant difference between the rehabilitated and reference sites. As per vegetation parameters previously described, these results were heavily influenced by the low values recorded at C8 and at C9 post-fire.

5.4.3. Railway Loop

Twelve years after rehabilitation was completed, the West Angelas Railway Loop sites were performing poorly, with few native species recorded and a complete absence of *Triodia* (rehabilitation performance at T2 demonstrated within Figure 17 and Figure 18). Perennial plant cover had decreased over time, and in 2017 the area was dominated by dense weed grasses (*Cenchrus ciliaris* and *C.setiger)*, with competition from these species likely contributing to the limited establishment of native vegetation.

Four 50 m transects (RL1a, RL1b, RL2 and RL3) were initially established and first monitored in 2010, with subsequent monitoring assessments undertaken at two transects only (RL1a and RL2). Monitoring data was obtained in 2021 for RL3 but due to the significant duration between monitoring events at this transect, the resultant trends do not accurately reflect vegetation parameter dynamics over time and consequently has been omitted from this Summary.

RailwayLoop_T2 and T1a follow roughly parallel trajectories in all three parameters, with the greatest similarity observed for species density and plant density. Less comparability was observed between the two transects for native perennial plant cover, however both show steep initial increases followed by a decline to less than 5% in 2017. Analogous trends in plant cover between 2010 to 2014 observed at T2 and C8 reflect the tendency for early rehabilitation to mimic sites of post-fire conditions.

Figure 17: WAN_Railwayloop_T2 (start) 2010

Figure 18: WAN_Railwayloop_T2 (start) 2017

Native perennial species density

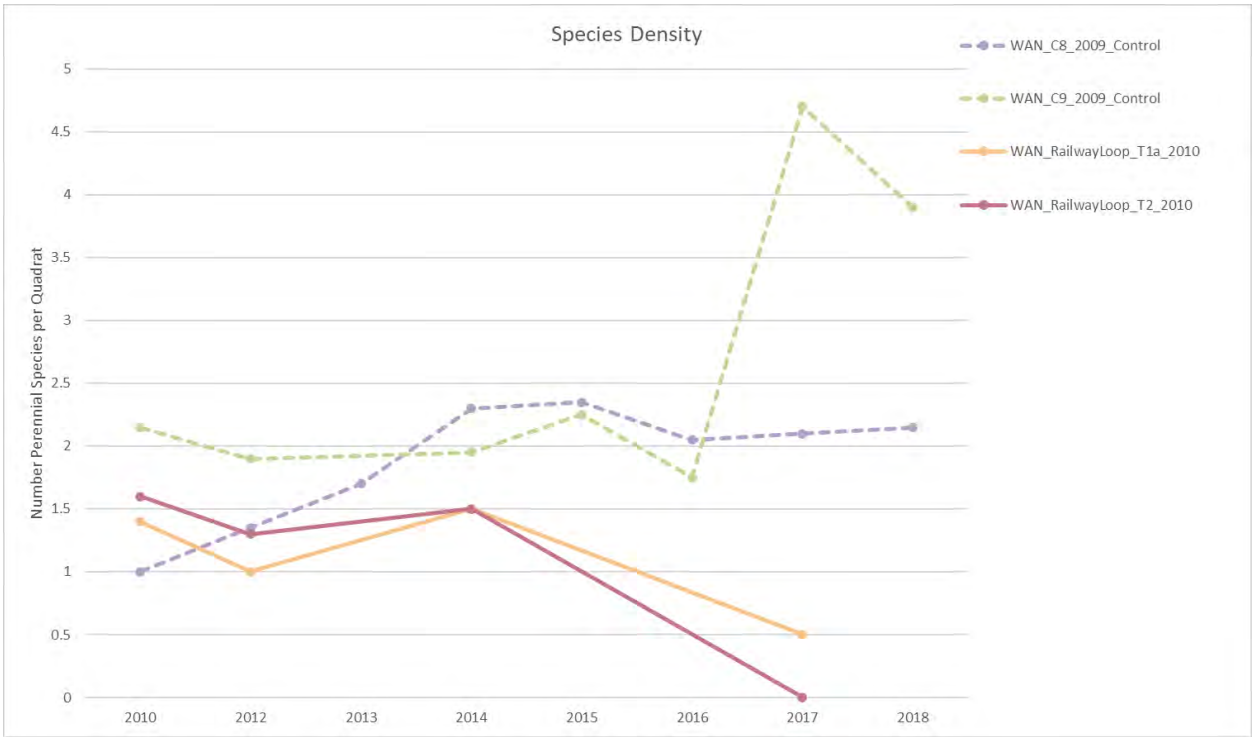

Figure 19: Native perennial species density (species/ quadrat) for the Railway Loop rehabilitation and reference sites over time

Numbers of species per quadrat recorded in the first monitoring year at the rehabilitated sites were within the reference range, although this is dependent on inclusion of reference site C8, which, with only 1 species per quadrat, had the lowest 2010 value (Figure 19). The 2012 and 2014 analyses found similar statistically significant differences, again influenced by the high values recorded at C9.

Species density between 2010 and 2012 declined marginally at the two monitored transects, with RL1a and RL2 losing 0.4 and 0.3 species per quadrat respectively. Values in both cases were below all three reference sites but comparable to C8 which had increased by 0.4 species per quadrat. The two rehabilitated transects showed inclining species density trends from 2012 to 2014, although the 1.5 species per quadrat recorded at both was below the range recorded across the reference sites. Declining trends ensued at both rehabilitated transects, with RL1a losing 1 species per quadrat and T2 decreasing to zero. This resulted in the rehabilitated sites showing significantly higher variation compared to the reference sites. The 2017 assessment recorded considerably more species per quadrat at the three recently burnt reference transects, with the highest value of 5 species per quadrat recorded at C4. The report also documented a dominance of *Cenchrus ciliaris* (Buffel Grass) and *C. setiger* (Birdwood Grass) at rehabilitation transect Rail_T1a, potentially impacting the survival of perennial species.

Native perennial plant density

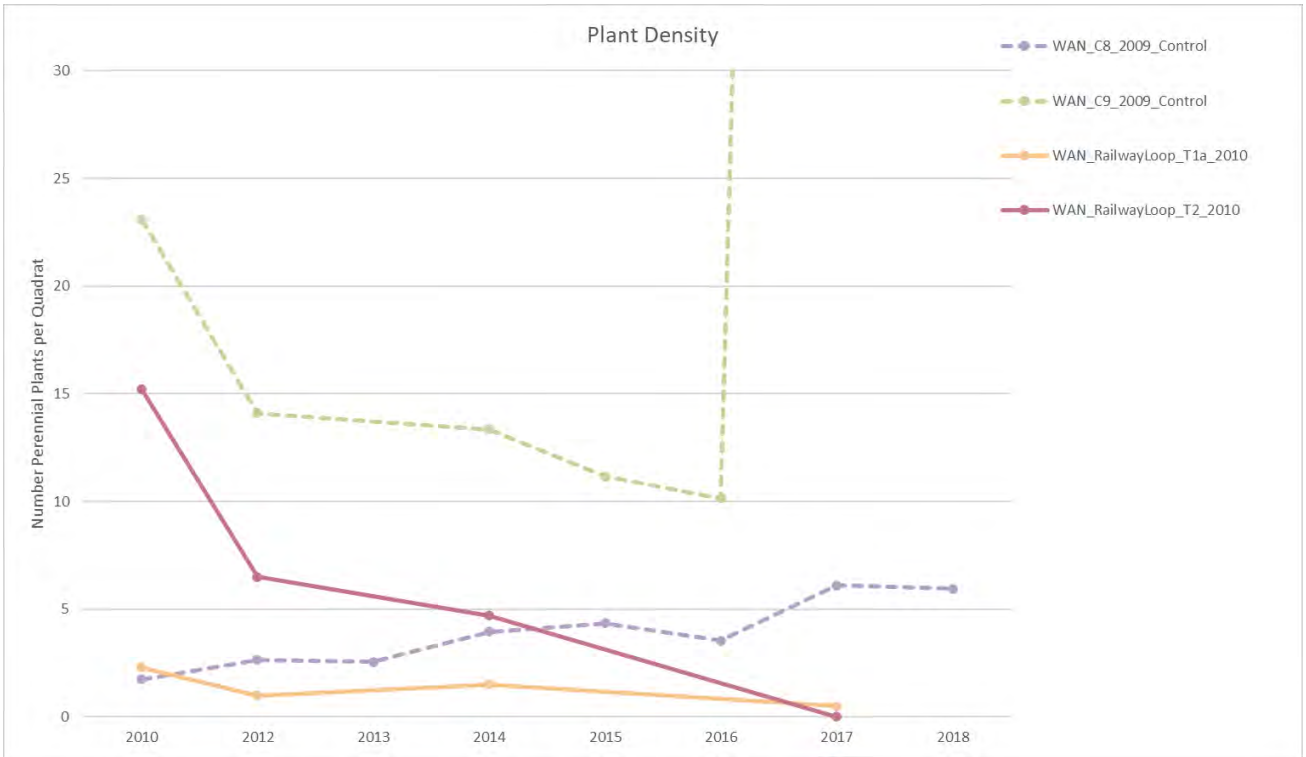

Figure 20: Native perennial plant density (plants/ quadrat) for the Railway Loop rehabilitation and reference sites over time

Plant density across the rehabilitation in 2010 ranged from 2.3 at RL1a to 15.2 at RL2, with all values existing within the reference range on the provision that the uncharacteristically low value recorded at C8 be included (Figure 20). The high number of plants per quadrat documented at RL2 in 2010 was attributed to a high abundance of short-lived *Themeda sp.,* with the ensuing natural senesce of these individuals (particularly *Themeda triandra*) generating the declining trends observed at the transect in subsequent monitoring years.

Plant density at RL1a increased from 1 plant per quadrat in 2012 to 1.5 plants in 2014, whilst decreasing by 1.8 plants per quadrat at RL2. Despite the decline, plant density at RL2 remained within the range of values recorded at the reference sites. Statistical analyses for every monitoring year showed significant differences in plant density between all sites, with the greatest variation observed in 2017 when the post-fire conditions at C9 stimulated a massive surge in plant recruitment and establishment. However, the 2010, 2012 and 2014 assessments found no significant variation in mean values between the rehabilitated and reference sites. Field notes from 2014 indicated the rehabilitation was impacted by dust, potentially resulting in plant degradation and loss at RL1a, whilst impacts were less severe at RL2 where opportunistic annuals had established at high densities.

The 2017 assessment recorded declines in plant density at each rehabilitation transect but comparability to reference transect C8 was maintained. No significant differences were found by pairwise comparison to references C3 and C4, although this is a questionable result considering both C3 and C4 had approximately 120 times the number of plants per quadrat than RL2 (none recorded at RL1a). Substantial increases and corresponding declines occurred at reference transects C9, C3 and C4, reflecting post-fire recruitment of large numbers of juvenile *Triodia*. Plant density had declined at Rail_T1a over time, with only 0.5 plants per quadrat recorded in 2017, which may be affected by the presence of weeds at this site.

Native perennial plant cover

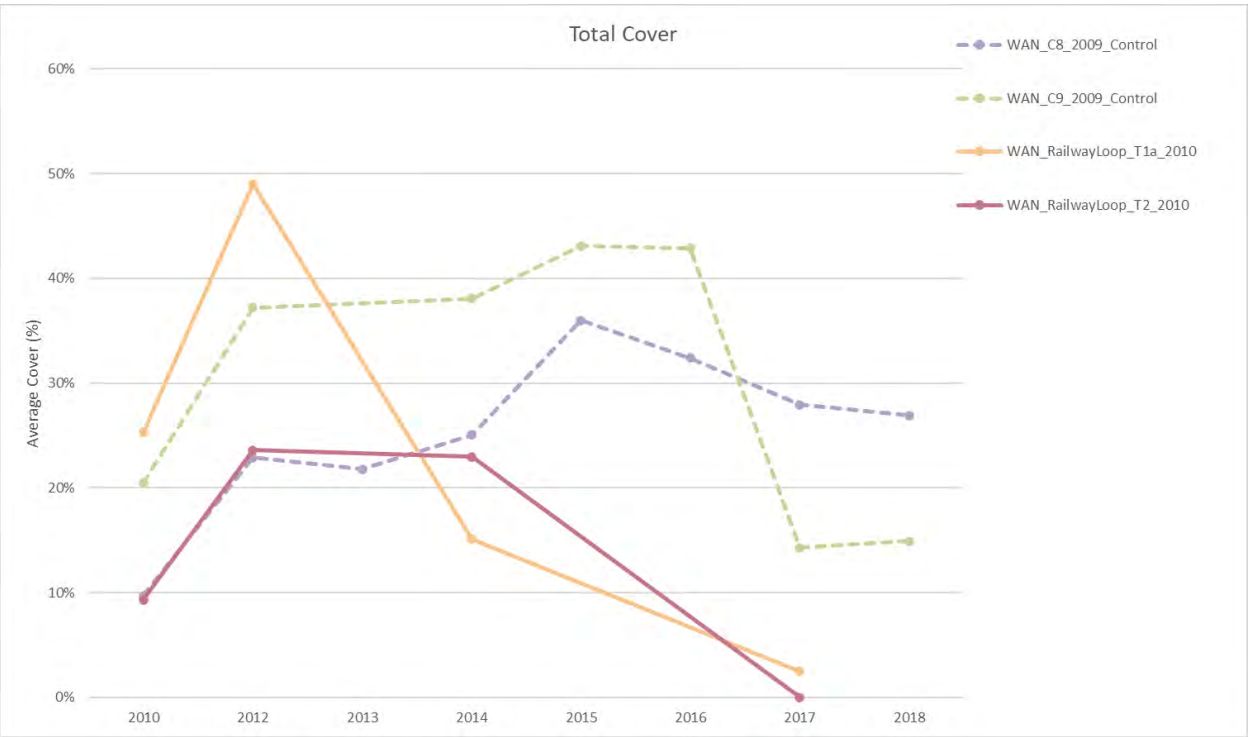

Figure 21: Native perennial total plant cover (species/ quadrat) for the Railway Loop rehabilitation and reference sites over time

Preliminary inclining trends in native perennial plant cover were observed at rehabilitation transects T1a and T2 between the first two monitoring assessments, with the highest increase occurring at T1a (Figure 21). The reference transects monitored in these years also showed increases in total cover, suggesting that the observed trends were, to some extent, influenced by favourable environmental conditions such as high rainfall. Cover recorded during the 2010 and 2012 assessments was lowest at C8 and T2, with T1a showing the least cover in 2014 due to a significant 34% loss from the previous year. This may be partly attributed to the omission of weed species (Buffel Grass) from the 2014 cover calculations, however, a loss still occurs after this is taken into consideration and 2014 field notes describe poor dusty conditions at the transect with many plants wilting. Cover remained the highest at reference site C7 for the entire monitoring period, whilst lower cover was consistently recorded at C8. This resulted in statistically significant differences between all transects in each monitoring year.

Trends observed in 2017 were particularly affected by fire history. The burnt reference transects C3, C4 and C9 all decreased substantially in cover compared to the previous assessment. Rehabilitation transect Rail_T1a had significantly less cover in 2017 than reference transect C8 and was comparable to the burnt reference transects. Cover at this transect declined from almost 50% in 2012 to just 3% in 2017, likely due to increasing populations of weed grasses outcompeting the native vegetation.

5.4.4. Airstrip

The Airstrip rehabilitation has developed well after 13 years, with a diverse array of native species present and whilst some weeds were observed, abundance was minimal. Perennial plant cover was moderate to high, although there was limited development of *Triodia* at two of the three transects. While the floristic composition of the vegetation was dissimilar to the reference sites, the presence of shrubs species and tussock grasses provided good structural and floristic diversity (evident in Figure 22 and Figure 23), anticipated to continue to develop over time toward a reflection of the target vegetation community.

Rehabilitation transects Airstrip_T2 and T3 follow similar trajectories from 2012 onwards in both species and plant density. Observed trends in these two parameters were less satisfactory at Airstrip_T1, with better results observed at this transect for native perennial plant cover.

Figure 22: WAN_Airstrip_T2 (end) 2010

Figure 23: WAN_Airstrip_T2 (end) 2017

Native perennial species density

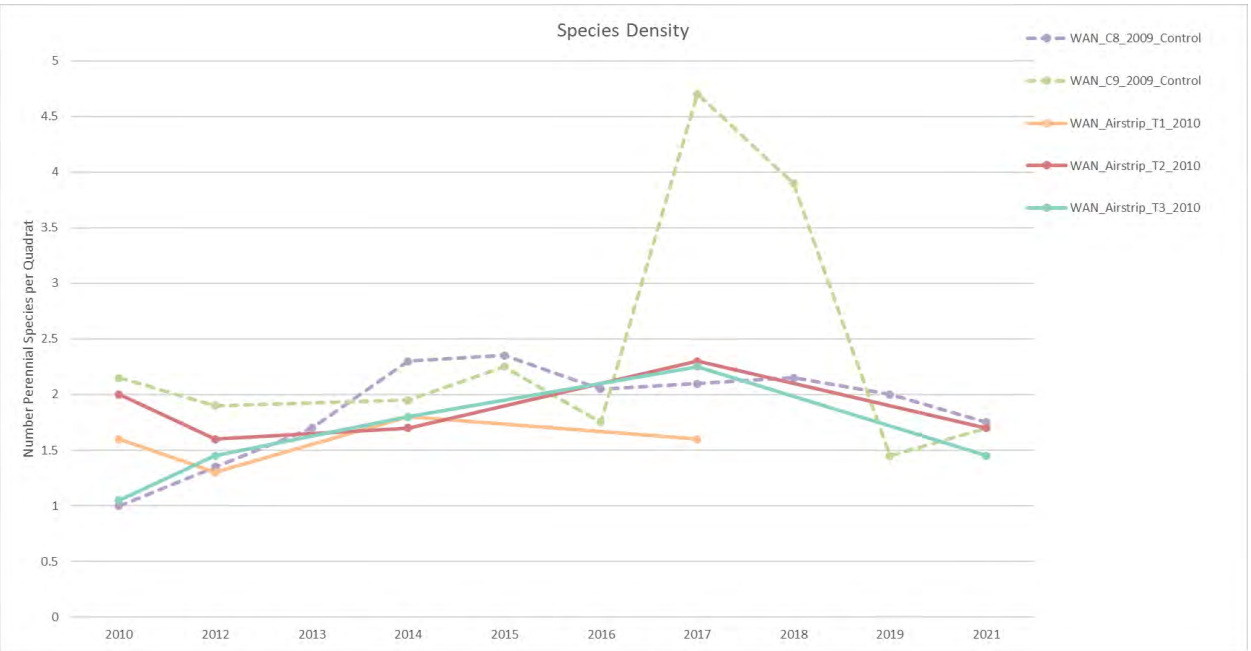

Figure 24: Native perennial species density (species/ quadrat) for the Airstrip rehabilitation and reference sites over time

Species density values recorded across the Airstrip rehabilitation in 2010 were within the range recorded at the reference sites, with a difference of 1.9 species per quadrat between the highest rehabilitation value (2.0 at T2) and the highest reference value (2.1 at C9) (Figure 24: Native perennial species density (species/ quadrat) for the Airstrip rehabilitation and reference sites over timeFigure 24). The 2012 monitoring report documented declines in the number of species per quadrat at all three rehabilitated transects, however data shows an increase of 0.4 species per quadrat at T3. The lowest 2012 value documented was observed at Airstrip_T1, where the 1.3 species per quadrat recorded was just below the lowest reference value of 1.4.

Despite favourable seasonal factors generating inclining trends across all transects between 2012 and 2014, rehabilitation values were all below the range of reference species densities and variation between the sites was of statistical significance. The 2017 monitoring assessment found the Airstrip rehabilitation transects to be most comparable to reference transect C8, which had 2.1 species per quadrat. As expected, the recently burnt reference transect C9 had considerably more species per quadrat than all other transects, with resultant analyses between all sites showing a significant difference.

Monitoring data obtained in 2021 revealed declining trends at Airstrip_T2 and T3, with no data recorded for T1. Rates of species density decline at the rehabilitation were comparable to reference site C8 between 2018 and 2021, and by 2021 Airstrip_T2 and T3 had achieved high similarity with each reference site.

Native perennial plant density

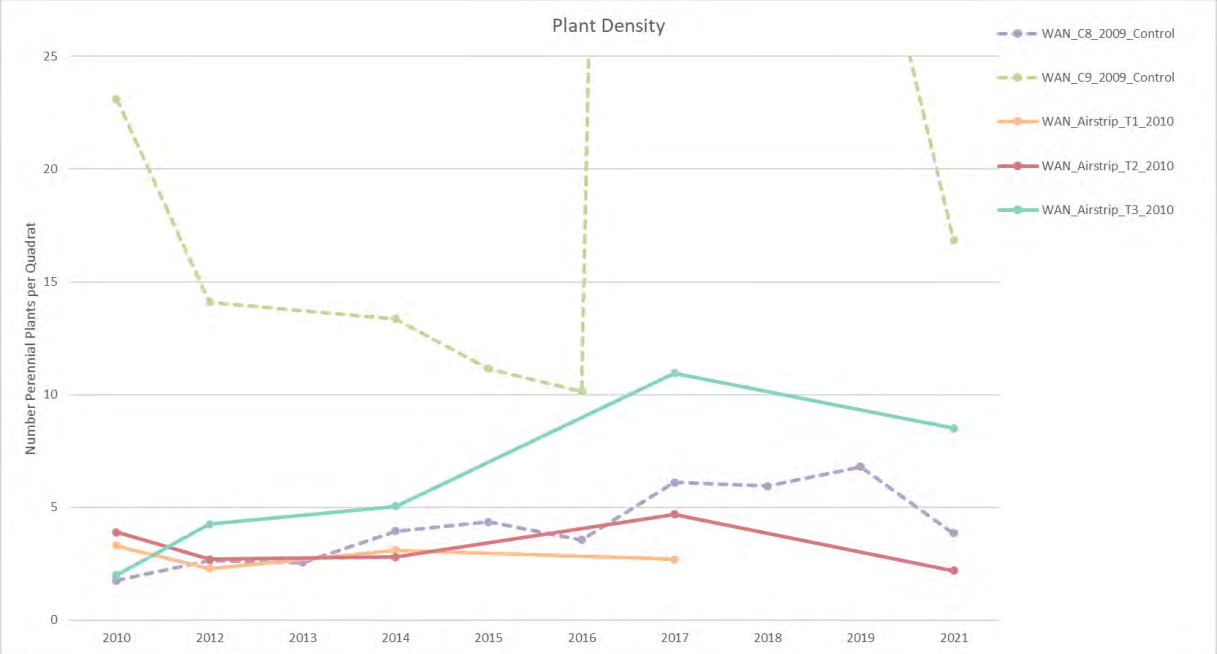

Figure 25: Native perennial plant density (plants/ quadrat) for the Airstrip rehabilitation and reference sites over time

First recorded plant density values at the rehabilitated sites were relatively similar and, due to the low number of plants per quadrat recorded at C8, were within the range recorded in the reference sites (Figure 25). The 2010 monitoring report noted varying compositions between the rehabilitated sites, with higher numbers of *Triodia* at sites Airstrip_T1 (AIR1) and Airstrip_T2 (AIR2), and higher grass numbers at Airstrip_T3 (AIR3a and AIR3b). Early trends in plant density across the rehabilitation varied, with Airstrip_T1 and T2 showing declining trajectories between the first two monitoring assessments, whilst T3 increased by 2.3 plants per quadrat. Plant density increased between 2012 and 2014 at all transects except C9, with the rehabilitated transects gaining between 0.1 and 0.8 plants (comprising mostly of *Triodia*) per quadrat.

Statistical analyses of 2010, 2012 and 2014 data showed significant differences between all sites, due to the consistently high densities observed at C9. In 2017, the numbers of perennial plants per quadrat at the rehabilitation transects did not differ significantly from reference transect C8 but were significantly less than burnt reference transect C9. The substantial increase in plants per quadrat at C9 was attributed to post-fire recruitment of large numbers of juvenile *Triodia*, with 2021 monitoring data showing the expected subsequent declines as juvenile species establish and some senesce. Fire disturbance also contributed to the doubling of plant density observed at Airstrip_T3 between 2014 to 2017, as the transect had been partially burnt during this time. A corresponding decline was observed at the transect between 2017 and 2021 but it maintained comparability with all reference sites. Interestingly, T2 exhibited analogous trends for both periods, yet was unaffected by fire.

Native perennial plant cover

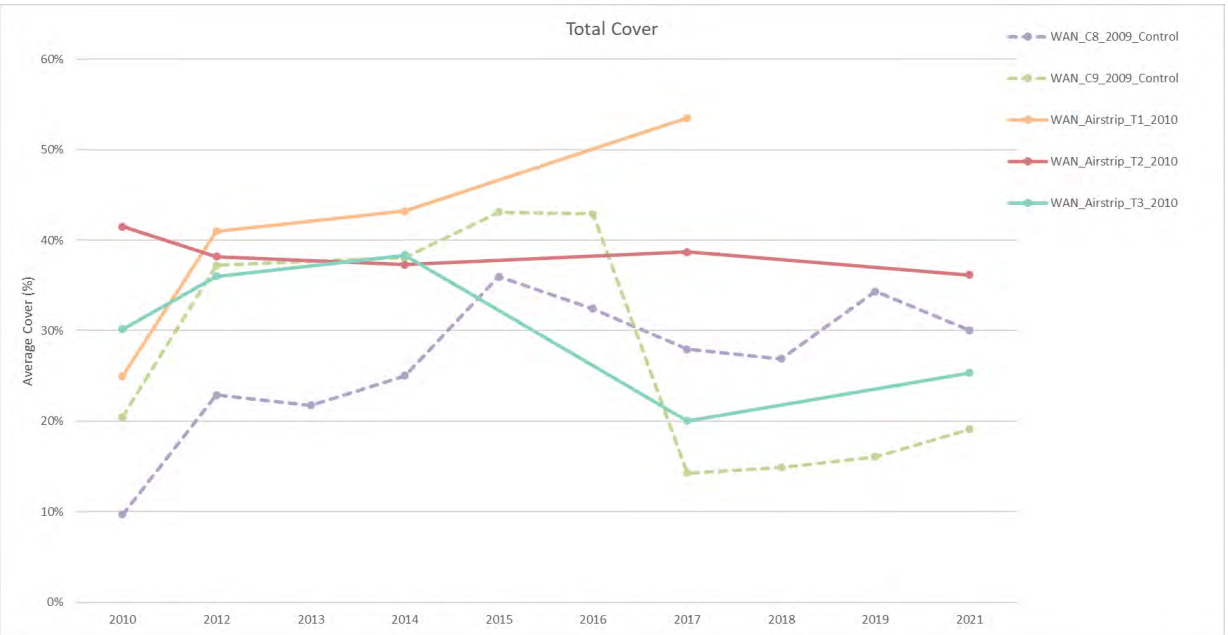

Figure 26: Native perennial total plant cover (%) for the Airstrip rehabilitation and reference sites over time

Initial values for native perennial plant cover were lowest at reference sites C8 and C9, with all rehabilitation plant density values sitting well within the reference range and showing comparability to the high (45%) C9 value (Figure 26). Although analysis of 2010 data exposed statistically significant difference between sites, no single site varied significantly to all other sites. Statistical analysis of the 2012 vegetation quadrat data also produced this result. Excluding Airstrip_T2, inclining trends in cover were observed at all transects (rehabilitation and reference) between 2010 and 2012, with the greatest increase of rehabilitated cover recorded at Airstrip_T1.

As observed in 2010, reference site C8 had the least amount of plant cover, whilst in contrast, T2 had the most plant cover when compared to the other sites in Figure 26. Rehabilitation cover values in 2012 were most alike those recorded at reference site C9.

Estimated perennial cover values did not change greatly between 2012 and 2014 at any of the rehabilitated transects, with Airstrip _T1 remaining the highest, and all comfortably within the range of values recorded at the reference sites. Variability in cover between the rehabilitation transects was highest in 2017, with a difference of 34% observed between T1 and T3. The influence of fire on native perennial plant cover was evident in 2017, with declining trends observed at burnt transects C9 and Airstrip_T3. Slight increases in cover were recorded at the two unburnt Airstrip rehabilitation transects, with the greatest increase of 11% occurring at T1. The burnt transects had begun to recover in this parameter as of the last monitoring assessment, evidenced by the inclines observed between 2017 and 2021.

5.4.5. West Angelas Gas Pipeline

Three years after rehabilitation was completed at West Angelas Gas Pipeline a diverse range of native species had established and the three rehabilitation transects exhibited high total cover, particularly given that the area had been burnt prior to the last assessment. The vegetation structure was dominated by tussock grasses, with *Triodia* present at some transects. The least success was observed at GasPL_T4 and GasPL_T5 which had low perennial vegetation cover, little or no *Triodia* establishment, and were dominated by annuals. The weed species *Cenchrus setiger* was present at GasPL_T5, potentially limiting native perennial establishment. As *Triodia* was also absent at reference site GasPL_C4, the *Triodia* density and overall perennial species richness and density at T4 and T5 were

still within the range recorded at the reference sites. Table 9 summarises the known rehabilitation techniques implemented at the Gas Pipeline site and Table 10 summarise the monitoring data for the site.

Fire affected the Gas Pipeline area prior to the 2016 assessment, with the burn predominately confined to GasPL_T1 and GasPL_C1 (Table 5). The resulting loss of cover at T1 is evident within Figure 27 and Figure 28, contrasted with GasPL_T5 where an inclining trend in cover was recorded (Figure 29 and Figure 30).

Table 9: West Angelas Gas Pipeline rehabilitation overview.

REHABILITATION PARAMETER	SITE
	Gas Pipeline
# Active transects (monitored)	2
Area (ha)	N/A
Closure domain	Infrastructure
Year of rehab	2014
Growth medium	Topsoil
Depth of growth medium application (mm)	N/A
Time of storage of growth medium (yr)	N/A
Seeding mix	N/A
Seeding rate (kg/ha)	0kg/ha
Soil ameliorant (type)	N/A
Rate of application of ameliorant (kg/ha)	N/A
Contour ripping (depth)	Yes (depth unknown)
Ripping technique	Yes, details unknown

Table 10: West Angelas Gas Pipeline monitoring parameter overview.

MONITORING	REHABILITATION SITE	REFERENCE SITES	TOTAL / RANGE
	Gas Pipeline	**GasPL_C1, C2, C3, C4, C5**	
Year rehabilitation completed / year reference site established	2014	2015	
Year of monitoring data	2016		
Number of transects monitored	5	5	10
Range of species richness values	7 to 16	4 to 15	4 to 16
Range of species density values	0.9 to 3.4	0.5 to 2.6	0.5 to 3.4
Range of plant density values	1.3 to 13.2	0.5 to 21.2	0.5 to 21.2
Range of spinifex density values	0 to 11.9	0 to 14	0 to 14
Range of total cover values (%)	4 to 53 %	17 to 43 %	4 to 53 %
Range of spinifex cover values (%)	0 to 47 %	0 to 21 %	0 to 47 %
Range of weed cover values (%)	0 to 0.7% (*M. americanum)* 0 to 0.2 % *(C. ciliaris)*	0 %	0 to 0.7%
Range of weed density values	0 to 0.75 (*M. americanum)* 0 to 0.2 *(C. ciliaris)*	0	0 to 0.75
Range of percentages of quadrats with weeds present	0 to 45 %	0 %	0 to 45 %
Range of percentages of quadrats with annuals present	0 to 100 %	15 to 100 %	0 to 100 %
Range of # of species flowering / fruiting (inc. walkaround assessment)	No data*	No data*	N/A
Erosion (number of gullies)	0 gullies	0 gullies	0 gullies

**2016 report states: "many plant species were flowering and fruiting at the time of the monitoring" but no raw data provided*

Figure 27: WA_GasPL_T1 (start) 2015

Figure 28: WA_GasPL_T1 (start) 2016

Figure 29: WA_GasPL_T5 (start) 2015

Figure 30: WA_GasPL_T5 (start) 2016

Native perennial species density

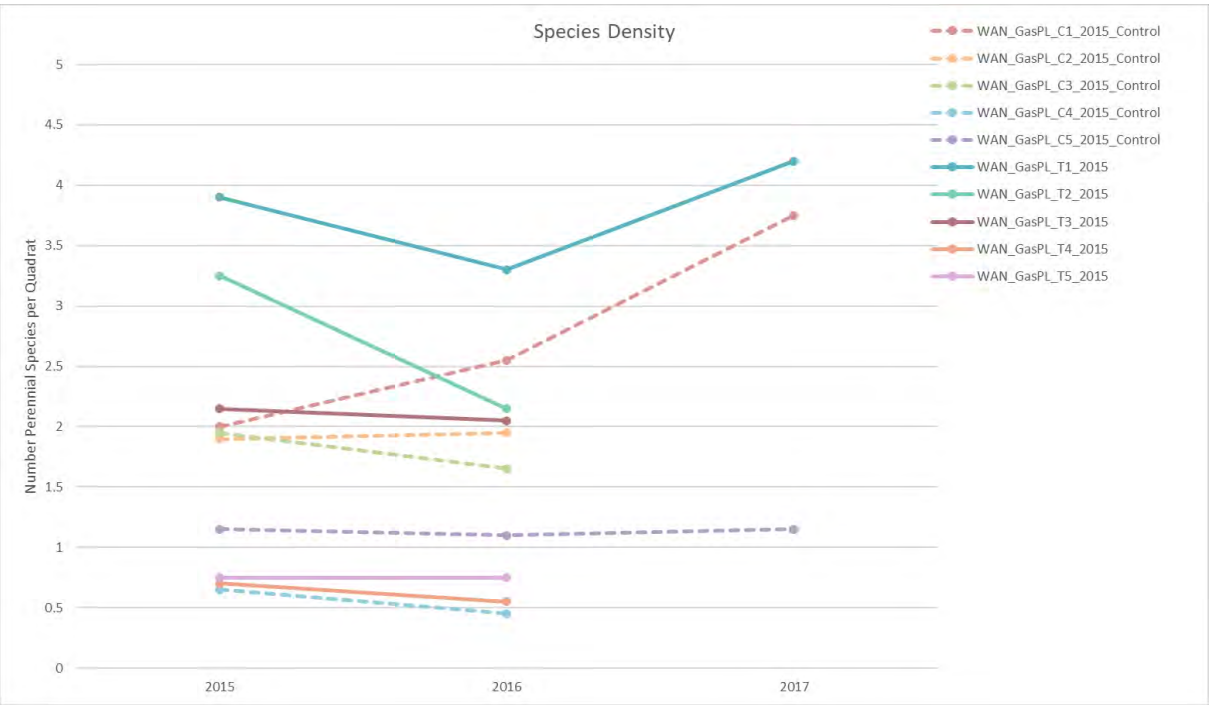

Figure 31: Native perennial species density (species/ quadrat) for the Gas Pipeline rehabilitation and reference sites over time

Overall, the number of species per quadrat recorded in 2015 indicate generally adequate species establishment across the rehabilitation, with the least success observed at T4 and T5, recording 0.7 and 0.8 species per quadrat respectively (Figure 31). Reference site C4 also contained 0.7 species per quadrat in the first monitoring year meaning all rehabilitated transects were within the reference range. Rehabilitation records indicate that no seeding was carried out, so it is assumed that the species originated predominately from topsoil.

Species density at the reference sites in 2016 ranged from 0.5 to 2.6 species per quadrat, with all rehabilitation values existing within this range, or, in the case of GasPL_T1, above. Variation analyses between all sites found some statistically significant differences, however rehabilitation transects had comparable species density (not significantly different) to at least one reference site. Changes in species density between 2015 and 2016 were mostly immaterial, with only two transects losing more than 0.1 species per quadrat (T1 and T2). The decline observed at T1 can be mostly attributed to the initial impacts of fire, with the 2017 assessment documenting a notable increase in species density, congruent with the early stages of post-fire succession. A similar post-fire incline was also observed at reference transect C1, with a higher relative rate of increase due to a greater proportion of the transect being burnt. As expected, the unburnt transect GasPL_C5 had significantly fewer species per quadrat in 2017 than both other transects accessed in 2017.

A range of native herb and shrub species were present across the rehabilitation, with common species including *Triodia pungens, Triodia longiceps*, *Themeda triandra*, *Aristida contorta* and *Ptilotus nobilis.*

Native perennial plant density

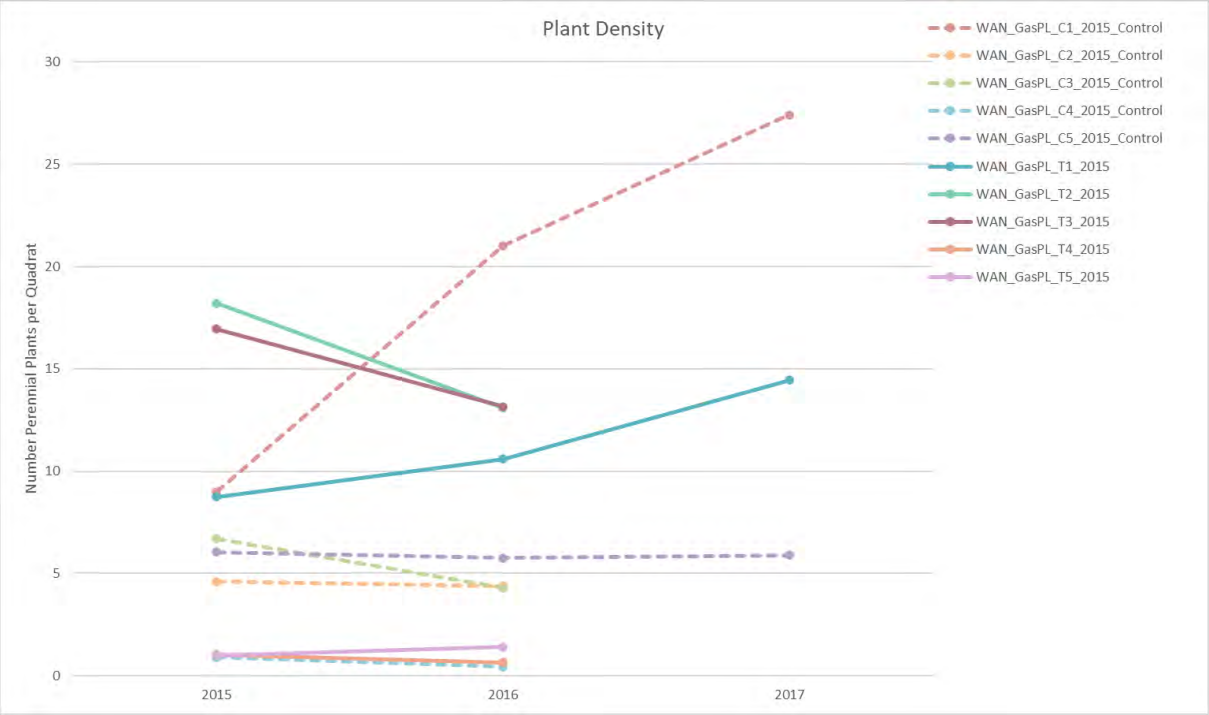

Figure 32: Native perennial plant density (plants/ quadrat) for the Gas Pipeline rehabilitation and reference sites over time

First documented values for plant density varied considerably, from 0.9 plants per quadrat at C4 to 18.2 at T2 (Figure 32). Plant establishment at the rehabilitation was mostly successful, facilitated by good rainfall received in March 2015. Limited success, however, was observed at GasPL_T4 and T5, where only 1.1 and 1 plants per quadrat were recorded.

Variability in perennial plant density was even higher in the second year of monitoring, ranging from 0.7 (T4) to 21 (C1) plants per quadrat. A notably large increase in plant density had occurred at reference transect GasPL_C1, resulting in plant density at this site being significantly different to all other sites. Highest plant densities recorded at the rehabilitation in 2016 were 13.1 plants per quadrat at GasPL_T2 and 13.2 at T3. These transects showed a significant difference to all reference sites except GasPL_C1.

The increased plant densities at GasPL_C1 and GasPL_T1 were likely a response to recent fire impact which had occurred prior to assessment. In 2017, the only accessible rehabilitated transect recorded significantly more plants per quadrat than reference transect GasPL_C5, but significantly less plants per quadrat than GasPL_C1. Trajectories over the three years were of an increasing nature at T1 and C1, whilst remaining stable at the unburnt reference transect.

Native perennial plant cover

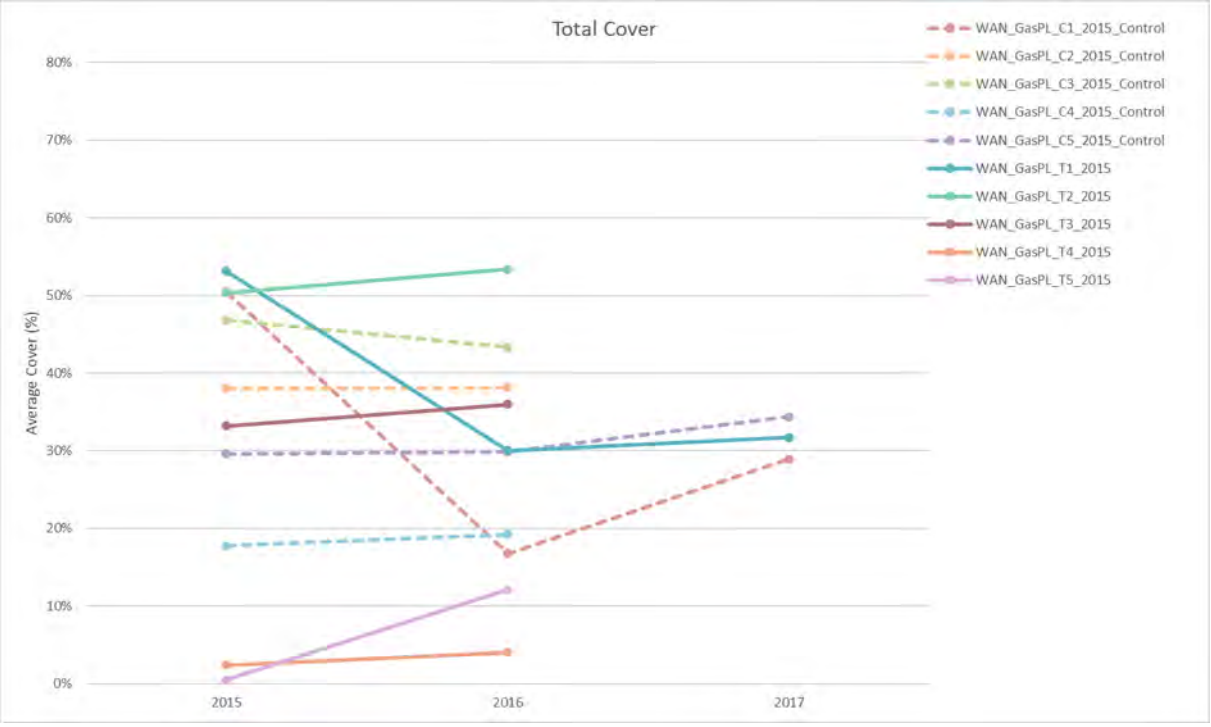

Figure 33: Native perennial plant cover (%) for the Gas Pipeline rehabilitation and reference sites over time

Initial perennial cover values indicated that most rehabilitated sites were comparable to or better than the reference sites (Figure 33). The exceptions are GasPL_T4 and GasPL_T5, which had much lower cover than all sites in both years they were monitored. The 2015 report also noted that both transects were dominated by annuals, which may partly explain the lack of cover. An additional limiting factor for GasPL_T5 is it being younger than the other rehabilitated sites with comparatively little rain falling in the months following its establishment. It is anticipated based on values recorded at the other sites that cover will increase as plants grow (rainfall dependent).

There were no significant differences in plant cover between rehabilitation transects GasPL_T1 and GasPL_T3 and the majority of reference sites. Plant cover decreased substantially between 2015 and 2016 at GasPL_T1 and reference site GasPL_C1, which can be attributed to recent fire activity (Table 5). Total cover remained stable over time at the unburnt reference transect GasPL_C5.

5.5. Monitoring results – High impact disturbance areas

Presently, four waste dumps (classified as high impact disturbance areas) have been partially rehabilitated at West Angelas, with associated monitoring schedules developed. Records of rehabilitation methodology for these sites (summarised in Table 11) predominately provide adequate detail to comprehensively analyse waste dump rehabilitation performance to date. Monitoring parameters for these high disturbance areas are presented in Table 12 with reference site data included for comparative value.

Table 11: West Angelas waste dump rehabilitation overview.

REHABILITATION PARAMETER	SITE					
	East and South WD	**Deposit A South-Western WD**	**Deposit A North WD**	**Deposit B West WD**	**Deposit A North WD**	**Deposit A South WD**
# Active transects (monitored)	4	12	None yet established	4	None yet established	None yet established
Area (ha)	7.5 hectares	78.1 hectares	Unknown	28.1 hectares	54.5 hectares	70.9 hectares
Closure domain	Waste dump	Waste dump	Waste dump	Waste dump	Waste dump	Waste dump
Year of rehab	2012	2021	2021	2020	2022	2022
Growth medium	Topsoil	Topsoil (used on 70% of site) and subsoil (used on western flank) recovered from nearby stockpiles	Topsoil from local stockpile	Topsoil (primary growth medium) from the nearby stockpile TSB03.	Topsoil	Topsoil
Depth of growth medium application (mm)	200 mm	200 mm	100 mm	200 mm	200 mm	200 mm
Time of storage of growth medium (yr)	Unknown	Unknown	Approximately 7 years	Approximately 6 years (recovered in 2015)	Unknown	Unknown
Seeding mix	Twenty-two native species (two annuals and twenty perennials) mixed with sandpit sand at 1:2 ratio.	Mix of 66 native species of local provenance (6 annuals, 60 perennials; comprised of 50% native grasses, 5% herbs, 35% shrubs and 10% tree species).	Two seed lists developed. Mix of 30 native species for flat areas. Mix of 19 species (including some duplicated species of alternative age or treatment). Comprised of 50% native grasses, 5% herbs, 35% shrubs and 10% tree species).	Mix of 66 native species of local provenance (6 annuals, 60 perennials; comprised of 50% native grasses, 5% herbs, 35% shrubs and 10% tree species).	Two seed lists developed. One for backslope berms and flats and one for slopes.	Two seed lists developed. One for backslope berms and flats and one for slopes.

REHABILITATION PARAMETER	SITE					
	East and South WD	**Deposit A South-Western WD**	**Deposit A North WD**	**Deposit B West WD**	**Deposit A North WD**	**Deposit A South WD**
Seeding rate (kg/ha)	Hand seeded at approximately 13 kg / ha.	8.0 kg/ha	6.7 kg /ha	8.0 kg/ha	7 kg/ha	7 kg/ha
Soil ameliorant (type)	None	None	None	None	None	None
Rate of application of ameliorant (kg/ha)	N/A	N/A	N/A	N/A	N/A	N/A
Contour ripping (depth)	Maximum depth of 500 mm	Surface ripped to 300mm	Shallow ripped (depth unknown)	300 mm	300 mm	300 mm
Ripping technique	Rip lines 100 to 200 mm apart.	6 tines. Depth of corrugation was approximately 100mm	Multi Tyne Ripper Assembly – 7 tynes	150 – 200 mm corrugation using an Elworx mechanical seeder mounted to a D8 dozer with a triple tine setup.	Multi Tyne Ripper Assembly – 7 tynes on D8 Dozer	Multi Tyne Ripper Assembly – 7 tynes on D8 Dozer

Table 12: West Angelas waste dump rehabilitation and reference sites monitoring overview.

MONITORING	SITE	
	East and South WD	***C3 C4 C8 C9***
Year rehabilitation completed / year reference sites established	2012	
Year of monitoring data	2019	
Number of transects monitored	4	4
Range of species richness values	4 to 9	12 to 16
Range of species density values	0.9 to 4.4	1.5 to 3.9
Range of plant density values	1.2 to 14.7	6.8 to 48.3
Range of spinifex density values	0.3 to 8.4	3.3 to 29.9
Range of total cover values (%)	17.2 to 57.0 %	16.1 to 34.6 %
Range of spinifex cover values (%)	5.8 to 39.0 %	7.4 to 15.0 %
Range of weed cover values (%)	0 %	0 %
Range of weed density values	0	0
Range of percentages of quadrats with weeds present	0 %	0 %
Range of percentages of quadrats with annuals present	0 %	0 to 5 %
Range of # of species flowering / fruiting (inc. walkaround assessment)	2 to 6	0 to 3
Erosion (number of gullies)	8 gullies, 1 of which is being monitored for active change	0 gullies

5.5.1. East and South waste dumps

Four transects were delineated at West Angelas' East and South waste dumps including EastWD_T1 on a flat area (categorised as lower slope) and EastWD_T2, SouthWD_T1 and SouthWD_T2 were positioned on mid-slopes. Rehabilitation works, which included reprofiling / dozing of waste dump slopes, topsoil application and contour ripping and seeding, and, were completed in 2012 (Table 11) with transects first monitored in 2013. Monitoring data obtained during the 2019 assessment for the East and South Waste Dump rehabilitation and reference sites is summarised in Table 12 to provide an indication of rehabilitation progression toward reference site parameter values.

Photographic evidence (Figure 34 to Figure 37) of the East and South Waste Dump rehabilitation indicates successful outcomes in some parameters, in particular total plant cover, further confirmed by monitoring data trends displayed within Figure 40. Vegetation quadrat values and overall trajectories observed at rehabilitation transect EastWD_T1 were most aligned with the corresponding reference site values, indicating an encouraging rehabilitation performance at the transect.

The species density trajectories observed over the entire monitoring period are characteristic of early rehabilitation (<10 years old), with early increases reflecting successful establishment of colonising species, and the ensuing gradual declines attributed to the expected natural senescence of the short-lived colonisers. Analogous declining trends in species density and plant density were observed at rehabilitation site SouthWD_T1 between 2013 and 2014 and were attributed to unusually high numbers of the short-lived perennial species *Ptilotus nobilis* recorded in 2013.

Based on the 2019 monitoring quadrat values (Table 12), the rehabilitation exhibited greatest success within total plant cover, an unusual outcome, as a high variation between rehabilitation and reference values is usually observed for this parameter. Upon further analysis, the apparent comparability of EastWD_T2, SouthWD_T1 and T2 with all four reference sites is likely nullified due to the post fire condition of each reference site and resultant atypical low cover values recorded in 2017 (Table 5 confirms extent and timing of fire disturbance aligns with the 2017 results). Thus, success in this parameter is mostly confined to EastWD_T1, where the extent of total plant cover was higher than the reference sites as they have yet to recover pre-fire parameter values.

Figure 34: WA_EastWD_T1 (lower slope) (start) 2013 (one year after rehabilitation).

Figure 35: WA_EastWD_T1 (lower slope) (start) 2017 (five years after rehabilitation).

Figure 36: WA_SouthWD_T2 (end) 2013 (one year after rehabilitation.

Figure 37: WA_SouthWD_T2 (end) 2013 (five years after rehabilitation.

Native perennial species density and species richness

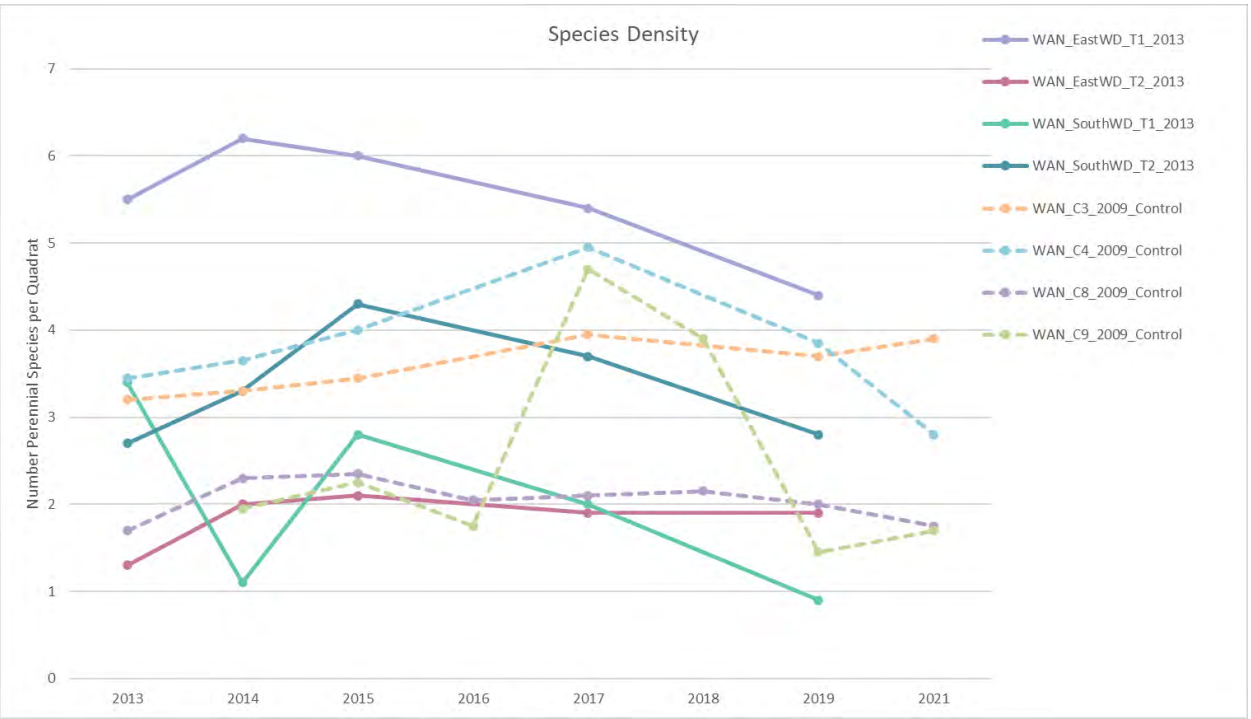

Figure 38: Native perennial total species density (species/quadrant) for the East and South Waste Dump transects and reference sites over time.

The East and South Waste Dump rehabilitation sites show mostly inclining trends in species density over the first three years of monitoring (2013 to 2015), with the only decline observed at SouthWD_T1 (Figure 38). There was no statistically significant variation between rehabilitation and reference species density values in 2015, indicating good establishment and early survival of native plant species. Establishment from seed was considered relatively effective, with thirteen of the twenty-two seeded species recorded in 2015 at one or more of the rehabilitated sites. Two transects, EastWD_T1 and SouthWD_T2 recorded higher numbers of species per quadrat (in 2015) than all four reference sites, with EastWD_T1 maintaining a trajectory above all reference values for the entire duration of monitoring.

Post 2015, the rehabilitation transects exhibit gradual declining trends in species density, with three of the four transects remaining within the relevant reference site range (C9 excluded due to being heavily impacted by fire). However, rehabilitation transects EastWD_T2 and SouthWD_T1 fall outside the range if reference site C8 is also excluded. The observed species density trajectory at C8 suggests the site has not yet fully recovered (in this parameter) from the pre-2013 fire event. Rather than informing vegetation parameter targets for rehabilitated sites, C8 data is more appropriate for establishing values that could be obtained in early rehabilitation.

From 2015 to 2019, the number of species per quadrat decreased at almost identical rates for EastWD_T1, SouthWD_T1 and SouthWD_T2, whilst EastWD_T2 remained relatively constant. Statistically, there were significant differences in species density between all eight sites in the last two monitoring years. However, the rehabilitated transects were comparable to at least one reference site. The greatest number of species per quadrat across all sites in 2019 was 4.4, observed at EastWD_T1 which also recorded the highest number of seeded species. Recording 0.9 species per quadrat, SouthWD_T1 had the lowest species density in 2019, decreasing by over half from 2017. Although species density at SouthWD_T1 was not significantly different to reference site C9, the low species density at the reference site was due to post-fire conditions, thus not reflective of the target vegetation community.

Native perennial plant density

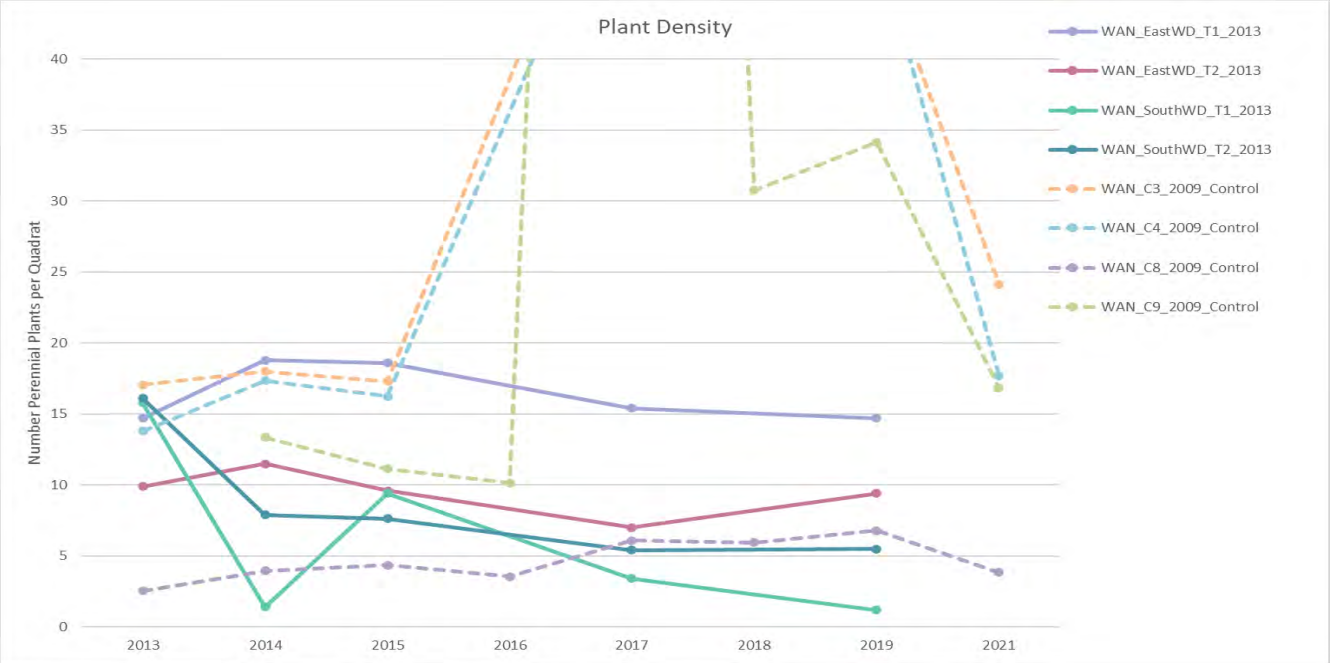

Figure 39: Native perennial plant density (plants/quadrant) for the East and South Waste Dump transects and reference sites over time

Native perennial plant density at the rehabilitated transects remained relatively constant from 2013 to 2019, with the greatest fluctuations observed at SouthWD_T1 (Figure 39). The number of plants per quadrat recorded at SouthWD_T1 decreased substantially between the first two monitoring years, with a gradual incline observed in the subsequent year. The high number of plants per quadrat recorded in 2013 at SouthWD_T1 was attributed to atypically high numbers of *Ptilotus nobilis*.

Significant variations between reference and rehabilitation plant density values exist for post-2016/17 data, mostly due to the considerably high post-fire values recorded at C3, C4 and C9. The greatest change in plant density in rehabilitated areas was observed at EastWD_T2, which increased from seven plants per quadrat in 2017 to 9.4 in 2019. Slightly higher plant densities were recorded at the East Waste Dump rehabilitation compared with the South Waste Dump rehabilitation, with SouthWD_T1 recording the lowest density of 1.2 plants per quadrat.

Native perennial plant cover

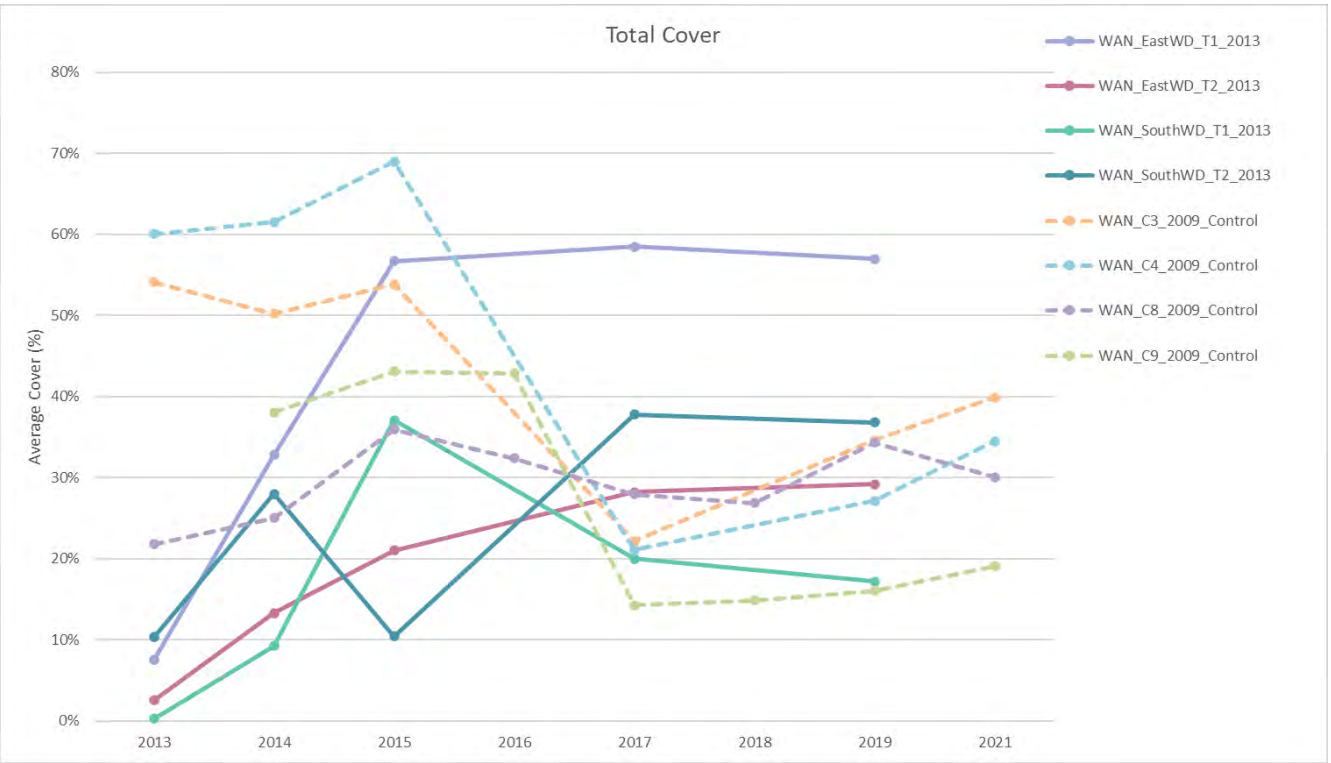

Figure 40: Native perennial total plant cover (%) for the East and South Waste Dump transects and reference sites over time.

Overall plant cover trajectories observed at the rehabilitation are roughly inverse to those observed at the post-fire reference transects – C3, C4 and C9 (Figure 40). Increasing trends were observed at all four rehabilitation transects between 2013 and 2014, with plant cover continuing to increase until 2015 at all transects except SouthWD_T2 which saw a steep decline in cover between 2014 and 2015. Rehabilitation cover begins to plateau post-2015 at both East Waste Dump transects, whilst cover at the South Waste Dump transects shows similar stabilising trends post-2017. This was least evident at SouthWD_T1 where a significant loss of cover occurred between 2015 and 2017, with the declining trend continuing but lessening in severity between 2017 and 2019. Despite this, cover at SouthWD_T1 at the time of the 2019 monitoring was notably higher than initial cover recorded in 2013. Although the 2019 monitoring report found some significant differences, plant cover at all rehabilitation transects was either within the reference site range (16% to 35% cover), or (at EastWD_T1) higher than the reference site range. The highest native perennial plant cover overall (57%) was recorded at rehabilitation transect EastWD_T1, where over 55% cover had been maintained since 2015, indicating an excellent rehabilitation outcome in this parameter.

5.5.2. Deposit A Southern and Northern Waste Dumps

Rehabilitation of Deposit A South West Dump involved re-profiling of slopes for final landform design, spreading of topsoil and subsoil, construction of crest and containment bunds, and contour ripping and seeding. Seed species were selected based on surrounding vegetation assessments, nearby rehabilitation reference sites, local provenance zones and legal obligations. Final ripping and seeding were completed in three stages between December 2020 and May 2021. All seeding works were undertaken using an Elworx mechanical seeder mounted to a D8 dozer. A slightly higher than recommended rate of seed application was applied at the site. The increased rate was due to having both topsoil and subsoil trialled in different areas at the site, and to have consistency across both types of growth mediums.

Presently no monitoring data is available for Deposit A North West Dump where the 2021 rehabilitation works encompassed several different trials. The following treatments were selected for testing:

- Seed mixes: a sloped species mixed versus a flat mix;
- Topsoil in comparison to subsoil and no topsoil (and soil cleaned from a stockpile with some Buffel grass); and
- Seeding apparatus: Mega sweeper in comparison to no precision seeding apparatus and the Multi Tyne Ripper Assembly.

South-Western Waste Dump vegetation quadrat data has been compared to first year data from the older South and East Waste Dump rehabilitation to evaluate initial establishment and germination success against values obtained from historical monitoring at West Angelas. High values were recorded for all parameters at South-Western Waste Dump transects T2 and T3, with good results in at least two parameters also observed at T6, T7 and T11.

Native perennial species density

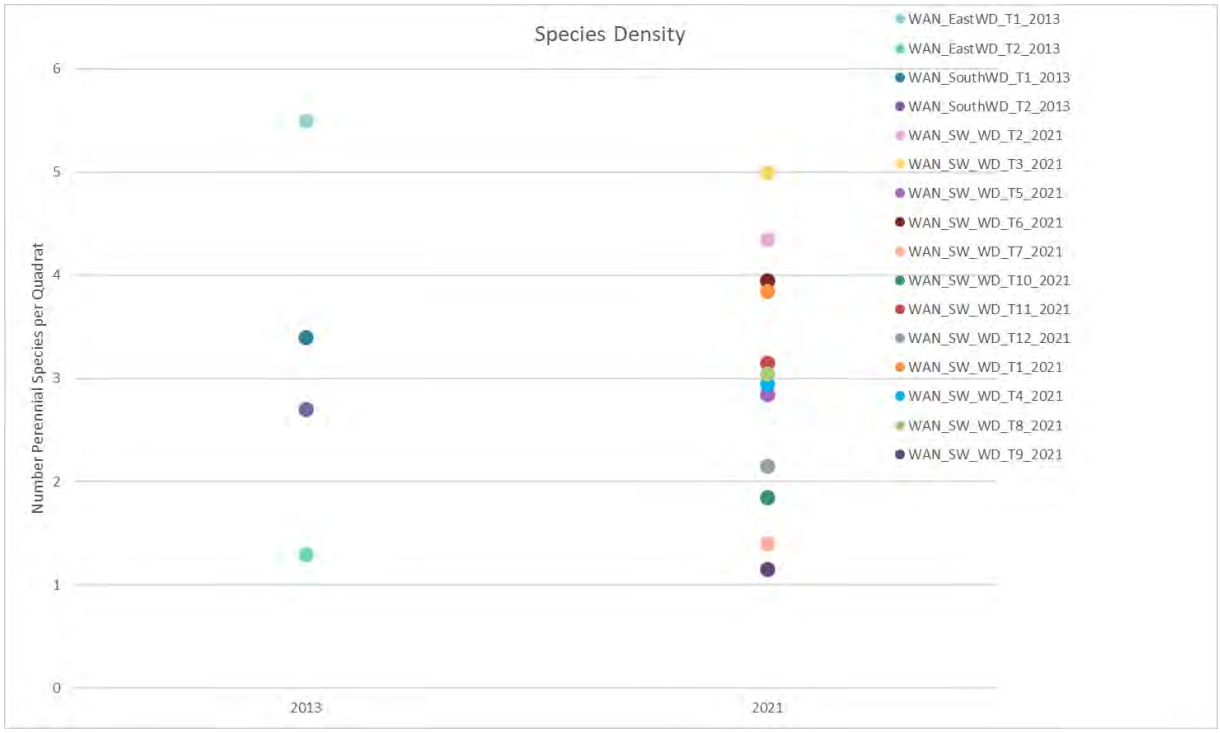

Figure 41: Native perennial species density (species/ quadrat) for the South-Western Waste Dump rehabilitation and reference sites over time.

Similar ranges of species density values were recorded in 2021 at the South-Western Waste Dump rehabilitation and in 2013 at the East/South Waste Dump rehabilitation (Figure 41). South-Western Waste Dump transect T9 had the least number of species per quadrat overall, with the next lowest value (recorded at EastWD_T2) being only 0.1 higher

Native perennial plant density

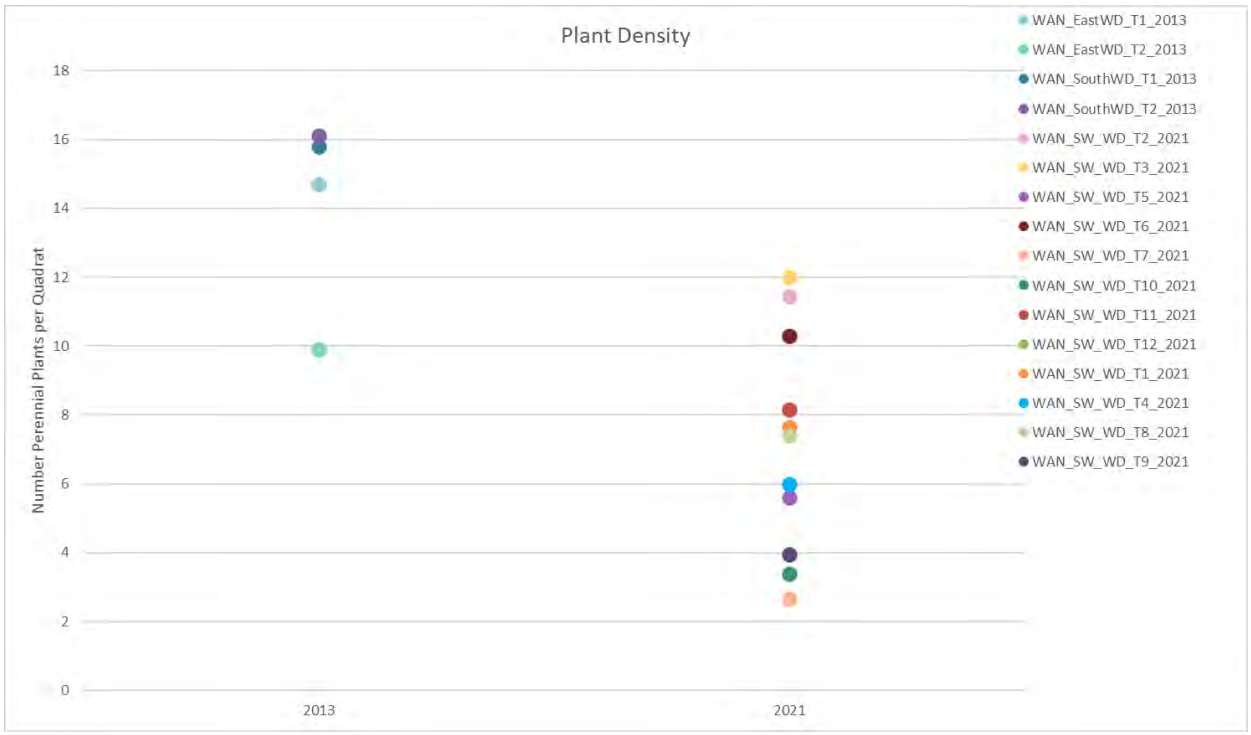

Figure 42: Native perennial plant density (plants/ quadrat) for the South-Western Waste Dump rehabilitation and reference sites over time.

The range of first year plant density values was greater at the South-Western Waste Dump site, with all but three transects having less plants per quadrat in 2021 than the four East/South Waste Dump transects in 2013 (Figure 42).

Native perennial plant cover

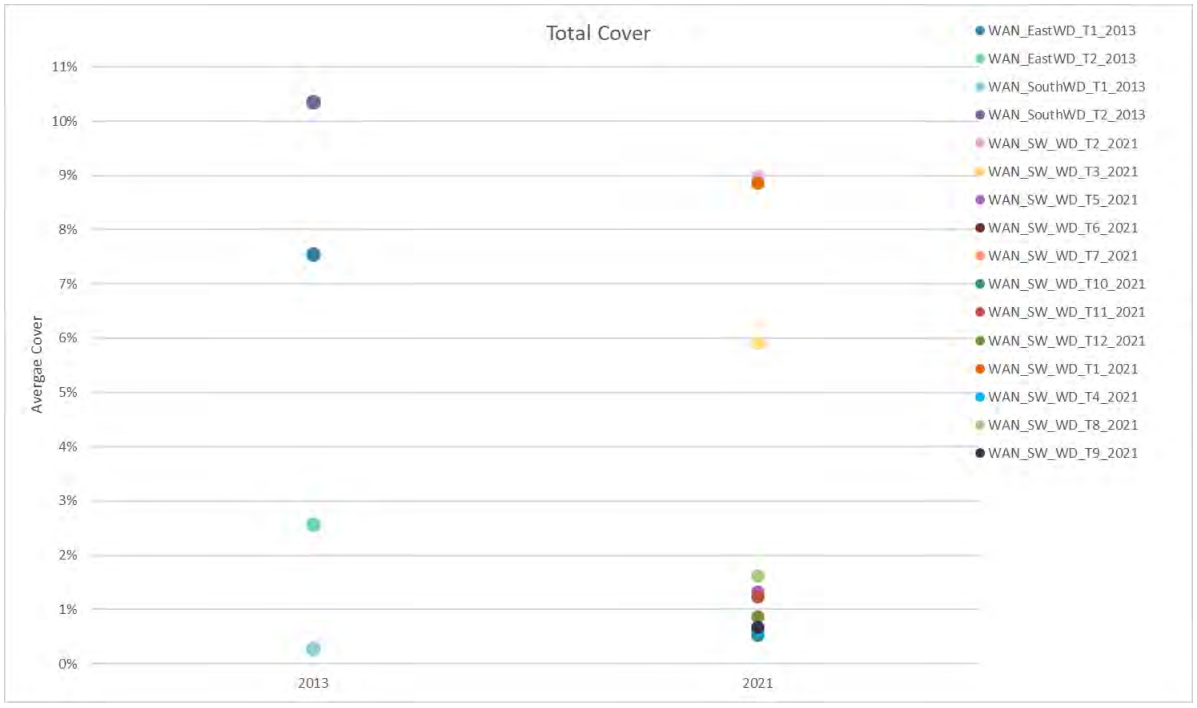

Figure 43: Native perennial total plant cover (%) for the South-Western Waste Dump rehabilitation and reference sites over time.

Initial percentages recorded for native perennial plant cover were comparable between the two rehabilitation sites, with all 2021 South-Western Waste Dump values sitting within the range recorded in 2013 at the East/South Waste Dump (Figure 43).

5.5.3. Deposit B West Waste Dump

Rehabilitation of Deposit B West Waste Dump followed generic design requirements, with a linear slope and back sloping berm design. Works involved clearing, re-profiling by dozing of slopes to the final landform design, hauling and spreading of topsoil, construction of crest and toe bunds, contour ripping and seeding. Some difficulty during topsoil application was reported due to it being 'soft and powdery'. A slightly higher than recommended seeding rate was applied due to originally intending to have both topsoil and subsoil trialled in different areas at the site, and to have consistency across both types of growth mediums. The seed mix selection was based on surrounding vegetation assessments, nearby rehabilitation reference sites, local provenance zones and legal obligations.

Deposit B West Waste Dump vegetation quadrat data has been compared to first year data from the older South and East Waste Dump rehabilitation to evaluate initial establishment and germination success.

The Deposit B West Waste Dump rehabilitation generally recorded lower values than the South and East Waste Dump rehabilitation for all three vegetation parameters. Plant density values between the two sites varied most significantly, whilst some comparability was observed for species density and plant cover. Transects T1 and T2 at the West Waste Dump rehabilitation were more successful than T3 and T4 across all parameters, with the highest variation between the four rehabilitation transects observed for species density.

Native perennial species density

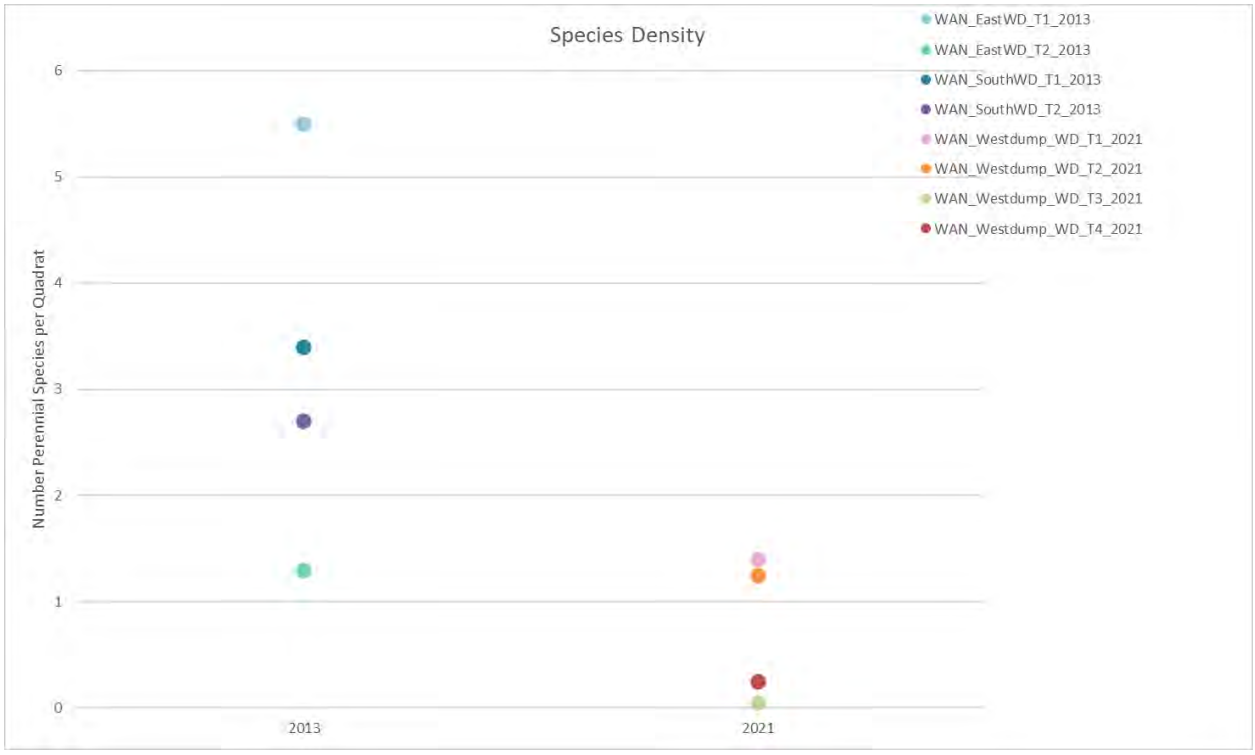

Figure 44: Native perennial species density (species/quadrat) at the West Waste Dump rehabilitation and reference sites in the first monitoring years.

The numbers of species per quadrat recorded in 2021 across the West Waste Dump rehabilitation were lower than three of the four South/East Waste Dump transects, with EastWD_T2 being comparable to at least two West Dump sites (Figure 44).

Native perennial plant density

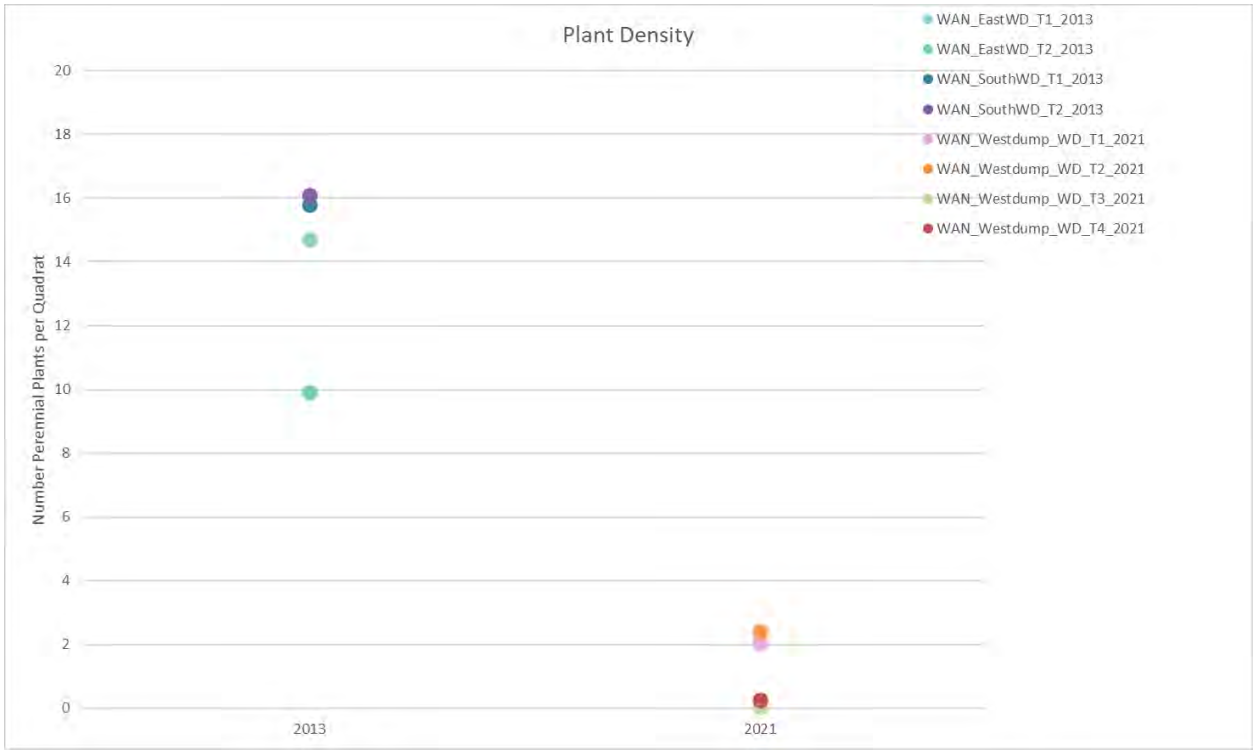

Figure 45: Native perennial plant density (plants/quadrat) at the West Waste Dump rehabilitation and reference sites in the first monitoring years.

Lower plant density values were recorded at all West Waste Dump transects in 2021 compared to those observed in 2013 at the South/East Waste Dump rehabilitation (Figure 45). The highest number of plants per quadrat recorded at the West Waste Dump rehabilitation (2.4) was approximately one quarter of the lowest number of plants per quadrat recorded at the South/East Waste Dump (9.9).

Native perennial plant cover

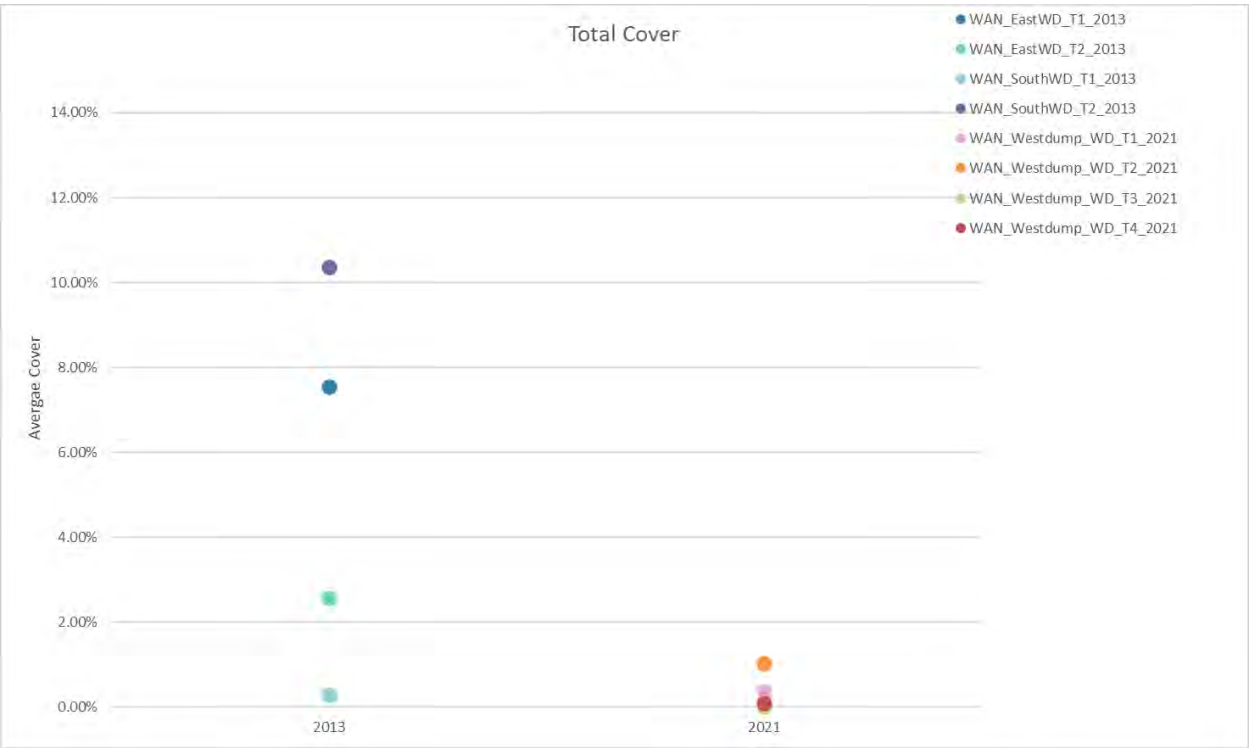

Figure 46: Native perennial total plant cover (%) at the West Waste Dump rehabilitation and reference sites in the first monitoring years.

Plant cover recorded during the first monitoring event at the South/East Waste Dump rehabilitation ranged from 0 to 10%, whilst only one West Dump transect had more than 0% cover in 2021 (Figure 46). Cover at the West Waste Dump rehabilitation was highly comparable to SouthWD_T1 and moderately comparable to EastWD_T2.

5.6. General discussion

Generally, higher plant density values (>10 plants per quadrat) were obtained in the first monitoring year at sites where seeding was conducted (the waste dump sites), whilst unseeded sites recorded less than 10 plants per quadrat during their first assessment. The two exceptions were RL2 (Rail Loop) which was attributed to abnormally high numbers of short-lived *Themeda sp*, and two Gas Pipeline transects with between 15 and 20 plants per quadrat which may be attributed to favourable conditions at the time of rehabilitation.

Species density values are generally lower than corresponding values in plant density, which is to be expected as extended time is required for rehabilitation sites to achieve high diversity of species. Encouraging trends in the number of species per quadrat were observed at the West Angelas Access Road and at two Highway Road transects, however unfavourable rainfall conditions resulted in declining trends post-2017 across most rehabilitation sites. Airstrip transects showed the most stability within species density trajectories, whilst least success was observed at the Rail Loop transects, likely influenced by the presence of invasive weed species.

Significant declines which are followed by corresponding inclines are usually attributed to fire disturbance, evidenced by Airstrip_T3, Highway_T3, Highway_T5 (Table 6), as well as reference sites (Table 5) with the trends most prominent within the parameter plant density.

Native perennial plant cover trajectories were highly variable both between and within sites, but generally show initial inclines which plateau in subsequent years. This is best reflected by rehabilitation outcomes at West Angelas Access Road, Rail Loop and East and South WD sites. Worst rehabilitation performance across all parameters occurred at the Rail Loop site, with both transects recording values between zero and one for all three key parameters. As discussed in the relevant sections, the location of the sites resulted in adverse impacts from dust and an increased risk of weed infestation, which may explain the unsatisfactory results.

5.7. Monitoring transects

Rehabilitated moderate and high impact disturbance areas within the West Angelas closure boundary discussed within Sections 5.4 and 5.5 comprise a total of 31 active rehabilitation transects and 9 reference sites. Locations of the rehabilitation and reference monitoring transects are presented in Figure 47 and Figure 48 below.

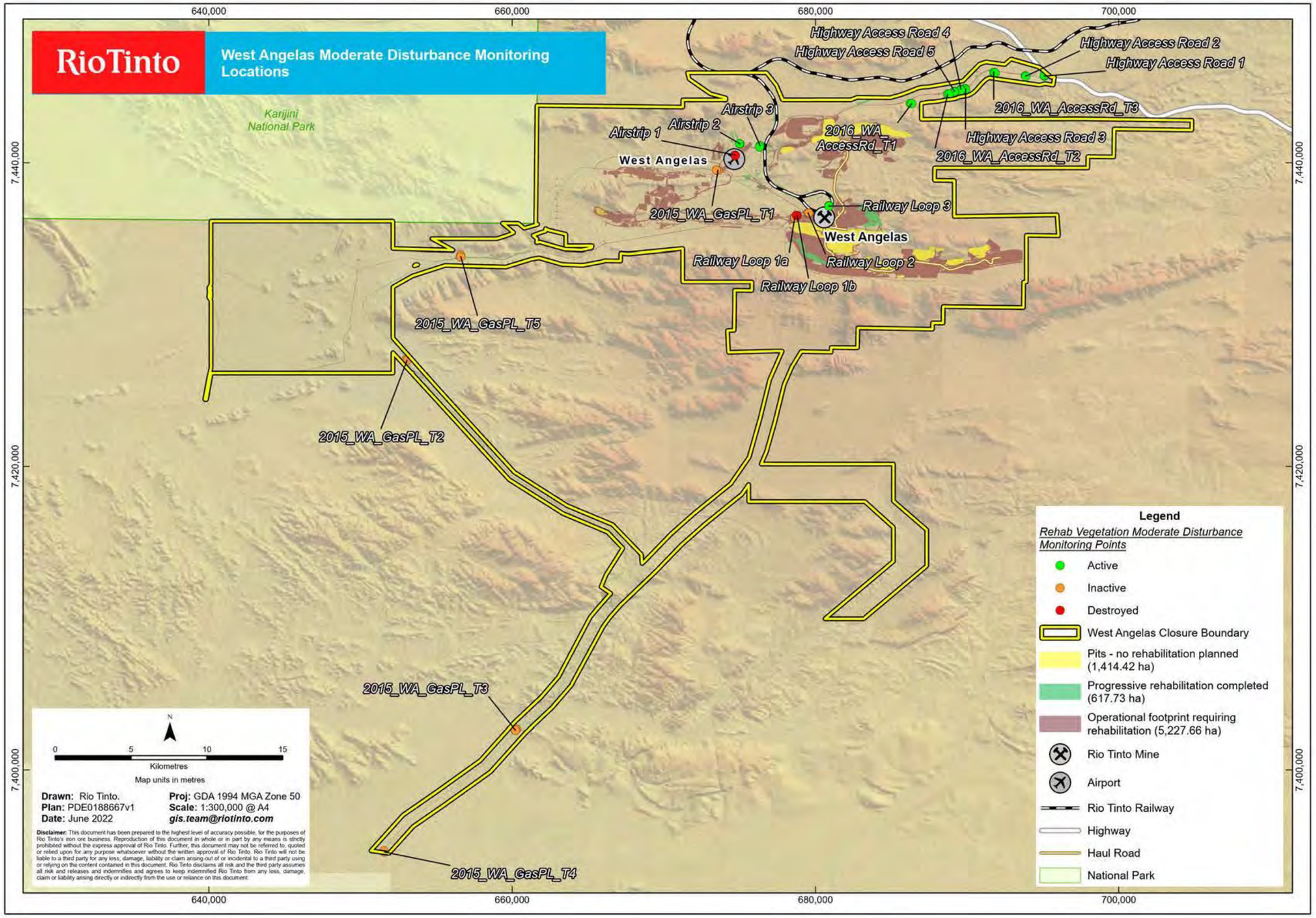

Figure 47: West Angelas moderate impact disturbance monitoring transects

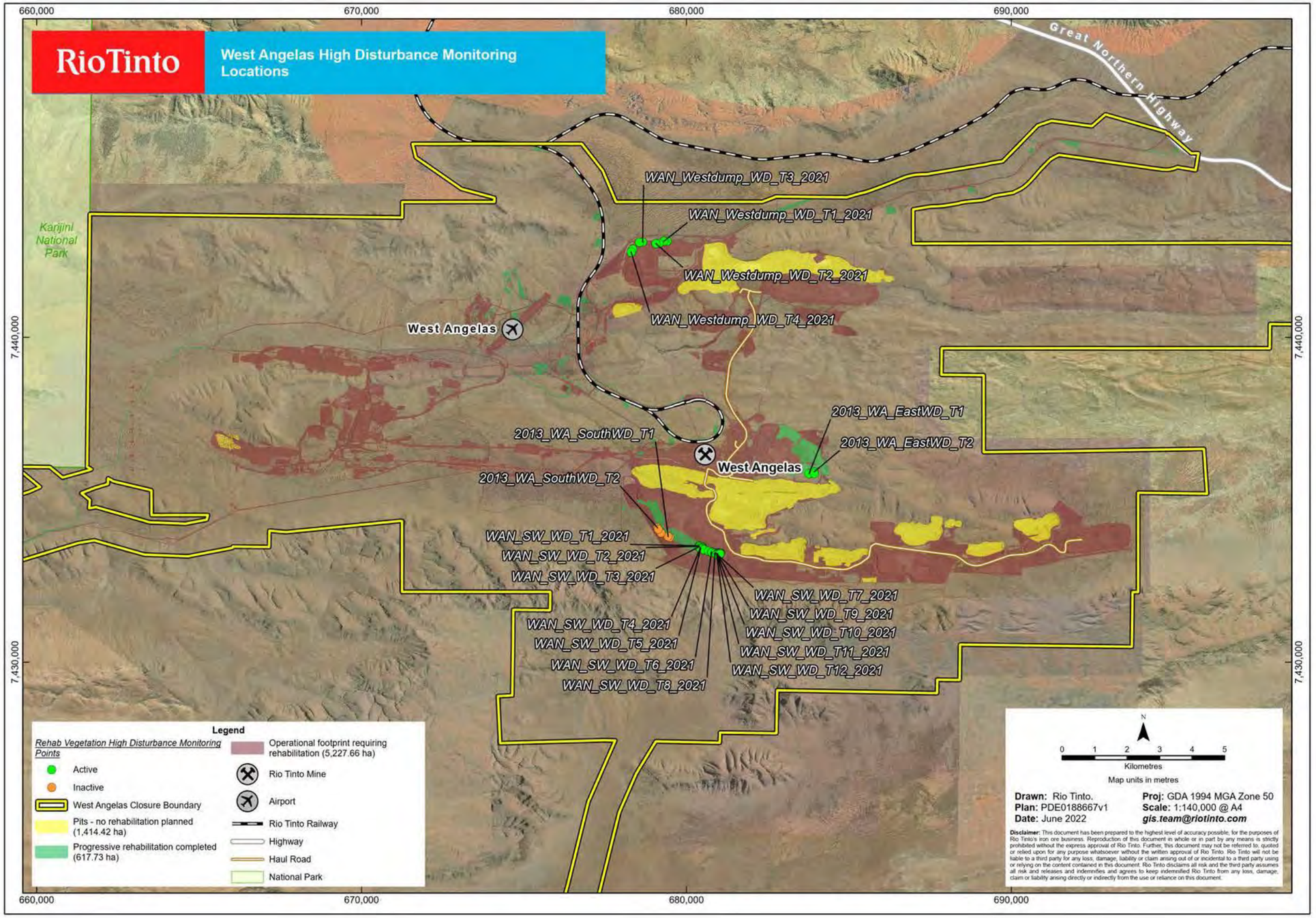

Figure 48: West Angelas high impact disturbance monitoring transects

6. RESEARCH AND DEVELOPMENT

Rio Tinto undertakes research and development to increase its understanding of the local natural ecosystems, optimise its rehabilitation techniques and improve confidence in the ability to achieve closure outcomes. Research and development projects range from opportunistic on-ground trials to large-scale multi-partner funded research programmes. Trial monitoring data is reviewed regularly to identify opportunities to refine rehabilitation techniques, such as the germination rates of sown seed, for continual improvement.

Although some research and trial projects described below were not conducted specifically on the tenements covered by this report, the learnings can be applied to works conducted on these sites and indicate the scientific approach applied to strive for continual improvement. A selection of recent research and development projects are summarised below.

6.1. Eco-engineering solutions to improve mine site rehabilitation outcomes

Rio Tinto Iron Ore and BHP Western Australia Iron Ore partnered in a federally funded research program investigating the rapidly developing field of Restoration Engineering, with a particular focus on the mining-intensive Pilbara region of Western Australia. This 4-year Global Innovation Linkages (GIL) project is led by the Kings Park Science research team and has additional partners from The University of Western Australia (UWA), Greening Australia, University of California, Brigham Young University, the University of Nevada, and Natural Resource Conservation LLC (a private US-based consultancy). The Restoration Engineering approach partners ecological research, focused on best practice use of seeds from a recruitment biology point of view, with innovative ecologically guided engineering solutions focussed on the invention and modification of seeding equipment needed to deliver native seeds at scale.

This project has continued to test a range of custom-built precision seeding machines for use in sloped and rocky soils of the Pilbara. Firstly, a critical evaluation of the field limitations of current mechanised seeding techniques has been undertaken. Broadcasting seeds onto the soil surface is now known to be problematic and un-desirable. With this, new precision seed delivery machines have been designed, constructed, and field tested over the past three Pilbara summers in sites operated by both mining partners. Preliminary findings of this work have demonstrated that seeds are being incorporated in the upper soil layer more efficiently than previously achieved. Monitoring of these sites after significant rain events is suggesting seedling recruitment and rehabilitation performance of targeted genera such as *Triodia* is improving.

By experimentally comparing seed sowing depth (standard practice versus precision placement with the newly designed machinery) and manipulating the recruitment dynamics of seeds (standard ‘off-the-shelf’ seed treatments versus seeds treated to maximise recruitment potential – using treatment such as flash flaming or smoke-priming of seeds), the research group have shown that perennial grasses establishment of focal *Triodia* species can be increased to 35 seedlings per square metre (6-fold higher that standard, common seeding practices). These findings were observed after this trial site received suitable cyclonic rainfall (Figure 49). In the summer season of 2020/2021, replicated, multi-hectare trials have been installed across both mining partner sites (Rio Tinto Iron Ore and BHP) in over 30 ha that are made up of different landforms and soil types. These repeat trials are critical to assess the performance of the precision seed delivery machinery and seed treatments across years and under varying conditions of rainfall.

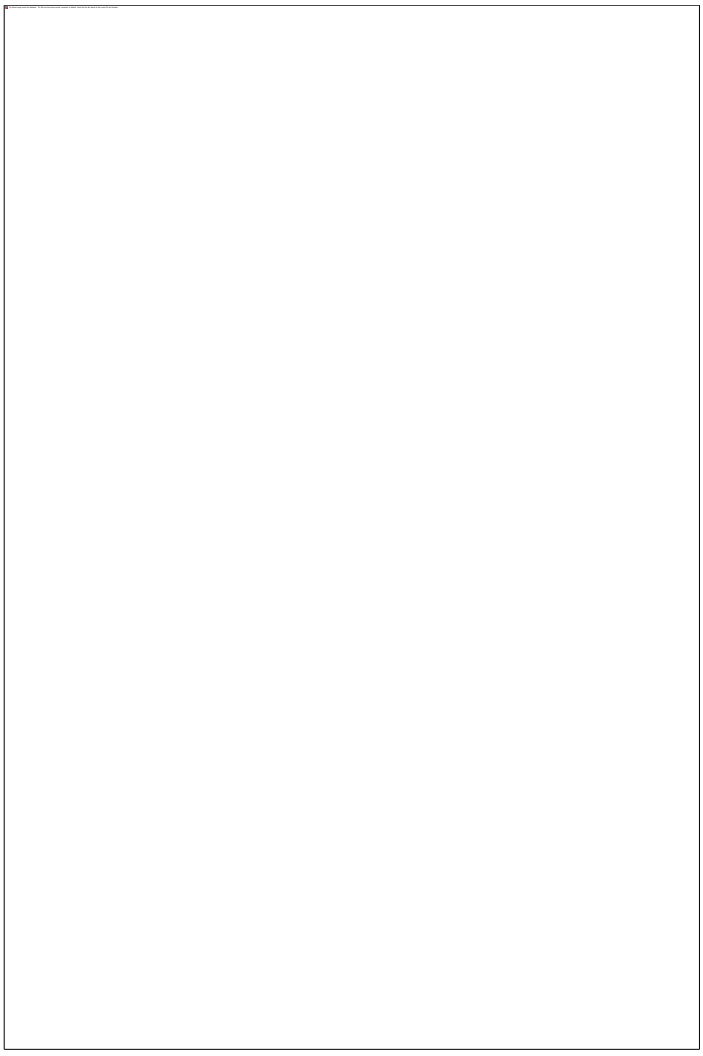

Figure 49: Germination of grass seed following trial of precision seeding equipment.

6.2. Acceptable rates of erosion for rehabilitated mineral waste landforms

A major consideration for rehabilitation and closure of waste landforms on mine sites is long-term erosion stability. In Western Australia, regulators require that landforms will remain 'stable' for hundreds of years or in the 'long-term'. Therefore, assessment of a landform's potential long-term erosion stability requires the use of erosion and/or landform evolution models and defensible erosion thresholds below which rehabilitation landform designs are considered acceptably erosion resistant or 'stable'.

To date, definitions of acceptable long-term erosion rates used in mining settings have been based on limiting the initiation of key erosion processes for steeply sloping land (i.e., rill and gully erosion). These approaches have been observed to achieve suitable results but may be somewhat conservative. Importantly, the rates currently applied as acceptable in landform design were based on measurements of erosion during rehabilitation monitoring and on landform evolution modelling for a limited range of materials and climates. To address this, Rio Tinto, with three other member companies of the Pilbara Rehabilitation Group (PRG), BHP, Fortescue Metals Group and Roy Hill, initiated a project aimed at defining acceptable rates of erosion for rehabilitation landform design for the Pilbara region of Western Australia. Landloch Pty Ltd (Landloch) was selected to undertake the work for this project using information derived from PRG member sites, with the Western Australian Biodiversity Science Institute (WABSI) acting as the project facilitator.

As part of the project, a review of information relating to erosion rates on natural and man-made landforms was conducted. This review showed that a wide range of approaches has been used to

define acceptable erosion rates, including a linking to rates of soil formation; maintenance of soil quality (which may include considerations of plant/crop productivity, effective soil depth and soil organic matter and nutrient stores); rates of natural erosion in adjoining areas; potential for gully formation; and water quality impacts. Based on this review, a guideline was developed to define acceptable erosion rates for use in the design of stable mine waste landforms in the Pilbara region. The guideline uses a risk-based approach, with erosion thresholds being linked to the physical properties of the waste material and the adverse environmental impacts that may result from landform failure. The first phase of this project was completed in 2018 and stakeholder engagement occurred to communicate key project findings. Further work is underway to define how to incorporate this guideline into Rio Tinto's landform design processes and to understand implications for the business.

6.3. Additional waste samples for batter selector

Rio Tinto is looking to build a more robust test work programme to determine erodibility data for waste types across Rio Tinto mine sites in the Pilbara. The key driver for the work is to ensure that key waste types across the various mine sites and lithologies are well understood and that detail is provided on the thresholds used to derive the Rio Tinto erodibility classifications of low, moderate, and high.

Rio Tinto utilise a Batter Selector Tool (BST), that is based on laboratory testing of individual waste types to optimise the final landform design by determining appropriate lift heights, slope angles, berm widths and berm back slope angles on an individual landform basis. The BST is based on the ongoing testing of waste material samples over a number of years; however, sampling has historically been biased towards some sites and some waste types more than others. This project seeks to address identified gaps and build greater certainty into the application of the BST.

Landloch undertook a gap analysis of the BST in 2018 and provided input on key wastes to consider in future revisions of the tool. Rio Tinto have developed a list of sampling priorities based on the gap analysis. The list provides detail on the site, geology, consolidated rock type and priority rating based on existing waste characterisation data completed by Landloch and presented within the BST. Test work will continue, facilitating advancements within waste type classification methodology, and the BST and landform design will continue evolve.

6.4. Channar scree slope trial

In 2014, as part of a preliminary closure study for the Channar mine, it was proposed to use rock armouring for a number of constructed legacy landforms, including land bridges and waste dumps, where access for standard rehabilitation earthworks purposes is constrained and/or too steep to safely bench and push down the slopes. Specific design criteria were developed based on modelling to meet acceptable erosion rates and long-term stability, including maximum batter heights, gradient, and rock size. The Department of Mines and Petroleum (now DMIRS) were consulted regarding this approach in May 2015 and indicated the requirement of further information and certainty before such an approach could be endorsed. In August 2019, DMIRS were advised that planning for a trial of the concept was underway. This project aimed to implement a scree slope (rock armouring) trial at the Channar mine on the CHE WD1 NE waste dump.

From October to late December 2020, contractors constructed a ~1m thick, rock armour on the CHE WD1 NE. This was achieved by screening various stockpiled or blasted material in Channar NE, to test for rocky material yield. This rocky material was then hauled to the tip head, where it was tipped short and pushed over. This process usually took 2 or 3 days for material to be built up enough to push over the tip head (Figure 50 and Figure 51). The trial demonstrated that sufficient rocky material to build the rock armour, is achievable through screening stockpiled/dumped (or blasted) material. However, productivity of the screening plant can be variable. Achieved Yield was lower in stockpiles. The trial indicated that, based on yield, the most suitable rock armour material would be a mix of banded iron formation (BIF) and hard cap. The trial was able to demonstrate that the scree slope design could be

achieved from a constructability perspective achieving a consistent 1m rock armour cap along the slope, with minor variation attributed to the pre-trial landform profile.

The scree slope trial will be monitored using high resolution UAV survey for a minimum of 5 years, to monitor the long-term stability of the scree slope rehabilitation strategy. A second scree slope trial at Channar is underway with planned completion in 2023.

Figure 50: Pre-project slope.

Figure 51: Post-project slope.

6.5. Growth media trials

Throughout the Pilbara, there is an ongoing opportunity to utilise mineral waste as soil substitutes or supplements for rehabilitation activities. It is anticipated that alternative growth media (AGM) will provide a suitable growth medium in rehabilitation areas where topsoil and subsoil are unavailable or limited. Research is underway to determine if utilising various types of AGM in various situation will provide acceptable rehabilitation outcomes.

When a waste type is identified as potentially suitable as an AGM, testing for standard parameters occurs, and then stockpiling will occur with relevant location information recorded on mine site survey records. Alternative growth media material has been previously identified and tested at Marandoo, Tom Price, Western Turner Syncline and Channar. Stockpiling of suitable material has commenced, with

additional investigations to incorporate materials into the mine plans for future recovery also underway. During 2017 the MMW4 rehabilitation project at Tom Price utilised S652 Gravels with monitoring of the rehabilitation showing positive trends and vegetation establishment. Monitoring progress of this area continued into 2020, and the materials are proposed for use at a future rehabilitation project at the MMS waste dump, tentatively planned for 2022 completion.

During 2019 a rehabilitation project, at the Brockman DP4 waste dump, had different ages of topsoil, subsoil and no soil incorporated into the design (Figure 52). The aim of the trial was to evaluate the performance of the soil materials, and to consider modifying the seed mix to better reflect the growth media. The rehabilitation of this area was completed in early 2020 and monitoring of its performance will be undertaken to provide a comparison of revegetation performance using fresh topsoil, stockpiled topsoil or subsoil.

Figure 52: Soil and alternative growth media trial design at the Brockman 4 DP1 and DP4 projects.

6.6. Mycorrhizal fungi trials at Middle Robe legacy rehabilitation sites

In 2020, a rehabilitation project targeting legacy areas was undertaken, which provided an opportunity to investigate the use of mycorrhizal fungi on rehabilitation performance. Most native Australian flora have a relationship with mycorrhizal fungi, which are often eradicated during heavy disturbance events. There is evidence that inoculating soil with a variety of mycorrhizae fungi will improve plant survivability and germination (Koziol *et al*., 2018). There is also evidence that mycorrhizae fungi may assist some native species to establish that otherwise wouldn't through traditional rehabilitation methods (Jeffries et al., 2003).

In the Middle Robe project, seed was coated in powder form mycorrhizae fungi for several trial areas (Figure 53). The expectation is that when moisture is encountered, the mycorrhizae will propagate and expand into the surrounding soil, inhabiting the new plants roots and assisting with plant nutrient uptake. The trial areas were incorporated into the 2021 monitoring program and will therefore enable control and trial data to be collected and analysed through time.

Figure 53: Mycorrhizal fungi trial areas.

6.7. Precision Seeding and Flash Flaming of *Triodia* Seed Trials

Broadcasting seeds directly onto the soil surface is now known to be problematic and un-desirable in terms of plant establishment rates, particularly of *Triodia* sp. The Deposit A South Waste Dump (DepA SWD) project participated in an 'eco-engineering' trial as part of the Global Innovation Linkages (GIL) project, in which a new precision seeding machine was trialled, as well as the use of 'flash flamed' *Triodia* sp. seed.

Preliminary findings of previous trials have demonstrated that seeds are being incorporated in the upper soil layer more efficiently than previously achieved, leading to an improvement in seedling recruitment and rehabilitation performance. Additionally, varying topsoil and subsoil depths (100 mm and 200 mm) were also implemented across the Dep A SWD trial area to determine any possible effects on plant establishment (Figure 54).

Anecdotally, there are positive signs in the outcome of the precision seeding trials implemented at DepA SWD, versus the traditional methods previously used. Ongoing monitoring of trial areas at DepA SWD will support the continual improvement of ripping and seeding practices of future rehabilitation projects.

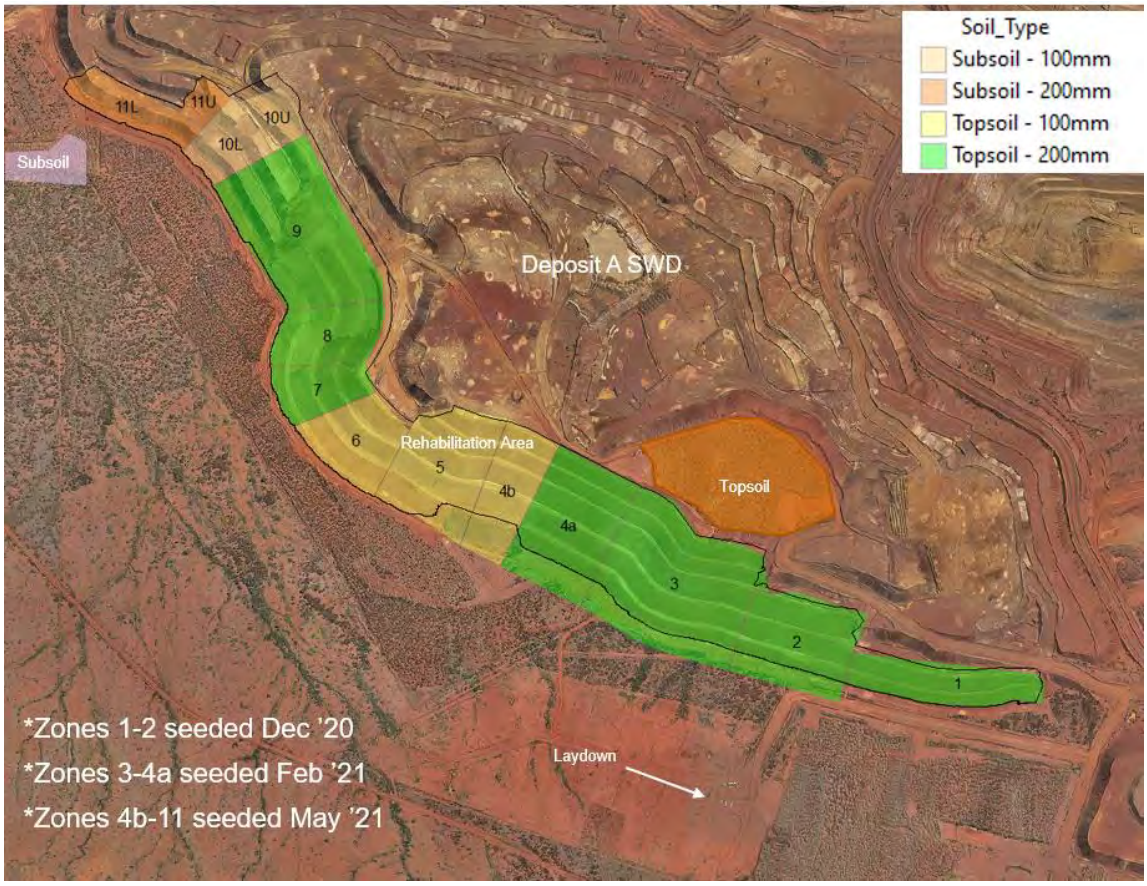

Figure 54: Topsoil and Subsoil Trials at DepA SWD

7. PLANNED STRATEGIC PROJECTS

The Rehabilitation and Closure team facilitates a quarterly regulator forum. It is intended that this forum is utilised for ongoing updates on the:

- Annual progressive rehabilitation program.
- Research and development.
- Strategic improvement projects.

7.1. Rehabilitation performance and completion criteria development

A Rehabilitation performance and improvement framework incorporating a plan, do, check and act (PDCA) cycle to centralise and improve the management and communication of rehabilitation performance status, learnings, remediation requirements, risks, knowledge gaps and associated actions is a planned initiative for 2022.

In association with this initiative, a strategic project to review both the current monitoring programme methodology and available rehabilitation monitoring data to develop a standardised method to develop suitable SMART completion criteria for all operations is also scheduled for development in 2022. The development of quantitative completion criteria will then follow with a prioritisation for those assets approaching closure.

This has already occurred at Eastern Range and Channar and the completion criteria have been submitted with the MCP to regulators in 2021. Pending regulator feedback will be utilised for the alignment of the development process.

An associated outcome of this strategic work will be a defined procedure for the determination of when and where remedial works are required for rehabilitated sites where performance is not tracking towards acceptable performance criteria.

7.2. Seed improvement project

If seed is not of a sufficient quantity, type and/or quality, the rehabilitation performance of implemented works will not meet agreed completion criteria to the satisfaction of stakeholders. Therefore, an improvement project will be undertaken to incorporate culturally significant species into rehabilitation, refine species lists and forecast improvements to ensure suitable seed species and volumes are available to meet increasing rehabilitation outputs through to 2027 and beyond. A pilot program to collect seed from pre mining areas at Western Range is planned for 2023. This will provide insights and learnings for future seed collection partnerships.

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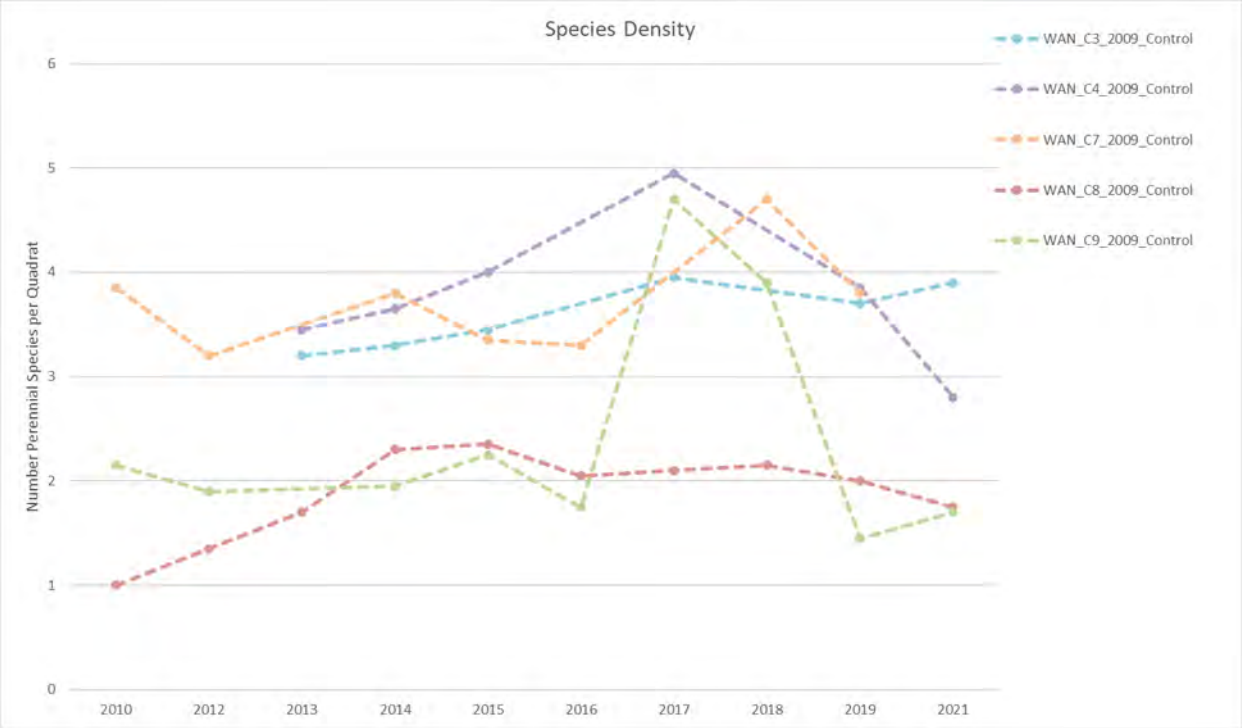
APPENDIX A: SUPPLEMENTARY REFERENCE SITE DATA

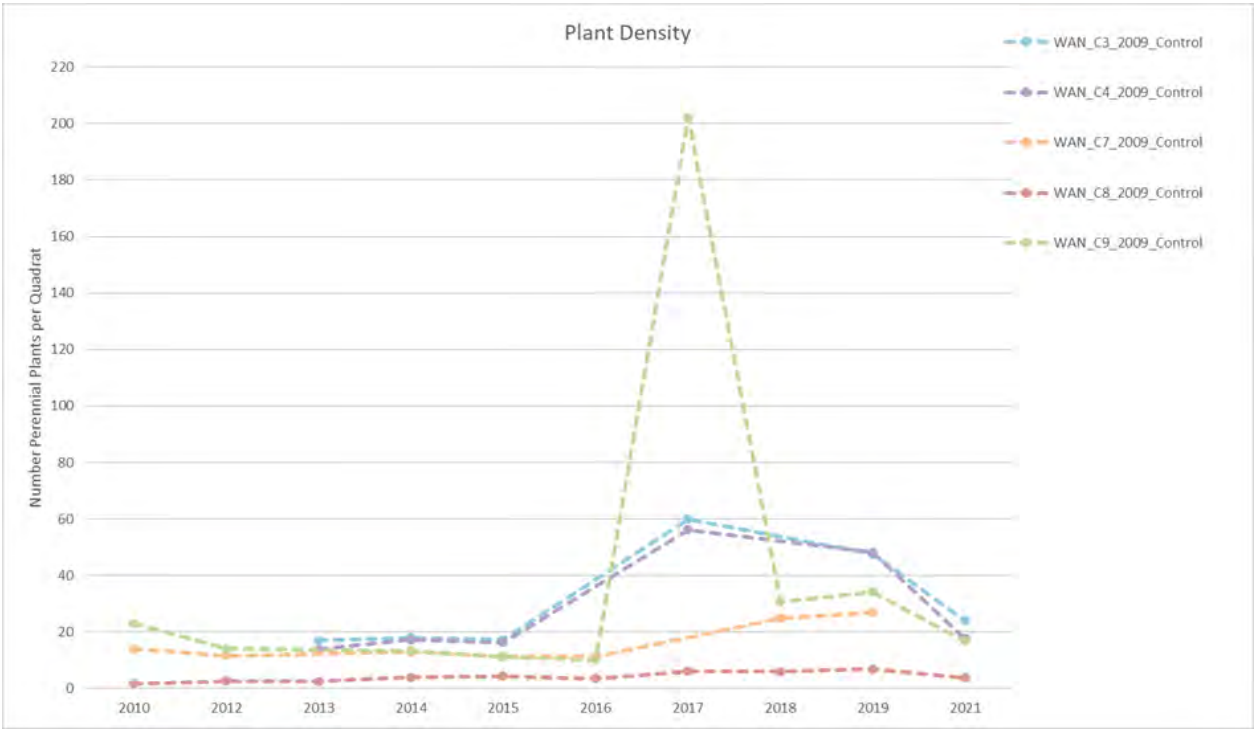
A.1: Overview of reference site selection for moderate impact sites

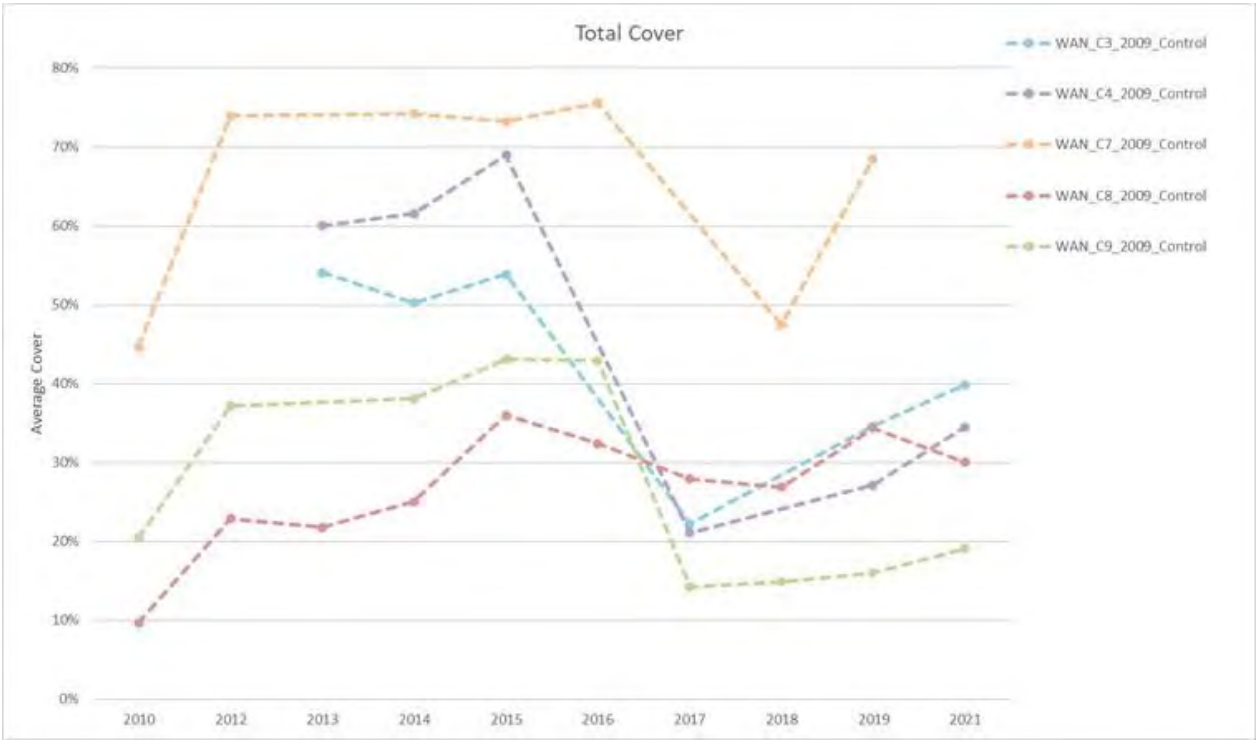
REHAB SITE	REFERENCE SITES USED IN MONITORING REPORTS					REFERENCE SITES USED IN THIS SUMMARY / RATIONALE
MODERATE IMPACT DISTURBANCE						
West Angelas Access Road	**2016:** C7, C8, C9	**2017:** C3, C4, C8, C9	**2018:** C7, C8, C9	**2020:** Unknown (report unavailable at time of writing)		C8, C9 – correspondingly flat terrain
Highway Access Road	**2010:** C7, C8, C9	**2012:** C7, C8, C9	**2014:** C3, C4, C7, C8, C9	**2017:** C3, C4, C8, C9	**2021** Unknown (report unavailable at time of writing)	C8, C9 – correspondingly flat terrain
Railway Loop	**2010:** C7, C8, C9	**2012:** C7, C8, C9	**2014:** C3, C4, C7, C8, C9	**2017:** C3, C4, C8, C9	**2021:** Unknown (report unavailable at time of writing)	C8, C9 – correspondingly flat terrain
Airstrip	**2010:** C7, C8, C9	**2012:** C7, C8, C9	**2014:** C3, C4, C7, C8, C9	**2017:** C3, C4, C8, C9	**2021:** Unknown (report unavailable at time of writing)	C8, C9 – correspondingly flat terrain
Gas Pipeline	**2015:** GasPL_C1, GasPL_C2, GasPL_C3, GasPL_C4, GasPL_C5	**2016:** GasPL_C1, GasPL_C2, GasPL_C3, GasPL_C4, GasPL_C5	**2017:** GasPL_C1, GasPL_C5			GasPL_C1, GasPL_C2, GasPL_C3, GasPL_C4, GasPL_C5 As although only C1 and C5 were monitored in 2017, only one rehab transect was included so reference sites that only have 2015 to 2016 trajectories are still valuable for rehab transects with corresponding trajectories
HIGH IMPACT DISTURBANCE AREAS						

East and South Waste Dump	**2013:** C3 C4 C8	**2014**: C3 C4 C7 C8 C9.	**2015:** C3 C4 C7 C8 C9	**2017:** C3 C4 C8 C9	**2019** C3 C4 C8 C9	C3 C4 – correspondingly sloped terrain C8, C9 – to account for C3 and C4 burnt in same event. Appropriate despite flat terrain as one East WD transect is located on a flat part of the slope

A.2: Vegetation parameter trends over time at reference sites WAN_C3, C4, C7, C8 and C9




Plant Density
Number Perennial Plants per Quadrat
220
200
180
160
140
120
100
80
60
40
20
0
2010
2012
2013
2014
2015
2016
2017
2018
2019
2021
WAN_C3_2009_Control
WAN_C4_2009_Control
WAN_C7_2009_Control
WAN_C8_2009_Control
WAN_C9_2009_Control


Total Cover
Average Cover
80%
70%
60%
50%
40%
30%
20%
10%
0%
2010
2012
2013
2014
2015
2016
2017
2018
2019
2021
WAN_C3_2009_Control
WAN_C4_2009_Control
WAN_C7_2009_Control
WAN_C8_2009_Control
WAN_C9_2009_Control

A.6: Consultation Register

APPENDIX A: SOCIAL SURROUNDINGS

A.6: Traditional Owner Consultation

Consultation Framework Under their respective Agreements, the Proponent and each Traditional Owner group have agreed heritage-specific engagement processes, including Heritage Protocols, which provide for archaeological and ethnographic surveys, associated consultation and meetings and Cultural Heritage Management Plans to be undertaken or developed.

Formal, informal and ad-hoc Traditional Owner meetings and forums include:

Six-monthly Local Implementation Committee (LIC) meetings: The LIC are existing Traditional Owner specific forums established through final Participation Agreements Rio Tinto has with Traditional Owner groups. The LIC forums facilitate the implementation of the regional standards contained in the Regional Framework Deed [1] or the implementation plan in the Participation Agreements. These standards or plans are in respect of cultural heritage management, land access, environmental management, life of mine planning and cultural awareness training, employment and training, business development and contracting. At least once a year, the forum discusses and makes recommendations to Rio Tinto on matters regarding the standards or implementation plans. The forum is constituted by six Traditional Owner group representatives and three senior Rio Tinto representatives. The LIC forum is convened at least once every six months.

Heritage surveys: Rio Tinto is committed to undertaking heritage surveys at the earliest practicable stage of project development including baseline surveys. Heritage surveys may be either ethnographic or archeological in nature. In-field heritage surveys are scheduled and completed via the Traditional Owner Registered Native Title Bodies Corporate (RNTBC) with Traditional Owner group representatives (including consultants) to identify sites of special significance and Aboriginal sites (including cultural values) of immediate concern to ensure these sites are considered in the long-term development decisions by Rio Tinto. Rio Tinto is committed to avoiding all identified heritage sites where possible however instances where this is not practical, prior to impact to any site, Rio Tinto consults Traditional Owners about how heritage values of Aboriginal sites may be preserved, recorded or impact mitigated.

Heritage specific consultation forums: Heritage specific consultations often are carried out through special function heritage subcommittees of the LIC. Both Ngarlawangga and Yinhawangka have these subcommittees. Unless otherwise determined by a special resolution of the LIC, the Heritage Sub Committee (HSC - Ngarlawangga) and Heritage Environment Committee (HEC – Yinhawangka) do not exceed four members (with at least one Rio Tinto and Traditional Owner member), they meet regularly, and they report directly to the LIC. The HSCs collaboratively manage and oversee the conduct of heritage surveys, consultations and other cultural heritage management procedures on the country of each Traditional Owner group.

Life of Mine Planning (LoMP) meetings: The Life of Mine Plan Forum is an avenue established through the Regional Framework Deed [2] to allow Rio Tinto and Traditional Owners to work collaboratively on land and water related aspects of mine planning and development of infrastructure. The forum meets at least twice a year and provides opportunity for Rio Tinto and Traditional Owner groups to discuss among others what mining is happening or what projects are planned on Traditional

[1] The Regional Framework Deed (RFD) is an Agreement between Rio Tinto and Pilbara Traditional Owners with the aim to change how Rio Tinto operates in engaging with local Traditional Owners and for the purpose of improving the wellbeing of Aboriginal people throughout the Pilbara.

Owner's Country in the Pilbara. Through LoMP engagements, Traditional Owners provide Rio Tinto timely information, feedback including concerns and ideas in relation to Rio Tinto's projects (across the different development stages) and key approval applications. LoMP forums constituted by four Rio Tinto representatives (at least one with senior managerial responsibility) and the LIC members of the Traditional Owner group. To date (September 2022) LoMP forums have been established with Ngarlawangga; but are yet to be established with Yinhawangka as standalone forums. LoMP updates are currently provided to Yinhawangka via their HEC or LIC meetings in place of an additional consultation forum.

Approvals specific consultation and engagement and other meetings as required: Additional specific consultations and engagements are undertaken with Yinhawangka or Ngarlawangga as required. These meetings are generally requested to consult on topics that may dominate agendas and discussions of other engagements and provide all parties with a separate opportunity to consider and discuss in depth. Additionally, subject matter experts or external consultants may be requested by Traditional Owners to specifically discuss topics and themes in more detail.

Social Surroundings consultation: Further to the significant consultation already undertaken (Table A6.1), Rio Tinto and each Traditional Owner group have established and are continuing to develop and undertake dedicated Social Surroundings consultation forums, including both in-field consultation as well as meetings and workshops to support their mutually agreed approach for codesigned development of approvals documents, including ERDs and SCHMPs. Each Traditional Owner group is represented by individuals from the group, including elders with cultural authority and others who are community-recognised spokespeople, along with officers from the relevant RNTBC and supporting personnel engaged by the RNTBC, such as anthropologists or environmental approval specialists as appropriate for any particular session. These supporting personnel may also be engaged by the RNTBC to assist in the development, revision and drafting of approvals documents. The Proponent can be represented by a range of personnel suited to the topics under discussion, but other senior personnel may also be present, such as study leads and managers, and various discipline representatives such as cultural heritage advisors.

Ethnobotanical/Land Management or Traditional Ecological Knowledge consultation: The primary purpose of TEK surveys is to develop a written record of existing knowledge and known language names of flora and fauna as provided by the Traditional Owners, for use within their community, cultural knowledge base and ranger programs. TEK surveys also record an understanding of plants that are traditionally and culturally important to the past and current lives of the Traditional Owners, to inform impact assessment with respect to both singular and cumulative mining developments.

Through this framework, the Proponent and the Traditional Owner groups work together to share information to support the management of the social, cultural, heritage and environmental values of the areas in which the Proponent operates on their Country.

Traditional Owner Agreements

The Proponent has also committed to not enforcing any Agreements clauses that restrict Traditional Owners from raising concerns about cultural heritage matters with anyone or applying for statutory protection of any cultural heritage sites.

The Proponent is working hard to rebuild trust with Traditional Owners and make changes to its business to strengthen its approach to cultural heritage and improve the way it engages to ensure incidents like Juukan Gorge never happen again. To improve its practices, Rio Tinto is moving to a co-management of Country approach which will enhance protection of heritage and better outcomes for Traditional Owners in the Pilbara. A key component of this is ongoing modernisation of Rio Tinto's Agreements with Traditional Owners which will introduce mechanisms into the Agreements to respond better to new information that may emerge about cultural heritage sites, cease enforcement of clauses such as those that restrict Traditional Owners from raising concerns about cultural heritage matters to anyone or

applying for a statutory protection of any cultural heritage site. In addition, Rio Tinto has established the Australian Advisory Group (AAG). The AAG brings together a broader, eminent group of independent advisers to provide guidance on current and emerging concerns, and better manage policies and positions that are important to both Australian communities and Rio Tinto's broader business.

Traditional Owner Social Surroundings Consultation Principles, Approach and Objectives

The Proponent is committed to the principles of authentic, meaningful, transparent and integrated consultation with each Traditional Owner group, and recognises it is important to understand the cultural context and norms of each Traditional Owner group and to integrate this into a jointly developed consultation process.

The consultation process developed by the Proponent with the Ngarlawangga and Yinhawangka Traditional Owners aims to take into account that each Traditional Owner group has its own governance structure and internal decision-making processes.

As with any group, the interests and views amongst the Elders/knowledge holders, other Traditional Owner individuals and their RNTBC, may differ from each other. Under relevant Agreements, the Proponent is required to engage with, and seek input/decisions from, each RNTBC. However, as part of its Social Surroundings consultation, the Proponent has sought to engage with a broader representative group of Traditional Owners who have authority to speak for the land, the subject of the Development Envelope. These individuals are selected through the RNTBC's governance processes to take part in both in-field and workshop style consultation.

As there are two Traditional Owner groups involved in the Proposal, the Proponent recognises that there are cultural protocols around which areas and concerns each group is able to advise and be consulted on. This has meant consultation includes qualitative and quantitative approaches following local protocols involving a variety of methods as appropriate to and as informed by each group and families within those groups, and the persons being consulted – examples of approaches used to date include one-on-one interviews with elders (recognising gender-specific knowledge holders), on-country Social Surroundings consultation with 10-20 Traditional Owners, as well as workshop-style meetings, archaeological and ethnographic heritage surveys and other heritage specific consultation, story-telling, filming and sound recordings, as well as ensuring supporting personnel have attended as required during these approaches, at the direction of the RNTBC s.

Traditional Owners and their support staff reside in widespread locations, mostly in Pilbara towns and communities (for example, Newman, Tom Price, Paraburdoo, Port Hedland and smaller Aboriginal communities) but also beyond (for example, Perth) so arrangements for in-person meetings and field trips are contingent on the Proponent being adaptable and flexible to ensure all key people are involved as needed.

Free, Prior and Informed Consent

The Proponent is committed to striving to achieve the free, prior and informed consent of the Traditional Owner groups affected by the Proposal with respect to:

- Achieving each group's endorsement of, and participation in, the mutually agreed upon consultation process and approvals document development
- Obtaining information from Traditional Owners regarding the tangible and intangible social surroundings values inherent in their Country
- Working with each group to understand potential impacts from the project, listening and responding to ensure impacts are minimised and managed on their key values.

However, the Proponent acknowledges that it is not culturally appropriate to request the outright and absolute support and consent of some or all Traditional Owners for all elements of the Proposal. In such circumstances the Proponent aims to obtain the non-opposition of the relevant RNTBC to the Proposal.

Consultation Objectives

The objectives for Traditional Owner consultation and engagement in respect of the Proposal are to:

- Keep Traditional Owners informed at all stages of the study and approvals process (and continuing throughout the life of the Proposal)
- Seek input and feedback to understand how the Proposal impacts social, cultural and heritage values and use this information to develop options to avoid, reduce and manage these impacts for consultation with Traditional Owners and seek their input on these options to inform decision making
- Obtain Traditional Owner non-opposition for the Proposal to be referred to the EPA and, ultimately, for the Proposal itself
- Identify, acknowledge and incorporate social, cultural and heritage values in Proposal design to, where possible, avoid negative impacts or where this is not possible to mitigate or manage negative impacts
- Co-design SCHMPs with Traditional Owners that:

  Address the EP Act objective for Social Surroundings

  Identify and minimise impacts of the Proposal on Traditional Owner social surroundings

  Provide an agreed framework for Traditional Owner involvement in Proposal decision-making, activities and oversight processes relevant to social surroundings

  Co-establish, implement and review minimization, mitigation and management activities, and oversight processes relevant to social surroundings through the life of the Proposal

  Meet Native Title Agreement (NTA) commitments

  Contribute to building and maintaining good, respectful relationships with Traditional Owners and other stakeholders

  Demonstrate, and continue to develop, good practice engagement.

Social Surroundings Consultation Process and Progress

The Proponent has undertaken targeted engagement with each of the Traditional Owner groups in respect of the Social Surroundings values relevant to the Proposal.

Consultation is ongoing and continues to be jointly developed with each Traditional Owner group, but the broad consultation process followed to date is outlined below:

- Provide background and context to the Proposal
- Identify key values or issues/concerns
- Identify design/planning/management options to address key issues/concerns, taking into account the mitigation hierarchy, being
  - Avoid significant impacts to social surroundings where possible
  - Otherwise minimise impacts, through the open discussion of design options and operation limits
  - Discuss rehabilitation strategies specific to individual areas
- Consultation in respect of options, seek input into key design decisions
- Communicate decisions and agree outcomes including ongoing planning and management, if required
- Provide the draft Social Surroundings chapter and draft ERD to Traditional Owner groups for review and feedback prior to lodgment with the EPA

- Joint development of SCHMPs with each Traditional Owner group to address specific issues/concerns and agreed management actions and framework for ongoing consultation.
- Consultation will continue throughout the environmental approvals process, including during the development of SCHMPs, and throughout the life of the Proposal.

Table A6.1 Social Surroundings Consultation Program

Consultation Stage	Purpose	Details of Consultation			
		Ngarlawangga	Date	Yinhawangka	Date
Initial / Pre-Referral Meeting	Introduce and establish a baseline understanding of the Proposal and work to investigate its potential development.	Local Implementation Committee (LIC) Meeting - Detailed Overview and introduction of WAN B2020 and Part IV	Sept 2019	LIC Meeting - Detailed Overview and introduction of WAN B2020 and Part IV .	Oct 2019
		West Angelas B2020 and Part IV Social Surroundings Meeting.	Oct 2020	West Angelas WAN B2020 and Part IV Social Surroundings Video Conference	July 2020
				Heritage and Environment Committee (HEC) Meeting – WAN B2020 and Part IV update	September 2020
Community Meeting / Pre-Field Work Consultation	To discuss the Proposal and to scope Social Surroundings fieldwork.	RTIO West Angelas, Mt Ella & Hope Down 2 Expansion Project Proposal and Introduction to Social Surroundings meetings and planning.	9–10 December 2020	N/A	N/A
		Social Surroundings Traditional Ecological Knowledge TEK Flora Project Proposal	August 2022		
In-Field Site Visits and Consultation (several as needed)	On-Country assessments to explain the proposal and development options to Traditional Owners, provide clarity where they may intersect values, seek to understand concerns or potential impacts to values, and to provide feedback on previously raised concerns, identify known and 'new' sites or areas of significance. Being on Country is generally the preferred setting for Traditional Owners to understand the Proposal and the development options, and to explain, clarify, confirm or provide	West Angelas, Mt Ella and Hope Downs 2 Phase 1 Scoping Field trip	9–13 April 2021	West Angelas Social Surroundings Field Trip 1	22–27 March 2021
		West Angelas Social Surrounding Fieldtrip 2	21–23 September 2021	West Angelas Social Surroundings Field Trip 2	(25–28 May 2021
		Mt Ella Ngarlawangga & Yinhawangka Mt Ella In-field Consultation 1	10–13 November 2021	West Angelas Social Surroundings Field Trip 3	10–14 November 2021

Consultation Stage	Purpose	Details of Consultation			
		Ngarlawangga	Date	Yinhawangka	Date
	further information on social and cultural heritage values or concerns. The site visits also include areas of direct and potential indirect impacts (including examples from nearby operating mines), with on-ground discussion of how Country may be affected, and the potential significance of this for people. Relevant data and information is recorded for input into project planning, impact assessment and mitigation and management strategies.	Mt Ella Ngarlawangga, Yinhawangka and Martu Mt Ella In-field Consultation 2	28 February–2 March 2022	West Angelas Social Surroundings Field Trip 4	1 March 2022
		Ngarlawangga Traditional Ecological Knowledge Flora Fieldtrip	19–24 August 2021 (ongoing)		
Post Site Visit Meetings (several as needed)	To review and discuss the outcomes of in-field consultation and to plan additional in-field consultation. Additional meetings will continue to be convened as required and Traditional Owner capacity permits.	NAC RTIO West Angelas, Mt Ella and Hope Downs 2 Phase 1 Scoping Fieldtrip debrief	29 July 2021	HEC Meeting – Study and WAN RP Overview and Values discussion: May 2021	
		Life of Mine Planning – High Level study update	September 2021	HEC Meeting – High level study update and Social Surroundings discussions	October 2021
		Social Surroundings Meeting - Yinhawangka and Ngarlawangga shared values	21 October 2021	Social Surroundings Meeting - Yinhawangka and Ngarlawangga shared values	21 October 2021
		Ngarlawangga Aboriginal Corporation WAN Social Surroundings Consolidation Workshop	10–11 May 2022	HEC Meeting – High level study and Social Surroundings update	March 2022
				Consolidation Workshop: Preliminary Advice	21 June 2022:
				YAC Board Meeting – WAN RP and Study Amendments:	Aug 2022
Document review and SCHMP development meetings/ workshops	Consultation workshops to review Social Surroundings recommendations, project development, mine planning and amendments, Subject Matter Expert updates, commitments and Environmental Review Document, Social Surroundings Chapter, and Social	Life of Mine Planning – Social Surroundings Recommendations discussion, Chapter and SCHMP introduction	June 2022	Social, Cultural and Heritage Management Plan Workshop (SCHMPW): SCHMP	22 June 2022
		Social Surroundings Chapter, SCHMP Workshops 1-3	13–14 Sept 2022 (Dampier)	Social Surroundings Chapter, SCHMP Workshops 1-3	6–7 Sept 2022 (Karratha)

Consultation Stage	Purpose	Details of Consultation			
		Ngarlawangga	Date	Yinhawangka	Date
	Cultural Heritage Management Plan development		13–14 Oct 2022 (West Angelas – On Country) 23–24 Nov 2022 (Point Samson)		4–5 Oct 2022 (Paraburdoo – On Country) 15–16 Nov 2022 (West Angelas – On Country)
		Social Surroundings Chapter, SCHMP & ERD workshops 4-5	27 – 28 April 2023 (West Angelas – On Country) ~July 2023 (Dates to be confirmed)	Social Surroundings Chapter, SCHMP & ERD workshops 4 -5	4–5 April 2023 (EPA Attended – West Angelas – On Country) ~August 2023 (Date to be confirmed)

Aboriginal Heritage Consultation

Under their respective Agreements, the Proponent and each Traditional Owner group have agreed heritage specific engagement processes, including Heritage Protocols, which provide for archaeological and ethnographic surveys, associated consultation and meetings and Cultural Heritage Management Plans.

These approaches are embedded in a Cultural Heritage Management System (CHMS) and strengthened by an Integrated Heritage Management Process (IHMP). The CHMS is guided by the Proponent's Cultural Heritage Procedure under the Communities and Social Performance Standard. All heritage surveys are undertaken in the field by qualified heritage professional consultants and completed with the participation and cultural leadership of the relevant Traditional Owner groups. Archaeological and ethnographic values of each place are recorded to a standard acceptable to both the Traditional Owners and in line withbest practice standards in cultural heritage management as well as applicable heritage legislation.

Ongoing Consultation

Social Surroundings and heritage consultation with each Traditional Owner group is ongoing and will continue through all stages of the environmental impact assessment and approval, into operation, construction and closure phases.

Processes for ongoing, post-approval, consultation throughout the Proposal operation and closure will be incorporated into the SCHMPs to be prepared and co-designed with each Traditional Owner group. In undertaking future consultation, the Proponent recognises the sometimes-limited capacity and resources of the Traditional Owner individuals, groups and their RNTBC to adequately address requests to examine and respond to, for example, environmental impact assessments. The Proponent is committed to working with each Traditional Owner group to achieve the right consultation and engagement balance in accordance with Traditional Owner wishes.

Proposal Visualisation

To support consultation with Traditional Owners, a visualisation tool produced for the Proposal positions the proposed mine layout within a 3D landscape, visualising potential designs and impacts (Figure A1 to Figure A4).

The 3D models have been well received and will continue to be developed, updated, and presented in consultation forums with both Traditional Owner groups. The visual aids support the groups to articulate concerns, in particular where they would like to further understand potential impacts within the landscape, as well as allowing the Proponent to communicate where changes to mine designs are occurring.

These models have been provided directly to YAC and NAC for use in their internal discussions and decision making with their members and consultants. Updated versions will be provided as the model is revised.

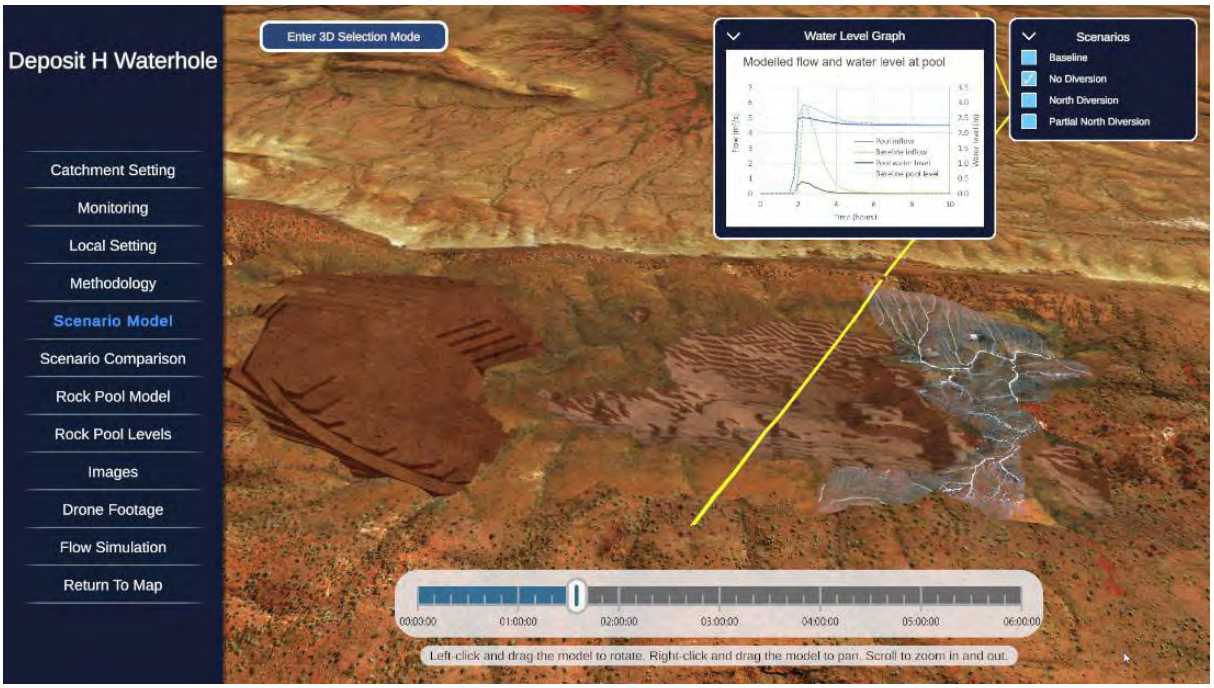


Figure A1: Sentient 3D Visualisation Tool for Deposit H and Waterhole Catchment

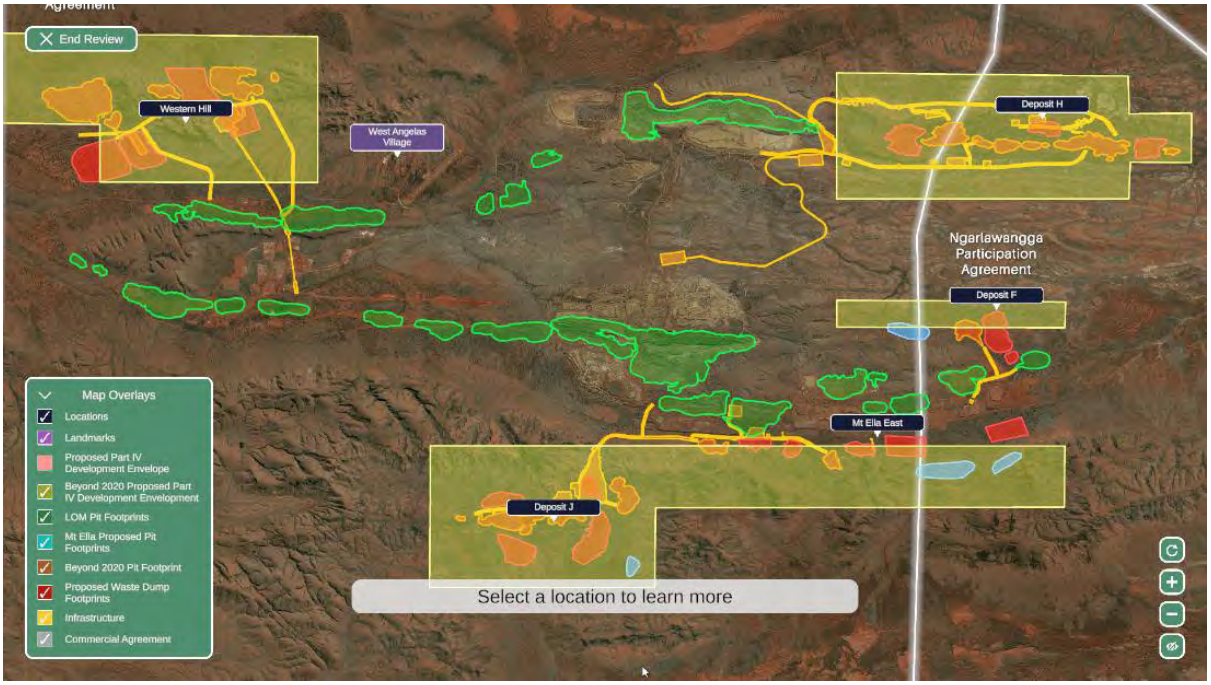


Figure A2: Sentient 3D Visualisation Tool for WAN B2020 and Revised Proposal Overview

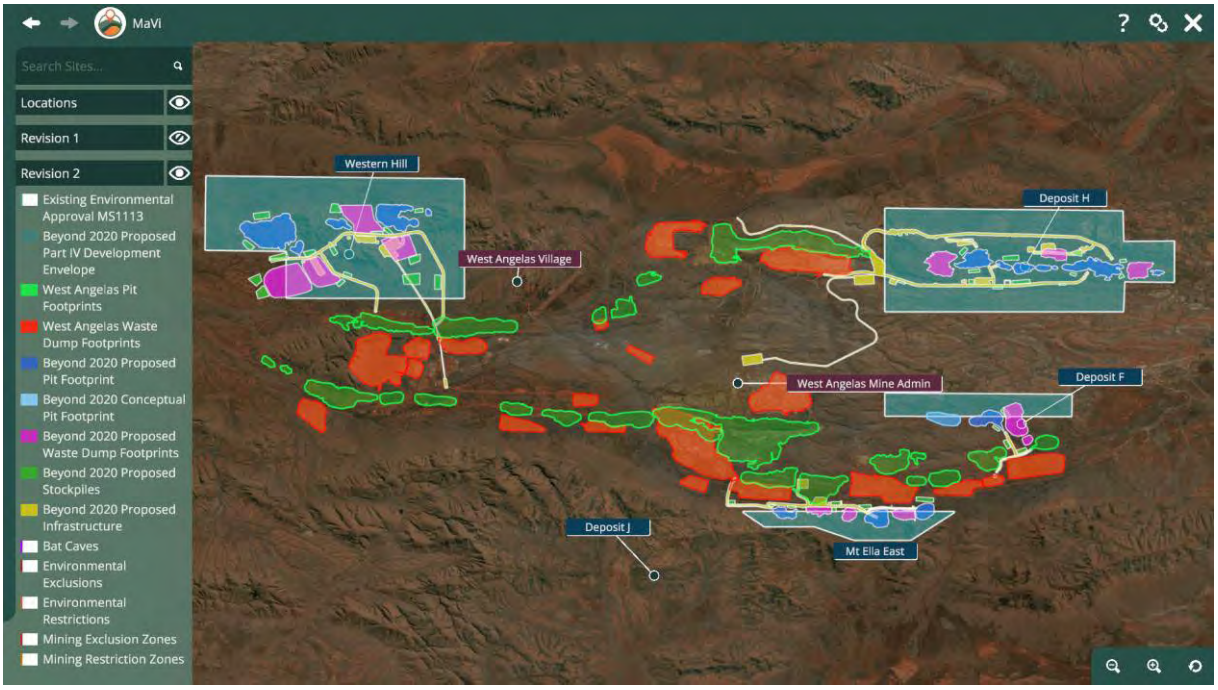


Figure A3: Sentient 3D Visualisation Tool for WAN B2020 and Revised Proposal Overview

Figure A4: Sentient 3D Visualisation Tool for Mt Ella East Deposit WAN B2020

A.7: Greenhouse Gas Management Plan

Greenhouse Gas Environmental Management Plan

West Angelas Revised Proposal

Robe River Mining Co. Pty. Limited

December 2023

Robe River Mining Co Pty. Limited

152-158 St Georges Terrace, Perth

GPO Box A42, Perth, WA 6837

Disclaimer and Limitation

This report has been prepared by Rio Tinto's Iron Ore Group (Rio Tinto), on behalf of Robe River Mining Co. Pty. Limited (the Proponent), specifically for the West Angelas Revised Proposal – Deposits C, D, G, Western Hill, Deposit H, F-North and Mt Ella East. Neither the report nor its contents may be referred to without the express approval of Rio Tinto, unless the report has been released for referral and assessment of proposals.

Document Status				
Description	Prepared by	Reviewed by	Approved by	Approval Date
Initial Draft	Energetics Rio Tinto	Rio Tinto	Rio Tinto	06 November 2019
V1.1	Rio Tinto	Rio Tinto	Rio Tinto	28 November 2019
V1.2	Rio Tinto	Rio Tinto	Rio Tinto	12 February 2020
V2	Rio Tinto	Rio Tinto	Rio Tinto	February 2022
V2.1	Rio Tinto	Rio Tinto	Rio Tinto	December 2023

Corporate endorsement

I hereby certify that to the best of my knowledge, the provisions within the West Angelas Revised Proposal – Greenhouse Gas Environmental Management Plan (Deposits C, D, G, Western Hill, Deposit H, F-North and Mt Ella East) are true and correct.

Name: Sean O'Hanlon **Signed:**

Designation: General Manager, West Angelas Operations **Date:** **22/12/2023**

1. EXECUTIVE SUMMARY

Proposal name	West Angelas Revised Proposal
Proponent name	Robe River Mining Co. Pty Limited
Proposal description and scope	Robe River Mining Co. Pty Limited (the Proponent) operates the existing West Angelas iron ore project, located approximately 130 km west of the township of Newman in the Pilbara Region of Western Australia. Additional ore sources are required to sustain production from West Angelas. These additional deposits and associated infrastructure, located adjacent to existing operations, include Deposits C, D and G (CDG) approved by MS 1113 and Western Hill, Deposit H, F-North and Mt Ella East deposits which are under assessment (the Proposal) pursuant to Part IV of the Environmental Protection Act 1986 (EP Act). Deposits C, D and G, and deposits associated with the Proposal are referred to as the Revised Proposal for the purpose of this Greenhouse Gas Environmental Management Plan (GHG EMP). A requirement of MS 1113 was to prepare and submit a GHG EMP for Deposits C, D and G. A GHG EMP had previously been prepared, submitted and was pending approval. To consolidate and streamline the approval/reporting process, this GHG EMP includes the Proposal deposits and Deposits C, D and G, and aligns with the April 2023 updates to the Environmental Protection Authority (EPA) Environmental Factor – Greenhouse Gases. Ore will be transported to existing processing facilities at West Angelas where existing infrastructure will be utilised.
Purpose of the GHG EMP	The GHG EMP has been prepared with due consideration to the Western Australian Government Greenhouse Gas Emissions Policy for Major Projects (State GHG Policy) and the Western Australian Environment Protection Authority (WA EPA) Greenhouse Gas Management Plan section of the Environmental Factor Guideline: Greenhouse Gas Emissions 2023 (Guideline) which requires a GHG EMP to be developed when a Proposal exceeds 100,000 tonnes CO_2-e of Scope 1 or Scope 2 emissions in any year. The GHG EMP demonstrates the Proponent's contribution towards the Western Australia aspiration of net zero emissions by 2050, making a commitment to implement initiatives that either avoid, reduce or offset emissions.
Emissions estimates	The principal source of emissions for the Revised Proposal includes diesel consumption and land clearing (Scope 1) and electricity supplied by the Pilbara Power Generation Network (Scope 2). Total emissions for the life of the Revised Proposal without emissions abatement, equates to **2,916,678 t CO_2-e** over the ~28-year project with an average emissions intensity value of **0.0080 t CO_2-e/ t SOP**. Emissions estimates for the Revised Proposal (Deposits C, D, G and Proposal) include;

	Annual average • 88,404 t CO_2-e Scope 1 emissions • 15,763 t CO_2-e Scope 2 emissions • 14,649,964 t CO_2-e Scope 3 emissions Total • 2,475,305 t CO_2-e Scope 1 emissions • 441,373 t CO_2-e Scope 2 emissions • 410,199,000 t CO_2-e Scope 3 emissions
Trajectory of emissions reductions	The Proponent proposes to align its emissions reduction targets to Rio Tinto corporate emissions reduction targets and from 2030 will reduce emissions along a linear trajectory to net zero by 2050. This is consistent with EPA expectations and results in the following emissions reductions for the Revised Proposal; • Reduce or abate absolute emissions by 15% by 2025 (approximately 121,974 t CO_2-e); • Reduce or abate absolute emissions by 50% by 2030 (approximately 555,294 t CO_2-e); • Reduce or abate absolute emissions by 36% by 2035 (approximately 231,397 t CO_2-e); • Reduce or abate absolute emissions by 0% by 2040; • Reduce or abate absolute emissions by 0% by 2045; • Reduce or abate absolute emissions by 100% by 2050 (approximately 13,618 t CO_2-e); Applying the mitigation hierarchy, the Proponent proposes a combination of avoidance measures and offsets to meet the Revised Proposal emissions reduction targets.
Other statutory decision-making processes which require reduction in GHG emissions	The Commonwealth of Australia regulates Scope 1 covered emissions from the West Angelas mine through the Safeguard Mechanism. It requires the West Angelas facility to keep emissions below a baseline (that rises and falls with production) or purchase Australian Carbon Credit Units (ACCUs) in the event of baseline exceedances. The Safeguard Mechanism baseline for West Angelas is now set on a combination of site-specific emissions intensity and the default industry average emissions intensity. The weighting towards the default industry average emissions intensity increases annually, rising to 100% in 2030. Concurrently, baselines also decline 4.9% year on year lowering the facility baselines each year. A facility can reduce Scope 1 covered emissions (e.g. diesel reductions) at the facility to avoid baseline exceedances or are required to purchase ACCUs. The West Angelas mine obtains power from the Pilbara Power Network which is subject to Commonwealth of Australia's Renewable Energy Target (RET). The RET is designed to reduce emissions of greenhouse gases in the electricity sector by encouraging additional generation of electricity from sustainable and renewable sources. Renewable Energy Certificates (RECs) must be surrendered based on the amount of electricity generated minus

	exemptions (e.g. electricity generated from renewables) multiplied by the Renewable Power Percentage (RPP) for the year. The 2023 RPP is 18.96%.
Key components in the GHG EMP	To achieve net zero by 2050, emission abatement projects could be implemented locally at West Angelas or throughout the Pilbara. This is focussed on displacement of gas in electricity generation throughout the Pilbara Power Network with renewable energy sources, including solar, wind and battery energy storage, along with energy efficiency opportunities, alternative fuels and technologies to reduce or replace diesel in mobile fleet (e.g. battery electric solutions). Future improvements in technology will be monitored and assessed for feasibility over the life of the Revised Proposal. The Proponent expects that abatement will be sufficient to meet a portion of the interim and long-term targets. The Proponent also proposes to offset GHG emissions by retiring high integrity offset units (ACCUs) on an annual basis to meet the remaining portion of the cumulative 5 yearly targets (or if abatement is insufficient against the Revised Proposal targets). Scope 3 emissions from steel making are the largest contribution to total emissions due to activities by customers outside of the Western Australia jurisdiction. Currently there is no proven process route at an industrial scale to produce primary net zero steel today, however the industry is developing and scaling a range of new technologies. Through a dedicated Steel Decarbonisation team, Rio Tinto is advancing numerous projects in partnership with over 30 customers, universities, researcher institutes, and other industry stakeholders, to build options to reduce emissions from steelmaking.
GHG EMP reviews and reporting	The Ministerial Statement Annual Compliance Assessment Report will include annual Revised Proposal emissions, tonnes of iron ore produced and emissions intensity. A summary report of performance against the Revised Proposal targets will be detailed in the Ministerial Statement Annual Compliance Assessment Report every five years, with the first report taking place in 2025. Where either the five yearly review cycle is triggered, or if a significant change to either the facility, activity, or material risk is identified, a revised GHG EMP will be submitted to the WA EPA.
Proposed construction date	2025
GHG EMP required pre-construction?	Yes ☒ No ☐
Proposed project end of life/decommissioning date	2046

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Abbreviations and Definitions

Table 1-1 Abbreviations and Definitions

Abbreviation	Term
ACCU	Australian carbon credit unit
ANFO	Ammonium nitrate and fuel oil
AHS	Autonomous haul trucks
Approved Proposal	Refers to operations approved under MS 1113 (including proposals approved by MS 514 and 970 – now superseded by MS 1113)
AWT	Above water table
BWT	Below water table
BESS	Battery energy storage system
BHT	Bedded Hilltop
BOF	Basic oxygen furnace
CDG	Applicable deposits approved under MS 1113 subject to abatement commitments
CH_4	Methane
CER	Clean Energy Regulator
CO_2	Carbon dioxide
CO_2-e	Carbon dioxide equivalent
Credible Offset Units	Offset units that meet offset integrity standards and principles outlined in ICROA's Technical Specification
CRI	Commercial readiness index
CCS	Carbon capture and storage
DMAs	Decision-making authorities
DRI	Direct reduced iron
EP Act	*Environmental Protection Act 1986*
EFH	Effective flat haul
ERD	Environmental Review Document
GHG	Greenhouse gas
GHG EMP	Greenhouse Gas Environmental Management Plan
GIS	Geographic Information Systems
GWP	Global warming potential
Ha	Hectares
HIR	Human induced regeneration
HME	Heavy mobile equipment
HVO	Hydrotreated vegetable oil
ICROA	International Carbon Reduction and Offset Alliance
IPCC	Intergovernmental Panel on Climate Change
JV	Joint venture
LED	Light emitting diode
MS	Ministerial statement
MS 1113	Ministerial statement for West Angelas Iron Ore Project Deposits C, D and G
Mtpa	Million tonnes per annum

Abbreviation	Term
MWh	Megawatt hour
NbS	Nature-based Solutions
NCC	National Construction Code
NGER	National Greenhouse and Energy Reporting
NGER Act	National Greenhouse and Energy Reporting Act 2007
NGER Determination	*National Greenhouse and Energy Reporting (Measurement) Determination 2008*
N_2O	Nitrous oxide
NLW	Ngarlawangga people
NPI	Non-processing infrastructure
PER	Public Environmental Review
Proponent	Robe River Mining Co. Pty Limited as manager of the Robe River Joint Venture between Rio Tinto (53%), Mitsui Iron Ore Development (33%), Nippon Steel (10.5%) and Sumitomo Metal Australia (3.5%)
Proposal	The Proposal is the significant amendment to the Approved Proposal and includes the extension and development of new above and below water table (AWT/BWT) iron ore deposits (Western Hill, Deposit H, F-North and Mt Ella East) and associated activities to extend the life of the Existing Operations
REC	Renewable Energy Certificate
RET	Renewable Energy Target
Revised Proposal	The Revised Proposal incorporates both the Approved Proposal (Dep C, D & G – approved under MS 1113) and the Proposal (Western Hill, Deposit H, F-North and Mt Ella East)
RTIO	Rio Tinto Iron Ore
Safeguard Mechanism	*National Greenhouse and Energy Reporting (Safeguard Mechanism) Rule 2015*
Scope 1	Emissions released into the atmosphere as a direct result of an activity, or series of activities, at a facility
Scope 2	Indirect emissions released into the atmosphere from the consumption of purchased energy
Scope 3	All other indirect GHG emissions (not included in Scope 2) that occur in the Company's value chain
SOP	Saleable ore product
State GHG Policy	*Greenhouse Gas Emissions Policy for Major Projects*
t CO_2-e	Tonnes of carbon dioxide equivalent
The Guideline	*Environmental Factor Guideline Greenhouse Gas Emissions 2023*
TMM	Total material movement
TRL	Technology readiness level
VSD	Variable speed drives
WA EPA	Western Australian Environment Protection Authority
West Angelas Hub	Refers to the existing iron ore operations approved under MS 1113 (including proposals approved by MS 514 and 970, and now superseded by MS 1113) and includes components of the Approved Proposals that have and those that are yet to be implemented.
WI	Work index
	Yinhawangka people

2. CONTEXT, SCOPE AND PURPOSE

Robe River Mining Co. Pty. Ltd. (the Proponent) proposes that, subject to approval of the Proposal, an updated Ministerial Statement (MS) be published which considers the management of Greenhouse Gas (GHG) emissions. Existing operations at West Angelas are included within the Greenhouse Gas Environmental Management Plan (GHG EMP) for reference, however are not included in the proposed five yearly emissions reduction commitments (approved under MS 514 and 970).

2.1. Proposal description and scope

The West Angelas Proposal centres around a greenfield development of new iron ore mining areas to sustain production from West Angelas iron ore mine, located approximately 130 kilometres west of Newman in the Pilbara region of Western Australia (Figure 2-1). This Proposal is an integral part of the Rio Tinto Group's (Rio Tinto) integrated network of iron ore mines in the Pilbara with construction proposed to commence in 2025.

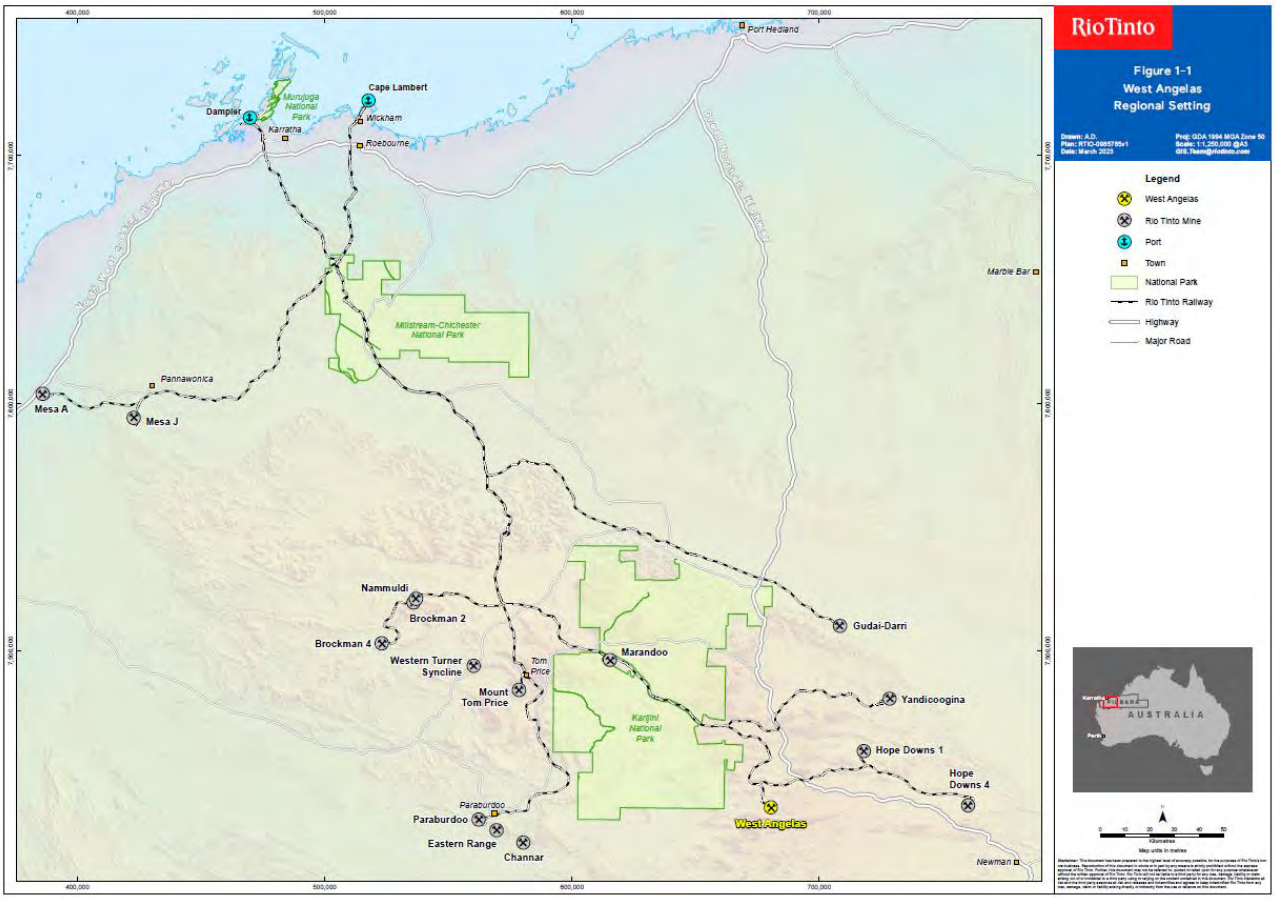

Figure 2-1 West Angelas regional setting

The proposed development includes the following deposits Western Hill, Deposit H, F-North and Mt Ella East (the Proposal) and along with associated infrastructure is located adjacent to existing operations. Current indicative layouts of the key components of the Proposal are depicted in (Figure 2-2), including the new proposed development envelope consisting of West Angelas existing operations and new deposits, as per the Proposal.

MS 1113 authorised the development of Deposits C, D and G (Figure 2-2) in September 2019 which included a condition to prepare and submit a GHG EMP for this development. A GHG EMP had previously been prepared, submitted and was pending approval. To consolidate and streamline the approval/reporting process, this GHG EMP includes the Proposal deposits and Deposits C, D and G, and aligns with the April 2023 updates to the Environmental Protection Authority (EPA) Environmental Factor – Greenhouse Gases.

Deposits C, D and G (approved under MS 1113) and deposits associated with the Proposal are referred to as the Revised Proposal. All other operational deposits within the West Angelas Hub are included for context

where required, however do not form part of the interim and long-term emissions reduction targets within this document (Table 2-1).

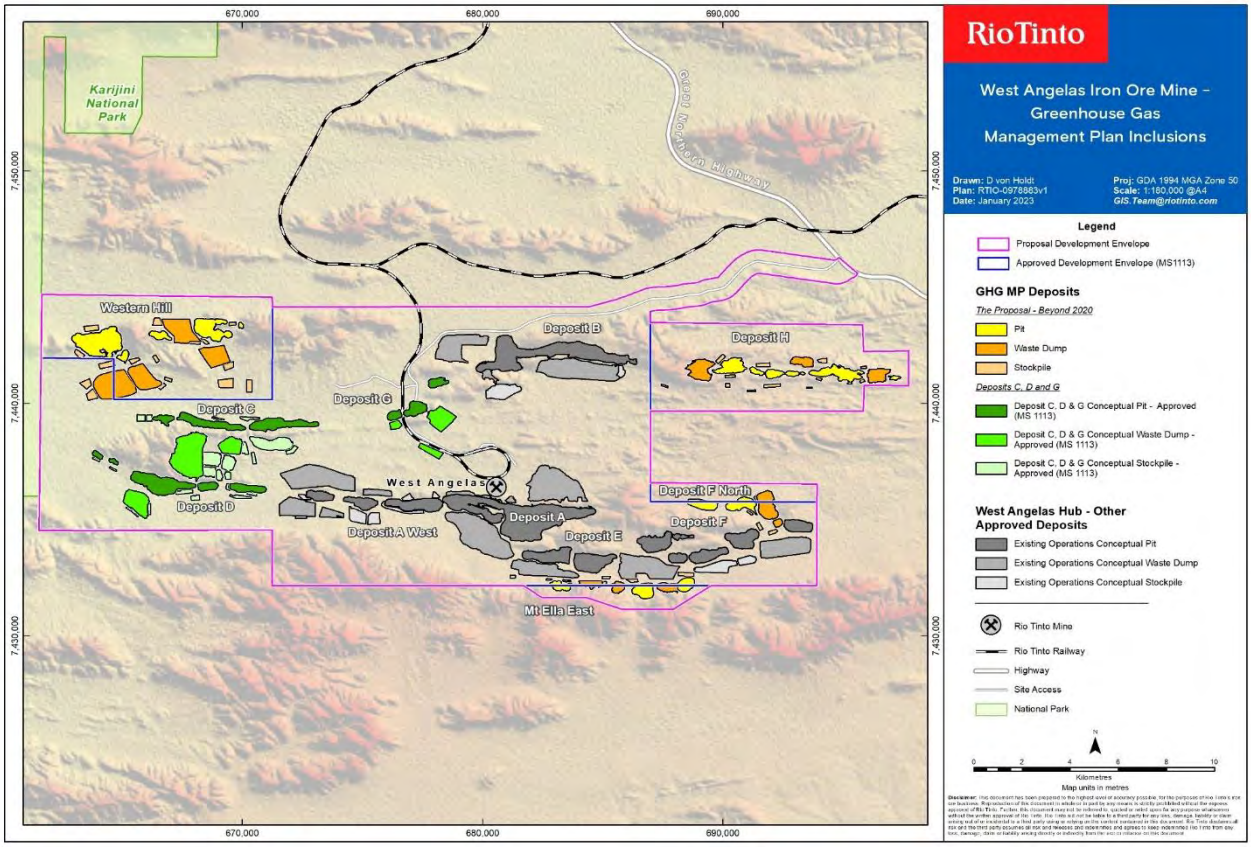

Figure 2-2 Revised development envelope and indicative location of key Revised Proposal elements

Table 2-1 Comparison of deposits within the Proposal, Revised Proposal and Greater West Angelas Hub

The Proposal	Revised Proposal	Greater West Angelas Hub
Western Hill	Deposit C	Deposit A
Deposit H	Deposit D	Deposit B
Deposit F-North	Deposit G	Deposit E
Mt Ella East	Western Hill	Deposit F
	Deposit H	Deposit C
	Deposit F-North	Deposit D
	Mt Ella East	Deposit G
		Western Hill
		Deposit H
		Deposit F-North
		Mt Ella East

The Revised Proposal includes, but is not limited to the following:

- Mine Pits: Development and operation of new and existing (Deposits C, D and G) open cut above and below water table pits, adjacent to the Proponent's existing operations at West Angelas;
- Existing West Angelas support facilities including ore processing infrastructure, train load out facilities and mining infrastructure to the extent utilised for the purpose of the existing and proposed new mining operations;

- Infrastructure for water supply, groundwater abstraction, creek crossings, diversion drains, levees and culverts;
- Linear infrastructure including heavy and light vehicle access roads, railway crossings, conveyors, pipelines, power and communication distribution network;
- Mineral waste management including waste rock landforms, land bridges, low grade ore dumps and topsoil and subsoil stockpiles;
- Infrastructure for management and use of water from dewatering; and
- Other associated mine infrastructure and support facilities such as workshops, hydrocarbon storage areas, ANFO facilities, laydown areas, turkey nests, transfer pads, and offices.

The Proposal excludes activities that include but are not limited to:

- Existing mining operations (Deposits A, B, E and F) and support infrastructure not utilised to support the Proposal or Deposits C, D and G.
- Rail and port export facilities: these facilities are approved under other ministerial statements, support numerous operations in the area and are outside the Proposal boundary;
- Power Station, switchyard and high voltage transformers: the power station generates electricity for several sites (i.e. not exclusive to West Angelas) and therefore excluded
- Existing West Angelas facilities not required to support the Proposal;
- Transmission and distribution emissions of electricity imported to site, these are outside the Proposal boundary;
- Low impact activities required to inform Part IV assessment of the Proposal, including drilling and associated activities for resource evaluation, geotechnical assessment and hydrogeological investigations. These activities will be subject to relevant provisions under Part V of the EP Act and the Rights in Water and Irrigation Act 1914 (RiWI Act);
- Mine closure and site rehabilitation;
- Emissions associated with landfill waste and wastewater effluent from the wastewater treatment plants are excluded as they are not reportable under the NGER framework and not material; and
- Environmental, heritage and other studies/ investigations involving fieldwork.

The scope of this GHG EMP is the Revised Proposal as defined in the Environmental Review Document (ERD) (Rio Tinto, 2023). This GHG EMP applies to emissions from activities associated with deposits as outlined in the Revised Proposal that are within the operational control of the Proponent (as defined under the National Greenhouse and Energy Reporting Act 2007 (NGER Act)). However, to provide context and where relevant, information is provided for the entire West Angelas hub.

2.2. Purpose of the GHG EMP

The purpose of this GHG EMP is to demonstrate:

- The interim and long-term emissions reductions targets the Revised Proposal aims to achieve throughout the project;
- The best practice design, technology, management and reasonably practicable alternatives and measures appropriate to avoid, reduce or offset Scope 1 and 2 emissions from this Revised Proposal;
- The partnerships and arrangements with third parties considered to reduce Scope 3 emissions;
- How the Revised Proposal is consistent with achieving corporate emissions reduction targets; and
- The other legal and policy instruments that require GHG emissions reductions from the Revised Proposal to meet the EPA's objectives.

A summary of key assumptions and uncertainties of the GHG EMP are presented in Table 2-2.

Table 2-2 Key assumptions and uncertainties of the West Angelas Revised Proposal GHG EMP

Key Assumption / Uncertainty	Justification / Explanation
Production and mine strategy may be amended in the future, resulting in a change to the emissions.	Production and mine strategy are market driven and may result in changes. Pilbara facilities are operated as a vertically integrated system, potentially resulting in higher or lower emissions from the Revised Proposal.
Alternative and/or innovative sources of energy may become available in the future that can avoid or minimise GHG emissions from the Revised Proposal.	The Proponent is part of Rio Tinto which has robust study and development processes that ensure innovation and new technology developments are sought, assessed and developed where applicable. The Proponent will investigate relevant alternative and/or innovative energy sources when they become viable in the future.
GHG policy and approaches continue to evolve at State and Commonwealth levels	State and Commonwealth Government policies continue to evolve. Key uncertainties include: • State's contribution to Commonwealth targets versus other states; • Setting of sector specific targets for industry versus other sectors (e.g. power, transport, agriculture, buildings).
Market price (carbon)	Whilst Australia has no formal carbon price in place large emitters over 100 kt CO_2-e per year have an emission cap in place, called the Safeguard Mechanism. If a project exceeds this emission cap they are required to obtain Australian Carbon Credit Units (ACCUs) for the gap. Declines to this emission cap are now in place, which will create a cap and trade system aligned with current practice in Europe and other carbon markets. This will in effect place a price on carbon for these large emitters. The Proponent will continue to assess opportunities for future capital expenditure to avoid and/or reduce emissions.
Cost of technology for renewable energy	Cost of renewables has changed significantly over the last ten years, and further downward trends are expected.
Existing capital expenditure and life of asset	Significant investment has occurred in fixed infrastructure and mobile fleet, therefore asset life is a consideration when assessing and implementing abatement opportunities to avoid or reduce emissions.

3. GHG EMP COMPONENTS

3.1. Emissions estimates

A summary of estimated annual average, peak and total Scope 1, 2 & 3 emissions over an estimated 22-year life of the Proposal is presented in Table 3-1. A summary of estimated annual average, peak and total Scope 1, 2 & 3 emissions over an estimated 28-year life of the Revised Proposal is presented in Table 3-2. A summary of estimated annual average, peak and total Scope 1, 2 & 3 emissions over the life of the mine for the West Angelas mine (including the Revised Proposal) is presented in Table 3-3.

Nameplate capacity for the West Angelas ore processing facility is 35 Mtpa. Expected operational throughput is scheduled to reach nameplate capacity during the life of the Revised Proposal before declining as ore reserves are exhausted. Operational throughput estimates account for plant maintenance shutdowns, downtime, other operational inefficiencies and are based on historical experience. Scheduled operating hours for the West Angelas plant are approximately 6,500 hours per year.

The emissions forecast has been generated from the expected operational throughputs rather than nameplate capacity to reflect the emissions associated during operation where nameplate capacity is reached and then operational throughputs decline as West Angelas ore reserves deplete.

Table 3-1 Estimate of peak, annual and total Scope 1, 2 & 3 emissions for the Proposal

	Peak emissions (t CO_2-e)	Annual average emissions (t CO_2-e)	Total Emissions (t CO_2-e)
Scope 1	157,498 (2029)	54,550	**1,200,099**
Scope 2	36,422 (2030)	8,985	**197,680**
Scope 3	35,151,487 (2030)	8,872,090	**195,185,975**

Table 3-2 Estimate of peak, annual and total Scope 1, 2 & 3 emissions for the Revised Proposal (Deposits C, D and G and the Proposal)

	Peak emissions (t CO_2-e)	Annual average emissions (t CO_2-e)	Total Emissions (t CO_2-e)
Scope 1	242,762 (2026)	88,404	**2,475,305**
Scope 2	40,610 (2028)	15,763	**441,373**
Scope 3	38,336,302 (2030)	14,649,964	**410,199,000**

Table 3-3 Estimate of peak, annual and total Scope 1, 2 & 3 emissions for the West Angelas Hub (including the Revised Proposal)

	Peak emissions (t CO_2-e)	Annual average emissions (t CO_2-e)	Total Emissions (t CO_2-e)
Scope 1	360,597 (2026)	150,495	**4,965,352**
Scope 2	48,045 (2028)	24,515	**809,002**
Scope 3	46,900,000 (2033)	36,402,018	**1,201,266,595**

3.1.1. Historic emissions

The West Angelas iron ore mine was opened in 2002 with production from Deposit A. An initial expected production rate was 20 Mtpa[1], with recent production averaging 34Mtpa since 2015 (Figure 3-1). Mining has now commenced in Deposits B, E and F and more recently C, D and G.

Emissions (Scope 1 & 2) were first reported in 2001, increasing to 2015 as West Angelas production neared nameplate capacity (Figure 3-1). Since 2018 emissions have trended upwards year on year as deposits deepen, overland conveyor construction/usage for Deposits C, D and haulage distances increased to recover ore.

[1] https://www.epa.wa.gov.au/sites/default/files/1MINSTAT/000514.pdf

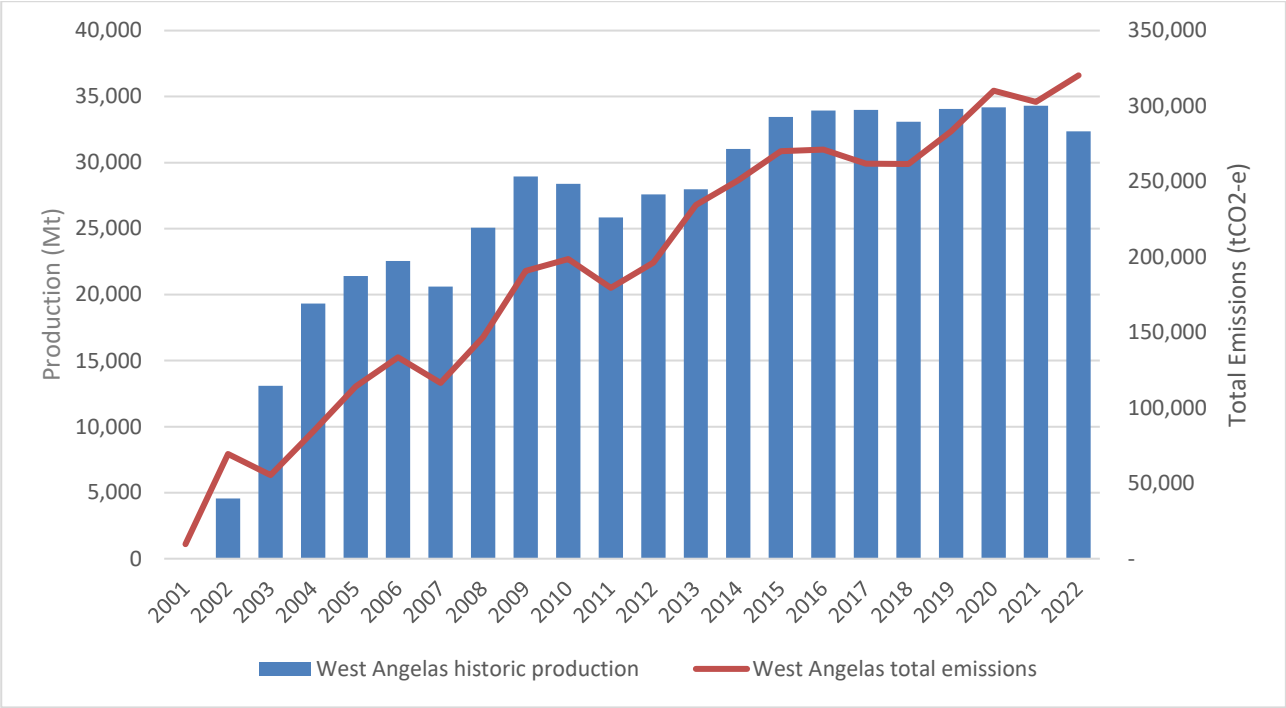

Figure 3-1 West Angelas historic production and emissions (Scope 1 & 2)

3.1.2. Proposed emissions baseline

The proposed emissions baseline scenario used to calculate baseline emissions, is the continuation of current technologies and practices involved at the current West Angelas mining operations. This scenario includes a diesel mining fleet and electricity generated from gas-fired power stations for the life of the project, using the most recent diesel, land clearing, production and electricity forecast data available.

The diesel forecast is a bottom-up calculation using operating hours from the fleet plan for Heavy Mobile Equipment (HME), generated from the current mine plan for the deposits. Historic fuel burn rates are applied to HME operating hours provided diesel usage. Non-HME diesel usage is calculated using a factor of historic non-HME diesel usage and Total Material Moved (TMM). Finally, diesel used in construction is included.

The electricity forecast uses 2022 actual electricity usage (post installation of the Dep C and D overland conveyor) with substation metered data used to determine fixed electricity (doesn't change with changes to SOP) and variable electricity usage (does change with changes to SOP). The substation supplying the overland conveyor was also isolated to provide an estimate of variable electricity usage from deposits that utilise this conveyor. 2022 actual throughputs were then used to calculate a MWh/t SOP factor for West Angelas variable electricity usage. These factors, along with apportioned fixed usage per deposit were applied to future scheduled production to provide the electricity forecast. This methodology was deemed acceptable as no additional changes/upgrades to plant infrastructure is currently planned which would otherwise change the electricity forecast.

Emissions are then calculated using appropriate factors in a similar method to how emissions are reported in the mining industry under the NGER framework. Due to the uncertainty on timing of large-scale diesel replacement technologies and the quantity of renewables in the Pilbara integrated power system, these abatement projects have not been included in the emissions baseline.

There are other methods to calculate emissions that have not been used, including;

- Work index
    - Total Material Moved (TMM) and Effective Flat Haul (EFH) can be used to calculate a Work Index (WI). EFH accounts for the distance from the mining area to the destination (e.g. crusher) and the change in elevation. An average fuel driver is calculated from actual diesel usage (total site usage which includes all heavy mining equipment through to light vehicles

and generators) and WI from the prior three years. The average fuel driver is multiplied by WI in future years to calculate the annual diesel forecast. Given a detailed fleet plan is available for the current mine plan the diesel forecast generated from this fleet plan was chosen for the forecast, however the total site usage was compared and found to be similar for both methods.

- Historic emissions intensity factor
    - Using a historic emissions intensity factor on future production is less accurate compared with the proposed emissions baseline. This is due to increasing haul distances (e.g. deeper mines and/or new deposits further from existing infrastructure) as the mine develops resulting in emissions intensities generally increasing over time. Therefore, using a historic emissions intensity for future years of operation could result in an under-estimation of emissions and not best represent the emissions generated from the Revised Proposal.

3.1.3. Breakdown of emissions by source

The principal sources of emissions include:

- Stationary, mobile and transport diesel combustion (Scope 1);
- Land clearing (Scope 1) and
- Consumption of electricity from the Pilbara Power Generation Network (Scope 2).

It should be noted that no fugitive emissions are expected for the Revised Proposal.

A summary of estimated peak, annual average and total emissions over an estimated ~22-year life of the Proposal and ~28-year life of the Revised Proposal by source and scope is presented in Table 3-4. A summary of the estimated peak, annual average and total emissions from the West Angelas Hub (including the Revised Proposal) is also presented in Table 3-4.

Table 3-4 Proposal, Revised Proposal and Greater West Angelas Hub operational peak, annual average and total GHG emissions by source and scope

Source	The Proposal		Revised Proposal		Greater West Angelas Hub	
	Scope 1 Emissions (t CO_2-e pa)	Scope 2 Emissions (t CO_2-e pa)	Scope 1 Emissions (t CO_2-e pa)	Scope 2 Emissions (t CO_2-e pa)	Scope 1 Emissions (t CO_2-e pa)	Scope 2 Emissions (t CO_2-e pa)
Diesel – Peak	157,498	-	242,762	-	354,231	-
Land Clearing – Peak	0	-	6,367	-	6,367	-
Electricity – Peak	-	28,442	-	34,441	-	42,338
Total (Scope 1 + 2) – Peak	**185,940 (2029)[2]**		**283,569 (2026)[3]**		**402,936 (2026)[4]**	
Diesel – Annual Average	53,689	-	87,505	-	149,702	-
Land clearing – Annual	861	-	899	-	763	-
Electricity – Annual Average	-	8,985	-	15,763	-	24,515
Total (Scope 1 + 2) – Annual Average	**63,535**		**104,167**		**174,980**	
Diesel – Total	1,181,162	-	2,450,128	-	4,940,175	-
Land Clearing – Total	18,937	-	25,177	-	25,177	-
Electricity – Total	-	197,680	-	441,373	-	809,002
Total (Scope 1 + 2)	**1,397,779[5]**		**2,916,678[6]**		**5,774,354[7]**	

[2] The Proposal land clearing and electricity peak occurs in different years to the Scope 1 & 2 peak (2026 and 2030 respectively)

[3] The Revised Proposal electricity peak occurs in a different year to the Scope 1 & 2 peak (2028)

[4] Greater West Angelas Hub electricity peak occurs in a different year to the Scope 1 & 2 peak (2028)

[5] Life of project for the Proposal is currently scheduled for 22 years (2025-2046)

[6] Life of project for the Revised Proposal is currently scheduled for 28 years (2019-2046)

[7] Life of project for the Greater West Angelas Hub (for comparison) is currently scheduled for 33 years (2019-2051)

3.1.4. Type of GHG's emitted and Global Warming Potential

The major emission types from the Revised Proposal are ~99% carbon dioxide (CO_2) along with minor amounts of methane (CH_4) and nitrogen oxide (N_2O). The Global Warming Potential (GWP) 100-year values for these three GHGs, according to the IPCC Fifth Assessment Report (AR5)[8], are;

- Carbon dioxide – 1
- Methane – 28
- Nitrous oxide – 265

3.1.5. Emissions baseline methodology and scope boundaries

The emissions baseline for diesel and electricity emissions has been calculated using methods and criteria in the National Greenhouse and Energy Reporting (Measurement) Determination 2008 (DoEE, 2008) (NGER Determination). The Australian Government's National Carbon Accounting methodology (FullCAM) has been used to determine emissions from land clearing.

Once calculated, emissions from the diesel forecast are calculated using the Clean Energy Regulator's (CER) Method 1 for emissions of carbon dioxide, methane and nitrous oxide from liquid fuels other than petroleum-based oils or greases; from the National Greenhouse Accounts national methodology. This is achieved by multiplying a (physical) quantity of fuel combusted by a fuel-specific energy content factor and a fuel-specific emission factor for each relevant greenhouse gas (in this case, carbon dioxide, methane and nitrous oxide)[9]. This methodology has a carbon dioxide emission factor uncertainty level of 2%.

Emissions associated with the forecast electricity usage is calculated using the CER Method 2 for emissions of carbon dioxide from the combustion of gaseous fuels. This allows a more accurate facility level calculation of emissions by sampling and analysing fuels for qualities that affect emissions levels when the fuel is combusted[10]. This methodology has a carbon dioxide emission factor uncertainty level of 4.3-4.5% across the Pilbara Power Network generators.

The boundary for the Revised Proposal emissions inventory has been defined using an operational control approach consistent with the NGER Act. The following sources of Scope 1 and 2 emissions occur within the boundary of the Revised Proposal:

- Development and operation of new deposits and associated infrastructure to sustain production from West Angelas; and
- Existing mining operations including overland conveyors, central processing plant, train load out facilities and mining operations support infrastructure to the extent utilised for the purpose of the proposed new mining operations.

No boundary has been set for the calculation of Scope 3 emissions as they occur nationally and internationally outside the Revised Proposal boundary, are not reportable under the NGER framework and are included in the assessment but not the mid or long-term targets.

The following sources of emissions are excluded from the emissions forecast:

[8] https://www.ipcc.ch/site/assets/uploads/2018/02/WG1AR5_Chapter08_FINAL.pdf

[9] https://www.cleanenergyregulator.gov.au/DocumentAssets/Documents/Estimating%20emissions%20and%20energy%20from%20fuel%20combustion%20guideline.pdf

[10] https://www.cleanenergyregulator.gov.au/DocumentAssets/Documents/Estimating%20emissions%20and%20energy%20from%20fuel%20combustion%20guideline.pdf

- Rail and port export facilities: these facilities are approved under other ministerial statements, support several operations in the area and are outside the Revised Proposal boundary;
- Switchyard and high voltage transformers: network services several sites (i.e. not exclusive to West Angelas and the Revised Proposal and therefore excluded);
- Transmission and distribution emissions of electricity imported to site, these are outside the Revised Proposal boundary; and
- Emissions associated with landfill waste and wastewater effluent from the wastewater treatment plants are excluded as they are not reportable under the NGER framework and not material.

3.2. Trajectory of emissions reductions

3.2.1. Scope 1 & 2 emissions trajectory

The estimated Proposal Scope 1 and 2 emissions baselines (without abatement), displayed separately, is shown in Figure 3-2. This shows Scope 1 emissions above the 100,000 tonnes of CO_2-e emissions in any year threshold requiring assessment by the EPA. The combined Scope 1 and 2 emissions baseline (without abatement), is shown in Figure 3-3.

The estimated Revised Proposal Scope 1 and 2 emissions baselines (without abatement), displayed separately, is shown in Figure 3-4. The combined Scope 1 and 2 emissions baseline (without abatement), is shown in Figure 3-5.

Rio Tinto has ambitious corporate emissions reductions targets, 15% reduction of absolute emissions by 2025 and 50% reduction of absolute emissions by 2030 (further detail in Section 3.7.1) and net zero by 2050. The Revised Proposal emissions reduction targets are consistent with these targets and as per EPA expectations, from 2030 will reduce emissions along a linear trajectory from 2030 to net zero by 2050.

The proposed annual emissions reduction targets required to meet the above targets is shown in Figure 3-5. The Revised Proposal estimated annual and total Scope 1 & 2 emissions (without abatement) with 5 yearly cumulative totals and reduction commitments is shown in Figure 3-6 and Table 3-5.

The Revised Proposal aims to achieve its emissions reduction targets through a combination of avoidance measures and offsets (Figure 3-7), with abatement projects implemented from the Pilbara wide abatement pathway applied against emissions from the Revised Proposal. Specific abatement initiatives (Section 3.4.1) implemented in Rio Tinto's Pilbara Power Generation Network, connected to the Revised Proposal will be applied to achieve Scope 1 & 2 interim emissions reduction targets. The long-term emissions reduction target is anticipated to be achieved through implementation of a range of existing or potential future GHG abatement opportunities.

The Revised Proposal estimated annual and total Scope 1 & 2 emissions (without abatement) with 5 yearly cumulative totals and reduction commitments in a tabular form is in Table 3-6.

Table 3-5 Interim and long-term emissions reduction targets for the Revised Proposal

Target Year	2025	2030	2035	2040	2045	2050
Total Scope 1 & 2 Emissions (t CO_2-e)	813,162	1,110,588	647,868	132,840	116,204	13,618
Emission Reduction Target (t CO_2-e)	121,974	555,294	231,397	0	0	13,618
Percentage Reduction Emissions (%)	15%	50%	36%	0%	0%	100%

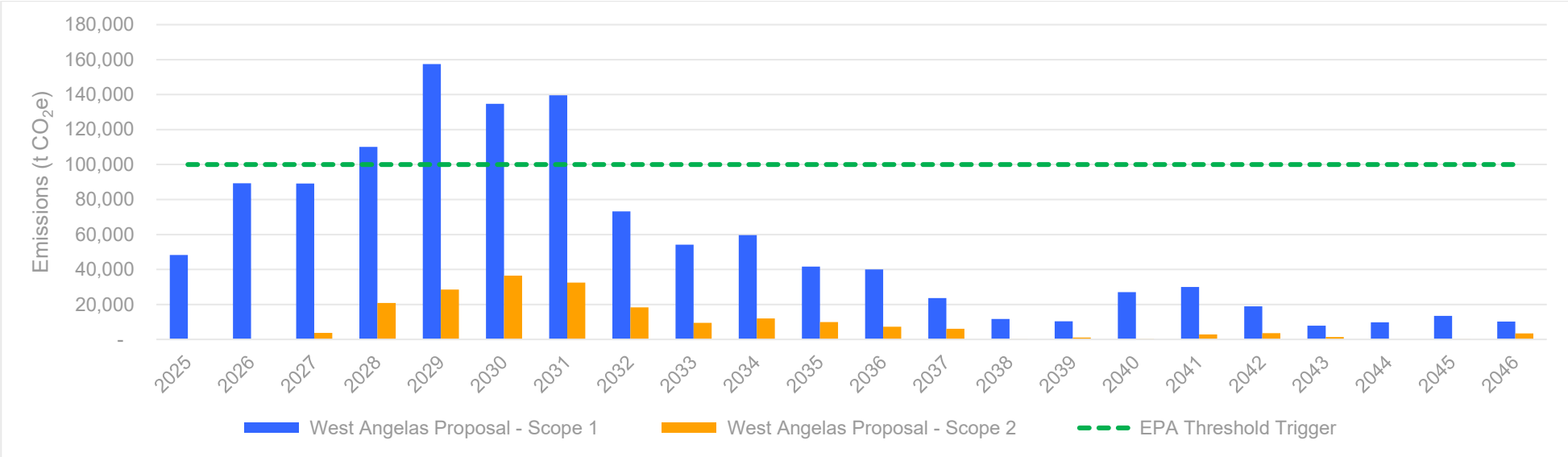

Figure 3-2 Proposal estimated annual Scope 1 & 2 (separate) baseline emissions (without abatement)

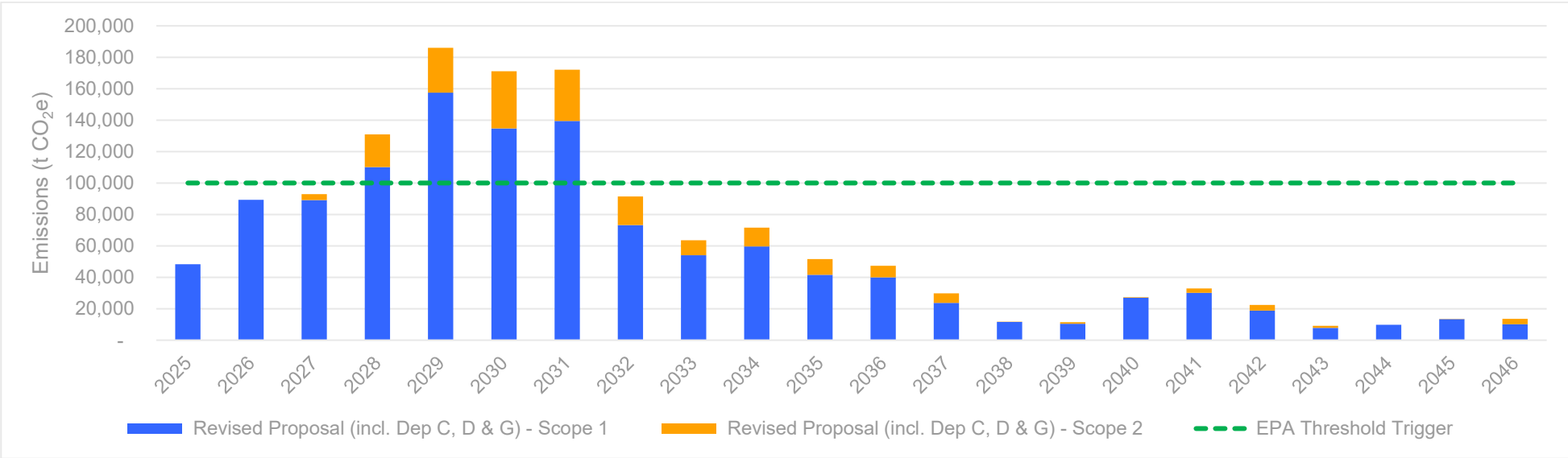

Figure 3-3 Proposal estimated annual Scope 1 & 2 (combined) baseline emissions (without abatement)

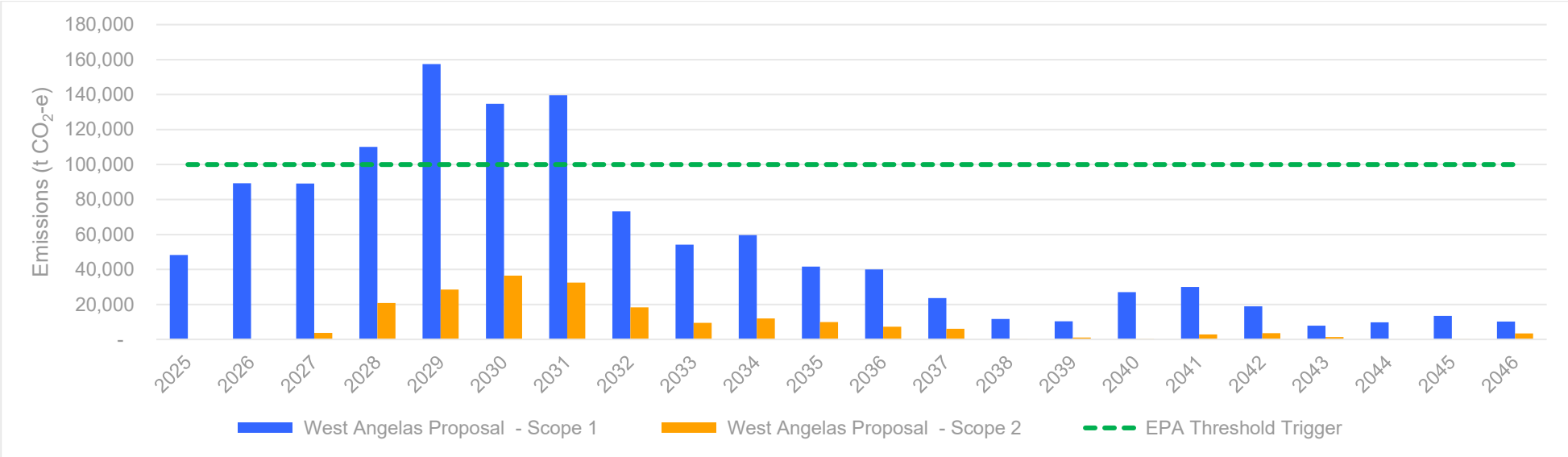

Figure 3-4 Revised Proposal estimated annual Scope 1 & 2 (separate) baseline emissions (without abatement)

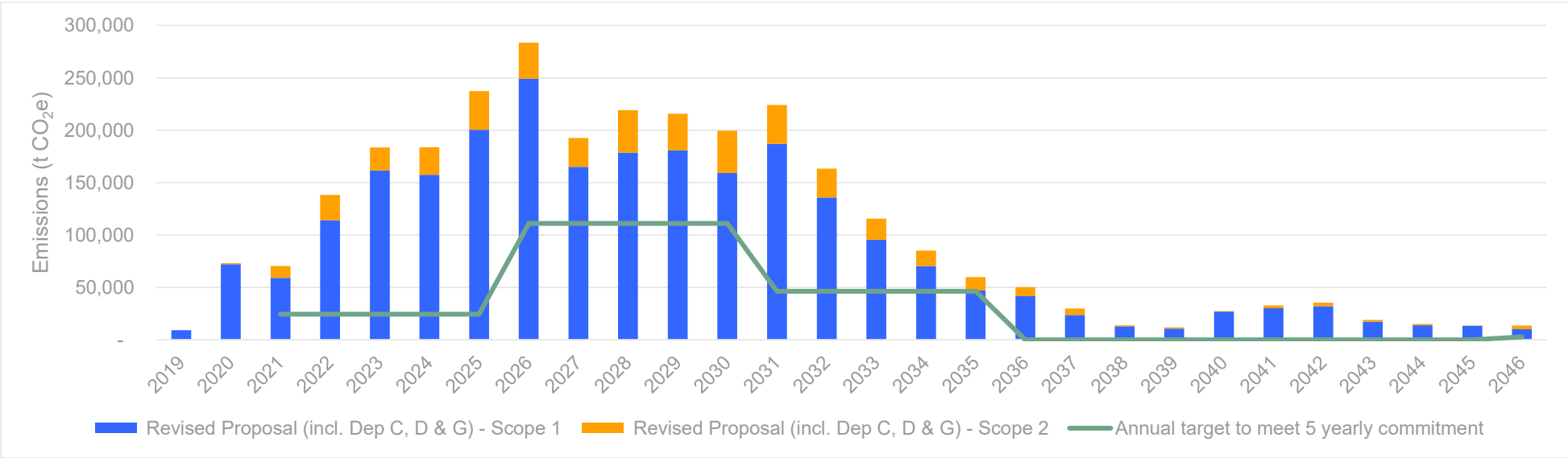

Figure 3-5 Revised Proposal estimated annual Scope 1 & 2 (combined) baseline emissions (without abatement) with annual targets required to meet 5 yearly commitment

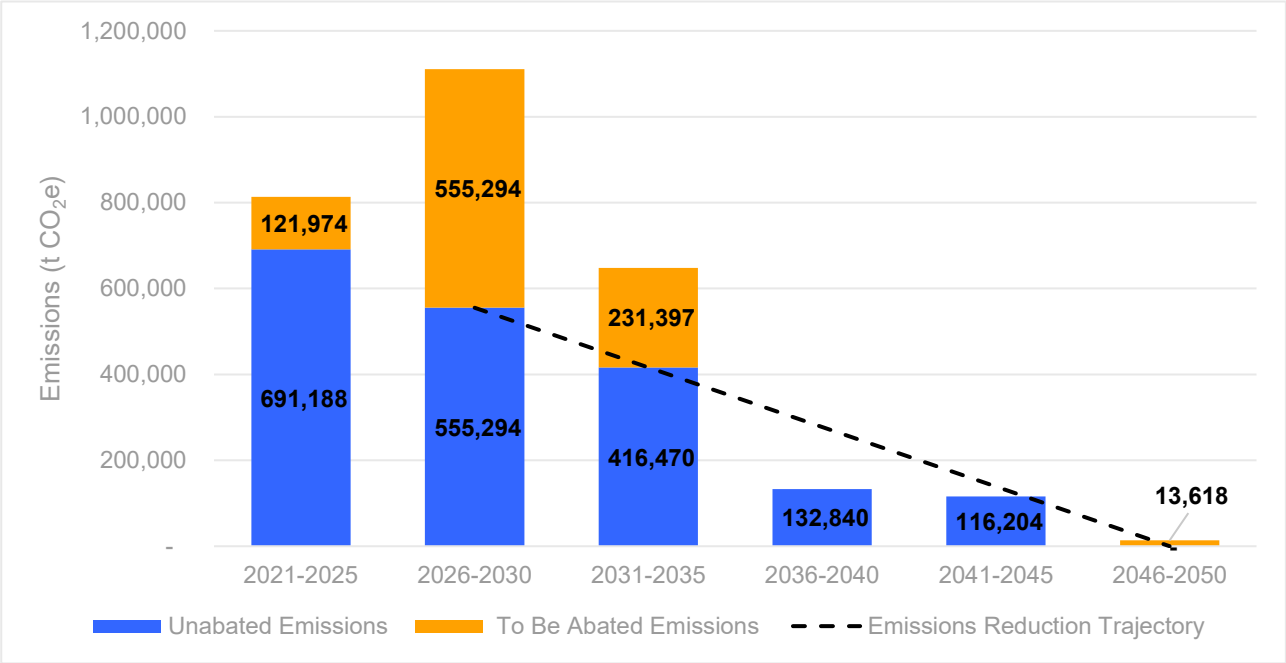

Figure 3-6 Revised Proposal 5 yearly targets and commitments

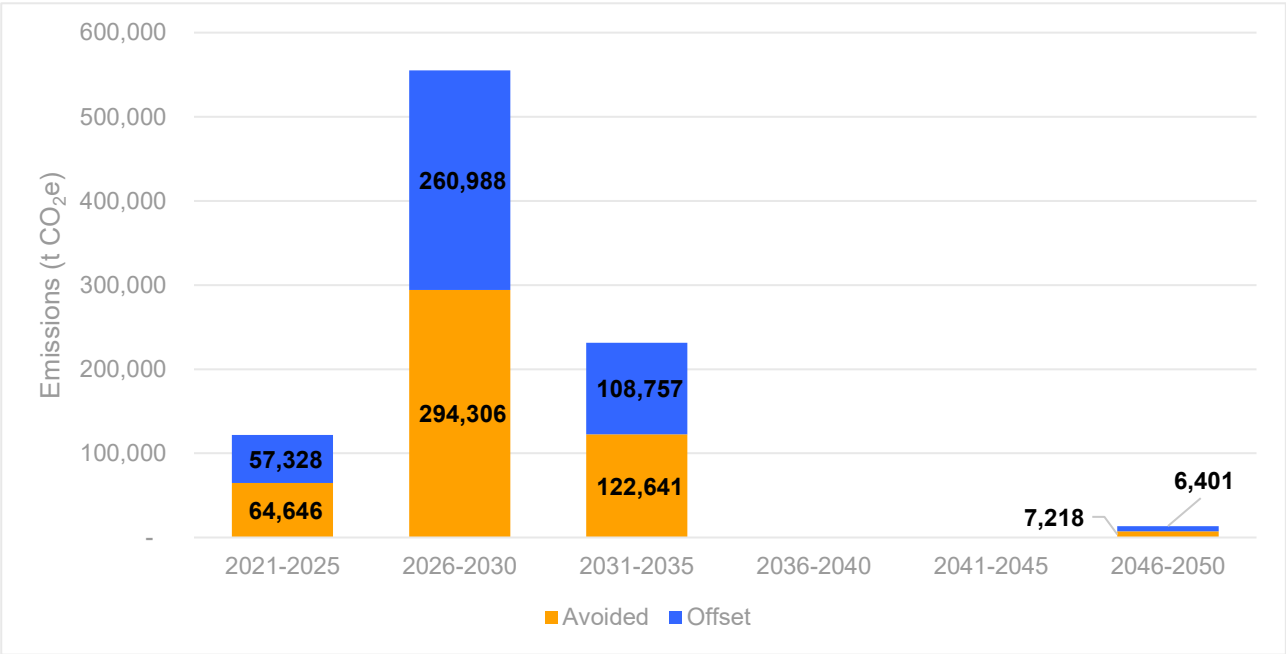

Figure 3-7 Trajectory of emissions which will be avoided, reduced and offset

Table 3-6 Revised Proposal estimated annual and total Scope 1 & 2 emissions (without abatement) with 5 yearly cumulative totals and reduction commitments

Year	Scope 1 GHG emissions t CO_2-e	Scope 2 GHG emissions t CO_2-e	Total GHG emissions (Scope 1 & 2) t CO_2-e	Cumulative total GHG emissions 5 yearly t CO_2-e	Cumulative GHG emissions reduction commitments t CO_2-e
2019	9,193	-	9,193	82,398	-
2020	72,022	1,183	73,204		
2021	59,006	11,456	70,463	813,162	121,974
2022	114,173	24,000	138,173		
2023	161,686	21,857	183,542		
2024	157,406	26,245	183,651		
2025	200,572	36,761	237,333		
2026	249,128	34,441	283,569	1,110,588	555,294
2027	165,064	27,501	192,565		
2028	178,639	40,610	219,249		
2029	180,739	34,970	215,709		
2030	159,205	40,291	199,496		
2031	186,890	37,131	224,021	647,868	231,397
2032	135,695	27,683	163,379		
2033	95,431	20,125	115,556		
2034	70,340	14,809	85,148		
2035	47,164	12,600	59,764		
2036	41,748	8,428	50,176	132,840	-
2037	23,699	6,056	29,755		
2038	12,901	902	13,803		
2039	10,758	1,047	11,805		
2040	27,007	294	27,301		
2041	30,052	2,814	32,866	116,204	-
2042	32,025	3,542	35,567		
2043	17,271	1,786	19,057		
2044	13,937	1,210	15,147		
2045	13,388	179	13,567		
2046	10,164	3,454	13,618	13,618	13,618
Total	**2,475,305**	**441,373**	**2,916,678**	**2,916,678**	**922,284**

3.2.2. Scope 3 emissions trajectory

The estimated Revised Proposal Scope 3 emissions baseline is shown in Figure 3-8 and Table 3-7.

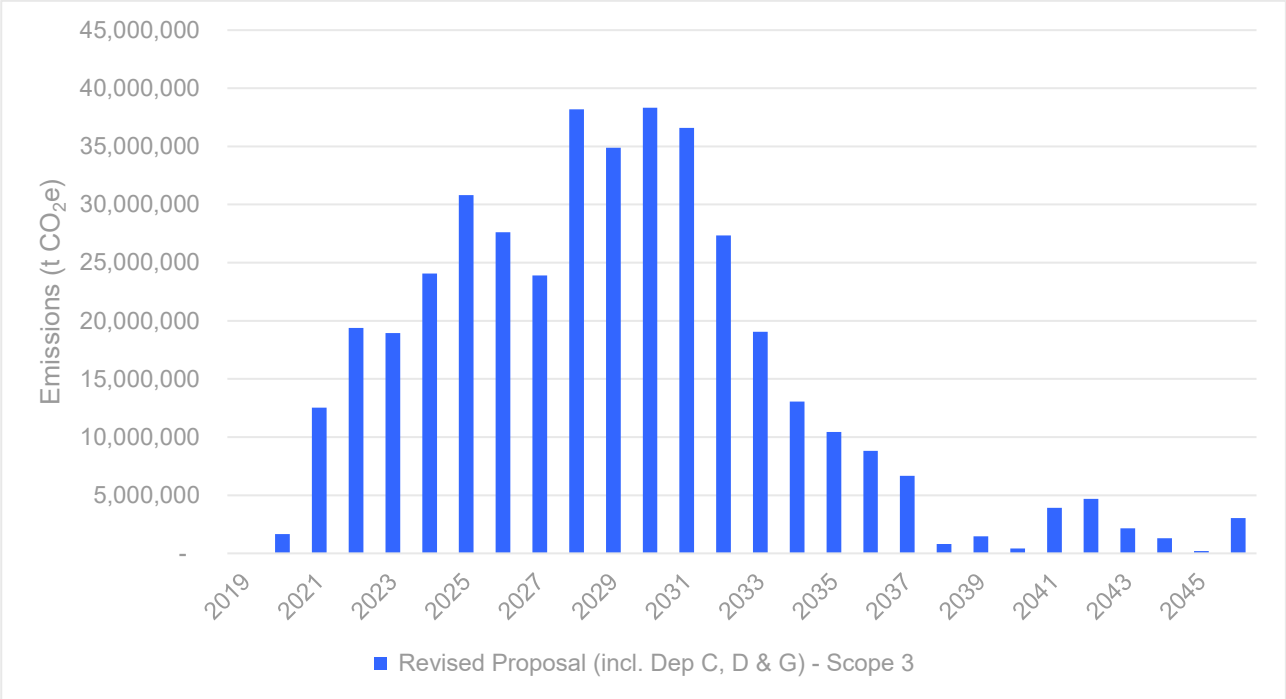

Figure 3-8 Revised Proposal estimated annual Scope 3 emissions

Table 3-7 Revised Proposal estimated annual and total Scope 3 emissions

Year	Scope 3 GHG Emissions t CO_2-e
2019	-
2020	1,655,017
2021	12,528,940
2022	19,389,293
2023	18,936,240
2024	24,061,095
2025	30,820,799
2026	27,630,372
2027	23,894,191
2028	38,178,702
2029	34,874,489
2030	38,336,302
2031	36,598,617
2032	27,331,756

Year	Scope 3 GHG Emissions t CO_2-e
2033	19,064,145
2034	13,045,029
2035	10,451,259
2036	8,814,419
2037	6,677,886
2038	807,387
2039	1,451,939
2040	410,066
2041	3,901,398
2042	4,679,630
2043	2,140,913
2044	1,295,517
2045	185,930
2046	3,037,670

Total	**410,199,000**

3.3. Scope 1 – Mitigation measures

3.3.1. Best practice design and operational Scope 1 emissions mitigation measures

Rio Tinto is exploring and implementing a range of short, medium and long-term low-carbon initiatives. Recently efforts have increased with the establishment of a dedicated abatement program for diesel reduction/elimination in 2022, in recognition of Rio Tinto's global diesel consumption in trucks, trains and other mobile equipment of approximately 1.3 billion litres annually, accounting for 13% of Rio Tinto's emissions[11].

The solutions to transition mobile fleet from diesel to low/no emissions energy are in the early stages of research and development with limited commercial and technical viability at this stage. Rio Tinto has an aspiration of no new purchases of diesel-powered haul trucks by 2030[12] and is therefore committed to trials and pilots through partnerships to develop new technological solutions to decarbonise diesel emissions.

Battery electrification is currently the target technology to eliminate diesel emissions from mining equipment, which is expected could be mass deployed from around the mid-2030s, however it is recognised that other technologies will be important. For example, investigation of sustainable biofuels as an interim step as well as working with equipment manufacturers to introduce smaller and more energy-efficiency equipment into mine sites is ongoing.[13]

Given the current limited commercial and technical viability of diesel replacement technologies, the deployment schedule for diesel reduction/elimination technologies for Pilbara mine sites is not yet defined and is currently under investigation. Therefore, in some cases, approvals may be sought, with diesel emissions abatement projects implemented at alternative locations, to ensure maximum abatement is realised as soon as practical.

At a project specific level, mine design optimisation, progressive backfilling of certain pits, engine upgrades to existing haul truck fleet, procurement of fuel-efficient dig units, fixed power supply to bores and variable speed generators/variable speed drives for bore pumps are proposed to be used to reduce emissions from the project. The Western Hill deposit will also utilise the existing Deposit C & D overland conveyor.

Alternates to haul with lower operating emissions were investigated during the early stages of the project. A new crusher and overland conveyor for the Western Hill deposit was considered and subsequently rejected due to the high cost of this option and marginal differences in annual operating emissions (4 kt CO_2-e savings per year using the conveyor). This does not include the embodied emissions in the construction of a new crusher and overland conveyor versus using the existing haul truck fleet either. Deposit H, Dep F-North and MTEE all have a much shorter mine life than Western Hill and therefore do not have production volumes to warrant the construction of additional crushing and conveying infrastructure.

A road train option for Dep H has also been considered, with road trains for long hauls often being a lower emissions option. In this instance however, annual operating emissions are higher for road trains (2.5 kt CO_2-e), due to two transfer pads required to drop off ore by haul trucks, with road trains taking ore closer to processing infrastructure before haul trucks pick it up again. This option also has safety concerns with increased exposure between road trains and autonomous haul trucks, more land clearing required and increased impacts to country.

A list of best practice design and operational measures for the project and under assessment for the Pilbara is contained in Table 3-8.

[11] https://www.riotinto.com/invest/reports/climate-change-report

[12] https://www.riotinto.com/en/news/releases/2022/scania-and-rio-tinto-agree-to-develop-autonomous-haulage-solutions-supporting-a-pathway-to-lower-emissions-mining

[13] https://www.riotinto.com/invest/reports/climate-change-report

Table 3-8 Scope 1 mitigation projects for the Revised Proposal and under assessment in the Pilbara

Description	Mitigation Hierarchy	Indicative Implementation Timeframe	Estimated Emissions Savings ($t CO_2$-e per annum)	Context
Project specific mitigation projects				
Mine design	Reduce	Project implementation	To be confirmed	The ongoing design and mine plan optimisation process assesses the following opportunities: • Mining areas, pit exits and waste dumps are optimised to reduce haul distances. • Progressive backfill to minimise rehandling of material post mining. • Haul road layout design – designed to smooth truck speeds to minimise stop/start and hence improve diesel use efficiency.
Engine upgrades to existing haul truck fleet	Reduce	Complete	12,000	930E-4's have undergone upgrades that have increased fuel efficiency by ~10% compared to original as build configuration, which includes; • Komatsu fuel saver kit (reducing engine RPM during low, high idle and retarding) • Engine upgrade to QSK60 Modular Common Rail System Single Stage (from High Pressure Injection – Tier 1-2 technology platform) platform (Note: estimated emissions savings have already been included in the emissions baseline)
Procurement of fuel-efficient dig units	Reduce	~2027	~1,500	West Angelas currently uses a mix of Hitachi -6 and -7 dig units. The -7 units use ~10-20% less fuel than -6 units. Three -6 (one EX3600's and two EX5600's) are due for replacement in 2027 and one new unit (EX3600) is required to be purchased. These units are scheduled to be replaced with the more fuel efficient -7 unit. Opportunities to bring forward early replacement of these units exist subject to operational and commercial considerations. (Note: estimated emissions savings have already been included in the emissions baseline)
Progressive backfill of pits	Reduce	To be confirmed	~200[14]	The Proponent is investigating progressive backfilling of the pits (e.g. at Deposit H) – this can provide short haul options compared to waste dumps and reduces the amount of total material moved (TMM) and therefore truck operating hours during mine closure.

[14] Total operating estimated emissions savings, does not include truck hours (and therefore emissions) saved at closure which have not yet been assessed

Description	Mitigation Hierarchy	Indicative Implementation Timeframe	Estimated Emissions Savings ($t CO_2$-e per annum)	Context
Variable speed generators (VSG) / variable speed drives (VSD) for water bores	Reduce	Complete – 6 bores 2024 – 1 bore 2029 – 1 bore	~150[15]	8 bores powered by diesel generators are required for the Revised Proposal and will include VSG's/VSD's. A VSG/VSD driven pump consumes less fuel than a conventional standard generator driven pump set, by 0% to 24% depending on pump speed and generator load. (Note: estimated emissions savings have already been included in the emissions baseline)
Mains powered water bores	Reduce	2024	~270	Powering ex-pit bores with a fixed power supply (currently gas-fired electricity) has lower emissions than powering the same bores with diesel generators. Estimated emissions savings are from 5 grid connected bores (3 already connected with two more in 2024) able to be connected to the Pilbara Power Network rather than diesel generators. With the installation of renewables, these bores will eventually be powered by green electrons and will result in further emissions savings. (Note: estimated emissions savings have already been included in the emissions baseline)
Pilbara wide mitigation projects under assessment				
Energy efficiency	Reduce	To be confirmed	To be confirmed	Reduction of diesel in existing assets makes good business sense due to fuel cost savings. A number of opportunities exist and are under investigation (e.g. utilising the engine shut of feature of autonomous fleet during certain idling instances and installing secondary power systems for dig units to be also shut off when idling) to be rollout out Pilbara wide.
Biofuels for Heavy Mining Equipment	Avoid	~2030	To be confirmed	Rio Tinto has successfully completed the full transition of its heavy machinery from fossil diesel to renewable diesel at its Boron, California operation[16] and Rio Tinto continues to investigate biofuels as an interim step. Rio Tinto has completed validation work with mining fleet engine vendors, testing engines for suitability to transition to HVO with all engines suitable to substitute diesel with HVO.
Trolley assist option	Avoid	To be confirmed	To be confirmed	Rio Tinto is investigating the development of a viable trolley assist option for existing haul fleet to enable substantial reduction in diesel use while on trolley[17]

[15] From 2029 when all 8 bores have been installed

[16] https://www.riotinto.com/en/news/releases/2023/rio-tinto-u_s_-borax-becomes-first-open-pit-mine-to-transition-to-renewable-diesel

[17] https://www.riotinto.com/invest/reports/climate-change-report

Description	Mitigation Hierarchy	Indicative Implementation Timeframe	Estimated Emissions Savings ($t CO_2$-e per annum)	Context
Zero emissions haul truck fleet	Avoid	~mid-2030s onwards	To be confirmed	In separate partnerships with Komatsu and Caterpillar, Rio Tinto is working to develop and implement battery electric haul solutions including haul trucks. Rio Tinto intends to trial the first large scale battery truck in the Pilbara in 2024-2518 Rio Tinto and Scania have been trialling 40-tonne-payload agile autonomous haul trucks at Rio Tinto's Channar mine with options for the future transition to electric powered vehicles19 An innovative partnership with Industry and Austmin, Rio Tinto was a founding partner in the 'Charge On Challenge', a collaboration initiative to identify and develop mobile fleet charging solutions.

[18] https://www.riotinto.com/invest/reports/climate-change-report

[19] https://www.riotinto.com/en/news/releases/2022/scania-and-rio-tinto-agree-to-develop-autonomous-haulage-solutions-supporting-a-pathway-to-lower-emissions-mining

3.3.2. Best practice review process

Rio Tinto has completed and continues to assess numerous technologies to transition away from diesel powered mining equipment. Technologies are more progressed for some equipment than others with the emissions reduction/elimination pathway for each equipment type analysed. The mining equipment assessed includes;

- Haul trucks
- Excavators
- Drill rigs
- Auxiliary vehicles (loaders, bulldozers, water trucks, fuel trucks, etc)
- Generators
- Light vehicles

The current best practice alternative energy sources to power mining equipment includes (but is not limited to);

- Electric (including trailing cables, overhead catenary and/or batteries)
- Hydrogen fuel cell electric
- Renewable diesel
- LPG
- Additives
- CNG/LNG
- Biodiesel

The selection criteria used to identify best practice diesel reduction/elimination measures and their effectiveness included a Technology Readiness Level (TRL) and Commercial Readiness Index (CRI) assessment. TRL is a globally accepted benchmarking assessment for tracking technology progress from early-stage research (TRL1) through to actual system demonstration (TRL9). The Australian Renewable Energy Agency (ARENA) has developed a CRI to be used in parallel with the TRL framework. This assessment allows emerging technologies to be assessed based on Hypothetical Commercial Proposition (CRI1) through to Bankable Grade Asset Class (CR6).

Following the assignment of TRL and CRI values for each technology available and associated emissions reduction benefits for different equipment types, a multi-criteria assessment is underway to determine what Pilbara sites are appropriate for deployment of various diesel reduction/elimination technologies. This assessment includes considerations such as, current fleet replacement schedules, mine planning requirements, site infrastructure, power demand/supply, maintenance, information systems, environmental/heritage considerations, etc. to determine future deployment scenarios and timings for individual sites and technologies.

Given the assessments completed to date, battery electrification of mine equipment has been adopted as the preferred long-term pathway however assessments continue for all available and future technologies as the diesel reduction/elimination pathway is likely to change and evolve over time.

3.3.3. Benchmarking Scope 1 emissions intensity review

Emissions intensity is expressed as tonnes CO_2-e (Scope 1 emissions not including emissions released directly from land management as per NGER Determination 2008) per unit of production. Production for the iron ore industry is currently defined as "*tonnes of iron ore, on a wet basis, that is produced as part of carrying on the iron ore mining activity at the facility and is of saleable quality*"[20].

[20] https://www.dcceew.gov.au/sites/default/files/documents/safeguard-mechanism-document-production-variable-definitions-2022.pdf

The Scope 1 emissions intensity for the Proposal and Revised Proposal was calculated from annual average emissions and production over the life of the project and is presented in Table 3-9.

Table 3-9 Scope 1 covered emissions intensity

Proposal	Average Scope 1 emissions (diesel only) ($t CO_2$-e)	Average emissions intensity ($t CO_2$-e / t iron ore)
West Angelas Proposal	53,689	0.0081
West Angelas Revised Proposal	87,505	0.0080

A GHG emissions intensity benchmarking assessment was undertaken to compare emissions performance of the Revised Proposal against other comparable open cut iron ore mining proposals located in Western Australia's Pilbara region and the default iron ore industry emissions intensity (Table 3-10 and Figure 3-9). The default iron ore industry emissions intensity value is set by the CER and defined in Schedule 2 of the Safeguard Mechanism. It represents the industry average emissions intensity of production over five years (FY2012-13 to FY2016-17).

Emissions intensity allows the comparison of different sized mining operations normalised by a relevant measure of production. Despite this normalisation, comparable benchmarking of emissions from individual mining operations is challenging, as it does not consider the site-specific circumstances which impact on GHG emissions intensity. Waste to ore ratios, grade characteristics and topography have a significant influence on GHG emissions intensity. Below water table mining requires dewatering infrastructure to be operated and a greater amount of waste material moved per tonne of iron ore.

Boundary conditions present a further challenge to benchmarking across facilities. Some aspects of mining, processing and transport may be contracted to a third party that assumes operational control and hence ownership of a portion of a facility's emissions. The Proponent has made every effort to present a comparable benchmarking assessment with consideration of the above challenges.

The benchmarking shown in Figure 3-9 indicates that the performance of the Proposal and Revised Proposal is comparable to other recent iron ore developments in the Pilbara.

Table 3-10 Scope 1 emissions intensity benchmarking against comparable iron ore mines in the Pilbara, WA

Facility	Average annual Scope 1 emissions (diesel only) ($t CO_2$-e)	Average Iron Ore production (Mt/annum)	Scope 1 emissions intensity ($t CO_2$-e/t iron ore)
West Angelas Proposal	**53,689**	**6.6**	**0.0081**
West Angelas Revised Proposal	**87,505**	**11**	**0.0080**
Default Emission Intensity Iron Ore Mining Safeguard Mechanism	-		0.0047
FMG – Eliwana[21]	272,315	39[22]	0.0070

[21] FMG Fortescue Metals Group (2018), Eliwana Iron Ore Mine Project, Environmental Review Document, EW-RP-EN-0003-0. Table 57

[22] Back calculated from average emissions and emissions intensity

Facility	Average annual Scope 1 emissions (diesel only) (t CO_2-e)	Average Iron Ore production (Mt/annum)	Scope 1 emissions intensity (t CO_2-e/t iron ore)
BHP – Western Ridge[23]	138,926	19[24]	0.0073
Roy Hill – Roy Hill Revised Proposal	430,981	59	0.0076

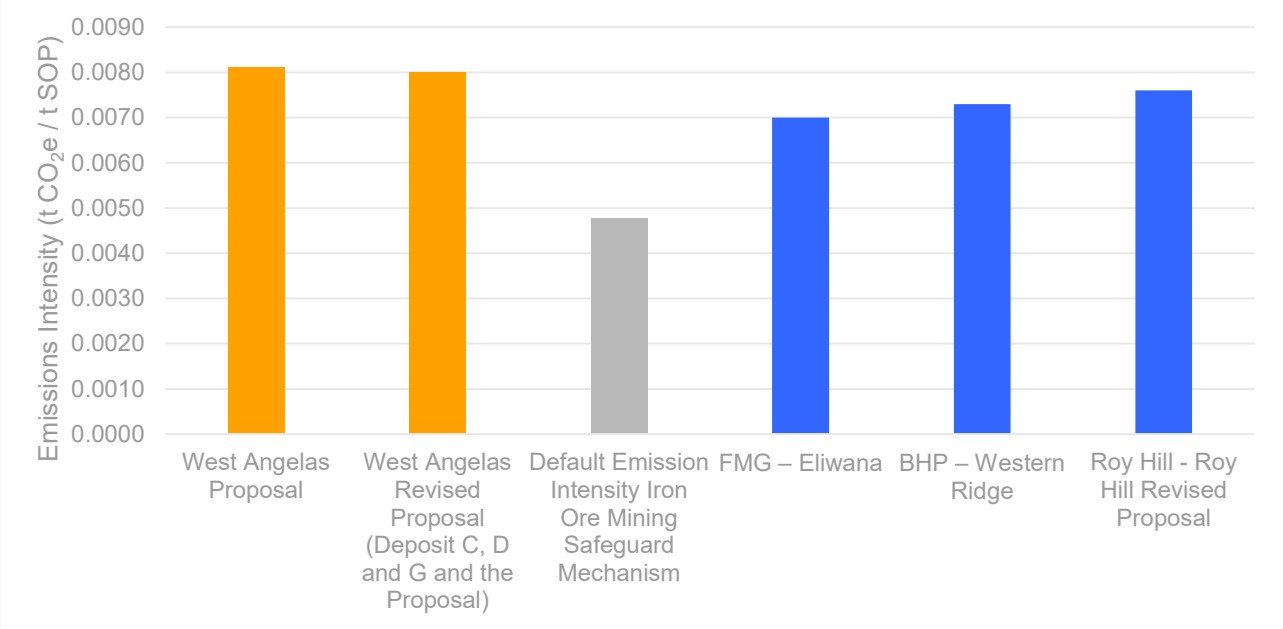

Figure 3-9 Scope 1 emissions intensity benchmarking against comparable iron ore mines in the Pilbara, WA

A similar benchmarking process against international iron ore mines was undertaken however the data was found to be unreliable due to different reporting and disclosure requirements in other jurisdictions. For example, emissions intensity values were obtained for iron ore operations in Canada however were for Scope 1 and 2 emissions, as they cannot be separated, they cannot be compared against Pilbara Scope 1 emissions intensities. Brazilian iron ore emission intensity values were also aggregated with non-iron ore mining operations and presented as a single emissions intensity also including both Scope 1 and 2 emissions, resulting in data that cannot be compared.

3.4. Scope 2 – Mitigation measures

3.4.1. Alternative energy options assessment

Rio Tinto has completed numerous studies and assessments of alternative energy options, testing a range of technologies available and suitability for implementation in the Pilbara region of Western Australia. Similar to Scope 1 mitigation technology assessment, this has included multi-criteria analysis (MCA) on various technologies, with consideration factors including economic viability (e.g. payback period), GHG emission reduction, speed of implementation, technological risk and environmental/heritage considerations.

Technologies assessed include (but not limited to);

- Solar PV

[23] https://www.epa.wa.gov.au/sites/default/files/Referral_Documentation/Appendix%2012%20-%20Western%20Ridge%20Greenhouse%20Gas%20Management%20Plan%20v1%20January%202023.pdf

[24] Back calculated from average emissions and emissions intensity

- Wind
- Battery technology for energy storage
- Pumped hydro storage
- Solar thermal plant
- Waste heat recovery
- Wave/tidal
- Geothermal

For technologies that scored well during the MCA, further development and interrogation was undertaken with more detailed consideration of locations, local climatic factors, size and scale, existing infrastructure, and conceptual network integration.

Based on this assessment, the short to medium term low-carbon transition strategy focusses on displacement of gas in electricity generation with solar, wind and battery storage solutions given economics, technological maturity and speed of deployment. Under assessment are renewable energy studies focused on deployment of 1GW of wind and solar power, to replace natural gas power for plant and infrastructure and support early electrification of mining equipment[25]. Rio Tinto is commissioning and has commenced generation of electricity at the Gudai-Darri 34MW Solar PV project and is focusing on delivering the Tom Price Battery Energy Storage System (BESS) to act as immediate back-up power generation, and up to 100MW Solar PV at the Pilbara coast[26] (Table 3-11). Full decarbonisation of the Pilbara including electrification of mobile and rail equipment beyond 2030 is estimated to require up to 3GW of installed renewable energy assets[27].

Scope 2 mitigation projects will be implemented at a Pilbara system level depending on the technical constraints of the network to ensure security, reliability and stability is upheld. This Pilbara wide approach enables abatement projects to service multiple developments and is a more cost efficient / flexible approach. Given the fast-evolving nature of renewable energy technologies, Rio Tinto is continuing to monitor numerous alternative energy options to determine suitability for implementation in the Pilbara and our interconnected electricity grid. The current grid electricity emissions intensity for the Pilbara Power Network, that Rio Tinto owns and operates, shows the impact of the deployment of renewables over time and resultant decrease in emissions intensity of the grid[28] (Figure 3-10).

At the Revised Proposal specific level, variable speed drives (VSDs) on existing plant motors and energy efficiency considerations for new infrastructure are important emissions reduction measures (Table 3-11).

[25] https://www.riotinto.com/en/news/releases/2021/rio-tinto-to-strengthen-performance-decarbonise-and-grow

[26] https://www.riotinto.com/en/news/releases/2022/rio-tinto-plans-further-investment-in-renewable-energy-in-the-pilbara

[27] https://www.riotinto.com/en/news/releases/2022/rio-tinto-plans-further-investment-in-renewable-energy-in-the-pilbara

[28] All potential projects and sites included in the grid emissions intensity chart are subject to further studies and if proposed to be pursued, would be conditional upon securing all necessary approvals (including internal, external, joint venture and regulatory approvals)

Table 3-11 Scope 2 mitigation projects for the Revised Proposal and under assessment, construction or operation, in the Pilbara

Description	Mitigation Hierarchy	Indicative Implementation Timeframe	Estimated Emission Savings ($t CO_2$-e per annum)	Context
Revised Proposal specific mitigation projects				
VSD's on existing low voltage plant motors	Reduce	Existing	To be confirmed	Existing West Angelas fixed plant low voltage motors that include variable speed drives (VSD's); • 52 motors in total (including conveyor motors, vibrating feeders, dust collectors, shuttle drives and stacker and reclaimer long travel and slew drives) • 29 of 52 VSDs are new models (with increased efficiency), with a further 14 of 52 planned for upgrade over the next 3 years. The remaining 9 older VSDs are not recommended for upgrade in the near future due to age / usage. • Any required motor or VSD replacements will practically utilise spares or have new equipment installed. Any fixed plant high voltage motors do not have VSD's installed due to, excessive cost, space limitations or ineffectiveness in installation (e.g. hydraulic drives). This is detailed in the Rio Tinto DC-E001 Electrical Design Criteria, which sets the standard for electrical design. This standard ensures efficiency in the electrical system as motor selection is limited at 1.25 times the equipment design (ensuring efficiency of motor selection) and VSD/Soft starter requirements set for effectiveness and motor size (motors above 250kW are required to install VSDs). (Note: any emissions savings have been included in the emissions baseline with the calculation of these savings of low value to include due to the time required to collect and collate the data)
Non-Processing Infrastructure (NPI) building designs	Reduce	Project Implementation	To be confirmed	Rio Tinto Iron Ore company specifications (including Environmental design criteria – Permanent and temporary facilities, DC-N001) apply to NPI required for the Revised Proposal. All buildings must meet thermal comfort and energy efficiency requirements of Section J of the National Construction Code (NCC) as well as a minimum NatHERS 6-star rating. For the Revised Proposal, this includes; • Energy efficiency a key design criterion for all electrical loads • Buildings orientated (wherever practical) to suit the climatic conditions • High efficiency air-conditioning units and heat pump hot water units • LED lighting • Natural lighting incorporated into designs where practical to reduce lighting requirements • Verandas installed where practical to reduce thermal loading on building doors/windows

Description	Mitigation Hierarchy	Indicative Implementation Timeframe	Estimated Emission Savings (t CO_2-e per annum)	Context
				(Note: estimated emissions saving not currently available, an independent energy efficiency report will be completed for all buildings after the engineering design process)
Pilbara wide mitigation projects in operation[29]				
Wind Monitoring	N/A	Underway	N/A	A wind monitoring program is underway at various locations in the Pilbara. The multi-year monitoring program will inform the viability of establishing wind farms as part of our overall efforts to transition our Pilbara operations to renewable energy sources.
Solar PV at Gudai-Darri Mine	Avoid	2023	~52,000	Consists of approximately 90,000 solar panels made up of photovoltaic cells to convert sunlight into electricity. Solar PV reduces emissions through direct displacement of gas in electricity generation with renewable energy sources
Pilbara wide mitigation projects under construction[30]				
Battery Energy Storage System (BESS)	Avoid	2023	~26,000	To support the Pilbara Power Network, the Tom Price BESS will provide spinning reserve generating capacity to support a stable and reliable network[31], reducing emissions through the direct displacement of gas that otherwise would be consumed to provide the same function
Pilbara wide mitigation projects under assessment[32]				
Solar PV at Pilbara Coast	Avoid	~2026	~145,000	Consists of approximately 225,000 solar panels made up of photovoltaic cells to convert sunlight into electricity. Solar PV reduces emissions through direct displacement of gas in electricity generation with renewable energy sources
Solar PV (TBD)	Avoid	~2027	~192,000	Solar PV reduces emissions through direct displacement of gas in electricity generation with renewable energy sources

[29] Note: t CO_2-e per annum savings are the average annual Pilbara wide savings as a result of the project (2024-2050)

[30] Note: t CO_2-e per annum savings are the average annual Pilbara wide savings as a result of the project (project commencement to 2050)

[31] https://www.riotinto.com/en/news/releases/2020/rio-tinto-to-build-first-solar-plant-in-western-australia-to-power-iron-ore-mine

[32] Note: t CO_2-e per annum savings are the Pilbara wide savings as a result of the project (project commencement to 2050)

Description	Mitigation Hierarchy	Indicative Implementation Timeframe	Estimated Emission Savings (t CO_2-e per annum)	Context
Pilbara Renewable Energy Studies	Avoid	~ 2030	To be confirmed	Additional renewable energy projects are in study phase to deliver substantial emissions abatement across all Pilbara assets.
Memorandum of Understanding with Yindjibarndi Energy Corporation (YEC)	Avoid	To be confirmed	To be confirmed	Rio Tinto and YEC will study and evaluate a range of opportunities including wind and solar power as well as battery energy storage systems. The initial focus is on rapidly exploring the potential development of a solar power generation facility for the supply of energy to Rio Tinto.[33]

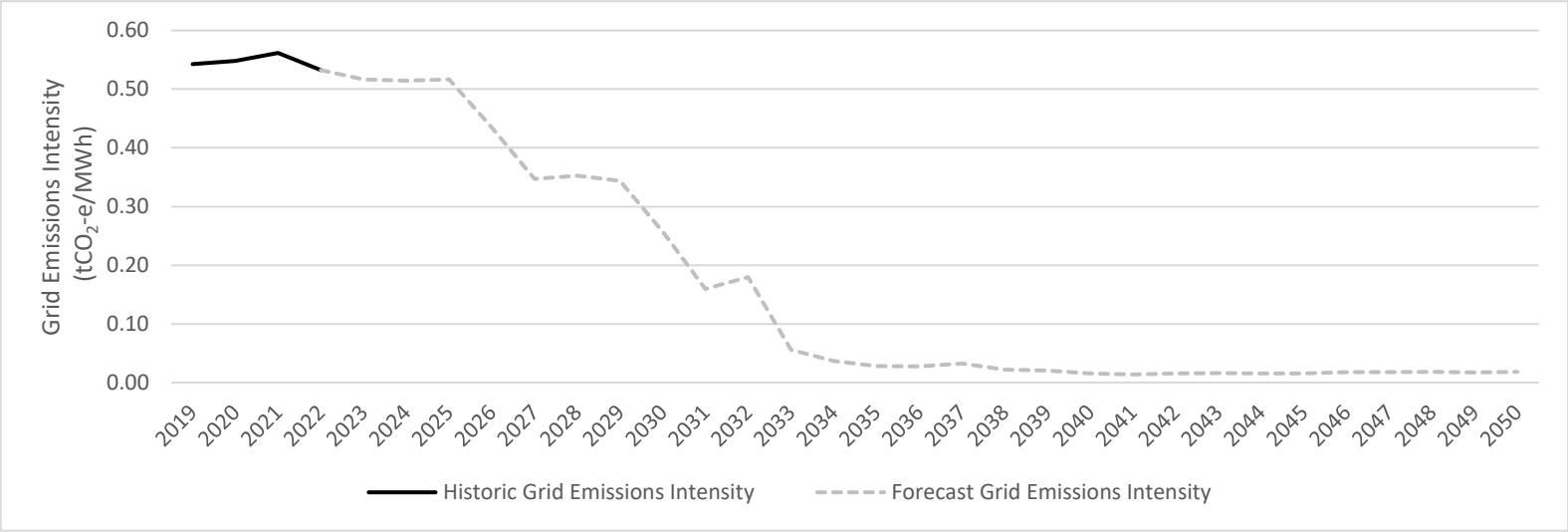

Figure 3-10 RTIO historic and forecast electricity grid emissions intensity

[33] https://www.riotinto.com/en/news/releases/2023/rio-tinto-and-yindjibarndi-energy-sign-pilbara-renewables-mou

3.4.2. Scope 2 emissions regulation

Scope 2 emissions associated with the Revised Proposal are not reported as Scope 2 emissions under NGERs and are reported under Scope 1 emissions due to Rio Tinto owning and operating its own gas-fired electricity grid. These emissions are regulated under the Renewable Energy Target (RET) with further information on this regulation provided in Section 3.6.3.

3.5. Scope 3 – Mitigation measures

Scope 3 emissions include, processing of produced iron ore to iron and steel, purchased goods, transport of materials, fuels and personnel to and from site. The steel making process is by far the largest contributor to emissions, with these emissions making up 96% of total Scope 1, 2 and 3 emissions from Rio Tinto Iron Ore (RTIO).

RTIO products from the Pilbara are processed via the blast furnace/basic oxygen furnace (BOF) steelmaking route. This process uses iron ore, metallurgical coal and other additives to produce steel. The other process for producing steel sees the electric arc furnace use recycled steel scrap and natural gas based direct reduced iron (DRI). Steel industry participants have announced a range of emission reduction targets. These targets vary by country and company but are largely aligned and have tiered reduction to achieve net zero between 2050-2070.

There is no proven process route at an industrial scale to produce primary net zero steel today. The industry is developing and scaling a range of new technologies. These include hydrogen-based DRI feeding into an electric arc furnace or into a BOF via an intermediary melt step, direct smelting, the use of sustainable biomass, and carbon capture and storage (CCS), as well as more speculative technologies such as electrolysis. The deployment of these new technologies will depend on technical breakthroughs, capital intensity improvements, consumer recognition of green products and government policy that encourages deployment, such as carbon prices.

In 2021, Rio Tinto established a dedicated steel decarbonisation team within our Commercial Group, to:

- Support the reduction of Rio Tinto's iron ore Scope 3 emissions.
- Protect the long-term value of Rio Tinto's iron ore through development and scale up of cost-effective technologies that utilise our iron ores in the future low-carbon steel industry.
- To position Rio Tinto to participate in the nascent green iron market.
- To provide steel decarbonisation analysis and intelligence to support decisions on Rio Tinto's future iron ore resource portfolio, product strategy, and renewable energy development.

In 2022, the Rio Tinto Steel Decarbonisation team,

- Extended collaboration with key customers including Baowu, POSCO, Nippon Steel Corporation and Shougang, with potential carbon emissions reductions of up to 30%.
- Successfully piloted the BioIron™ innovative low carbon iron making process, suitable for Pilbara iron ore.
- Collaborated with industry participants such as BlueScope and Salzgitter Flachstahl to test direct reduction of our products using green hydrogen and develop cleaner processing options.

Rio Tinto is currently advancing 49 projects in partnership with over 30 customers, universities, researcher institutes, and other industry stakeholders, to build options for our shared aim of net zero steelmaking.

RTIO's main customers are in the Asia-Pacific region, where a significant portion of global steelmaking occurs. China is the largest producer of steel, with over half of the world's annual production, and as a primary customer of RTIO's a significant quantity of Scope 3 emissions will be emitted in China with the balance in other Asian steelmaking hubs (e.g. Japan, Korea, India, etc). These countries are all subject to emissions reduction targets, with net zero pledges ranging from 2050 to 2070 (China has pledged a 2060 net zero target).

3.6. Other statutory decision-making processes which require reduction in GHG emissions

3.6.1. Other relevant statutory decision-making processes – Western Australia State GHG Policy

In 2019, the Western Australian Government announced its State GHG Policy to guide Government decision making for major projects that are assessed by the Western Australian Environmental Protection Authority (WA EPA). The WA EPA released an updated Guideline in April 2023. Table 3-12 details how the contents of this GHG EMP addresses the State GHG Policy.

Table 3-12 Addressing State GHG policy requirements

State GHG Policy Considerations on Contents of a GHG EMP	Proponent Response
The policy supports the development of GHG EMPs for proponents which: Outline strategies to avoid, reduce, mitigate and offset the project's emissions contributing towards the State's aspiration of net zero by 2050	The Proponent is committed to contributing towards the State's aspiration of net zero by 2050 through achievement of interim and long-term targets. Strategies to avoid, reduce, mitigate and offset Scope 1 & 2 emissions from the Revised Proposal are outlined in Section 3.3.1 and 3.4.1.
Are unique to a proposal's specific circumstances	The GHG EMP has been developed specifically to support the Proposal, which consists of the extension and development of new deposits and associated activities to extend the life of existing iron ore operations at West Angelas. The Proposal includes: • 5,350 ha of clearing • Transport of ore to existing processing facilities at West Angelas via haul and haul plus overland conveyor (Western Hill). • Power supplied by existing 33 kV transmission lines and additional substations.
Allow proponents to take account of opportunities at either facility level or across national operations	In some cases, emission abatement projects may be implemented at alternative locations to the Revised Proposal, depending on a range of criteria applicable both to energy supply (e.g. renewable energy facilities, topology and technical constraints) and energy demand (e.g. technology readiness). Using the Rio Tinto owned and operated interconnected Pilbara Power Network, it is anticipated that Rio Tinto will account for emissions abatement at various Pilbara locations to meet the abatement requirements of the Revised Proposal. Rio Tinto's emissions reduction projects in Western Australia are outlined in Section 3.3.1 and 3.4.1. Local or national credible offset units (ACCUs) may be sourced to offset Revised Proposal emissions in order to meet targets set out in Section 3.8.
Allow proponents to propose their own timeframes and targets; Include requirements for periodic public reporting against their targets; and Account for and align with Commonwealth requirements.	The GHG EMP includes reduction targets and abatement initiatives that either avoid, minimise or offset emissions from the Revised Proposal (Section 3.3.1 and 3.4.1). The Proponent is committed to contributing towards the State's aspiration of net zero by 2050 through achievement of interim and long-term targets. Performance against the Revised Proposal target will be reported in the Ministerial Statement Annual Compliance Assessment Report every five years, with the first review taking place in the 2025 report, as outlined in Section 4.1. Emissions from West Angelas (including the Revised Proposal) will also be reported annually through NGER, in accordance with the NGER Act.
Consistent with the Government's focus on economic development and diversification, plans that include undertakings to develop Western Australian expertise, carry out research, pilot new initiatives and technologies, and	Rio Tinto is implementing and further developing a range of abatement initiatives in Western Australia, leveraging local expertise and ensuring benefits to local communities and industry participants. In addition, the ongoing activities of the Proponent, and more broadly Rio Tinto in the Pilbara, will continue to support social and economic development projects, including: • continued education, training, employment and business opportunities for local people, including local Aboriginal people; and

support local communities are encouraged.	• continued funding for a range of organisations in the region, including sporting and cultural groups.

3.6.2. Other relevant statutory decision-making processes – Safeguard Mechanism

The National Greenhouse and Energy Reporting (Safeguard Mechanism) Rule 2015 applies baselines to large GHG-emitting facilities, to ensure that net emissions are kept below a defined emissions limit (baseline) aligned with Australia's climate targets. It is administered by the CER and applies to facilities with Scope 1 emissions (covered emissions) of more than 100,000 t CO_2-e per year.

Baselines are calculated by multiplying the quantity of product by an emissions intensity (existing products from facilities will transition from a 'facility-specific' emissions intensity value to 'industry average' values by FY2029-30). The current iron ore industry average emissions intensity is 0.0047 t CO_2-e/t iron ore. A default decline rate of 4.9% per annum is also applied to the baselines from FY2023-24. If a facility reduces its emissions below their baseline Safeguard Mechanism Credits can be generated to be sold to other Safeguard facilities or banked for future use.[34]

Differences in the emissions baseline or reduction trajectory of the Safeguard Mechanism compared with those proposed by the EPA include;

- Baseline emissions covered under Safeguard Mechanism only apply to Scope 1 covered emissions, for West Angelas this does not include Scope 1 land clearing emissions.
- Safeguard Mechanism baselines rise and fall with production.
- Baselines decline annually due to the 4.9% annual decline and could be higher for certain facilities if they have a current production specific baseline higher than the default industry average due to the transition of all facilities to the default industry average by 2030.
- Declines continue annually until a facility reaches a baseline of 100,000 t CO_2-e.

The emissions reduction required under Safeguard Mechanism compared with that of the EPA include;

- Scope 1 emissions reduction must occur at the facility where Scope 1 emissions occur
- Baseline exceedances under Safeguard Mechanism require the purchase of Australian Carbon Credit Units (ACCUs). No other offsets are currently allowed under this scheme (e.g. international carbon credits).
- Production productivity measures (e.g. more production for the same emissions) results in an increase in the baseline and a decrease in liability (if over baseline)

3.6.3. Other relevant statutory decision-making processes – Renewable Energy Target (RET)

Rio Tinto is the owner-operator of the Pilbara Power Network and is subject to the Renewable Energy Target (RET). The RET is administered by CER and designed to reduce emissions of greenhouse gases in the electricity sector by encouraging additional generation of electricity from sustainable and renewable sources[35]. Renewable Energy Certificates must be surrendered based on the amount of electricity generated minus exemptions (e.g. electricity generated from renewables) multiplied by the Renewable Power Percentage (RPP) for the year. The 2023 RPP is 18.96%.

The RET differs to the proposed EPA reduction trajectory due to it being an incentive to add renewable electricity generation (currently legislated to 2030) rather than reduce emissions. However, the intent is by increasing renewables, electricity generated from fossil fuels should reduce along with emissions. The RPP

[34] https://www.cleanenergyregulator.gov.au/NGER/The-Safeguard-Mechanism/The-Safeguard-Mechanism-for-financial-years-commencing-on-or-after-1-July-2023

[35] https://www.cleanenergyregulator.gov.au/RET/About-the-Renewable-Energy-Target

has generally increased annually however as it is calculated annually, it is not possible to compare trajectories between the RET and the EPA proposal.

3.6.4. Monitoring and reporting requirements – National Greenhouse and Energy Reporting (NGER)

The NGER Act is a single national framework for reporting GHG emissions, energy production and energy consumption. The objectives of the NGER scheme are to:

- Inform government policy and the Australian public;
- Help meet Australia's international reporting obligations;
- Assist Commonwealth, State and Territory government programs and activities; and
- Avoid duplicating reporting requirements in the states and territories.

The methods and criteria for calculating GHG emissions and energy data under the NGER Act are detailed in the National Greenhouse and Energy Reporting (Measurement) Determination 2008 (Department of the Environment and Energy (DoEE), 2008) (NGER Determination). West Angelas emissions are reported annually under the NGER Act.

Emissions from the Proposal will contribute to the West Angelas NGER report inventories and be accounted against its baselines under the Safeguard Mechanism. Results of monitoring and reporting against Safeguard Mechanism baselines are made available to the public on the CER website.

3.7. Consistency with other (non-statutory) GHG reduction instruments

3.7.1. Corporate emissions reduction targets

Rio Tinto has announced its ambition to reach net zero emissions by 2050 across all operations. To support this ambition, medium-term global targets have been introduced for Scope 1 and 2 emissions, effective from 2021, to:

- Reduce absolute emissions by 15% by 2025 (approximately 4.9 Mt CO_2-e equity basis)
- Reduce absolute emissions by 50% by 2030 (approximately 16.3 Mt CO_2-e equity basis).

The target is measured against a 2018 global equity baseline, currently 32.6 Mt CO_2-e, which will be adjusted for divestments and acquisitions.

3.7.2. Industry transition strategy

Scenarios for the decarbonisation of the steel sector exist, such as the one presented in the Net-Zero Steel Sector Transition Strategy report published in October 2021 by the Net Zero Steel Initiative (NZSI). NZSI is an industry platform, part of the Mission Possible Partnership, that brings together stakeholders across the whole steel supply chain to help put the sector on a path to net zero emissions by mid-century. In this report, NZSI considers 20 technology archetypes and the decision-making process to deploy these at individual steel plants based on lowest total cost of ownership. The analysis compares two pathways that deliver net zero emissions from the steel sector by 2050 against a baseline business-as-usual scenario:

- Carbon Cost scenario: with a global carbon price (or policies equivalent to a carbon price) applied across all emissions and all geographies, rising globally from \$9/t CO_2 in 2023 to \$250/t CO_2 by 2050.
- Tech Moratorium scenario: restricting major investment decisions post-2030 to technologies that are compatible with reaching a net zero outcome by 2050.

The two scenarios result in different carbon emission pathways ranging from 15 % to 37% emissions reduction by 2030. The analysis is a useful illustration of the complexity and challenges faced by the steel industry to reach net zero by 2050. Our approach is to pursue and support a range of decarbonisation options aligned with the technology pathways highlighted by the NZSI analysis, through proactive partnerships with our customers, suppliers, universities and research institutes.

3.8. Offsets

In 2022, Rio Tinto increased investment in the Nature Solutions team in recognition that high integrity offsets will play a significant role in our decarbonisation strategy this decade[36]. The Proponent aims to achieve its emissions reduction targets through a combination of avoidance measures and offsets. The Proponent proposes to offset GHG emissions by retiring high integrity offset units on an annual basis, for example to meet Safeguard Mechanism obligations, to also meet cumulative 2025, 2030, 2035 and 2040 targets.

Rio Tinto defines high integrity as projects that balance positive outcomes for people, nature and climate and take an integrated landscape perspective with the intent to secure permanent, additional carbon emissions reductions. Using an assessment criterion based on existing standards for the voluntary market and in conjunction with this high integrity definition two workstreams are underway;

- Developing Nature-based Solutions (NbS) at, or near our assets (including Australia)
- Securing high-quality carbon credits from the market

The assessment criteria in use ensures a defensible carbon baseline and accounts for real carbon reductions focusing on permanence, additionality and quantification along with the ability to deliver biodiversity and social benefits. This aligns with integrity principles of the International Carbon Reduction and Offset Alliance (ICROA) in relation to the sourcing and use of credible offset units based on the principles of real, measurable, permanent, additional, independently verified, and unique[37].

Where offsets are required, the Proponent proposes to use Australian Carbon Credit Units (ACCUs), that may have also been retired to meet any Safeguard Mechanism obligations, to meet any EPA commitments. ACCUs must be surrendered in the Australia National Registry of Emissions Unit (ANREU) of which the CER is the certifying body. Rio Tinto is focused on securing high quality 'nature-based' ACCUs, with a vintage year from 2018 and onwards, that meet our high-quality thresholds due to the potential for strong carbon, nature and social benefits. Given this focus our investments prioritise the development and sourcing of ACCUs generated by methods including but not limited to;

- Environmental planting
- Savanna burning
- Human induced regeneration (HIR – to be replaced by integrated farm method Q4 2023)

A project assessment strategy has been developed across the savanna burning and HIR methodologies to increase the confidence of the integrity of projects Rio Tinto wishes to invest in. A summary of this assessment strategy which aims to answer a series of key questions per project is included in Table 3-13.

Table 3-13 Offsets project assessment strategy for savannah burning and HIR methodologies

	GIS analysis	Assessment rubrics	Ground truthing
Human induced regeneration	*Has there been an observable change in vegetation density between a baseline period and today?*	*Evidence based assessment on how additional and effective are the interventions, providing a definitive score and 'tiering' of projects*	*Do observations on the ground match with the outcomes claimed?*
Savannah burning	*Has there been a noticeable decrease in frequency of late season fires from a previous time period to a recent time period?*	*Evidence based assessment on how additional and effective are the interventions, providing a definitive score and 'tiering' of projects*	*Do observations on the ground match with the outcomes claimed?*

[36] https://www.riotinto.com/invest/reports/climate-change-report

[37] "ICROA Code of Best Practice, Version 2.1, July 2023", published by ICROA, downloaded from https://icroa.org/wp-content/uploads/2023/07/ICROA_Code_Best_Practice_v2.1_04072023.pdf on 11th September 2023

Rio Tinto is ramping up commercial activities to ensure high-quality carbon credits are available in the volumes required to meet any Safeguard Mechanism obligations (ACCUs) as well as interim and long-term targets for the Proposal. A range of upstream partnership models (including long-term offtakes, co-investment, and co-development) with high-quality partners and developers is currently being explored.

As part of annual NGERs reporting (due end of October each year), CER provide a position statement of any Safeguard Mechanism exceedance and resultant liability. The Proponent has until February the following year to surrender the appropriate quantity of ACCUs in the event of a liability. This information is recorded on the CER website as evidence as part of the Safeguard Mechanism facility data. Any offsets purchased to meet Safeguard Mechanism obligations which the Proponent proposes to also use against interim targets for the Revised Proposal will be included in the 2025 Ministerial Statement Annual Compliance Assessment Report (and five yearly post this report).

3.9. Projects operating beyond 2050

The Revised Proposal is not expected to be operating beyond 2050.

4. ADAPTIVE MANAGEMENT, CONTINUOUS IMPROVEMENT AND REVIEW OF THE GHG EMP

The GHG EMP will nominally be reviewed at least every five years, with the first review taking place at the beginning of 2026 (unless required before this date), to ensure that it reflects the current situation with regards to GHG management and monitoring. Re-submission of the most recent confirmed GHG EMP shall be included with the 2025 Ministerial Statement Annual Compliance Assessment Report by 30th April 2026.

In line with the concept of adaptive management (Table 4-1), the management actions presented in the GHG EMP shall be monitored, reviewed, evaluated and updated as required considering:

- If new abatement technology is proposed to achieve interim and long-term targets in Section 3.3.1 or 3.4.1 not already considered
- If a new process or activity is proposed to be introduced that has the potential to significantly change the emissions from the Revised Proposal, and that was not already considered (and that is not in accordance with this GHG EMP)
- Feedback or recommendations from the third party independent expert review of best practice measures and offsets integrity/availability
- Comments from the WA EPA and other decision-making authorities (DMAs) during the Public Environmental Review (PER) approval process;
- Changes in State or Commonwealth climate change legislation or policy; and
- Material change in risk (opportunities, processes and procedures) related to climate change identified by Rio Tinto.

Where either the five yearly review cycle is triggered, or if a significant change to either the facility, activity, or risk is identified, a revised GHG EMP will be submitted to the WA EPA.

Table 4-1 Adaptive management based provisions for the GHG EMP

Objective Based Management - Provisions Greenhouse Gas Emissions				
WA EPA Factor: Greenhouse Gas Emissions **Key impacts and risks:** Emissions and subsequent contribution to climate change				
Management-based provisions				
Objective: To reduce net greenhouse gas emissions to minimise the risk of environmental harm associated with climate change				
Management Actions	**Management Targets**	**Monitoring**	**Timing / Frequency**	**Reporting**
Achieve emissions reduction trajectory as defined in Figure 3-6 and Table 3-5	*Interim and Long-term Targets* Interim and long-term emissions reduction targets for the Revised Proposal (as outlined in Section 3.2) are to: • Reduce or abate emissions by 15% by 2025 (approximately 121,974 t CO_2-e); • Reduce or abate absolute emissions by 50% by 2030 (approximately 555,294 t CO_2-e); • Reduce or abate absolute emissions by 36% by 2035 (approximately 231,397 t CO_2-e); • Reduce or abate absolute emissions by 0% by 2040; • Reduce or abate absolute emissions by 0% by 2045; • Reduce ore abate absolute emissions by 100% by 2050 (approximately 13,618 t CO_2-e). Implementation of the Pilbara emissions abatement projects in Section 3.2.1 & 3.4.1 as required to achieve interim and long-term targets described in Section 3.2.	Monitoring of Revised Proposal emissions and quantification of realised emissions reductions in accordance with NGER Act and NGER Determination.	Five yearly with the first report taking place in the 2025 Ministerial Annual Compliance Assessment Report.	A summary report of performance against the Revised Proposal interim and long-term emissions reduction targets in Section 3.2 will be reported in the Ministerial Statement Annual Compliance Assessment Report every five years, with the first report taking place in the 2025 Report. For details refer to Section 4.1. Retirement of Credible Offset Units (ACCUs) to meet EPA commitments, that may have also been retired to meet any Safeguard Mechanism obligations, in relation to the Revised Proposal for 2025, 2030, 2035, 2040, 2045 and 2050 compared to interim and long-term targets in Section 3.2. Summary of purchased and retired ACCUs over the previous 5 years will be included in the Ministerial Statement Annual Compliance Assessment Report as described in Section 4.1.

Objective Based Management - Provisions Greenhouse Gas Emissions				
WA EPA Factor: Greenhouse Gas Emissions **Key impacts and risks:** Emissions and subsequent contribution to climate change				
Management-based provisions				
Objective: To reduce net greenhouse gas emissions to minimise the risk of environmental harm associated with climate change				
Management Actions	**Management Targets**	**Monitoring**	**Timing / Frequency**	**Reporting**
Continuously work towards achieving net zero emissions by 2050 for the Revised Proposal.	Implementation of reasonable and practicable measures to avoid, reduce and offset Revised Proposal Scope 1 & 2 GHG emission described in Section 3.2.	Review of identified reasonable and practicable measures to avoid, reduce, mitigate and offset the Revised Proposal's Scope 1 & 2 emissions completed.	Five-yearly, with the first review taking place in the 2025 Ministerial Annual Compliance Assessment Report.	A summary of delivered Pilbara abatement projects will be presented in the Ministerial Statement Annual Compliance Assessment Report every five years, as described in Section 4.1.
Implement GHG monitoring and reporting	Monitor and report all Scope 1 and Scope 2 (if applicable) emissions	Monitoring in accordance with NGER Measurement Determination.	Annually	Annual reporting of emissions is performed in accordance with the NGER Act. Summary of Scope 1 emissions published as part of annual Safeguard Mechanism data tables by the CER.
Operate under Safeguard Mechanism to maintain net emissions at or below West Angelas baselines	West Angelas (including the Revised Proposal) operates under the Safeguard Mechanism baseline.	Monitoring of net emissions performed in accordance with Safeguard Mechanism. Purchase and surrender Australian Carbon Credit Units (if required) in accordance with Safeguard Mechanism.	Annually	Summary of any surrendered Australian Carbon Credit Units published as part of annual Safeguard Mechanism data tables by the CER.
Undertake review and re-submission of GHG EMP	Update GHG EMP every five years as a minimum or as required following significant changes as described in Section 4.1.	Review and re-submission of the GHG EMP completed every five years as a minimum or as required following significant changes.	Five-yearly, with the first review taking place in 2026. Re-submission shall be completed by 30th April 2026.	Submission of revised GHG EMP for WA EPA approval.

4.1. Continuous improvement processes

4.1.1. Integrating GHG Considerations in Project Development Design

In line with the Rio Tinto's ambition to reach net zero emissions by 2050 across all operations and carbon neutral growth, internal guidelines are in place to integrate GHG considerations into design and planning of development projects.

Strategic decisions are made throughout the development of projects to ensure energy efficient lower emission solutions are prioritised where practicable. Each project, in conjunction with the Rio Tinto Study Definition Guidelines, and aligned with the State GHG Policy and Guideline, considers throughout design, construction and operational phases:

- Application of a mitigation hierarchy to avoid, reduce and offset emissions;
- Contribution to emissions reduction targets;
- Adoption of best practice design, technology and management appropriate to the mitigation measures implemented; and
- Continuous improvement to reduce emissions over the life of the project and across the Pilbara in a holistic, measured and consistent manner.

4.1.2. Integrating GHG considerations in existing operations

In accordance with Business Improvement Process, assets are required to develop optimised production improvements which identifies and implements opportunities to improve production and energy efficiency whilst minimising emissions.

The process outlines a framework for structured decision making, planning, governance and delivery approach to ensure opportunities are matured based on knowledge-based decisions, and account for uncertainty and residual risk.

5. REPORTING

An annual report will be included in the Ministerial Statement Annual Compliance Assessment Report that will include the following;

- Quantity of the Revised Proposal GHG emissions
- The number of tonnes of iron ore produced
- The emissions intensity (including calculation and calculation methodology)

A consolidated report of performance against the Revised Proposal targets will be detailed in the Ministerial Statement Annual Compliance Assessment Report every five years (e.g. 2025, 2030, 2035, etc), with the first report taking place in the 2025 Report. The consolidated report will include the following:

- Quantity of total GHG emissions from the facility
- Net GHG emissions
- GHG emission reduction measures, the source of these measures and the accounting methodology that has been implemented to avoid or reduce GHG emissions
- Quantity of offsets required to meet interim targets (if required)
- Performance (emissions intensity) against benchmarking for comparable facilities
- Statement whether interim targets have been achieved

Actual emissions for the Revised Proposal will be compared against targeted forecast emissions. If total actual emissions reductions for the Revised Proposal are less than the target emission reduction in 2025, 2030, 2035 and 2040, abatement projects implemented from the Pilbara wide abatement pathway will be applied against total actual emissions from the Revised Proposal. Rio Tinto has identified specific abatement initiatives (Table 3-11) which will be implemented in Rio Tinto's Pilbara Power Generation Network, connected to the Revised Proposal where the abatement from these projects will be applied to achieve Scope 1 & 2 interim emissions

targets. The long-term emissions reduction target is anticipated to be achieved by the implementation of a range of existing or potential future GHG abatement opportunities.

This GHG EMP will also be made publicly available on the Rio Tinto website at the following location;

- https://www.riotinto.com/Operations/australia/pilbara

6. STAKEHOLDER CONSULTATION

A summary of stakeholders and consultation outcomes to date regarding the Revised Proposal GHG EMP is located in Table 6-1.

The opportunities for stakeholder consultation during the life of the West Angelas Revised Proposal GHG EMP is continuing to evolve and current opportunities to discuss the GHG EMP includes;

- Robe River Iron Associates
    - Joint venture (JV) update meetings – quarterly
- Department of Water and Environmental Regulation – Environmental Compliance and Enforcement
    - Informal meeting with Senior Environmental Officer – monthly
- Ngarlawangga (NLW)
    - Local Implementation Committee – half yearly
    - Heritage Sub-Committee – monthly/bi-monthly
    - Life of Mine Planning – quarterly
- Yinhawangka (YHW)
    - Local Implementation Committee – half yearly
    - Cultural Heritage Language Committee – monthly/bi-monthly
    - Mine Closure Working Group - quarterly
- Turee Creek Pastoral Station
    - Engagement Meeting – half yearly
- Shire of Ashburton
    - Engagement Meeting – quarterly
- Shire of East Pilbara
    - Engagement Meeting – quarterly

Table 6-1 West Angelas Revised Proposal GHG EMP stakeholder consultation and outcomes

Stakeholder	Date	Topics/issues discussed	Rio Tinto response
Ngarlawangga	Aug 2023	Draft ERD – Greenhouse Gas Emissions Estimates *The Proponent is committed to achieving net-zero GHG emissions by 2050, consistent with the State GHG Policy and Guidelines.* • Committed – but no plan?	Rio Tinto's decarbonisation agenda is led by the Chief Decarbonisation Officer who was appointed in February 2023 to drive the Group's climate strategy, manage decarbonisation investment and deliver carbon abatement through Global Decarbonisation Programs. Our decarbonisation work is delivered under six Global Decarbonisation Programs that address 99% of the source of Scope 1 & 2 emissions. Each program has identified a pathway to progressively reduce emissions to achieve net zero Scope 1 & 2 emissions by 2050, though much of the technology required does not yet exist. • Repowering our Australian east coast aluminium smelting operations (Pacific Operations) • Electricity • Diesel use • Process heat in alumina processing • Process heat in minerals processing • Anodes consumed in aluminium smelting The largest sources of emissions from our WA iron ore operations are the diesel fuel used in haul and rail fleets and electricity generated by fossil fuel sources. • Rio Tinto's Diesel Transition team is working on a roadmap to transition our fleets away from diesel use by purchasing more fuel-efficient equipment, investigating the use of biofuels of our fleets while also continuing to partner with equipment suppliers such as Caterpillar and Komatsu to develop and then pilot battery electric haul trucks. • Rio Tinto's Renewable Energy team is developing a plan to reduce reliance on gas-generated electricity by developing up to 1GW of renewable energy assets (solar, wind and storage) in the Pilbara region. The updated GHG EMP will include avoidance measures from the above work streams and the proposed quantity of emissions avoided versus the quantity of emissions offset.
Ngarlawangga	Aug 2023	Draft ERD – Greenhouse Gas Emissions Estimates *Strategic decisions have been made throughout the development of the Proposal to ensure energy efficient lower-emission solutions are prioritised where practicable* • Any examples?	Examples are included in the GHG EMP which will be included with the next version of the ERD

Ngarlawangga	Aug 2023	Draft ERD – Greenhouse Gas Emissions Estimates *Measure to Avoid and Measure to Reduce* • All very business as usual – not sure that is going to work	Updated Avoidance and Reduction measures to be included in the GHG EMP which will be included in the next version of the ERD
Ngarlawangga	Aug 2023	Draft ERD – Greenhouse Gas Emissions Estimates *Measures to reduce* *Investigate opportunities to continuously improve productivity and minimise Scope 1 emissions during the construction and operation of the Proposal include:* *Increasing effective utilisation through reducing idle time/ queue time and parking up equipment wherever possible* *Increasing the efficiency of operations (including waste and ore haulage) through mine planning, design and scheduling* *Regular maintenance and servicing of equipment* • They should be doing all of this anyway	Noted and will continue to do this for the Revised Proposal
Ngarlawangga	Aug 2023	Draft ERD – Greenhouse Gas Emissions Estimates *Measures to Offset* • Read together, one gets the impression that RTIO intends to go BAU and just buy offsets	The GHG EMP will include specific avoidance measures assigned to the Revised Proposal as well as some offsets where required (e.g. where technologies do not yet exist).
EPA	Aug 2023	**Comment** • Need the most updated version of the Greenhouse Gas Management Plan • Refer to the *Environmental Factor Guidelines Greenhouse Gas Emissions*, dated April 2023 and associated Attachments and Templates **Action** • Provide the updated WAN RP Greenhouse Gas Management Plan	• Rio Tinto and EPAS agreed at the August monthly meeting that it would be suitable for Rio Tinto to provide the updated GHG EMP prior to public release of the ERD. • Updated GHG EMP will be provided to EPAS prior to public release of the WAN RP ERD • Section 11 of the WAN RP ERD has been amended

7. CHANGES TO GHG EMP

Complexity of changes	Minor revisions ☐	Moderate revisions ☐	Major revisions ☒
Date revision submitted to EPA: January 2024			
Is the change proposed to be implemented under condition C3-3? If so, the proponent must provide a copy to the CEO at least 20 days before commencing implementation Yes ☐ No ☒			
Proponent's operational requirement timeframe for approval of revision Reason for Timeframe: < One Month ☐ < Six Months ☒ > Six Months ☐ None ☐			

Item no.	GHG EMP section no.	GHG EMP page no.	Summary of change (separate track changes document to be provided)	Reason for change	New or increased adverse impacts to the environment? Risk to the achievement of limits, outcomes or objectives?
1.	All	All	New GHG EMP to align with latest Environmental Factor Guideline - GHG	New GHG EMP to align with latest Environmental Factor Guideline - GHG	Emissions forecast has been updated with most current mine planning schedules. The Proposal emissions forecast is similar to previous, however the Dep C, D and G portion of the Revised Proposal has sourced additional data from previous submission and has an increased diesel and electricity forecast. The achievement of emission reduction objectives can still be met with a combination of avoidance measures and offsets.
2.					
3.					

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A.7a: West Angelas Greenhouse Gas Environmental Management Plan Expert Review

ENERGET1°C5

West Angelas Greenhouse gas environmental management plan

Expert review

Rio Tinto | 21/12/23 - V2 | 127481

Executive summary

Energetics has undertaken a review of the greenhouse gas environmental management plan ("the Plan") prepared by Rio Tinto for the proposed expansion at the West Angelas iron ore project ("the Revised Proposal")[1]. This review has been prepared in a manner that is consistent with the definition of an expert review, as defined in the April 2023 version of the WA Environmental Protection Agency's ("the EPA") 'Environmental Factor Guideline: Greenhouse Gas Emissions' ("the Guideline") (WA Environmental Protection Authority, 2023). Per the Guideline, an expert review of the Plan should be undertaken to evaluate whether:

- best practice measures have been adopted to avoid or reduce scope 1 and 2 emissions associated with the Revised Proposal
- offsets that satisfy integrity principles are likely to be reasonably practicable and available at the time of proposed future surrender
- the Revised Proposal is consistent with, or outperforming, relevant sector pathways and milestones.

In undertaking our review of the Plan, Energetics has drawn on a range of publicly available sources, including peer greenhouse gas environmental management plans (GHG EMPs) and independent reports. Where relevant, we have provided our expert opinion based on our experience in developing and assessing emissions reduction, net zero and offsets strategies.

The findings of our review are summarised in Table 1:

Table 1: Summary of findings and recommendations

Guideline reference	Abridged findings	Recommendations
Best practice measures: power generation	The following best practice measures were identified within the Plan: 34MW and 100MW solar PV systems and 12MWh battery storage system to be integrated into the Proponent's "Pilbara Power Network"[2].	None
Best practice measures: fleet decarbonisation	The following best practice measures were identified within the Plan: supply chain engagement to support the commercialisation of zero emissions vehicles (electric haul trucks) and integration of biodiesel as a transition fuel. A Proposal-specific implementation timeline has not, however, been provided for either measure.	The Plan should include a Proposal-specific implementation timeline for both zero emissions vehicles and biodiesel. Timeline for update: First Ministerial Statement Annual Compliance Assessment Report (2025).
Best practice measures: materials handling	No best practice measures were identified within the Plan.	None

[1] Energetics have reviewed version 2.1 of the Plan.
[2] As the Revised Proposal will be connected to this network, Energetics have assumed that any measures implemented at the network level will result in direct emissions reductions at the Revised Proposal. Energetics have not assessed this best practice measure from a capacity perspective.

Guideline reference	Abridged findings	Recommendations
	The Plan does, however, outline which best practice measures were considered for the Revised Proposal (including overland conveyors and road trains) as well as the reasons why these were not practicable to implement.	
Best practice measures: energy efficiency (fleet)	The following best practice measures were identified within the Plan: engine upgrades for existing haul trucks to improve efficiency and procurement of new fuel-efficient dig units.	None
Best practice measures: energy efficiency (general)	The following best practice measures were identified within the Plan: Mains powered water bores.	None
Offset integrity	The Plan indicates that ACCUs will be surrendered to meet offset obligations where required, which is in accordance with the EPA requirements.	None
Offset availability	The Plan provides sufficient recognition that a multi-pronged approach may be required in securing sufficient offsets to manage supply risks, including increased purchasing as well as through offtake arrangements and direct investment.	The Plan would be enhanced by providing targets and timelines associated with Rio Tinto's risk mitigation strategies, in particular, the development of nature-based solutions. Timeline for update: First Ministerial Statement Annual Compliance Assessment Report (2025).
Pathways and milestones	The targets presented within the Plan suggest that the Revised Proposal will meet relevant sector pathways and milestones.	None

Based on these findings, it is our conclusion that, subject to the adoption of recommendations outlined in Table 1, the Plan demonstrates that the environmental objective of the Guideline will be met and provides a clear and credible plan for meeting the EPA's minimum expectations for emissions reductions.

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1.0 Background

1.1 Context

Greenhouse gas environmental management plans (GHG EMPs) are required by the Western Australian Environmental Protection Authority ("the EPA") for projects considered to be "reasonably likely" to have GHG emissions in excess of 100,000 tonnes CO_2-e of scope 1 or 2 emissions in any year (WA Environmental Protection Authority, 2023).

GHG EMPs are required to be developed in accordance with the EPA's 'Environmental Factor Guideline: Greenhouse Gas Emissions' ("the Guideline") (WA Environmental Protection Authority, 2023). Per the Guideline, an expert review of the Plan should be undertaken to evaluate whether:

- best practice measures have been adopted to avoid or reduce scope 1 and 2 emissions associated with a Proposal
- offsets that satisfy integrity principles are likely to be reasonably practicable and available at the time of proposed future surrender
- a Proposal is consistent with, or outperforming, relevant sector pathways and milestones.

Energetics has been engaged by Rio Tinto to undertake the expert reviews described above for the GHG EMP ("the Plan") prepared by Rio Tinto for the proposed expansion at the West Angelas iron ore project ("the Revised Proposal")[3].

Note that the West Angelas iron ore project is operated by the Robe River Mining Co. Pty. Limited ("the Proponent") which is a joint venture between Rio Tinto (53%), Mitsui Iron Ore Development (33%), Nippon Steel Australia Pty. Ltd. (10.5%) and Sumitomo Metal Australia (3.5%).

1.2 Overview of the Revised Proposal

The Revised Proposal includes the development of four new iron ore deposits: Western Hill, Deposit H, F-North and Mt Ella East. The deposits, comprising both above and below water table pits, are an extension of the West Angelas iron ore project, located approximately 130km north-west of Newman, WA.

It is Energetics' understanding that the Revised Proposal will be limited to the development of the above-mentioned deposits (including direct supporting infrastructure such as water supply systems) and "linear infrastructure" to transport ore between the new deposits and existing processing facilities. The Revised Proposal will utilise existing infrastructure located at West Angelas, including train load out facilities and materials processing and mining infrastructure.

In addition to the new deposits described above, Energetics understands that the Revised Proposal includes three existing deposits (Deposits C, D and G). These deposits were authorised previously under MS 1113 (WA Environmental Protection Authority, 2019) conditional on submission of a GHG EMP in alignment with the Guideline.

The Revised Proposal will be connected to the Proponent's existing "Pilbara Power Network".

[3] Energetics have reviewed version 2.1 of the Plan.

1.3 Statement of independence

Energetics takes seriously our obligation to act with integrity and our commitment to managing real and perceived conflicts of interest to the standard incumbent upon similar professional services providers in Australia. As such, we specifically acknowledge the need for independence in this particular assignment, namely, the review of a GHG EMP for referral to the EPA.

Energetics provided support to the Proponent in the drafting of the initial version of the Plan in November 2019. Energetics have not, however, had any input into the preparation of subsequent versions of the Plan (including the current version), nor have we had any involvement in the drafting of the sections of the Plan that are the subject of this expert review.

2.0 Approach

2.1 Scope of review

Energetics has undertaken our review in a manner that is consistent with the definition of an 'expert review', as defined in the Guideline.

Per the Guideline, an expert review of the Plan should be undertaken to evaluate whether:

- best practice measures have been adopted to avoid or reduce scope 1 and 2 emissions associated with the Revised Proposal
- offsets that satisfy integrity principles are likely to be reasonably practicable and available at the time of proposed future surrender
- the Revised Proposal is consistent with, or outperforming, relevant sector pathways and milestones.

As such, while we have reviewed the Plan in its entirety from a context-setting perspective, the primary focus of our review is on the sections of the Plan relating to the scope outlined above.

2.2 Specific interpretations

In preparing this review, Energetics has taken the following interpretation of the intent of the Guideline:

- The EPA, as part of their process to assess a proposal, are seeking to understand the specific contribution the Revised Proposal will have on the state's GHG emissions and, by consequence, what measures will be implemented under a GHG EMP to reduce or avoid those emissions.
- Notwithstanding the interpretation above, Energetics acknowledges that larger organisations frequently take a portfolio-wide approach to emissions abatement. We have considered portfolio-level initiatives in this report where the Plan clearly demonstrates how such initiatives could achieve emissions reductions for the Revised Proposal.
- GHG EMPs should be comprehensive, providing all information necessary to demonstrate that objectives and requirements of the Guideline have been met. As such, Energetics has not considered any reports, assessments or studies undertaken by Rio Tinto that are not referenced and detailed within the Plan.

2.3 Methodology

Review of best practice measures

Energetics has reviewed publicly available GHG EMPs for iron ore proposals in Western Australia alongside government and industry reports focussed on decarbonisation within the mining sector. This research has been used to establish the definitions of best practice that have been used to benchmark the measures included in the Revised Proposal.

Based on our research, a detailed summary of which is presented in Appendix A, abatement measures have been grouped into five broad categories: power generation, fleet[4] decarbonisation, optimisation of materials handling, energy efficiency (fleet) and energy efficiency (other). For each category, we have established minimum criteria for demonstrating best practice (refer Table 2).

Table 2: Minimum criteria for demonstrating compliance – best practice measures

Guideline reference	Category	Minimum criteria for demonstrating best practice
Best practice measures	Power generation	• Electricity supply to Revised Proposal should include large-scale (>10MW)[5] renewable generation. • Battery energy storage systems (BESS) systems should be considered for implementation as a minimum.
	Fleet decarbonisation	• Clear evidence of engagement with supply chain to fast-track zero emissions vehicles. • High-level narrative of expected timelines for implementation of zero emissions vehicles.
	Optimisation of materials handling	• There should be clear evidence that alternate haul methods (conveyors, trolley-assist systems or other novel technologies) have been considered and/or implemented to optimise materials handling.
	Energy efficiency (fleet)	• There should be clear evidence that measures have been considered and implemented to improve the fuel efficiency of the proposed diesel fleet.
	Energy efficiency (other)	• There should be clear evidence that measures have been considered and implemented to improve the efficiency of non-fleet equipment and infrastructure.
	All categories	• Best practice measures should be: o specific o linked to reduction or avoidance of emissions associated with the Revised Proposal o quantified.

Review of offsets strategy

In reviewing the offsets strategy in accordance with the requirements under the Guideline, Energetics considers two key elements within the GHG EMP, namely compliance with the 'offset integrity principles' and reasonable consideration of 'offset availability'. Table 3 outlines our approach in undertaking our expert review with respect to offsets, including specific elements within each criteria.

[4] The term "fleet" has been used throughout this report to refer to load and haul equipment. As such, it excludes light vehicles on site which would be included under "energy efficiency (other)".
[5] Systems identified in peer GHG EMPs ranged from 30MW – 100MW.

Table 3: Minimum criteria for demonstrating compliance – carbon offsets

Guideline reference	Guideline requirements	Minimum criteria for demonstrating compliance
Offset integrity principles	• Offset selection for the purposes of the GHG EMP needs to consider 'offset integrity principles'. • Integrity principles under the Commonwealth Carbon Credits (Carbon Farming Initiative) (CFI) Act 2011 as well as the principles under the Climate Active Carbon Neutral Standard for Organisations, Commonwealth of Australia, 2022 can be used by way of guidance/reference in addressing this requirement (WA Environmental Protection Authority, 2023). • Domestic offsets under the Safeguard Mechanism, namely Australian Carbon Credit Units (ACCUs) are deemed acceptable. • Voluntary offsets can be used to manage any residual emissions as long as they are consistent with offset integrity principles. • Whilst the Guideline does not prescribe specific voluntary offset types, given the Guideline's reference to Climate Active, the following international offsets could be considered as being eligible: o Certified Emissions Reductions (CERs) o Removal Units (RMUs) o Verified Emissions Reductions (VERs) o Verified Carbon Units (VCUs).	• Specification of offset type(s), including domestic (i.e. ACCUs) or voluntary/international. • Specification of offset standard/program under which offsets are issued. • Consistency of the integrity principles for the nominated standard/program(s) and with integrity standards, which the EPA has a 'due regard', such as the CFI and Climate Active (Carbon Credits (Carbon Farming Initiative) Act 2011, 2011) (Climate Active, 2022). • Approach to undertaking offset due diligence and any 'quality' thresholds (e.g. vintage, permanence and co-benefits). Although, this is not explicitly required under the Guideline, this approach is considered prudent to manage any reputational / 'greenwashing' risks arising from selection of 'poor' quality offsets.
Offset availability	Provision of details on whether selected offsets are likely to be 'reasonably' available at the time they are proposed to be surrendered.	• Acknowledgement of potential future offset supply risks. • Outlining contingency measures to mitigate supply availability risks, including consideration of: o spot markets o hedging strategies o long-term offtake agreements o direct project investment o sourcing alternative class of offsets.

Review of pathways and milestones

To evaluate performance of the Revised Proposal in this element of the Guideline, Energetics has undertaken a review of the targets and pathways established by relevant government agencies and industry bodies to identify relevant sector pathways and milestones[6]. The most relevant sector-specific milestone or pathways are currently:

- 2030 target: aligned with Safeguard Mechanism obligations
- 2050: net-zero: aligned with Federal commitments.

These pathways / milestones have been compared to any pathways and milestones identified within the Plan to determine whether the Plan is "consistent with, or outperforming those pathways".

A detailed summary of the research findings is presented in Appendix A.

[6] We have assumed that the pathways and milestones referenced in the Guideline refer to the iron ore mining industry.

3.0 Review of GHG EMP

3.1 Findings – best practice measures

Energetics has reviewed the measures proposed in the Plan against the criteria identified in Table 2. Our findings are detailed in Table 4.

Table 4: Review of the measures proposed in the Plan

Item	Category of best practice measure	Findings
1	Power generation	The Plan provides clear evidence of how best practice measures are being adopted within the Pilbara Power Network (which is understood to supply all power to the Revised Proposal). Measures adopted include: • 12MWh battery energy storage system (BESS) (under construction) • 34MW solar PV system (under construction) and 100MW solar PV system (construction to commence 2024) Implementation timeframes and expected emissions savings have been confirmed, at a portfolio (i.e. "Pilbara wide") level, for all applicable measures. The Plan provides a forecast of how the emissions intensity of the Pilbara Power Network is anticipated to decline over time. This provides increased surety that the proposed renewable energy systems have sufficient capacity to guarantee emissions savings over the life of the Revised Proposal.
2	Fleet decarbonisation	The Plan provides evidence that the proponent is engaging with their supply chain to: • support the commercialisation of zero emissions vehicles (electric haul trucks), including target dates for near-term trials, and • support the integration of biodiesel as a transition fuel with formal trials underway at an international Rio Tinto operation. A high-level narrative of expected timelines for implementation has been confirmed at a portfolio (i.e. "Pilbara wide") level, including near-term trials. The Plan should specify the indicative implementation timeframes for these measures *at the Revised Proposal*. This information should be provided by no later than the First Ministerial Statement Annual Compliance Assessment Report (2025).
3	Optimisation of materials handling	The Plan does not include any best practice measures targeting the optimisation of materials handling. The Plan does, however, provide evidence that the Proponent has considered alternatives to heavy haul trucks for materials handling (including overland conveyors and road trains). An overview of why best practice measures were not implemented has been provided in section 3.3.1 of the Plan. The Plan indicates that a "mine plan optimisation process" is underway to assess a range of potential optimisation initiatives (refer to 'mine design' measure in Table 3-8 of the Plan). Insufficient evidence is presented,

Item	Category of best practice measure	Findings
		however, to demonstrate that this measure represents best practice. In order to demonstrate best practice, a list of Proposal-specific design decisions / measures should be provided, including the estimated emissions savings.
4	Energy efficiency (fleet)	The Plan references several measures aimed at improving the fuel efficiency of the proposed diesel fleet. Of the measures referenced, the following are considered to be best practice: • Engine upgrades for existing haul fleet to improve efficiency • Procurement of fuel-efficient dig-units Implementation timeframes and emissions savings have been quantified for all measures. The Plan states that "a number of opportunities exist and are under investigation" to reduce fleet emissions (refer to 'energy efficiency' in Table 3-8 of the Plan). Insufficient evidence is presented to demonstrate that these opportunities represent best practice however. In order to demonstrate best practice, a list of Proposal-specific measures should be provided, including the estimated emissions savings.
5	Energy efficiency (other)	The Plan includes several measures targeting energy efficiency (other). Of the measures referenced, the following are considered to be best practice: • Mains powered water bores Implementation timeframes have been defined and emissions savings have been quantified. The Plan also references the following measure targeting energy efficiency of water bores: 'variable speed generators (VSG) / variable speed drives (VSD) for water bores'. A review of recent case studies suggests, however, that solar powered dewatering bores represent best practice for remote dewatering systems (refer Table 7). As such, any measure supporting the continued use of diesel-only dewatering systems would not be considered best practice (noting that this measure will be used exclusively for diesel powered water bores). In addition to the measures above, the Plan states that non-processing infrastructure will be required to meet the Proponent's internal energy efficiency standards (refer to 'Non-Processing Infrastructure (NPI) building designs' in Table 3-11 of the Plan). Although a range of potential best practice measures are outlined in the Plan (including LED lighting, high-efficiency HVAC systems and building passive design), insufficient evidence is presented to demonstrate best practice. In order to demonstrate best practice, a list of Proposal-specific measures should be provided, including the estimated emissions savings.

3.2 Findings – offsets

Energetics have evaluated the offsets strategy described in the Plan against the Guideline and specific elements identified in Table 3, with findings detailed in Table 5.

Energetics notes that whilst the Plan applies the mitigation hierarchy, it indicates that the utilisation of offsets will be required to achieve emissions reductions targets.

Table 5: Review of GHG EMP offsets strategy

Item	Element of offsets strategy	Findings
6	Offset integrity	The Plan outlines that, where offsets are required, ACCUs will be used. Further, Energetics notes that the Plan has been explicit in naming land based ACCUs (Environmental Planting, Savanna Burning and Human Induced Regeneration), which will be developed and/or sourced. Further, the Plan recognises the sunsetting of Human Induced Regeneration offsets and contemplates the future use of ACCUs from the Integrated Farm method instead (subject to the availability of this method). The Plan specifies the use of ACCUs for future compliance with the requirements of the Guideline as determined by the Commonwealth Carbon Credits (Carbon Farming Initiative) Act 2011. The Plan does not include ACCU generation methods that are being phased out of the ACCU Scheme and likely to be deemed ineligible under the Guideline. While the requirements of the EPA are satisfied through the selection of ACCUs, it is noted that the plan defines Rio Tinto's internal quality principles and assessment criteria (e.g., co-benefits, additionality and permanence). Further, alignment with International Carbon Reduction and Offset Alliance (ICROA) has been identified as an indicator of credible offsets. The Plan discloses Rio Tinto's 'vintage' criteria for offsets to be generated from 2018 onwards, aligning with Climate Active's current vintage requirement for vintage years no later than 2012 (Climate Active, 2023). Although not required by the Guideline, the Plan has also detailed Rio Tinto's offset project assessment strategy for Human Induced Regeneration and Savannah Burning, including GIS analysis, assessment rubrics and ground-truthing, which enhances its approach to quality risk management.
7	Offset availability	There is recognition in the Plan that a multi-pronged approach may be required in securing sufficient offsets and to avoid offset shortfalls. Multiple procurements models are identified in the Plan to ensure access to high-quality offsets as required to satisfy the Guideline, these include direct investment in nature-based solutions, co-investment and long-term offtake arrangements. Energetics notes that the Plan also identifies a ramp up in commercial activity to secure offsets. The Plan would benefit from some indication on targets and timelines associated with the development of nature-based solutions at or near Rio Tinto sites.

3.3 Findings – pathways and milestones

This section outlines key findings from the review of pathways and milestones in the Plan.

Table 6: Review of GHG EMP pathways and milestones

Item	Sector-specific pathway / milestone	Finding
8	Findings on whether the Plan is consistent with the relevant sector-specific pathways and milestones	The emissions reduction targets presented in the Plan (50% reduction by 2030, net zero by 2050) exceed the relevant sector pathways and milestones, as established in our research (refer Section 2.3 and Appendix A). Table 4-1 of the Plan outlines the approach to achieving compliance with the requirements of the Safeguard Mechanism.

3.4 Conclusion

The Plan outlines a wide range of measures to reduce emissions associated with the Revised Proposal. Of the measures outlined, the following are considered to be best practice:

- Power generation: 12MWh battery energy storage system (BESS) and two large-scale solar PV systems (34MW and 100MW) to be integrated into the Proponent's "Pilbara Power Network"
- Fleet decarbonisation: supply chain engagement to support the commercialisation of zero emissions vehicles (electric haul trucks) and integration of biodiesel as a transition fuel
- Energy efficiency (fleet): engine upgrades for existing haul trucks to improve efficiency and procurement of new fuel-efficient dig units
- Energy efficiency (other): mains powered water bores

The following recommendations should be incorporated into the Plan by no later than the first Ministerial Statement Annual Compliance Assessment Report (2025):

- "Zero emissions haul truck fleet" and "biofuels for Heavy Mining Equipment": The Plan should specify a Proposal-specific implementation timeline for both measures.

The Plan clearly outlines its approach for the use and selection of carbon offsets that satisfy the requirements of the Guideline. The exclusive use of ACCUs to meet offset obligations is compliant with offset integrity standards required by the WA EPA (i.e., as set out in the Commonwealth Carbon Credits (Carbon Farming Initiative) Act 2011) and the principles in the Climate Active Carbon Neutral Standard for Organisations (Climate Active, 2022).

The Plan provides sufficient recognition that a multipronged approach may be required to manage supply risks associated with the availability of high integrity ACCUs. In order to enhance the Plan, Rio Tinto should provide some indication on targets and timelines associated with the development of nature-base solutions at or near sites.

The targets presented within the Plan suggest that the Revised Proposal will meet relevant sector pathways and milestones.

Appendix A: Research findings

Best practice measures

Energetics has reviewed publicly available GHG EMPs for iron ore proposals in Western Australia to identify the measures that have been implemented, considered, or planned at comparable mine site operations and which, by consequence, are considered to represent best practice. The following GHG EMPs were included in our research:

- FMG Iron Bridge – North Star Magnetite Project (July 2022) (FMG Iron Bridge, 2022)
- Roy Hill Iron Ore Mine – Revised Proposal (November 2020) (Roy Hill, 2020)
- Rio Tinto – Greater Paraburdoo Iron Ore Hub (April 2022) (Rio Tinto, 2022)
- Atlas Iron – McPhee Creek (April 2022) (Atlas, 2022)
- BHP – Newman Hub (Western Ridge) (January 2023) (BHP, 2023).

In addition to the GHG EMPs mentioned above, Energetics reviewed a range of other sources to assist in supporting the conclusions drawn from the GHG EMPs. These included:

- government and industry reports focussed on decarbonisation of the mining sector
- case studies of measures adopted at other mining operations.

Table 7 provides a summary of our research findings.

Table 7: Summary of research findings – best practice measures for avoiding or reducing emissions in iron ore mining operations

Category	Elements of best practice from peer GHG EMPs	Conclusions from independent reports	Case studies
Power generation	• Power supplies include approved, large-scale[7] renewable power generation. Implementation schedules provided (Rio Tinto, 2022; FMG Iron Bridge, 2022; Roy Hill, 2020). • Battery energy storage systems (BESS) considered or implemented with indicative implementation timeframes stated (Rio Tinto, 2022; FMG Iron Bridge, 2022). • Emissions abatement quantified in all cases (Rio Tinto, 2022; FMG Iron Bridge, 2022; Roy Hill, 2020) (BHP, 2023). • Measures linked to reduction or avoidance of emissions at proposal level (Rio Tinto, 2022; FMG Iron Bridge, 2022; Roy Hill, 2020) (BHP, 2023).	• Renewable power generation systems (wind and solar PV) considered commercially and technically ready (Roy Hill, 2020). • Electro-chemical battery storage systems considered commercially and technically ready (Roy Hill, 2020).	• Sandfire Resources – DeGrussa Copper Mine (WA): 10.6MW solar PV power plant, completed 2016 (Degrussa Solar Project Pty Ltd, 2022). • Gold Fields – Agnew, Granny Smith and Gruyere gold mines (WA): total of 18MW wind, 25MW solar PV and 19MW BESS implemented across operations, completed 2020-2022 (Government of Western Australia - Department of Mines, Industry Regulation and Safety, 2022).
Fleet decarbonisation	• Active engagement with original equipment manufacturers (OEMs) to fast-track commercialisation of zero emissions vehicles (Rio Tinto, 2022) (BHP, 2023). • High-level narrative of when diesel vehicles will be displaced at the proposal and estimated abatement provided (Rio Tinto, 2022) (BHP, 2023). • Measures linked to reduction or avoidance of emissions at proposal level (Rio Tinto, 2022) (BHP, 2023).	• Zero-emissions vehicles have not achieved technical or commercial readiness. • Significant work is being undertaken with expected displacement of diesel vehicles over the next 10 years (Trove Research and University College London, 2021).	• Anglo American Platinum – Mogalakwena platinum mine (South Africa): trial of 300t zero-emissions haul truck (hydrogen fuel cells and batteries). Over 1,200 hrs of operation since May 2022 (First Mode, 2023).

[7] Systems identified ranged from 30MW to 100MW

Category	Elements of best practice from peer GHG EMPs	Conclusions from independent reports	Case studies
Optimisation of materials handling	• Feasibility studies into the use of conveyors as a means of displacing diesel fleet vehicles (FMG Iron Bridge, 2022) (Roy Hill, 2020) (BHP, 2023). • Feasibility studies into the use of trolley-assist systems as a means of displacing diesel fleet vehicles (Roy Hill, 2020) (BHP, 2023). • Measures linked to reduction or avoidance of emissions at proposal level (FMG Iron Bridge, 2022) (BHP, 2023).	• "Conveyor belt systems have been shown to be significantly more energy efficient in transporting materials than haul trucks, using about 20% of the energy required by heavy-duty trucks" (Rio Tinto, 2022) • Trolley-assist systems considered technically and commercially ready (Roy Hill, 2020).	• Boliden Kevitsa mine (Sweden): 13 x 227t haul trucks converted to operate partially with trolley assist; trial commenced in 2022 • Copper Mountain Mining Corporation (Canada): One kilometre trolley-assist haul ramp and seven pantograph-equipped Komatsu 830E-5 electric haul trucks adopted (Moore, n.d.).
Energy efficiency (fleet)	• Several measures considered and implemented to improve the efficiency of diesel vehicles (including fuel additives, lightweight truck trays and vehicle engine tuning) (Roy Hill, 2020). • Implementation timeframes and estimated abatement specified (Roy Hill, 2020). • Descriptions of measures are specific and detailed (Roy Hill, 2020). • Measures linked to reduction or avoidance of emissions at proposal level (Roy Hill, 2020).	• A wide range of potential measures identified, including the use of biodiesel (Rocky Mountain Institute), payload management, driver training, optimising mine design and the use of lightweight truck trays (Department of Foreign Affairs and Trade, 2016).	• FMG Chichester operations (WA): diesel savings in excess of 350kL/yr associated with modelling and optimisation of haul road design (Department of Foreign Affairs and Trade, 2016). • Remote Energy's 'Eco-Drive' APU system maintains operation of air conditioner and critical systems, allowing for the shutdown of haul truck engines when stationary (Remote Energy, n.d.).
Energy efficiency (general)	• Several measures considered and implemented to reduce scope 2 emissions associated with ancillary systems and site infrastructure, including LED lighting selection, smart lighting controls (daylight sensors, motion detection, timers), solar powered lighting towers and the use of variable speed drives (Rio Tinto, 2022). • No examples of energy efficiency measures were identified to reduce scope 2 emissions associated with processing plant.	• Wide range of potential measures available to improve energy efficiency across mining operations. Measures identified include: improvements to site buildings (optimisation of HVAC systems, improved building thermal characteristics), lighting design improvements (installation of LED lighting, smart lighting controls), optimisation of dewatering systems, improvements to mobile lighting controls and optimisation of processing circuits.	• RTIO – Hope Downs 4 (WA): trial of a UON-supplied solar powered dewatering system with diesel power for backup only (UON, 2023) • Northern Star – WA mine site: solar powered bore pump for remote dewatering (98kW solar, 104kWh BESS) (UON, 2023) • Our research identified a wide array of solar lighting towers suitable for mining applications

Category	Elements of best practice from peer GHG EMPs	Conclusions from independent reports	Case studies
			(PR Power, n.d.; Blue Diamond Machinery, n.d.).

Based on our research, abatement measures have been grouped into five broad categories: power generation, fleet decarbonisation, optimisation of materials handling, energy efficiency (fleet) and energy efficiency (other). For each category, we have established minimum criteria for demonstrating best practice (refer Table 8). In establishing these criteria, Energetics have avoiding being overly prescriptive, noting that specific measures which are suitable for one mining operation may not be suitable for implementation at another mining operation.

Table 8: Minimum criteria for demonstrating compliance – best practice measures

Category	Minimum criteria for demonstrating best practice
Power generation	• Electricity supply to proposal should include large-scale[8] renewable generation. • Battery energy storage systems (BESS) systems should be considered for implementation as a minimum.
Fleet decarbonisation	• Clear evidence of engagement with supply chain to fast-track zero emissions vehicles. • High-level narrative of expected timelines for implementation of zero emissions vehicles.
Optimisation of materials handling	• There should be clear evidence that alternate haul methods (conveyors, trolley-assist systems or alternate novel technologies) have been considered and/or implemented to optimise materials handling.
Energy efficiency (fleet)	• There should be clear evidence that measures have been considered and implemented to improve the fuel efficiency of the diesel fleet proposed.
Energy efficiency (general)[9]	• There should be clear evidence that measures have been considered and implemented to improve the efficiency of non-fleet equipment and infrastructure (excluding processing plant).

[8] Systems identified in peer GHG EMPs ranged from 30MW – 100MW.
[9] Note that no examples of energy efficiency measures were identified to reduce scope 2 emissions associated with processing plant.

Category	Minimum criteria for demonstrating best practice
All categories	• Best practice measures should be: o specific o linked to reduction or avoidance of emissions at the proposal o quantified.

Pathways and milestones

Table 9 below outlines all of the domestic and global sector-specific pathways and milestones identified which are relevant to the Plan.

Table 9: Pathways and milestones relevant to iron ore mining

Pathway/milestone reviewed	Targets	
Australian Government targets	Interim target of 43% reduction by 2030 and net zero by 2050 (Department of Climate Change, Energy, the Environment and Water, 2023).	Australia's interim target was legislated in September 2022. The primary mechanism for achieving this target is the Safeguard Mechanism which was reformed in early 2023 and commenced on 1 July 2023. The reformed legislation imposes linear annual baseline reductions and requires facilities to achieve industry average emissions intensity by FY30. The exact decline rate will vary depending on an organisation's individual circumstances (e.g. financial performance, whether the organisation is an emissions-intensive trade-exposed entity) [10].
Western Australian Government targets	Net zero by 2050[11] (Department of Water and Environmental Regulation, 2022).	The Western Australian Climate Policy, issued in 2020 confirms the government's commitment to "adapting to climate change and working with all sectors of the economy to achieve net zero greenhouse gas emissions". No interim emissions target (applicable to Western Australian industry) has been announced by the State Government[12].
Minerals Council of Australia	Net zero by 2050 (Minerals Council of Australia, 2021).	The Minerals Council of Australia has "confirmed the industry's ambition to achieve net zero emissions by 2050". No commitment to an interim target has been declared.

[10] Under the reformed Safeguard Mechanism, the decline rate varies between a minimum of 1% and a maximum of 4.9%.
[11] No interim target announced, however development of sectoral emissions reduction strategies expected to be completed in 2023 (Department of Climate Change, Energy, the Environment and Water, 2023)
[12] The state government has commenced a project to "develop sectoral emissions reduction strategies". This work is expected to be completed in late 2023.

Pathway/milestone reviewed	Targets	
International Council for Mining and Metals (ICMM)	Net zero by 2050 (International Council on Mining & Metals, 2021)	The ICMM note "we collectively commit as members of the International Council on Mining and Metals (ICMM) to a goal of net zero Scope 1 and 2 greenhouse gas (GHG) emissions by 2050 or sooner in line with the ambitions of the Paris Agreement."

Based on the findings in Table 9, the most relevant sector-specific milestone or pathway is currently:

- 2030 target: aligned with Safeguard Mechanism obligations
- 2050: net-zero aligned with Australian Federal commitments.

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Document control

Quality assurance covers all dimensions of Energetics' customer offering. All documents produced are reviewed by senior subject matter expert before being presented to clients. Below is a record of the consultants and subject matter expertise involved in the development and quality assurance of this document.

Description	Prepared by	Reviewed by	Approved by	Approval date
V1 (Draft)	Payton Seeto Marc Nardini	Bahador Tari Joel Hextall Andrew Tipping	Marc Nardini	15/12/2023
V2	Payton Seeto Marc Nardini	Bahador Tari Joel Hextall Andrew Tipping	Marc Nardini	20/12/2023

Sustainability at Energetics

Sustainability is core to Energetics' business.
We became a 'Climate Active' certified organisation in 2019, adding our services to the certification in 2020, and in 2021 we verified our SBT through the SBTi.

Information security

In February 2022, we achieved our Information Security Management certification. It's internationally recognised and demonstrates our commitment to protecting all client information and data.

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Sydney

Cammeraygal Country

Level 7, 5 Blue St
North Sydney NSW 2060

PO Box 294
North Sydney NSW 2059

Melbourne

Wurundjeri Country

Level 14, 356 Collins St
Melbourne VIC 3000

Brisbane

Meeanjin Country

Level 12, 410 Queen St
Brisbane Qld 4000

Perth

Nyoongar Whadjuk Country

Level 8, 182 St Georges Tce
Perth WA 6000

+61 2 9929 3911 | info@energetics.com.au | energetics.com.au

ABN 67 001 204 039 | ACN 001 204 039 | AFSL 329935

A.8: Environmental Management Plan

Environmental Management Plan

West Angelas Iron Ore Revised Proposal

Ministerial Statement 1113

November 2023

RTIO-HSE-0311343

Robe River Mining Co. Pty. Ltd

152-158 St Georges Terrace, Perth

GPO Box A42, Perth WA 6837

Disclaimer and Limitation

This Environmental Management Plan has been prepared by Rio Tinto's Iron Ore group (Rio Tinto), on behalf of Robe River Mining Co. Pty. Ltd. (the Proponent), specifically for the West Angelas Iron Ore Revised Proposal. Neither the report nor its contents may be referred to without the express approval of Rio Tinto, unless the report has been released for referral and assessment of proposals.

Document Status					
Rev	Author	Reviewer/s	Date	Approved for Issue	
				To Whom	Date
1	Rio Tinto	Rio Tinto	June 2017	EPA Services	June 2017
2	Rio Tinto	Rio Tinto	November 2017	EPA Services	November 2017
3	Rio Tinto	Rio Tinto	April 2018	EPA Services	April 2018
4	Rio Tinto	Rio Tinto	October 2018	EPA Services	October 2018
5	Rio Tinto	Rio Tinto	November 2018	EPA Services	November 2018
6	ELA/Rio Tinto	Rio Tinto	December 2018	DotEE, EPA Services	December 2018
7	Rio Tinto	Rio Tinto	February 2019	DotEE, EPA Services	February 2019
8	Rio Tinto	Rio Tinto	February 2019	DotEE, EPA Services	February 2019
9	Rio Tinto	Rio Tinto	December 2019	EPA Services	December 2019
9.1	Rio Tinto	Rio Tinto	February 2020	EPA Services	February 2020
9.2	Rio Tinto	Rio Tinto	April 2020	EPA Services	April 2020
10	ELA/Rio Tinto	Rio Tinto	May 2023	EPA Services	May 2023
11	Rio Tinto	Rio Tinto	August 2023	EPA Services	August 2023
12	Rio Tinto	Rio Tinto	November 2023	EPA Services	November 2023

EXECUTIVE SUMMARY

The West Angelas Revised Proposal Environmental Management Plan (EMP) is submitted by Rio Tinto on behalf of Robe River Mining Co. Pty. Ltd. (the Proponent) as the authorised manager and agent for the participants in the Robe River Iron Associates Joint Venture. The EMP is submitted in accordance with Ministerial Statement xxxx (MS xxxx), approved under the *Environmental Protection Act 1986*, and Decision Notices (DN) 2018/8299 and 2021/8923 for separate Controlled Actions within the Revised Development Envelope approved under the *Environment Protection Biodiversity Conservation Act 1999* (EPBC Act).

This EMP satisfies the following Conditions in relation to the environmental factors associated with the Revised Proposal as specified:

- 5-1 of MS xxxx (a new Ministerial Statement, which incorporates and supersedes MS 1113) for the Revised Proposal (all Deposits)
- 3, 4, 5 and 6 of DN 2018/8299 for Deposit C, Deposit D and Deposit G
- x of DN 2021/8923 for Deposits; Western Hill, Deposit H, Deposit F North and Mt Ella East.

Environmental factors addressed:

- Flora and Vegetation:
  - West Angelas Cracking Clay Priority Ecological Community (PEC)
  - Weeds within the West Angelas rail corridor
- Terrestrial Fauna
  - Matters of National Environmental Significance (MNES) fauna species and their critical and supporting habitat (roosting, breeding, shelter, foraging and dispersal): Northern Quoll (*Dasyurus hallucatus*), Pilbara Leaf-nosed Bat (*Rhinonicteris aurantia*), Ghost Bat (*Macroderma gigas*) and Pilbara Olive Python (*Liasis olivaceus barroni*)
- Inland Waters:
  - Surface discharge of surplus dewatered water from existing approved mining pits
  - Riparian vegetation.

Table ES 1 below presents the environmental objective for each environmental factor that must be met through the implementation of this EMP, as well as the environmental criteria and management targets to measure the achievement of the associated environmental outcomes and objectives.

Table ES 1: Environmental Criteria to Measure Achievement of Environmental Outcomes and Objectives

Project Title	West Angelas Iron Ore Revised Proposal
Proponent	Robe River Mining Co. Pty. Ltd
Purpose of this EMP	This EMP provides management for environmental values with the potential to be impacted by the West Angelas Revised Proposal. This EMP fulfils the anticipated requirements: • Ministerial Statement xxxx which incorporates and supersedes MS 1113 • Decision Notice 2018/8299 for the approved controlled action in relation to Deposits C, D and G • Decision Notice 2021/8923 for the proposed controlled action in relation to Western Hill, Deposit H, Deposit F North and Mt Ella East

Flora and Vegetation – West Angelas Cracking Clay Priority Ecological Communities		
Outcome-based provisions	**Environmental Outcome**	The Proponent shall ensure no direct or indirect disturbance to the West Angelas Cracking Clay Priority Ecological Community (Representation PEC-2015-5) due to the Revised Proposal that results in an irreversible impact
	Trigger Criteria	**Trigger Criteria:** 1. Clearing within 100 m of the mapped representation (West Angelas Cracking Clay PEC 2015-15) OR 2. Decline in relative abundance of key species[1] within the mapped representation since baseline not seen in reference sites OR 3. Establishment of new[2] high priority weed species previously not detected within the mapped representation OR 4. Significantly[3] increased extent of existing weed species within the mapped representation since baseline relative to reference sites
	Threshold Criteria	1. Clearing within the mapped representation (West Angelas Cracking Clay PEC 2015-15) OR 2. Loss of any key species present at baseline from 50 per cent or more of transects within the mapped representation as a result of direct or indirect disturbance from the Revised Proposal
	Environmental Outcome	The Proponent shall ensure no more than 22 ha of direct or indirect disturbance due to the Revised Proposal to "other representations" of the West Angelas Cracking Clay Priority Ecological Community
	Trigger Criteria	Reduction in extent greater than 15 ha as a result of direct or indirect disturbance from the Revised Proposal
	Threshold Criteria	Reduction in extent greater than 22 ha as a result of direct or indirect disturbance from the Revised Proposal

Flora and Vegetation – Weeds within the West Angelas Rail Corridor		
Objective-based provisions	**Environmental Objective**	The Proponent shall avoid, where possible, or otherwise minimise the introduction to and spread of weeds due to the Revised Proposal within the West Angelas Rail Corridor
	Management Target	No establishment of new[4] high priority weed species within the West Angelas rail corridor adjacent to national parks, TECs and PECs due to the Revised Proposal
		No consecutive increase in the extent of high priority weed species within the West Angelas rail corridor adjacent to national parks, TECs and PECs over three years due to the Revised Proposal
		No establishment of new[4] high priority weed species within the West Angelas rail corridor, adjacent to other targeted significant areas due to the Revised Proposal

[1] Key species as defined in the description of the West Angelas Cracking Clay PEC, i.e. *Astrebla pectinata, Astrebla elymoides, Aristida latifolia* and *Sida fibulifera*

[2] Existing weed species as listed in Appendix 8

[3] Weed species occurring in significantly greater number of quadrats compared to baseline and reference (α=0.05)

[4] New species based on the weed inventory compiled in the initial three years of control i.e., new species found after three years of data collection

Terrestrial Fauna – Ghost Bat Roosts		
Outcome-based provisions	**Environmental Outcome**	The Proponent will avoid direct and significant indirect impacts to Ghost Bat roosts retained within Mining Restriction Zones (MRZ) and Mining Exclusion Zones (MEZ) attributable to the Proposal to maintain ecological function of the retained Ghost Bat roosts
	Early Response Criteria Proposal	Mining activities approach within 30 m of an MRZ (as per Table 1-6)
	Trigger Criteria <u>Approved Proposal</u>	1. Ground disturbance within 150 m (but not closer than 100 m) of Category 2 Ghost Bat roosts (Table 1-5) OR 2. Blast vibration levels exceed (as per Table 1-5): - 25 mm/s PPV (Cave WA-21) - 40 mm/s PPV (Cave AA1) - 50 mm/s PPV (Cave WA-17) - 75 mm/s PPV for L2, L3, WA-12, WA-20 and A1 (category 3) and category 4 roosts
	Trigger Criteria <u>Proposal</u>	1. Direct disturbance within 150 m (but not closer than 100 m) of retained category 2 Ghost Bat roosts (Table 1-6) OR 1. Blast vibration or noise levels exceed (as per Table 1-6): • Primary Apartment block roosts (CWAN-04) Secondary Apartment block roosts (CWAN-01, 02 and 03), Isolated Category 2 caves (CWAN 06 and 07) - 10 mm/s PPV during breeding months (1 October to 31 December) or 25 mm/s PPV during non-breeding months • Category 2 caves (CWAN-04, 06 and 07) and Category 3 caves within an apartment block (CWAN 01, 02 and 03) – L_{Z10}>70 db(Z) over one hour • Retained Category 3 caves (CWAN-28 and 30) - 50 mm/s PPV OR 2. Decline in visual structural integrity[5] at any retained Category 2 Ghost Bat roosts
	Threshold Criteria Approved <u>Proposal</u>	1. Disturbance within 100 m of retained (category 2) Ghost Bat roosts (Table 1-5) OR 2. Significant damage to retained Ghost Bat roosts (Table 1-5)
	Threshold Criteria <u>Proposal</u>	1. Direct disturbance within 100 m of retained (category 2) Ghost Bat roosts (Table 1-6) OR 2. Significant damage to any retained Ghost Bat caves (CWAN-01, 02, 03, 04, 06, 07, 08, 11, 27, 28, 29, 30, 31, 32, 34, CDHI-001 and 002), supported by a significant step change in microclimate (temperature and humidity) data, attributable to the Proposal (Table 1-5)

[5] Structural integrity is defined as a negative change to the integrity of the cave. The trigger will be exceeded where changes are observed after a blast event for which a vibration level criteria is exceeded, including significant rockfalls (in comparison to baseline data).

Inland Waters – Surplus Water Discharge and Riparian Vegetation		
Outcome-based provisions	**Environmental Outcome**	The Proponent shall ensure there is no irreversible impact to the health of riparian vegetation of Turee Creek East as a result of the discharge of surplus water
	Trigger Criteria	1. Greater than 10% increase in the proportion of *Eucalyptus victrix* canopy area within the maximum predicted surface discharge extent in Turee Creek East that falls below the MSAVI baseline 5th percentile[6] in comparison to reference sites and the trend continues over two consecutive annual monitoring events OR 2. Establishment of new[7] high priority weed species within the maximum predicted surface discharge extent in Turee Creek East or the discharge tributary, previously not detected in Turee Creek East within the Revised Development Envelope OR 3. Significantly[8] increased extent of existing high priority weed species within the maximum predicted surface discharge extent in Turee Creek East or the discharge tributary since baseline relative to reference sites
	Threshold Criteria	1. Greater than 50% of the *Eucalyptus victrix* canopy area within the maximum predicted surface discharge extent in Turee Creek East is below the MSAVI baseline 5th percentile; trend continues over two consecutive monitoring events; with no evidence of seasonal recovery; and outside of variation observed within extended baseline period, in comparison to reference sites OR 2. Significant structural or compositional change[9] to channel and terrace habitats of Turee Creek East over 50 per cent of the maximum predicted surface discharge extent, in comparison to baseline and trends different to reference sites

Inland Waters – Deposit H Pool		
Outcome-based provisions	**Environmental Outcome**	The Proponent shall ensure there is no significant change to the water levels at Deposit H Pool as a result of any impacts attributable to the Proposal to the catchment
	Early Response Indicator	1. Retained surface catchment area of Deposit H Waterhole is reduced to less than 0.6 km2
	Threshold Criteria	1. Retained surface catchment area of Deposit H Waterhole is reduced to less than 0.4 km2

[6] Refer to Appendix 5 for baseline values. The Proponent will update criteria after baseline monitoring is complete, and as knowledge develops based on empirical observations of tree health and/or improvements in monitoring methodology

[7] Existing weed species as listed in 0

[8] Weed species occurring in significantly greater number of quadrats compared to baseline and reference (α=0.05)

[9] Change from baseline of i) two or more structural formation classes applied to National Vegetation Information System (NVIS) Level IV sub-formation, classes (ESCAVI 2003 and see Appendix 7) due to decreased or increased cover of native or weed species or ii) loss of native species listed as dominant at baseline within any of the upper, mid or ground vegetation strata Appendix 6

Inland Waters – Turtle Pool		
Outcome-based provisions	**Environmental Outcome**	The Proponent shall ensure there is no significant change to the Turtle Pool as a result of any impacts of the Proposal to the catchment
	Trigger Criteria	1. Water level in monitoring bore (WAH-M03) falls below lowest recorded pre mining water level[10]
	Threshold Criteria	1. Turtle pool depth is below lowest recorded pre-mining depth over two consecutive wet seasons attributable to the Proposal

Social Surroundings – Deposit H Waterhole Downstream Gully		
Outcome-based provisions	**Environmental Outcome**	The Proponent shall ensure there is no significant impact to vegetation downstream of the Deposit H Waterhole as a result of impacts to the reporting catchment
	Trigger Criteria[11]	1. Decrease in vegetation density of TBD% in gully downstream of Deposit H Waterhole as measured by Annual MSAVI assessment over two consecutive monitoring periods.
	Threshold Criteria[12]	2. Decrease in vegetation density of TBD% in gully downstream of Deposit H Waterhole as measured by Annual MSAVI assessment over two consecutive monitoring periods.

[10] Minimum water level to be determined once sufficient baseline data, minimum 2 years factoring seasonal fluctuations, has been recorded and prior to disturbance at Deposit H

[11] Interim Triggers and Thresholds - Investigations to inform potential triggers and thresholds are ongoing. Triggers and thresholds will be updated as the investigations progress.

Corporate endorsement

I hereby certify that to the best of my knowledge, the provisions within this West Angelas Environmental Management Plan are true and correct.

Name: Sean O'Hanlon

Signed:

Designation: General Manager, West Angelas Mine Date: 21/12/23

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Abbreviations and Terminology

Abbreviation	Description
ACAR	Annual Compliance Assessment Report
Approved Proposal	Refers to operations approved under MS 1113 (including proposals approved by MS 514 and 970 and now superseded by MS 1113) and includes approved components yet to be implemented
ANFO	Hydrocarbon and ammonium nitrate/fuel oil
AWT	Above Water Table
BC Act	*Biodiversity Conservation Act 2016*
BWT	Below Water Table
CEO	Chief Executive Officer
DBCA	Department of Biodiversity, Conservation and Attractions
DWER	Department of Water and Environmental Regulation
EMP	Environment Management Plan
EP Act	*Environmental Protection Act 1986*
EPA	Environmental Protection Authority
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999*
ERD	Environmental Review Document
Established	A weed or other species that have grown into maturity and reproduced, producing a viable second generation of individual plants signifying persistence at a given location
Existing Operations	Refers to the existing iron ore operations currently being undertaken as approved under MS 1113
Extension Areas	Refers to the new development areas that are to be added to the Approved Development Envelope to become the Revised Development Envelope
Framework for EMPs	Rio Tinto's conceptual framework for the development of EMPs, as described in Appendix 1
High priority (weed species)	High priority weed species are those that demonstrate the capability to spread and cause impact to the surrounding environment. These weed species are determined following the Weed Prioritisation Process for DPaW (formerly DEC), "*An integrated approach to Weed Management on DPaW-managed lands in WA*", and are those rated Rapid invasiveness and High ecological impact (according to the *Pilbara Impact and Invasiveness Ratings*) while taking into account the feasibility of control; or as otherwise classified as high priority within the Pilbara Region by the DBCA
Irreversible impact	An impact resulting in a permanent loss of environmental value(s), or where intensive and/or un-proven management intervention, potentially over a long timeframe, would be required to restore the environmental value(s)
Linear Infrastructure Development Envelope	As defined by MS 1113, comprising the rail network from West Angelas mine to Emu Siding and the Turee Creek B Borefield, pipeline, powerline, access roads and other associated infrastructure
Management level	Level of management appropriate to meet the environmental objective for an environmental value, as determined by risk assessment described in the framework for EMPs (Appendix 1)

Abbreviation	Description
Mining Exclusions Zone (MEZ)	Refers to an area within the Revised Development Envelope where no direct disturbance is permitted except for activities that support monitoring, management and implementation of contingency actions (if required) as part of this EMP
Mining Restriction Zone (MRZ)	Refers to a demarcated zone where no mining excavation is permitted. Only low-impact activities associated with environmental monitoring, management and implementation of contingency actions (if required). No more than 20% of the MRZ can be cleared for low-impact activities
MNES	Matter of National Environmental Significance
Mapped representation	As pertaining to the West Angelas Cracking Clay priority ecological community; refers to the extent mapped by the DBCA as of 2018
Proponent	Robe River Mining Co. Pty Ltd
Proposal	The proposal is the significant amended to the Approved Proposals and includes the extension and development of new above and below water table (AWT/BWT) and includes components of the Approved Proposals yet to be amended
Proposal Area	Refers to the proposed Extension Areas currently outside of the Approved Development Envelope and areas of the Approved Development Envelope that are within the proposed Conceptual Footprint
Revised Development Envelope	Refers to the combined Development Envelope of the Approved Proposal and the Proposal
Revised Proposal	West Angelas Iron Ore Revised Proposal as defined in Section 1.1.
Significant damage (to Ghost Bat caves)	Damage that negatively impacts the integrity of the cave such that future Ghost Bat use of the site is prevented
Tier value	Tiers are assigned to environmental values based on statutory and conservation significance, as per the framework for EMPs, as described in Appendix 1
WRL	Waste rock landform

1. CONTEXT, SCOPE AND RATIONALE

Rio Tinto has prepared this Environmental Management Plan (EMP) on behalf of Robe River Mining Co. Pty Ltd (the Proponent) as a consolidated and modernised EMP for the Approved Proposal (approved under MS 1113) and the Proposal (collectively termed the Revised Proposal). The Proposal includes a proposed consolidation and modernisation of the existing MS 1113. A new consolidated MS for the Revised Proposal will be published, including the Existing Operations and new operations, with new conditions that supersede MS 1113 (Appendix 8).

This EMP replaces the approved management plan associated with the West Angelas Project (Rio Tinto 2020, RTIO-HSE-0311343).

This EMP has been developed in accordance with the following policy and guidance documents:

- EPA (2021a) Environmental Impact Assessment (Part IV Divisions 1 and 2) Administrative Procedures 2021
- EPA (2021b) Environmental Impact Assessment (Part IV Divisions 1 and 2) Procedures Manual
- EPA (2021c) Instructions on how to prepare Environmental Protection Act 1986 Part IV Environmental Management Plans
- EPA (2021d) Environmental outcomes and outcomes based conditions, Interim Guidance
- Department of the Environment (DoE) (2014) Environmental Management Plan Guidelines
- DoE (2016a) Outcomes-based conditions policy
- DoE (2016b) Outcomes-based conditions guidance
- Rio Tinto internal conceptual framework for the development of EMPs (Appendix 1).

This EMP is expected to meet future conditions and will be subject to approval before implementation by the Western Australian Environmental Protection Authority (EPA) and the Commonwealth Department of Climate Change, Energy, the Environment and Water (DCCEEW).

1.1. Terminology

The following terminology is used throughout this document:

- **Approved Proposal**: Refers to operations approved under MS 1113 (including proposals approved by MS 514 and 970 and now superseded by MS 1113) and includes approved components yet to be implemented.
- **Approved Development Envelope:** Refers to the extent of the existing Development Envelope approved under MS 1113 and EPBC Decision Notice (DN) 2018/8299, as shown in Figure 1-2.
- **Approved Conceptual Layout:** Refers to the indicative location of key elements as approved under MS 1113 and shown in Figure 1-2.
- **Existing Operations**: Refers to the existing iron ore operations currently being undertaken as approved under MS 1113.
- **The Proposal**: The Proposal is the significant amendment to the Approved Proposal and includes the extension and development of new above and below water table (AWT/BWT) iron ore deposits and associated activities to extend the life of the Existing Operations. The Proposal is the subject of this assessment and includes the amendments proposed to the EPA in December 2022.
- **Extension Areas**: Refers to the new development areas that are to be added to the Approved Development Envelope to become the Revised Development Envelope as shown in Figure 1-2.
- **Conceptual Footprint**: Refers to the indicative direct disturbance footprint of the Proposal for the purpose of environmental impact assessment in this ERD. To provide for project flexibility, this footprint is indicative only and includes key elements such as miner pits, waste rock landforms (WRL) and infrastructure to a maximum extent of 5,350 ha. The final location of key elements and infrastructure may occur outside the Conceptual Footprint but will be contained within the Revised

Development Envelope and within any approval limits. This flexibility within the Revised Development Envelope is part of this assessment, as the proponent has allocated and undertaken survey work throughout the entire Revised Development Envelope to support this assessment.

- **Proposal Area**: Refers to the proposed Extension Areas currently outside of the Approved Development Envelope as shown in Figure 1-2, and areas of the Approved Development Envelope that are within the Proposed Conceptual Footprint.
- **Proposed Conceptual Layout**: Refers to the indicative location of key Proposal elements, as shown in Figure 1-2.
- **Revised Proposal**: The Revised Proposal incorporates both the Approved Proposal and the Proposal.
- **Revised Development Envelope**: Refers to the combined Development Envelope of the Approved Proposal and the Proposal, as shown in Figure 1-2.
- **Mining Restriction Zone** (MRZ): Refers to a demarcated zone where no mining excavation is permitted. Only low-impact activities associated with environmental monitoring, management and implementation of contingency actions (if required) will be undertaken in this zone. No more than 20% of the MRZ can be cleared for low-impact activities.
- **Mining Exclusion Zone** (MEZ): Refers to an area within the Revised Development Envelope where no direct disturbance is permitted except for activities that support monitoring, management and implementation of contingency actions (if required) as per this EMP.
- **West Angelas Area:** Includes the Revised Development Envelope and Survey Reference Areas (Deposit J and Mt Ella East) as shown on Figure 1-2.

1.2. Revised Proposal Description

The Revised Proposal is located approximately 100 km west of Newman in the Pilbara region of Western Australia on Mineral Lease 248SA (ML248SA), which was granted in 1976 under the *Iron Ore (Robe River) Agreement Act 1964* (WA) (Figure 1-1). The Revised Proposal includes the following (as depicted in Figure 1-2):

Approved Proposal (Existing Operations)

- Development of Deposits A and B and rail link to Cape Lambert referred to the EPA under Part IV of the EP Act in 1997, and the Minister approved the development in 1999 (MS 514)
- AWT mining of Deposit E and the discharge of surplus dewatering to the environment referred to the EPA in 2010 and were granted *Not Assessed.* A contemporized MS 970 was approved by the Minister in 2014, superseding MS 514
- Development of Deposit A West and F referred to the EPA in 2014. The Minister approved the development in 2015 as an amendment to MS 970, subject to the conditions of MS 1015
- Development of Deposits C, D and G, referred to the EPA in 2017. The Minister approved the development in 2019 and it is subject to the conditions in MS 1113, which supersede the previous Statements 970 and 1015
- Clearing no more than 4,310 ha of vegetation within the Revised Development Envelope at deposits C, D and G. The Commonwealth Minister approved clearing up to 4,310 ha for deposits C, D and G subject to the conditions of Decision Notice (DN) 2018/8299.

The Approved Proposal (including Existing Operations) are subject to *Iron Ore (Robe River) Agreement Act 1964* (WA) and, as approved under the existing MS 1113 and Deposits C, D and G under DN 2018/8299, currently consist of the following:

- Clearing of up to 12,205 ha within the existing 28,322 ha approved development envelope
- Open cut AWT and BWT mining of iron ore from Deposits A, A West, B, C, D, E, F and G by conventional drill, blast and load and haul techniques

- Ore processing in central processing facilities at approximately 35 Mt/a
- Dewatering to allow BWT mining of pits
- Discharge of excess water to Turee Creek East in accordance with limitations as prescribed in MS 1113 (surface discharge extent will not extend within 2 km from Karijini National Park under natural no-flow conditions).

Shared Infrastructure

The Approved Existing Operations at West Angelas include approved infrastructure that will be utilised for this Proposal, including:

- Administration buildings
- West Angelas Airport
- Dewatering and water supply borefields, including Turee Creek B Borefield and mine dewatering borefields
- Laydown yards
- Mobile and fixed plant equipment workshops
- Power distribution network
- Processing facilities
- Surface water management infrastructure, including diversions to direct surface water flows around deposits
- Warehouses
- Wastewater treatment plants
- West Angelas accommodation village
- Linear infrastructure, including a 413 km rail network that transports processed ore from West Angelas to port facilities located at Cape Lambert.

Proposal

The Proposal is located approximately 130 km northwest of Newman in the East Pilbara region of Western Australia. The Proposal is located within Yinhawangka and Ngarlawangga Peoples Native Title Determination Areas. The Proposal includes the development of AWT and BWT iron ore deposits and associated infrastructure including:

- Development of above and below water table mine pits
- Associated activities which may include as relevant, but are not limited to, the following:
    - Mineral waste management: including WRL, land bridges, low grade ore dumps, topsoil and sub-soil stockpiles, in-pit WRL and storage of waste fines
    - Ore processing (including crushing) infrastructure
    - Other facilities including workshops, hydrocarbon and Ammonium Nitrate Fuel Oil (ANFO) storage and laydown areas
    - Linear infrastructure, including heavy and light vehicle access roads, rail and associated infrastructure, conveyors, utility corridors, pipelines and power (including sub-stations) and communications distribution networks
    - Infrastructure for surface water management, including crossings, diversion drains, levees and culverts
    - Groundwater abstraction and utilisation and associated infrastructure

  - Dewatering to enable below water table mining and associated infrastructure (including bores and pipelines)
  - Infrastructure for management and use of water from dewatering
- Offices and accommodation villages
- Renewable energy including renewable energy generation, energy storage and associated ancillary infrastructure.

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Figure 1-1
West Angelas
Regional Setting

Drawn: A.D.
Plan: RTIO-0985785v1
Date: March 2023

Proj: GDA 1994 MGA Zone 50
Scale: 1:1,250,000 @A3
GIS.Team@riotinto.com

400,000 500,000 600,000 700,000

7,700,000 7,600,000 7,500,000

Port Hedland
Cape Lambert
Wickham
Dampier
Karratha
Roebourne
Murujuga National Park
North West Coastal Highway
Great Northern Highway
Marble Bar
Millstream-Chichester National Park
Pannawonica
Mesa A
Mesa J
Nammuldi
Brockman 2
Brockman 4
Western Turner Syncline
Tom Price
Mount Tom Price
Marandoo
Gudai-Darri
Yandicoogina
Karijini National Park
Hope Downs 1
Hope Downs 4
West Angelas
Paraburdoo
Paraburdoo
Eastern Range
Channar
Newman

Legend

- West Angelas
- Rio Tinto Mine
- Port
- Town
- National Park
- Rio Tinto Railway
- Highway
- Major Road

N

0 10 20 30 40 50
Kilometres

Map units in metres

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660,000
670,000
680,000
690,000
7,450,000
7,440,000
7,430,000

Karijini National Park

Great Northern Highway

Western Hill

Deposit B

Deposit G

Deposit H

Deposit C

Deposit D

Deposit A West

Deposit A

Deposit E

Deposit F

Deposit F North

Mt Ella East

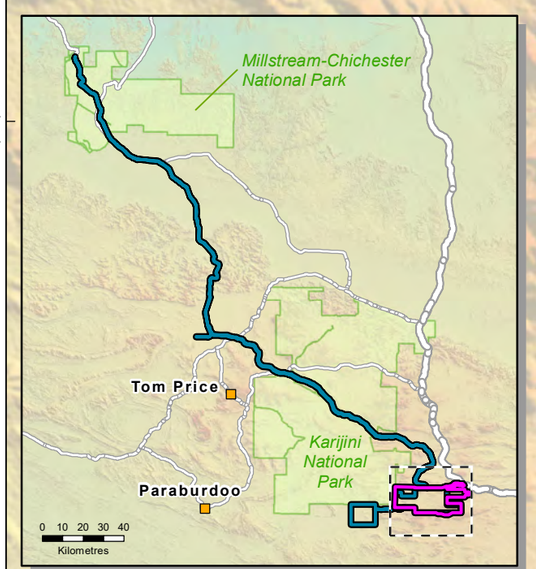

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Figure 1-2
Revised Development Envelope and Indicative Location of Key Proposal Elements

Drawn: GIS Team
Plan: PDE0186387v7
Date: November 2023

Proj: GDA 1994 MGA Zone 50
Scale: 1:120,000 @A3
GIS.Team@riotinto.com

Legend

- Revised Development Envelope
- Approved Development Envelope 1113 - Linear Infrastructure
- Survey Reference

Conceptual Footprint

- Conceptual Pit
- Conceptual Waste Landform
- Conceptual Associated Mine Disturbance

Approved Conceptual Layout

- Pit
- Waste Landform
- Stockpile

- National Park
- Rio Tinto Railway
- Highway
- Major Road

N

0 1 2 3 4 5
Kilometres

Map units in metres

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1.3. Key Environmental Factors

This EMP addresses the key environmental factors relevant to the Revised Proposal and Proposal, and the potential impacts of the Revised Proposal and Proposal that require management (Table 1-1 and Table 1-2 respectively). A summary of the previously authorised extents for the Approved Proposal compared to the Revised Proposal's consolidation is provided in Table 1-3.

The Proponent will request an amendment to the Proposal Content Document via s43A prior to the EPA's assessment of the Proposal to align the PCD with the Proposal as described and presented in this ERD.

Table 1-1: Environmental Factors and Values and the Predicted Potential Impacts from the Revised Proposal

Environmental Value (Environmental Receptor)	Predicted Potential Impacts from the Revised Proposal	
	Direct	**Indirect**
Flora and Vegetation		
West Angeles Cracking Clay Priority Ecological Community (PEC)	**Clearing** • No direct or indirect impact to PEC mapped representation 2015-5 predicted • Loss of up to 22 ha of "other representations" of the West Angeles Cracking Clay PEC[12]	• Changes to hydrological regime • Changes in fire regime • Potential for weed invasion
Values occurring adjacent to the West Angelas rail corridor: • Karijini National Park • Millstream-Chichester National Park • Themeda Grassland Threatened Ecological Community (TEC) • Brockman Cracking Clay Priority Ecological Community (PEC) • Wona Land System PEC • Vegetation in good to excellent condition; riparian areas		**Introduced Flora** • Potential for weed ingress/proliferation from rail corridor into adjacent values • No additional risks to these areas are anticipated as a result of the Revised Proposal, as the development footprint of the rail network will not increase
Terrestrial Fauna		
Foraging, dispersal, roosting and/or breeding habitat for significant fauna species	**Clearing**[13] • Clearing up to: o 128 ha of Gorge/Gully o 4,215 ha of Hillcrest/Hillslope	**Activities resulting in increased levels of introduced flora (weeds), increased feral predation and fragmentation of habitat** Environmental changes from activities may influence significant fauna use of the fauna habitat within the Revised Development Envelope

[12] As mapped by DBCA

[13] Combined Proposal and Deposits C, D and G approval clearing only. Approvals prior to 2019 do not itemise clearing by habitat type

Environmental Value (Environmental Receptor)	Predicted Potential Impacts from the Revised Proposal	
	Direct	**Indirect**
	These habitats are considered of high significance to fauna • Clearing up to: o 22 ha of "other representations" of the West Angeles Cracking Clay PEC o Approximately 79 ha of Drainage Line o Approximately 1,787 ha of Footslopes and Plain o Approximately 374 ha of Mixed Acacia Woodland These habitat types are considered of moderate to low significance to fauna.	**Other threatening processes (noise, dust, light and fauna interactions)** Changes to the environment from general activities associated with the Proposal may degrade habitats, and/or influence/change species use of habitats in the Development Envelope
Ghost Bat (*Macroderma gigas*) and significant habitat	**Clearing**[13] • Loss of up to four category 4 roosts (not considered critical habitat), attributable to the Proposal (none were impacted for Deposits C, D and G) • Clearing up to 4,343 ha of Gorge/Gully and Hillcrest/Hillslope habitat, which is considered critical habitat as it provides roosting and foraging habitat • Clearing approximately 6,584 ha of Drainage Line, Footslopes and Plain, Cracking Clay and Mixed Acacia Woodland habitat, which are considered supporting habitat as they provide foraging and dispersal habitat	**Change in the structure of caves (roosts)** Blasting and/or mine pit development creates instability to caves, cracks/holes, which change microclimate (i.e., temperature and humidity) **Vibration** Blasting may cause structural damage to caves that are retained within the Revised Development Envelope and/or disturbance to roosting bats **Other threatening processes (noise, dust, light and fauna interactions)** Changes to the environment from general activities associated with the Proposal may degrade habitats, and/or influence/change species use of habitats in the Development Envelope. **Hydrogeology/Hydrology** Reduction in surface water fed pools due to reduced catchment

Environmental Value (Environmental Receptor)	Predicted Potential Impacts from the Revised Proposal	
	Direct	Indirect
Inland Waters		
Riparian vegetation[14]	**Clearing**[13] • Clearing no more than 60 ha of riparian vegetation (25 ha specified under MS 1113 and 35 ha associated with the Proposal)	**Surplus water discharge** • Changes to riparian vegetation community structure • Changes in health of dominant riparian tree species (*Eucalyptus victrix*) • Vegetation augmentation • Enhanced potential for weed ingress/proliferation, including downstream of the surface discharge extent
Deposit H Pool	**Clearing** • Clearing for the Revised Proposal will impact up to 2.8 km^2 of the 3.3 km^2 catchment that feeds Deposit H Pool	**Increased sediments in runoff from infrastructure and drainage** Potential reduced water quality of Deposit H Waterhole resulting in decreased environmental (and associated cultural heritage) value
Turtle Pool	**Clearing** • Clearing for the Revised Proposal may result in a reduction of the upper reaches of the catchment that supports Turtle Pool	**Increased sediments in runoff from infrastructure and drainage** Potential reduced water quality of Turtle Pool resulting in decreased environmental (and associated cultural heritage) value

[14] No impacts to riparian vegetation to Turee Creek East from groundwater drawdown is predicted.

Table 1-2: Environmental Factors and Values and the Predicted Potential Impacts from the Proposal

Environmental Value (Environmental Receptor)	Predicted Potential Impacts from the Proposal	
	Direct	**Indirect**
Flora and Vegetation		
West Angeles Cracking Clay Priority Ecological Community (PEC)	**Clearing** • No direct or indirect impact to PEC mapped representation 2015-5 predicted • Loss of up to 2 ha of "other representations" of the West Angeles Cracking Clay PEC[15]	• Changes to hydrological regime • Changes in fire regime • Potential for weed invasion
Terrestrial Fauna		
Foraging, dispersal, roosting and/or breeding habitat for significant fauna species	**Clearing**[16] • Clearing up to: o 126 ha of Gorge/Gully habitat o 3,731 ha of Hillcrest/Hillslope habitat These habitats are considered of high significance to fauna • Clearing up to: o 2 ha of "other representations" of the West Angeles Cracking Clay PEC o Approximately 79 ha of Drainage Line o Approximately 1,787 ha of Footslopes and Plain	**Activities resulting in increased levels of introduced flora (weeds), increased feral predation and fragmentation of habitat** Environmental changes from activities may influence significant fauna use of the fauna habitat within the Revised Development Envelope

[15] As mapped by DBCA

[16] Combined Proposal and Deposits C, D and G approval clearing only. Approvals prior to 2019 do not itemise clearing by habitat type

Environmental Value (Environmental Receptor)	Predicted Potential Impacts from the Proposal	
	Direct	**Indirect**
	o Approximately 374 ha of Mixed Acacia Woodland These habitat types are considered of moderate to low significance to fauna	
Ghost Bat (*Macroderma gigas*) and significant habitat	**Clearing**[13] • Loss of up to four category 4 roosts (not considered critical habitat • Clearing up to 3,857 ha of Gorge/Gully and Hillcrest/Hillslope habitat, which is considered critical habitat as it provides roosting and foraging habitat • Clearing approximately 2,242 ha of Drainage Line, Footslopes and Plain, Cracking Clay and Mixed Acacia Woodland habitat, which are considered supporting habitat as they provide foraging and dispersal habitat	**Change in the structure of caves (roosts)** Blasting and/or mine pit development creates instability to caves, cracks/holes, which change microclimate (i.e., temperature and humidity) **Vibration** Blasting may cause structural damage to caves that are retained within the Revised Development Envelope and/or disturbance to roosting bats **Activities resulting in increased levels of introduced flora (weeds) and fauna (predators), dust and light** Changes to the environment from activities may influence/change bat behaviour, the use of caves and/or fauna habitat in the Revised Development Envelope **Hydrogeology/Hydrology** Reduction in surface water fed pools due to reduced catchment

Environmental Value (Environmental Receptor)	Predicted Potential Impacts from the Proposal	
	Direct	**Indirect**
Inland Waters		
Riparian vegetation[17]	**Clearing**[13] • Clearing no more than 35 ha of riparian vegetation	• NA (no discharge to Turee Creek East associated with this Proposal)
Deposit H Pool	**Clearing** • Clearing for the Proposal will impact up to 2.8 km^2 of the 3.3 km^2 catchment that feeds Deposit H Pool	**Increased sediments in runoff from infrastructure and drainage** Potential reduced water quality of Deposit H Waterhole resulting in decreased environmental (and associated cultural heritage) value
Turtle Pool	**Clearing** • Clearing for the Proposal may result in a reduction of the upper reaches of the catchment that supports Turtle Pool	**Increased sediments in runoff from infrastructure and drainage** Potential reduced water quality of Turtle Pool resulting in decreased environmental (and associated cultural heritage) value

[17] No impacts to riparian vegetation to Turee Creek East from groundwater drawdown is predicted.

Table 1-3: Summary of Previously Authorised Extents for the Existing Operations and the Proposed Extents for the Revised Proposal

Proposal Element	Location/Description	Revised Proposal Extent (as referred)	Proposed Amendment	Revised Proposal Extent (as amended)
Physical Elements				
Mine and associated infrastructure	Figure 1-2	Clearing of up to an additional 19,405 ha of native vegetation within a mine development envelope of 41,484 ha • No clearing within Ghost Bat Cave AA1, WA-13, WA-21 and WA-23 Exclusion Zones • No clearing within the West Angelas Cracking Clay Priority Ecological Community (PEC-2015-5) • No more than 20 ha of clearing to other representations of the West Angelas Cracking Clay Priority Ecological Community • No more than 25 ha of clearing of riparian vegetation • No clearing of Hilltop, Hillslope, Ridge or Cliff habitat for the Managed Aquifer Recharge Scheme infrastructure No clearing of: • Water features - WMAR-01 and WMAR-03 • Caves - CMAR-02, CMAR-03 and CMAR-04 • Clearing of no more than 0.6 ha of Major Drainage habitat for the Managed Aquifer Recharge scheme infrastructure • Below water table pits are to be backfilled to a level to prevent the formation of permanent pit lakes	Reduction by 4,705 ha to the Development Envelope and reduction in the clearing of 1,850 ha	• Clearing no more than **17,555 ha** within a **36,779 ha** Development Envelope • No clearing within Ghost Bat Cave AA1, WA-13, WA-21 and WA-23 Exclusion Zones • No direct disturbance to Ghost bat roosts listed in Table 1-6 • No clearing within the West Angelas Cracking Clay Priority Ecological Community (PEC-2015-5) • No more than 22 ha of clearing to other representations of West Angelas Cracking Clay Priority Ecological Community • No more than 60 ha of clearing of riparian vegetation • No clearing of Hilltop, Hillslope, Ridge or Cliff habitat for the Managed Aquifer Recharge Scheme infrastructure No clearing of: • Water features - WMAR-01 and WMAR-03 • Caves - CMAR-02, CMAR-03 and CMAR-04 • Clearing of no more than 0.6 ha of Major Drainage habitat for the Managed Aquifer Recharge scheme infrastructure

Proposal Element	Location/Description	Revised Proposal Extent (as referred)	Proposed Amendment	Revised Proposal Extent (as amended)
				• Below water table pits are to be backfilled to a level to prevent the formation of permanent pit lakes. • No direct impacts to Deposit H Waterhole • Below water table pits are to be backfilled to a level to prevent the formation of permanent pit lakes
Rail Infrastructure	Figure 1-2	A 413 km rail network transports processed ore from West Angelas to port facilities located at Cape Lambert Clearing no more than 1,500 ha within a 19,400 ha Linear Infrastructure Development Envelope, including: • Five existing sidings (Spoonbill, Bellbird, Rosella, Brockman Refuge and Emu) and potential additional sidings to support the rail network • Turee Creek B Borefield, pipeline, powerline, access roads and other associated infrastructure	No change	A 413 km rail network transports processed ore from West Angelas to port facilities located at Cape Lambert Clearing no more than 1,500 ha within a 19,400 ha Linear Infrastructure Development Envelope, including: • Five existing sidings (Spoonbill, Bellbird, Rosella, Brockman Refuge and Emu) and potential additional sidings to support the rail network • Turee Creek B Borefield, pipeline, powerline, access roads and other associated infrastructure
Operational Elements				
Surplus water management	Figure 1	Management of surplus water via water management options including, but not limited to: • Use and storage onsite • Discharge to disused mine pits • Controlled discharge to the environment: Turee Creek East (not to extend within 2 km of the boundary of Karijini National Park) and other unnamed ephemeral creeks	Amended to more clearly identify water use hierarchy and proposed use of surface water Addition of use in Managed Aquifer Recharge Project and Provision to other users	Dewatering water will be used on-site in the first instance to supply water for operational purposes. Use of surplus water may include: • Use in processing • On-site other use • Options for temporary storage in disused mine pits • Infiltration to the aquifer

Proposal Element	Location/Description	Revised Proposal Extent (as referred)	Proposed Amendment	Revised Proposal Extent (as amended)
				• Use in Managed Aquifer Recharge Project • Provision to other users Surplus dewatering water exceeding the operational requirement is discharged to a local ephemeral tributary of Turee Creek East The surface discharge extent will not extend within 2 km of the boundary of Karijini National Park under natural no-flow conditions
Proposal Elements with Greenhouse Gas Emissions				
Annual Average emissions				
Scope 1		Diesel and land clearing –approximately 54,550 t CO_2-e pa.		
Scope 2		Electricity – approximately 8,985 t CO_2-e pa.		
Scope 3		Annual average approximately 8.9 Mt CO_2-e pa.		
Rehabilitation				
The key closure objective is to rehabilitate the site to create a safe, stable, non-polluting landscape consistent with the post-mining land use and maintain environmental and cultural heritage values. Rehabilitation and closure activities will be carried out in accordance with the approved Mine Closure Plan (MCP).				
Other Elements that Affect the Extent of Effects on the Environment				
Proposal Time		Maximum project life	The operational phase is estimated at ~ 15 years (not including construction and closure implementation phases)	

1.4. Condition Requirements

The Proposal is currently being assessed under Part IV of the *Environmental Protection Act 1986* (EP Act) and under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). The Approved Proposal was assessed under Part IV of the EP Act, and Deposits C, D and G were assessed under the EPBC Act. Considering the information provided in the ERD (Rio Tinto 2022a), this EMP proposes environmental management and monitoring to ensure environmental outcomes and objectives are achieved. This EMP also addresses previous conditions included in MS 1113 and DN 2018/8299, as described in Appendix 9 and Appendix 10, respectively.

1.5. Approach

This EMP was drafted in accordance with the Rio Tinto Conceptual Framework for Developing EMPs (internal guidance described in Appendix 1). This conceptual approach considers the conservation significance of the environmental value (receptor) based on local, state and regional conservation status. Management level (low, moderate or high) is assigned in order to achieve the environmental objective according to the conservation significance of the environmental value and the risk of impact predicted over spatial and temporal scales. Assessment of the pathways over which impacts may occur provides the rationale for choosing provisions and appropriate indicators to measure against the environmental outcome or objective.

A summary of the identified proposed and potential impacts (direct and indirect) to relevant environmental values is presented in Table 1-2.

This EMP provides provisions for potential impacts to environmental values specific to the Proposal. The significance of all potential threats to environmental values that may be impacted by the Proposal, including threatening processes to MNES fauna (that is: presence of weed species and fauna, vibration, dust, light, noise, fire and fauna interactions), are considered during the conceptual framework assessment to ensure appropriate measures.

This EMP addresses the key environmental factors and their associated values that have been identified as potentially being impacted by the Proposal and requiring management, as outlined in the ERD (Rio Tinto 2023).

As outlined in the ERD, maximum clearing limits are proposed for the clearing of fauna habitats of potential high value / critical habitat. These clearing limits will be included in the Ministerial Statement and Decision Notice for the Proposal and compliance with these conditions will be reported annually. No further specific management or monitoring is proposed in relation to those limits and hence they are not addressed in this EMP.

1.6. Management Rationale

This EMP combines outcome-based and objective-based provisions to achieve environmental objectives.

Outcome-based provisions are applied where sufficient information exists to establish objective and measurable criteria (EPA 2021a). Environmental criteria are defined to assess performance against the environmental outcome. These are:

- **Trigger criteria** are set at a conservative level to forewarn the approach of threshold criteria and ensure trigger level actions are implemented well before the environmental outcome is compromised. Trigger criteria are related to the indicators identified in Table 1-4
- **Threshold criteria** represent the limit of acceptable impact beyond which there is likely a significant effect on the environment. This indicates there is risk that the environmental outcome will not be met.

Objective-based provisions are applied where monitoring an action rather than a measurable impact or outcome is more effective. In this case, management targets are established to measure the success of management actions in achieving the environmental objective.

Complementary supporting provisions are monitoring and management commitments that will assist in achieving outcomes and objectives but are not directly tied to them. The rationale for the choice of provisions is provided in Table 1-4.

The tables of EMP provisions (Table 2-1 to Table 2-3) contain environmental outcomes that include 'no irreversible impact' for consistency with MS 1113: 5-1 (1 and 2). Whilst general provision for EPBC Act listed species related to threatening processes are described in Table 2-8.

For the purpose of this EMP, an irreversible impact is defined as:

> *"An impact resulting in a permanent loss of environmental value(s), or where intensive and/or un-proven management intervention, potentially over a long timeframe, would be required to restore the environmental value(s)".*

Table 1-4: Rationale for Choice of Provisions

Current Knowledge	Key Assumptions and Uncertainties	Rationale for Choice of Provision and Monitoring Indicators
Environmental Value: Flora and Vegetation – West Angelas Cracking Clay PEC		
Key surveys and studies: Biota 2006, Ecologia 2013, Trudgen 1995, Trudgen 1998, Biologic 2021a		
• The Priority 1 West Angelas Cracking Clay PEC is defined as 'Open tussock grasslands of *Astrebla pectinata*, *A. elymoides*, *Aristida latifolia*, in combination with low scattered shrubs of *Sida fibulifera*, on basalt derived cracking-clay loam depressions and flowlines' • Approximately 435 ha of this community has been mapped within the Revised Development Envelope[18] (Figure 1-3) • The West Angelas Cracking Clay PEC is considered significant because the community is relatively uncommon in the Pilbara and is generally in very good condition, attributed to the absence of historic cattle grazing • Mapped representation PEC-2015-5 is considered to be a particularly good representation of the community and thought to be one of the largest representations in the West Angelas region (approximately 230 ha) • Other mapped representations are considered less significant. These 'other representations' are either more marginal or consist of substantial areas of mosaic-type clay flat community assemblages, interspersed with sections of cracking clays and, in some areas, contain species slightly different to those listed in the PEC description • Threats to this community include clearing and associated indirect impacts such as changes to hydrological regime and weed invasion • For the Approved Proposal (under MS 1113), approximately 20 ha of 'other representation of the PEC overlies development areas; therefore, avoidance is not possible. The Proposal may result in direct disturbance to an additional 2 ha of the PEC, with a total of 22 ha of disturbance associated with the Revised Proposal	Assumptions: • As most of the mapped representation of the West Angelas Cracking Clay PEC occurs within the Revised Development Envelope, reference sites may need to be other comparable community types outside the Revised Development Envelope (e.g., Astrebla cracking clay communities); it is assumed these communities respond similarly to environmental variables • Threshold criterion 2 for PEC 2015-5 assumes that a temporary loss of any individual key species present at baseline from less than 50% of transects within the community would be reversible, as other species would remain, and it is assumed that regeneration of any impacted species from surrounding areas would occur Uncertainties: • Baseline monitoring of species presence and abundance (including weeds) within the West Angelas Cracking Clay PEC in the Revised Development Envelope is limited (initiated in 2018) and may not represent the full range of natural variability • There is uncertainty as to what would constitute an irreversible impact on the West Angelas Cracking Clay PEC representation 2015-5 • Similar unmapped representations of the West Angelas Cracking Clay PEC may be present outside the Revised Development Envelope elsewhere in the Pilbara	The environmental objective is to prevent any direct (clearing) or indirect disturbance that results on PEC 2015-5 and to ensure no more than 22 ha of direct or indirect disturbance to other representations as a result of the Revised Proposal. As disturbance is easily measurable, outcome-based provisions have been chosen to meet the environmental objective (as specified in Table 2-1). • The extent of all mapped representations[12] within the Revised Development Envelope will be assessed through annual imagery capture • Due to the higher significance of PEC 2015-5, annual monitoring of presence and abundance of key species (including weeds) will be undertaken to detect potential indirect impacts. Any indirect impacts will be assessed and managed in accordance with the trigger and threshold criteria and associated response actions specified in Table 2-1 • Indirect impacts are considered unlikely, but likelihood may be greater adjacent to disturbed areas; therefore, monitoring of key species presence and abundance (including weeds) in 'other representations' will occur at selected locations near disturbed areas if the trigger criteria is exceeded
Environmental Value: Flora and Vegetation – Weeds within the West Angelas Rail Corridor		
Key surveys and studies: Biota 2010, Biota 2011, Biota 2012, CALM 1999, CALM 2011, Pilbara Flora 2010		
The West Angelas rail corridor is the portion of the MS 1113 Linear Infrastructure Development Envelope that contains the rail network. It goes from West Angelas Mine to Emu siding, encompassing Spoonbill, Bellbird, Rosella, Brockman Refuge sidings, and potential additional sidings to support the rail network. The corridor itself is cleared and, therefore, of little environmental value. It runs adjacent to several significant vegetation communities and conservation estates (Figure 1-4), including: Karijini National Park • Karijini National Park was first gazetted as an A Class reserve in 1969. The National Park is located within the central portion of the Hamersley Range and includes a representative sample of the Range's various geological types, landscape forms and floristic communities. Covering a total area of	Assumptions • Accurate vegetation mapping is not available for the extent of the rail corridor. It has therefore been assumed that the remainder of the vegetation in the West Angelas rail corridor (other than areas already listed) is in good to excellent condition. Priority areas (other than areas already listed), species and timing for focusing weed control will be established as knowledge develops during the program's implementation Uncertainties • There is uncertainty around the ongoing pressure from surrounding weed vectors, including other users and fauna	Objective-based provisions have been chosen to meet the environmental objective. It is difficult to set measurable criteria due to the limited baseline data, the large extent of the West Angelas rail corridor, the complexity in determining causes of new weeds, and the spread of weeds due to mining, pastoral or other activities. The Proponent proposes to update priorities for weed management within the West Angelas rail corridor with weed inventory data collected during the first three years of the weed control program and in consultation with the Department of Biodiversity, Conservation and Attractions. • Areas adjacent to National Parks and TEC and PECs are considered a higher priority for management than the remainder of the West Angelas rail corridor. Weeds will be managed within the West Angelas rail corridor to avoid, where possible, or otherwise, minimise the introduction to and spread of weeds to adjacent environmental values as a result of the Revised Proposal • Management targets are aimed at preventing the establishment of new high priority species to conservation significant areas and other significant vegetation and to prevent an increase in the extent of priority species adjacent to national parks, TECs and PECs (as specified in Table 2-1) • All weeds will be assessed against the Weed Prioritisation Process for DPaW (formerly DEC), "*An integrated approach to Weed Management on DPaW-managed lands in WA*"[19]. Those rated Rapid invasiveness and High ecological

[18] Mapped extent prior to clearing for Existing Operations

[19] https://www.dpaw.wa.gov.au/images/documents/plants-animals/plants/weeds/weed_prioritisation_process.pdf

Current Knowledge	Key Assumptions and Uncertainties	Rationale for Choice of Provision and Monitoring Indicators
630,000 ha allows for adequate buffers to disturbances from surrounding land uses (largely grazing of pastoral leases) • The key values of the National Park are conservation, culture, tourism, and recreation <u>Millstream-Chichester National Park</u> • Millstream-Chichester National Park was first gazetted as a wildlife sanctuary in 1956. The National Park overlays a portion of the Millstream aquifer and includes the significant wetland ecosystem of the Millstream delta that feeds into the Fortescue River. Tanberry Creek, located east of the National Park, is recognised as a near-pristine waterway. The total area of the National Park is 240,000 ha • The key values of the National Park are conservation and cultural <u>Themeda Grasslands on Cracking Clays Threatened Ecological Community (TEC) (Vulnerable)</u> • Grassland plains are dominated by the perennial *Themeda* (kangaroo grass) and many annual herbs and grasses. The dominant *Themeda* species, *Themeda* sp. Hamersley Station is also listed as a Priority 3 flora species <u>Brockman Iron Cracking Clay PEC of the Hamersley Range (Priority 1)</u> • Rare tussock grassland dominated by Astrebla lappacea (although not every site has the presence of Astrebla). Tussock grassland on cracking clays - derived in valley floors, and depositional floors. *Astrebla lappacea* is listed as a Priority 3 flora species. This is a rare community and landform, only known from near West Angeles, Newman, Tom Price and the boundary of Hamersley and Brockman Pastoral Stations <u>Four Plant Assemblages of the Wona Land System PEC</u> • Cracking Clays of the Chichester and Mungaroona Range (Priority 1). This grassless plain of stony gibber community occurs on the tablelands with very little vegetative cover during dry season; however, during the wet a suite of ephemerals/annuals and short-lived perennials emerge, many of which are poorly known and range-end taxa • Annual Sorghum Grasslands on Self-mulching Clays (Priority 1). This community appears very rare and restricted to the Pannawonica-Robe valley end of Chichester Range • Mitchell Grass Plains (*Astrebla* spp.) on Gilgai (Priority 3) • Mitchell Grass and Roebourne Plain Grass (*Eragrostis xerophila*) Plain on Gilgai (typically heavily grazed) (Priority 3)	• There is limited existing baseline data on the presence and extent of weed species within the West Angelas rail corridor and adjacent conservation areas • Landscape-scale infestations of weeds are known to exist in some areas but the extent may not be fully understood	impact (according to the *Pilbara Impact and Invasiveness Ratings*[20]), while considering the feasibility of control, will be rated high priority for control as they demonstrate the capability to spread beyond the disturbance footprint of the rail corridor. The priority of other weeds identified will be determined during consultation with DBCA • Management efforts will be prioritised to annual weed control programs and monitoring of weed presence, and extent will be undertaken at the same time • Timing and/or frequency of weed control actions (including follow-up control measures) at priority areas within the West Angelas rail corridor is intended to be flexible to undertake weed control and monitoring of presence and extent of weed control during optimal local environmental conditions, e.g., after rainfall events • It is noted that there is an area of overlap between the MS 1113 Linear Infrastructure Development Envelope and the MS 1074 Development Envelope. The Proponent will continue to implement the weed management commitments required by MS 1074 in the overlapping area, in addition to management measures described in this EMP
Environmental Value: Terrestrial Fauna – Ghost Bat		
Key surveys and studies: Biologic 2016, Biologic 2018a, Biologic 2018b, Biologic 2021b, Biologic 2021c, Biologic 2021d, Biologic 2021e, Biologic 2018b		
Ghost Bat (*Macroderma gigas*) is listed as Vulnerable under the EPBC Act and BC Act. Ghost Bat monitoring at West Angelas suggests that Ghost Bats have continued to utilise roosts adjacent to mining activities and that applying exclusion zones and blast management measures can be expected to avoid physical impacts to roosts effectively.	<u>Assumptions</u> • Protection of roosting habitat will enable the persistence of Ghost Bats within the Revised Development Envelope.	A high management level has been assigned to manage impacts (potential indirect) to MNES fauna species and high value / critical habitat within the Development Envelope. The overall management strategy for all MNES species is to maintain the integrity of the high-quality habitat, which is achieved through the establishment of MEZs/MRZs and both outcome-based and objective based provisions. Objective based (supplementary provisions) specific to Ghost bats are detailed in Table 2-3 and objective based provisions for all listed EPBC species are detailed in Table 2-8.

[20] https://www.dpaw.wa.gov.au/images/documents/plants-animals/plants/weeds/pilbara_region_-_impact_and_invasiveness_ratings.xlsx

Current Knowledge	Key Assumptions and Uncertainties	Rationale for Choice of Provision and Monitoring Indicators
A total of 41 caves occur within the Revised Development Envelope, of which 20 are located in the Approved Development Envelope and 21 are located within the Proposal Area of which 17 will be retained. All caves have the potential to provide roosting habitat for the Ghost Bat. This includes caves of the following categories (as per Bat Call WA 2021a): • Seven (7) category 2 roosts (AA1, WA-13, WA-21, WA-23, CWAN-04, CWAN-06, CWAN-07) • Thirteen (13) category 3 roosts (L2*, L3, WA-17, WA-20, A1, WA-12, WA-22, CMAR-01, CWAN-01, CWAN-02, CWAN-03 CWAN-29, CWAN-31) • Seventeen retained (17) category 4 roosts: (I1, A2, WA-09, WA-10, WA-11, CWAN-27, CWAN-28, CWAN-32, CWAN-08, CWAN-11, CWAN-30, CWAN-34, CDHI-001, CDHI-002, CMAR-01, CMAR-02, CMAR-03) Category 2 caves are considered critical habitat for the species. The grouping of category 3 and 4 caves immediately surrounding these caves is also considered critical and described as "apartment blocks" that support the ecological function of category 2 caves. Isolated category 3 or 4 caves are not considered critical habitat, as these caves are used opportunistically. The only apartment block complexes are located within the Western Hill deposit area. Of the 41 caves within the Revised Development Envelope, four category 4 roosts for the Ghost Bat occur within the Conceptual Footprint and are expected to be directly impacted by the Proposal. The remaining 37 roosts will be retained. Recent geotechnical investigations have determined suitable trigger values for vibration levels at cave entrances to develop blast management measures, which will be implemented to ensure cave stability of remaining roosts within the Revised Development Envelope. Twenty (20) caves within the Approved Development Envelope are retained within MS 1113 Restriction and/or Exclusion areas. The management of these caves will not be modified.	<u>Uncertainties</u> • Limited data is available on the sensitivity of Ghost Bats to light, noise and vibration • There is limited understanding of the long-term behaviour of Ghost Bats in relation to the use of roosts and movement between or abandonment of roosts • There is limited data on the likely impact of climate change and drought on the Ghost Bat	The Proponent shall maintain the structural integrity of all significant Ghost Bat roosts (Category 2 and Apartment Blocks) in the Development Envelope. This includes establishing MRZs and MEZs around all retained Ghost bat roosts within the Proposal area (Table 1-6, Figure 2-1). These significant Ghost Bat roosts may also be utilised as Category 4 roosts for the Pilbara Leaf-nosed Bat. The protection of cave stability and habitat can be measured and reported; therefore, an outcome-based provision is considered suitable. For all significant caves that are retained, blast management plans will be implemented in accordance with the PPV limits outlined in Table 1-6, and visual inspections of stability to ensure no impact, as predicted within 300 m of active mining, including monitoring of the cave microclimates whereby a significant step change in temperature and humidity may be an indication of potential changes to the structural integrity of a cave and its ongoing suitability. Data collected at other operations indicates temperature and humidity naturally vary significantly. A change in structural integrity independent of a change in temperature and humidity (and vice versa) may not indicate the cave is no longer suitable. As such, trigger and threshold criteria have been developed that reflect a combined change in structural integrity supported by a step change in microclimate values to identify a change in cave suitability. The targets and criteria presented in Table 2-2a, Table 2-3 and Table 2-8 will be updated as required with consideration of additional baseline data and adaptive management (as described in Section 3). In addition to the measures included in this plan, clearing limits on high significance critical (breeding and roosting) habitat are included in the limits proposed in the ERD. For caves within 300 m of the conceptual pit footprint provisions include implementation of Mining Restriction Zones and measures to manage vibrations from blasting activities. Vibration levels for caves within 300 m of the conceptual pit footprint have been conservatively set according to Cave categories. The objective based provisions as detailed in Table 2-3 will improve knowledge of Ghost Bat presence and utilisation of high value / critical habitat (Gorge/Gully and Hillcrest/Hillslope habitat) within the Development Envelope. The environmental objectives aim to increase knowledge of Ghost Bat behaviour, with the view to maintaining the population within the Development Envelope. Management-based provisions have been proposed, as current application of population criteria (trigger or threshold) would be arbitrary and not statically robust as: Monitoring to meet the environmental objectives will be targeted at the Western Hill deposit as this area had the greatest number of Ghost Bat records and the majority of the high value / critical habitats. Additional management parameters to address other threatening processes (feral animals, changed fire regimes human presence, and vehicle strikes) and support this objective are included in Table 2-8 and include (but are not limited to): **Management of feral animals.** Vegetation clearing can increase access of feral predators to fauna habitats, resulting in increased competition and predation causing injury or mortality to Ghost Bats. To reduce these potential impacts to the population within the Development Envelope, feral cat monitoring and management will be undertaken in the Development Envelope based on consultant advice. The Proponent will engage a consultant to assist in the development of a survey and control program to ensure a robust approach to identifying and managing feral animals, including feral cats and cane toads and is undertaken. The survey and control program will include a review to identify and target high risk areas (e.g. environmental value, and potential for further transfer/dispersal). The survey and control program will also consider opportunities to utilise automated feral cat control technology (e.g. Felixers), or other technologies on the advice of consultants in high value areas (subject to regulatory approval). Traditional trapping will still be utilised as required in other areas (e.g. accommodation and waste storage facilities). The requirement to report sightings of feral cats (and other feral animals) will be included in site inductions. **Management of changed fire regimes.** West Angelas and surrounds have been an operational mine site for several decades, and there has been changes to fire regime during this time. The Proponent does not propose to actively undertake prescribed burning within the Development Envelope due to the inaccessibility of areas to control prescribed burns, and the risk prescribed burns pose to personnel, active mining areas and the surrounding land uses. The management actions ensure procedures are in place and equipment available to reactively control and manage localised outbreaks of fire, including potential fire impacts to high value areas (where safe to do so). Having procedures in place (including a hot work permit system) and equipment available is considered the most appropriate way to reduce potential impacts to high value areas from fire. **Management of human presence and vehicle strikes.** Human presence, particularly at Ghost Bat caves, may result in disturbance and flushing of bats. Vehicle strike may directly impact Ghost Bat numbers. Administrative tools will manage these potential impacts. To reduce these potential impacts to the population within the Development Envelope, access to high value areas (MRZ and MEZ) will be limited to authorised personnel, and speed limits will be implemented based on a risk assessment that considers environmental values (in addition to safety/other required legislation).

Current Knowledge	Key Assumptions and Uncertainties	Rationale for Choice of Provision and Monitoring Indicators
Environmental Value: Terrestrial Fauna – Habitat for all recorded MNES species Ghost Bat, Pilbara Leaf-nosed Bat, Northern Quoll and Pilbara Olive Python		
Key surveys and studies: Biologic 2018a, Biologic 2018b, *ecologia* 2014, Biologic 2022b, Biologic 2021c, Biologic 2021d, Biologic 2021e, Biologic 2018b		
Seven significant fauna species have been recorded within the Revised Development Envelope, including five MNES species: Northern Quoll, Ghost Bat, Pilbara Leaf-nosed Bat, Pilbara Olive Python and Fork-tailed Swift. The Fork-tailed Swift has been recorded flying over the Revised Development Envelope; however, given the species is largely aerial, it would not depend on any of the habitat present within the Revised Development Envelope. The Northern Quoll is listed as Endangered under both the BC Act and EPBC Act. The Northern Quoll has been recorded at one location within the Revised Development Envelope (cave CWAN-04). Due to limited species records despite adequate sampling, this record is thought to reflect a transient individual rather than a resident population. The Pilbara Leaf-nosed Bat is listed as Vulnerable under the EPBC Act and BC Act. The species has been recorded at five locations within the Revised Development Envelope and an additional 12 locations in the surrounding areas. None of the 41 caves within the Revised Development Envelope represent critical habitat for this species, with all caves representing category 4 potential nocturnal refuges for the species (as defined by Bat Call WA 2021b). The closest known critical roost occurs approximately 12.5 km outside the Revised Development Envelope. The Ghost Bat is listed as Vulnerable under the EPBC Act and BC Act. The species has been recorded via scats, direct sightings, echolocation calls and skeletal remains, with a total of 37 records within the revised Development Envelope. Of the 41 caves known within the revised Development Envelope, two are confirmed maternity roosts (category 2), five are potential maternity roosts (category 2), three are confirmed diurnal roosts (category 3), ten are potential diurnal roosts (category 3), twelve (12) confirmed night roosts (category 4), and nine potential night roosts (category 4). The only apartment block complexes (Cat 2 roost surrounded by cat 3 or 4 caves) are located within the Western Hill deposit area. The Pilbara Olive Python is listed as Vulnerable under the EPBC Act and BC Act. The species has been recorded twice within the Revised Development Envelope. Due to the species' highly cryptic nature, more individuals are likely to reside within the Revised Development Envelope. The Revised Development Envelope includes the presence of two high significance fauna habitats, including 627 ha of Gorge/Gully and 12,202 ha of Hillcrest/Hillslope habitat. With flexibility to alter the location of mining elements within the Revised Development Envelope, the Proponent has proposed upper clearing limits for each of these habitat types: • Up to 128 ha (Revised Proposal), 126 ha (Proposal) of Gorge/Gully habitat • Up to 4,215 ha (Revised Proposal), 3,731 ha (Proposal) of Hillcrest/Hillslope habitat	<u>Assumptions</u> • Protection of high significance fauna habitat will enable the persistence of significant fauna species within the Revised Development Envelope <u>Uncertainties</u> • There is limited data available on the likely impact of climate change and drought on significant fauna species • There is limited data on the sensitivity of fauna species to noise, dust and vibration	An objective-based provision is considered appropriate to manage impacts (direct and indirect) to the MNES fauna species (Northern Quoll, Pilbara Olive Python, Ghost Bat and Pilbara Leaf-nosed Bat) associated with the Proposal. The objective-based provision is: • Ghost Bat will continue to persist within the Revised Development Envelope Supporting/complementary provisions, including collecting climatic data, managing feral animals and managing fauna interactions on site, are proposed to support the achievement of the environmental outcome. Monitoring will be undertaken to assess the efficacy of these actions. Monitoring will also be undertaken to verify the current understanding of the likelihood of presence of Ghost Bat within the Revised Development Envelope.

Current Knowledge	Key Assumptions and Uncertainties	Rationale for Choice of Provision and Monitoring Indicators
Environmental Value: Inland Waters – Riparian vegetation of Turee Creek East		
Key surveys and studies: *ecologia* 2013, Froend 2018, Independent Groundwater Consultants 2017, Rio Tinto 2017a, Rio Tinto 2018a, Rio Tinto 2018b		
Turee Creek East is an ephemeral watercourse that flows westward across the Revised Proposal, through Karijini National Park, before eventually flowing into the Ashburton River. The vegetation community type of Turee Creek East (Appendix 6) is common in the Pilbara and is considered of low conservation significance in a regional context. In addition, groundwater elevation beneath Turee Creek East within the Revised Development Envelope is typically between 20 m and 70 m below ground level, most likely inaccessible to the riparian vegetation. Surplus dewatering water is discharged to an ephemeral tributary (discharge tributary) of Turee Creek East and is expected to be contained within the low flow channel and will not overtop the creek banks in natural dry conditions. The maximum surface discharge extent is modelled to extend up to 22 km (as measured along the creek channel/s) (Figure 1-6) and will not reach as far as Karijini National Park. Annual transect monitoring of species presence and abundance (including weeds) has been undertaken since 2011 (not all locations shown in Figure 1-6 have been monitored every year), providing baseline information on weeds and riparian vegetation composition and structure. An index of vegetation health has also been assessed from satellite imagery captured annually since 2017.	Assumptions • The modelled surface discharge extent is influenced by the input parameters for topography, surface roughness, evaporation and infiltration rates. Maximum predicted surface discharge extent has been conservatively estimated, assuming peak dewatering rates and low creek bed infiltration rates • Due to the presence of dormant seeds, weeds are expected to persist over several years, irrespective of control actions Uncertainties • After cessation of discharge, riparian vegetation is expected to revert to a pre-impact condition gradually; however, there is uncertainty as to what constitutes an irreversible impact and studies of riparian vegetation response post-discharge are currently limited • Weed distribution and abundance in the Pilbara fluctuates considerably depending on seasonal conditions and other factors, which creates uncertainty in determining causes of potential changes in distribution and abundance	The environmental objective is to prevent an irreversible impact on riparian vegetation's health due to surplus water discharge from the Revised Proposal (MS Condition 5-1(1) (Appendix 8)). As the health of riparian vegetation is easily measurable, outcome-based provisions have been chosen in order to meet the environmental objective (as specified in Table 2-4): • The health of the overstorey canopy in Turee Creek East will be assessed from analysis of annual satellite imagery capture and a vegetation health index, which will provide an early warning indicator of potential adverse impact to riparian vegetation • Additional transect monitoring will be undertaken in Turee Creek East as triggered to ground-truth and further investigate potential decline seen from remote sensing metrics • On-ground weed presence and extent surveys will be undertaken annually in Turee Creek East and the discharge tributary. It is acknowledged that discharge may affect the distribution of weeds downstream of the discharge extent, possibly including Karijini National Park. Therefore, more conservative trigger and threshold criteria have been assigned for weed species
Environmental Value: Inland Waters – Deposit H Waterhole		
Key surveys and studies: Rio Tinto 2020, Rio Tinto 2021a, Rio Tinto 2021b		
Deposit H Waterhole (WB-WAH1) is a small surface water fed ephemeral pool located within the Proposal Area at Deposit H (Figure 1-7) The pool is located at the base of a gorge, which is significant to the Ngarlawangga People. The pool is approximately 175 m^2 in area and holds an estimated 207 m^3 when full. The pool has a rocky floor and sits at the base of a steep waterfall at the outlet of the main creek line. High velocity plunging flows scour sediment from the pool and maintain depth and water. Water has persisted in the pool for >6 months following flow events. Deposit H Waterhole likely fills in most years if catchment flow occurs but can dry out in low rainfall periods. Based on observations, relatively small frequent storm events (typical in most wet seasons) are adequate to fill the pool. This has been confirmed by modelling of the pool and its contributing catchment (Rio Tinto 2020b), with the results indicating that a 1:2 Annual Exceedance Probability (AEP) event (i.e., an event occurring every two years) would see 24,000 m^3 flow to the pool, which is more than 110 times its capacity. The Proposal will impact up to 2.8 km^2 (88%) of the 3.3 km^2 catchment that feeds Deposit H Waterhole. The impacts to the hydrological regime of the Deposit H Waterhole are considered over two different timeframes: during mining (approximately six years) and post-mining. Depending on final mine plan and delay in introduction of surface water diversion, the scale of impact will likely be greatest during mining/operational phase, as most of the catchment (up to 2.8 km^2) could be isolated from the pool and the watercourse in general to prevent flooding of the mine area and protect water quality.	Assumptions • Hydrological modelling and water level monitoring has been used to provide an indicative surface water regime of the pool • The hydrological model will be reviewed as additional data becomes available, and revisions to management may be required Uncertainties • There is insufficient scientific knowledge available regarding the flow and fill regime of Deposit H Waterhole in relation to rainfall events and therefore determine irreversible impact thresholds with absolute certainty. Over the life of the Revised Proposal, trigger and threshold levels and their suitability will be reviewed and updated where appropriate	The catchment that feeds the Deposit H Waterhole is proposed to be directly impacted by the Proposal. However, the Proposal has been designed to avoid changes to the water levels at Deposit H Waterhole, and outcome-based provisions are considered appropriate to monitor and ensure this outcome is met: • The Proponent shall ensure there is no irreversible impact to Deposit H Pool as a result of any impacts of the Proposal to the catchment Due to the ephemeral nature of the Deposit H Waterhole it was not appropriate to set minimum water depth values in the upstream gully or the water hole itself. The waterhole relies on rainfall to fill and in low or no rainfall seasons the pre mining baseline levels would not provide a useful measure in which to benchmark triggres and thresholds against. etrigger and threshold criteria (Table 2-5) are linked to catchment clearing as an indicator of potential impacts on the waterhole, such that maximum catchment clearing has been modelled to ensure sufficient flows to the pool are retained and compliance will be assessed against clearing within the catchment. The Proponent has predicted that despite changes in the surface water catchment feeding Deposit H Waterhole from implementing the Proposal, the pool frequency and depth is modelled to remain persistent within catchment disturbance up to 88% of the catchment. Trigger and threshold criteria have been developed to reflect this while also acknowledging the limited baseline information, which will be expanded prior to mining commencing. The Deposit H Waterhole is a surface water feature fed by a small catchment to the west of the Waterhole, there is no connection to groundwater. Provisions related to monitoring of catchment clearing in relation to agreed limits are considered the most appropriate provisions as they will provide an indication of potential impacts on the pool from excessive clearing. Additionally waterhole and upstream gully depth will be monitored (with a minimum of 2 years baseline data) to support the accumulation of knowledge in relation to Deposit H Waterhole, climate variability and/or the Proposal and inform amendments to triggers and thresholds in the future through adaptive management.

Current Knowledge	Key Assumptions and Uncertainties	Rationale for Choice of Provision and Monitoring Indicators
Environmental Value: Inland Waters – Turtle Pool		
Key surveys and studies: Rio Tinto 2021a, Rio Tinto 2022b		
Turtle Pool is a semi-permanent surface/groundwater water feature located approximately 700 m east of Deposit H, outside of the Revised Development Envelope, in a tributary of Weeli Wolli Creek. The pool is of high significance to the Ngarlawangga People. The hydrology of Turtle Pool indicates it is potentially replenished via a combination of groundwater and surface water flows. It is confirmed to be dependent on rainfall and direct surface flows, through observation of filling after rainfall and subsequent streamflow events. However, Turtle pool may be partly dependent on groundwater with LiDAR undertaken to compare Deposit H groundwater level to Turtle Pool indicating the water level within Turtle Pool to be approximately the same height above sea level as the aquifer (approximately 735 mRL). A groundwater connection therefore cannot be ruled out. Pits and waste landforms at Deposit H are primarily located outside the catchment supplying Turtle Pool to minimise impacts to the environmental and cultural values of the area.. The proposed infrastructure, which includes culverts and floodways, will be limited to the upper reaches of the catchment to ensure existing ephemeral flows to Turtle Pool are maintained to minimise impacts attributable to the Proposal. Turtle Pool is likely to be partly groundwater fed and connected to the same aquifer as Deposit H, and as such, sump pumping rather than abstraction via dewatering bores to access BWT ore, and an alternative supply source within the Revised Proposal Development Envelope is proposed.	<u>Assumptions</u> • Hydrological modelling has been used to provide an indicative surface water regime of the pool • The hydrological model will be reviewed as additional data becomes available, and revisions to management may be required <u>Uncertainties</u> • Confirmation of the likely hydrological regime of Turtle Pool is pending. A data logger has been installed at Turtle pool in Q1 2023 and a monitoring bore (WAH-M03) is scheduled to be drilled prior to commencement of mining • Insufficient scientific knowledge is available to determine irreversible impact thresholds with absolute certainty. Over the life of the Revised Proposal, trigger and threshold levels and their suitability will be reviewed and updated where appropriate	The Proposal is not predicted to impact Turtle Pool, however as a result of the significance of Turtle Pool to Ngarlawangga People a low management level has been applied to confirm no impacts associated with the Proposal from surface or groundwater (drawdown) activities. The Proposal has been designed to avoid changes to the water level at Turtle Pool, and outcome-based provisions are considered appropriate to monitor and ensure this outcome is met: • The Proponent shall ensure there is no irreversible impact to Turtle Pool as a result of any impacts of the Proposal to the catchment • The Proponent shall ensure there is no irreversible impact to Turtle Pool as a result of any impacts of the Proposal to groundwater levels The hydrology of Turtle Pool indicates it is potentially replenished via a combination of groundwater and surface water flows. As a groundwater link cannot be ruled out, potential impact to Turtle Pool from dewatering activities is included; trigger criteria via groundwater level monitoring in groundwater monitoring bore (WAH-M03). WAH-M03 is located between the Deposit H mining area and Turtle pool and will identify any potential groundwater impacts prior to impacting Turtle Pool. Additionally, an assessment of drawdown in relation to modelled aquifer response will be carried out as an early response action to confirm aquifer response is in accordance with the expected outcomes. Trigger criteria (Table 2-6) have been set at a level sufficient to identify if impacts may occur, with time to implement required action and prevent threshold criteria from being met. A water level depth value cannot be included at this stage as sufficient baseline monitoring to establish pre mining water level over time has not been completed. Monitoring of flow depth and pool depth will be carried to establish a trigger value prior to mining commencing. Trigger and threshold criteria will be updated as required with the consideration of additional baseline data and adaptive management practices.
Environmental Value: Flora and Vegetation – Deposit H Downstream Gully		
Key surveys and studies: In progress		
The vegetation that occurs downstream of the pool does not comprise phreatophytic or generally mesic vegetation. Two species that could be considered low level mesophytes occur in the gully; *Corymbia ferriticola & Dodonaea viscosa.* Similar vegetation is found in drainage systems in the local area that occur in similar incised gully habitats where the reporting catchment is smaller (and at times larger) than that of Deposit H Pool. Investigations to date indicate that this variability in catchment size, while still supporting similar vegetation types, suggests that the flow regimes and ecophysical setting, rather than the volumes, are more influential on community composition and structure. This in turn suggests that such vegetation is capable of persisting in habitats with lower reporting catchment size and potentially lower water availability. Traditional Owners have raised the potential impacts to the amenity of the gully downstream of the Deposit H pool during consultation and have requested that there are no significant impacts to the amenity of the downstream gully as a result of catchment reduction. Further investigation into the composition and likely impacts on the downstream gully at Deposit H are currently in progress.	<u>Assumptions</u> • Vegetation in the downstream of Deposit H pool does not comprise phreatophytic or generally mesic vegetation. Two species that could be considered low level mesophytes occur in the gully; *Corymbia ferriticola & Dodonaea viscosa* • Reduction in catchment size may result in a small-moderate decrease over time in the abundance of flora species and thus a change in vegetation density downstream of the ephemeral pool • Altered water balance is likely to result in changes in vegetation abundance and density, however changes in vegetation composition are unlikely, due to the low risk profile held by the species present within the downstream gully <u>Uncertainties</u> • Insufficient knowledge is available to determine the trigger and threshold values for potential impacts to vegetation in the downstream gully. Over the life of the Revised Proposal, trigger and threshold levels and their suitability will be reviewed and updated where appropriate • Traditional Owners (Ngarlawangga) request further investigation into potential impacts on amenity of Deposit H downstream gully	The downstream gully at deposit H is expected to result in a small-moderate decrease over time in the abundance of flora species and thus a change in vegetation density/abundance downstream of the ephemeral pool. Changes in vegetation composition are unlikely, due to the low risk profile held by the species present within the downstream gully, however further investigation is being carried out in relation to the potential impacts on the downstream gully and will be used in consultation with Traditional Owners (Ngarlawangga People) to reach agreement on the nature and extent of mining that is supported at Deposit H. As the continued amenity of the downstream gully at Deposit H pool is important to Traditional Owners (Ngarlawangga), potential impacts on vegetation from catchment reduction is included in this EMP. Investigations include an ecohydrologic assessment of the gully and similar gullies in the area to determine and quantify expected changes to the gully as a result of impact on the catchment and visual assessment and representation of expected changes to vegetation within the Deposit H gully and consequently support development of triggers and thresholds. Trigger and threshold criteria will be updated as required with the consideration of additional baseline data and adaptive management practices.

RioTinto

Figure 1-3
West Angelas Cracking Clay Priority Ecological Community Mapping

Drawn: A.D.
Plan: RTIO-0985787v1
Date: March 2023

Proj: GDA 1994 MGA Zone 50
Scale: 1:120,000 @A3
GIS.Team@riotinto.com

660,000 670,000 680,000 690,000

7,450,000 7,440,000 7,430,000

Karijini National Park

Great Northern Highway

Western Hill

Deposit B

Deposit H

Deposit G

Turee Creek East Branch

Deposit C

Deposit D

Deposit A West

Deposit A

Deposit F North

Deposit F

Deposit E

Mt Ella East

Spearhole Creek

Legend

- Revised Development Envelope

Proposed Conceptual Layout

- Pit
- Waste Landform

Approved Conceptual Layout

- Pit
- Waste Landform

- Cracking Clays P1 (2015-5) - Good Representation
- Cracking Clays P1 - Other Representation
- National Park
- Rio Tinto Railway
- Highway
- Major Creek

N

0 1 2 3 4 5

Kilometres

Map units in metres

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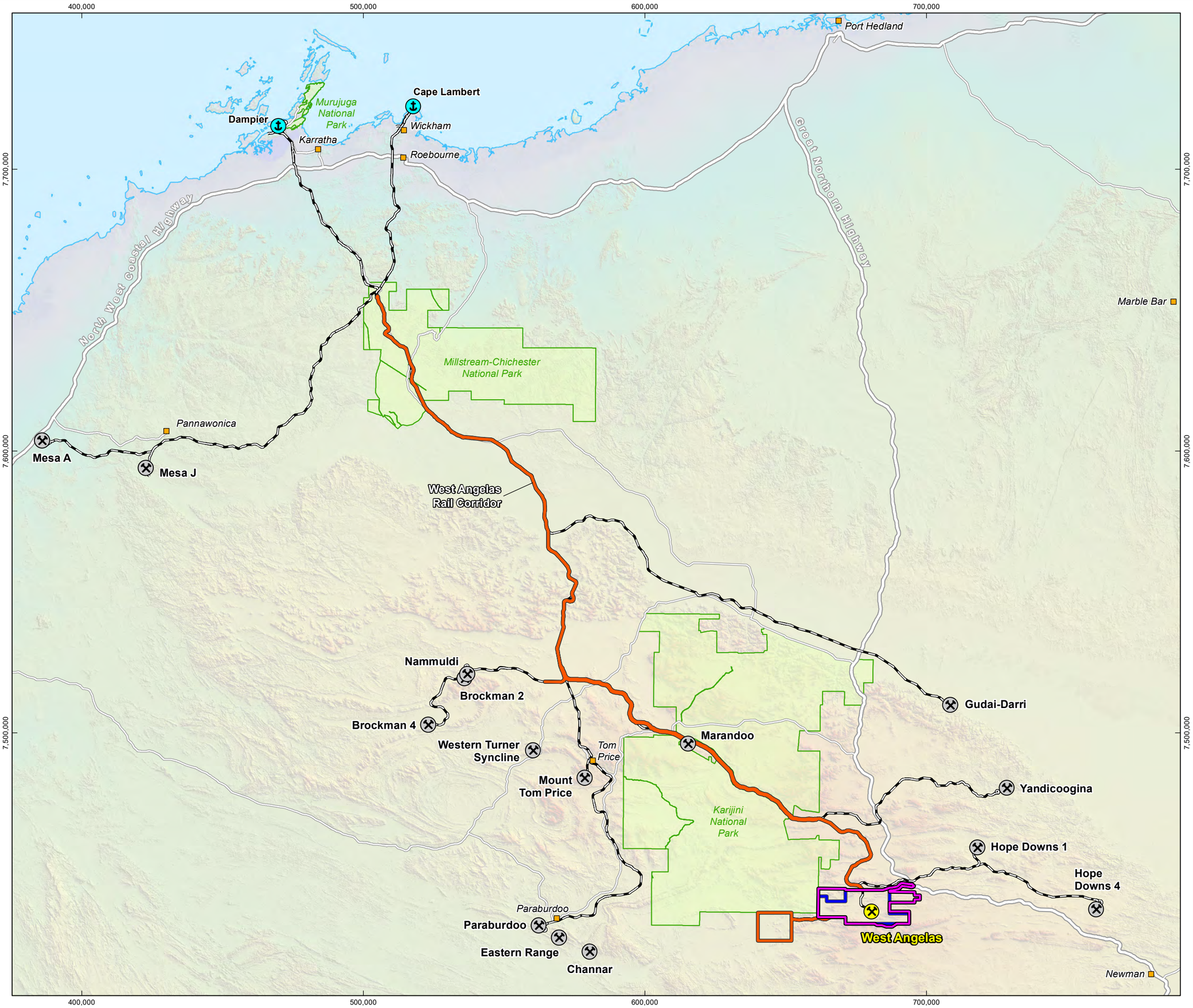


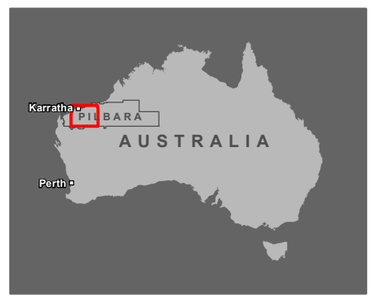
RioTinto

Figure 1-4
West Angelas Linear Infrastructure Development Envelope including Rail Corridor

Drawn: A.D.
Plan: RTIO-0985788v1
Date: March 2023
Proj: GDA 1994 MGA Zone 50
Scale: 1:1,250,000 @A3
GIS.Team@riotinto.com

Legend

- West Angelas
- Rio Tinto Mine
- Port
- Town
- Revised Development Envelope
- Approved Mine Development Envelope
- Approved Linear Infrastructure Development Envelope
- National Park
- Rio Tinto Railway
- Highway
- Major Road



N

0 10 20 30 40 50

Kilometres

Map units in metres

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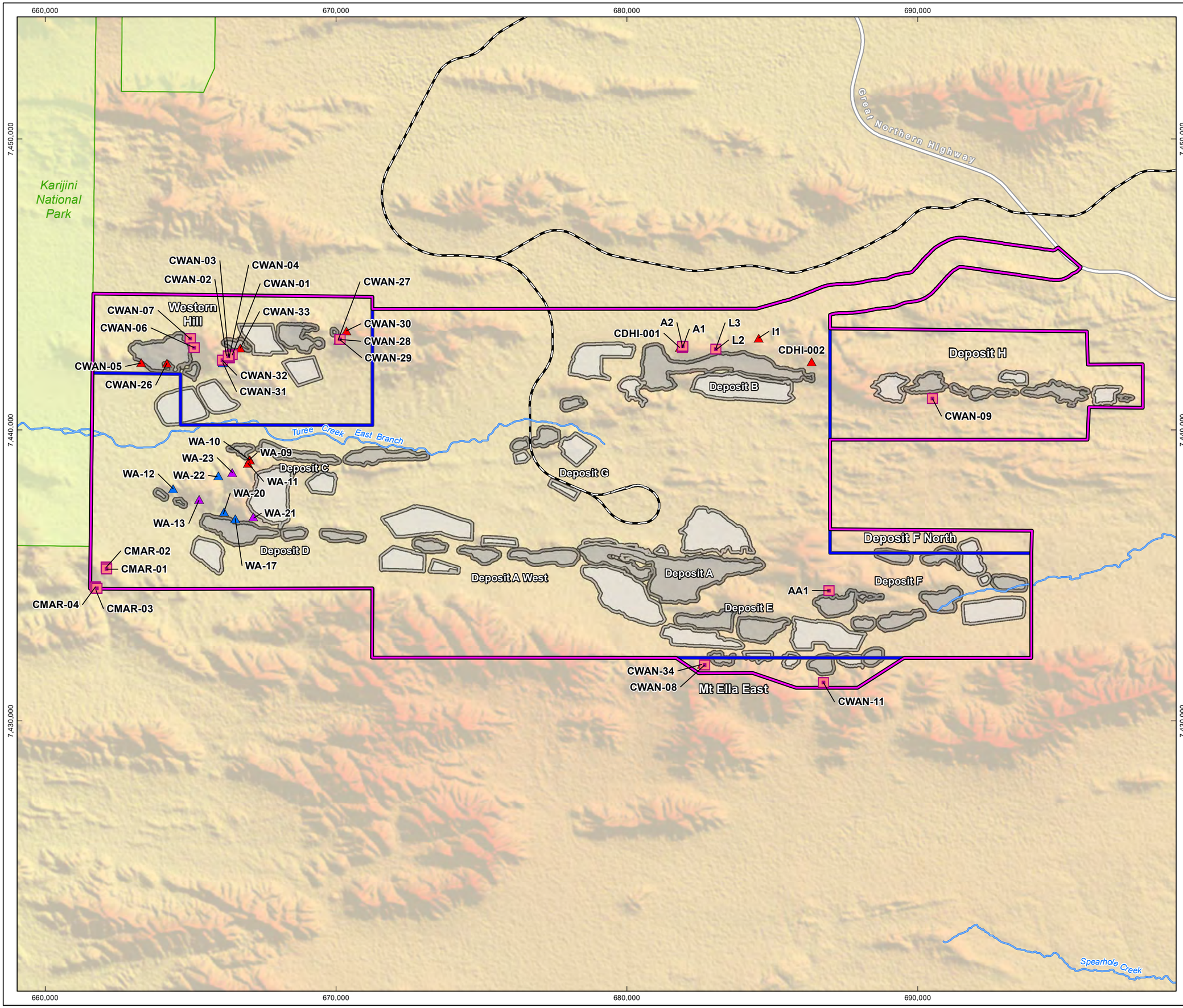

RioTinto

Figure 1-5
Ghost Bat (Macroderma gigas) Roosts

Drawn: A.D.
Plan: RTIO-0985793v2
Date: May 2023

Proj: GDA 1994 MGA Zone 50
Scale: 1:120,000 @A3
GIS.Team@riotinto.com

Legend

- Revised Development Envelope
- Approved Mine Development Envelope

Conceptual Layout

- Pit
- Waste Landform

Caves

- Category 2
- Category 3
- Category 4

Significant Fauna

- Ghost Bat

- National Park
- Rio Tinto Railway
- Highway
- Major Creek

N

0 1 2 3 4 5
Kilometres

Map units in metres

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RioTinto

Figure 1-6
Turee Creek East and Discharge Tributary Vegetation and Discharge Monitoring Locations

Drawn: A.D.
Plan: RTIO-0985796v2
Date: May 2023

Proj: GDA 1994 MGA Zone 50
Scale: 1:175,000 @A3
GIS.Team@riotinto.com

660,000
680,000
700,000
7,460,000
7,440,000
7,420,000

Karijini National Park

Western Hill
Deposit B
Deposit C
Deposit G
Deposit H
Deposit F North
Deposit D
Deposit A West
Deposit A
Deposit F
Deposit E
Mt Ella East
CD
A
B

Great Northern Highway
Turee Creek East Branch
Turee Creek
Spearhole Creek
Angelo River
Indabiddy Creek

Legend

- Revised Development Envelope
- Approved Mine Development Envelope
- Approved Linear Infrastructure Development Envelope

Proposed Conceptual Layout

- Pit
- Waste Landform

Approved Conceptual Layout

- Pit
- Waste Landform

- Existing Licenced Discharge Point
- Discharge Monitoring Camera

Turee Creek East Riparian Vegetation Transect Quadrats

- Potential Impact
- Reference
- Surplus Water Discharge Extent
- Low Flow Channel Extent
- National Park
- Pastoral Station
- Rio Tinto Railway
- Highway
- Major Creek/Branchline

N

0 1 2 3 4 5
Kilometres

Map units in metres

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Figure 1-7
Surface water catchments and surface water features

Drawn: A.D.
Plan: RTIO-0985803v2
Date: May 2023

Proj: GDA 1994 MGA Zone 50
Scale: 1:130,000 @A3
GIS.Team@riotinto.com

660,000 670,000 680,000 690,000

7,450,000 7,440,000 7,430,000 7,420,000

Karijini National Park

Guburingu

Western Hill

Great Northern Highway

14

Dep H Ephemeral Pool

Deposit B

B

Deposit G

1a

12 (Turtle Pool)

Deposit H

Turee Creek East Branch

22

Deposit C

Weeli Wolli/Marillana

Gajiringu

Deposit F North

CD

A

Deposit D

Deposit A West

Deposit A

Deposit F

Deposit E

WMAR-03

WMAR-01

Turee Creek East

Mt Ella East

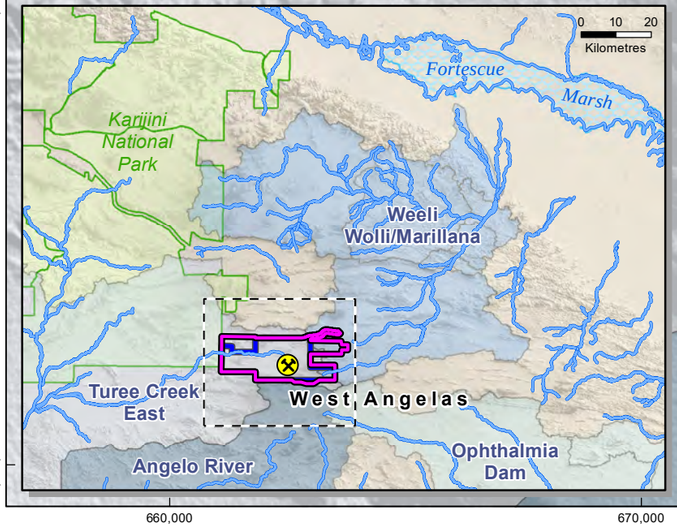
WB-WAJ2

WB-WAJ1

Angelo River

Ophthalmia Dam

Spearhole Creek



Legend

- Rio Tinto Mine
- Revised Development Envelope
- Approved Mine Development Envelope

Proposed Conceptual Layout

- Pit
- Waste Landform
- Conceptual Footprint

Approved Conceptual Layout

- Pit
- Waste Landform

- Heritage Site
- Water Feature
- Existing Licensed Discharge Point
- Potential GDE
- Marsh

Sub Catchment

- Angelo River
- Ophthalmia Dam
- Weeli Wolli/Marillana
- Turee Creek East

- National Park
- Rio Tinto Railway
- Highway
- Major Creek

N

0 1 2 3 4 5
Kilometres

Map units in metres

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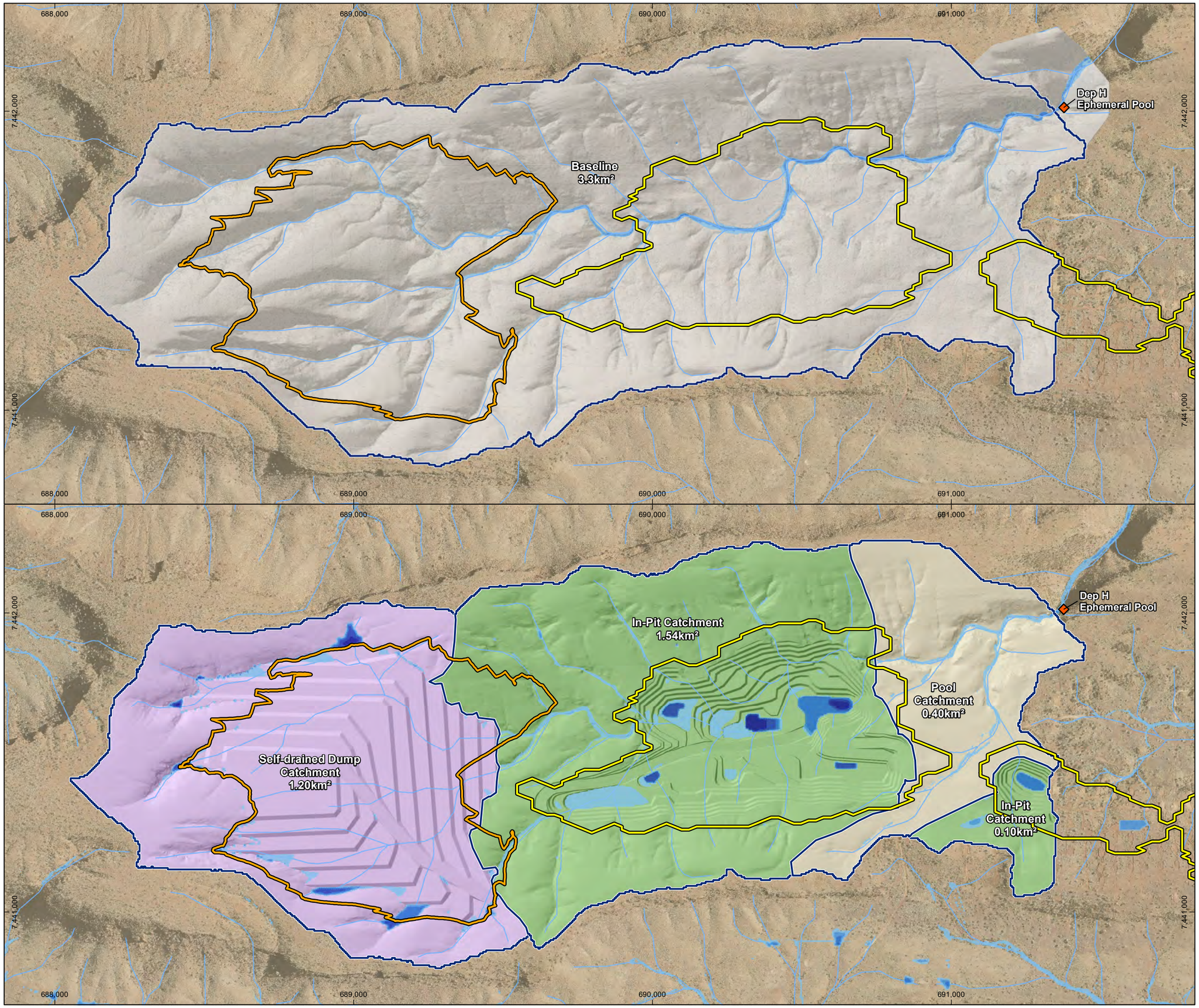
RioTinto

Figure 1-8
Deposit H Waterhole Pre- and Post-development Impact Modelling (88% mpact)

Drawn: A.D.
Plan: RTIO-0983843v2
Date: November 2023

Proj: GDA 1994 MGA Zone 50
Scale: 1:12,000 @A3
GIS.Team@riotinto.com



Legend

Proposed Conceptual Layout

- Pit
- Waste Landform

Flood Impact Modelling

1:100 AEP Flood - Depth (m)

- 0 - 0.1
- 0.1 - 0.5
- 0.6 - 1
- 1.1 - 2
- 2.1 - 5
- 5.1 - 10

Catchment

- In-pit
- Pool
- Self-drained Dump

- Sensitive Receptor
- Pool Catchment
- Minor Creek

N

0 100 200 300 400 500
Metres

Map units in metres

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Table 1-5: Cave Structures Currently Restricted and Excluded in MS 1113

Cave Category	Cave ID	Ground Disturbance and Peak Particle Velocity (PPV) Limits	Monitoring
MS 1113 / DN 2018/8299 Restrictions			
Category 3	I1 L2* L3 WA-17 WA-20 A1# WA-12# WA-22*#	Minimise disturbance 50 mm/s PPV for WA-17 75 mm/s PPV for L2, L3, WA-12 and WA-20, A1	• Vibration (when triggered by blasting or mining operations are within 300 m of roost; refer Table 2-b) • Quarterly visual inspection where blast vibration levels exceed criteria • Annual assessment of evidence of presence/absence of Ghost Bat use (refer Table 2-b)
Category 4	A2 WA-09 WA-10 WA-11	Minimise disturbance 75 mm/s PPV for category 4 cave	• Vibration (when triggered by blasting or mining operations are within 300 m of roost; refer Table 2-b) • Quarterly visual inspection where blast vibration levels exceed criteria • Annual assessment of evidence of presence/absence of Ghost Bat use (refer Table 2-b)
MS 1113 / DN 2018/8299 Exclusion Area			
Category 2	AA1 WA-13* WA-21 WA-23*	Ground disturbance is restricted to within 100 m of retained category 2 cave. 40 mm/s PPV for Cave AA1 25 mm/s PPV for Cave WA-21	• Vibration (when triggered by blasting or mining operations are within 300 m of roost; refer Table 2-b) • Quarterly visual inspection where blast vibration levels exceed criteria • Annual assessment of evidence of presence/absence of Ghost Bat use (category 2 caves)
Category 3	CMAR-02* CMAR-03* CMAR-04*	N/A PPV levels not applicable to these caves as they are located greater than 300 m from the closest pit	Nil
Category 4	CMAR-01*	N/A PPV levels not applicable to this cave as it is located greater than 300 m from the closest pit	Nil

**PPV levels not applicable to these caves as they are located greater than 300 m from the closest pit*

#Caves A1, WA-12 and WA-22 have been downgraded from Category 2 to category 3 since initial assessment based on ongoing monitoring; however, the management has not altered

Table 1-6: Proposed MEZ and MRZ Noise and Vibration Limits for Cave Structures in Proposal Area

Cave Category	Cave ID	Mining Restriction Zone and Mining Exclusion Zone	Peak Particle Velocity (PPV)	Monitoring
Apartment Block – Primary Roosts	CWAN-04	MRZ: Low impact~ activities permitted within 150–100 m of primary category 2 roost MEZ: Direct disturbance is not permitted^ within 100 m of primary category 2 roost	10 mm/s PPV during maternity months (1 October to 31 December), or 25 mm/s PPV in non-maternity months LZ_{10}>70 db(Z) over a one hour period	• Vibration (when triggered by blasting or mining operations are within 300 m of roost; refer Table 2-2a) • Quarterly visual inspection where blast vibration levels exceed criteria • Temperature & Humidity (structural integrity assessment if triggered; refer Table 2-2a)
Apartment block – Secondary Roosts	CWAN-01 CWAN-02 CWAN-03	MRZ: Low impact~ activities permitted within 150–100 m of secondary category 3 roost MEZ: Direct disturbance is not permitted^ within 100 m of secondary category 3 roost	10 mm/s peak particle velocity (PPV) during maternity months (1 October to 31 December), or 25 mm/s PPV in non-maternity months LZ_{10}>70 db(Z) over a one hour period	• Vibration (when triggered by blasting or mining operations are within 300 m of roost; refer Table 2-2a) • Quarterly visual inspection where blast vibration levels exceed criteria • Temperature & Humidity (structural integrity assessment if triggered; refer Table 2-2a)
Isolated Category 2	CWAN-06 CWAN-07	MRZ: Low impact~ activities permitted within 150–100 m of isolated category 2 roost MEZ: Direct disturbance is not permitted^ within 100 m of isolated category 2 roost	10 mm/s PPV during maternity months (1 October to 31 December), or 25 mm/s PPV in non-maternity months LZ_{10}>70 db(Z) over a one hour period	• Vibration (when triggered by blasting or mining operations are within 300 m of roost; refer Table 2-2a) • Quarterly visual inspection where blast vibration levels exceed criteria • Temperature & Humidity (structural integrity assessment if triggered; refer Table 2-2a)
Retained Category 3	CWAN-29 CWAN-31	MRZ: Low impact~ activities permitted within 65–75 m of retained category 3 roost MEZ: Direct disturbance is not permitted^ within 65 m of retained category 3 roost	50 mm/s PPV	• Vibration (when triggered by blasting or mining operations are within 300 m of roost; refer Table 2-2a) • Quarterly visual inspection where blast vibration levels exceed criteria • Temperature & Humidity (structural integrity assessment if triggered; refer Table 2-2a)

Cave Category	Cave ID	Mining Restriction Zone and Mining Exclusion Zone	Peak Particle Velocity (PPV)	Monitoring
Retained Category 4 within Category 3 cave MEZ/MRZ	CWAN-27 CWAN-28 CWAN-32	MEZ: Partial protection from overlap of nearby category 3 cave MEZ MRZ: Low impact~ activities permitted within 20 m of retained category 4 roost	N/A	Nil
Retained Category 4	CWAN-08 CWAN-11 CWAN-30 CWAN-34 CDHI-001 CDHI-002	MRZ: Low impact~ activities permitted within 20 m of retained category 4 roost	N/A	Nil

~ Disturbance can be up to 20% of MRZ for low impact activities to support monitoring, management and implementation of contingency actions (if required) as outlined in an approved EMP

^ except for activities that support monitoring, management and implementation of contingency actions (if required) as outlined in an approved EMP

2. EMP PROVISIONS

This section of the EMP identifies the provisions that the Proponent will implement to ensure that the defined environmental objectives are met during the implementation of the Revised Proposal. Outcomes-based and objective-based provisions are detailed in Table 2-1 to Table 2-8 and monitoring and reporting are further detailed in Section 2.1.

The EMP will be updated to align with the adaptive management approach (refer to Section 3).

Table 2-1: EMP Provisions Flora and Vegetation – Conservation Significant Ecological Communities and Vegetation

Flora and Vegetation
EPA objective: To protect flora and vegetation so that biological diversity and ecological integrity are maintained **Key environmental values:** West Angelas Cracking Clay PEC, vegetation adjacent to the West Angelas Rail Corridor including conservation significant vegetation and conservation estates **Key impacts and risks:** Potential adverse impacts on conservation significant vegetation as a result of clearing and introduction of weeds

Outcome-based Provisions				
Outcome: The Proponent shall ensure no direct or indirect disturbance to the West Angelas Cracking Clay Priority Ecological Community (PEC-2015-5) due to the Revised Proposal that results in an irreversible impact				
MODERATE MANAGEMENT LEVEL				
Environmental Criteria	**Response Action**	**Monitoring**	**Responsible**	**Reporting**
Trigger Criteria: 1. Clearing within 100 m of the mapped representation (West Angelas Cracking Clay PEC 2015-15) **OR** 2. Decline in relative abundance of key species[21] within the mapped representation since baseline not seen in reference sites **OR** 3. Establishment of new[22] high priority weed species previously not detected within the mapped representation **OR** 4. Significantly[23] increased extent of existing weed species within the mapped representation since baseline relative to reference sites	**Investigate potential cause of exceedance by review of:** • Internal incident reports relating to clearing • Land clearing reconciliation against mine plan • Hydrological assessment to determine whether clearing within 100 m of PEC 2015-5 will impact surface water drainage • Local and regional reference data, including rainfall, temperature, flooding and fire regime **If investigations indicate that the trigger exceedance is due to the Revised Proposal, implement trigger level actions, for example:** • Review mine plan and clearing procedures to minimise clearing approaching the PEC boundary • Implement weed management controls as appropriate for target species, size and location of population, considering the priority rating of species and feasibility of control • Update and improve weed control and hygiene procedures where appropriate • If appropriate, install additional barriers or signage to the boundaries of PEC 2015-5 **If assessments indicate the threshold criteria are likely to be exceeded and are due to the Revised Proposal, investigate contingency actions to be implemented should the threshold criteria be exceeded**	• Annual assessment of extent of representations using satellite and/or aerial imagery • Annual assessment of presence and abundance of key species (including weeds) at established representative locations[24] • Annual land clearing reconciliation compared against mapped representation	• Environment Operations supported by Biological Assessments Team	• The environmental objective will be reported against the trigger criteria for each calendar year by 30 April in the annual compliance assessment reporting (ACAR) • If any trigger criterion was exceeded during the reporting period, the ACAR will discuss potential reasons for exceedance of the trigger criterion and include a description of the effectiveness of trigger level actions
Threshold Criteria: 1. Clearing within the mapped representation (West Angelas Cracking Clay PEC 2015-5) **OR** 2. Loss of any key species present at baseline from 50 per cent or more of transects within the	**Implement previously determined threshold contingency actions within twenty-four (24) hours, for example:** • Cease clearing/disturbance within PEC 2015-5 • Undertake additional weed management adjacent to disturbed areas to prevent further indirect impacts due to ingress of weeds • Continue to implement threshold contingency actions until the CEO has confirmed by notice in writing that it		• Mining • Environment Operations supported by Biological Assessments Team	• Notify the CEO within 7 days and provide a report within 21 days of the non-compliance being known • The environmental objective will be reported against the ACAR's threshold criterion for each calendar year • If the threshold criterion was exceeded during the reporting period, the ACAR will

[21] Key species as defined in the description of the West Angelas Cracking Clay PEC, i.e. *Astrebla pectinata, Astrebla elymoides, Aristida latifolia* and *Sida fibulifera*

[22] Existing weed species as listed in 0

[23] Weed species occurring in significantly greater number of quadrats compared to baseline and reference (α=0.05)

[24] Sampling design to be determined

Outcome-based Provisions				
mapped representation as a result of direct or indirect disturbance from the Revised Proposal	has been demonstrated that the threshold criteria are being met • Monitor threshold contingency actions to validate success of mitigation strategy			include a description of the effectiveness of threshold contingency action/s implemented to manage the potential impact
Outcome: The Proponent shall ensure no more than 22 ha of direct or indirect disturbance due to the Revised Proposal to other representations of the West Angelas Cracking Clay Priority Ecological Community				
MODERATE MANAGEMENT LEVEL				
Environmental Criteria	**Response Action**	**Monitoring**	**Responsible**	**Reporting**
Trigger Criterion: Reduction in extent greater than 15 ha as a result of direct or indirect disturbance from the Revised Proposal	**Investigate potential cause of exceedance by review of:** • Internal incident reports relating to clearing • Land clearing reconciliation against mine plan • Local and regional reference data, including rainfall, temperature, flooding and fire regime **If investigations indicate that the trigger exceedance is due to the Revised Proposal, implement trigger level actions, for example:** • Undertake an assessment of vegetation composition and abundance of key species (including weeds) within and /or adjacent to disturbed areas to determine if further indirect impacts are likely • If warranted, implement weed management controls as appropriate for target species, size and location of population, considering the priority rating of species and feasibility of control • If appropriate, install additional barriers or signage to PEC boundaries **If assessments indicate the threshold criterion is likely to be exceeded and is due to the Revised Proposal, investigate contingency actions to be implemented should the threshold criteria be exceeded**	• Annual assessment of the extent of representations using satellite and/or aerial imagery • Annual land clearing reconciliation compared against extent of mapped representation • As triggered, annual assessment of presence and abundance of key species (including weeds) at selected locations[25]	• Mine Technical Services • Environment Operations supported by Biological Assessments Team	• The environmental objective will be reported against the trigger criteria for each calendar year by 30 April in the ACAR • If any trigger criterion was exceeded during the reporting period, the ACAR will discuss potential reasons for the exceedance of the trigger criterion and include a description of the effectiveness of trigger level actions
Threshold Criterion: Reduction in extent greater than 22 ha as a result of direct or indirect disturbance from the Revised Proposal	**Implement previously determined threshold contingency actions within twenty-four (24) hours for example:** • Cease clearing/disturbance within PEC boundaries • Undertake additional weed management adjacent to disturbed areas to prevent further indirect impacts due to the ingress of weeds • Review surface water management procedures to ensure hydrological flow regime is maintained Continue to implement threshold contingency actions until the CEO has confirmed by notice in writing that it has been demonstrated that the threshold criteria are being met Monitor threshold contingency actions to validate success of mitigation strategy			• Notify the CEO within 7 days and provide a report within 21 days of the non-compliance being known • The environmental objective will be reported against the threshold criterion for each calendar year in the ACAR • If the threshold criterion was exceeded during the reporting period, the ACAR will include a description of the effectiveness of threshold contingency action/s implemented to manage the potential impact

[25] If triggered, certain locations established at baseline will be selected adjacent to disturbance to focus on areas most susceptible to further indirect impacts.

Outcome-based Provisions				
Objective: The Proponent shall avoid where possible, or otherwise minimise the introduction to and spread of weeds due to the Revised Proposal within the West Angelas Rail Corridor				
Weeds within the West Angelas rail corridor; adjacent to Karijini National Park, Millstream-Chichester National Park, Themeda Grasslands on Cracking Clays TEC, Brockman Cracking Clay and Wona Land System PEC's (Figure 1-4**)**				
LOW MANAGEMENT LEVEL				
Management Actions	**Management Targets**	**Monitoring**	**Responsible**	**Reporting**
Implementation of an adaptive annual weed control program[26] along the rail corridor; majority of control effort to be prioritised in these areas of the rail corridor; where possible timing of control efforts will be optimised based on environmental conditions (e.g., following rain events) Implementation of equipment hygiene procedures to ensure equipment is cleaned to minimise the introduction and spread of weeds Annual review of weed management effectiveness and future priorities in consultation with the Department of Biodiversity, Conservation and Attractions	No establishment of new[27] high priority weed species within the West Angelas rail corridor adjacent to national parks, TECs and PECs due to the Revised Proposal No consecutive increase in the extent of high priority weed species within the West Angelas rail corridor adjacent to national parks, TECs and PECs, over three years due to the Revised Proposal	• Annual collation of weed species presence and extent during control events • Annual monitoring of known weed- free areas[28] • Annual audit of weed control effort • Audit equipment hygiene records	• Environment Operations supported by Biological Assessments Team	• The environmental objective will be reported against the management target for each calendar year by 30 April in the ACAR • If the management targets were not achieved during the reporting period, the ACAR will discuss potential reasons and the improvements or additional controls that will be applied (if required)
Weeds within other areas of the West Angelas rail corridor (Figure 1-4**)**				
Management Actions	**Management Targets**	**Monitoring**	**Responsible**	**Reporting**
Implementation of an adaptive annual weed control program along the rail corridor; control effort to be targeted to areas of elevated significance[29] (e.g., adjacent to creeklines and/or vegetation in good to excellent condition, as appropriate); where possible timing of control efforts will be optimised based on environmental conditions (e.g., following rain events) Implementation of equipment hygiene procedures to ensure equipment is cleaned to minimise the introduction and spread of weeds Annual review of weed management effectiveness and future priorities in consultation with the Department of Biodiversity, Conservation and Attractions	No establishment of new[26] high priority weed species within the West Angelas rail corridor, adjacent to other targeted significant areas due to the Revised Proposal	• Annual collation of weed species presence and extent during control events • Three yearly monitoring of known weed-free areas[12] • Audit equipment hygiene records • Annual audit of weed control effort	• Environment Operations supported by Biological Assessments Team	• The environmental objective will be reported against the management target for each calendar year by 30 April in the ACAR • If the management targets were not achieved during the reporting period, the ACAR will discuss potential reasons and the improvements or additional controls that will be applied (if required)

[26] Data collected during the first three years of the weed control program will be used in consultation with DBCA to inform priority areas, species and timing for future control programs

[27] New species based on the weed inventory compiled in the initial three years of control i.e., new species found after three years of data collection

[28] Weed free areas are to be determined from data collected during the first three years of the weed control program

[29] Areas of elevated conservation significance will be determined from the data collected during the first three years of the weed program, in consultation with DBCA

Table 2-2a: EMP Provisions Terrestrial Fauna – Ghost Bat Roosts - Proposal

Terrestrial Fauna
EPA objective: To protect terrestrial fauna so that biological diversity and ecological integrity are maintained **Key environmental values:** Habitat of conservation significant fauna species – Ghost Bat roosts **Key impacts and risks:** Potential loss of degradation of high significance roosting habitat as a result of implementation of the Revised Proposal

Outcome-based Provisions					
Outcome: The Proponent will avoid direct and significant indirect impacts to Ghost Bat roosts retained within Mining Restriction Zones (MRZ) and Mining Exclusion Zones (MEZ) attributable to the Proposal to maintain ecological function of the retained Ghost Bat roosts (Figure 2-1)					
HIGH MANAGEMENT LEVEL					
Indicators	**Response Actions**	**Monitoring**	**Timing/Frequency**	**Responsible**	**Reporting**
Early Response Criteria Mining activities approach within 30 m of an MRZ (as per Table 1-6)	Investigate by review of: • In-field inspections • Site specific observations, e.g., clearing extent	• Land clearing reconciliation (against GIS exclusion and disturbance layers) to ensure the cave buffers are not impacted or entered without authorisation • Aerial image capture (satellite or Remotely Piloted Aircraft) • Annual review of internal incident reporting and internal approval request process	• Annual, or as triggered by clearing reconciliation • Bi-annual imagery captures and analysis	• Environment Operations Team supported by Biological Assessments Team	• The environmental objective will be reported against the trigger criteria for each calendar year by 30 April in the ACAR
Trigger Criterion: 1. Direct disturbance within 150 m (but not closer than 100 m) of retained category 2 Ghost Bat roosts (Table 1-6)	**Investigate potential cause of exceedance by review of:** • In-field inspections • Site specific observations, e.g., clearing extent • Review of mine plan	• Annual land clearing reconciliation against Ghost Bat roosts, MRZs and MEZs • Annual review of incidents of unauthorised access to the identified MRZs and MEZs	• Annual, or as triggered by clearing reconciliation • Bi-annual imagery captures and analysis	• Environment Operations Team supported by Biological Assessments Team • Drill and Blast team	• The environmental objective will be reported against the trigger criteria for each calendar year by 30 April in the ACAR • If any trigger criterion was exceeded during the reporting period, the ACAR will discuss potential reasons for the exceedance of the trigger criterion and include a description of the effectiveness of the trigger level actions
Trigger Criterion: 2. Blast vibration or operational noise levels exceed set levels (as per Table 1-6): • Primary Apartment block roosts (CWAN-04) Secondary Apartment block roosts (CWAN-01, 02 and 03), Isolated Category 2 caves (CWAN 06 and 07) – 10 mm/s PPV during breeding months (1 October to 31 December) or 25 mm/s PPV during non-breeding months • Category 2 caves (CWAN-04, 06 and 07) and Category 3 caves within an apartment block (CWAN-01, 02 and 03) – L_{Z10}>70 db(Z) over 1 hour limit attributed to the proposal • Retained Category 3 caves (CWAN-29 and 31) – 50 mm/s PPV OR	**Investigate potential cause of exceedance by review of:** • Blast vibration and noise monitoring data • Other monitoring and supporting data, e.g., seasonal, climatic data, mine plan • Temperature and humidity monitoring data to determine if the roost cave microclimate has been compromised • Other monitoring and supporting data e.g., seasonal, climatic data, mine plan **If investigations indicate the trigger exceedance is due to the Revised Proposal, implement trigger level actions, for example:** • Cease disturbance within 150 m of Ghost Bat clearing exclusion zones • Visual inspection where blast vibration levels exceed criteria • Alter short-term mine plan to avoid blasting activities within 300 m	• Blast vibration monitoring for all blasts within 300 m of Apartment block primary and secondary roosts and retained Category 3 roosts (as detailed in Table 1-6), including: • Noise monitoring for Category 2 caves CWAN-04, 06 and 07 and Category 3 caves within an apartment block (CWAN-01, 02 and 03) • Temperature and humidity monitoring at Primary and secondary apartment block, and retained category 2 and 3 Ghost Bat roosts within 300 m of cave activities (Table 1-6)	• Event based, all blasts within 300 m of cave/s • Continuous noise (device dependant) monitoring, with quarterly analysis at Category 2 and 3 (within an apartment block) Ghost Bat roosts within 300 m of activities and other significant roosts	• Environment Operations Team supported by Biological Assessments Team • Drill and Blast team • Mine Technical Services	• The environmental objective will be reported against the trigger criteria for each calendar year by 30 April in the ACAR • If any trigger criterion was exceeded during the reporting period, the ACAR will discuss potential reasons for the exceedance of the trigger criterion and include a description of the effectiveness of the trigger level actions

Outcome-based Provisions					
3. Decline in visual structural integrity[30] at any retained Category 2 (CWAN-04, 06 and 07) and Category 3 (CWAN-01, 02, 03, 29 and 31) Ghost Bat roosts	• Review and update blast model • Re-assess work practices and training needs • Conduct structural assessment of cave entrance • Review blasting model and blast management procedures • Analyse call activity data from same period for evidence of impact from noise and vibration • Undertake any practical corrective rehabilitation (e.g., removal of significant rockfall or sealing of significant fractures)				
Threshold Criterion: 1. Direct Disturbance within 100 m of retained (category 2) Ghost Bat roosts (Table 1-6)	Implement initial threshold response actions within 24 hours of exceedance being identified, including: • Cease all disturbance within 300 m of cave/s Implement trigger response actions as detailed above. Implement measures as agreed by relevant stakeholders. Continue to implement threshold contingency actions until the CEO has confirmed by notice in writing that it has been demonstrated that the threshold criteria are being met. Monitor threshold contingency actions to validate success of mitigation strategy.	• Annual land clearing reconciliation against Ghost Bat roosts, MRZs and MEZs • Annual review of incidents of unauthorised access to the identified MRZs and MEZs	• Annual, or as triggered by clearing reconciliation • Bi-annual imagery captures and analysis	• Environment Operations Team supported by Biological Assessments Team • Drill and Blast team	• Notify the CEO within seven (7) days and provide a report within 21 days of the non-compliance being known • The environmental objective will be reported against the threshold criterion for each calendar year in the ACAR • If the threshold criterion was exceeded during the reporting period, the ACAR will include a description of the effectiveness of threshold contingency action/s implemented to manage the potential impact
Threshold Criterion: 2. Significant damage[31] to any retained Ghost Bat caves (CWAN-01, 02, 03, 04, 06, 07, 08, 11, 27, 28, 29, 30, 31, 32, 34, CDHI-001 and 002), supported step change in microclimate (temperature and humidity) data, attributable to the Proposal (Table 1-6)	Implement initial threshold response actions within 24 hours of exceedance being identified, including: • Cease blasting activities within 300 m of cave/s Implement trigger response actions as detailed above. Implement measures as agreed by relevant stakeholders. Continue to implement threshold contingency actions until the CEO has confirmed by notice in writing that it has been demonstrated that the threshold criteria are being met. Monitor threshold contingency actions to validate success of mitigation strategy.	• Blast vibration monitoring for all blasts within 300 m of Apartment block primary and secondary roosts and retained Category 3 roosts (as detailed in Table 1-6), including: • Noise monitoring for Category 2 caves CWAN-04, 06 and 07 and Category 3 caves within an apartment block (CWAN-01, 02 and 03) • Temperature and humidity monitoring at Primary and secondary apartment block, and retained category 2 and 3 Ghost Bat roosts within 300 m of cave activities (Table 1-6)	• Event based, all blasts within 300 m of cave/s • Quarterly (or as triggered), for Ghost Bat caves within 300 m of proposed pits • Continuous (device dependant) monitoring, with quarterly analysis at Ghost Bat roosts within 300 m of activities and other significant roosts	• Environment Operations Team supported by Biological Assessments Team • Drill and Blast team	• Notify the CEO within seven (7) days and provide a report within 21 days of the non-compliance being known • The environmental objective will be reported against the threshold criterion for each calendar year in the ACAR • If the threshold criterion was exceeded during the reporting period, the ACAR will include a description of the effectiveness of threshold contingency action/s implemented to manage the potential impact

[30] Structural integrity is defined as a negative change to the integrity of the cave. The trigger will be exceeded where changes are observed after a blast event for which a vibration level criteria is exceeded, including significant rockfalls (in comparison to baseline data).

[31] Significantly damage is considered to be damage that negatively impacts the structural integrity of the cave such that the future use of the site is prevented.

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Figure 9-13
Mine Restriction and Exclusion Zones, Roosts and Water Features

Drawn: A.D.
Plan: RTIO-0955058v2
Date: March 2023
Proj: GDA 1994 MGA Zone 50
Scale: 1:120,000 @A3
GIS.Team@riotinto.com

660,000 670,000 680,000 690,000
7,450,000 7,440,000 7,430,000

CWAN-30 CWAN-28 CWAN-27 CWAN-29
0 50 100 Metres

0 25 50 Metres
CDHI-001 A2 A1

0 25 50 Metres
CDHI-002

Great Northern Highway

Karijini National Park

CWAN-02 CWAN-03 CWAN-01 CWAN-33 Western Hill CWAN-07 CWAN-06 CWAN-05 CWAN-26 CWAN-04 CWAN-32 CWAN-31 CWAN-30 CWAN-28 CWAN-29 CWAN-27

CDHI-001 A2 A1 L3 L2 I1 CDHI-002 Deposit B

Dep H Ephemeral Pool Deposit H Turtle Pool CWAN-09

Turee Creek East Branch

WA-09 WA-10 WA-11 WA-12 WA-22 WA-23 WA-21 WA-13 WA-20 WA-17 Deposit C Deposit G Deposit D

CMAR-02 CMAR-01 CMAR-04 CMAR-03 WMAR-01 WMAR-03

Deposit A West Deposit A Deposit F North Deposit F AA1 Deposit E

CWAN-34 CWAN-08 Mt Ella East WB-WAJ2 WB-WAJ1 CWAN-11

0 200 400 Metres
CWAN-07 Western Hill CWAN-33 CWAN-06 CWAN-01 CWAN-02 CWAN-03 CWAN-32 CWAN-04 CWAN-31

0 25 50 Metres
CWAN-34 CWAN-08

0 25 50 Metres
CWAN-11

Legend

- Revised Development Envelope
- Mining Exclusion Zone
- Mining Restriction Zone

Proposed Conceptual Layout
- Pit
- Waste Landform

Approved Conceptual Layout
- Pit
- Waste Landform

- Water Feature

Caves
- Category 2
- Category 3
- Category 4

Fauna Habitat
- Drainage Line
- Cracking Clay
- Gorge/Gully
- Footslopes and Plains
- Hillcrest and Hillslope
- Mixed Acacia Woodland
- Disturbed

- National Park
- Rio Tinto Railway
- Highway
- Major Creek

N
0 1 2 3 4 5 Kilometres
Map units in metres

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Table 2-2b: EMP Provisions Terrestrial Fauna – Ghost Bat Roosts - Approved Proposal

Terrestrial Fauna
EPA objective: To protect terrestrial fauna so that biological diversity and ecological integrity are maintained **Key environmental values:** Habitat of conservation significant fauna species – Ghost Bat roosts **Key impacts and risks:** Potential loss of degradation of high significance roosting habitat as a result of implementation of the Revised Proposal

Outcome-based Provisions					
Outcome: The Proponent will avoid direct impacts to Ghost Bat roosts within exclusion zones and minimise indirect impacts to Ghost Bat roosts attributable to the Approved Proposal					
MODERATE MANAGEMENT LEVEL					
Indicators	**Response Actions**	**Monitoring**	**Timing/Frequency**	**Responsible**	**Reporting**
Trigger Criterion: 1. Ground disturbance within 150 m (but not closer than 100 m) of retained category 2 roosts (Table 1-5)	**Investigate potential cause of exceedance by review of:** • In-field inspections **If investigations indicate the trigger exceedance is due to the Revised Proposal, implement trigger level actions, for example:** • Cease disturbance within 150 m of Ghost Bat clearing exclusion zones	• Annual land clearing reconciliation against Ghost Bat roosts, MRZs and MEZs • Annual review of incidents of unauthorised access to the identified MRZs and MEZs	Annual or as triggered	• Environment Operations supported by Biological Assessments Team	• The environmental objective will be reported against the trigger criteria for each calendar year by 30 April in the ACAR (DWER and DCCEEW) • If any trigger criterion was exceeded during the reporting period, the ACAR will discuss potential reasons for the exceedance of the trigger criterion and include a description of the effectiveness of the trigger level actions
Trigger Criterion: 2. Blast vibration levels exceed (as per Table 1-5: • 25 mm/s PPV for WA-21 (category 2) • 40 mm/s PPV for AA1 • 50 mm/s PPV for WA-17 (category 3) • 75 mm/s PPV for L2, L3, WA-12, WA-20 and A1 (category 3) and category 4 roosts	**Investigate potential cause of exceedance by review of:** • Site specific observations; clearing extent, blast vibration predictions • Blast vibration monitoring data • Other monitoring and supporting data, e.g., seasonal, climatic data, mine plan **If investigations indicate the trigger exceedance is due to the Revised Proposal, implement trigger level actions, for example:** • Alter short-term mine plan to avoid blasting activities within 300 m • Update blast model and blast management procedures	• Blast vibration monitoring for all blasts within 300 m of roosts • Quarterly visual inspection where blast vibration levels exceed criteria • Annual assessment of evidence of presence / absence of Ghost Bat use within Caves AA1, A1, A2, L2, L3, WA-9, WA-10, WA-11, WA-12, WA-13, WA-17, WA-20, WA-21, WA-22 and WA-23	Annual or as triggered	• Environment Operations supported by Biological Assessments Team	• The environmental objective will be reported against the trigger criteria for each calendar year by 30 April in the ACAR (DWER and DCCEEW) • If any trigger criterion was exceeded during the reporting period, the ACAR will discuss potential reasons for the exceedance of the trigger criterion and include a description of the effectiveness of the trigger level actions
Threshold Criterion: 1. Disturbance within 100 m of retained (category 2) Ghost Bat roosts (Table 1-5)	Implement initial threshold response actions within 24 hours of exceedance being identified, including: • Cease blasting activities within 300 m of cave/s Implement trigger response actions as detailed above. Implement measures as agreed by relevant stakeholders. Continue to implement threshold contingency actions until the CEO has confirmed by notice in writing that it has been demonstrated that the threshold criteria are being met.	• Annual land clearing reconciliation against Ghost Bat roosts, MRZs and MEZs • Annual review of incidents of unauthorised access to the identified MRZs and MEZs	As triggered	• Environment Operations supported by Biological Assessments Team	• seven days and provide a report within 21 days of the non-compliance being known • The environmental objective will be reported against the threshold criterion for each calendar year in the ACAR • If the threshold criterion was exceeded during the reporting period, the ACAR will include a description of the effectiveness of threshold contingency action/s implemented to manage the potential impact
Threshold Criterion: 2. Significant damage to retained Ghost Bat roosts (Table 1-5)	Implement initial threshold response actions within 24 hours of exceedance being identified, including: • Cease blasting activities within 300 m of cave/s	• Blast vibration monitoring for all blasts within 300 m of roosts	As triggered	• Environment Operations supported by Biological	• Notify the CEO and DCCEEW within seven days and provide a report within

Outcome-based Provisions					
	Implement trigger response actions as detailed above. Implement measures as agreed by relevant stakeholders. Continue to implement threshold contingency actions until the CEO has confirmed by notice in writing that it has been demonstrated that the threshold criteria are being met. Monitor threshold contingency actions to validate success of mitigation strategy.	• Quarterly visual inspection where blast vibration levels exceed criteria • Annual assessment of evidence of presence / absence of Ghost Bat use within Caves AA1, A1, A2, L2, L3, WA-9, WA-10, WA-11, WA-12, WA-13, WA-17, WA-20, WA-21, WA-22 and WA-23		Assessments Team	21 days of the non-compliance being known • The environmental objective will be reported against the threshold criterion for each calendar year in the ACAR • If the threshold criterion was exceeded during the reporting period, the ACAR will include a description of the effectiveness of threshold contingency action/s implemented to manage the potential impact

Table 2-3: EMP Provisions for Ghost Bat

Terrestrial Fauna
EPA objective: To protect Ghost bats so that biological diversity and ecological integrity are maintained **Key environmental values:** Ghost Bat critical and supporting habitat **Key impacts and risks:** Potential loss Ghost Bat population (for Objectives related to all EPBC listed species refer to Table 2-8)

Supporting/Complementary Provisions for Threatened Fauna Management (Proposal Area)					
Management Targets	**Response Actions**	**Monitoring**	**Timing/Frequency**	**Responsible**	**Reporting**
Demonstrate the ongoing presence of Ghost Bat within the Revised Development Envelope	Supporting parameter review will inform the assessment and review of targets and actions	Acoustic OR camera OR observation AND/OR secondary evidence records presence (device dependent) and assessment at significant Cat 2 Ghost Bat roosts selected for long-term monitoring	Annual or opportunistic, for five to ten nights Bi-annual (device and access dependent)	Environment Operations supported by Biological Assessments Team	NA
Collection of local climatic data at West Angelas	Supporting parameter review will inform the assessment and review of targets and actions	Weather station at West Angelas, including rainfall data and wind direction, to determine local climatic conditions	Continuous	Environment Operations	NA

Table 2-4: EMP Provisions Inland Waters – Surplus Water Discharge and Riparian Vegetation

Inland Waters				
EPA objective: To maintain the hydrological regimes and quality of groundwater and surface water so that environmental values are protected **Key environmental values:** Riparian vegetation of Turee Creek East **Key impacts and risks:** Potential adverse impact on native riparian vegetation as a result of surplus water discharge				
Outcome-based Provisions				
Outcome: The Proponent shall ensure there is no irreversible impact to the health of riparian vegetation of Turee Creek East as a result of the discharge of surplus water				
LOW MANAGEMENT LEVEL				
Environmental Criteria	**Response Actions**	**Monitoring**	**Responsible**	**Reporting**
Trigger Criteria: 1. Greater than 10 per cent increase in the proportion of Eucalyptus *victrix* canopy area within the maximum predicted surface discharge extent in Turee Creek East that falls below the MSAVI baseline 5th percentile[32] in comparison to reference sites and the trend continues over two consecutive annual monitoring events **OR** 2. Establishment of new[33] high priority weed species within the maximum predicted surface discharge extent in Turee Creek East or the discharge tributary, previously not detected in Turee Creek East within the Revised Development Envelope **OR** 3. Significantly[34] increased extent of existing high priority weed species within the maximum predicted surface discharge extent in Turee Creek East or the discharge tributary since baseline relative to reference sites	**Investigate potential cause of exceedance by review of:** <u>All trigger criteria:</u> • Discharge regime, frequency, extent, and timing • Hydrological model • Local and regional reference data, including rainfall, temperature, flooding and fire regime <u>Trigger criteria 1:</u> • Visual census of remote sensing imagery to confirm areas of canopy health exceedance • If the above step confirms exceedance, undertake on-ground assessment of canopy condition and cover to ground truth areas of exceedance detected in remote sensing imagery • If the above step also confirms exceedance, assess seasonal trends (Sentinel imagery) and longer term and regional trends (Landsat imagery) • If the above step also confirms exceedance, capture high resolution topography data (LiDAR) of monitoring areas to determine presence/absence and extent of canopies • Review and revise current MSAVI trigger levels as appropriate **If investigations indicate that trigger exceedance is due to the Revised Proposal and may continue to be exceeded with no indication of recovery, implement trigger level actions, for example:** <u>All criteria</u> • Instigate annual on-ground monitoring of the condition, cover and health of riparian vegetation (overstorey and understorey, including weeds) within Turee Creek East and reference sites	• Visual recording of observed surface discharge extent in natural no-flow conditions using remote monitoring cameras (Figure 1-6) • Annual (dry season) assessment of canopy condition and cover using satellite imagery within the maximum predicted surface discharge extent in Turee Creek East and reference sites • Annual weed survey (wet season) at selected established location[35] within the maximum predicted surface discharge extent in Turee Creek East, the discharge tributary and reference sites • As triggered, annual (wet season) condition, cover and health of riparian vegetation (overstorey and understorey, including weeds) at selected established locations within the maximum predicted surface discharge extent in Turee Creek East[36] and reference sites • As triggered, high resolution topography data (LiDAR) capture to assess presence/absence and total canopy extent	• Environment Operations supported by Biological Assessments Team	• The environmental objective will be reported against the trigger criteria for each calendar year by 30 April in the ACAR • If any trigger criterion was exceeded during the reporting period, the ACAR will discuss potential reasons for exceedance of the trigger criterion and include a description of the effectiveness of trigger level actions

[32] Refer to 0 for baseline values. The Proponent will update criteria after baseline monitoring is complete, and as knowledge develops based on empirical observations of tree health and/or improvements in monitoring methodology

[33] Existing weed species as listed in 0

[34] Weed species occurring in significantly greater number of quadrats compared to baseline and reference (α=0.05)

[35] Locations will be selected from transects monitoring during baseline based on observed surface discharge extent and accessibility

[36] 'As triggered' locations will be selected from transects monitored during baseline based on location of trigger exceedance, observed surface discharge extent and accessibility

Outcome-based Provisions				
	Trigger criteria 1: • Temporarily change the frequency/duration of the discharge as warranted Trigger criteria 2 and 3: • Instigate weed management controls as appropriate for target species, size and location of population and considering the feasibility of control • Update and improve where appropriate, weed management controls for target species, size and location of population • Monitor to ensure control measures have been successful **If assessments indicate threshold criteria are likely to be exceeded and are due to the Revised Proposal, investigate contingency actions to be implemented should the threshold criteria be exceeded**			
Threshold Criteria: 1. Greater than 50 per cent of the *Eucalyptus victrix* canopy area within the maximum predicted surface discharge extent in Turee Creek East is below the MSAVI baseline 5th percentile; trend continues over two consecutive monitoring events; with no evidence of seasonal recovery; and outside of variation observed within extended baseline period, in comparison to reference sites **OR** 2. Significant structural or compositional change[37] to channel and terrace habitats of Turee Creek East over 50 per cent of the maximum predicted surface discharge extent, in comparison to baseline and trends different to reference sites	**Commence previously determined threshold contingency actions within twenty-four (24) hours, for example:** • Use of alternative discharge location (subject to additional approval by DWER if required) • Use of a managed aquifer recharge system (including passive recharge in pit voids or planned managed aquifer recharge scheme for closure) to dispose of surplus dewatering water • If threshold exceedance is due to increased cover of weeds or other species augmented due to discharge, undertake additional control measures as warranted Continue to implement threshold contingency actions until the CEO has confirmed by notice in writing that it has been demonstrated that the threshold criteria are being met. Monitor threshold contingency actions to validate success of mitigation strategy.	• Visual recording of observed surface discharge extent in natural no-flow conditions using remote monitoring cameras (Figure 1-6) • Annual (dry season) assessment of canopy condition and cover using satellite imagery within the maximum predicted surface discharge extent in Turee Creek East and reference sites • Annual weed survey (wet season) at selected established locations within the maximum predicted surface discharge extent in Turee Creek East, the discharge tributary and reference sites • As triggered, annual (wet season) condition, cover and health of riparian vegetation (overstorey and understorey, including weeds) at selected established locations within the maximum predicted discharge extent in Turee Creek East and reference sites	• Environment Operations supported by Biological Assessments Team	• Notify the CEO within 7 days and provide a report within 21 days of the non-compliance being known • The environmental objective will be reported against the threshold criterion for each calendar year in the ACAR • If the threshold criterion was exceeded during the reporting period, the ACAR will include a description of the effectiveness of threshold contingency action/s implemented to manage the potential impact

[37] Change from baseline of i) two or more structural formation classes applied to National Vegetation Information System (NVIS) Level IV sub-formation, classes (ESCAVI 2003 and see Appendix 7) due to decreased or increased cover of native or weed species or ii) loss of native species listed as dominant at baseline within any of the upper, mid or ground vegetation (0)

Table 2-5: EMP Provisions Inland Waters – Deposit H Waterhole

Inland Waters
EPA objective: To maintain the hydrological regimes and quality of groundwater and surface water so that environmental values are protected **Key environmental values:** Deposit H Waterhole **Key impacts and risks:** Potential adverse impact on Deposit H Waterhole as a result of catchment impacts

Outcome-based Provisions				
Outcome: The Proponent shall ensure there is no irreversible impact to Deposit H Pool as a result of any impacts of the Proposal to the catchment				
MODERATE MANAGEMENT LEVEL				
Environmental Criteria	**Response Actions**	**Monitoring**	**Responsible**	**Reporting**
Early Response Indicator: 1. Retained surface catchment area of Deposit H Waterhole is reduced to less than 0.6 km^2	**Investigate early response indicator by review of:** • Mine planning within the Deposit H Waterhole catchment • Approval Requests (ARs), approved disturbance footprint and relevant GIS layers • Reconcile disturbance footprint	• Calculate the remaining contributing catchment to Deposit H Waterhole using up to date high resolution topography data (LiDAR) (Annual)	• Environment Operations supported by Water Resource Evaluation Team	• The environmental outcome will be reported against the early response indicator for each calendar year in the ACAR
Threshold Criteria: 1. Retained surface catchment area of Deposit H Waterhole is reduced to less than 0.4 km2	**Implement previously determined early response contingency actions plus:** • Review mine planning within the Deposit H Waterhole catchment and ensure at least 0.4 km2 as shown on figure Figure 1-8 will be retained at all times during operation and closure. • Supplement creek flows with clean water abstracted from Deposit H or other source during rainfall events. • Continue to implement threshold contingency actions until the CEO has confirmed by notice in writing that the impact is below threshold and trigger criteria • Monitor threshold contingency actions to validate success of contingency actions. • Rehabilitate landform to an extent where pre-disturbance surface water flows are re-established to the effective catchment size of 0.4 km^2.			

Supporting and complementary Monitoring to Support Knowledge and Criteria for Management of Deposit H Waterhole				
Deposit H Waterhole depth (pressure transducers located within Deposit H waterhole and upstream gully) and water quality (Deposit H Waterhole). Supporting parameter to increase knowledge of water quality and depth patterns at Deposit H Waterhole	To support baseline and operational knowledge of the Deposit H Waterhole a review of monitoring data against local or regional rainfall, climate and local catchment clearing (early response indicator) data will be undertaken.	• Pre and post wet season and monthly depth monitoring at Deposit H Pool at SW18WAN004 (Dep H Pool) and SW18WAN006 (upstream drainage line) over the wet season • Annual visual or camera time lapse inspection of Deposit H Waterhole for observation of potential impacts to fill level of the pool (device/access dependent) • Calculate the remaining contributing catchment to Deposit H Waterhole using up to date high resolution topography data (LiDAR) • Prior to clearing occurring within the Deposit H Waterhole catchment, target at least two years where possible (dependent on water presence in the Deposit H waterhole) of (quarterly) water quality monitoring to inform baseline conditions (This information and any changes to provisions	• Water Resource Evaluation Team supported by Environment Operations	• NA

Supporting and complementary Monitoring to Support Knowledge and Criteria for Management of Deposit H Waterhole				
		as a result, will be captured through an update to the approved EMP via the adaptive management process) • Monitor parameters in water for: o Field: Electrical Conductivity (EC), Dissolved Oxygen (DO), Oxidation Reduction Potential (ORP), pH o Lab: Total Suspended Solids (TSS), Total Dissolved Solids (TDS), Total Nitrogen, Total Phosphorus, Nitrate as N (NO3-N), Ammonium as N (NH3-N), Major Cations (Sodium, Potassium, Calcium and Magnesium), Major Anions (sulfate and chloride)		

Table 2-6: EMP Provisions Inland Waters – Turtle Pool

Inland Waters				
EPA objective: To maintain the hydrological regimes and quality of groundwater and surface water so that environmental values are protected **Key environmental values:** Turtle Pool **Key impacts and risks:** Potential adverse impact on Turtle Pool as a result of catchment impacts				
Outcome-based Provisions				
Outcome: The Proponent shall ensure there is no irreversible impact to Turtle Pool as a result of any impacts of the Proposal to the catchment				
LOW MANAGEMENT LEVEL				
Environmental Criteria	**Response Actions**	**Monitoring**	**Responsible**	**Reporting**
Trigger Criteria: 1. Water level in monitoring bore (WAH-M03) falls below lowest recorded pre mining water level[38] and is attributable to the Proposal	**Early Response Action:** **Investigate potential cause of exceedance by review of:** • Local and regional groundwater level data and climatic information to assess if groundwater trends in early response well indicate a potential risk to Turtle Pool • Review groundwater abstraction rate, number of bores and bore location **If investigations indicate that exceedance is due to the Proposal implement early response actions, for example:** • Initiate an options analysis with the aim of maintaining catchment flows to Turtle Pool at pre-mining levels in consultation with Traditional Owners (Ngarlawangga) • Revise rate and/or location of groundwater abstraction and adjust as necessary Review and recalibrate hydrogeological and hydrological models as required	• Monthly water level monitoring at ground water bore	• Water Resource Evaluation Team supported by Environment Operations	• The environmental objective will be reported against the trigger criteria for each calendar year by 30 April in the ACAR • If any trigger criterion was exceeded during the reporting period, the ACAR will discuss potential reasons for exceedance of the trigger criterion and include a description of the effectiveness of trigger level actions to prevent pool level decline
Threshold Criteria: 1. Turtle pool depth is below lowest recorded pre-mining depth over two consecutive wet seasons and is attributable to the Proposal	**Implement previously determined trigger contingency actions, plus:** • Implement supplementation strategy using water from a suitable source following investigations conducted as part of the trigger criteria actions • If groundwater level of the hydrolithic unit associated with pool recharge is impacted by an expanding cone of depression, investigate remedial options capable of raising the groundwater mounding in the area and implement preferred strategy Continue to implement threshold contingency actions until the CEO has confirmed by notice in writing that the impact is below threshold and trigger criteria Monitor threshold contingency actions to validate success of contingency actions	• Monthly depth monitoring at Turtle Pool in conjunction with supplementation volumes/rate (access dependent[39]) • Monthly water level monitoring at ground water bore • Quarterly visual or camera time lapse inspection of Turtle Pool for observation of potential impacts to fill level or frequency of the regime of the pool (device/access dependent)[41]	• Water Resource Evaluation Team supported by Environment Operations	• The proponent will notify the CEO within seven (7) days and provide a report within twenty-one (21) days of the non-compliance being known • The environmental objective will be reported against the threshold criterion for each calendar year in the ACAR • If the threshold criterion was exceeded during the reporting period, the ACAR will include a description of the effectiveness of threshold contingency action/s that have been implemented to manage the potential impact

[38] Minimum water level to be determined once sufficient baseline data, minimum 2 years factoring seasonal fluctuations, has been recorded and prior to disturbance at Deposit H

[39] Requires Ngarlawangga representative to escort or authorize access (for download of loggers and visual inspection). If escort or authorization cannot be secured, inspection/monitoring cannot be carried out and is not considered a non-compliance

Table 2-7: EMP Provisions Social Surroundings – Deposit H Waterhole Downstream Gully

Inland Waters
EPA objective: To maintain the hydrological regimes and quality of groundwater and surface water so that environmental values are protected **Key environmental values:** Deposit H Waterhole Downstream Gully **Key impacts and risks:** Potential adverse impact on Deposit H Pool as a result of catchment impacts

Outcome-based Provisions				
Outcome: The Proponent shall ensure there is no significant impact to vegetation downstream of the Deposit H Waterhole as a result of impacts to the reporting catchment				
LOW MANAGEMENT LEVEL				
Environmental Criteria	**Response Actions**	**Monitoring**	**Responsibility**	**Reporting**
Trigger Criteria[12]: 1. Decrease in vegetation density of TBD% in gully downstream of Deposit H Waterhole as measured by Annual MSAVI assessment over two consecutive monitoring periods.	**Investigate potential cause of trigger exceedance by review of:** <u>Trigger criteria:</u> • All upstream flow and Deposit H pool monitoring data • Weather and climate data • Clearing within the catchment **If investigations indicate that trigger exceedance is due to the Proposal and may continue to be exceeded with no indication of recovery, implement trigger level actions, for example:** • Review and revise current trigger levels as appropriate • Minimise clearing within the catchment that supports Deposit H Waterhole • Investigate methods to maximise and/or reinstate catchment flows to the gully downstream of Deposit H Waterhole in consultation with Traditional Owners (Ngarlawangga) **If assessments indicate trigger criteria are likely to be exceeded and are due to the Proposal, investigate and consult with DWER to ensure the threshold actions remain appropriate**	• Annual MSAVI Assessment	• Environment Operations supported by Biological Assessments Team	• The environmental objective will be reported against the trigger criteria for each calendar year by 30 April in the ACAR • If any trigger criterion was exceeded during the reporting period, the ACAR will discuss potential reasons for exceedance of the trigger criterion and include a description of the effectiveness of trigger level actions
Threshold Criteria[12]: 1. Decrease in vegetation density of TBD% in gully downstream of Deposit H Waterhole as measured by Annual MSAVI assessment over two consecutive monitoring periods.	**Implement previously determined trigger contingency actions plus:** • Supplement gully flows with clean water abstracted from Deposit H or other source during rainfall events. Continue to implement threshold contingency actions until the CEO has confirmed by notice in writing that the impact is below threshold and trigger criteria Monitor threshold contingency actions to validate success of contingency actions	• Annual MSAVI Assessment	• Environment Operations supported by Biological Assessments Team	• Notify the CEO within 7 days and provide a report within 21 days of the non-compliance being known • The environmental objective will be reported against the threshold criterion for each calendar year in the ACAR • If the threshold criterion was exceeded during the reporting period, the ACAR will include a description of the effectiveness of threshold contingency action/s that have been implemented to manage the potential impact

Table 2-8: EMP Provisions - General Provisions for EPBC Act Listed Species

EPBC Act listed threatened species (Ghost Bat, Northern Quoll, Pilbara Leaf-nosed and Pilbara Olive Python)
Key environmental values: EPBC Act listed threatened species - Ghost Bat, Northern Quoll, Pilbara Leaf-nosed Bat and Pilbara Olive Python **Key impacts and risks:** Potential loss or degradation of high value habitat, or injury to MNES fauna, as a result of implementation of the Action **Outcome:** Minimise impacts to EPBC Act listed threatened species (Ghost Bat, Northern Quoll, Pilbara Leaf-nosed Bat and Pilbara Olive Python) associated with implementation of the Action

Management-based provisions					
Objective: Manage threatening processes associated with implementation of the Action, where relevant to minimising impacts to EPBC Act listed threatened species (Northern Quoll, Pilbara Leaf-nosed Bat, Ghost Bat and Pilbara Olive Python)					
Management Target	**Management Actions**	**Monitoring**			
		Method	**Location**	**Frequency/Timing**	**Responsibility**
Threatening Process - Fire					
1. Provision and maintenance of firefighting equipment in accordance with the relevant fire safety standards 2. Firefighting emergency response procedures are in place	• Appropriate firefighting equipment is to be available to control localised outbreaks of fire. Regular inspection and maintenance of firefighting equipment will be implemented to comply with relevant fire safety standards • Emergency response (firefighting) procedures are to be implemented to control fires arising as a result of implementation of the Project • Hot work permit system required to authorise all work scopes that are likely to produce a source of ignition (e.g., cutting, grinding, welding etc.)	• Inspection of firefighting equipment to ensure availability and compliance with fire safety standards • Inspection of hazard/incident records • Inspection of permit to work system records	Development Envelope	Annual, or as appropriate, during the operational mine life	• Safety Representatives • Emergency Services team
Threatening Process – Vehicle and Machinery Movement					
1. No incidents of vehicles being used off designated roads outside operational areas unless in the case of emergency or for necessary activities, that result in significant impacts to high value MNES habitat 2. Implementation of speed limits in areas identified as having high value for MNES fauna	• Vehicles and machinery to remain on designated roads unless in the case of emergency or for undertaking necessary activities • Roads and tracks signposted with speed limits and warnings of fauna in areas identified as having high value for MNES fauna • Prior to commencing clearing in high significance critical value habitats, consideration is given to planning/staging progressive clearing to allow fauna to safely leave the vicinity of clearing	• Inspection of incident records	Development Envelope	Annual, or as appropriate, during the operational mine life	• Mine Operations team
Threatening Process – Fauna Encounters/Interactions					
1. Induction material contains information relating to Northern Quoll, Pilbara Leaf-nosed Bat, Ghost Bat and Pilbara Olive Python 2. Records of all EPBC Act listed threatened species observed are appropriately maintained 3. Fauna handling is undertaken in accordance with Rio Tinto's Wildlife Interaction Guidelines and the requirements of the BC Act 4. No incidents of native fauna feeding, hunting or keeping of firearms or pets on site 5. Access to the MEZs/MRZs (which potentially contain significant roosts or caves) is restricted to	• All site personnel to be informed during their site induction of EPBC Act listed threatened species (Northern Quoll, Pilbara Leaf-nosed Bat, Ghost Bat and Pilbara Olive Python) that may occur on site, associated high value habitats and measures to be taken to minimise impacts to these values • Any EPBC Act listed threatened species encountered on site are to be recorded and records maintained for the Project. This will include locations, and animal status (alive/dead). EPBC Act listed threatened species' injury or fatality to be documented as an incident • If EPBC Act listed threatened fauna species are required to be moved, fauna are to be handled and transported in accordance with Rio Tinto's Wildlife Interaction Guidelines and the requirements of the BC Act • Feeding of native fauna, hunting, keeping of firearms[40] or pets on site is prohibited • Each MEZ/MRZs is to be demarcated on online systems. Consideration will be given to on ground demarcation where in	• Inspection of records, related to sightings, records, encounters and fauna removal • Review of MEZ/MRZs procedures restricting access to the MEZs/MRZs (where applicable) • Inspection of barbed wire installation to ensure reflectors are in place	Development Envelope	Annual, or as appropriate, during the operational mine life	• Training Department • Environment Operations team

1. [40] Excluding firearms for use in pastoral management activities or by licensed and authorised personnel (e.g., feral animal control contractors etc.)

Management Target	Management Actions	Monitoring			
		Method	Location	Frequency/Timing	Responsibility
authorised personnel and there are no incidents of unauthorised access 6. No use of barbed wire on site, except in the case of statutory requirements 7. Where barbed wire is used in accordance with statutory requirements, reflectors are installed	operational areas and where demarcation does not introduce potential risk to MNES species (and subject to Traditional Owner engagement) and access restricted to authorised personnel • Barbed wire use is to be avoided in the Revised Development Envelope, except where there is a legislative requirement to do so. Where barbed wire is required by legislation, reflectors are to be installed on the barbed wire				
Threatening Process - Weeds					
1. Compliance with equipment hygiene procedures 2. Weed control is informed and targeted 3. Induction material contains information relating weed management and control	• Weed management measures, including equipment hygiene procedures, are to be implemented to ensure weeds are recorded and controlled, and equipment is cleaned to minimise the spread of weeds: o Equipment hygiene inspection required for all earth moving vehicles, heavy machinery and drill rig equipment entering and leaving the Revised Development Envelope or moving between identified weed infestation areas to areas that are not infested o Where weed infested material is required to be removed, it will be disposed of appropriately. • A consultant will be engaged to assist in the development of a survey and control program to ensure a robust approach to identifying and managing introduced species within the Revised Development Envelope: o A baseline weed and introduced species survey will be commissioned to inform the survey and control program o The survey and control program will include a review to identify and target high risk areas (e.g., environmental value, existing weed presence, the status of weeds that are present, and potential for further transfer/dispersal, e.g., waterways and high trafficable areas) o Implement the targeted survey and control program at target high risk areas o Use the results of the survey and control program to inform targeted management o The results of the survey and outcomes of weed management will be reported annually in the Annual Compliance Assessment Report (including to DoCCEEW) • All site personnel are to be informed during their site induction of the risk of weeds and requirements for weed management to ensure the risk of introduction and weed spread are minimised	• Inspection of earth moving equipment and hygiene certificates • Inspections to assess material storage. • Targeted monitoring and management in high-risk areas (as identified by a consultant) • Inspection of induction material and records	High risk areas (as identified by a consultant)	• Inspection of earth moving equipment and hygiene certificates will be undertaken for the life of the Proposal • Monitoring and management frequency as determined by development of a survey and control program	• Environment Operations team • Mine Operations team and Environment Operations team • Training Department
Threatening Process – Feral Animals					
1. Feral animal control is informed and targeted 2. Feral animal control actions are implemented 3. Feral animal presence is discouraged 4. Induction material contains information relating feral animals	• A consultant will be engaged to assist in the development of a survey and control program to ensure a robust approach to identifying and managing feral animals, including feral cats, cane toads and European Red Fox within the Revised Development Envelope: o The survey and control program will include a review to identify and target high risk areas (e.g., environmental value, and potential for further transfer/dispersal). o The survey and control program will consider opportunities to utilise automated feral cat control technology (e.g., Felixers), or other technologies on the advice of consultants	• Targeted monitoring and management in high-risk areas (as identified by a consultant) • Inspection of records related to sightings, records, encounters and fauna removal • Inspection of induction material and records	High risk areas (as identified by a consultant) Construction village, plant and administration areas	Frequency as determined by the development of a survey and control program	• Environment Operations team • Training Department

Management Target	Management Actions	Monitoring			
		Method	Location	Frequency/Timing	Responsibility
	and regulators, in high value areas (subject to regulatory approval). o Survey results and incidental sightings will inform further targeted management. o Traditional trapping utilised as required in readily accessible areas (e.g., accommodation and waste storage facilities). o Survey results and incidental sightings will be reported in the Annual Compliance Assessment Reports to regulators (including to DoCCEEW) o Cane toads are not currently known within the nearby area. If cane toads were identified within the Revised Development Envelope in the future, they will be reported to the appropriate Western Australian authorities, including DBCA. Monitoring techniques and control technology at the time will be reviewed, in consult with consultants and regulators, to consider the most effective way to manage cane toads • Feral animal presence will be discouraged on site by: o Prohibiting feeding animals o Prohibiting keeping pets o Appropriate waste disposal for food scraps and other wastes as per the Rio Tinto waste management guidelines • During their site induction, all site personnel must be informed of potential feral animal species (including feral cats, European Red Fox and cane toad) that may occur on site, and are required to report sites immediately to site environmental representative				
Threatening Process – Nosie and Vibrations					
1. No disturbance, other than existing and authorised clearing, in the MEZ or MRZ 2. Implementation of blast management controls for Ghost Bat caves within 300 m of proposed pits 3. No blasting undertaken outside of daylight hours	• Implement Mining Exclusion Zones and Mining Restriction Zones to ensure potential high-value MNES habitat retention • Implement blast management where relevant to minimise potential impacts to Category 2 and Category 3 (within an apartment block, or isolated roosts) Ghost Bat caves from vibration associated with mining activities • All site personnel will be informed during their site induction of requirements for no blasting to be undertaken outside daylight hours	• Annual land clearing reconciliation against relevant MEZ and MRZ • Blast vibration monitoring for all blasts within 300 m of Category 2 and Category 3 (within an apartment block) Ghost Bat caves • Noise monitoring for Category 2 caves (CWAN-04, 06 and 07) and Category 3 caves within an apartment block (CWAN-01, 02 and 03)	Proposal Development Envelope	• Annual land clearing reconciliation • Noise and blast vibration monitoring – as required by distance from Category 2 and Category 3 within an apartment block specified Ghost Bat caves	• Environment Operations team • Mine Operations team • Drill and Blast team
Threatening Process – Dust and Light					
1. No disturbance, other than existing and authorised clearing[32], in the MEZ or MRZ 2. Lighting and dust management actions are implemented	• Delineate MEZ and MRZ in online systems to ensure potential high value MNES habitat is retained. Consideration will be given to on ground demarcation where in operational areas and where demarcation does not introduce potential risk to MNES species (and subject to Traditional Owner engagement) and access restricted to authorised personnel • Install permanent lighting only where required within operational areas • Permanent and temporary lighting will be shielded to minimise light spills. Permanent lighting will be directed away from sensitive areas (e.g., MEZ and MRZ, ghost bat caves etc.). Temporary lighting (e.g., trailer mounted units) may be required to provide safe working environments for short periods, where practicable and while still	• Annual land clearing reconciliation against relevant MEZ and MRZ	Proposal Development Envelope	• Land clearing reconciliation – annual	• Environment Operations team • Mine Operations team

Management Target	Management Actions	Monitoring			
		Method	Location	Frequency/Timing	Responsibility
	providing a safe work environment. These will be positioned to minimise direct light spill to sensitive areas • Manage dust emissions through: o Application of dust suppression methods, including water sprays, where applicable o Implementing blast management protocols where relevant to minimise potential impacts of dust to bat caves				

2.1. Reporting

For each calendar year in the Revised Proposal's Annual Compliance Assessment Report (ACAR), the environmental objectives will be reported against their associated trigger, threshold criteria, and management targets. A separate ACAR (reporting on MNES values) will be provided to the Department of Climate Change, Energy, the Environment and Water (DCCEEW).

The ACAR's will also include a summary of the analysis of monitoring data to facilitate adaptive management.

In the event that trigger criteria are exceeded or management targets are not met during the reporting period, it will be reported to the CEO and DCCEEW in the ACAR. The ACAR will include a description of the effectiveness of any management contingency actions that have been implemented to manage the impact.

In the event that a threshold criteria is exceeded, it will be reported to the CEO and DCCEEW within seven (7) days. A report will also be produced for the CEO and to the DCCEEW within 21 days of the exceedance of any threshold criteria. A follow up report detailing the adequacy of the response actions will also be submitted to the DWER and the DCCEEW within 12 months of the initial notification.

Compliance against the conditions of EPBC Act approval 2018/8299, 2021/8923 will be reported annually as required by condition 19 and Condition x respectively. For condition 2 related to this EMP (as required by MS xxxx condition x), the information to be reported as part of the Commonwealth annual compliance reporting is shown in Table 2-9.

Table 2-9: West Angelas Environmental Management Plan Reporting

Key Environmental Factors: Flora and Vegetation, Terrestrial Fauna and Inland Waters	
Trigger and Threshold Criteria and Management Targets	**Reporting periods:** **1 January - 31 December**
<u>Trigger Criteria</u>	Status report: Environmental criteria achieved Environmental criteria not achieved
1. Clearing within 100 m of the mapped representation (West Angelas Cracking Clay PEC 2015-5)	
2. Decline in relative abundance of key species within the mapped representation since baseline not seen in reference sites (West Angelas Cracking Clay PEC 2015-5)	
3. Establishment of new high priority weed species previously not detected within the mapped representation (West Angelas Cracking Clay PEC 2015-5)	
4. Significantly increased extent of existing weed species within the mapped representation since baseline relative to reference sites (West Angelas Cracking Clay PEC 2015-5)	
5. Reduction in extent greater than 15 ha as a result of direct or indirect disturbance from the Revised Proposal (other representations of the West Angelas Cracking Clay PEC)	
6. Proposal: Direct disturbance within 150 m (but not closer than 100 m) of Category 2 Ghost Bat roosts (Table 1-6)	
7. Proposal: Noise and blast vibration levels exceeded (as specified in Table 2-2a)	
8. Proposal: Decline in visual structural integrity[41] at any retained Category 2 Ghost Bat roosts	
9. Approved Proposal: Disturbance within 150 m (but not closer than 100 m) of retained category 2 Ghost Bat roosts (Table 2-b and Table 1-5)	
10. Approved Proposal: Blast vibration levels exceeded (as specified in Table 2-b and Table 1-5)	

[41] Structural integrity is defined as a negative change to the integrity of the cave. The trigger will be exceeded where changes are observed after a blast event for which a vibration level criteria is exceeded, including significant rockfalls (in comparison to baseline data).

Key Environmental Factors: Flora and Vegetation, Terrestrial Fauna and Inland Waters	
Trigger and Threshold Criteria and Management Targets	**Reporting periods:** **1 January - 31 December**
11. Greater than 10% increase in the proportion of *Eucalyptus victrix* canopy area within the maximum predicted surface discharge extent in Turee Creek East that falls below the MSAVI baseline 5th percentile in comparison to reference sites and the trend continues over two consecutive annual monitoring events, with no evidence of seasonal recovery	
12. Establishment of new high priority weed species within the maximum predicted surface discharge extent in Turee Creek East or the discharge tributary, previously not detected within Turee Creek East within the Revised Development Envelope	
13. Significantly increased extent of existing high priority weed species within the maximum predicted surface discharge extent in Turee Creek East or the discharge tributary since baseline relative to reference sites	
14. Water level in monitoring bore (WAH-M03) falls below historically recorded natural range[42]	
15. Decrease in vegetation density of TBD% of key indicator species TBD in gully downstream of Deposit H Waterhole	
Threshold Criteria:	Status report: Environmental criteria achieved Environmental criteria not achieved
1. Clearing within the mapped representation (West Angelas Cracking Clay PEC 2015-5)	
2. Loss of any key species present at baseline from 50 per cent or more of transects within the mapped representation as a result of direct or indirect disturbance from the Revised Proposal (West Angelas Cracking Clay PEC 2015-5)	
3. Reduction in extent greater than 22 ha as a result of direct or indirect disturbance from the revised proposal (other representations of the West Angelas Cracking Clay PEC)	
4. Proposal: Direct Disturbance within 100 m of retained (category 2) Ghost Bat roosts (Table 1-6)	
5. Proposal: Significant damage to any retained Ghost Bat caves (caves CWAN-01, 02, 03, 04, 06, 07, 08, 11, 27, 28, 29, 30, 31, 32, 34, CDHI-001 and 002), supported by a significant step change in microclimate (temperature and humidity) data, attributable to the Proposal (Table 1-5)	

[42] Minimum water level to be determined once sufficient baseline data, minimum 2 years factoring seasonal fluctuations, has been recorded and prior to disturbance at Deposit H.

Key Environmental Factors: Flora and Vegetation, Terrestrial Fauna and Inland Waters	
Trigger and Threshold Criteria and Management Targets	**Reporting periods:** **1 January - 31 December**
6. Approved Proposal: Disturbance within 100 m of retained (category 2) Ghost Bat roosts (Table 1-5)	
7. Approved Proposal: Significant damage to retained Ghost Bat roost (Table 1-5)	
8. Greater than 50 per cent of the Eucalyptus victrix canopy area within the maximum predicted surface discharge extent in Turee Creek East is below the MSAVI baseline 5th percentile; trend continues over two consecutive monitoring events; with no evidence of seasonal recovery; and outside of variation observed within extended baseline period, in comparison to reference sites	
9. Significant structural or compositional change to channel and terrace habitats of Turee Creek East over 50 per cent of the maximum predicted surface discharge extent, in comparison to baseline and trends different to reference sites	
10. Retained surface catchment area of Deposit H Waterhole is reduced to less than 0.4 km^2	
11. Significant impact to the visual amenity of the downstream gully over two consecutive monitoring periods.	
12. Turtle pool depth is below lowest recorded pre-mining depth over two consecutive wet seasons attributable to the Proposal	
13. Decrease in vegetation density of TBD% of key indicator species TBD	
Management Target:	Status report: Management target achieved Management target not achieved
1. No establishment of new high priority weed species within the West Angelas rail corridor adjacent to national parks, TECs or PECs due to the Revised Proposal	
2. No consecutive increase in the extent of high priority weed species within the West Angelas rail corridor adjacent to national parks, TECs or PECs, over a period of three years due to the Revised Proposal	
3. No establishment of new high priority weed species within the West Angelas rail corridor, adjacent to other targeted conservation significant areas due to the Revised Proposal	

3. ADAPTIVE MANAGEMENT AND REVIEW OF THIS EMP

The framework for EMPs provides details of the review and adaptive management process (Appendix 1). The approach will include an evaluation of the following:

- Monitoring data and comparison to baseline and reference site data regularly to verify responses to potential impacts
- The effectiveness and relevance of trigger and threshold contingency actions against environmental objectives on an annual basis to determine if any changes to the criteria, monitoring or response actions are required
- The effectiveness and relevance of management actions and targets against environmental objectives on an annual basis to determine if any changes to actions, targets or monitoring are required.

Based on the review process results, the Proponent will update and adjust the management measures and strategies in consultation with DWER.

4. STAKEHOLDER CONSULTATION

Consistent with the EPA's expectations for this EMP to align with the principles of environmental impact assessment, the Proponent consulted with stakeholders, including but not limited to the Department of Biodiversity, Conservation and Attractions, EPA Services and the Department of Water and Environmental Regulation during the environmental impact assessment of the Revised Proposal. This draft EMP will be released for public comment along with the ERD for the Proposal.

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Appendix 1: Rio Tinto Conceptual Framework for the Development of Environmental Management Plans

A conceptual framework model has been applied to develop Environmental Management Plans (EMPs) (Figure A 1). The framework for EMPs ensures linkages between current understanding, potential impacts, outcomes, adaptive management, and consistent monitoring and management practices. The framework for EMPs is a stepwise process that considers the environmental values identified in the Proposal's Environmental Review Document (ERD), to implement appropriate management measures and actions to ensure the environmental objective can be achieved.

The first step of the framework for EMPs examines current knowledge of the environmental value(s) associated with the Proposal. This is compiled from information provided in the ERD document, examined with input from internal experts.

Environmental values associated with the Proposal are assigned a Tier value based on their local, state and regional conservation status (Table A1 1). Generally, Tier 1 values represent those values with statutory protection, Tier 2 values are those with policy based protection, and Tier 3 are those considered to be of local significance. These descriptions are a guide only and each environmental value will be considered with reference to the specifics of the individual proposal and the surrounding environment. Where values are considered to be of heightened conservation significance for a Proposal, they will also be considered representative of a higher Tier.

The second step of the framework for EMPs is to define relevant indicators, level of management and criteria to meet the objective or the environmental outcome.

A source-pathway-environmental receptor (SPER) conceptual modelling approach is used to inform the selection of indicators, as recommended by national and international guidance (DIIS 2016). The SPER conceptual model sets out the collective knowledge, experience and perspective on the environmental value (system of interest) and illustrates assumptions about how the value (system) functions and what is believed to be the important or dominant processes and their linkages. This includes factors that are perceived to be driving changes in the value (system) and the consequences of changes in these factors. The conceptual model also includes factors such as spatial boundaries as well as temporal and seasonal variations.

The number and type of indicators selected to monitor and measure changes in individual environmental values will depend on several factors including; the Tier value; the level of management required; the environmental outcome or objectives; location; and the types of pressures and stressors identified.

The required level of management (Low, Moderate or High) is determined using a risk- based assessment with four factors relating to predicted impacts from the Proposal including: likelihood; consequence (i.e., tier value of receptor); spatial extent; and temporal duration (Table A1 2). The higher the level of management, the more lines of evidence deemed necessary to meet the environmental outcome or objective (e.g., more indicators and / or more frequent monitoring schedules).

Draft (interim) trigger and threshold criteria and/or draft management targets will be determined for each environmental value. Trigger criteria may be defined by both indicators (e.g., groundwater depth) or the environmental value (e.g., vegetation health), while threshold criteria will be directly related to the environmental value, as this relates directly to the environmental outcome to be achieved. Therefore, there may be a greater number of trigger criteria when compared to thresholds. The number of trigger criteria, and the sensitivity of both trigger and threshold criteria, will be determined by the associated management level for the environmental value.

The third and fourth steps of the framework for EMPs is to undertake an evaluation of the baseline data to assess against criteria and determine whether the environmental outcome or objectives are likely to be met with existing proposed indicators. This step should also occur as part of reporting requirements when criteria are exceeded. Where criteria are not being met the adaptive management process should be implemented.

The fifth step of the framework for EMPs is to implement the EMP. To ensure successful implementation, relevant internal and external (regulatory) stakeholders are consulted to ensure the EMP meets management expectations and can be implemented for the associated Proposal.

The sixth, final step of the framework for EMPs considers a revision of or alternatives of management objectives, indicators and/ or criteria. This step is considered where monitoring and assessment indicates objectives are not being met (Step 3). Where data suggests that objectives cannot be met using current associated indicators and criteria, repeat the second to fifth step of the framework for EMPs, with consideration of the additional information gained through monitoring.

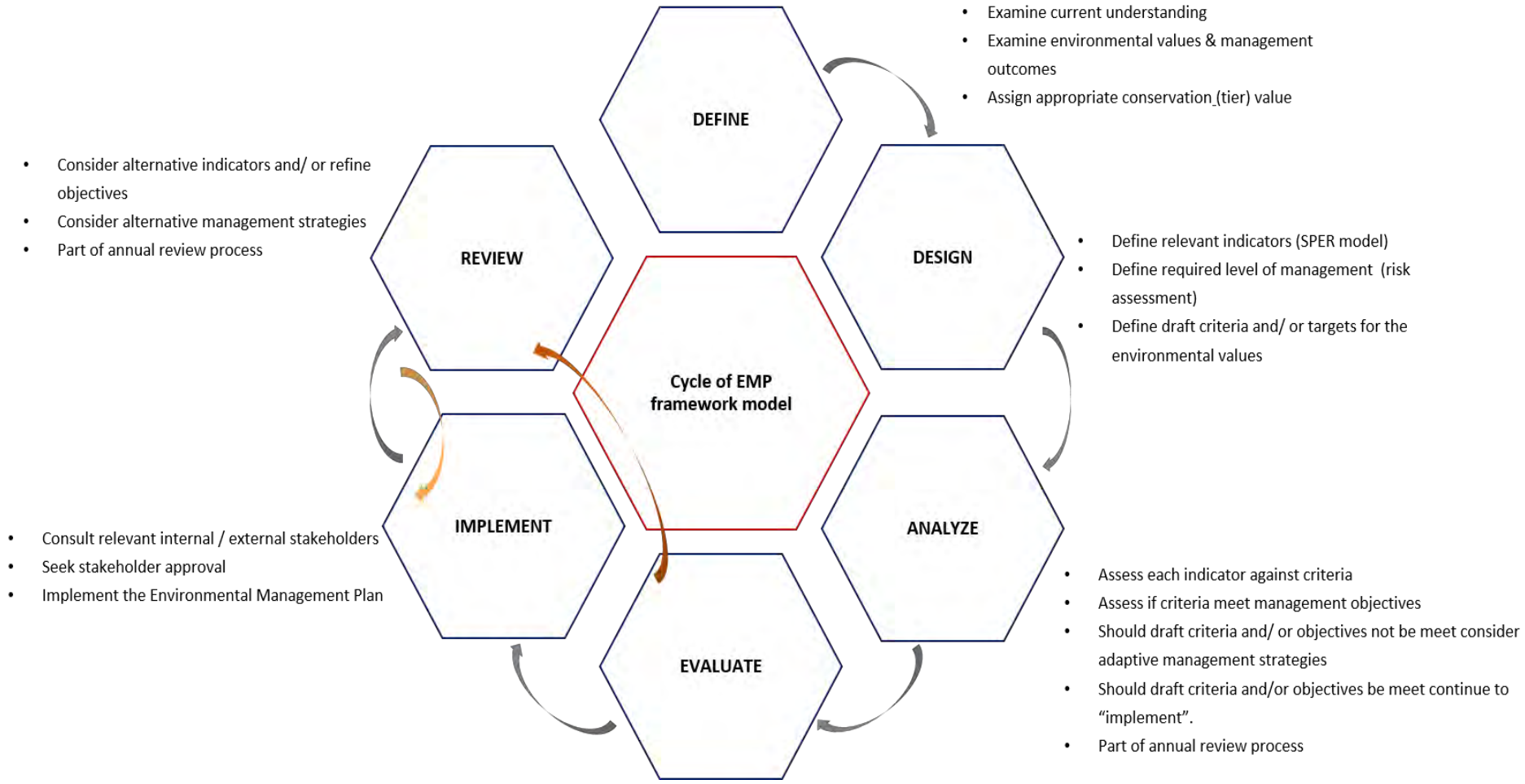

Figure A 1: Cycle of the Conceptual Framework for Development of Environmental Management Plans

Table A1 1: Description of Tiers and Examples of Environmental Value for Each[43]

Tier	Example of Values Included
1. Environmental Values directly protected under State or Commonwealth legislation (*Environmental Protection Act 1986, Biodiversity Conservation Act 2016, Environmental Protection and Biodiversity Conservation Act 1999*)	• Matters of National Environmental Significance • National Parks • Threatened flora and communities • Environmentally sensitive areas • Listed wetlands/aquatic Groundwater Dependent Ecosystems (GDE's)
2. Environment Value recognised by State policy	• Priority species and communities • Subterranean fauna communities • Other wetlands/terrestrial GDE's
3. Environment Values with no formal recognition for conservation purposes	• Short Range Endemics • Other values of interest (e.g., unique or range restricted, high interest, high quality representation, potential new taxa, high value to Rio Tinto or regulators) • Other riparian habitats/ riparian communities/pools

Table A1 2: Risk Assessment Factors

Factor	Risk (increasing to right)				
Likelihood	Rare	Unlikely	Possible	Likely	Almost certain
Consequence	No Tier	Tier 3	Tier 2	Tier 1	Tier 1 (potential severe consequence)
Extent	Immediate	Surrounds	Local	Catchment	Sub-regional
Duration	Days	Months	Years	Decades	Centuries

The factors act independently of one another, and an increased risk of one factor will not necessarily result in other factors with higher risk.

Reference

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[43] Note that the list of Tier values is not explicit and may be changed based on legislative and/or guideline updates

Appendix 2: Summary of risk assessment for assignment of management level

Environmental Value	Risk assessment					Management level
	Predicted and potential impact (s)	Likelihood	Consequence	Extent	Duration	
Flora and Vegetation						
West Angelas Cracking Clay Priority Ecological Community (PEC)	Direct and Indirect	**Unlikely** The revised proposal has been designed to avoid any clearing of mapped representation 2015-5 and minimise clearing to other representations to 22 ha. Surface water management will ensure the natural surface water flows are maintained thereby minimising indirect impacts to the West Angelas Cracking Clay PEC.	**Serious** Tier 2 value: Priority Ecological Community Priority 1 relatively uncommon in Pilbara; good condition (absence of grazing); representation 2015-5 is a particularly good example in regional context.	**Catchment** Although occurring within the Mine Development Envelope, disturbance to mapped representation 2015-5 may have wider implications in a regional context. The other representations are less significant and consist of a mosaic of vegetation types.	**Decades:** If disturbed, it may potentially take the West Angelas Cracking Clay PEC decades to recover.	MODERATE
Weeds within the West Angelas rail corridor	Direct and Indirect	**Possible** Weed hygiene protocols will be in place. Additional introduction of weeds due to the revised proposal along pre-existing infrastructure are unlikely.	**Serious to Major** Tier 1 values: Karijini and Millstream-Chichester National Parks, Themeda grasslands TEC. Tier 2 values: Brockman Cracking Clay PEC, Wona Land System PEC.	**Surrounds** The areas of interest are adjacent to the West Angelas rail corridor.	**Years** If seriously impacted by weeds of high significance, long term control may be required.	MODERATE
Weeds within the West Angelas rail corridor	Direct and Indirect	**Possible** Weed hygiene protocols will be in place. Additional introduction of weeds due to the revised proposal along pre-existing infrastructure are unlikely.	**Medium** Tier 3 values: Riparian vegetation, vegetation in good to excellent condition.	**Surrounds** The areas of interest are adjacent to the West Angelas rail corridor.	**Years** If seriously impacted by weeds of high significance, long term control may be required.	LOW
Terrestrial Fauna						
Ghost bat maternity and potential maternity roosting caves (AA1, WA-13, WA-21, WA-23, CWAN-04, CWAN-06, CWAN-06)	Potential indirect	**Possible** An exclusion zone has been delineated around the most significant roosts. It is possible, as a result of the location and type of activities (namely blasting), that the revised proposal will have indirect impacts to the Ghost Bat caves within the Mine Development Envelope. Blast management measures will be implemented for blasts undertaken within 300 m of Ghost Bat roosts.	**Serious to Major** Tier 1 value: Ghost Bats and their habitats have statutory protection under the BC Act and the EPBC Act as a Vulnerable species.	**Immediate** The revised proposal is not expected to cause a reduction in the area of occupancy, a decline in, or interfere with the recovery of MNES species. Therefore, potential impacts will be confined to the Mine Development Envelope.	**Years** The revised proposal is not expected to cause a long term decrease in the size of populations of Ghost Bat; as caves will be retained the assumption is that they will be suitable habitat after mining ceases.	HIGH
Other Ghost bat roosting caves (A1, A2, L2, L3, WA-9, WA-10, WA-11, WA- 12,WA-17, WA-20, CWAN-01, 02, 03, 29, 31, 27, 28, 32, 08, 11, 30, 34, CDHI-001 & 002, CMAR-01, 02, 03 & 04))	Potential indirect	**Possible** It is possible, as a result of the location and type of activities (namely blasting), that the revised proposal will have indirect impacts to the Ghost Bat caves within the Mine Development Envelope. Blast management measures will be implemented for blasts undertaken within 300 m of Ghost Bat roosts.	**Major** Tier 1 value: Ghost Bats and their habitats have statutory protection under the BC Act and the EPBC Act as a Vulnerable species.	**Immediate** The revised proposal is not expected to cause a reduction in the area of occupancy, a decline in, or interfere with the recovery of MNES species. Therefore, potential impacts will be confined to the Mine Development Envelope.	**Years** The revised proposal is not expected to cause a long term decrease in the size of populations of Ghost Bat; as caves will be retained the assumption is that they will be suitable habitat after mining ceases.	MODERATE

Environmental Value	Risk assessment					Management level
	Predicted and potential impact (s)	Likelihood	Consequence	Extent	Duration	
High value habitat for MNES species (Ghost Bat, Pilbara leaf-nosed Bat; Northern Quoll and Pilbara Olive Python)	Potential indirect	**Unlikely** It is unlikely that the revised proposal will have additional impacts to these habitats, as maximum clearing limits have been put in place. In addition, there is a low likelihood of significant populations of Pilbara leaf-nosed Bat, Northern Quoll and Pilbara Olive Python in the Mine Development Envelope. Pilbara Lea-nosed Bat have not been detected in the Revised Development Envelope, and individual records of Pilbara Olive Python and Northern Quoll scats only have been detected in the Revised Development Envelope.	**Major** <u>Tier 1 value:</u> high value habitat critical for species listed by the BC Act and the EPBC Act as a Vulnerable or Endangered species.	**Immediate** The revised proposal is not expected to cause, a reduction in the area of occupancy, a decline in, or interfere with the recovery of MNES species. Therefore, impacts will be confined to the Mine Development Envelope.	**Years** The revised proposal is not expected to cause a long term decrease in the size of populations of relevant MNES species.	LOW
Inland Waters						
Deposit H Waterhole	Direct and potential Indirect	**Likely** Up to 88% of the catchment that supplies Deposit H pool is proposed to be impacted by the Revised Proposal. Direct impact to flows to the pool will occur, direct impacts from dust, and potentially sediment deposition may occur.	**Major** Tier 2 Value: riparian vegetation associated with Deposit H pool, support Tier 1 (MNES) values as opportunistic water source.	**Immediate** Changes to flows from catchment impacts have the potential to directly affect the hydrological function of Deposit H waterhole.	**Years** If significant changes to the Deposit H Waterhole hydrology occur, it may be evident within a short duration, i.e. years.	MODERATE
Riparian vegetation of Turee Creek East	Direct and Indirect	**Likely** Discharge is expected to result in changes to community structure, declining health of *Eucalyptus victrix* and increased abundance of weeds and/or other species within the discharge extent.	**Medium** <u>Tier 3 value</u>: riparian vegetation with facultative groundwater dependence. Vegetation community type is common in the Pilbara, considered of low conservation significance in a regional context.	**Immediate** Discharge will be contained within the Mine Development Envelope.	**Decades** If significant changes to riparian vegetation structure and composition occur, it may take decades for recovery to occur.	LOW[25]
Turtle Pool	No direct impacts proposed, potential Indirect impacts are unlikely	**Unlikely** Connection to groundwater is considered unlikely and evidence suggests the pool is surface water fed, however work is ongoing to confirm this. The Revised Project will be managed such that there will be no impact to Turtle pool. No direct or indirect impacts are likely to occur to Turtle Pool as a result of the Revised Proposal.	**Serious** Tier 3 value: riparian vegetation associated with Turtle pool, likely to support Tier 1 (MNES) values as opportunistic water source.	**Immediate** No impact proposed to Turtle Pool.	**Decades** If significant changes to surface flows and/or groundwater occurs, it may take decades for recovery to occur.	LOW
Social Surroundings						
Deposit H Waterhole Downstream gully	Potential Indirect	**Likely** Up to 88% of the catchment that supplies Deposit H pool and the downstream gully is proposed to be impacted by the Revised Proposal. Indirect impact to flows to the downstream gully will occur.	**Medium** Ngarlawangga have indicated that whilst insignificant impact to the gully may occur, significant impact to this gully is not supported. Tier 3 flora and vegetation value. Vegetation community is common in the Pilbara and considered of low conservation significance.	**Surrounds** Gully downstream of Deposit H pool is likely to be impacted as a result of reduced downstream **flows**	**Decades** **If significant changes downstream vegetation structure and composition occurs, it may take decades for recovery to occur.**	LOW

[25] Although the level of management required for Turee Creek East is low, it is acknowledged that the potential for surplus discharge to affect weed species may be relevant to spread of weeds downstream of the discharge extent, possibly including Karijini National Park. Therefore, a higher level of management is required for weed species and will include on-ground surveys and associated criteria, see Table 2.3 in this EMP

Appendix 3: Monitoring Required to Evaluate Performance Against the Environmental Objectives and to Assess the Effectiveness of Management Action for Environmental Values within the Mine Development Envelope and West Angelas Rail Corridor

Monitoring action	Location	Frequency and timing	Data collection method and analysis	Responsible
West Angelas Cracking Clay PEC 2015-5 (Figure 1-3**)**				
Imagery capture (satellite and/or aerial imagery) (trigger criterion 1 and threshold criterion 1 for PEC 2015-5 in Table 2-1)	PEC-2015-5	Annual during operational mine life	Visual assessment of clearing or disturbance within mapped representation	Operations Environment team
Vegetation transect monitoring (trigger criteria 2, 3 and 4 and threshold criterion 2 for PEC-2015-5 in Table 2-1)		Annual during operational mine life	Transect monitoring, including visual assessment of presence and abundance of key species (including weeds) at established locations	
Land clearing reconciliation (trigger criteria 1 and threshold criterion 1 for PEC 2015- 5 in Table 2-1)		Annual during operational mine life	• GIS avoidance and disturbance layers • Internal approvals request process • Internal incident reporting process	
Other representations of West Angelas Cracking Clay PEC (Figure 1-3**)**				
Imagery capture (satellite and/or aerial imagery) (trigger and threshold criteria for other mapped representations in Table 2-1)	WACC PEC	Annual during operational mine life	Visual assessment of clearing or disturbance within mapped representations	Operations Environment team
As triggered, vegetation transect monitoring (supporting data trigger and threshold criteria for other mapped representations in Table 2-1)		As triggered, annual during operational mine life	As triggered, transect monitoring, including visual assessment of presence and abundance of key species (including weeds) at selected locations adjacent to disturbed areas	
Land clearing reconciliation (trigger and threshold criteria for other mapped representations in Table 2-1)		Annual during operational mine life	• GIS avoidance and disturbance layers • Internal approvals request process • Internal incident reporting process	
Weeds within the West Angelas rail corridor - Karijini & Millstream-Chichester National Parks, Themeda Grasslands on Cracking Clays TEC, Brockman Cracking Clay and Wona Land System PECs (Figure 1-4**)**				
Annual collation of weed species presence and extent during control events Annual monitoring of known weed-free areas Annual audit of weed control effort Audit equipment hygiene records	Rail corridor	Annual during operational mine life	• Visual assessment of new weeds • Visual assessment of the extent of existing weeds	Operations Environment team
Weeds within other areas of the West Angelas rail corridor (Figure 1-4**)**				
Annual collation of weed species presence and extent during control events Annual audit of weed control effort Audit equipment hygiene records	Rail corridor	Annual during operational mine life	• Visual assessment of new weeds • Visual assessment of the extent of existing weeds	Operations Environment team
Three yearly monitoring of known weed-free areas		Every three years during operational mine life		
Ghost Bat roosts (Figure 1-5**)**				
Land clearing reconciliation (trigger criterion 1 and threshold criterion 1 in Table 2-2a and Table 2-b)	As per Figure 2-1 and specified in Table 2-b	Annual during operational mine life	• GIS avoidance and disturbance layers • Internal approvals request process • Internal incident reporting process	Operations Environment team
Noise and vibration levels (trigger criterion 2 in Table 2-2a and Table 2-b)	As per Figure 2-1 and specified in Table 2-b	For all blasts within 300 m of specified retained Ghost Bat caves	• Modelling of noise and peak particle velocity prior to blast • Vibration monitoring of actual peak particle velocityAnalysis of modelled versus actual peak particle velocity • Noise monitoring at Category 2 and Category 3 apartment block Ghost Bat caves	Drill and Blast team

Monitoring action	Location	Frequency and timing	Data collection method and analysis	Responsible
Assessment of cave structure (threshold criterion 2 in Table 2-2a and Table 2-b)	As per Figure 2-1 and specified in Table 2-b	Annual during operational mine life; quarterly if blast vibration levels exceed trigger criteria	Visual inspections	Operations Environment team
Monitoring of Ghost Bat use of significant caves (supporting monitoring in Table 2-2a and Table 2-b)	As per Figure 2-1 and specified in Table 2-b	Annual during operational mine life	Active or passive monitoring	
Significant habitat for MNES fauna species				
Land clearing reconciliation	Development Envelope	Annual during operational mine life	• GIS avoidance and disturbance layers • Internal approvals request process • Internal incident reporting process	Operations Environment team
Audit of MNES fauna records, feral animal sightings, fauna encounters and induction records (supporting information, Table 2-3)			Internal administrative systems	
Fencing inspections (supporting information, Table 2-3)			Visual inspections	
Riparian vegetation of Turee Creek East (Figure 1-6**)**				
Observed surface discharge extent (supporting information)	Turee Creek East within observed surface discharge extent and reference areas	Camera and other ad-hoc recording of observed discharge extent during operational mine life	Remote camera monitoring of surface water flow extent (during natural no-flow conditions)	Operations Environment team
Satellite image capture (trigger criterion 1 and threshold criterion 1 in Table 2-3	Turee Creek East within maximum predicted surface discharge extent and reference areas (as shown in Appendix 4)	Annual (dry season) during operational mine life	Assessment of MSAVI values for overstorey canopy health	
Weed survey (trigger criteria 2 and 3 in **Table 2-4**)	Turee Creek East and discharge tributary within maximum predicted surface discharge extent and reference areas (selected locations from Figure 1-6)	Annual (wet season) during operational mine life	Assessment of weed species present and cover	
As triggered, riparian vegetation transect survey (threshold criterion 2 in	Turee Creek East within maximum predicted surface discharge extent and reference areas (selected locations from Figure 1-6)	As triggered, annual (wet season) during operational mine life	As triggered, transect monitoring, including species present (understorey and overstorey, including weeds), condition and cover	
Deposit H Waterhole				
Calculate the remaining contributing catchment to Deposit H Waterhole using up to date high resolution topography data (LiDAR)	Deposit H Watehole catchment	Annual	Collect recent LiDAR imagery and use to calculate remaining catchment to determine compliance against early response indicator and threshold	Operations Environment team
Pre and post wet season and monthly depth monitoring at Deposit H Pool at SW18WAN004 (Dep H Pool) and SW18WAN006 (upstream drainage line) over the wet season.	SW18WAN004 (Dep H Pool) and SW18WAN006	Pre and post wet season and monthly depth monitoring at Deposit H Pool at SW18WAN004 (Dep H Pool) and SW18WAN006 (upstream drainage line) over the wet season.	Download pressure transducer data from continuous recording.	WRE

Deposit H Waterhole depth (pressure transducers located within Deposit H waterhole and upstream gully) and water quality (Deposit H Waterhole). Supporting parameter to increase knowledge of water quality and depth patterns at Deposit H Waterhole	Deposit H Waterhole	Annual visual or camera time lapse inspection of Deposit H Waterhole for observation of potential impacts to fill level of the pool (device/access dependent)	Download pressure transducer data from continuous recording.	WRE
Turtle Pool				
Monthly water level monitoring at ground water bore	WAH-M03	Monthly	Take water level reading at WAH-M03	WRE
Depth monitoring at Turtle Pool in conjunction with supplementation volumes/rate (access dependent44)	Turtle Pool	Monthly	Pressure transducer located at Turtle Pool	WRE
Quarterly visual or camera time lapse inspection of Turtle Pool for observation of potential impacts to fill level or frequency of the regime of the pool (device/access dependent)41	Turtle Pool	Quarterly	Download fixed timelapse camera quarterly	WRE
Deposit H Downstream Gully				
Modified Soil Adjusted Vegetation Index (MSAVI)	Gully downstream of Deposit H Watehole	Annual	Obtain satellite imagery to assess MSAVI	Env. Operations supported by Biological Assessments Team

[44] Requires Ngarlawangga representative to escort or authorize access (for download of loggers and visual inspection). If escort or authorization cannot be secured, inspection/monitoring cannot be carried out and is not considered a non-compliance

Appendix 4: Monitoring Methods

Flora and Vegetation – West Angelas Cracking Clay PEC

The extent of the mapped representations of the West Angelas Cracking Clay PEC and direct disturbance, (i.e., clearing, if any) will be determine through annual assessment of aerial imagery and/or satellite remotely sensed data. Annual land clearing reconciliation will be compared against the extent of mapped representations of the West Angelas Cracking Clay PEC and assessed against the trigger and threshold criteria (Table 2-1 of this EMP).

Potential indirect impacts to the West Angelas Cracking Clay PEC will be assessed by monitoring vegetation composition and abundance of key species (including weeds); this will be undertaken annually in mapped representation PEC-2015-5 and as triggered in other representations, according to Table 2-1 of this EMP. The monitoring will record vegetation description, species present (including weeds) and abundance/cover of key species and weeds. Multiple representative monitoring locations will be established within mapped representations of the PEC to establish the baseline condition before implementing the Revised Proposal. As most of the mapped representations of the West Angelas Cracking Clay PEC occurs with the Revised Development Envelope, reference sites may need to be other comparable community types outside the Revised Development Envelope (e.g., Astrebla cracking clay communities). Ongoing monitoring will then occur annually within mapped representation PEC-2015-5 at established locations (dependent on accessibility). Monitoring in other representations will be undertaken in the event of an exceedance of the trigger criteria adjacent to disturbed areas. Monitoring will be focused adjacent to disturbed areas as this may cause further indirect impacts (e.g., increased establishment of weeds or hydrological changes); indirect impacts are considered unlikely in undisturbed areas.

Flora and Vegetation – Weeds within the West Angelas Rail Corridor

Weed presence and extent data will be captured in parallel with weed control efforts. These data will be used to determine ongoing and future management priorities (in consultation with DBCA). Data from the first three years of monitoring will be used to determine priority weed species. Priority of weed species for control will be determined following the Weed Prioritisation Process for DPaW (formerly DEC) '*An integrated approach to Weed Management on DPaW-managed lands in WA*[45]'. High priority weeds are species rated with high ecological impact and rapid invasiveness, according to the *Pilbara Impact and Invasiveness Ratings*[46]. Priority for control will also consider feasibility of control and priority control areas and be used to inform timing of control efforts. Priority weed species will be reviewed on an ongoing basis in consultation with DBCA to capture changes to knowledge (i.e., new weed species, change in risk profile, increase in weed extent).

Weed inspections will be undertaken during control events (at least annually) to record the extent of weeds within the rail corridor. The inspections report the spatial extent of a weed species, life stage, density and treatment method (if applicable). In addition, an inspection of areas where no weeds are known to occur will be inspected annually adjacent to national parks, TECs and PECs and every three years in other areas.

Weed inspection data will be reconciled annually, compared against the previous two years of weed extent data, and assessed against the management targets in Table 2-1 of this EMP.

[45] https://www.dpaw.wa.gov.au/images/documents/plants-animals/plants/weeds/weed_prioritisation_process.pdf

[46] https://www.dpaw.wa.gov.au/images/documents/plants-animals/plants/weeds/pilbara_region_-_impact_and_invasiveness_ratings.xlsx

Threatened Fauna – Ghost Bat Caves

a) Blast Vibration Prediction and Monitoring

Blast vibration shall be predicted using a 'scaled distance' blast vibration model for every blast within 300 m of retained Ghost Bat roosts. Blasts shall not proceed where predicted blast vibration exceeds criteria to ensure that the caves are protected from significant damage (damage that negatively impacts the integrity of the cave such that future Ghost Bat use of the site is prevented).

Blast vibration monitoring shall be implemented for all retained Ghost Bat caves within 300 m to confirm blast vibration predictions are met, to ensure that blast vibrations do not exceed criteria and that the caves are protected from significant damage.

b) Ghost Bat Presence / Absence Monitoring

Ghost Bat presence/absence has been monitored annually since 2012 and intermittently prior to 2012, within Caves AA1, A1, A2, L2 and L3, WA-9, WA-10, WA-11, WA-12, WA-13, WA-17, WA-20, WA-21, WA-22 and WA-23. This monitoring program will be expanded to include Category 2 caves CWAN-04, 06 and 07 with the first monitoring event at these caves, to occur in late 2023. .

Monitoring protocols have been based on the protocols established at other Rio sites (i.e., Greater Paraburdoo), so that data from the programs are comparable.

Ghost Bat use of Monitoring Caves will be monitored by on-going remote detection (dependant on device). Bat auto monitoring detectors (or other equipment where deemed appropriate and/or recommended by experts) will be placed in the entrance of the Monitoring Caves (where safe access is available). Data analysis will be conducted bi-annually.

Categorisation of the Monitoring Caves is based on the results of the most recent survey and/or on the advice of independent experts.

Presence data will be considered with reference to all other relevant data (e.g., cave structure and microclimate, seasonal, climatic) to increase knowledge of the population and their use of caves within the Revised Development Envelope.

The monitoring program will be reviewed biennially. However, the Proponent reserves the right to align with current methodologies and understanding as appropriate, in consultation with external experts and/or regulators (i.e., DBCA).

Threatened Fauna – Significant Habitat for MNES Fauna Species

Annual land clearing reconciliation will be conducted to ensure clearing remains with approved clearing limits.

There are no known Pilbara Leaf-nosed Bat roosts, Northern Quoll dens or Pilbara Olive Python dens within the Revised Development Envelope. However, if roosts and/or dens are observed in the future, the Proponent will implement appropriate avoidance and management measures, including monitoring, in consultation with the relevant agencies.

Monitoring and management will be undertaken as part of the Proponent's existing environmental management system to minimise potential impacts to EPBC Act listed threatened species or their habitats (Table 2-3 of this EMP).

Inland Waters – Surplus Water Discharge and Riparian Vegetation

The potential impacts of surplus water discharge on the riparian vegetation of Turee Creek East will be assessed with remote sensing in the first instance. Data will be captured via satellite imagery annually and used to assess against trigger criterion 1 (decline in overstorey tree health) due to increased water availability. Monitoring of these changes is designed to prevent the threshold criteria from being reached.

The technique for monitoring riparian trees using remote sensing imagery has been established and refined in recent years involving automated delineation (segmentation) of canopies of the riparian tree species across time series of imagery captured towards the end of the dry season. This period coincides with the period in which trees are under greatest stress and when the contrast between the greenness of the tree canopy and lower storey canopy is more discernible. Values of a spectral index that are positively related to canopy health, the modified soil adjusted index (MSAVI), are extracted from the delineated canopy polygons (segments). A time series of MSAVI values from the baseline to the latest date is then used to monitor the condition of the riparian tree canopy.

Ideally, an extended baseline period that covers typical levels of seasonal and longer-term variability is needed to capture the natural variability for this statistical method. In most mining projects, it is rarely possible to capture an extended baseline. In addition, statistically based criteria, such as the baseline 5th percentile, may bare no relationship to ecological values. That is, if the whole vegetation community was in poor health at baseline, the MSAVI during mining operations may be above the baseline 5th percentile but the vegetation be in poor condition. Alternatively, a very healthy system may be monitored during baseline and the 5th percentile then represents healthy vegetation. For these reasons, the Proponent proposes to develop empirically based criteria as knowledge is acquired during the implementation of the Revised Proposal. This would be based on the relationship between MSAVI and visual indications of canopy decline. As this information is currently unavailable for West Angelas, the baseline statistics will be used as a conservative criterion and refined over time in line with adaptive management and the framework for EMPs. In addition, the baseline 5th percentile will be updated as further baseline data is collected before implementing the Revised Proposal.

Annual monitoring of weed species, including cover, will be undertaken at selected established locations within the maximum predicted surplus discharge extent of Turee Creek East and the discharge tributary to assess against trigger criteria 2 and 3.

Riparian vegetation transect monitoring (including weeds) has been undertaken since 2011 and will comprise the baseline data (i.e., before implementation of the Revised Proposal). Transects for ongoing monitoring will be selected based on observed discharge extent and accessibility.

Annual (wet season) monitoring of the condition, cover and health of both native and weed species will also be undertaken in Turee Creek East as triggered to ground-truth and further investigate exceedances of trigger criteria based on remote sensing (trigger criterion 1). Monitoring will include vegetation description, species present and foliage cover for each species (including weeds). The riparian vegetation transect monitoring referred to above will comprise the baseline data against which threshold criterion 2 will be assessed.

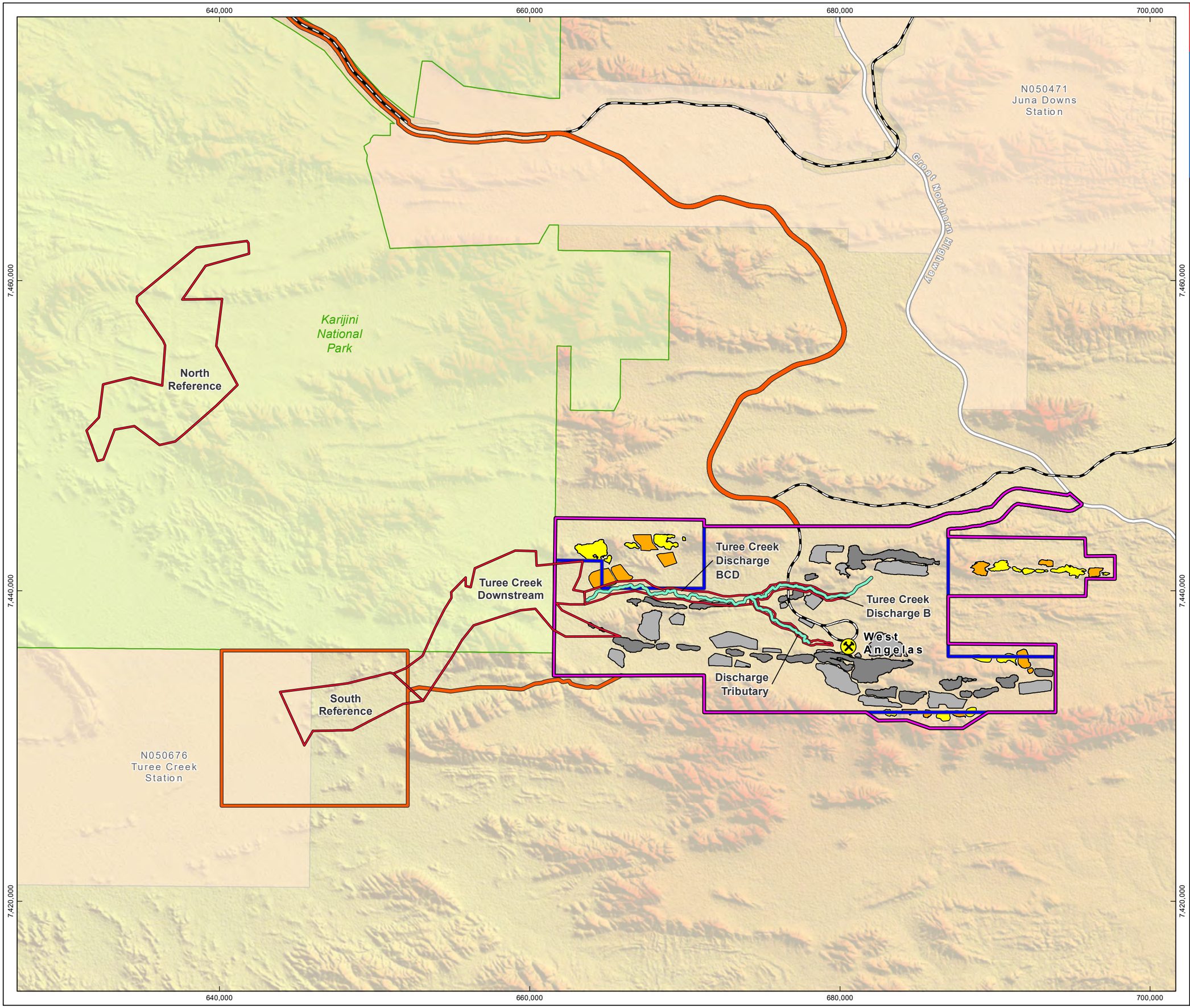
Monitoring of discharge extent will be undertaken using permanently mounted remote cameras installed at two sites, approximately 3.1km and 7km (measured along the length of the channel; *cf* 2km and 5km straight line distance) from the Karijini National Park boundary. Daily image captures at each site will be examined to determine discharge extent under natural no-flow conditions.

Appendix 5: Remote Sensing (Modified Soil Adjusted Vegetation Index, MSAVI) Baseline Data for Turee Creek East

Table A4 1: Baseline MSAVI Median and 5th Percentile for Turee Creek East Remote Sensing Zones

	2017		2018	
Zone	**5th percentile**	**Median**	**5th percentile**	**Median**
Discharge Tributary	0.4418	0.5016	0.4136	0.4618
North Reference	*N/A*	*N/A*	0.4138	0.4850
South Reference	*N/A*	*N/A*	0.4426	0.4904
Turee Creek Discharge B	0.4574	0.5036	0.4195	0.4707
Turee Creek Discharge BCD	0.4374	0.4828	0.3958	0.4474
Turee Creek Downstream	0.4330	0.4899	0.4499	0.4910

This information is used to inform Inland Waters trigger criterion 1 and threshold criterion 1 Note that the baseline statistics will continue to be updated until the Revised Proposal is implemented



RioTinto

Figure A4-1
Turee Creek East
Remote Sensing Zones

Drawn: A.D.
Plan: RTIO-0986737v1
Date: March 2023

Proj: GDA 1994 MGA Zone 50
Scale: 1:225,000 @A3
GIS.Team@riotinto.com

Legend

- Rio Tinto Mine
- Revised Development Envelope
- Approved Mine Development Envelope
- Approved Linear Infrastructure Development Envelope

Proposed Conceptual Layout

- Pit
- Waste Landform

Approved Conceptual Layout

- Pit
- Waste Landform

- Surplus Water Discharge Extent
- Low Flow Channel Extent
- Turee Creek Remote Sensing Zone

- National Park
- Pastoral Station
- Rio Tinto Railway
- Highway

N

0 2 4 6 8 10
Kilometres

Map units in metres

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Appendix 6: Main Riparian Vegetation Mapping Unit and Species within the Maximum Predicted Surface Discharge Extents on Turee Creek East (Biologic 2022H)

Vegetation Code	Landscape position	Broad Vegetation Description
D2: EvAcTErTHtTp	Incised channel zone - generally representing the main low flow channel, banks and initial terrace habitat	*Eucalyptus victrix* low open woodland *Acacia citrinoviridis* tall open shrubland over *Tephrosia rosea* var. Fortescue Creeks (M.I.H. Brooker 2186) scattered low shrubs *Themeda triandra* very open tussock grassland over *Triodia pungens* scattered hummock grasses to very open hummock grassland.

Appendix 7: Turee Creek East Riparian Vegetation NVIS Level IV[47] Structural Classes and Integration with Aplin[48] Structural Classes

Stratum		Canopy Cover (%)				
NVIS Level IV (Sub-association)	**Growth Form**	**70-100%**	**30-70%**	**10-30%**	**2-10%**	**<2%**
Upper Stratum	Trees over 30 m	Tall closed forest	Tall open forest	Tall woodland	Tall open woodland	Scattered tall trees
	Trees 10-30 m	Closed forest	Open forest	Woodland	Open woodland	Scattered trees
	Trees under 10 m	Low closed forest	Low open forest	Low woodland	Low open woodland	Scattered low trees
Mid Stratum	Shrubs over 2 m	Tall closed shrub	Tall open shrub	Tall shrubland	Tall open shrubland	Scattered tall shrubs
	Shrubs 1-2 m	Closed heath	Open heath	Shrubland	Open shrubland	Scattered shrubs
	Shrubs under 1 m	Low closed heath	Low open heath	Low shrubland	Low open shrubland	Scattered low shrubs
Ground Stratum	Hummock grasses	Closed hummock grassland	Hummock grassland	Open hummock grassland	Very open hummock grassland	Scattered hummock grasses
	Grasses, Sedges, Herbs	Closed tussock grassland/ bunch grassland/ sedgeland/ herbland	Tussock grassland/ bunch grassland/ sedgeland/ herbland	Open tussock grassland/ bunch grassland/ sedgeland/ herbland	Very open tussock grassland/ bunch grassland/ sedgeland/ herbland	Scattered tussock grasses/ bunch grasses/ sedges/ herbs

This information is used to inform Inland Waters Threshold Criterion 2

[47] Executive Steering Committee for Australian Vegetation Information (ESCAVI) 2003, Australian Vegetation Attribute Manual: National Vegetation Information System, Version 6.0. Department of the Environment and Heritage, Canberra

[48] Aplin T.E.H 1979, The Flora. Chapter 3 In O'Brien, B.J (ed). Environment and Science. University of Western Australia Press

Appendix 8: Weed Species Recorded in Revised Development Envelope, Including Turee Creek East and the West Angelas Cracking Clay PEC, During Baseline Monitoring (as of 2019)

Weed Species Found in Development Envelope	Common Name	Turee Creek East	West Angelas Cracking Clay PEC	Ecological Impact	Invasiveness	Feasibility of Control
Aerva javanica	Kapok Bush	x	x	High	Rapid	Medium - high
Bidens bipinnata	Bipinnate Beggartick	✓	✓	Unknown	Rapid	Low
Cenchrus ciliaris	Buffel Grass	✓	✓	High	Rapid	Low
Cenchrus setiger	Birdwood Grass	✓	x	Unknown	Rapid	Low
Chloris barbata	Purpletop Chloris	x	x	High	Rapid	Unknown
Chloris virgata	Feathertop Rhodes Grass	✓	x	High	Rapid	Unknown
Citrullus amarus	Pie Melon	x	x	Low	Rapid	Low
Datura leichhardtii	Native Thornapple	✓	x	Low	Slow	Unknown
Flaveria trinervia	Speedy Weed	✓	✓	Low	Moderate	Low - medium
Lactuca serriola	Prickly Lettuce	✓	x	High	Slow	Medium
Malvastrum americanum	Spike Malvastrum	✓	✓	High	Rapid	Low
Rumex vesicarius (Acetosa vesicaria)	Ruby Dock	✓	x	High	Rapid	High
Setaria verticillata	Whorled Pigeon Grass	✓	x	High	Rapid	Low
Sigesbeckia orientalis	Indian Weed			Unknown	Rapid	Low
Solanum nigrum	BlackBerry Nightshade	✓		Low	Rapid	Low - medium
Sonchus oleraceus L.	Common Sowthistle	✓		Low	Rapid	Low
Tribulus terrestris	Calltrop		✓	Low	Slow	High

This information is used to inform Flora and Vegetation (West Angelas Cracking Clay PEC) trigger criteria 3 and 4 (Table 2-1 of this EMP) and Inland Waters trigger criteria 2 and 3. This list of weed species will be updated with further monitoring prior to the implementation of the Revised Proposal

Appendix 9: Condition Requirements of Existing Ministerial Statement

No	Aspect	Condition	Status	Proposed Strategy for Consolidation of Conditions
MS 1113: West Angelas Iron Ore Project – Revised Proposal				
1-1	Proposal Implementation	When implementing the revised proposal, the proponent shall not exceed the authorised extent of the revised proposal as defined in Table 2 of Schedule 1, unless amendments to the revised proposal and the authorised extent of the revised proposal have been approved under the EP Act.	Retain but update	The Condition is still relevant and should be retained. However, it should be updated to reflect contemporary approaches and to include new limits relevant to the Revised Proposal.
2-1	Contact Details	The proponent shall notify the CEO of any change of its name, physical address or postal address for the serving of notices or other correspondence within twenty-eight (28) days of such change. Where the proponent is a corporation or an association of persons, whether incorporated or not, the postal address is that of the principal place of business or of the principal office in the State.	Retain but update	This Condition is still relevant and should be retained. However, it should be updated to reflect contemporary approaches.
3-1	Compliance Reporting	The proponent shall prepare, and maintain a Compliance Assessment Plan which is submitted to the CEO at least six (6) months prior to the first Compliance Assessment Report required by condition 3-6, or within six (6) months of this Statement being issued, whichever is sooner.	Retain but update	This Condition is still relevant and should be retained. However, it should be updated to reflect contemporary approaches.
3-2	Compliance Reporting	The Compliance Assessment Plan shall indicate: (1) the frequency of compliance reporting (2) the approach and timing of compliance assessments (3) the retention of compliance assessments (4) the method of reporting of potential non-compliances and corrective actions taken (5) the table of contents of Compliance Assessment Reports (6) public availability of Compliance Assessment Reports.	Retain but update	This Condition is still relevant and should be retained. However, it should be updated to reflect contemporary approaches.
3-3	Compliance Reporting	After receiving notice in writing from the CEO that the Compliance Assessment Plan satisfies the requirements of condition 3-2 the proponent shall assess compliance with conditions in accordance with the Compliance Assessment Plan required by condition 3-1.	Retain but update	This Condition is still relevant and should be retained. However, it should be updated to reflect contemporary approaches.
3-4	Compliance Reporting	The proponent shall retain reports of all compliance assessments described in the Compliance Assessment Plan required by condition 3-1 and shall make those reports available when requested by the CEO.	Retain but update	This Condition is still relevant and should be retained. However, it should be updated to reflect contemporary approaches.
3-5	Compliance Reporting	The proponent shall advise the CEO of any potential non-compliance within seven (7) days of that non-compliance being known.	Retain but update	This Condition is still relevant and should be retained. However, it should be updated to reflect contemporary approaches.
3-6	Compliance Reporting	The proponent shall submit to the CEO the first Compliance Assessment Report by 30 April 2020 addressing the previous calendar year period and then annually from the date of submission of the first Compliance Assessment Report, or as otherwise agreed in writing by the CEO. The Compliance Assessment Report shall: (1) be endorsed by the proponent's CEO or a person delegated to sign on the CEO's behalf (2) include a statement as to whether the proponent has complied with the conditions (3) identify all potential non-compliances and describe corrective and preventative actions taken (4) be made publicly available in accordance with the approved Compliance Assessment Plan (5) indicate any proposed changes to the Compliance Assessment Plan required by condition 3-1.	Retain but update	This Condition is still relevant and should be retained. However, it should be updated to reflect contemporary approaches.
4-1	Public Availability of Data	Subject to condition 4-2, within a reasonable time period approved by the CEO of the issue of this Statement and for the remainder of the life of the proposal the proponent shall make publicly available, in a manner approved by the CEO, all validated environmental data (including sampling design, sampling methodologies, empirical data and derived information products (e.g., maps)), management plans and reports relevant to the assessment of this proposal and implementation of this Statement.	Retain but update	This Condition is still relevant and should be retained. However, it should be updated to reflect contemporary approaches.
4-2	Public Availability of Data	If any data, plans and reports referred to in condition 4-1 contain particulars of: (1) a secret formula or process; or (2) confidential commercially sensitive information the proponent may submit a request for approval from the CEO to not make these data publicly available. In making such a request the proponent shall provide the CEO with an explanation and reasons why the data should not be made publicly available.	Retain but update	This Condition is still relevant and should be retained. However, it should be updated to reflect contemporary approaches.

No	Aspect	Condition	Status	Proposed Strategy for Consolidation of Conditions
5-1	Environmental Management Plan	The proponent shall implement the revised proposal to meet the following environmental objectives: (1) the proponent shall ensure there is no irreversible impact, as a result of the discharge of surplus water from the revised proposal to the health of riparian vegetation of Turee Creek East (Figure 3 in Schedule 1) (2) the proponent shall ensure that there is no direct or indirect disturbance to the West Angelas Cracking Clay Priority Ecological Community (PEC2015-5, Figure 3 in Schedule 1), due to the revised proposal that results in an irreversible impact (3) the proponent shall ensure no more than 20 ha of direct or indirect disturbance due to the revised proposal to other representations of the West Angelas Cracking Clay Priority Ecological Community (Figure 3 in Schedule 1) (4) the proponent shall ensure that there is no disturbance due to the revised proposal to the potential maternity Ghost Bat roosts (Caves AA1, WA13, WA-21 and WA-23) (Figure 4 in Schedule 1) (5) the proponent shall minimise disturbance due to the revised proposal to other Ghost Bat roosts (Caves A1, A2, L1, L2, L3, WA-9, WA-10, WA-11, WA-12, WA-17, WA-20 and WA-22) (Figure 4 in Schedule 1) (6) the proponent shall avoid where possible, or otherwise minimise the introduction to and spread of weeds due to the revised proposal within the West Angelas rail corridor (Figure 5 in Schedule 1).	Retain but update	This Condition is still relevant and should be retained. However, it should be updated to reflect contemporary approaches.
5-2	Environmental Management Plan	In order to meet the objectives of condition 5-1, the proponent shall prepare and submit the Environmental Management Plan within three (3) months of this Statement.	Delete	
5-3	Environmental Management Plan	The Environmental Management Plan shall: (1) specify trigger criteria that must provide an early warning that the threshold criteria identified in condition 5-3 may not be met (2) specify threshold criteria to demonstrate compliance with the environmental objectives specified in condition 5-1. Exceedance of the threshold criteria represents non-compliance with these conditions (3) specify monitoring to determine if trigger criteria and threshold criteria are exceeded (4) specify trigger level actions to be implemented in the event that trigger criteria have been exceeded (5) specify threshold contingency actions to be implemented in the event that threshold criteria are exceeded (6) provide the format and timing for the reporting of monitoring results against trigger criteria and threshold criteria to demonstrate that condition 5-1 has been met over the reporting period in the Compliance Assessment Report required by condition 3-1.	Retain but update	This Condition is still relevant and should be retained. However, it should be updated to reflect contemporary approaches.
5-4	Environmental Management Plan	After receiving notice in writing from the CEO in consultation with the Department of Biodiversity, Conservation and Attractions that the Environmental Management Plan satisfies the requirements of condition 5-3, the proponent shall: (1) implement the provisions of the Environmental Management Plan (2) continue to implement the Environmental Management Plan until the CEO has confirmed by notice in writing that the proponent has demonstrated the objectives specified in condition 5-1 have been met.	Retain	
5-5	Environmental Management Plan	In the event that monitoring, tests, surveys or investigations indicates exceedance of threshold criteria specified in the Environmental Management Plan, the proponent shall: (1) report the exceedance in writing to the CEO within seven (7) days of the exceedance being identified (2) implement the threshold contingency actions specified in the Environmental Management Plan within twenty-four (24) hours and continue implementation of those actions until the CEO has confirmed by notice in writing that it has been demonstrated that the threshold criteria are being met and the implementation of the threshold contingency actions is no longer required (3) investigate to determine the cause of the threshold criteria being exceeded (4) investigate to provide information for the CEO to determine potential environmental harm or alteration of the environment that occurred due to threshold criteria being exceeded (5) provide a report to the CEO within twenty-one (21) days of the exceedance being reported as required by condition 5-5(1). The report shall include: (a) details of threshold contingency actions implemented (b) the effectiveness of the threshold contingency actions implemented against the threshold criteria; (c) the findings of the investigations required by conditions 5-5(3) and 5-5(4) (d) measures to prevent the threshold criteria being exceeded in the future (e) measures to prevent, control or abate the environmental harm which may have occurred; and (f) justification of the threshold remaining, or being adjusted based on better understanding, demonstrating that objectives will continue to be met.	Retain	
5-6	Environmental Management Plan	The proponent: (1) may review and revise the Environmental Management Plan, or	Retain	

No	Aspect	Condition	Status	Proposed Strategy for Consolidation of Conditions
		(2) shall review and revise the Environmental Management Plan as and when directed by the CEO.		
5-7	Environmental Management Plan	The proponent shall implement the latest revision of the Environmental Management Plan, which the CEO has confirmed by notice in writing, satisfies the requirements of condition 5-3.	Retain	
5-8	Environmental Management Plan	The proponent shall implement the *West Angelas Operations Environmental Management Program* (RTIO-HSE-0210871) dated November 2013 until the CEO has confirmed by notice in writing the Environmental Management Plan required by condition 5-2 satisfies the requirements of condition 5-3.	Retain but update	
6-1	Groundwater Management	Prior to dewatering of Deposit C or D, the proponent shall prepare and submit a Condition Environmental Management Plan to meet the following outcome: (1) ensure that there is no drawdown of groundwater associated with the proposal at the boundary of, or within, Karijini National Park.	Retain	
6-2	Groundwater Management	The Condition Environmental Management Plan shall: (1) specify trigger criteria that must provide an early warning that the threshold criteria identified in condition 6-2 may not be met; (2) specify threshold criteria to demonstrate compliance with the environmental outcomes specified in condition 6-1. Exceedance of the threshold criteria represents non-compliance with these conditions; (3) specify monitoring to determine if trigger criteria and threshold criteria are exceeded; (4) specify trigger level actions to be implemented in the event that trigger criteria have been exceeded; (5) specify threshold contingency actions to be implemented in the event that threshold criteria are exceeded; and (6) provide the format and timing for the reporting of monitoring results against trigger criteria and threshold criteria to demonstrate that condition 6-1 has been met over the reporting period in the Compliance Assessment Report required by condition 3-1.	Retain	
6-3	Groundwater Management	After receiving notice in writing from the CEO in consultation with the Department of Biodiversity, Conservation and Attractions that the Condition Environmental Management Plan satisfies the requirements of condition 6-2, the proponent shall: (1) implement the provisions of the Condition Environmental Management Plan; and (2) continue to implement the Condition Environmental Management Plan until the CEO has confirmed by notice in writing that the proponent has demonstrated the outcome specified in condition 6-1 have been met.	Retain	
6-4	Groundwater Management	In the event that monitoring, tests, surveys or investigations indicates exceedance of threshold criteria specified in the Condition Environmental Management Plan, the proponent shall: (1) report the exceedance in writing to the CEO within seven (7) days of the exceedance being identified; (2) implement the threshold contingency actions specified in the Condition Environmental Management Plan within twenty-four (24) hours and continue implementation of those actions until the CEO has confirmed by notice in writing that it has been demonstrated that the threshold criteria are being met and the implementation of the threshold contingency actions is no longer required; (3) investigate to determine the cause of the threshold criteria being exceeded; (4) investigate to provide information for the CEO to determine potential environmental harm or alteration of the environment that occurred due to threshold criteria being exceeded; and (5) provide a report to the CEO within twenty-one (21) days of the exceedance being reported as required by condition 6-4(1). The report shall include: (a) details of threshold contingency actions implemented; (b) the effectiveness of the threshold contingency actions implemented, against the threshold criteria; (c) the findings of the investigations required by conditions 6-4(3) and 6-4(4); (d) measures to prevent the threshold criteria being exceeded in the future; (e) measures to prevent, control or abate the environmental harm which may have occurred; and (f) justification of the threshold remaining, or being adjusted based on better understanding, demonstrating that outcomes will continue to be met.	Retain	
6-5	Groundwater Management	The proponent: (1) may review and revise the Condition Environmental Management Plan, or (2) shall review and revise the Condition Environmental Management Plan as and when directed by the CEO.	Retain	
6-6	Groundwater Management	The proponent shall implement the latest revision of the Condition Environmental Management Plan, which the CEO has confirmed by notice in writing, satisfies the requirements of condition 6-2.	Retain	
6-7	Groundwater Management	The proponent shall implement the *Groundwater Management Plan* component of the *West Angelas Operations Environmental Management Program* (RTIOHSE-0210871) dated November 2013 until the CEO has confirmed	Retain and update	

No	Aspect	Condition	Status	Proposed Strategy for Consolidation of Conditions
		by notice in writing the Condition Environmental Management Plan required by condition 6-1 satisfies the requirements of condition 6-2.		
7-1	Rehabilitation and Decommissioning	The proponent shall manage the implementation of the revised proposal to meet the following environmental objectives: (1) the proponent shall ensure that the revised proposal is rehabilitated and decommissioned in an ecologically sustainable manner; and (2) ensure that closure planning and rehabilitation are undertaken in a progressive manner.	Delete	DMIRS through Mine Closure Plans ensure that mining activities are rehabilitated and closed in a manner to make them physically safe to humans and fauna, geo-technically stable, geo-chemically non-polluting/non-contaminating and capable of sustaining an agreed post mining land use without unacceptable liability to the State. The EPA has provided advice on other recent projects that decommissioning, and rehabilitation can be adequately regulated through the Mine Closure Plan rather than a condition under part IV of the EP Act.
7-2	Rehabilitation and Decommissioning	Within twelve (12) months of the issue of this Statement the proponent shall prepare and submit a Mine Closure Plan in accordance with the *Guidelines for Preparing Mine Closure Plans*, May 2015, (or any subsequent revisions of the guidelines), to the requirements of the CEO, on advice of the Department of Mines, Industry Regulation and Safety, and the Department of Water and Environmental Regulation.	Delete	As above
7-3	Rehabilitation and Decommissioning	The proponent shall review and revise the Mine Closure Plan required by condition 7-2 at intervals not exceeding three (3) years, or as otherwise specified by the CEO, and submit the plan to the CEO at the agreed interval.	Delete	As above
7-4	Rehabilitation and Decommissioning	The proponent shall implement the latest revision of the Mine Closure Plan, which the CEO has confirmed by notice in writing, satisfies the requirements of condition 7-2.	Delete	As above
7-5	Rehabilitation and Decommissioning	The proponent shall implement the *West Angelas Closure Plan* (RTIO-HSE0228290) dated April 2018 until the CEO has confirmed by notice in writing the Mine Closure Plan required by condition 7-2 satisfies the requirements of the CEO on advice of the Department of Mines, Industry Regulation and Safety, and the Department of Water and Environmental Regulation.	Delete	As above
8-1	Offsets	In view of the significant residual impacts and risks as a result of the implementation of the revised proposal, the proponent shall contribute funds to the Pilbara Environmental Offsets Fund calculated pursuant to condition 8-2, subject to any reduction approved by the CEO under condition 8-9.	Retain	
8-2	Offsets	The proponent's contribution to the Pilbara Environmental Offsets Fund shall be paid biennially, with the amount to be contributed calculated based on the clearing undertaken in each year of the biennial reporting period in accordance with the rates in condition 8-3. The first biennial reporting period shall commence from vegetation clearing activities for the environmental values identified in condition 8-3.	Retain	
8-3	Offsets	Calculated on the 2018 calendar year, the contribution rates are: (1) $821 AUD (excluding GST) per hectare of 'Good' to 'Excellent' condition native vegetation cleared within the development envelope (delineated in Figure 2 and defined by the geographic coordinates in Schedule 2) within the Hamersley IBRA subregion. (2) $1,642 AUD (excluding GST) per hectare of the West Angelas Cracking Clay Priority Ecological Community cleared within the development envelope (delineated in Figure 3 and defined by the geographic coordinates in Schedule 2) within the Hamersley IBRA subregion. (3) $1,642 AUD (excluding GST) per hectare of riparian vegetation communities within Turee Creek East affected by discharge within the development envelope (delineated in Figure 3 and defined by the geographic coordinates in Schedule 2) within the Hamersley IBRA subregion. (4) $1,642 AUD (excluding GST) per hectare of foraging and roosting habitat for the Ghost Bat ('major gorge or gully'; 'hilltop, hillside, ridge or cliff'; and 'major drainage' habitat), including removal of one night roost (WA-16), cleared within the development envelope (delineated in Figure 4 and defined by the geographic coordinates in Schedule 2) within the Hamersley IBRA subregion.	Retain	
8-4	Offsets	From the commencement of the 2019 calendar year, the rates in condition 8-3 will be adjusted annually each subsequent calendar year in accordance with the percentage change in the CPI applicable to that calendar year.	Retain	
8-5	Offsets	Within three (3) months of the issue of this Statement, the proponent shall prepare and submit an Impact Reconciliation Procedure to the CEO, for the CEO to provide written confirmation that the Impact Reconciliation Procedure satisfies the requirements of condition 8-6.	Retain	
8-6	Offsets	The Impact Reconciliation Procedure required pursuant to condition 8-5 shall: (1) state that clearing calculations for the first biennial reporting period will commence from vegetation clearing activities for the environmental values identified in condition 8-3 in accordance with condition 8-2 and end on the second 31 December following this date (2) state that clearing calculations for each subsequent biennial reporting period will commence on 1 January of the required reporting period, unless otherwise agreed by the CEO	Retain but update	

No	Aspect	Condition	Status	Proposed Strategy for Consolidation of Conditions
		(3) include a methodology to calculate the amount of clearing undertaken during each year of the biennial reporting period for each of the environmental values identified in condition 8-3 (4) indicate the timing and content of the Impact Reconciliation Reports (5) include the clearing previously approved and undertaken under Ministerial Statement 1015 subject to the rate of $750 AUD (excluding GST) per hectare of 'good to excellent' condition native vegetation, adjusted in accordance with the percentage change in the CPI applicable to that calendar year.		
8-7	Offsets	The proponent shall submit an Impact Reconciliation Report in accordance with the Impact Reconciliation Procedure approved in condition 8-5.	Retain	
8-8	Offsets	The Impact Reconciliation Report required pursuant to condition 8-7 shall provide the location and spatial extent of the clearing undertaken within the development envelope during each biennial reporting period.	Retain	
8-9	Offsets	The proponent may apply in writing and seek the written approval of the CEO to reduce all or part of the contribution payable under condition 8-2 where: (1) a payment has been made to satisfy a condition of an approval under the Environment Protection and Biodiversity Conservation Act 1999 in relation to the revised proposal (2) the payment is made for the purpose of counterbalancing impacts of the proposal on matters of national environmental significance (3) the payment is made for the purpose of counterbalancing the significant residual impacts to the environmental value identified in condition 8-3(4).	Retain	
8-10	Offsets	The 4,667 ha of clearing of native vegetation previously approved under Ministerial Statement 970 is exempt from the requirement to offset under condition 8-1.	Retain	
8-11	Offsets	Where clearing coincides with more than one category of habitat under conditions 8-3(1) to 8-3(4) the higher contribution rate applies.	Retain up update	
9-1	Greenhouse Gas Reporting	The proponent shall manage the implementation of the proposal to meet the following environmental objective: (1) avoid, where possible, and minimise greenhouse gas emissions as far as practicable.	Retain up update	
9-2	Greenhouse Gas Reporting	Within three (3) months of the issue of this Statement, the proponent shall prepare and submit a Greenhouse Gas Management Plan to meet the objective required by condition 9-1.	Delete	
9-3	Greenhouse Gas Reporting	The Greenhouse Gas Management Plan shall address the following matters: (1) benchmarking against applicable standards for iron ore processing (2) design of the proposal to minimise greenhouse gas emissions as far as practicable (3) monitoring and public reporting (4) opportunities for continuous improvement and minimising net emissions in the future within the existing design of the proposal.	Delete	
9-4	Greenhouse Gas Reporting	After receiving notice in writing from the CEO that the Greenhouse Gas Management Plan satisfies the requirements of conditions 9-2 and 9-3, the proponent must implement the Greenhouse Gas Management Plan.	Retain but update	
9-5	Greenhouse Gas Reporting	The proponent may review and revise the Greenhouse Gas Management Plan.	Retain	
9-6	Greenhouse Gas Reporting	The proponent shall review and revise the Greenhouse Gas Management Plan as and when directed by the CEO.	Retain	
9-7	Greenhouse Gas Reporting	The proponent shall continue to implement the version of the Greenhouse Gas Management Plan most recently approved by the CEO until the CEO has confirmed by notice in writing that the plan meets the objective specified in condition 9-1.	Retain but update	
10-1	Aboriginal Heritage	Prior to the commencement of ground disturbing activities, the proponent shall consult with the relevant Traditional Owners group(s) and ensure that the proponent complies with its obligations under the *Aboriginal Heritage Act 1972*.	Retain	
10-2	Aboriginal Heritage	That any contractors are made aware of their obligations under the *Aboriginal Heritage Act 1972*.	Retain	

Appendix 10: Condition requirements of Decision notice 2018/8299

Condition Number	Condition
1	To minimise impacts to EPBC Act listed threatened species, the approval holder must not clear more than 4 310 ha of vegetation within the development envelope at deposits C, D and G as shown in Attachment A, and for associated infrastructure for the development of deposits C, D and G.
2	To minimise impacts to EPBC Act listed threatened species, the approval holder must comply with conditions 5-1(1), 5-1(4), 5-1(5), 5-1(6), 5-2, 5-3, 5-4, 5-5, 5-6, 5-7 and 5-8 (Environmental Management Plan) of the Western Australia approval.
3	To minimise impacts to EPBC Act listed threatened species or their habitat the approval holder must ensure that there is: (a) no drawdown of groundwater associated with the proposal at the boundary of, or within, Karajini National Park; and (b) no change in groundwater water quality at the boundary of, or within, Karajini National Park.
4.	A Condition Environmental Management Plan to achieve the outcomes specified in Condition 3 must be submitted for approval by the Minister. The approved Condition Environmental Management Plan must be implemented. The approval holder must not commence dewatering activities unless the Minister has approved the Condition Environmental Management Plan in writing.
5	The Condition Environmental Management Plan must: (a) provide a discussion on the method to be used to recharge the aquifers; (b) specify threshold criteria to demonstrate compliance with the environmental outcomes specified in condition 3. Exceedance of the threshold criteria represents non-compliance with these conditions; (c) specify trigger criteria that must provide an early warning that the threshold criteria identified in the Condition Environmental Management Plan may not be met; (d) specify monitoring capable of determining if trigger criteria and threshold criteria are exceeded. The action must have a high degree of certainty that they will ensure the outcomes at condition 3 are met; (e) specify actions to be implemented in the event that trigger criteria have been exceeded; (f) specify threshold contingency actions to be implemented in the event that threshold criteria are exceeded, including ceasing water extraction if necessary; and (g) provide the format and timing for the reporting of monitoring results against trigger criteria and threshold criteria to demonstrate that condition 3 has been met.
6	In the event that monitoring, tests, surveys or investigations indicate exceedance of triggers or threshold criteria specified in the Condition Environmental Management Plan, the approval holder must: (a) report the exceedance in writing to the Department within seven (7) days of becoming aware of the exceedance; (b) commence implementing the trigger or threshold contingency actions specified in the Condition Environmental Management Plan specified at Condition 4 within 24 hours of becoming aware of the exceedance and continue implementation of those actions until the Department has confirmed by notice in writing that the approval holder has demonstrated that the threshold trigger or contingency actions are no longer required; (c) investigate to determine the cause of the trigger or threshold criteria being exceeded; (d) investigate to provide information for the Department to determine potential environmental harm or alteration of the environment that occurred due to threshold criteria being exceeded; and (e) provide a report to the Department within twenty-one business days of the exceedance being reported as required by condition 6(a). The report must include: (i) details of trigger or threshold contingency actions implemented; (ii) the effectiveness of the trigger or threshold contingency actions implemented, against the threshold criteria; (iii) the findings of the investigations required by conditions 6(c) and 6(d); (iv) measures to prevent the threshold criteria being exceeded in the future; (v) measures to prevent, mitigate and remedy the environmental harm which may have occurred; and (vi) justification of the threshold remaining, or being adjusted based on better understanding, demonstrating that outcomes will continue to be met.
7	Groundwater management and monitoring must continue until it can be demonstrated that the outcomes specified at Condition 3 can be met without active management.
8	To compensate for the residual significant impacts of clearing Ghost Bat (Macroderma gigas) habitat and Pilbara Leaf-nosed Bat (Rhinonicteris ourantia (Pilbara form)) habitat, the approval holder must within six months of the date of this approval, submit an Offset Strategy for the Minister's written approval. The Offset Strategy must be consistent with the principles of the EPBC Act Environmental Offsets Policy and must: (a) specify the approach for providing offsets for the clearing of 507 ha of Ghost Bat habitat and 507 ha of Pilbara Leaf-nosed Bat habitat; (b) identify threats for the Ghost Bat and Pilbara Leaf-nosed Bat; (c) nominate detailed offset projects that will realise a conservation benefit for the Ghost Bat and the Pilbara Leaf-nosed Bat in accordance with relevant approved conservation advice, recovery plans and threat abatement plans and regional conservation plans;

Condition Number	Condition
	(d) if the proposed Offset Strategy includes offset(s) that are not land aquisition, specify a financial commitment to offset projects of at least $3,000 AUD (exclusive of GST) per hectare of Ghost Bat habitat cleared and, in addition, at least $821.00 AUD (exclusive of GST) per hectare of Pilbara Leaf-nosed bat habitat cleared. Payments in respect of this commitment must be adjusted in accordance with the CPI for each financial year from the date of this approval decision until the date on which any particular payment is made; (e) specify the location and nature of each proposed offset, along with detailed objectives, budget, timeframes, performance and completion critieria for evaluating conservation outcomes, monitoring and reporting requirements; (f) include a description of the potential risks to the successful implementation of each proposed offset (including but not limited to environmental, administrative, financial, and governance risks); (g) include a description of the measures that will be implemented to mitigate risks associated with each proposed offset and a description of the contingency measures that will be implemented if triggers arise or completion criteria are not met; (h) include processes to adaptively manage proposed offsets; and (i) include a justification for how the proposed offsets meet the EPBC Act Environmental Offsets Policy. The approval holder must implement the approved Offset Strategy. The approval holder must implement the proposed offsets under the Offset Strategy within two months of the approval of the Offset Strategy, or another time as agreed in writing by the Department.
9	Subject to condition 11, within eight months of approval of the Offset Strategy by the Minister, the approval holder must submit a report to the Department detailing the extent of Ghost Bat habitat and Pilbara Leaf-nosed Bat habitat cleared, and the total amount of offset funds that have been allocated to the offset projects committed under the Offset Strategy and detail the implementation of offset projects. Subsequent reporting periods will be biennial, with the first biennial reporting period beginning the day after the first reporting period ends.
10	The approval holder may apply to the Department for a variation to the approved Offset Strategy under condition 8 by submitting an application in writing to the Department. The application must include: (a) the approval holders contact details, including referral number and ABN/ACN (b) a draft of the proposed variation (c) a written statement that sets out the reasons why the approval holder considers that the proposed variation is required. A variation to the approved Offset Strategy must be approved by the Department in writing. If the varied Offset Strategy is approved by the Department, the varied Offset Strategy must be implemented from the date of approval of the varied Offset Strategy.
11	If a Conservation Offset Fund has been established by the Western Australian Government, and approved by the Minister, then Conditions 8, 9 and 10 may not apply (or may cease to be applied) with the agreement by the Department in writing. In such a case, the approval holder must provide funds biennially to the Conservation Offset Fund. The amount of funds must be based on the area of bat habitat cleared in the biennial reporting period as set out below. The first biennial reporting period shall begin on the date of commencement of the action. The funds to be paid must be equivalent to the 2019 value of the following amounts by the application of the CPI in each financial year from the date of this approval decision until the date on which any particular payment is made: (a) at least $3,000 AUD (exclusive of GST) per hectare of Ghost Bat habitat cleared and, in addition; (b) at least $821.00 AUD (exclusive of GST) per hectare of Pilbara Leaf-nosed bat habitat cleared. Each payment required by this condition must comprise the total required in respect of the most recently ended biennial reporting period and be received by the Conservation Offset Fund within one month of the end of that biennial reporting period.
12	Prior to making the payment required by Condition 11, the approval holder must submit written evidence to the Department of the total area, including shapefiles, of Ghost Bat habitat and Pilbara Leaf-nosed Bat habitat cleared during the most recently ended biennial reporting period and the calculation (including working out) of the amount of funding that is required to be contributed to the Conservation Offset Fund for that biennial reporting period. Within 48 hours of the payment into the Conservation Offset Fund, evidence of these payments must be provided to the Department in writing.
13	The approval holder must notify the Department in writing of the date of commencement of the action within 10 business days after the date of commencement of the action.
14	If the commencement of the action does not occur within 5 years from the date of this approval, then the approval holder must not commence the action without the prior written agreement of the Minister.
15	The approval holder must maintain accurate and complete compliance records.
16	If the Department makes a request in writing, the approval holder must provide electronic copies of compliance records to the Department within the timeframe specified in the request.
17	The approval holder must: a. submit plans electronically to the Department for approval by the Minister; b. publish each plan on the website within 20 business days of the date the plan is approved by the Minister or of the date a revised action management plan is submitted to the Minister, unless otherwise agreed to in writing by the Minister; c. exclude or redact sensitive ecological data from plans published on the website or provided to a member of the public; and d. keep plans published on the website until the end date of this approval.
18	The approval holder must ensure that any monitoring data (including sensitive ecological data), surveys, maps, and other spatial and meta data required under a plan is prepared in accordance with the Department's Guidelines for biological survey and mapped data (2018) and submitted electronically to the Department in accordance with the requirements of the plan.

Condition Number	Condition
19	The approval holder must prepare a compliance report for each 12 month period following the date of commencement of the action,. The approval holder must: a. publish each compliance report on the website within 60 business days following the relevant 12 month period; b. notify the Department by email that a compliance report has been published on the website within five business days of the date of publication; c. keep all compliance reports publicly available on the website until this approval expires; d. exclude or redact sensitive ecological data from compliance reports published on the website; and e. where any sensitive ecological data has been excluded from the version published, submit the full compliance report to the Department within 5 business days of publication.
20	The approval holder must notify the Department in writing of any: incident; non-compliance with the conditions; or non-compliance with the commitments made in plans. The notification must be given as soon as practicable, and no later than two business days after becoming aware of the incident or non-compliance. The notification must specify: a. the condition which is or may be in breach; and b. a short description of the incident and/or non-compliance.
21	The approval holder must provide to the Department the details of any incident or non compliance with the conditions or commitments made in plans as soon as practicable and no later than 10 business days after becoming aware of the incident or non-compliance, specifying: a. any corrective action or investigation which the approval holder has already taken or intends to take in the immediate future; b. the potential impacts of the incident or non-compliance; and c. the method and timing of any remedial action that will be undertaken by the approval holder.
22	The approval holder must ensure that independent audits of compliance with the conditions are conducted as requested in writing by the Minister.
23	For each independent audit, the approval holder must: a. provide the name and qualifications of the independent auditor and the draft audit criteria to the Department; b. only commence the independent audit once the audit criteria have been approved in writing by the Department; and c. submit an audit report to the Department within the timeframe specified in the approved audit criteria.
24	The approval holder must publish the audit report on the website within 10 business days of receiving the Department's approval of the audit report and keep the audit report published on the website until the end date of this approval.
25	The approval holder may, at any time, apply to the Minister for a variation to an action management plan approved by the Minister under condition 4 or as subsequently revised in accordance with these conditions, by submitting an application in accordance with the requirements of section 143A of the EPBC Act. If the Minister approves a revised action management plan (RAMP) then, from the date specified, the approval holder must implement the RAMP in place of the previous action management plan.
26	The approval holder may choose to revise an action management plan approved by the Minister under condition 4, or as subsequently revised in accordance with these conditions, without submitting it for approval under section 143A of the EPBC Act, if the taking of the action in accordance with the RAMP would not be likely to have a new or increased impact.
27	If the approval holder makes the choice under condition 21 to revise an action management plan without submitting it for approval, the approval holder must: a. notify the Department in writing that the approved action management plan has been revised and provide the Department with: i. an electronic copy of the RAMP; ii. an electronic copy of the RAMP marked up with track changes to show the differences between the approved action management plan and the RAMP; iii. an explanation of the differences between the approved action management plan and the RAMP; iv. the reasons the approval holder considers that taking the action in accordance with the RAMP would not be likely to have a new or increased impact; and v. written notice of the date on which the approval holder will implement the RAMP (RAMP implementation date), being at least 20 business days after the date of providing notice of the revision of the action management plan, or a date agreed to in writing with the Department. b. subject to condition 24, implement the RAMP from the RAMP implementation date.
28	The approval holder may revoke their choice to implement a RAMP under condition 21 at any time by giving written notice to the Department. If the approval holder revokes the choice under condition 21, the approval holder must implement the previous action management plan approved by the Minister.
29	If the Minister gives a notice to the approval holder that the Minister is satisfied that the taking of the action in accordance with the RAMP would be likely to have a new or increased impact, then:

Condition Number	Condition
	a. condition 21 does not apply, or ceases to apply, in relation to the RAMP; and b. the approval holder must implement the action management plan specified by the Minister in the notice.
30	At the time of giving the notice under condition 23, the Minister may also notify that for a specified period of time, condition 21 does not apply for one or more specified action management plans.
31	Within 30 days after the completion of the action, the approval holder must notify the Department in writing and provide completion data.

A.9: Groundwater Environmental Management Plan

Groundwater Environmental Management Plan

West Angelas Revised Proposal

RTIO-HSE-0349522

Robe River Mining Co. Pty. Ltd.

152-158 St Georges Terrace, Perth

GPO Box A42, Perth WA 6837

Disclaimer and Limitation

This Groundwater Environmental Management Plan has been prepared by Rio Tinto's Iron Ore group (Rio Tinto), on behalf of Robe River Mining Co. Pty. Ltd. (the Proponent), specifically for the West Angelas Revised Proposal. Neither the document nor its contents may be referred to without the express approval of Rio Tinto unless the document has been approved for implementation under Ministerial Statement xxxx and Decision Notice 2018/8299.

Document Status					
Rev	**Author**	**Reviewer/s**	**Date**	**Approved for Issue**	
				To Whom	**Date**
1	Rio Tinto	Water Resource Evaluation Approvals Operations	12 – 22 January 2021	DWER, DCCEEW	10 February 2021
2	Rio Tinto	Water Resource Evaluation Approvals Operations	4 October 2021	DWER, DCCEEW	4 October 2021
3	Rio Tinto	Water Resource Evaluation Approvals Operations	4 February 2022	DWER, DCCEEW	7 February 2022
4	Rio Tinto	Water Resource Evaluation Approvals Operations	30 November 2023	DWER, DCCEEW	30 November

EXECUTIVE SUMMARY

The West Angelas Revised Proposal Groundwater Environmental Management Plan (Groundwater EMP) is submitted by Rio Tinto on behalf of Robe River Mining Co. Pty. Ltd. (the Proponent) as the authorised manager and agent for the participants in the Robe River Iron Associates Joint Venture, in accordance with Ministerial Statement xxxx (MS xxxx), and *Environment Protection Biodiversity Conservation Act 1999* (EPBC Act) Approval Decision Notice 2018/8299 (DN 2018/8299).

The purpose of this Groundwater EMP is to satisfy Condition 6 of MS xxxx and Conditions 3, 4, 5 and 6 of DN 2018/8299 in relation to groundwater drawdown associated with dewatering activities at Deposit C and Deposit D and use of a Managed Aquifer Recharge (MAR) scheme to mitigate potential impacts to Karijini National Park (Karijini National Park).

This Groundwater EMP has been updated to include information regarding the minimal water abstraction from deposit Western Hill.

This Groundwater EMP provides details of the adaptive management approach and supporting monitoring, which will ensure compliance with relevant State and Commonwealth Conditions. Table 1 below presents the environmental criteria and targets to measure achievement of the environmental outcomes and objectives to be met through implementation of this Groundwater EMP.

Table 1: Environmental criteria to measure achievement of environmental outcomes and objectives

Proposal title		West Angelas Revised Proposal
Proponent		Robe River Mining Co. Pty. Ltd.
Ministerial Statement		xxxx
EPBC Decision Notice (DN)		2018/8299 and 2021/8923
Purpose of this EMP		This Groundwater EMP fulfills the requirements of Condition 6 of MS xxxx and the requirements of Conditions 3, 4, 5 and 6 of DN 2018/8299 and condition x of DN 2021/8923 in relation to values associated with groundwater at the boundary of Karijini National Park.
***Environmental Protection Act 1986*: Key environmental factor, outcome and objective**		**Inland Waters – Karijini National Park** **EPA Objective:** *To maintain the hydrogeological regimes of groundwater and surface water so that environmental values are protected.*
Environmental Protection and Biodiversity Conservation Act 1999:		**Protection of EPBC Act listed species** **Condition 3:** *Minimise impacts to EPBC Act listed threatened species or their habitat.*
Drawdown (MS xxxx, DN 2018/8299 and DN 2018/8922)		
Objective-based Provisions Deposit D (DN 2018/8299)	**Target 1:**	Water levels in boundary bores to the south and north of the MAR scheme in areas outside of the regional aquifer are above or equal to rolling 3 year, seasonally adjusted water levels (mbgl).
	Target 2:	Water levels in Zone 3 monitoring bores and modelled are above or equal to rolling 3 year, seasonally adjusted water levels (mbgl).

	Target 3:	Water levels in Zone 3 monitoring bores and modelled are above or equal to rolling 5 year, seasonally adjusted water levels (mbgl).
	Target 4:	Water levels in Zone 3 monitoring bores and modelled are above or equal to rolling 10 year, seasonally adjusted water levels (mbgl).
Outcome-based Provisions Deposit D (DN 2018/8299)	**Conditioned Environmental outcome**	**Ministerial Statement xxxx Condition 6-1(1):** • Ensure that there is no drawdown of groundwater associated with the proposal at the boundary of, or within, Karijini National Park. **Decision Notice 2018/8299 Condition 3(a):** • '…no drawdown of groundwater associated with the action at the boundary of, or within, Karijini National Park.
	Early Response Indicator 1	Injection bores non operational outside of proposed plan for operation of the MAR scheme (more than 1 of a paired set of bores inoperable for more than 1 week).
	Early Response Indicator 2	Two consecutive monitoring periods of drawdown 25 cm greater than Grey Box level for modelled mitigation scenario in Zone 2 monitoring bores.
	Trigger Criteria Level 1	Two consecutive monitoring periods of drawdown 50 cm greater than Grey Box level for modelled mitigation scenario in Zone 2 monitoring bores.
	Trigger Criteria Level 2	Two consecutive monitoring periods of drawdown of 10 cm or greater than the Grey Box level for modelled mitigation scenario in Zone 3 monitoring bores or a single monitoring period of drawdown greater than 10 cm in Zone 3 monitoring bores if Trigger Criteria Level 1 exceeded in the current or preceding monitoring period or a single monitoring period of drawdown greater than 10 cm or greater than the Grey Box level recorded in two or more adjacent monitoring bores.
	Threshold Criteria	Two consecutive monitoring periods of drawdown associated with the proposal of 20 cm or greater than Grey Box level for modelled mitigation scenario in Zone 3 monitoring bores or a single monitoring period of drawdown exceeding 20 cm in Zone 3 monitoring bores if Trigger Criteria Level 2 exceeded in current or preceding monitoring period. or a single monitoring period of significant drawdown (over 40 cm drawdown) and the equipment is not damaged.
	Water Quality (DN 2018/8299 only)	
	Conditioned Environmental outcome	**Decision Notice 2018/8299 Condition 3(b):** • No change in groundwater water quality associated with the action at the boundary of, or within, Karijini National Park

	Early Response Indicator 1	pH trend in Zone 2 monitoring bores over two consecutive monitoring periods is not consistent with trend in control bore or Proportional change in EC in Zone 2 monitoring bores is greater than 20% of proportional change in control bore EC over two consecutive monitoring periods.
	Trigger Criteria Level 1	pH in Zone 2 monitoring bores is not between 6.5 and 8 for two consecutive monitoring periods and trend is not consistent with trend in control bore or Proportional change in EC in Zone 2 bores is greater than 50% of proportional change in control bore EC over two consecutive monitoring periods.
	Trigger Criteria Level 2	pH in Zone 2 monitoring bores is not between 6 and 8.5 for two consecutive monitoring periods and trend is not consistent with trend in control bore pH. or Proportional change in EC in Zone 3 monitoring bores is greater than 50% of proportional change in control bore EC over two consecutive monitoring periods.
	Threshold Criteria	pH in Zone 3 monitoring bores is not between 6 and 8.5 for two consecutive monitoring periods and trend is not consistent with trend in control bore pH and is associated with the action or Proportional change in EC in Zone 3 monitoring bores is greater than 80% of proportional change in control bore EC over two consecutive monitoring periods and is associated with the action.
Outcome-based Provisions Western Hill Deposit (MS xxxx and DN 2021/8923)	**Early Response Indicator**	Two consecutive monitoring periods of drawdown associated with the proposal of 25 cm or greater in Zone 1 monitoring bores.
	Trigger Criteria	Two consecutive monitoring periods of drawdown associated with the proposal of 50 cm or greater in Zone 1 monitoring bores.
	Threshold Criteria:	Two consecutive monitoring periods of drawdown associated with the proposal greater than 50 cm Zone 2 monitoring bores.

Corporate endorsement

I hereby certify that to the best of my knowledge, the provisions within this West Angelas Revised Proposal Groundwater Environmental Management Plan are true and correct.

Name: Sean O'Hanlon **Signed:**

Designation: GM, West Angelas **Date:** 22/12/23

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Abbreviations

Abbreviation	Description
ACAR	Annual Compliance Assessment Report
BWT	Below water table
DCCEEW	Department of Climate Change, Energy, Environment and Water (Cwth)
DBCA	Department of Biodiversity, Conservation and Attractions
DN	EPBC Act Decision Notice
DWER	Department of Water and Environmental Regulation
EC	Electrical Conductivity
EMP	Environmental Management Plan
EP Act	*Environmental Protection Act 1986*
EPA	Western Australian Environmental Protection Authority
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999*
Framework for EMPs	Rio Tinto Framework for development of EMPs as described in Appendix 1.
Long term	Greater than 2 years (where possible)
Management level	Level of management appropriate for an environmental value, as determined by assessment described in the Framework for the Development of Rio Tinto Environmental Management Plans
MAR	Managed Aquifer Recharge
MNES	Matters of National Environmental Significance
Proponent	Robe River Mining Co. Pty. Ltd.
Project	West Angelas Revised Proposal
SPR	A '*causal pathway conceptual model*' (Pressure, Stressor, Receptor) approach for potential impacts due to project (refer to Appendix 1).

1. CONTEXT, SCOPE AND RATIONALE

This Groundwater Environmental Management Plan (Groundwater EMP) has been prepared by Rio Tinto on behalf of Robe River Mining Co. Pty. Ltd. (the Proponent) as the authorised manager and agent for the participants in the Robe River Iron Associates Joint Venture, for the West Angelas Revised Proposal (the Project), in accordance with Ministerial Statement xxxx (MS xxxx), and *Environment Protection Biodiversity Conservation 1999* (EPBC Act) Approval Decision Notice 2018/8299 (DN 2018/8299).

This Groundwater EMP was developed according to the Conceptual Framework for the Development of Rio Tinto Environmental Management Plans (internal guidance described in Appendix 1). This framework provides a standardised approach to environmental management at Rio Tinto's Pilbara Iron Ore Operations, in accordance with Western Australian (WA) and Commonwealth Policy and Guidance, including:

- *Environmental Impact Assessment (Part IV Divisions 1 and 2) Administrative Procedures 2016* (EPA 2016)
- Environment Protection Authority's (EPA) *Instructions on how to prepare Environmental Protection Act 1986 Part IV Environmental Management Plans* (EPA 2018a)
- *Environmental Impact Assessment (Divisions 1 and 2) Procedures Manual* (EPA 2018b)
- *Environmental Management Plan Guidelines* (Australian Government 2014)
- *Australian and New Zealand Guidelines for Fresh and Marine Water Quality* (ANZECC & ARMCANZ 2000).

The scope of this Groundwater EMP is limited to satisfying the requirements of Condition 6 of MS xxxx, which specifies no impact on groundwater water levels at the boundary of, or within Karijini National Park as a result of the proposal, and Condition 3 of DN 2018/8299 which specifies no impact on groundwater level and groundwater quality at the boundary of, or within Karijini National Park as a result of the proposal. The scope of these conditions does not require the assessment of or outcomes for any receptors other than groundwater level and groundwater quality at the boundary of Karijini National Park.

This Groundwater EMP is subject to approval by the Commonwealth Department of Agriculture, Water and Environment (DAWE) and the WA Environmental Protection Authority (EPA), and once approved, will subsequently be implemented. The original version (v1) of the Groundwater EMP applies to Phase 1 of the Managed Aquifer Recharge (MAR) operation to support dewatering for Deposit D only. Further revisions of this Groundwater EMP will be submitted to DCCEEW and EPA for progressive phases as the Project progresses. This version of the Groundwater EMP (v4) includes data regarding the minimal water abstraction at the above water table mine at deposit Western Hill. In accordance with Condition 4 of DN 2018/8299, dewatering of Deposits C and D will not commence until such time as the Federal Minister for the Environment has approved a relevant version of the Condition Environmental Plan for the required Phase in writing. In accordance with DN 2021/8923 supply abstraction at Western Hill will not commence until such time as the the Groundwater EMP (v4) has been approved.

.

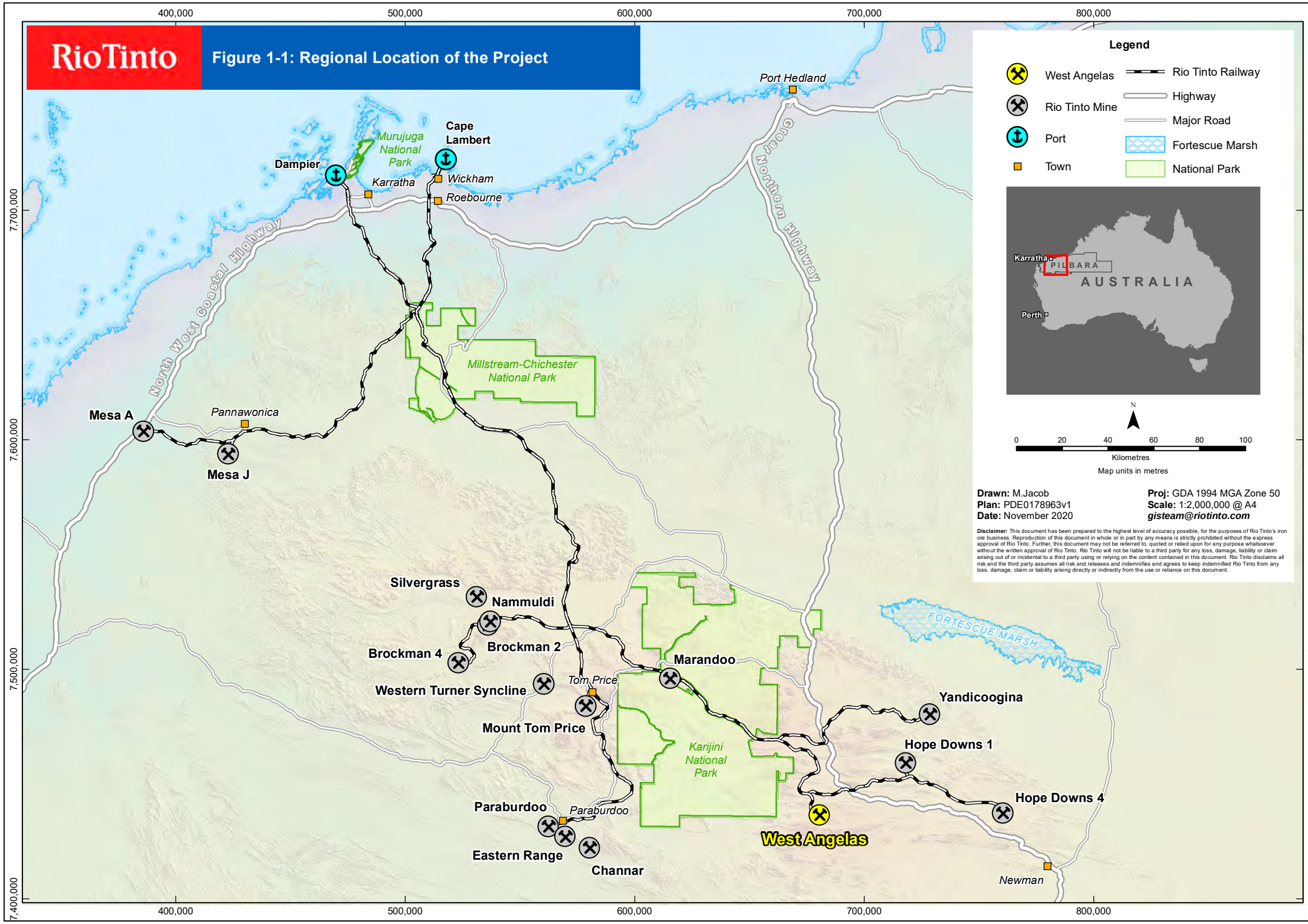
1.1 Project Description

The Project is located approximately 130 km west of Newman in the Pilbara region of Western Australia (Figure 1-1). Mineral Lease 248SA (ML248SA) was granted in 1976 under the *Iron Ore (Robe River) Agreement Act 1964* (WA). The Project includes the following (Figure 1-2).

- Mining of above and below water table (AWT and BWT) open cut iron ore Deposits A, A west, B, C, D, E, F and G by conventional drill, blast, and load and haul techniques
- Mining of AWT Deposit Western Hill by conventional drill, blast, and load and haul techniques, supply abstraction to support AWT mining at Western Hill
- Ore processing in central processing facilities
- Surface waste dumps, which are used in backfilling of the mine pits as far as practicable
- Infrastructure including but not limited to the following:
    (a) Dewatering and surplus water management infrastructure, including the Turee Creek B borefield which provides potable water to the mine and camp facilities (and, when required, water for operational purposes) and the mine dewatering borefield which dewaters the ore bodies to allow below water table mining. Dewatering water is used onsite in the first instance to supply water for operational purposes. Surplus dewatering water, exceeding the operational requirement, is discharged to a local ephemeral tributary of Turee Creek East (TCE) at licenced discharge points.
    (b) Installation of groundwater production bores at Western Hill to supply water for dust suppression and other purposes during construction and initial operations (up to 1 ML/d for 5 years)
    (c) Surface water management infrastructure, including diversions to direct surface waterflows around deposits and infrastructure.
    (d) Linear infrastructure Development Envelope, including the 413 km rail network which transports processed ore to port facilities located at Cape Lambert; the Turee Creek B borefield, pipeline and powerline and the 35 km mine access road which links the mine with the Great Northern Highway.
    (e) Support facilities, including, but not limited to, dewatering and surplus water management infrastructure, surface water management infrastructure, roads, conveyor, power and communications distribution networks, hydrocarbon storage, offices, laydown areas and an accommodation village.

The Project was approved with Conditions by the State and Commonwealth in September 2019. Subsequent to these approvals, an application has been submitted to amend the Development Envelope prescribed in MS xxxx via Section 45C of the *Environmental Protection Act 1986* (EP Act). The amendment will allow for infrastructure associated with the MAR scheme, authorised via MS xxxx, to be located fully within the Development Envelope (Figure 1-2).

A Proposal under Section 40AA of the Environmental Protection Act 1986 as an extension to the Approved Proposal has been assessed and approved under the (WA) EP Act. The extension will allow for additional mining, including AWT mining and supply abstraction at the Western Hill deposit. The Proposal was referred to the DCCEEW under the EPBC Act and was determined to be a Controlled Action, the Proposal is being assessed via accredited assessment (2018/8923).


RioTinto
Figure 1-1: Regional Location of the Project
400,000
500,000
600,000
700,000
800,000
7,700,000
7,600,000
7,500,000
7,400,000
Port Hedland
Cape Lambert
Murujuga National Park
Dampier
Karratha
Wickham
Roebourne
North West Coastal Highway
Great Northern Highway
Millstream-Chichester National Park
Mesa A
Pannawonica
Mesa J
Silvergrass
Nammuldi
Brockman 4
Brockman 2
Marandoo
Western Turner Syncline
Tom Price
Mount Tom Price
FORTESCUE MARSH
Yandicoogina
Hope Downs 1
Karijini National Park
Hope Downs 4
Paraburdoo
Paraburdoo
Eastern Range
Channar
West Angelas
Newman
Legend
West Angelas
Rio Tinto Railway
Rio Tinto Mine
Highway
Port
Major Road
Town
Fortescue Marsh
National Park
Karratha
PILBARA
AUSTRALIA
Perth
N
0 20 40 60 80 100
Kilometres
Map units in metres
Drawn: M.Jacob
Plan: PDE0178963v1
Date: November 2020
Proj: GDA 1994 MGA Zone 50
Scale: 1:2,000,000 @ A4
gisteam@riotinto.com
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660,000
670,000
680,000
690,000
7,450,000
7,440,000
7,430,000

Karijini National Park

Great Northern Highway

Western Hill

Deposit B

Deposit G

Deposit H

Deposit C

Deposit D

Deposit A West

Deposit A

Deposit E

Deposit F

Deposit F North

Mt Ella East

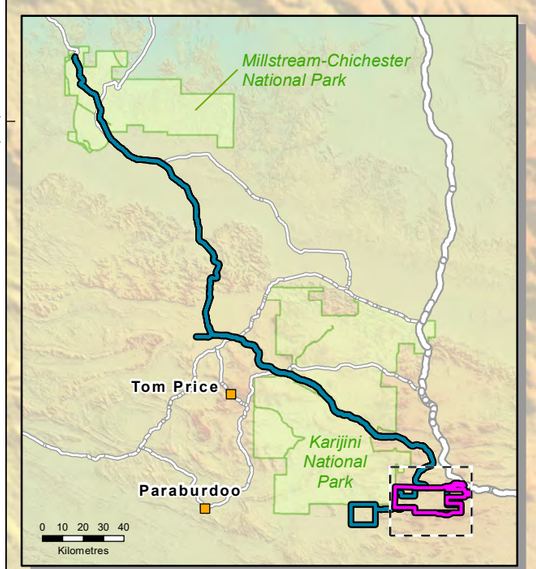

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Figure 1-2
Revised Development Envelope and Indicative Location of Key Proposal Elements

Drawn: GIS Team
Plan: PDE0186387v7
Date: November 2023

Proj: GDA 1994 MGA Zone 50
Scale: 1:120,000 @A3
GIS.Team@riotinto.com

Legend

- Revised Development Envelope
- Approved Development Envelope 1113 - Linear Infrastructure
- Survey Reference

Conceptual Footprint

- Conceptual Pit
- Conceptual Waste Landform
- Conceptual Associated Mine Disturbance

Approved Conceptual Layout

- Pit
- Waste Landform
- Stockpile

- National Park
- Rio Tinto Railway
- Highway
- Major Road

N

0 1 2 3 4 5
Kilometres

Map units in metres

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1.2 Key Environmental Factors

The key EPA environmental factor relevant to this Groundwater EMP is *Inland Waters*, and the associated environmental value is:

- Karijini National Park.

Potential impacts from the Project on this value are summarised in Table 1-1 and further detail on the regional groundwater system is provided in Section 1.2.1.

Table 1-1: Key environmental factors, associated environmental values, and potential impacts from the Project as addressed in this Groundwater EMP (as per the SPR model[1])

Environmental value (receptor)	Predicted impacts		Potential impacts Not predicted to occur	
	Direct (stressor, pressure)	Indirect (stressor, pressure)	Direct (stressor, pressure)	Indirect (stressor, pressure)
Environmental Factor: Inland Waters				
Deposit D				
Environmental value: Groundwater located at boundary of, and within Karijini National Park.	None predicted	**Dewatering of Deposit C and Deposit D:** Lowering of groundwater levels at the boundary of, or within, Karijini National Park.	None predicted	**Dewatering of Deposit C and Deposit D:** Change to groundwater quality at the boundary of, or within, Karijini National Park.
Western Hill				
Environmental value: Groundwater located at boundary of, and within Karijini National Park.	None predicted	None predicted - There will be no dewatering at Western Hill deposit. Supply abstraction is not modelled to propagate towards Karijini National Park.	None predicted	None predicted - There will be no dewatering at Western Hill deposit. Supply abstraction is not modelled to propagate towards Karijini National Park.

1.2.1 West Angelas Groundwater System

The conceptual groundwater system is characterised as a large basin-type aquifer with water in storage within the weathered Wittenoom formation, mineralised Marra Mamba formation and overlying alluvial dolocrete/detrital units.

1.2.1.1 Deposit C and D

The groundwater system at Deposit C and Deposit D (the source for both dewatering and mitigation activities as a part of the Project) underlies part of the drainage system of TCE, a tributary of the Ashburton River. Groundwater is present within an interconnected alluvial and bedded stratigraphy that underlies mining tenure and a relatively small area of the Karijini National Park (Figure 1-3 and **Figure 1-4**).

[1] A '*causal pathway conceptual model*' (Stressor, Pressure, Receptor [SPR]) approach for potential impacts due to a Project (Appendix 1).

The system is bounded to the west, north and south by prominent ridges of outcropping Brockman Iron Formation with an internal anticline (Wonmunna anticline) of unmineralized Marra Mamba Formation forming part of the eastern boundary. Two prominent dolerite dyke barriers are present in the system which bisect the groundwater system with observed groundwater compartments on either side. Several Brockman Iron Formation areas are remnants atop the Wittenoom Formation and have been identified as hosting perched and disconnected to semi-connected aquifer systems. The Wittenoom Formation beneath these remnants is expected to be relatively impermeable.

The water table is relatively consistent (flat) at between 623mRL and 627mRL with a slight gradient from east to west. The gradient is inferred to be due to the presence of a discharge/evaporative zone (within Karijini National Park) where groundwater is relatively shallow (5-15 m below ground level (mbgl)) and an area where creek alluvium provides a subsurface discharge pathway. Depth to water varies according to topography with depths in the vicinity of the deposits greater than 50mbgl and depths inside Karijini National Park as shallow as 7 m in observed locations.

Hydrogeological information is restricted both spatially within the groundwater system and temporally in certain areas of the system. Pumping tests to date have been focussed in the vicinity of the orebody deposits with minor testing completed in areas both within and near the eastern boundary of Karijini National Park. Manual water level monitoring of the aquifer has occurred since 2004 with continuous levels recorded since 2016 via data loggers. A discrete field investigation in 1978 yielded several static groundwater level observations in Karijini National Park. Water quality information is similarly limited, however, static records for hydrochemistry have been collected in Karijini National Park for the period prior to 2019.

Water level fluctuations are most pronounced in areas of potential recharge and pumping, with minimal seasonal variability in groundwater levels (~10 cm) recorded in years lacking large episodic rainfall events. Monitored observations and historical investigations have shown a reversal of hydraulic gradient away from Karijini National Park for periods following significant rainfall/ recharge events.

A review of available information suggests that groundwater levels in the late 1970's have historically been lower than the present day which indicates that present day groundwater levels are possibly higher as a direct result of higher than average rainfall in the past ~20 years (Figure 1-5). Recharge response in the aquifer is expected to be most significant in the part of the aquifer system within Karijini National Park where groundwater is closer to surface.

A cross section of the hydrogeology at Deposit D and the eastern end of Karijini National Park is shown in Figure 1-3 and a conceptual overview of the groundwater system and main geological units is shown in Figure 1-4.

Temporal groundwater level and water quality observations since mid-2000 within Karijini National Park indicate an aquifer that is influenced by changes in climate, which is dissimilar to data collected over the 20 years of operation at West Angelas (Deposits A, B, E and F), which demonstrate very little by way of variability in both groundwater level fluctuation and fairly consistent chemical characteristics (Section 1.2.1.2) over time. This is believed to be a direct result of substantially shallower water tables and the potential for rapid infiltration of the aquifer through a dolocrete unit

(Figure 1-3). Actively mined and pumped areas have the potential for hydraulic barriers and laterally perching detrital layers that may smooth out or even prevent groundwater response to present day rainfall.

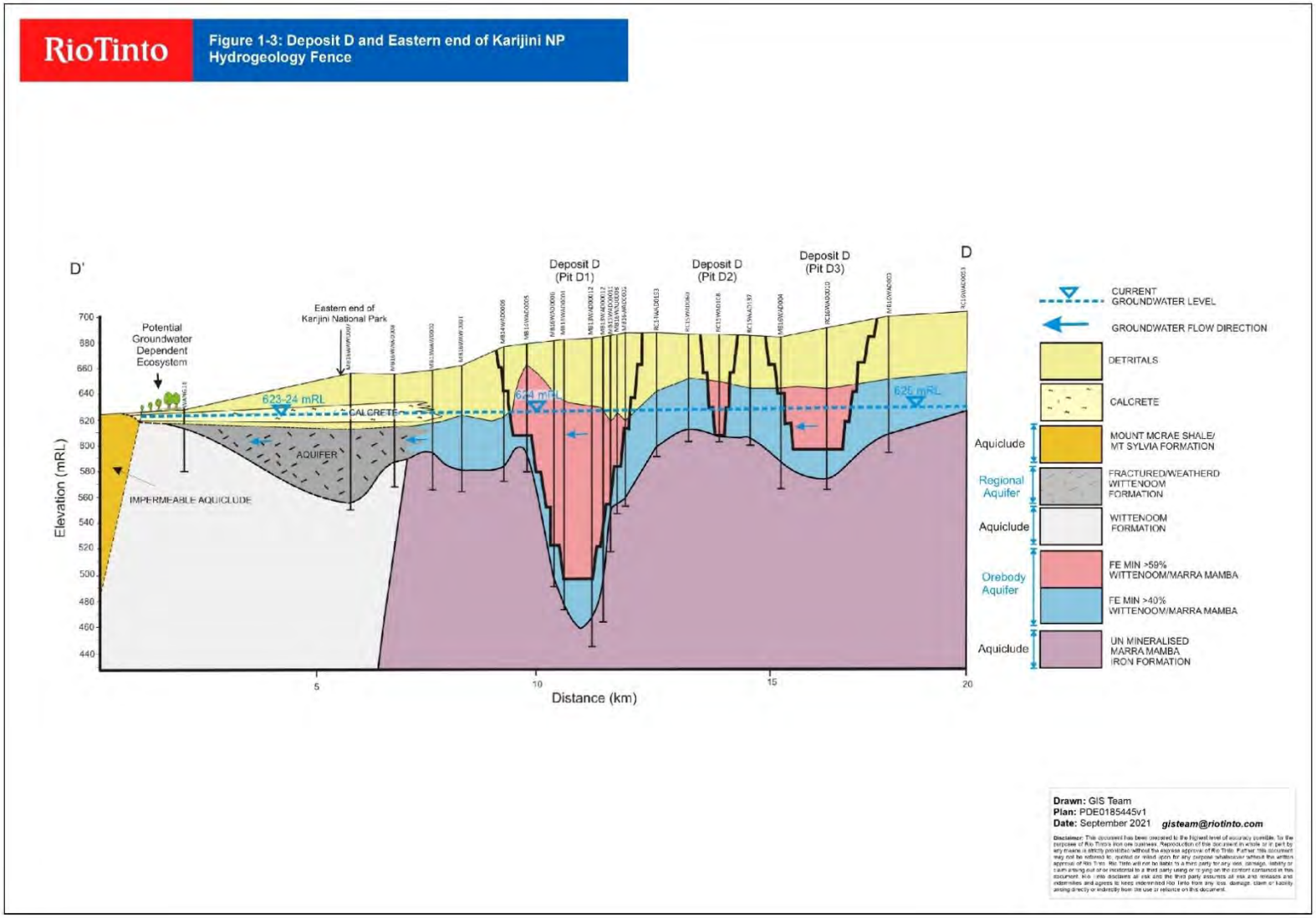


Figure 1-3: Deposit D and Eastern end of Karijini National Park Hydrogeology Fence Diagram Note: bores are transposed onto section line

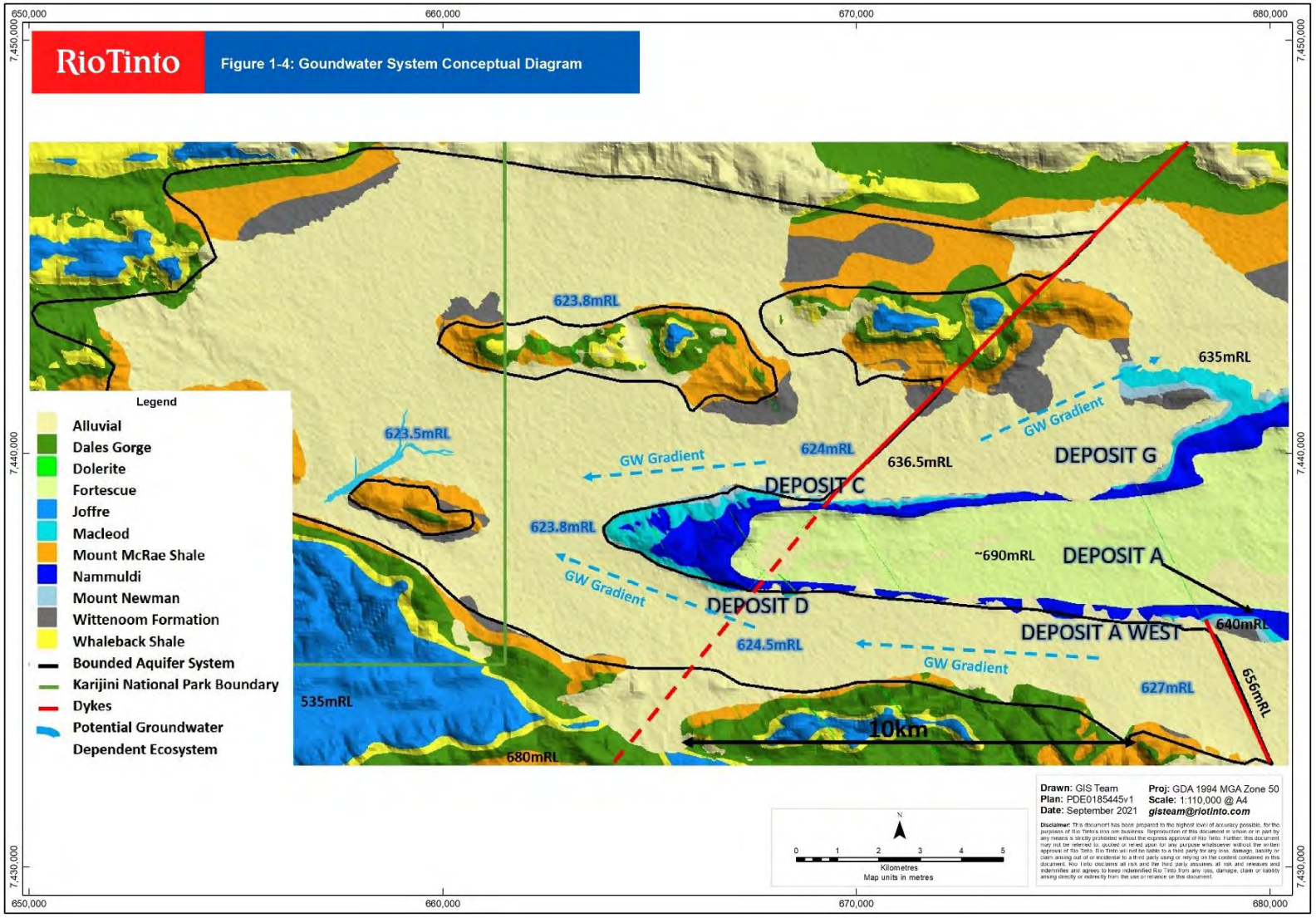


Figure 1-4: Groundwater System Conceptual Diagram

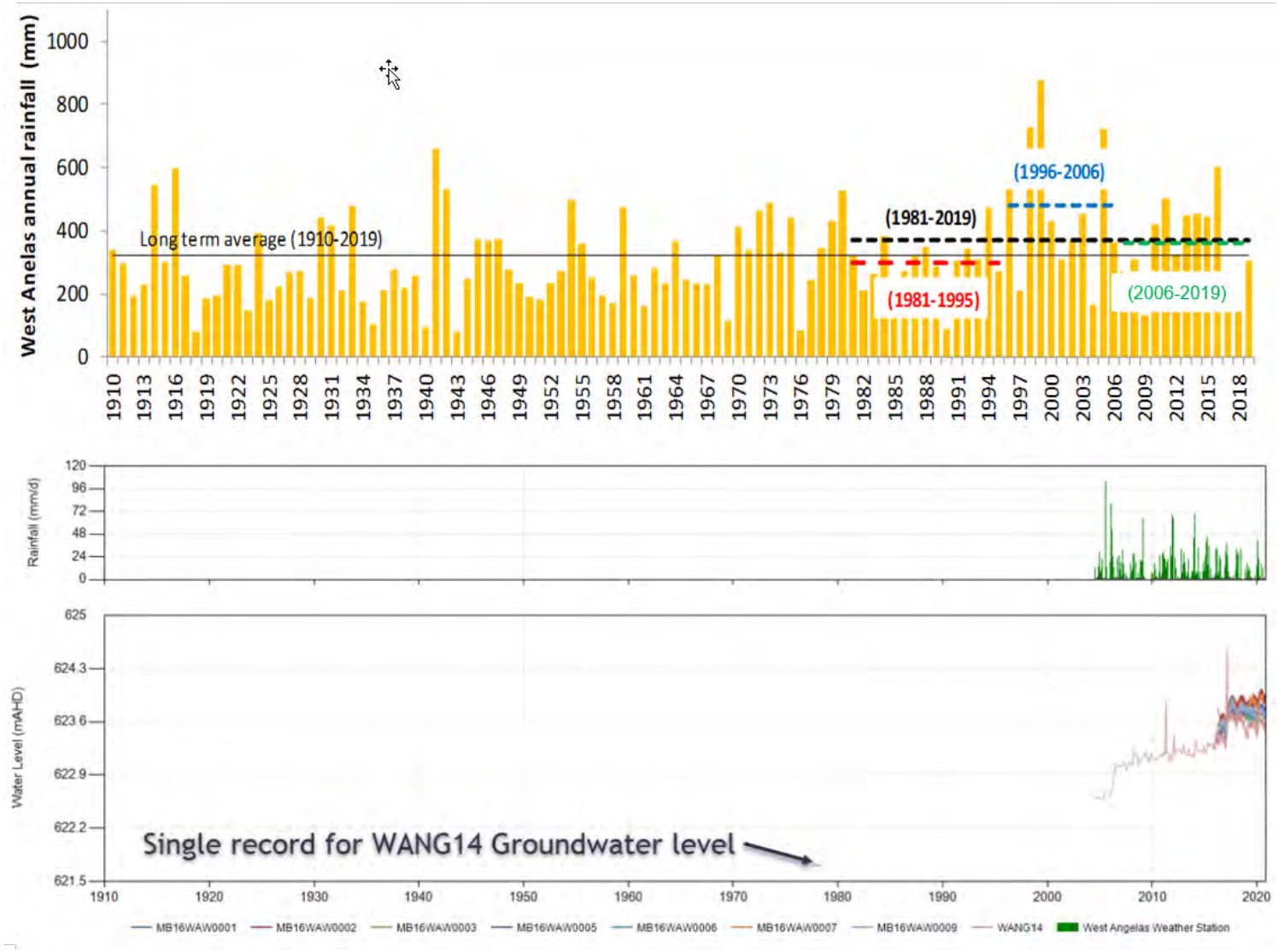


Figure 1-5: Historic Rainfall Record and Water Levels at West Angelas (rainfall source: SILO patched point)

The current Pilbara climate is characterised by episodic, cyclonic rainfall with wet/ dry seasons and significantly higher evaporation than annual rainfall. This means these cyclonic and highly variable seasonal events are a potential source of groundwater recharge. This depends on the capacity of the groundwater system to receive the water; currently, much of the natural groundwater system is full due to post-glacial maxima recharge. After rainfall recharge events, groundwater levels recede following a typical relaxation response with more substantial and rapid rises within Karijini National Park, in proximity of TCE where recharge may be concentrated for a longer period during streamflow, and more subdued responses are observed in areas of greater depth to groundwater and further away from Karijini National Park.

Numerical modelling suggests that unmitigated dewatering of the western end of Deposit C and Deposit D could result in groundwater drawdown extending west to the Karijini National Park boundary as early as 2024. Modelling of drawdown with inclusion of mitigation (e.g. MAR) suggests that drawdown can be negated.

1.2.1.2 Western Hill Groundwater

The Western Hill deposit is located in the upper reaches of the Turee Creek East catchment. The deposit sits elevated and intercepts several small catchments (all <0.5 km2) associated with steep drainage, which convey runoff to two main creeks north and south of the deposit. Both these un-named creeks are minor tributaries of Turee Creek East and flow directly westwards and into Karijini National Park. Several sensitive receptors are downstream of Western Hill, including Karijini National Park, and the Guburingu Heritage site.

A regionally significant dolerite dyke exists to the east of Western Hill, which imparts a 13 m head difference across it and acts as an aquitard (Rio Tinto 2021). The groundwater table is relatively flat across the Western Hill area at approximately 624 mAHD.

Groundwater within the Wittenoom Formation surrounding Western Hill is inferred to flow southwesterly towards an alluvial channel beneath Turee Creek East south-west in shallow groundwater within Karijini National Park. The Wittenoom Formation to the south is hydraulically connected to the Deposit C orebody aquifer, and the Wittenoom Formation to the north is conceptually bounded by a Marra Mamba Iron Formation range 3.5 km to the north of the pits.

The two discrete Western Hill orebodies are both surrounded by Mt McRae Shale (a low permeability unit known for its ability to impede groundwater flow). However, there may be some limited connectivity with the underlying and surrounding Wittenoom Formation (the regional aquifer unit) that may support potential GDE in the nearby Karijini National Park (Rio Tinto 2021).

The depth to groundwater is >50 m across the Western Hill mine area. Groundwater is fresh (425 mg/L TDS), pH is neutral, alkalinity is low (<28 mg/L), and metal concentrations are low, indicating limited rock-water interaction and hydrochemical development (Rio Tinto 2020).

The groundwater chemistry indicates there is a likelihood that groundwater within Western Hill is connected at least to some extent to groundwater outside Western Hill as shown by the similarity in chemistry between the shallow monitoring bore and other regional bores. However, the deeper production bores' chemistry indicates that connectivity to the surrounding Wittenoom Formation may decrease with depth.

The Proposal includes installing a series of groundwater production bores screened in the localised Brockman Iron Formation to supply water for dust suppression and other purposes during construction

and initial operations of up to 1 ML/d for 5 years (approximately 0.37 GL/a). The bores will be located central to the Western Hill development, more than 3 km from the boundary with Karijini National Park

Groundwater modelling (Rio Tinto 2021) has shown that the estimated drawdown associated with water supply is highly unlikely to impact groundwater levels at the Karijini National Park boundary outside of natural recorded groundwater level seasonal variations (See Section 1.5.2).

1.2.1.3 Groundwater Quality

The groundwater system comprises areas of deep, relatively immobile (partly compartmentalised by dykes or other geological structures) groundwater within orebodies, areas of relatively deep groundwater which does not respond significantly to modern day recharge (nearby to the deposits in the Wittenoom Formation) and an area of shallow groundwater where water may be released through a narrow alluvial channel beneath the modern day TCE palaeo-drainage (within Karijini National Park). The water quality in each area may fluctuate as a response to recharge and, in time, to subsequent MAR mitigation activities.

Groundwater within, and at the boundary of, Karijini National Park varies in both pH and electrical conductivity (EC) as a direct result of rainfall recharge. Prior to 2020, laboratory samples of groundwater within Karijini National Park comprised data from initial exploration boreholes (Layton Consultants, 1978) and several borehole samples collected from the Deposit C and Deposit D pre-feasibility and feasibility studies (RTIO 2016, RTIO 2017 and RTIO 2019).

Manual observation (bailed groundwater samples) from WANG14 (Figure 1-3) were collected from 2004 with a change in monitoring requirements in 2008 resulting in sampling for this dataset not being continued. Continuous monitoring of EC in WANG14 via a datalogger commenced in 2017 (Figure 1-6). pH in WANG14 has fluctuated within the range of 6.5 and 9.2 (although results from 2006 including a quite significant change in pH may indicate a calibration issue), with a recorded average pH of 8. EC is low in all bores, with an average EC of 715.5 uS/cm.

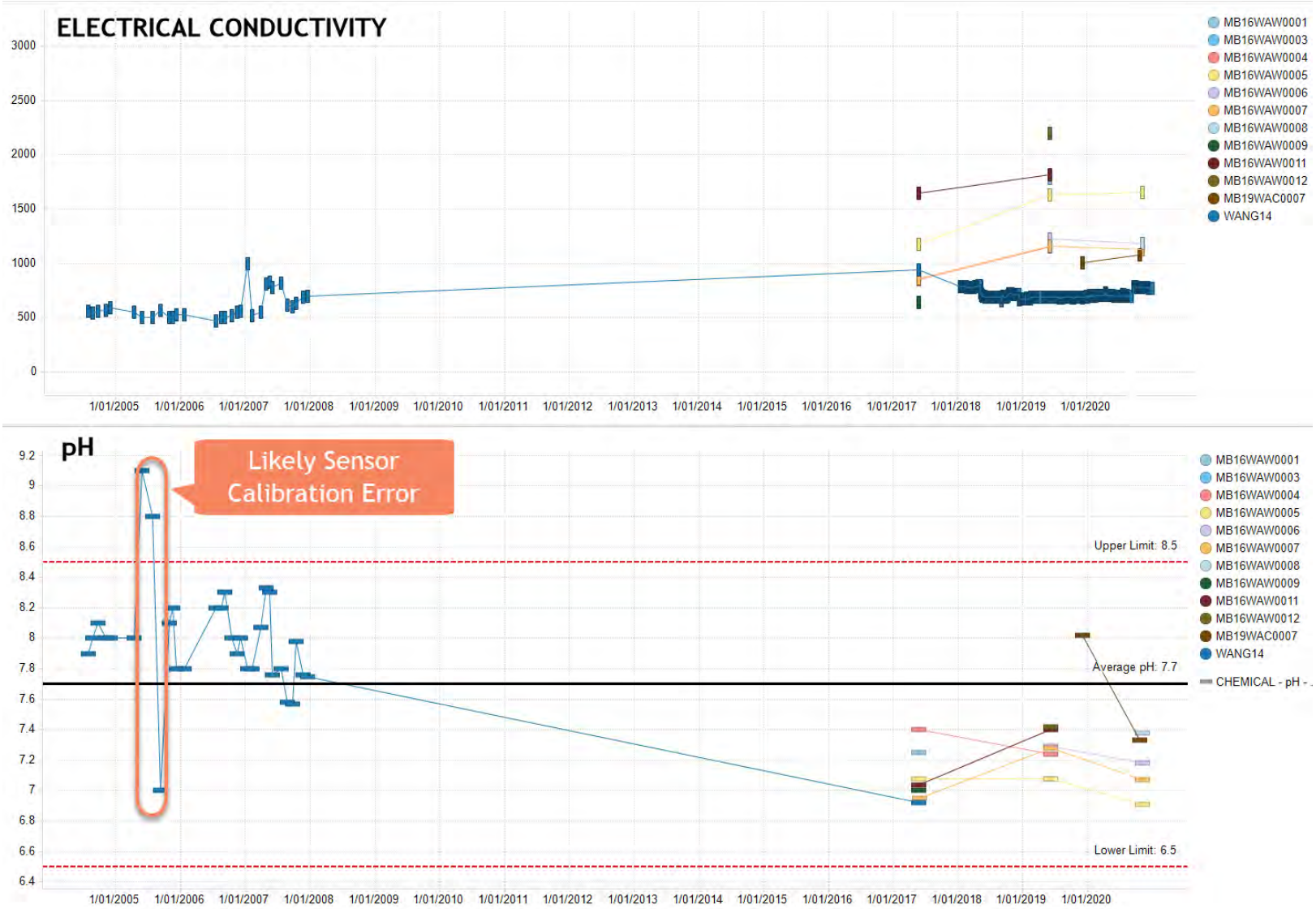


Figure 1-6: Temporal variability of pH and EC data for bores in the area nearby to or within Karijini National Park

Groundwater at West Angelas has been broadly classified into zones to allow for evaluation of trends and for investigation of any potential source/receiving environment interaction in the event of mitigation. In each zone, an assessment of spatial coverage (i.e. all areas intended for pumping or injection are sampled at least once) and seasonal variability (all bores sampled before and after a wet season) was included (Table 1-2). The low number of samples (<15) presents a clear limitation in available information for all areas except Deposit E; hence, further sampling and analysis before any detailed assessment of potential water quality change is proposed.

Table 1-2: **Summary of Zonal Groundwater Physicochemical Characteristics**

Parameter	Deposit D	Deposit C	Deposit E	Phase 1 MAR Area	KNP Area
No of Samples	13	4	72	20	15 (only 1 since 1978)
Seasonal Sampling	No	No	Yes	Yes	No
Spatial Coverage	Yes	No	Yes	Yes	No
pH	6.7-8.5	7.4-8.3	6.7-8.6	6.8-9.5	7-9.1
Electrical Conductivity (μS/cm)	400-1301	562-1271	440-1252	641-2200	470-1000
Sodium (mg/L)	64-79	72-105	27-92	36-156	49-130
Potassium (mg/L)	2-12	3-4	4-17	7-18	4-15
Calcium (mg/L)	43-84	68-84	30-72	5-111	60-110
Magnesium (mg/L)	55-66	63-80	25-42	27-88	68-106
Chloride (mg/L)	72-147	104-145	37-230	67-460	95-236
Sulphate (mg/L)	75-239	192-273	28-110	2-167	85-170
Total Nitrogen (mg/L)	3-6.2	0.3-3.0	0.4-10	2.3-2.6	1-10 (?)
Bicarbonate (from Alk) (mg/L)	199-314	235-266	101-229	86-378	205-544

Note: All production bores were used for Deposits D, C and E character and all available information was used for both the MAR and Karijini National Park areas

Individual analyte concentrations are summarised and plotted in a piper diagram (Figure 1-7). The distribution of analytes demonstrates very little difference between waters in each zone which can be broadly taken to mean that mixing of waters from each zone would not result in significant changes in receiving zone analyte concentration.

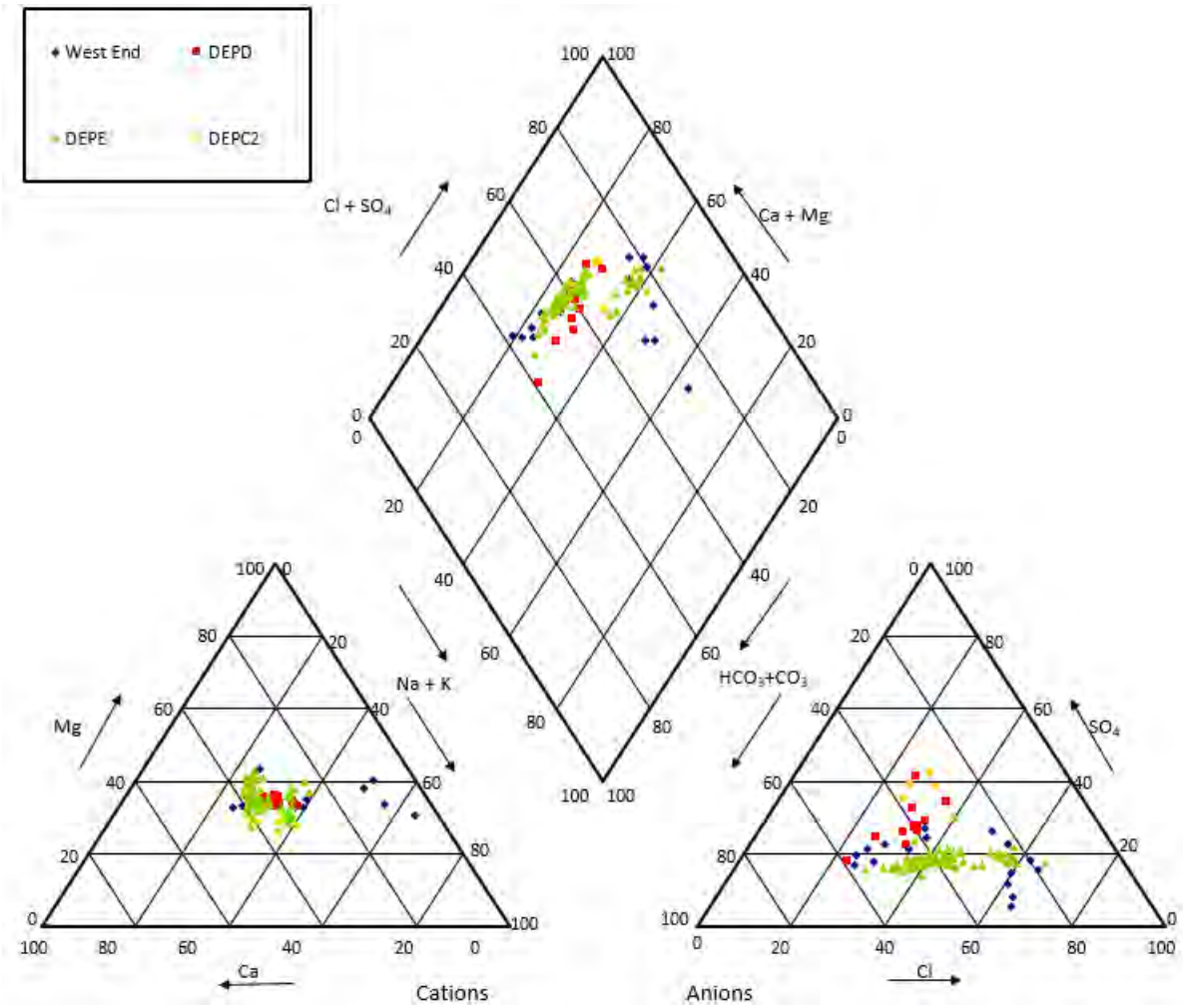


Figure 1-7: Piper diagram of individual major ion concentrations for water quality zones

To ensure that any change relating to reactions produced from the mixing of injectant and receiving waters does not propagate into the Karijini National Park, particle tracking modelling has been undertaken (Appendix 3) to evaluate the worst case distribution of injectant given an 100 year duration of injection and book-end (or minimum/ maximum drawdown) parameter sets (Figure 1-8). This is viewed as highly conservative in that it both provides confidence in both the timeframes expected and also assumes that injectant water/ inferred contaminants are not diluted as they flow through the aquifer.

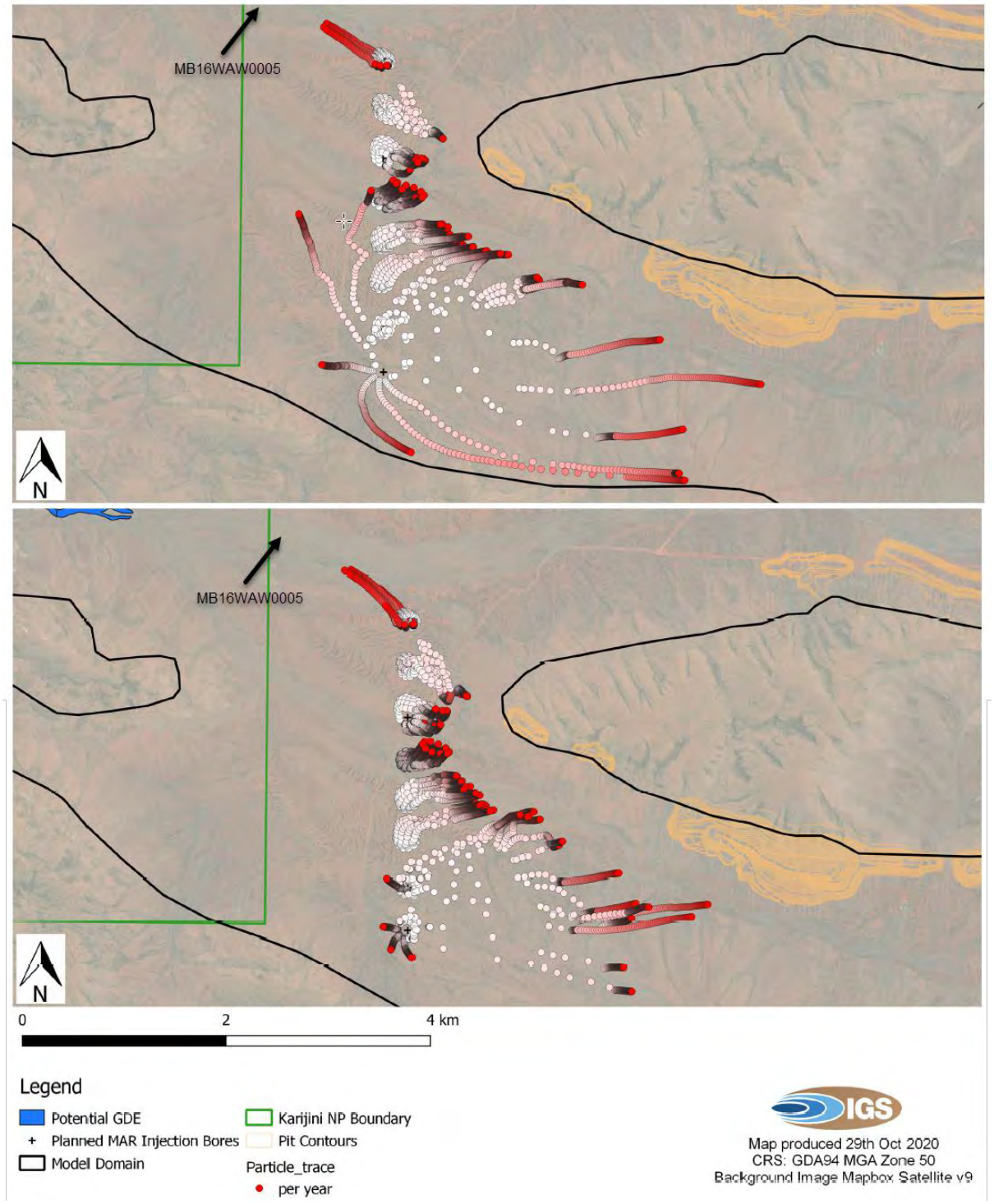


Figure 1-8: Particle tracking profiles for maximum (top) and minimum (bottom) drawdown models. Models run for 100 years with each dot representing a single year of water movement.

1.3 Condition Requirements

The Project was assessed under Part IV of the EP Act and the EPBC Act. Conditions, as per MS xxxx, and DN 2018/8299, relevant to this Groundwater EMP are identified in Table 1-3 and Table 1-4 respectively.

Requirements of the relevant MS xxxx and DN 2021/8923 Conditions relate to management of groundwater levels, while relevant DN 2018/8299 Conditions relate to management of groundwater levels and groundwater quality.

The Proponent anticipates that the Revised Ministerial Statement (MS xxxx) and Decision Notice 2021/8923 will retain conditions as specified in current MS xxxx and DN 2018/8922 (Table 1-3 and Table 1-4).

Table 1-3: MS xxxx Condition 6 for the Project relevant to this Groundwater EMP

Condition		Section in EMP
6	**Groundwater Management**	
x	Prior to dewatering of Deposits C or D, the Proponent shall prepare and submit a Condition Environmental Management Plan to meet the following outcome: (1) Ensure that there is no drawdown of groundwater associated with the proposal at the boundary of, or within, Karijini National Park.	Section 2
x	The Condition Environmental Management Plan shall: (1) specify trigger criteria that must provide an early warning that the threshold criteria identified in Condition 6-2 may not be met; (2) specify threshold criteria to demonstrate compliance with the environmental outcomes specified in Condition x. Exceedance of the threshold criteria represents non-compliance with these conditions; (3) specify monitoring to determine if trigger criteria and threshold criteria are exceeded; (4) specify trigger level actions to be implemented in the event that trigger criteria have been exceeded; (5) specify threshold contingency actions to be implemented in the event that threshold criteria are exceeded; and (6) provide the format and timing for the reporting of monitoring results against trigger criteria and threshold criteria to demonstrate that Condition x has been met over the reporting period in the Compliance Assessment Report required by Condition 3-1.	Section 2, Table 2-1 and Table 2-2
x	After receiving notice in writing from the CEO in consultation with the Department of Biodiversity, Conservation and Attractions that the Condition Environmental Management Plan satisfies the requirements of Condition 6-2, the Proponent shall: (1) implement the provisions of the Condition Environmental Management Plan; and (2) continue to implement the Condition Environmental Management Plan until the CEO has confirmed by notice in writing that the Proponent has demonstrated the outcomes and objectives specified in Condition x have been met.	Section 2
x	In the event that monitoring, tests, surveys or investigations indicates exceedance of threshold criteria specified in the Condition Environmental Management Plan, the Proponent shall: (1) report the exceedance in writing to the CEO within seven (7) days of the exceedance being identified; (2) implement the threshold level contingency actions specified in the Condition Environmental Management Plan within twenty-four (24) hours and continue implementation of those actions until the CEO has confirmed by notice in writing	Section 2, Table 2-1 and Table 2-2

	Condition	Section in EMP
	that it has been demonstrated that the threshold criteria are being met and the implementation of the threshold contingency actions is no longer required; (3) investigate to determine the cause of the threshold criteria being exceeded; (4) investigate to provide information for the CEO to determine potential environmental harm or alteration of the environment that occurred due to threshold criteria being exceeded; and (5) provide a report to the CEO within twenty-one (21) days of the exceedance being reported as required by condition 6-4(1). The report shall include; (a) details of threshold contingency actions implemented; (b) the effectiveness of the threshold contingency actions implemented, against the threshold criteria; (c) the findings of investigations required by Condition 6-4(3) and 6-4(4); (d) measures to prevent the threshold criteria being exceeded in the future; (e) measures to prevent, control or abate the environmental harm which may have occurred; and (f) justification of the threshold remaining, or being adjusted based on better understanding, demonstrating that outcomes would continue to be met.	
x	The Proponent: (1) may review and revise the Condition Environmental Management Plan, or (2) shall review and revise the Condition Environmental Management Plan as and when directed by the CEO.	Section 3
x	The Proponent shall implement the latest revision of the Condition Environmental Management Plan, which the CEO has confirmed by notices in writing, satisfies the requirements of Condition 6-2.	N/A
x	The Proponent shall implement the Groundwater Management Plan component of the West Angelas Operations Environmental Management Program (RTIO-HSE-0210871) dated November 2013 until the CEO has confirmed by notice in writing the Condition Environmental Management Plan required by Condition x satisfies the requirements of Condition 6-2.	Section 3

Table 1-4: EPBC Act Approval DN 2018/8299 Conditions for the Project relevant to this Groundwater EMP

	Condition	Section in EMP
3	To minimise impacts to EPBC Act listed threatened species or their habitat the approval holder must ensure that there is: a) no drawdown of groundwater associated with the action at the boundary of, or within, Karijini National Park and b) no change in groundwater quality associated with the action at the boundary of, or within, Karijini National Park.	Section 2
4	A Condition Environmental Management Plan to achieve the outcomes specified in Condition 3 must be submitted for approval by the Minister. The approved Condition Environmental Management Plan must be implemented. The approval holder must not commence dewatering activities unless the Minister has approved the Condition Environmental Management Plan in writing.	Section 1
5	The Condition Environmental Management Plan must: (a) provide an explanation of the method to be used to ensure the outcome required by Condition 3(a) is met;	Section 1.1, Section 2, Table 2-1 and Table 2-2 and Table **2-4**.

	Condition	Section in EMP
	(b) specify threshold criteria to demonstrate compliance with the environmental outcomes specified in Condition 3. Exceedance of the threshold criteria represents non-compliance with these conditions; (c) specify trigger criteria that must provide an early warning that the threshold criteria identified in the Condition Environmental Management Plan may not be met; (d) specify monitoring capable of determining if trigger criteria and threshold criteria are exceeded. The approval holder must have a high degree of certainty that they will ensure the outcomes at Condition 3 are met; (e) specify actions to be implemented in the event that trigger criteria have been exceeded; (f) specify threshold contingency actions to be implemented in the event that threshold criteria are exceeded, including ceasing water extraction if necessary; (g) provide the format and timing for the reporting of monitoring results against trigger criteria and threshold criteria to demonstrate that Condition 3 has been met.	
6	In the event that monitoring, tests, surveys or investigations indicate exceedance of triggers or threshold criteria specified in the Condition Environmental Management Plan, the approval holder must: (a) report the exceedance in writing to the Department within five (5) business days of becoming aware of the exceedance; (b) commence implementing the trigger or threshold contingency actions specified in the Condition Environmental Management Plan specified at Condition 4 within 24 hours of becoming aware of the exceedance and, in respect of exceedance of threshold criteria, continue implementation of those actions until the Department has confirmed by notice in writing that the approval holder has demonstrated that the threshold contingency actions are no longer required; (c) investigate to determine the cause of the trigger or threshold criteria being exceeded; (d) investigate to provide information for the Department to determine potential environmental harm or alteration of the environment that occurred due to threshold criteria being exceeded; and (e) provide a report to the Department within twenty-one business days of the exceedance being reported as required by Condition x. The report must include: (i) details of trigger or threshold contingency actions implemented; (ii) the effectiveness of the trigger or threshold contingency actions implemented, against the threshold criteria; (iii) the findings of the investigations required by Condition 6(c) and 6(d); (iv) measures to prevent the threshold criteria being exceeded in the future; (v) measures to prevent, mitigate and remedy the environmental harm which may have occurred; and (vi) justification of the threshold remaining, or being adjusted based on better understanding, demonstrating that outcomes will continue to be met.	Section 2, Table 2-1 and Table 2-2 and Table **2-4**
7	Groundwater management and monitoring must continue until it can be demonstrated that the outcomes specified at Condition 3 can be met without active management.	Section 3

1.4 Approach

This Groundwater EMP was drafted in accordance with the Conceptual Framework for the Development of Rio Tinto Environmental Management Plans (internal guidance described in Appendix 1). This conceptual approach to management considers the conservation significance of the environmental value based on conservation status at local, state and regional levels. Management level (low, moderate or high) is assigned in order to achieve the environmental objective and/or outcome according to the conservation significance of the environmental value and the significance of impact/s predicted over spatial and temporal scales (Appendix 2). Assessment of the pathways over which impacts may occur provides the rationale for choice of provisions and choice of appropriate indicators to measure against the environmental outcome and/or objective.

1.5 Management Rationale

This Groundwater EMP adopts a combination of objective and outcome-based provisions, in order to achieve the environmental outcomes.

Environmental criteria are defined to assess performance against the environmental outcome. These are:

Trigger Criteria Measures set at a conservative level to forewarn the approach of threshold criteria and ensure trigger level actions are implemented well in advance of the environmental outcome being compromised.

Threshold Criteria This indicates there is risk that the environmental outcome will not be met.

Both objective and outcome-based provisions have been developed for this Groundwater EMP for the MAR scheme. Outcome-based provisions have been developed for the management of the MAR scheme as a High[2] level of management is required, and/or a degree of uncertainty and complexity exists. The MAR scheme is only relevant to the dewatering of Deposit C and D and does not include Western Hill. Outcome-based provisions in this Groundwater EMP are quantitative triggers and threshold criteria for groundwater drawdown and quality characteristics based on modelling chosen to achieve the stated environmental outcome.

Objective-based provisions are applied where a level of uncertainty exists that prevents setting objective and measurable criteria. In this case, triggers are established to measure, review and refine the accuracy of Grey Box modelling which is used as the basis for the outcome-based provisions. This will ensure that outcome-based provisions are assessed using the most accurate and relevant modelling available and to accurately reflect groundwater status to ensure the stated environmental outcomes are achieved.

Details of the MAR scheme to be implemented to mitigate drawdown impacts is provided in Section 1.5.1, and rationale for the choice of provisions is provided in Table 1-5.

1.5.1 Managed Aquifer Recharge (MAR) Scheme

The Proponent will mitigate groundwater drawdown associated with dewatering activities (specifically at Deposit C and Deposit D) using a MAR scheme. The MAR scheme is not being used for Western Hill, as no dewatering is proposed. There will be minimal water abstraction for operational supply at Western Hill which is not expected to propagate towards Karijini National Park.

MAR is the intentional recharge of water to suitable aquifers for subsequent recovery and maintenance of groundwater level. Aquifer reinjection is an actively implemented technique within the Pilbara region for disposal of surplus water. It will be used at the Project to mitigate potential impacts on groundwater within Karijini National Park from drawdown associated with dewatering at Deposit C and Deposit D.

[2] In accordance with the Rio Tinto conceptual framework for development of EMPs (Appendix 1).

The planned MAR scheme will comprise four phases (Rio Tinto 2020). Initial phases will utilise aquifer reinjection, however future phases may include use of alternate MAR techniques, i.e. infiltration galleries. The planned phased approach is grouped as follows:

- Phase 1: mitigate drawdowns from active dewatering in Deposit D (from 2021)
- Phase 2: mitigate drawdowns from active dewatering in Deposit C2 (from ~2028)
- Phase 3: reinstate water levels in Deposit D to pre-mining water levels (from ~2028)
- Phase 4: reinstate water levels in Deposit C2 to pre-mining water levels (from ~2036).

The Phase 1 Scheme includes:

- a supply and return pipeline
- chlorination treatment system
- injection supply and backflush removal lines
- injection bore headworks and backflush pump/ generators in fenced enclosures
- sedimentation pond
- transfer pumping station.

The initial 2019 Phase 1 MAR drilling programme and injection trial (Dec 2019 to Feb 2020) has proven that MAR using reinjection bores is practicable in the Phase 1 area. Custom built injection bores and discretely screened monitoring networks were installed to enable capture of detailed information during pumping and injection trials. Injection rates were in excess of 20 L/s with a potential for rates of over 40 L/s assuming no supply limitations. Impress heads (i.e. increases in water level due to injection) were observed at up to 700 m away from injection bores and backflush cycles were identified as being capable of the minimal clogging risk.

Injection volumes were identified to flow predominantly into below water table and near water table voids within subsurface dolocrete with response to injection in both the Wittenoom formation and Dolocrete units. A 2020 drilling and testing investigation in the Phase 1 area has further supported initial estimates of injection rates and capacity with significant volumes injected (>20 L/s) and relatively small impress head in all tests completed to date.

The Phase 1 MAR scheme will include re-injection of dewatered groundwater from Deposit D into the Phase 1 injection area of the MAR scheme, approximately 1.4 km away from the Karijini National Park boundary. The MAR scheme has been designed so that groundwater abstracted via dewatering activities could be piped directly to the injection bore/s via an overland pipeline to eliminate the requirement for holding tanks and potential air ingress which minimises potential water quality impacts. The chlorination treatment system is likely to be via a trickle-feeder mechanism and is required only to ensure biological activity in injection bores is kept to a minimum to prevent biological clogging. Injection rates are expected to vary depending upon aquifer drawdown propagation, aquifer responsiveness, clogging and infrastructure capacity. In addition, each injection bore will be equipped with a backflush pump to enable the active management of clogging and ensure capacity of injection assets. Backflush water will be piped to a central sedimentation pond where it will be collected and transferred to active mining areas for re-use.

An indicative Phase 1 scheme layout is provided in Figure 1-9, however note the layout is indicative only and is subject to change during construction.

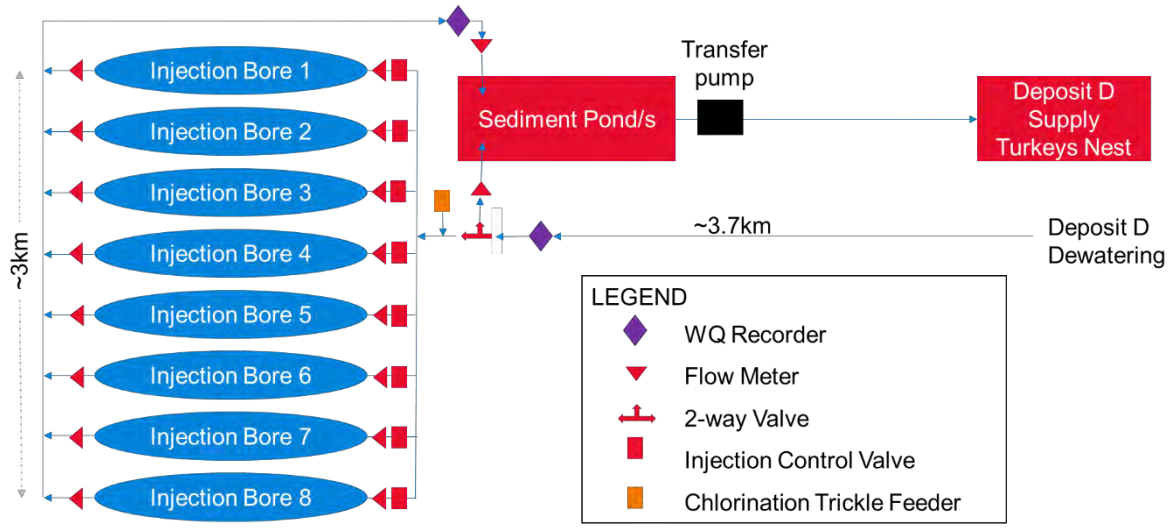


Figure 1-9: Indicative Phase 1 MAR Scheme Layout

Design of the MAR scheme has considered external influences, including: flood risk, animal/livestock interaction and access constraints with telemetered control and observation systems installed to enable automated operation and remote access to avoid any uncontrolled discharge or injection of water (RTIO, 2020).

Injected volumes will be sourced from abstraction in nearby deposits within the same aquifer system which will ensure compatibility of source and receiving environment water quality (Section 1.5.2.2) while maintaining a simple operating system.

The MAR scheme will be operated dependent upon measured and modelled aquifer responses within a purpose-built observation network in place to track progression of drawdown from dewatering activities with use of discrete observations being validated to continuous trends. Injection rates will then be adaptively managed to target no exceedance of triggers.

Adaptive management of drawdown will include but not be limited to changes to injection rates, distribution of injection, targeted monitoring and further drilling activities as required and permitted. Adaptive management of quality may include, but not be limited to filtration, de-sanders, chemical treatment and settling ponds. Treatment options will be designed to respond to the water quality objective.

Comprehensive observation and injection networks related to Phase 2 mitigation will be drilled in advance of further dewatering in Deposit C and be incorporated into management zone observation lists and this Groundwater EMP updated as required (Section 3).

1.5.2 Rationale for the choice of provisions

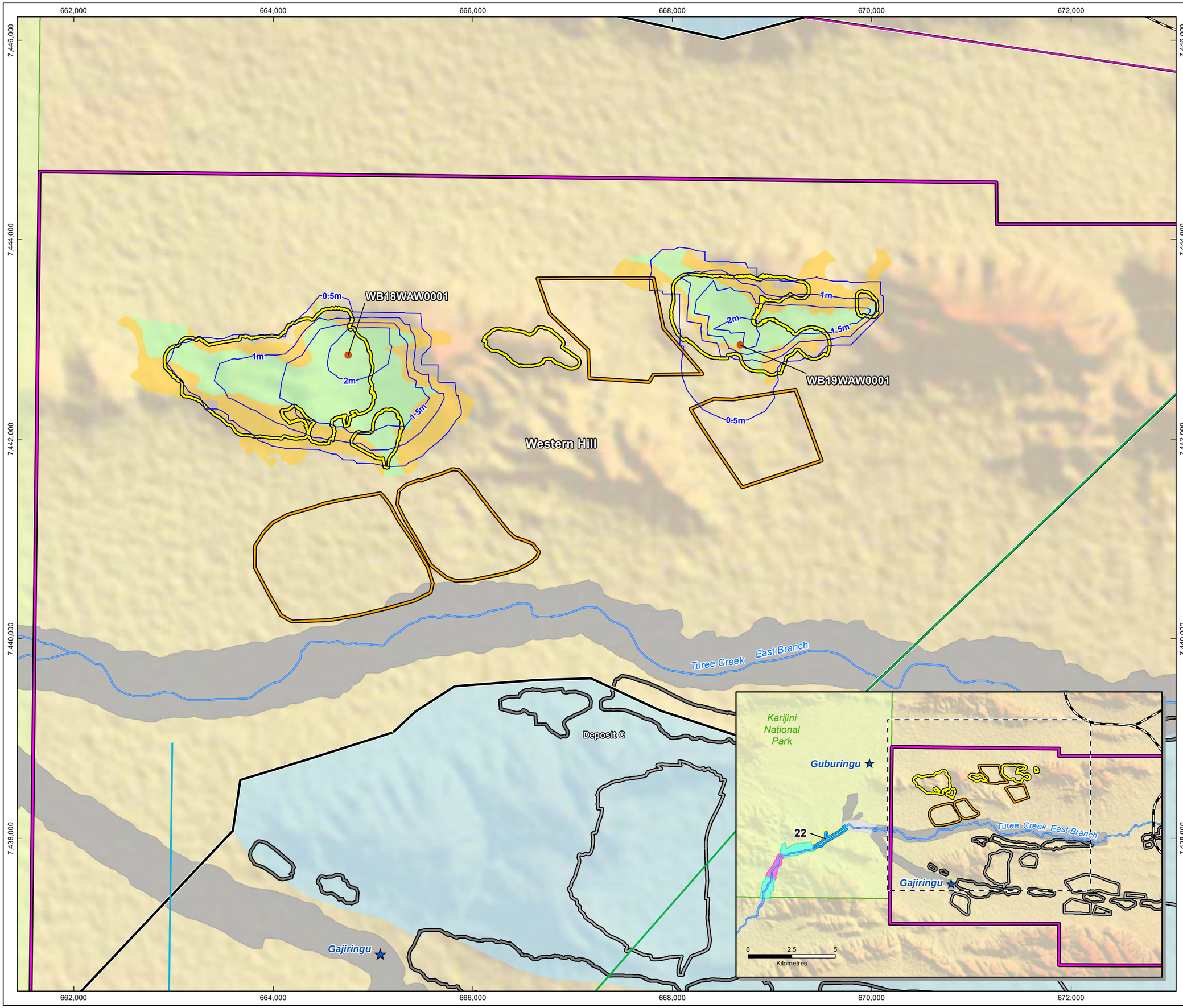
1.5.2.1 Groundwater Level

A numerical groundwater model was developed in MODFLOW-USG by Innovative Groundwater Solutions Pty Ltd (IGS 2021) to predict potential drawdown impacts to Karijini National Park from the dewatering of Deposit C and Deposit D and to inform the optimisation of the MAR scheme to mitigate these impacts. No BWT mine pit dewatering will occur at the Western Hill deposit due to its proximity to Karijini National Park. Only minimal water abstraction will occur for operational supply.

1.5.2.1.1 Western Hill

Groundwater modelling has shown that the estimated drawdown associated with the low volume and short duration water supply for Western Hill is highly unlikely to impact groundwater levels at the Karijini National Park boundary outside the naturally recorded groundwater level seasonal variations. The model is conservative concerning drawdown propagation as all potential connections between the source aquifer and the regional Wittenoom Formation via gaps in the McRae Shale are assumed to exist and are included in the model. Model sensitivity was examined with the model run 981 times with the key parameters (specific yield and hydraulic conductivity) randomly (within statistically valid ranges) varied for each domain. This resulted in 95% of model runs showing no impact to groundwater levels at the Karijini National Park boundary. The other 5% of runs are characterised by low specific yield for the Wittenoom Formation and any resultant modelled drawdown at the Karijini National Park boundary was less than 0.1 m, which is less than the naturally recorded groundwater level seasonal variations.

The P50 model simulation (probability of 50% that will occur) is considered the most likely and has been used to generate groundwater drawdown contours (Figure 1-10). This scenario does not predict a drawdown to approach the Karijini National Park boundary. The P80 simulation (20% chance that this will occur) is considered the most conservative realistic simulation. In this scenario drawdown is also not predicted to approach the Karijini National Park boundary (Figure 1-11).



RioTinto

Figure 1-10
Western Hill Simulated P50 drawdown extents

Drawn: A.D.
Plan: RTIO-0983812v1
Date: March 2023

Proj: GDA 1994 MGA Zone 50
Scale: 1:35,000 @A3
GIS.Team@riotinto.com

Legend

- Revised Development Envelope

Proposed Conceptual Layout

- Pit
- Waste Landform

Approved Conceptual Layout

- Pit
- Waste Landform

- Heritage Site
- Production Bore
- Drawdown (m)
- WANG MAR Scheme
- Dolerite Dyke
- Aquifer Barrier
- Model Domain Outerboundary
- Brockman Iron Formation
- Mount McRae Shale
- Marra Mamba Iron Formation
- Potential GDE

Potentially Groundwater Dependent Vegetation Zones

- Zone A
- Zone B
- Zone C-1
- Zone C-2
- Zone C-3
- Zone D
- Zone E

- National Park
- Rio Tinto Railway
- Major Creek

N

0 0.5 1
Kilometres

Map units in metres

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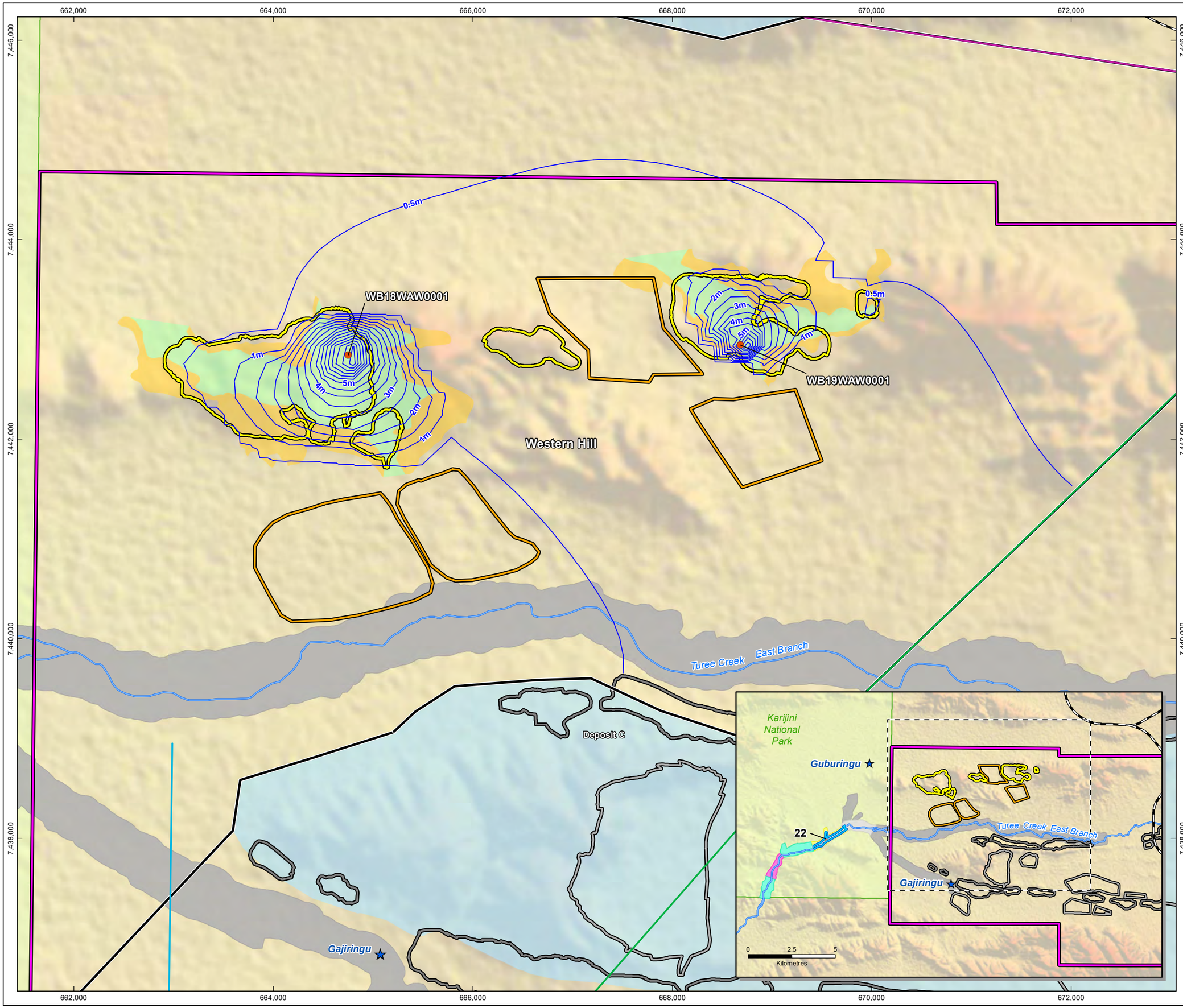

RioTinto

Figure 1-11
Western Hill Simulated P80 drawdown extents

Drawn: A.D.
Plan: RTIO-0983813v1
Date: March 2023

Proj: GDA 1994 MGA Zone 50
Scale: 1:35,000 @A3
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1.5.2.1.2 Deposit C and D

The groundwater model encompasses the West Angelas regional groundwater system described in Section 1.2.1. The model was calibrated against hydraulic head values at monitoring locations and the MAR injection trial data, as summarised in Section 1.5.1. Based on this information, a conditioned ensemble of models with distributions of hydraulic conductivities and storage parameters were generated to capture the uncertainty in model predictions. Numerical modelling of the system was undertaken using a risk averse and conservative conceptual model (which effectively allowed for a worst-case drawdown, given conceptual uncertainty) and a range of hydraulic parameter sets which were based upon realistic and measured Pilbara wide parameters.

The ensemble of models was then used to simulate unmitigated and mitigated impacts from dewatering activities. Unmitigated impact simulations using the complete ensemble show drawdown propagating faster in the south than the north, reaching a maximum drawdown of between 1.9 m and 5.2 m at Karijini National Park boundary by end of mining. Predictions were modelled for the full range of parameter sets. Mitigated impact results from the ensemble demonstrate the capacity for the MAR infrastructure to mitigate the likely propagation of drawdown to Karijini National Park boundary associated with pit dewatering. Mitigation simulations comprised optimisation of injection volumes to ensure compliance with approval condition requirements of no drawdown impact at the Karijini National Park boundary. Although a wide range of parameters were modelled to deliver different unmitigated drawdown distributions, the whole ensemble of models was effectively mitigated with Phase 1 reinjection with injection volumes not exceeding dewatering volumes at Deposit D. A summary of the model development, inputs and results is provided in Appendix 3.

Groundwater decline in the vicinity of Karijini National Park is conceptually influenced by both climate and groundwater abstraction at Deposit C and Deposit D, which means that if drawdown from climate impacts are accepted while drawdown from dewatering must be mitigated, provisions must be triggered by the latter of these drawdowns. An approach was taken to accurately determine, isolate and remove climate related decline from observed water levels by means of simple, purpose built Grey Box models for each observation bore. This approach allows Rio Tinto to analyse ongoing climate related changes to the groundwater level and consider it within its management response.

Predictions of future climate in the Pilbara are numerous and variable with no clear reliable trend ([3]: *CSIRO 2015*). Modelling completed to support water management rationale at West Angelas has allowed for this variability through grey box models calibrating water level response to measured rainfall with ongoing recalibration to climate. Climate change is likely to be a factor in future water management at West Angelas, particularly in areas where dewatering has lowered the groundwater table, increasing the storage potential of the groundwater system. Rio Tinto acknowledge that there may be residual uncertainty in modelling predictions and have accommodated conservatism and utilised parameter uncertainty to ensure that mitigation is effective. Rio Tinto will integrate key climate trends into its modelling to ensure various climatic predictive trends are accommodated. Time Series (TS) analysis can be used to assess the effects of stresses (e.g. groundwater pumping, climate variability, etc.) on groundwater system. Grey Box models using TS analysis are much simpler than numerical groundwater model and often provide a good fit. For this study, Grey Box models were developed and calibrated at relevant monitoring bores to simulate groundwater response from rainfall and evapotranspiration. These calibrated models can be used throughout the life of mine to predict groundwater level responses as a result of trends in rainfall and evapotranspiration and therefore quantify the contribution of natural system responses to observed hydrographs. Significant departure from the predicted system behaviour

[3] CSIRO (2015) Pilbara Water Resource Assessment: past, present and future hydroclimate. An overview report to the Government of Western Australia and industry partners from the CSIRO Pilbara Water Resource Assessment. CSIRO Land and Water, Australia

in drawdown would require a review of the Grey Box model, and potentially an adjustment to the MAR scheme. The Grey Box model approach is described in more detail in Appendix 3.

Multiple levels of triggers with an escalating severity of response based upon consecutive and validated exceedances is intended to ensure an appropriate level of adaptive management. As triggers are at the sub metre scale, measurement error is expected to be dealt with by means of manual validation and comparison with continuous trends.

1.5.2.2 Groundwater Quality

Groundwater quality information, and interpreted knowledge of natural variability, is only available over discrete periods of time in a highly restricted number of bores which impedes the ability to allow the groundwater system to vary naturally in a highly erratic and variable climate. As a result, water quality provisions incorporate use of a comparison with a control bore (MB16WAW0005) (as per Appendix 3) that is inside of the aquifer relevant to the provision and outside of the worst-case area of influence (Figure 1-8) from the MAR scheme.

Groundwater quality triggers are physical water characteristic based (i.e. EC and pH). These have been demonstrated as likely to fluctuate dependent upon injectant water quality (RTIO, 2020) and are expected to remain relevant to the condition until a specific analyte becomes apparent in subsequent trend analysis (during subsequent compliance reporting or trigger particulate dispersion modelling).

Condition 3(b) (as per DN 2018/8299) states a requirement for no change in groundwater quality as a result of the action at the boundary of, or within, Karijini National Park. As a direct result, any bores inside the Karijini National Park are, by default, unable to be used as trigger bores. Impacts to water quality values inside Karijini National Park are assumed to be impacted by the proposal as a direct transmission through the aquifer at the boundary of the mapped aquifer, therefore observation of water quality change inside the Karijini National Park is to be a part of regional baseline and modelling inputs.

Impacts to water quality values inside Karijini National Park can only be as a direct transmission through the aquifer at the boundary therefore, observation of water quality change inside Karijini National Park is not to be relied upon as a trigger.

Table 1-5: Summary of Rationale for choice of provisions

Current knowledge and description of impacts	Key assumptions and uncertainties	Rationale for choice of provision
Karijini National Park		
Level of Management[4] HIGH		
Key surveys and studies: Rio Tinto 2016, 2017, 2018, 2019 and 2020, IGS 2021		
Dewatering of Deposit C: • The geological model indicates that a large proportion of the Deposit C resource occurs below the water table. The Proponent conservatively estimates that up to approximately 20 GL of groundwater will need to be pumped from Deposit C, commencing in 2023. The expected maximum depth of mining is the 568 m RL, with an associated maximum depth of dewatering of up to approximately 68 m in the eastern end of the deposit. **Dewatering of Deposit D:** • The geological model indicates that a significant proportion of the Deposit D resource occurs below the water table. The Proponent conservatively estimates that up to approximately 26 GL of groundwater will need to be pumped from Deposit D, commencing in 2021. The expected maximum depth of dewatering is up to approximately 130 m in the western end of the deposit. **Abstraction of groundwater at Western Hill (~0.37 GL/a) for water supply:** • The Western Hill deposit is located nearby to Karijini National Park and the orebody aquifer at this deposit, which will be targeted for supply, is expected to be somewhat connected to the regional Wittenoom aquifer, which is located to the south of Western Hill at Deposits C and D and extends westwards into Karijini National Park. While BWT mining at Western Hill has been removed owing to its proximity to Karijini National Park, the abstraction of a small portion of groundwater (~0.37 GL/a) for water supply to meet operational requirements is required. Abstraction will be carried out to ensure the risk to groundwater levels at the Karijini National Park boundary is as low as reasonably practicable. **Groundwater System:** • Below water table portions of Deposit C and Deposit D lie within a connected groundwater system, with the aquifer extending inside Karijini National Park. • Unmitigated dewatering of the western end of Deposit C and Deposit D could result in groundwater drawdown extending west to Karijini National Park around 2024. **MAR:** • The Proponent will mitigate groundwater drawdown associated with dewatering activities (specifically at Deposit C and Deposit D) by use of a MAR scheme. • The MAR scheme will comprise 4 phases. Trials confirm Phase 1 is practicable and it will include re-injection of dewatered groundwater from Deposit D into an area approximately 1.4 km away from the Karijini National Park boundary. • Water level response to injection was observed at distances greater than adjacent injection bores. • Water quality response to injection was very minor with very little change in pH or EC and no observable change to dissolved chemistry. **Predictive Modelling:** • Numerical modelling suggests that southern injection bores are likely to be in use early, at higher rates and for extended periods. • Mitigation simulations suggest that conditions can be met under a full range of hydraulic parameter sets. • Uncertainties in hydraulic conductivity contrast between dolocrete and detrital units was identified as resulting in some significantly different unmitigated drawdown distributions.	**Assumptions:** • The aquifer between Deposit C and Deposit D and Karijini National Park is not intersected by any hydraulic barriers (i.e. Dolerite dykes/ faults). • Hydraulic parameters within the aquifer are within ranges applied to groundwater modelling. • The aquifer does not extend beyond barriers associated with surrounding low permeability Brockman Formation or Marra Mamba Formation units (i.e. Mt Macrae Shale). • Modelling inputs and therefore outputs represent potential actual scenarios and are based on the best knowledge of the aquifer and constraints at the time. • Trigger level criteria do not represent an impact on either water level and/or quality at the boundary of, or within Karijini National Park. No impact on water level or quality at sentinel bores (Karijini National Park boundary) indicates no impact on water level or quality within Karijini National Park. • The Western Hill Ore body aquifer utilised for supply abstraction is confined on three sides, with minimal connection to the regional Wittenoon aquifer. • Abstraction associated with the Project is unlikely to impact the regional Wittenoon aquifer significantly. **Uncertainties:** • A variable climate may either naturally recharge or deplete the groundwater system in the same timeframe as pumping induces drawdown. • The spatial distribution and character of the aquifer inside Karijini National Park is not validated by any drilling information. • Water quality temporal variability during periods of dry climate.	The intent of the environmental outcomes is to ensure that the potential impacts from dewatering of Deposit C and Deposit D do not reach the Karijini National Park boundary. A high level of management has been assigned to mitigate and manage the drawdown associated with dewatering activities at Deposit C and Deposit D and complementary provisions (including both outcome and objective-based) have been applied to manage the MAR scheme and monitor changes in groundwater level and quality to ensure no change at the boundary of, or within, Karijini National Park. MS xxxx specifies the requirement for triggers and thresholds (outcomes-based) provisions in the Groundwater EMP. Outcomes-based provisions in this Groundwater EMP include a comparison of groundwater levels in monitoring bores against seasonally adjusted predicted water levels as modelled by Grey Box modelling (IGS 2021). To provide certainty that Grey Box modelling accurately predicts natural groundwater levels for the life of the project, and ensure outcome-based provisions are accurately assessed, targets for Grey Box modelling have been included as objective-based provisions. If targets are exceeded, Grey Box modelling will be assessed and updated if required to ensure accuracy. A summary of the rationale for objective-based and outcome-based provisions is below. **Objective-based Provisions:** Objective-based provisions have been applied to groundwater modelling within the project area and eastern Karijini National Park to ensure currency and accuracy of groundwater modelling and to guarantee it is a representative and robust base to inform outcome-based provisions. Objective-based management targets and indicative monitoring zones have been established in Table 2-1 and Figure 2-2. Objective-based targets identify groundwater levels in Zone 2 and 3 monitoring bores which are to be used for assessment of outcome-based provisions. Target 1 was chosen as an indicator to confirm that the regional aquifer is modelled correctly. These bores should reflect natural seasonal variations in water level and not fluctuate as a result of mine groundwater activities. Remaining targets were chosen using different duration rolling seasonally adjusted averages in Zone 3 monitoring bores to ensure that the model is accurately capturing natural variations in groundwater due seasonal and climatic influences. Zone 3 monitoring bores were chosen as they are the most distant from the MAR scheme and most likely to represent natural variation at Karijini National Park. As additional data are collected the model should become more accurate at simulating trends, which is reflected in targets. **Outcome-based Provisions** Outcome-based provisions have been applied to drawdown and water quality based on monitoring against modelling outputs to: • Ensure that there is no drawdown of groundwater associated with the Project at the boundary of, or within, Karijini National Park (MS xxxx and DN 2018/8299). • Ensure no change in groundwater quality at the boundary of, or within, Karijini National Park (DN 2018/8299). The MAR scheme will be implemented over four phases. Monitoring data collected during each phase, including inputs and responses, will be reviewed regularly and used to update models and adapt the use of the scheme to mitigate observed impacts from drawdown associated with dewatering activities.

[4] Summary of assessment for determination of required level of management provided in Appendix 2, as per the conceptual framework for development of Rio Tinto's EMPS (Appendix 1).

		Groundwater Level Early Response Indicators, Trigger and Threshold Criteria Deposit D: Early Response Indicator 1 for groundwater level is based on the premise that if the MAR scheme is not operating as expected then there is a risk that groundwater levels may be impacted at the boundary of or within Karijini National Park. Any deviation from the operational plan for the MAR will be investigated and rectified or adjustments made as required. Early Response Indicator 2 and Trigger and Threshold Criteria were determined through assessment of natural (simulated unimpacted seasonally adjusted) water levels (as predicted by Grey Box modelling, Appendix 3), proximity of monitoring bores to Karijini National Park and modelled timeframe of potential impact, and limits of measurement accuracy. Groundwater level Early Response Indicator 2 and Trigger and Threshold Criteria are based on comparison of groundwater levels in monitoring bores against simulated unimpacted, seasonally adjusted water levels (as predicted by Grey Box modelling) levels in different monitoring Zones (Section 2, Figure 2-2). Early Response Indicator and Trigger Level 1 Criteria are assessed in Zone 2 monitoring bores, located approximately 600 m from MAR injection bores and 1.4 km from Karijini National Park (Section 2, Figure 2-2). Trigger Level 2 and Threshold Criteria are assessed in Zone 3 monitoring bores located approximately 600 m from Karijini National Park and 1.4 km from MAR injection bores. Zone 1 monitoring bores are operational monitoring bores, located adjacent to MAR injection bores and are not used to assess Early Response Indicators or Trigger and Threshold Criteria (Figure 2-3). Early Response Indicator 2 and Trigger and Threshold Criteria require groundwater levels to be within the specified drawdown limit over two consecutive monitoring periods to account for anomalies in results due to errors in field measurement or calculation, extreme natural events e.g. cyclone, or unforeseen access issues or damage to monitoring bores. This is not considered to be a risk as maximum modelled unmitigated drawdown in Zone 2 monitoring bores is not expected to occur until approximately 3 years after commencement of dewatering and at the Karijini National Park boundary (Zone 3), between 5 and 10 years after commencement of dewatering. It is expected that if an exceedance of Early Response Indicators and/or Trigger Level 1 criteria in Zone 2 monitoring bores occurs, there will be sufficient time to implement identified response actions to mitigate potential impacts prior to Trigger Level 2 or Threshold criteria being exceeded. During this time modelling will continue to be updated to ensure accuracy and relevance of model as a basis for Early Response Indicator 2, and Trigger and Threshold Criteria. **Groundwater Level Early Response Indicators, Trigger and Threshold Criteria Western Hill:** Groundwater level Early Response Indicator, Trigger and Threshold Criteria are based on a comparison of groundwater levels in monitoring bores against historic groundwater levels in the bores and consideration of climate and seasonal influences. Groundwater levels have been recorded consistently in Zone 1 MB18WAW0003 and MB18WAW0003 (monitored since July 2018) and Zone 2 MB 17WAW0001, (monitored since July 2018), bore 24WAW-M01 and 21WAW-M02 are yet to be drilled. Monitored bores show a consistent trend and seasonal fluctuation. These bores are located outside of the expected drawdown zone, in the low permeability Mt McRae shale and are not expected to be affected by groundwater abstraction at Western Hill. The proximity of Zone 1 bores to the drawdown zone and distance from Karijini National Park would provide sufficient warning to allow implementation of response actions such that no drawdown at the boundary of or within Karijini National Park would occur. Zone 2 bores are located adjacent to the Karijini National Park boundary and as such the threshold for potential drawdown from the Proposal. Historic water monitoring has indicated that the natural variation in groundwater levels is up to 50cm. Zone 2 threshold is set to within natural fluctuations (50cm) which takes into consideration climate and seasonal influences. **Groundwater Quality Trigger and Threshold Criteria:**

		Groundwater quality in the area is good with circum-neutral pH and low EC, and groundwater quality Early Response Indicator and Trigger and Threshold Criteria are based on known previous ranges of pH and EC. There is a lack of historic water quality data for the Karijini National Park and also within the MAR scheme area of impact. Historic pH data indicates the range of these analytes are between 6.5 and 8.5, however a pH of greater than 8 is not common historically. Historic EC data indicates that EC is fairly constant over time, taking into account seasonal variation. Any significant variation in EC from control bores may indicate an impact on groundwater quality from the MAR scheme. Modelled particle tracking profiles for maximum and minimum drawdowns (Figure 2-2) indicate that potential water quality impacts will not occur within Zone 3 monitoring bores within 100 years, with impacts only predicted in Zone 2 monitoring bores for maximum drawdown model and only in isolated locations. The requirement for two consecutive monitoring periods (6 months) to determine compliance with Early Response Indicator, and Trigger or Threshold Criteria is not considered to present a risk of potential impact at the boundary of or within Karijini National Park as modelled timeframes indicate that potential impacts will occur over a period of years rather than months. It is expected that an exceedance of Early Response Indicator and/or Trigger Level 1 criteria in Zone 2 monitoring bores will allow sufficient time to implement identified response actions to mitigate potential impacts prior to Trigger Level 2 or Threshold criteria being exceeded.

2. EMP PROVISIONS

This section identifies the provisions that the Proponent will implement upon approval of this Groundwater EMP by DWER in consultation with DBCA, and DCCEEW to meet the requirements of Condition x of MS xxxx, Condition 3(a) and 3(b) of DN 8299/2018 and Condition x of DN 2021/8923 and to ensure that the defined environmental outcomes are met during implementation of the Project. Objective-based and outcome-based provisions will be implemented concurrently for the duration of the Groundwater EMP. Objective-based provisions apply to groundwater levels only and are used to ensure the model used to determine compliance with outcome-based triggers and thresholds for drawdown is accurate. Review of the model (objective-based) and drawdown and water quality (outcome-based) provisions will occur concurrently with the model adjusted and refined as required based on management targets, to inform outcome-based provisions. Outcome-based provisions apply to drawdown and water quality and are assessed against deviation from the modelled drawdown scenarios and water quality in control bores.

Objective-based water level provisions are detailed in Table 2-1. Outcome-based drawdown provisions for Deposit D (MS xxxx and DN 2018/8922) are detailed in Table 2-2 and outcome based provisions for Western Hill (MS xxxx and DN 2021/8923) are detailed in Table **2-4**. Outcome-based water quality provisions Deposit D (MS xxxx and DN 2018/8922) are detailed in Table **2-4**. Monitoring and reporting for each provision is also detailed in these tables. A summary of relevant criteria applied to each monitoring zone and current and future Phase 1 bores is provided in Appendix 5. Appendix 5 will be updated as project phases progress. Interactions between objective-based and outcome-based provisions and response flow to different level provisions are shown in Figure 2-1.

For Deposit D, manual observations will be compared to objective-based (water level) triggers and will initially trigger a validation of drawdown. This drawdown will then be cross-checked against Grey Box quantified drawdown and may then trigger response actions. Drawdown will be evaluated using Grey Box modelling which is intended to apportion groundwater level decline to either climate or pumping induced impacts.

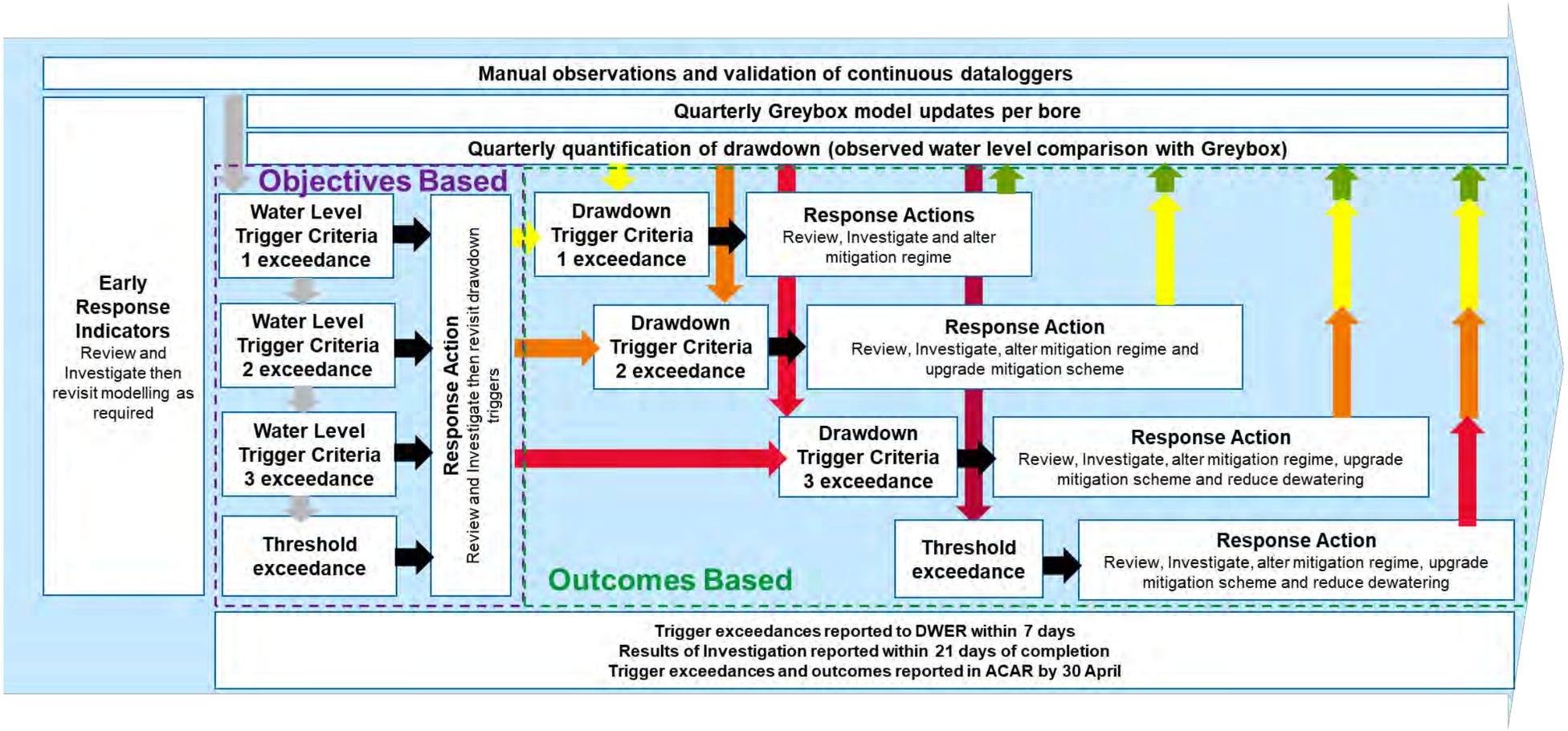


Figure 2-1: **Interaction between observation, interaction and objective-based/outcome-based triggers (MS xxxx and DN 2018/8922)**

Table 2-1: Objective-based Groundwater EMP Provisions – Inland Waters - Karijini National Park Groundwater Level – Deposit D (MS xxxx and DN 2018/8922)

EPA Factor: Inland waters						
EPA objective: *To maintain the hydrogeological regimes of groundwater and surface water so that environmental values are protected.*						
Objective: Maintain an accurate and up to date groundwater model of the West Angelas Deposit C and Deposit D and East Karijini National Park to inform outcomes-based provisions to ensure that there is no drawdown of groundwater associated with the Project at the boundary of, or within, Karijini National Park.						
Key environmental values: Karijini National Park						
Key impacts and risks: Accuracy of Grey Box model (to enable assessment of Change to groundwater levels at the boundary of, or within, Karijini National Park, as a result of Project dewatering at Deposit C and/or Deposit D.)						
Objective-based provisions (to ensure relevance and accuracy of modelling used to access outcomes-based provisions) Deposit D MS xxxx and DN 2018/8922						
High Management Zone (Appendix 2)						
Applicability: Targets selected to support Grey Box accuracy to verify: • **MS xxxx Condition xx:** Ensure that there is no drawdown of groundwater associated with the proposal at the boundary of, or within, Karijini National Park. • **DN 2018/8299 Condition 3 (a)**: No drawdown of groundwater associated with the action at the boundary of, or within, Karijini National Park.						
Management Target	**Management Actions**	**Monitoring**	**Responsibility**	**Location**	**Timing/Frequency**	**Reporting**
Target 1: **1.** Water levels in boundary bores to the south and north of the MAR scheme in areas outside of the regional aquifer are above or equal to rolling 3 year, seasonally adjusted water levels (mbgl).	1. Review and check modelling inputs and other complimentary monitoring data to ensure model is accurate and current. 2. Review MAR operational monitoring data and compare against modelled operation. 3. Review monitoring data to assess whether model is accurate and representative of the current environment and activities. If not, investigate and reinterpret models if required or implement corrective/mitigation actions which could include: a. Amend/increase monitoring frequency and/or location. b. Conduct additional monitoring to validate model. c. Review outcome-based provisions and implement response actions as appropriate.	Comparison of manual water levels in boundary bores with Grey Box model.	Water Resource Evaluation Team supported by Environment Operations	Boundary Bores, Figure 2-2, Appendix 4[5].	Monthly water level of bores reviewed against quarterly.	**MS xxxx:** • Management actions and targets will be reported annually by 30 April in the ACAR. **DN 2018/8299:** • Monitoring, management actions and outcomes against targets will be reported annually by 30 April in the ACAR.
Target 2: **2.** Water levels in Zone 3 monitoring bores and modelled are above or equal to rolling 3 year, seasonally adjusted water levels (mbgl).		Comparison of recorded (data logger) water levels in Zone 3 monitoring bores (mbgl) and modelled 3 year (seasonally adjusted) water levels.	Water Resource Evaluation Team supported by Environment Operations	Data logger output from Zone 3 monitoring bores, Figure 2-2 Appendix 4[5].	Continuous logging data to be reviewed and assessed quarterly.	
Target 3: **3.** Water levels in Zone 3 monitoring bores and modelled are above or equal to rolling 5 year, seasonally adjusted water levels (mbgl).		Comparison of recorded (data logger) water levels in Zone 3 monitoring bores (mbgl) and modelled 5 year (seasonally adjusted) water levels.	Water Resource Evaluation Team supported by Environment Operations	Data logger output from Zone 3 monitoring bores, Figure 2-2 Appendix 4[5].	Continuous logging data to be reviewed and assessed quarterly.	
Target 4: **4.** Water levels in Zone 3 monitoring bores and modelled are above or equal to rolling 10 year, seasonally adjusted water levels (mbgl).		Comparison of recorded (data logger) water levels in Zone 3 monitoring bores (mbgl) and modelled 10 year (seasonally adjusted) water levels.	Water Resource Evaluation Team supported by Environment Operations	Manual water levels in Zone 3 monitoring bores, Figure 2-2 Appendix 4[5].	Continuous logging data to be reviewed and assessed quarterly.	

[5] Some bores are not drilled as at Q1 2021. RTIO commits to commission monitoring bores as per Appendix 4.

Table 2-2: Outcome-based Groundwater EMP Provisions – Inland Waters - Karijini National Park Groundwater Level – Deposit D (MS xxxx and DN 2018/8922)

EPA Factor: Inland waters					
EPA objective: *To maintain the hydrogeological regimes of groundwater and surface water so that environmental values are protected.*					
Outcome: Ensure that there is no drawdown of groundwater associated with the Project at the boundary of, or within, Karijini National Park.					
Key environmental values: Karijini National Park.					
Key impacts and risks: Change to groundwater levels at the boundary of, or within, Karijini National Park, as a result of Project dewatering at Deposit C and/or Deposit D.					
Outcome-based Provisions					
High Management Zone (Appendix 2)					
Applicability: **MS xxxx Condition x:** Ensure that there is no drawdown of groundwater associated with the proposal at the boundary of, or within, Karijini National Park. **DN 2018/8299 Condition 3 (a)**: No drawdown of groundwater associated with the action at the boundary of, or within, Karijini National Park.					
Criteria	**Response Actions**	**Monitoring**	**Responsibility**	**Timing/Frequency**	**Reporting**
Early Response Indicator 1: 1. Injection bores non operational outside of proposed plan for operation of the MAR scheme (more than 1 of a paired set of bores inoperable for more than 1 week).	**Investigate and if appropriate implement corrective actions:** • Bore maintenance/refurbishment if required • Improve operability of scheme -better planning, maintenance, scheduling etc.	Zone 1 injection bores as per Figure 2-2, Appendix 4[5].	Water Resource Evaluation Team supported by Environment Operations	Quarterly	**MS xxxx** • Outcomes of this Groundwater EMP will be reported annually by 30 April in the ACAR. • Early response criterion exceeded during the reporting period will be summarised in the ACAR, including potential reasons for exceedance and a description of the effectiveness of trigger level actions. **DN 2018/8299:** • In the event that an exceedance of trigger criteria, the exceedance will be reported in writing to the DCCEEW within five (5) business days of becoming aware of the exceedance. • The Proponent will provide a report to DCCEEW within twenty-one (21) business days of the exceedance being reported specifying details as required by Condition 6(e) of DN 2018/8299. • Outcomes, monitoring and response actions will be reported annually by 30 April in the ACAR.
Early Response Indicator 2: 2. Two consecutive monitoring periods of drawdown 25 cm greater than Grey Box level for modelled mitigation scenario in Zone 2 monitoring bores.	**Investigate, this could include but is not limited to:** • Review MAR operational monitoring data. • Review monitoring data. • Investigate and reinterpret models if required. • Water balance assessment. If investigations determine early response represents impact on groundwater due to the Project, the Proponent will implement response actions which may include: • Amend/increase monitoring frequency and/or location. • Conduct additional monitoring. • Increase or alter reinjection rate and/or location (as appropriate). • Monitor until results indicate water level is in accordance with modelling prediction.	Zone 2 monitoring bores as per Figure 2-2, Appendix [5].	Water Resource Evaluation Team supported by Environment Operations	Quarterly water level recording (manual).	**MS xxxx** • Outcomes of this Groundwater EMP will be reported annually by 30 April in the ACAR. • Early response criterion exceeded during the reporting period will be summarised in the ACAR, including potential reasons for exceedance and a description of the effectiveness of trigger level actions. **DN 2018/8299:** • In the event that an exceedance of trigger criteria, the exceedance will be reported in writing to the DCCEEW within five (5) business days of becoming aware of the exceedance. • The Proponent will provide a report to DCCEEW within twenty-one (21) business days of the exceedance being reported specifying details as required by Condition 6(e) of DN 2018/8299. • Outcomes, monitoring and response actions will be reported annually by 30 April in the ACAR.

EPA Factor: Inland waters

EPA objective: *To maintain the hydrogeological regimes of groundwater and surface water so that environmental values are protected.*

Outcome: Ensure that there is no drawdown of groundwater associated with the Project at the boundary of, or within, Karijini National Park.

Key environmental values: Karijini National Park.

Key impacts and risks: Change to groundwater levels at the boundary of, or within, Karijini National Park, as a result of Project dewatering at Deposit C and/or Deposit D.

Outcome-based Provisions

High Management Zone (Appendix 2)

Applicability:

MS xxxx Condition x: Ensure that there is no drawdown of groundwater associated with the proposal at the boundary of, or within, Karijini National Park.

DN 2018/8299 Condition 3 (a): No drawdown of groundwater associated with the action at the boundary of, or within, Karijini National Park.

Criteria	Response Actions	Monitoring	Responsibility	Timing/Frequency	Reporting
Trigger Criteria Level 1: 3. Two consecutive monitoring periods of drawdown 50 cm greater than Grey Box level for modelled mitigation scenario in Zone 2 monitoring bores.	**Implement within twenty-four (24) hours:** • Investigations as per Early Response Indicator 2. If investigations determine trigger exceedance represents impact on groundwater due to the Project, the Proponent will implement response actions which may include but are not limited to: • As per Early Response Indicator 2. • Commence infrastructure upgrades to accommodate any further increases to injection rate and investigate alternative supply.	Zone 2 monitoring bores as per Figure 2-2, Appendix 4[5].	Water Resource Evaluation Team supported by Environment Operations	Quarterly water level recording (manual).	**MS xxxx** • Outcomes of this Groundwater EMP will be reported annually by 30 April in the ACAR. • Trigger criterion exceeded during the reporting period will be summarised in the ACAR, including potential reasons for exceedance and a description of the effectiveness of trigger level actions. **DN 2018/8299:** • In the event that an exceedance of trigger criteria, the exceedance will be reported in writing to the DCCEEW within five (5) business days of becoming aware of the exceedance. • The Proponent will provide a report to DCCEEW within twenty-one (21) business days of the exceedance being reported specifying details as required by Condition 6(e) of DN 2018/8299. • Outcomes, monitoring and response actions will be reported annually by 30 April in the ACAR.
Trigger Criteria Level 2: 4. Two consecutive monitoring periods of drawdown of 10 cm or greater than the Grey Box level for modelled mitigation scenario in Zone 3 monitoring bores or 5. a single monitoring period of drawdown greater than 10cm in Zone 3 bores if Trigger Criteria Level 1 exceeded in the current or preceding monitoring period or 6. a single monitoring period of drawdown greater than 10 cm or greater than the Grey Box level recorded in two or more adjacent monitoring bores.	**Implement within twenty-four (24) hours:** • Investigations as per Trigger Criteria level 1: If investigations determine trigger exceedance represents impact on groundwater due to the Project, the Proponent will implement response actions which may include but is not limited to: • As per Trigger Criteria Level 1. • Cease dewatering from drawdown source areas while maintaining safe operations and supply of water to the MAR scheme.	Zone 3 monitoring bores as per Figure 2-2, Appendix 4[5].	Water Resource Evaluation Team supported by Environment Operations	Quarterly water level recording (manual).	**MS xxxx** • Outcomes of this Groundwater EMP will be reported annually by 30 April in the ACAR. • Trigger criterion exceeded during the reporting period will be summarised in the ACAR, including potential reasons for exceedance and a description of the effectiveness of trigger level actions. **DN 2018/8299:** • In the event that an exceedance of trigger criteria, the exceedance will be reported in writing to the DCCEEW within five (5) business days of becoming aware of the exceedance. • The Proponent will provide a report to DCCEEW within twenty-one (21) business days of the threshold exceedance being reported specifying details as required by Condition 6(e) of DN 2018/8299. • Outcomes, monitoring and response actions will be reported annually by 30 April in the ACAR.

EPA Factor: Inland waters

EPA objective: *To maintain the hydrogeological regimes of groundwater and surface water so that environmental values are protected.*

Outcome: Ensure that there is no drawdown of groundwater associated with the Project at the boundary of, or within, Karijini National Park.

Key environmental values: Karijini National Park.

Key impacts and risks: Change to groundwater levels at the boundary of, or within, Karijini National Park, as a result of Project dewatering at Deposit C and/or Deposit D.

Outcome-based Provisions

High Management Zone (Appendix 2)

Applicability:

MS xxxx Condition x: Ensure that there is no drawdown of groundwater associated with the proposal at the boundary of, or within, Karijini National Park.

DN 2018/8299 Condition 3 (a): No drawdown of groundwater associated with the action at the boundary of, or within, Karijini National Park.

Criteria	Response Actions	Monitoring	Responsibility	Timing/Frequency	Reporting
Threshold Criteria: **7.** Two consecutive monitoring periods of drawdown associated with the proposal of 20 cm or greater than Grey Box level for modelled mitigation scenario in Zone 3 monitoring bores or **8.** a single monitoring period of drawdown exceeding 20cm in Zone 3 bores if Trigger Criteria Level 2 exceeded in current or preceding monitoring period. or **9.** a single monitoring period of significant drawdown (over 40 cm drawdown) and the equipment is not damaged.	**Implement within twenty-four (24) hours:** • Review data, investigate driver of threshold breach using Grey Box model to determine the degree to which the project has contributed. • Develop and implement recovery plan which may include ceasing dewatering, increasing or altering reinjection rate and/or locations (as appropriate) and potential additional reinjection bores. • Monitor until results indicate water level is in accordance with modelling prediction. • Continue to implement threshold contingency actions until the CEO has confirmed by notice in writing that it has been demonstrated that the impact is below the threshold criteria. • Monitor to validate success of threshold contingency actions.	Zone 3 monitoring bores as per Figure 2-2, Appendix 4[5].	Water Resource Evaluation Team supported by Environment Operations	Quarterly water level recording (manual).	**MS xxxx:** • Report as non compliance with Condition x of MS xxxx within seven (7) days. • Outcomes will be reported annually by 30 April in the ACAR. • If any trigger criterion was exceeded during the reporting period, the ACAR will discuss potential reasons for exceedance of the trigger criterion and include a description of the effectiveness of trigger level actions. **DN 2018/8299:** • In the event that an exceedance of threshold criteria, the exceedance will be reported in writing to the DCCEEW within five (5) business days of becoming aware of the exceedance. • The Proponent will provide a report to DCCEEW within twenty-one (21) business days of the exceedance being reported specifying details as required by Condition 6(e) of DN 2018/8299. • Outcomes, monitoring and response actions will be reported annually by 30 April in the ACAR.

Table 2-3: Outcome-based Groundwater EMP Provisions – Inland Waters - Karijini National Park Groundwater Level – Western Hill (MS xxxx and DN 2021/8923)

EPA Factor: Inland waters					
EPA objective: *To maintain the hydrogeological regimes of groundwater and surface water so that environmental values are protected*					
Outcome: Ensure that there is no drawdown of groundwater associated with the Project at the boundary of, or within, Karijini National Park					
Key environmental values: Karijini National Park					
Key impacts and risks: Change to groundwater levels at the boundary of, or within, Karijini National Park as a result of water abstraction at Western Hill.					
Outcome-based Provisions					
High Management Zone (Appendix 2)					
Applicability: **MS xxxx Condition x:** Ensure that there is no drawdown of groundwater associated with the proposal at the boundary of, or within, Karijini National Park. **DN 2021/8923 Condition x**: No drawdown of groundwater associated with the action at the boundary of, or within, Karijini National Park.					
Criteria	**Response Actions**	**Monitoring**	**Responsible**	**Timing/Frequency**	**Reporting**
Early Response Indicator: 1. Two consecutive monitoring periods of drawdown associated with the proposal of 25 cm or greater in Zone 1 monitoring bores.	**Investigate, this could include but is not limited to:** • Review monitoring data. • Review abstraction volumes. • Review climate data and regional monitoring bores trend. • Bore maintenance/refurbishment if required. If investigations determine early response represents an impact on groundwater due to the Proposal, the Proponent will implement response actions, which may include: • Amend/increase monitoring frequency and/or location. • Conduct additional monitoring.	Zone 1 monitoring bores (MB18WAW0003 and MB18WAW0004) as per Figure x, Appendix 4	Water Resource Evaluation Team supported by Environment Operations	Quarterly water level recording (manual).	**MS xxxx** • Outcomes of this Groundwater EMP will be reported annually by 30 April in the ACAR. • Early response criterion exceeded during the reporting period will be summarised in the ACAR, including potential reasons for exceedance and a description of the effectiveness of trigger-level actions. **DN 2021/8923:** • Early response criterion exceeded during the reporting period will be summarised in the ACAR, including potential reasons for exceedance and a description of the effectiveness of trigger-level actions. • .
Trigger Criteria: 2. Two consecutive monitoring periods of drawdown associated with the proposal of 50 cm or greater in Zone 1 monitoring bores.	**Implement response actions as per Early Response Indicator.** **Commence within twenty-four (24) hours:** If investigations determine trigger exceedance represents impact on groundwater due to the Project, the Proponent will implement response actions which may include but are not limited to: • Amend/increase monitoring frequency and/or location. • Conduct additional monitoring. • Investigate alternative supply.	Zone 1 monitoring bores (MB18WAW0003 and MB18WAW0004)as per Figure x Appendix 4	Water Resource Evaluation Team supported by Environment Operations	Quarterly water level recording (manual).	**MS xxxx** • Outcomes of this Groundwater EMP will be reported annually by 30 April in the ACAR. • Trigger criterion exceeded during the reporting period will be summarised in the ACAR, including potential reasons for exceedance and a description of the effectiveness of trigger level actions. **DN 2021/8923:** • In the event of an exceedance of trigger criteria, the exceedance will be reported in writing to the DCCEEW within five (5) business days of becoming aware of the exceedance. • The Proponent will provide a report to DCCEEW within twenty-one (21) business days of the exceedance being reported specifying details as required by Condition x of DN 2021/8923. • Outcomes, monitoring and response actions will be reported annually by 30 April in the ACAR.

EPA Factor: Inland waters

EPA objective: *To maintain the hydrogeological regimes of groundwater and surface water so that environmental values are protected*

Outcome: Ensure that there is no drawdown of groundwater associated with the Project at the boundary of, or within, Karijini National Park

Key environmental values: Karijini National Park

Key impacts and risks: Change to groundwater levels at the boundary of, or within, Karijini National Park as a result of water abstraction at Western Hill.

Outcome-based Provisions

High Management Zone (Appendix 2)

Applicability:

MS xxxx Condition x: Ensure that there is no drawdown of groundwater associated with the proposal at the boundary of, or within, Karijini National Park.

DN 2021/8923 Condition x: No drawdown of groundwater associated with the action at the boundary of, or within, Karijini National Park.

Criteria	Response Actions	Monitoring	Responsible	Timing/Frequency	Reporting
Threshold Criteria: 3. Two consecutive monitoring periods of drawdown associated with the proposal of 50 cm or greater in Zone 2 monitoring bores.	**Implement response actions as per Trigger Criteria.** **Commence within twenty-four (24) hours:** • Review data, investigate driver of threshold breach to determine the degree to which the project has contributed. • Develop and implement recovery plan which may include ceasing supply abstraction, and/or locations (as appropriate). • Increased monitoring until water levels have recovered. • Continue to implement threshold contingency actions until the CEO has confirmed, by notice in writing, that it has been demonstrated that the impact is below the threshold criteria. • Monitor to validate success of threshold contingency actions.	Zone 2 monitoring bores (MB 17WAW0001, bore 24WAW-M01 and 21WAW-M02) as per Figure x, Appendix 4	Water Resource Evaluation Team supported by Environment Operations	Quarterly water level recording (manual).	**MS xxxx:** • Report as non compliance with Condition x of MS xxxx within seven (7) days. • Outcomes will be reported annually by 30 April in the ACAR. • If any trigger criterion was exceeded during the reporting period, the ACAR will discuss potential reasons for exceedance of the trigger criterion and include a description of the effectiveness of trigger level actions. **DN 2021/8923:** • In the event of an exceedance of threshold criteria, the exceedance will be reported in writing to the DCCEEW within five (5) business days of becoming aware of the exceedance. • The Proponent will provide a report to DCCEEW within twenty-one (21) business days of the exceedance being reported specifying details as required by Condition x of DN 2021/8923. • Outcomes, monitoring and response actions will be reported annually by 30 April in the ACAR.

Table 2-4: Outcome-based Groundwater EMP Provisions – Inland Waters - Karijini National Park Groundwater Water Quality – Deposit D, DN 2018/8299 Only

EPA Factor: N/A				
EPA objective: N/A				
Outcome: Ensure no change in groundwater quality at the boundary of, or within, Karijini National Park.				
Key environmental values: Karijini National Park.				
Key impacts and risks: Change to groundwater quality at the boundary of, or within, Karijini National Park, as a result of Project dewatering at Deposit C and/or Deposit D.				
Outcome-based Provisions				
High Management Zone (Appendix 2)				
Applicability: **DN 2018/8299 Condition 3(b):** No change in groundwater quality associated with the action at the boundary of, or within, Karijini National Park.				
Criteria	**Response Actions**	**Monitoring**	**Timing/Frequency**	**Reporting**
Early Response Indicator: **1.** Long term pH trend in Zone 2 monitoring bores over two consecutive monitoring periods is not consistent with trend in control bore. or **2.** Proportional change in EC in Zone 2 monitoring bores is greater than 20% of proportional change in control bore EC over two consecutive monitoring periods.	**Investigate potential cause of exceedance which may include:** • Resample monitoring bores and reinjection feed water. • Investigate potential cause of change. • Review/ complete particulate dispersion modelling to ensure model is calibrated and accurate. Re-model particulate dispersal if required to inform water quality modelling. If investigations indicate that trigger exceedance is due to the Project, implement trigger level response actions, for example: • Investigate treatment or alternative source of feed water. • Investigate reduction in reinjection until water quality improves (only if no impact to groundwater levels).	Field analysis for pH and EC of water samples from Zone 2 bores as per Figure 2-2, Appendix 4[5]	Quarterly	**DN 2018/8299:** • In the event that an exceedance of trigger criteria, the exceedance will be reported in writing to the DCCEEW within five (5) business days of becoming aware of the exceedance. • The Proponent will provide a report to DCCEEW within twenty-one (21) business days of the exceedance being reported specifying details as required by Condition 6(e) of DN 2018/8299. • Outcomes, monitoring and response actions will be reported annually by 30 April in the ACAR.
Trigger Criteria Level 1: **3.** Long term pH in Zone 2 monitoring bores is not between 6.5 and 8 for two consecutive monitoring periods and trend is not consistent with trend in control bore **or** **4.** Proportional change in EC in Zone 2 monitoring bores is greater than 50% of proportional change in control bore EC over two consecutive monitoring periods.	**Implement within twenty-four (24) hours:** • Investigate potential cause of exceedance as per Early Response Indicator with the addition of a review of monitoring. If investigations indicate that trigger exceedance is due to the Project, implement trigger level response actions, for example: . • As per Early Response Indicator. • If necessary, expand the monitoring network.	Field analysis for pH and EC of water samples from Zone 2 Bores as per Figure 2-2, Appendix 4[5]	Quarterly	**DN 2018/8299:** • In the event that an exceedance of trigger criteria, the exceedance will be reported in writing to the DCCEEW within five (5) business days of becoming aware of the exceedance. • The Proponent will provide a report to DCCEEW within twenty-one (21) business days of the exceedance being reported specifying details as required by Condition 6(e) of DN 2018/8299. • Outcomes, monitoring and response actions will be reported annually by 30 April in the ACAR.
Trigger Criteria Level 2: **5.** Long term pH in Zone 3 monitoring bores is not between 6 and 8.5 for two consecutive monitoring periods and trend is not consistent with trend in control bore pH. **or** **6.** Proportional change in EC in Zone 3 monitoring bores is greater than 50% of proportional change in control bore EC over two consecutive monitoring periods.	**Implement within twenty-four (24) hours:** • **I**nvestigate potential cause of exceedance as per Trigger Criteria Level 1: If investigations indicate that trigger exceedance is due to the Project, implement response actions, which could include but are not limited to: • As per Trigger Criteria Level 1 response. • Investigate and implement if required alternatives and/or treatment options for injection feedwater. • Investigate reduction in reinjection until water quality improves (only if no impact to groundwater levels). • Commence infrastructure upgrades required for treatment or alternative supply options if appropriate.	Field analysis for pH and EC of water samples from Zone 3 monitoring bores as per Figure 2-2, Appendix 4[5]	Quarterly	
Threshold Criteria: **7.** Long term pH in Zone 3 monitoring bores is not between 6 and 8.5 for two consecutive	**Implement within twenty-four (24) hours:** • Investigate potential cause of exceedance as per Trigger Criteria Level 2:			**DN 2018/8299:** • In the event that an exceedance of threshold criteria, the exceedance will be reported in

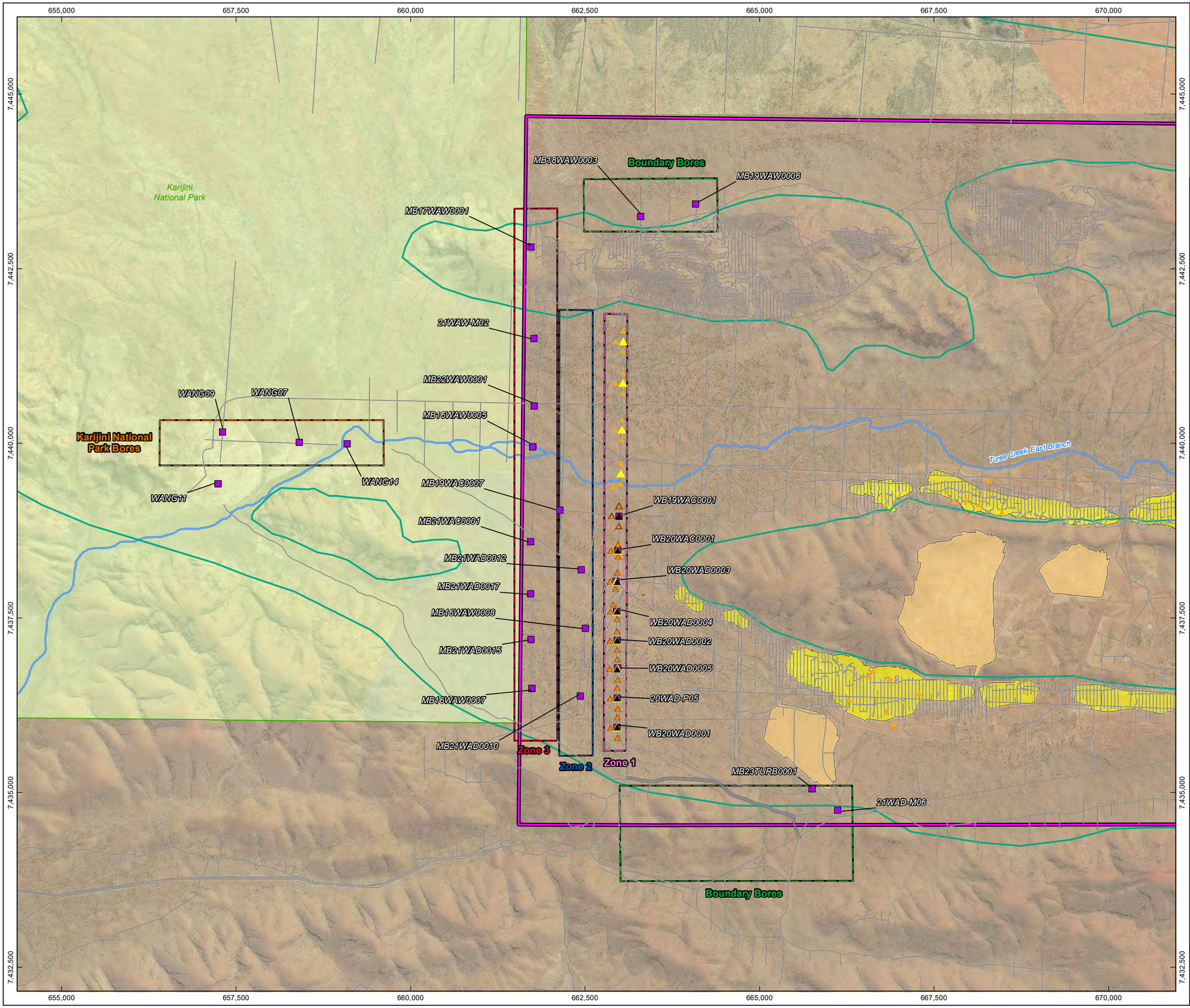
EPA Factor: N/A				
EPA objective: N/A				
Outcome: Ensure no change in groundwater quality at the boundary of, or within, Karijini National Park.				
Key environmental values: Karijini National Park.				
Key impacts and risks: Change to groundwater quality at the boundary of, or within, Karijini National Park, as a result of Project dewatering at Deposit C and/or Deposit D.				
Outcome-based Provisions				
High Management Zone (Appendix 2)				
Applicability: **DN 2018/8299 Condition 3(b):** No change in groundwater quality associated with the action at the boundary of, or within, Karijini National Park.				
Criteria	**Response Actions**	**Monitoring**	**Timing/Frequency**	**Reporting**
monitoring periods and trend is not consistent with trend in control bore pH as a result of the action **or** 8. Proportional change in EC in Zone 3 monitoring bores is greater than 80% of proportional change in control bore EC over two consecutive monitoring periods as a result of the action.	If investigations indicate that trigger exceedance is due to the Project, implement response actions, which could include but are not limited to: • As per Trigger Criteria Level 2 response. • Investigate in situ treatment options if detrimental impacts to Karijini National Park and/or other environmental values are expected. • Continue to implement threshold contingency actions until the CEO has confirmed by notice in writing that it has been demonstrated that the impact is below the threshold and trigger criteria. • Monitor to validate success of threshold contingency actions.	Field analysis for pH and EC of water samples from Zone 3 monitoring bores as per Figure 2-2, Appendix 4[5].	Quarterly	writing to the DCCEEW within five (5) business days of becoming aware of the exceedance. • The Proponent will provide a report to DCCEEW within twenty-one (21) business days of the exceedance being reported specifying details as required by Condition 6(e) of DN 2018/8299. • Outcomes, monitoring and response actions will be reported annually by 30 April in the ACAR.

Baseline water quality data will be collected throughout the planning, construction and early implementation phases of the MAR scheme to ensure the threshold criteria are reflective of groundwater quality and will capture any potential changes early enough to ensure potential impacts to Karijini National Park are not realised. It is intended to review the threshold criteria for water quality when an appropriate baseline dataset has been established.

Particle modelling to date has shown that potential migration of particles in groundwater towards Karijini National Park is very slow with particles not reaching Karijini National Park for a modelled period of 100 years after reinjection commences. The risk of potential impacts to Karijini National Park groundwater is very low in the initial stages of the Project. Anticipated timeline for baseline data collection and intended review of threshold criteria is detailed below.

Table 2-5: Phased Groundwater Quality data collection & threshold review

Phase	Implementation Stage	Timing	Threshold review	Potential Risk of Impact at Karijini National Park Boundary
1	Planning	~ 2 years (8 quarterly monitoring periods)	Threshold adequate – risk to groundwater nil to very low.	Nil (dewatering not commenced)
	Construction	~ 18 months (6 quarterly monitoring periods)		Nil (dewatering not commenced)
	Implementation (Dewatering Commence)	Ongoing (quarterly monitoring)		Very low - changes to groundwater would be identified in Zone 2 monitoring bores (Early Response Indicator and Trigger Criteria Level 1). Modelled particle tracking profiles for maximum and minimum drawdowns (Figure 2-2) indicate that potential water quality impacts will not occur within Zone 3 monitoring bores within 100 years, with impacts only predicted in Zone 2 monitoring bores for maximum drawdown model and only in isolated locations
	Implementation (Reinjection commences if required – years 1 - 5)	Ongoing (quarterly monitoring)	Threshold to be reviewed 3 – 5 years after commencement of reinjection.	Very low - changes to groundwater would be identified in Zone 2 monitoring bores (Early Response Indicator and Trigger Criteria Level 1). Modelled particle tracking profiles for maximum and minimum drawdowns (Figure 2-2) indicate that potential water quality impacts will not occur within Zone 3 monitoring bores within 100 years, with impacts only predicted in Zone 2 monitoring bores for maximum drawdown model and only in isolated locations.
	Implementation (Reinjection - year 5 onwards)	Ongoing (quarterly monitoring)	Review annually and update threshold if required.	Low - modelling indicates particles move towards mining area to the east, away from Karijini National Park in the west. Modelling predicts potential changes to groundwater quality near Karijini National Park are unlikely to be realised within 100 years.x. Reinjected water is from the same aquifer and is unlikely to differ in quality to that near Karijini National Park.
2	As above (schedule for each phase to be as per Phase 1).	To be determined - additional groundwater baseline monitoring to be carried out to support this Phase and inform water quality threshold.	Review annually and update threshold if required	Very low – modelling indicates particles move towards mining area, away from Karijini National Park.



RioTinto

Figure 2-2
Indicative Monitoring Zones and Monitoring Bores

Drawn: M.L
Plan: RTIO-1030433v1
Date: November 2023

Proj: GDA 1994 MGA Zone 50
Scale: 1:50,000 @A3
GIS.Team@riotinto.com

Legend

- Monitoring Bore
- Vibrating Wire Piezometer
- Planned Vibrating Wire Piezometer
- Phase 1 Injection Bore
- Phase 2 Injection Bore
- Revised Development Envelope
- West Angelas CDG Approved
- West Angelas CDG Approved Waste Dump
- Aquifer Boundary
- MAR Access
- National Park
- Major Creek
- Track

Indicative Monitoring Zone

- Zone 1
- Zone 2
- Zone 3
- Boundary Bores
- Karijini National Park Bores

N

0 1 2 3
Kilometres

Map units in metres

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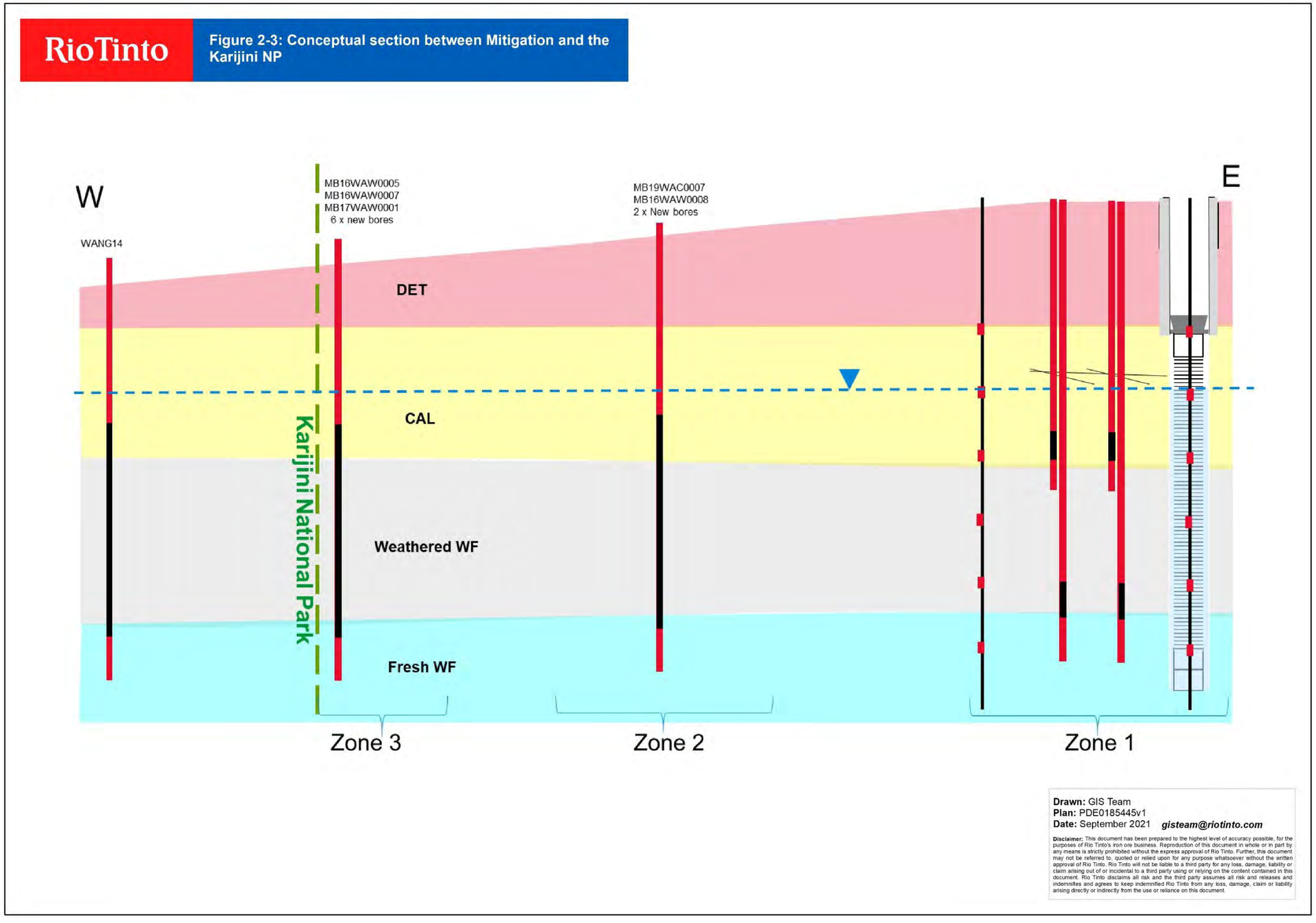

Figure 2-3: **Conceptual section between Mitigation and the Karijini National Park. Zones relate to observation/ trigger zones**

660,000
662,500
665,000
667,500
7,445,000
7,442,500
7,440,000

MB18WAW0003
MB17WAW0001
WB18WAW0001
WB19WAW0001
Western Hill
Karijini National Park
24WAW-M01
MB18WAW0004
21WAW-M02
Zone 1
Zone 2
Turee Creek East Branch
Deposit C

RioTinto

Figure 2-4
Indicative Monitoring Zones and Monitoring Bores related to Western Hill

Drawn: A.D.
Plan: RTIO-1030497v1
Date: November 2023
Proj: GDA 1994 MGA Zone 50
Scale: 1:30,000 @A3
GIS.Team@riotinto.com

Legend

- Revised Development Envelope

Proposed Conceptual Layout

- Pit
- Waste Landform

Approved Conceptual Layout

- Pit
- Waste Landform

- Monitoring Bore - Zone 1
- Monitoring Bore - Zone 2
- Supply Bore - Zone 2

Indicative Monitoring Zone

- Zone 1
- Zone 2

- National Park
- Aquifer
- Track
- Major Creek

N

0 0.25 0.5 0.75 1
Kilometres

Map units in metres

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2.1 Reporting

MS xxxx

Any exceedance of threshold criteria specified in this Groundwater EMP will be reported to the CEO in writing within seven (7) days of the exceedance being identified (Condition 6-4).

For each calendar year, during the operational phase, monitoring results will be reported against associated trigger and threshold criteria and objectives in the Annual Compliance Assessment Report (ACAR) for the Project. The ACAR will include a summary of quarterly monitoring results for the period specified in Table 2-1, Table 2-2 and Table 2-3 against trigger and threshold criteria to demonstrate that Condition x has been met during the reporting period. A summary of compliance against triggers and thresholds for the reporting period will be reported in the ACAR as shown in Table 2-6.

Monitoring results will be presented with trigger and threshold criteria indicated. Graphs (where appropriate) will include results of previous monitoring periods and include an assessment of current and historic monitoring results to allow adaptive management. A description of the effectiveness of any management contingency actions that have been implemented to manage the impact will be included in the ACAR (Condition 6-2(6)).

DN 2018/8299 and DN 2021/8923

Compliance against the conditions of DN 2018/8299 and DN 2021/8923 will be reported annually in the Annual Compliance Report as required by Condition 19 of DN 2018/8299 and Condition x of DN 2021/8923. Monitoring data recorded through implementation of provisions stated in Table 2-1, Table 2-2, Table 2-3 and Table 2-4 will be provided in graph format along with a written assessment of:

- Function and adequacy of Grey Box modelling and any updates to the model throughout the monitoring period (DN 2018/8922 only).
- Groundwater levels and quality in relation to Grey Box modelling and triggers and thresholds (DN 2018/8922 only).
- Groundwater level and quality trends over the reporting period and historically.
- Assessment of any potential future trends or issues and amendments to modelling, triggers and thresholds, or monitoring (DN 2018/8922 only).
- Summary of groundwater impacts and compliance.

For conditions related to this Groundwater EMP, the information to be reported as part of annual compliance reporting is shown in Table 2-7. In the event that trigger and threshold criteria are exceeded, the Proponent will notify DCCEEW within five (5) business days of becoming aware of the exceedance and any further reporting will be provided as per response actions for triggers and thresholds as specified in Table 2-1, Table 2-2, Table 2-3 and Table 2-4.

In the event of an incident, non-compliance against the conditions of DN 2018/8299, 2021/8923, or non-compliance with the commitments made in plans, the DCCEEW will be notified in writing as soon as practicable, and no later than two (2) business days of the non-compliance being known. The Commonwealth Department will also be provided with details of the non-compliance as required by Condition 20 of DN 2018/8299 as soon as practicable, and no later than ten (10) business days of the non-compliance being known.

Table 2-6: West Angelas Revised Proposal Groundwater EMP Reporting Table for MS xxxx

EPA Key environmental factors: Inland waters – Karijini National Park Groundwater Level	
Condition x – Ensure that there is no drawdown of groundwater associated with the proposal at the boundary of, or within, Karijini National Park	**Reporting periods 1 January-31 December**
Objective-based Provisions	
Management Targets	**MS xxxx Status report:** Target achieved Target not achieved
1. **Target 1**: Water levels in bores to the south and north of the MAR scheme in areas outside of the regional aquifer are above or equal to rolling 3 year, seasonally adjusted water levels (mbgl). 2. **Target 2:** Water levels in Zone 3 monitoring bores and modelled are above or equal to rolling 3 year, seasonally adjusted water levels (mbgl). 3. **Target 3:** Water levels in Zone 3 monitoring bores and modelled are above or equal to rolling 5 year, seasonally adjusted water levels (mbgl). 4. **Target 4:** Water levels in Zone 3 monitoring bores and modelled are above or equal to rolling 10 year, seasonally adjusted water levels (mbgl).	
Outcome-based Provisions (Triggers and Thresholds)	
Early Response Indicators	**MS xxxx Status report:** Early Response Indicator not reached Early Response Indicator reached
1. **Early Response Indicator 1:** Injection bores non-operational outside of proposed plan for operation of the MAR scheme (more than 1 of a paired set of bores inoperable for more than 1 week). 2. **Early Response Indicator 2:** Two consecutive monitoring periods of drawdown 25 cm greater than Grey Box level for modelled mitigation scenario in Zone 2 monitoring bores.	
Trigger Criteria	**MS xxxx Status report:** Trigger criteria not exceeded Trigger criteria exceeded
3. **Trigger Level 1:** Two consecutive monitoring periods of drawdown 50 cm greater than Grey Box level for modelled mitigation scenario in Zone 2 monitoring bores. 4. **Trigger Level 2:** Two consecutive monitoring periods of drawdown associated with the proposal of 10 cm or greater than the Grey Box level for modelled mitigation scenario in Zone 3 monitoring bores.	
Threshold criteria:	**MS xxxx Status report:** Threshold criteria not exceeded Threshold criteria exceeded
5. **Threshold Criteria**: Two consecutive monitoring periods of drawdown associated with the proposal of 20 cm or greater than Grey Box level for modelled mitigation scenario in Zone 3 monitoring bores.	

Table 2-7: West Angelas Revised Proposal Groundwater EMP Reporting Table for DN 2018/8299 and DN 2021/8923

Key environmental values: Karijini National Park Groundwater Level – DN 2018/8922 (Deposit D)	
Condition 3(a) - Ensure that there is no drawdown of groundwater associated with the action at the boundary of, or within, Karijini National Park	**Reporting periods 1 January-31 December**
Objective-based Provisions	
Management Targets	**DN 2018/8299 Status report:** Target achieved Target not achieved
1. **Target 1**: Water levels in bores to the south and north of the MAR scheme in areas outside of the regional aquifer are above or equal to rolling 3 year, seasonally adjusted water levels (mbgl). 2. **Target 2:** Water levels in Zone 3 monitoring bores and modelled are above or equal to rolling 3 year, seasonally adjusted water levels (mbgl). 3. **Target 3:** Water levels in Zone 3 monitoring bores and modelled are above or equal to rolling 5 year, seasonally adjusted water levels (mbgl). 4. **Target 4:** Water levels in Zone 3 monitoring bores and modelled are above or equal to rolling 10 year, seasonally adjusted water levels (mbgl).	
Outcome-based Provisions (Triggers and Thresholds)	
Early Response Indicators	**DN 2018/8299 Status report:** Early Response Indicator not reached Early Response Indicator reached
1. **Early Response Indicator 1:** Injection bores non-operational outside of proposed plan for operation of the MAR scheme (more than 1 of a paired set of bores inoperable for more than 1 week). 2. **Early Response Indicator 2:** Two consecutive monitoring periods of drawdown 25 cm greater than Grey Box level for modelled mitigation scenario in Zone 2 monitoring bores.	
Trigger Criteria	**DN 2018/8299 Status report:** Trigger criteria not exceeded Trigger criteria exceeded
3. **Trigger Level 1:** Two consecutive monitoring periods of drawdown 50 cm greater than Grey Box level for modelled mitigation scenario in Zone 2 monitoring bores. 4. **Trigger Level 2:** Two consecutive monitoring periods of drawdown associated with the proposal of 10 cm or greater than the Grey Box level for modelled mitigation scenario in Zone 3 monitoring bores.	

Threshold criteria:	**DN 2018/8299 Status report:** Threshold criteria not exceeded Threshold criteria exceeded
5. **Threshold Criteria**: Two consecutive monitoring periods of drawdown associated with the proposal of 20 cm or greater than Grey Box level for modelled mitigation scenario in Zone 3 monitoring bores.	
Key environmental values: Karijini National Park Groundwater Level – Western Hill	
DN 2021/8923 Condition x - Ensure that there is no drawdown of groundwater associated with the action at the boundary of, or within, Karijini National Park – Western Hill	**Reporting periods 1 January-31 December**
Outcome-based Provisions (Triggers and Thresholds)	
Early Response Indicators	**DN 2021/8923 Status report:** Early Response Indicator not reached Early Response Indicator reached
6. Two consecutive monitoring periods of drawdown associated with the proposal of 25 cm or greater in Zone 1 monitoring bores	
Trigger Criteria	**DN 2021/8923 Status report:** Trigger criteria not exceeded Trigger criteria exceeded
7. Two consecutive monitoring periods of drawdown associated with the proposal of 50 cm or greater in Zone 1 monitoring bores	
Threshold criteria:	**DN 2021/8923 Status report:** Threshold criteria not exceeded Threshold criteria exceeded
8. Two consecutive monitoring periods of drawdown associated with the proposal greater than 50 cm Zone 2 monitoring bores	
Key environmental Value: Karijini National Park Groundwater Quality – DN 2018/8299 Deposit D	
Condition 3(b) - no change in groundwater water quality associated with the action at the boundary of, or within, Karijini National Park.	**Reporting periods 1 January-31 December**
Early Response Indicators	**DN 2018/8299 Status report:** Early Response Indicator not reached Early Response Indicator reached

Early Response Indicator: 1. Long term pH trend in Zone 2 monitoring bores over two consecutive monitoring periods is not consistent with trend in control bore. or 2. Proportional change in EC in Zone 2 monitoring bores is greater than 20% of proportional change in control bore EC over two consecutive monitoring periods.	
Trigger Criteria	**DN 2018/8299 Status report:** Trigger criteria not exceeded Trigger criteria exceeded
Trigger Criteria Level 1: 3. Long term pH in Zone 2 monitoring bores is not between 6.5 and 8 for two consecutive monitoring periods and trend is not consistent with trend in control bore and is associated with the action. or 4. Proportional change in EC in Zone 2 monitoring bores is greater than 50% of proportional change in control bore EC over two consecutive monitoring periods and is associated with the action.	
Threshold Criteria	**DN 2018/8299 Status report:** Threshold criteria not exceeded Threshold criteria exceeded
Threshold Criteria: 7. Long term pH in Zone 3 monitoring bores is not between 6 and 8.5 for two consecutive monitoring periods and trend is not consistent with trend in control bore pH and is associated with the action. or 8. Proportional change in EC in Zone 3 monitoring bores is greater than 80% of proportional change in control bore EC over two consecutive monitoring periods and is associated with the action.	

3. ADAPTIVE MANAGEMENT AND REVIEW OF THIS EMP

The conceptual framework for the development of Rio Tinto Environmental Management Plans provides details of the review and adaptive management process (Appendix 1). The approach will include evaluation of:

- Monitoring data and comparison to baseline and reference site data on a regular basis to verify responses to potential impacts.
- The effectiveness and relevance of trigger and threshold criteria and contingency actions against environmental objectives, on an annual basis, to determine if any changes to the criteria, monitoring or response actions are required.
- The effectiveness and relevance of management actions and targets against environmental objectives, on an annual basis, to determine if any changes to actions, targets or monitoring are required.

Based on the results of the review process the Proponent will update and adjust the management measures and strategies in consultation with DWER (Table 3-1). No changes to early response indicators, triggers, thresholds or management actions will be implemented without prior consultation with and approval by DWER and DCCEEW.

This Groundwater EMP will be updated with the necessary monitoring, outcome modelling and reporting for all phases of the proposed MAR scheme and in relation to supply abstraction at Western Hill as required. Updates to this Groundwater EMP will be approved as required as specified in Condition 6-2 of MS xxxx, Condition 4 of DN 2018/8299 and Condition x of DN 2021/8923. The updated Groundwater EMP will be implemented in accordance with Condition x of MS xxxx.

Groundwater management and monitoring will continue until it can be demonstrated that the outcomes specified at Condition 3 of DN 2018/8299 and Condition x of DN 2021/8923 can be met without active management as required by Condition 7 of DN 2018/8299 and Condition x of DN 2021/8923. The Proponent will consult with DWER and DCCEEW prior to amending or ceasing groundwater management and/or monitoring to develop a plan to demonstrate that outcomes specified in Condition 3 of DN 2018/8299, Condition x of DN 2021/8923 Condition x of MS xxxx can be achieved without active management.

Table 3-1: Changes to the West Angelas Revised Proposal Groundwater EMP

Complexity of Changes	**Minor Revisions** ☐		**Moderate Revisions** ☐	**Major Revisions** ☐
Number of Key Environmental Factors	**One** ☐	**2 – 3**	**> 3** ☐	☐
Date Revision submitted to EPA and DCCEEW: DD/MM/YYYY				
Proponent's operational requirement timeframe for approval of revision Timeframe:	**< One Month** ☐	**Six Months** ☐	**> Six Months** ☐	**None** ☐ **Reason f** ☐

Item No.	EMP Section No.	EMP Page No.	Summary of Change	Reason for Change
1	1.2.1	Pg 11	Added in Western Hill Groundwater information	Requested by EPA
2	1.5.2, Table 1-5	Pg 26	Added in Western Hill Groundwater information	Requested by EPA
3	Table 2-3	Pg 33	Added in triggers and threshold table for Western Hll	Requested by EPA

4. STAKEHOLDER CONSULTATION

Consistent with the DCCEEW and DWER expectations for this Groundwater EMP to align with the principles of EIA, the Proponent has consulted with stakeholders, including but not limited to the Department of Biodiversity, Conservation and Attraction - Park and Wildlife Service, the DWER EPA Services, and DCCEEW during the development of this Groundwater EMP and the West Angelas Revised Proposal in relation to Western Hill.

The Proponent has consulted with the Yinhawangka Traditional Owners, on whose country the MAR scheme will operate. The Proponent is committed to continued engagement with the Yinhawangka Traditional Owners regarding the development and implementation of this Groundwater EMP.

A summary of stakeholder consultation with respect to this Groundwater EMP is provided in Table 4-1.

Table 4-1: Stakeholder Consultation

Stakeholder	Date	Purpose of Contact	Comments Raised	Resolution Comments
DWER- EPA, DWER-Water, DBCA, DCCEEW	27th May 2020	Briefing to provide overview of the conditions, MAR, EMP development and timing.	Queries with regards to MAR project, key points: • Water quality appears to be very good, how will this affect triggers and thresholds? • Modelling approach; single layer was used and did not consider indirect recharge. • Rainfall levels have changed since 1970's how has this been considered? • Number of aquifers being interacted with?	Response: • Water quality is good, some analytes only have trace concentrations so % change may not apply. Water quality inside KNP is likely to be more of an end member that is the product of evapotranspiration, while water in the deposits (source) and water near the MAR scheme (receiving) is likely to be the product of flow and infiltration processes which means it's quite similar. • A multi-layer model has been developed to support the development of the MAR scheme. • Recent rainfall levels have been used in modelling and will continue to be amended to include more recent knowledge. • Effectively only one aquifer present.
DWER- EPA, DWER-Water, DBCA, DCCEEW	19th August 2020	Briefing to provide hydrogeology background relevant to the EMP.	Queries with regards to hydrogeological setting, key points: • Hydrogeological setting including presence of different formations within the project area. • Presence of dykes before and after mining. • Hydraulic connections and further monitoring.	Response: • Further information supplied in response to queries regarding hydrogeological setting. • An overview of additional/future monitoring was provided.
DWER-EPA, DCCEEW	3rd November 2020	Briefing to present modelling inputs	Queries with regards to model and triggers, key points: • Will mean be presented in model outputs? • Will triggers be provided for each associated aquifer or specific to bores? • Will control bores be included in monitoring network?	Response: • All model simulations will be presented. • All units are connected, triggers and thresholds will be related to the aquifer system and bore specific. • Control bores will be included in monitoring network.
DWER- EPA, DWER-Water, DBCA, DCCEEW	23rd November 2020	Briefing to present modelling outputs and propose trigger and threshold criteria.	Queries with regards to model and monitoring, key points: • Linear regression was used but not adequate? • Has Grey Box modelling been used in similar scenarios? Will it be updated regularly? • Include justification for triggers and thresholds in Groundwater EMP.	Response: • Linear regression used initially to simulate climate variability on groundwater levels but has been replaced by grey box model. • Not that the proponent is specifically aware of, data driven models such as the Grey Box modelling are widely used in hydrological applications. Modelling will be checked for accuracy every three months and updated required.
DCCEEW, DWER and DBCA	20th April 2021 (DCCEEW), 8th	Comments on draft Groundwater EMP received.	Comments as specified in correspondence.	Groundwater EMP amended as determined appropriate. Response sent to DCCEEW and DWER 5 October 2021.

Stakeholder	Date	Purpose of Contact	Comments Raised	Resolution Comments
	June 2021 (DWER, DBCA)			
DCCEEW, DWER and DBCA	24th November 2021 (DCCEEW), 27th January 2022 (DWER, DBCA)	Comments on draft Groundwater EMP received.	Comments as specified in correspondence.	Groundwater EMP amended as determined appropriate. Response sent to DCCEEW and DWER 9 February 2022.

5. REFERENCES

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6. APPENDICES

Appendix 1: Conceptual Framework for the Development of Rio Tinto Environmental Management Plans

For the development of Environmental Management Plans (EMPs), a conceptual framework model has been applied. The framework ensures linkages between current understanding, potential impacts, outcomes, adaptive management, and consistent monitoring and management practices. The framework is a stepwise process that considers the environmental values as identified in the Proposal's Environmental Impact Assessment Documents, in order to implement appropriate management measures and actions to ensure the environmental objective can be achieved.

The first step of the framework examines in detail the current knowledge of the environmental value(s) associated with the Proposal. This is compiled from information provided in the EIA documents, any additional environmental surveys and examined with input from internal experts. Environmental values associated with the Proposal are evaluated based on their conservation status at local, state and regional levels.

The second step of the framework is to define relevant indicators, level of management and type of provisions (outcome vs management-based) and associated criteria and/or targets.

A source-pathway receptor (SPR) conceptual modelling approach is used to inform the selection of indicators, as recommended by national and international guidance (DIIS 2016). The SPR conceptual model sets out the collective knowledge, experience and perspective on the environmental value (system of interest) and illustrates assumptions about how the value (system) functions and what is believed to be the important or dominant processes and their linkages. This includes factors that are perceived to be driving changes in the value (system) and the consequences of changes in these factors. The conceptual model also includes factors such as spatial boundaries as well as temporal and seasonal variations.

The number and type of indicators selected to monitor and measure changes in individual environmental values will depend on several factors including; the conservation status of the environmental value; the level of management required; the environmental outcome or objectives; location; and the types of pressures and stressors identified.

The required level of management (Low, Moderate or High) is determined using an matrix assessment with four factors relating to predicted impacts from the Proposal including: likelihood; consequence; spatial extent; and temporal duration (Table A 1). The higher the level of management, the more lines of evidence may be deemed necessary to meet the environmental outcome or objective (that is more indicators and / or more frequent monitoring schedules).

Draft (interim) trigger and threshold criteria and/or draft management targets will be determined for each environmental value. Early response criteria (if appropriate) may be defined for indicators for the environmental value (e.g. groundwater depth) or the environmental value itself (e.g. vegetation status). Trigger and threshold criteria will directly relate to the environmental value and objective itself.

The number of trigger criteria, and the sensitivity of both trigger and threshold criteria, will be determined by the associated management level for the environmental value.

The third step of the framework is to undertake an evaluation of the baseline and/ or current data to assess against criteria and determine whether the environmental outcome or objectives are likely to be met with existing proposed indicators. This step should also occur as part of reporting requirements when criteria are exceeded. Where criteria are not being met the adaptive management process should be implemented.

The fourth step of the framework is to implement the EMP. To ensure successful implementation, relevant internal and external (regulatory) stakeholders are consulted to ensure the EMP meets management expectations, and can be implemented for the associated Proposal.

The fifth, final step of the framework considers a revision of or alternatives of management objectives, indicators and/ or criteria. This step is considered where monitoring and assessment indicates

objectives are not being met. Where data suggests that objectives cannot be met using current associated indicators and criteria, repeat the second to fifth step of the framework, with consideration of the additional information gained through monitoring.

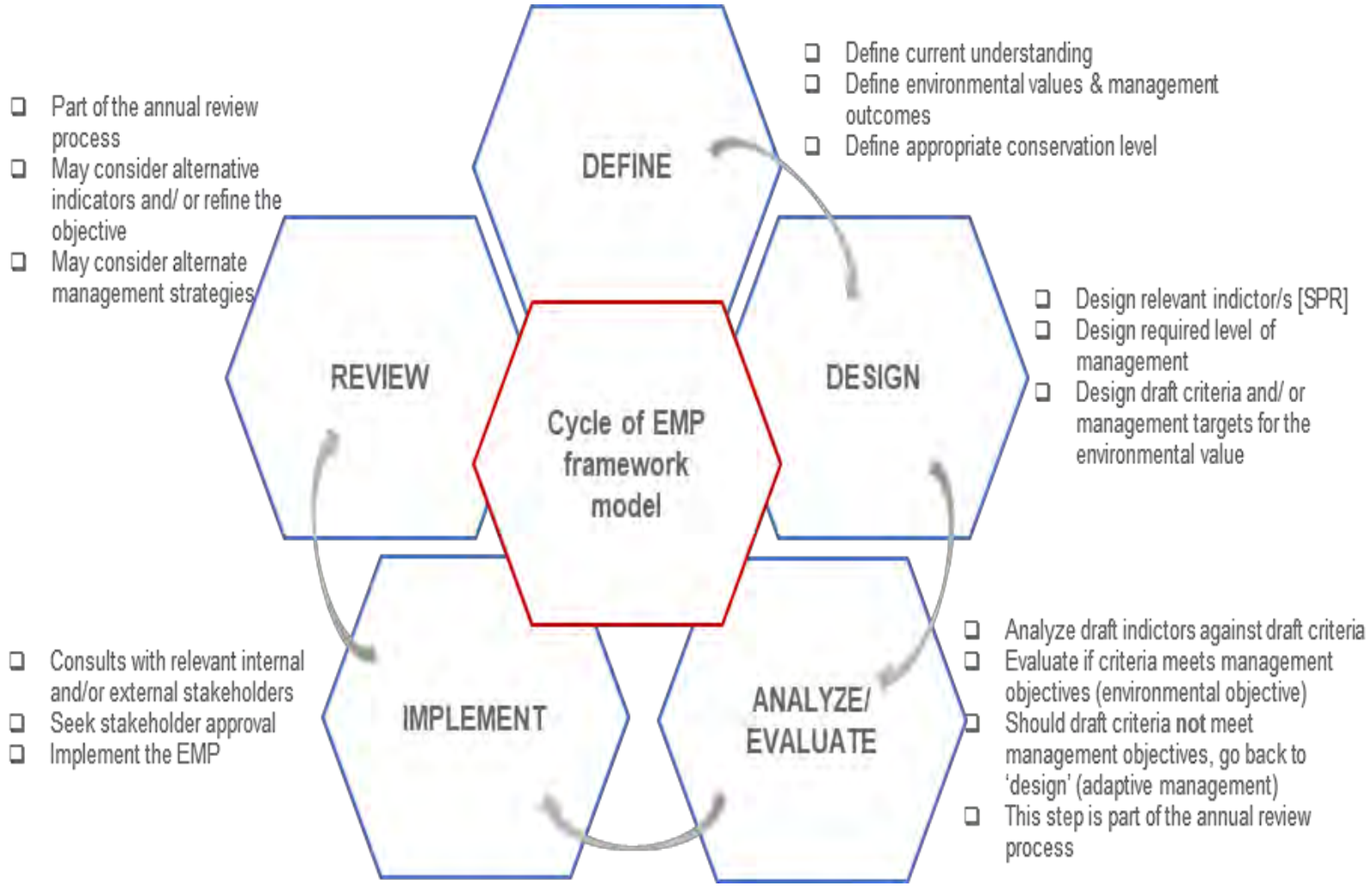

Figure A 1: Cycle of the conceptual Environmental Management Plan framework model

Table A 1: Management level assessment matrix

Factor	Level of required management (increasing to right)				
Likelihood	Rare	Unlikely	Possible	Likely	Almost Certain
Consequence	Environmental values (species, communities /ecosystems) with no formal recognition for conservation purposes	Environmental values (species, communities /ecosystems) with no formal recognition for conservation purposes but may hold local environmental significance	Environmental values (species, communities /ecosystems) recognised as being of conservation interest	Environmental values (species, communities /ecosystems) directly protected under State and Commonwealth legislation	Environmental values (species, communities /ecosystems) directly protected under State and Commonwealth legislation (with potential severe consequence).
Extent	Immediate	Surrounds	Local	Catchment	Sub-regional
Duration	Days	Months	Years	Decades	Centuries

- The factors act independently of one another, and an increased risk of one factor will not necessarily result in other factors with higher risk.
- Level/s of management gives an indication of potential importance, however important to note that regulatory focus, cumulative impact and heritage values may impact the way the environmental values are treated/ managed.

Reference

DIIS (2016). *Leading Practice Sustainable Development Program for the Mining Industry - Preventing Acid and Metalliferous Drainage Handbook.* Department of Industry, Innovation and Science (DIIS), Canberra, Australia.

Appendix 2: Summary of assessment for required management zone

The environmental value, described in Section 1.4, was assigned a level of management based on the matrix level assessment (Appendix 1, Step 2). A summary of the assessment for the Project, which takes into account information provided in 1 and Table 1-5 is provided in the table below along with the resulting management zone for the environmental value relevant to this Groundwater EMP. The assessment considers all impacts collectively (direct, indirect) and assigns against the highest level of management zone.

Table A-2: Summary of assessment for assignment of management zone.

Environmental Value	Predicted and potential impact/s	Assessment				Management Zone
		Likelihood	Consequence	Extent	Duration	
Inland Waters						
Karijini National Park	**Indirect**: potential for changes to groundwater level and groundwater quality at the boundary of, and within, Karijini National Park as a result of dewatering associated with the Project.	**Unlikely** Unmitigated dewatering of the western end of Deposit C and Deposit D will result in groundwater drawdown extending west to Karijini National Park (Rio Tino, 2018). An initial 2019 Phase 1 MAR drilling programme and injection trial (Dec 2019 to Feb 2020) has proven that MAR using reinjection bores is practicable in the Phase 1 area, and is expected to mitigate impacts from dewatering. Drawdown from supply abstraction at Western Hill is not modelled to propagate towards Karijini National Park.	**Major** Potential impact on values within a National Park.	**Catchment** The Project (including Deposit C and D) are located in the Turee Creek catchment. Deposits C and D lie within a connected groundwater system, with the aquifer extending inside Karijini National Park (Rio Tino, 2018).	**Centuries** Numerical groundwater modelling conservatively assumes that the drawdown of the groundwater beneath Karijini National Park will recover but not to initial conditions within 100 years (Rio Tinto, 2018).	HIGH

Appendix 3: West Angelas Groundwater Modelling Report (IGS 2021).

West Angelas Groundwater Modelling to Support MAR Design and Operation – Summary to Support Groundwater Environmental Management Plan

A report prepared for Rio Tinto Iron Ore

30 November 2023

Innovative Groundwater Solutions

West Angelas Groundwater Modelling to Support MAR Design and Operation – Summary to Support Groundwater Environmental Management Plan

A report prepared for Rio Tinto Iron Ore

by

Innovative Groundwater Solutions

30 November 2023

Document control

Version	Date Issued	Author	Reviewed by	Date Approved	Revision Required
1.3	14th Dec 2020	T. Laattoe N. Harrington	G. Harrington	14th Dec 2020	Minor
Final	16th Dec 2020	T. Laattoe N. Harrington	RTIO	5th Feb 2021	Minor.
					Revision to suit inclusion in EMP.

Distribution

Date	Version	Issued To
16th Dec 2020	Final	R. Milton, I. Dionne (RTIO)
10th Feb 2021	Revised Final Report	R. Milton, I. Dionne (RTIO)
10th Feb 2021	Summary to Support EMP	R. Milton, I. Dionne (RTIO)

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Cover photo: Rob Milton

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DISCLAIMER

This report is solely for the use of Rio Tinto Iron Ore and may not contain sufficient information for purposes of other parties or for other uses. Any reliance on this report by third parties shall be at such parties' sole risk.

The information in this report is considered to be accurate with respect to information provided and conditions encountered at the site at the time of investigation. IGS has used the methodology and sources of information outlined within this report and have made no independent verification of this information beyond the agreed scope of works. IGS assumes no responsibility for any inaccuracies or omissions. No indications were found during our investigations that the information provided to IGS was false.

Innovative Groundwater Solutions Pty Ltd.
PO Box 2123, Victor Harbor SA 5211
Phone: 0458 636 988
ABN: 17 164 365 495 ACN: 164 365 495
Web: www.innovativegroundwater.com.au
Email: glenn@innovativegroundwater.com.au

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1. Introduction

Dewatering of deposits C and D at Rio Tinto Iron Ore's (RTIOs) West Angelas mining operations (Figure 6-1) is planned to allow below water table mining of these deposits.

The cone of water table depression caused by dewatering in deposits C and D is predicted to reach the boundary of Karijini National Park (KNP) and RTIO propose to mitigate this impact using a Managed Aquifer Recharge (MAR) Scheme installed between the mine pits and the KNP boundary.

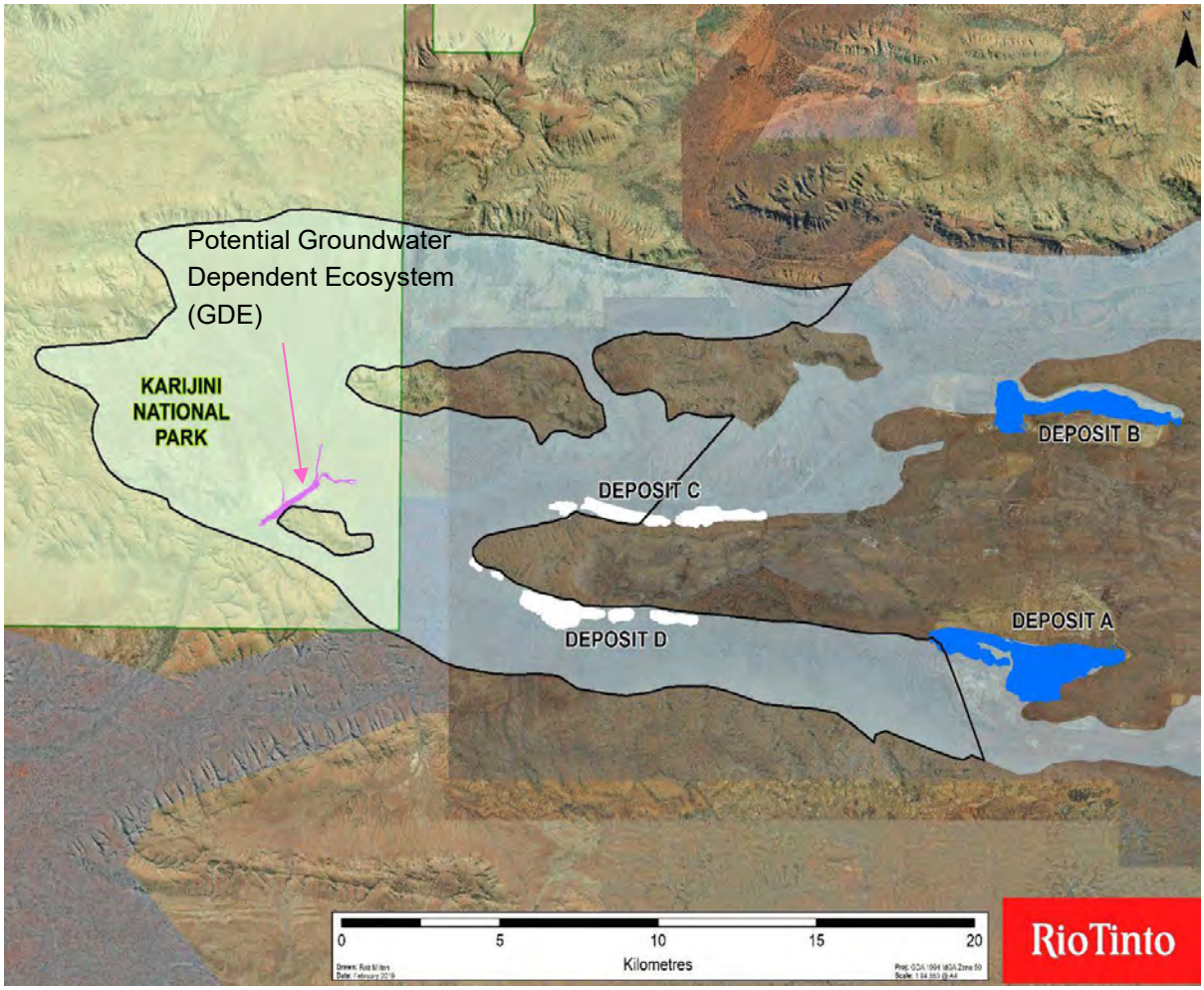


Figure 6-1. Locations of West Angelas deposits A, B, C and D relative to the boundary of Karijini National Park. The groundwater domain for deposits C and D is delineated by the thick black line. This is separated from deposits A and B by dykes, which form barriers to groundwater flow. Source: RTIO (2019).

Innovative Groundwater Solutions Pty Ltd (IGS) was contracted by RTIO to undertake groundwater flow modelling to simulate drawdown impacts from the dewatering of deposit D1, and to inform the optimization of the proposed MAR scheme to mitigate these impacts. The receptor for drawdown impacts is Karijini National Park. The objective of the proposed MAR scheme is to ensure that there is zero drawdown impact at the boundary of Karijini National Park.

Furthermore, approval and operation of the proposed MAR scheme requires the identification of any potential water quality risks to Karijini National Park as a result of injection of groundwater dewatered from the mine pits. An understanding of these risks is also required to provide a basis for establishing regulatory water quality triggers.

The heterogeneous nature of any groundwater system, and the general deficiencies in field data sets available to characterize them, mean that all groundwater models carry uncertainty. In addressing the above requirements, predictions of unmitigated and mitigated drawdown, optimization of the MAR scheme and predictions of water quality impacts must account for this uncertainty.

Finally, a methodology is required to account for the effects of natural climate variability on groundwater levels in both the operation of the MAR scheme and setting and assessing regulatory water level triggers. The MAR scheme is required to mitigate mine-related impacts only. As there is insufficient information available on recharge processes and rates for the West Angelas area to allow for the incorporation of climate variability in a regional groundwater model, a robust and defensible methodology is required to untangle mine-related impacts from natural climate effects.

Based on the above requirements, the objectives of the modelling project were therefore to:

1. Inform the design of the proposed MAR scheme to mitigate drawdown impacts from dewatering of deposit D1. That is, determine the optimum injection rates for the planned MAR bores.
2. Inform the development of operational and management groundwater level triggers.
3. Determine the risk of MAR injectant reaching the KNP boundary.
4. Account for uncertainty in the hydrogeological conceptual model in 1-3 above.
5. Identify the best locations for water quality triggers and areas outside the zone of influence that can be used to collect baseline water quality information.
6. Support the H3 Hydrogeological Assessment and Environmental Management Plan currently being prepared by RTIO.

A final project report, containing all background information and datasets required for internal review, and to support ongoing studies by RTIO was delivered on 16th December 2020. Minor revisions were made in response to RTIO's comments, with the final version of that report delivered on 10th February 2021 (IGS, 2020a). The current version of the report has undergone further minor modifications to make it suitable for inclusion as an appendix in the Groundwater Environmental Management Plan.

2. Project Approach

The overall approach for this project was divided into a series of tasks, based around two stages of modelling.

The first stage of modelling utilized an analytical element model of the MAR injection trial carried out in February/March 2020 (IGS, 2020b). Calibration of this model to the transient injection trial data was used to assess local- and sub-regional-scale hydraulic properties of each aquifer unit intersected by the injection bore. The outcomes of the injection trial simulation were then used to inform the ranges in aquifer parameters adopted in the calibration of an initial regional-scale groundwater flow model (IGS, 2020b).

The second stage, which is described in this report and summarized visually in Figure 6-2, includes refinement of the regional model calibration, whereby the model was calibrated to both regional historical (steady-state) head data and transient data collected during the injection trial. An ensemble of models capturing the range of uncertainty in aquifer parameters was then developed and conditioned to both the steady-state and transient MAR trial data. This ensemble was used to simulate unmitigated drawdown due to dewatering of pit D1 and as a basis for an optimized injection regime with high confidence of mitigating drawdown whilst accounting for uncertainty in the model.

Particle tracking has been used with the regional groundwater flow model and optimized injection regime to provide a preliminary risk assessment for water quality impacts at the KNP boundary; that is, the likelihood of MAR injectant reaching the boundary.

Finally, a new approach has been developed to account for climate variability in the selection and assessment of operational and management water level triggers. This approach is designed for use alongside the regional model outputs in designing water level triggers. It uses historical ranges of observed water level declines and historical hydraulic gradients to determine appropriate triggers. As a next step, a Grey Box Model for the relationship between rainfall and groundwater levels is used to determine the contribution of mining to any trigger exceedances.

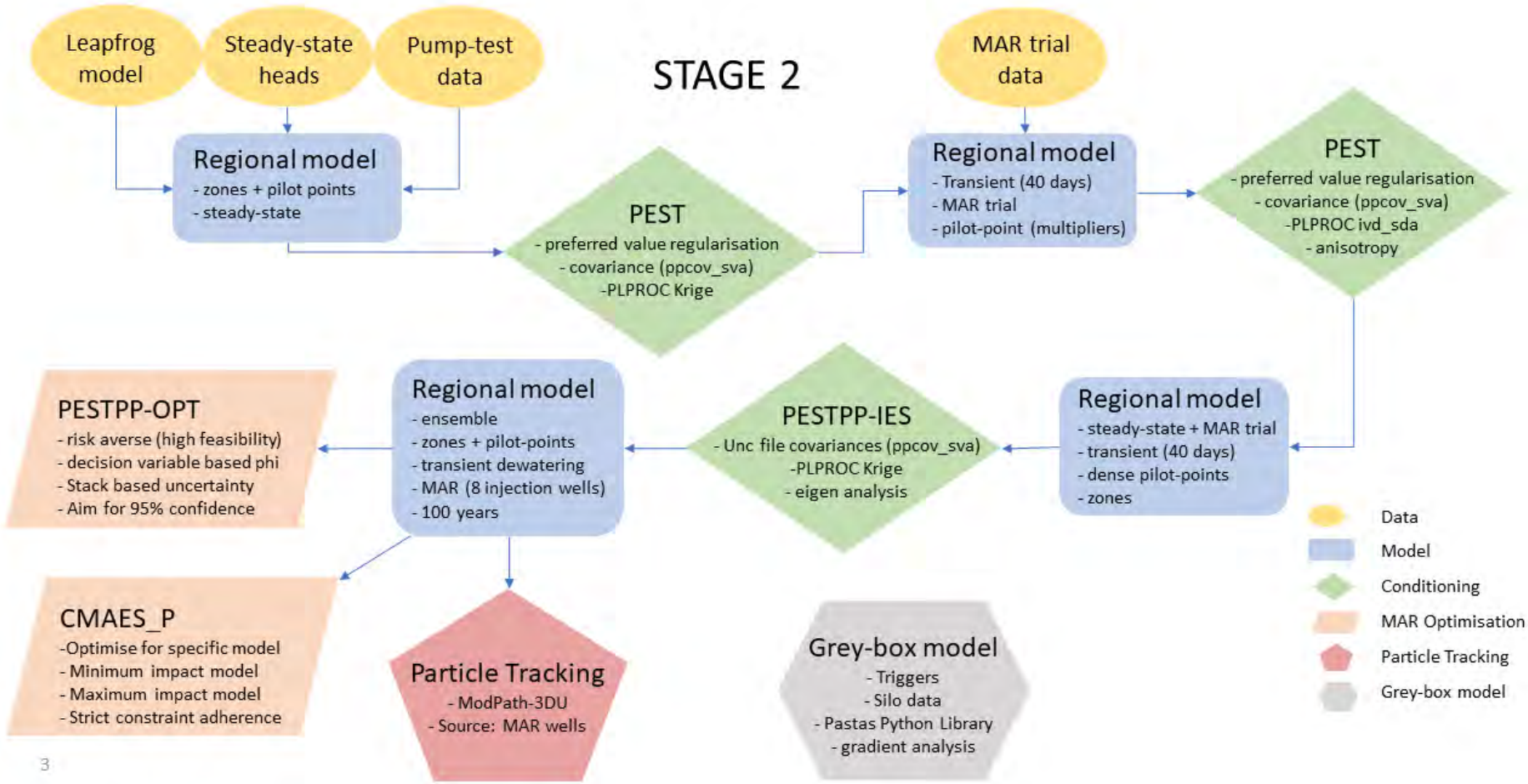


Figure 6-2. Flowchart showing the interactions between the modelling tasks undertaken in Stage 2 of this project and described in this report.

3. Conceptual Hydrogeological Model

3.1. Site Description

RTIO's West Angelas mining operations are located in the Pilbara region of Western Australia, and approximately 100 km west-northwest of the township of Newman. Geologically, the study area is situated in the Hamersley Basin of the central Pilbara Craton. The Hamersley Basin extends approximately 400 km inland and covers an area of more than 100,000 km^2 (Dogramaci et al., 2012). The region is characterised by a sub-tropical semi-arid to arid climate, with a mean annual rainfall of 296 mm/yr. at Paraburdoo (BoM station no. 7185) and a mean annual evaporation of 3,258 mm/yr. Rainfall is highly variable from year to year and there are prolonged periods of drought (Figure 6-3a). Rainfall is generally concentrated during the months of January to March, coinciding with high evaporation, although significant rainfall events can occur any time throughout the year (Figure 6-3b and c). Rainfall events associated with tropical cyclones and localised thunderstorm events over the summer months can be intense, producing very large runoff. The low annual rainfall coupled with high evaporation rates result in extreme water deficits and short retention times for surface water across the Pilbara region.

Surface water flows across the Hamersley Basin occur via braided, meandering flow paths across the plains and single channels in discrete valleys within the ranges. Surface flow only occurs after heavy rainfall events (Dogramaci et al., 2012). There is no permanent surface water in the study area, although ephemeral surface water drainage lines can be observed from aerial photography (Figure 6-4). Figure 6-4 also shows the location of a potential groundwater dependent ecosystem that has been identified within Karijini National Park, where a major watercourse crosses an area of shallow water tables (depth to groundwater < 5m).

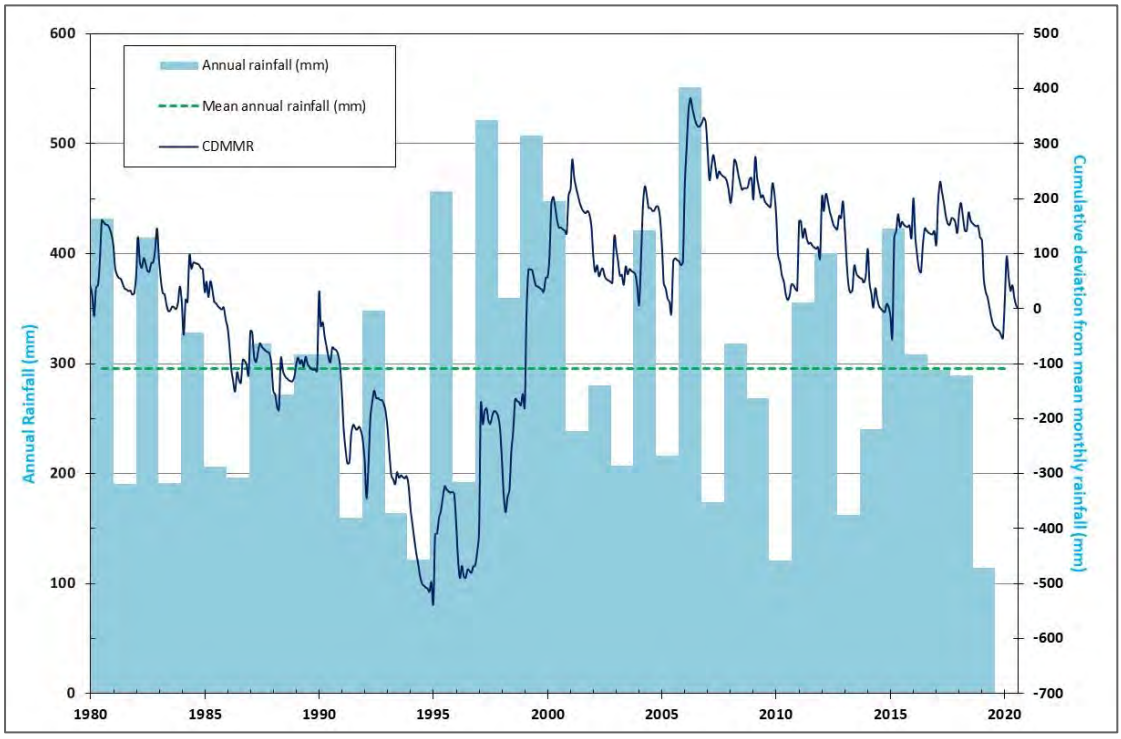


Figure 6-3 (a)

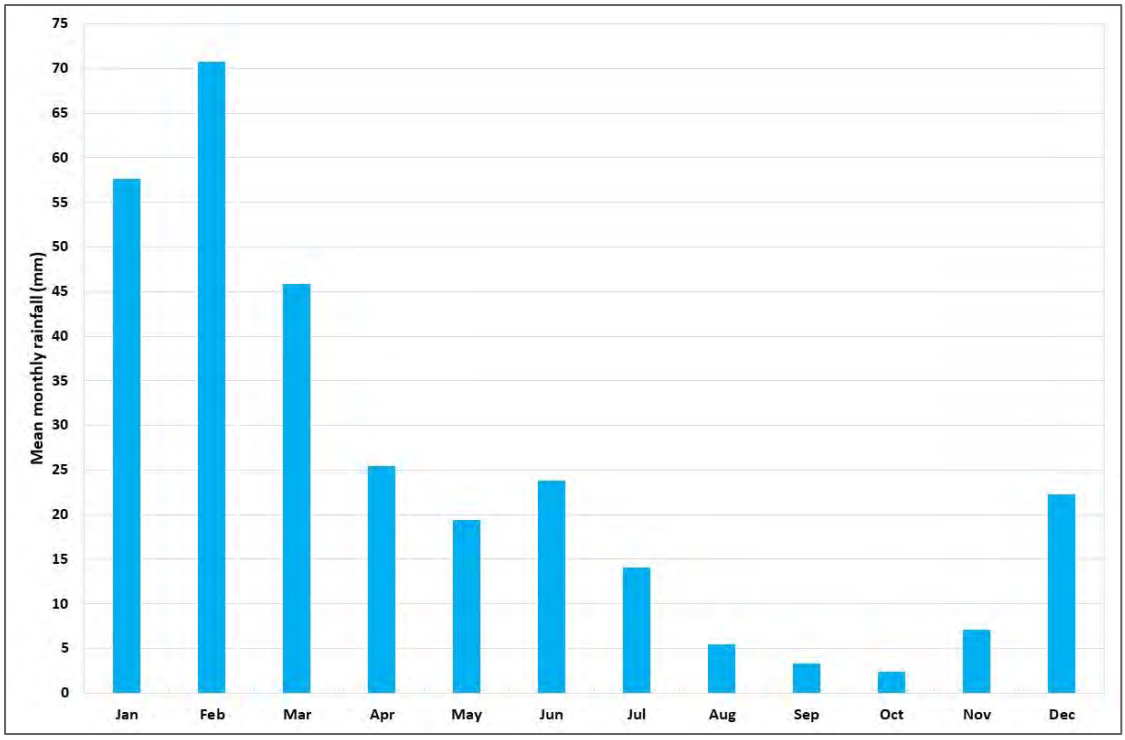


Figure 6-3 (b)

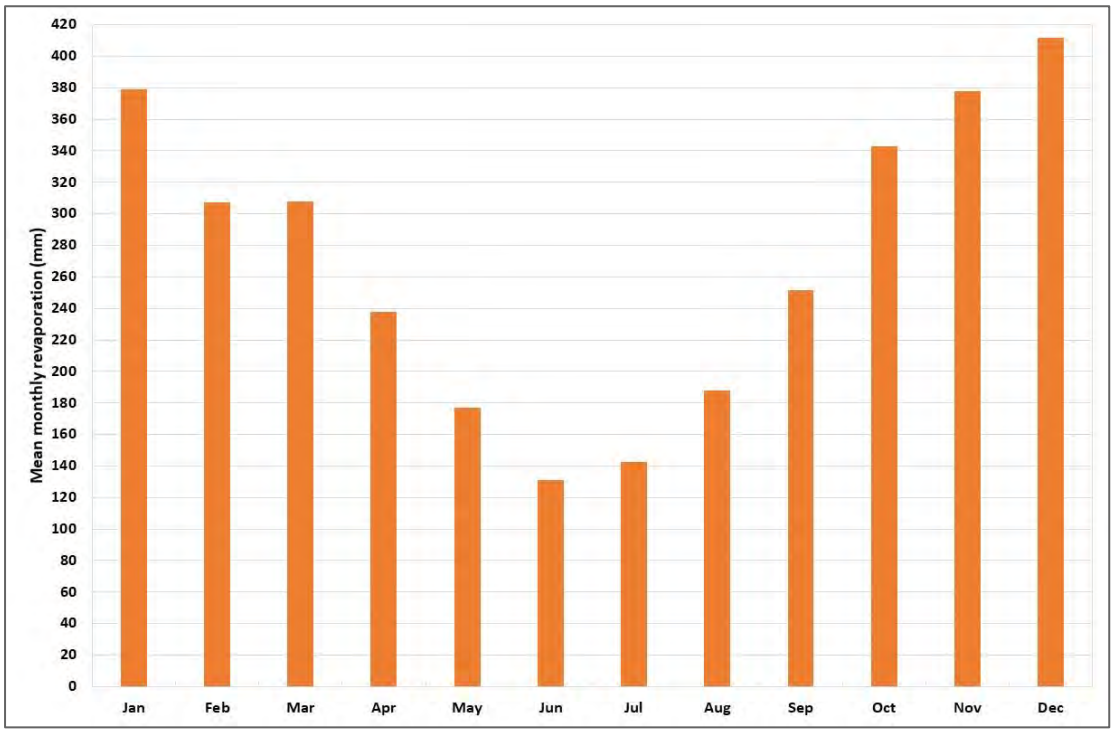


Figure 6-3 (c)

Figure 6-3. Rainfall and evaporation for the West Angelas site, obtained using Bureau of Meteorology SILO data. (a) Annual rainfall with Cumulative Deviation from Mean Monthly Rainfall (CDMMR) (b) Mean monthly rainfall (c) Mean monthly evaporation.

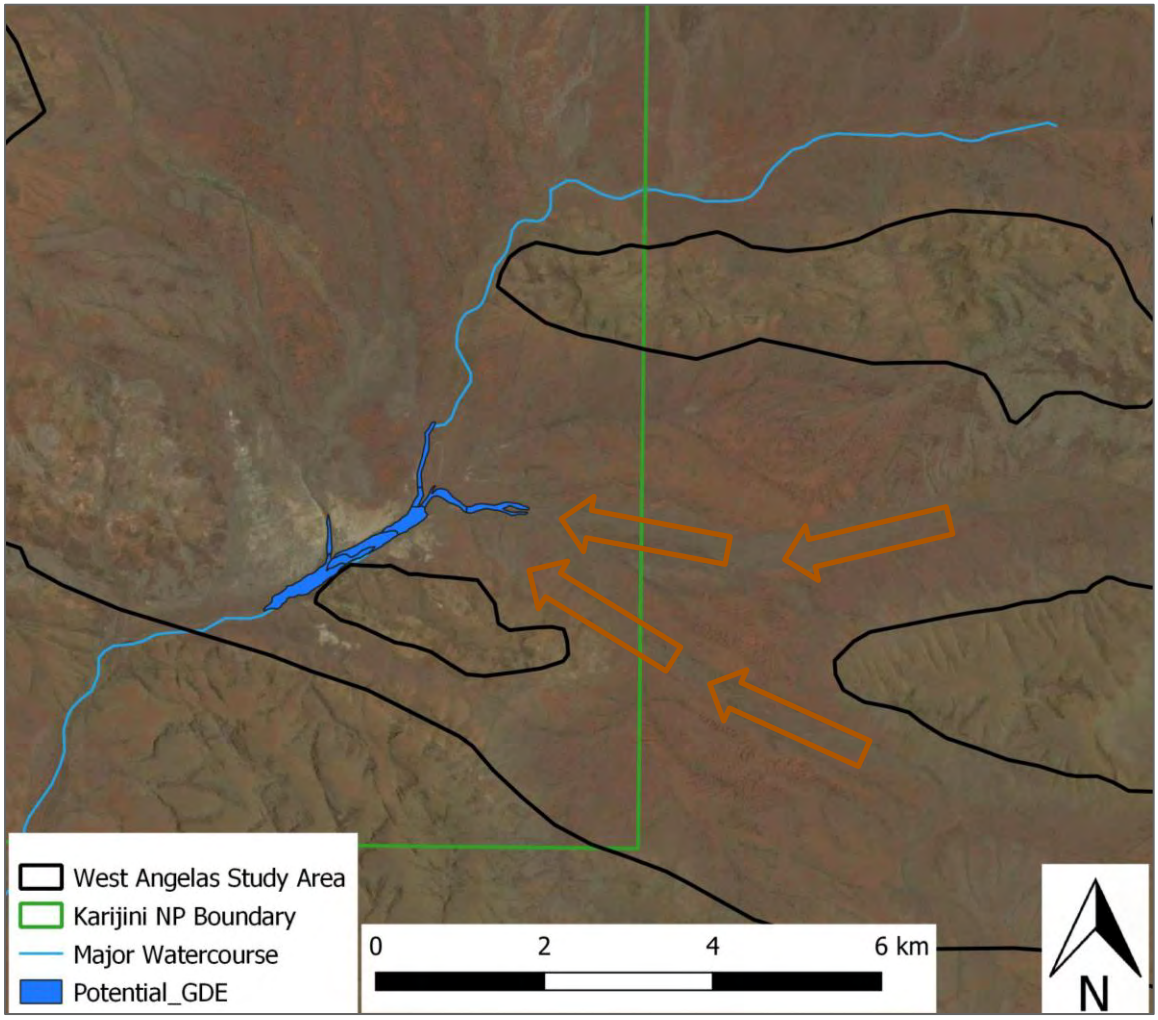


Figure 6-4. Aerial view of the western portion of the study area, from which surface water drainage lines can be identified, and the potential GDE with associated major watercourse. Arrows indicate locations of major surface water drainage lines identified from the aerial imagery. Minor drainage lines can also be identified from the aerial imagery. Imagery source: Mapbox Satellite v9.

Vegetation across the study area is consistent with typical vegetation for the Hamersley Basin, which comprises scattered eucalypts and *Acacia* over shrubs and hummock grassland on the rugged ridges, with mulga (*Acacia aneura*) woodlands, shrubs and *Triodia pungens* and *T. wiseanna* in the valleys. Eucalypt woodlands consisting of coolabah (*Eucalyptus victrix*), river redgums (*E. camaldulensis* subsp. *refulgens*) and *Acacia citrinoviridis* line major rivers and larger streams. *Melaleuca argentea* can be found only where permanent water exists close to the surface.

3.2. Regional Geology

The following description of the regional geology of the Hamersley Province of the Pilbara Craton is obtained from the Parsons Brinckerhoff (2013) report on the nearby Koodaideri project area. In the Hamersley Province, the Pilbara Craton is unconformably overlain by a thick sequence of late

Archean to Proterozoic (2,770–2,300 Ma) sedimentary and volcanic rocks of the Mount Bruce Supergroup (MacLeod et al. 1963, subsequently redefined by Trendall 1979).

The Mount Bruce Supergroup includes three stratigraphic units (Table 2):

- Fortescue Group (Richards & Blockley, 1984; Ardnt et al., 1991): the oldest stratigraphic unit, this is a sequence of predominantly plateau volcanic rocks up to 6 km thick that were deposited during a period of tectonic crustal extension (Arndt et al., 1991).
- Hamersley Group (MacLeod et al., 1963; Trendall & Blockley, 1990): conformably overlies the Fortescue Group and is a sequence of Banded Iron Formation approximately 2.5 km thick (James, 1954, 1983) that was deposited in a subsiding passive margin setting (Simonson et al., 1993). Four Banded Iron formations are recognised: the Marra Mamba, Brockman and Boolgeeda iron formations and the Weeli Wolli Formation. The Wittenoom Formation, a carbonate dominated sequence of sedimentary rocks, separates the Marra Mamba and Brockman iron formations.
- Turee Creek Basin Group (Krapez 1996): the youngest stratigraphic unit, this is a sequence of sediments, up to 5 km deep, deposited in a basin environment (Krapez 1996). The Turee Creek Basin conformably overlies the Hamersley Group rocks and is located close to the southern margin of the Pilbara Craton.

Table 2. Regional geological sequence of the Pilbara Craton. From Parsons Brinckerhoff (2013). After Thorne and Tyler (1997).

Age	Group	Formation	Member	Dominant lithology
Cainozoic		Alluvium		Unconsolidated silt, sand, and gravel, in drainage channels and on adjacent floodplains
		Colluvium		Unconsolidated quartz and rock fragments in soil
		Eolian deposits		Sand in sheets and longitudinal dunes
		Calcrete		Sheet carbonate; found along major drainage lines
		Alluvium and colluvium		Red brown sandy and clayey soil; on low slopes and sheetwash areas
		Lateritic deposits		Massive and pisolitic ferruginous duricrust
Proterozoic	Turee Creek Group			Pelites, sandstones and conglomerates. Quartzites, carbonates and shales.
Proterozoic	Hamersley Group	Brockman Iron Formation	Boolgeeda Iron Formation	BIF, shales and chert
			Woongarra Rhyolite	Lower and upper rhyolite separated by BIF, dolerite, shale
			Weeli Wolli Formation	Alternating BIF and shale with dolerite sills
			Yandicoogina Shale Member	Interbedded chert and shale
			Joffre Member	BIF with minor shale bands
			Whaleback Shale Member	Interbedded shale, chert and BIF
			Dales Gorge Member	Interbedded BIF and shale
Early Proterozoic - Achaean		Mount McRae Shale		Shale and dolomitic shale with minor thinly bedded chert
		Mount Sylvia Formation		Shale, dolomitic shale, and BIF
		Wittenoom Formation	Bee Gorge Member	Graphitic shale with minor sequences of carbonate, chert, volcaniclastic rock, and BIF
			Paraburdoo Member	Dolomite with minor amounts of chert and shale - karstic in areas
			West Angela Member	Dolomite, dolomitic shale, and chert
		Marra Mamba Iron Formation	Mount Newman Member	Chert, banded iron-formation, and shale
			MacLeod Member	BIF, cherts, carbonates and interbedded shales
			Nammuldi Member	Poddy cherty BIF, interbedded thin shales
Achaean	Fortescue Group	Jeerinah Formation	Jeerinah Formation	Shale, chert, and thin-bedded metasandstone
			Woodiana Member	Metamorphosed silicified sandstone, shale, and chert
		Maddina Formation	Maddina Basalt	Amygdaloidal metabasaltic flows and breccia
			Kuruna Member	Metamorphosed volcanic sandstone, shale, chert, and metadolomite
		Tumbiana Formation		Mafic to intermediate volcaniclastic rocks, stromatolitic carbonate rock, basalt and minor chert
		Kylena Formation		Thin to very thick, massive or amygdaloidal metabasaltic flows, minor metabasaltic breccia and metasandstone
	Shaw/Yule Granitic Complex	Granite and greenstone belt		Granodiorite, metamorphosed biotite, and monzogranite

3.3. Regional Hydrogeology

Three major aquifer systems have been identified in the Pilbara Region (Johnson and Wright, 2001):

1. Unconsolidated Sedimentary Aquifers, which are further sub-divided into:
    a. Valley Fill Aquifers, consisting of unconsolidated valley fill typically alluvium and colluvium.
    b. Calcrete Aquifers characterised by secondary porosity with karstic features. In the study area calcrete typically forms as a chemical precipitate in weathered horizons within igneous units of the Fortescue Group. The calcrete deposits coincide with existing drainage channels.
2. Pisolitic Limonite Aquifers, which can be high yielding but generally only constitute an aquifer where it occupies channels incised into basement rock developed in paleodrainage systems.
3. Fractured Rock Aquifers, which occur where secondary porosity has developed in basement rock due to fracturing, weathering or mineralisation. The regional aquifer for the Pilbara is the weathered dolomite associated with the Wittenoom Formation. However, depending on the degree of mineralisation, orebodies in the Marra Mamba Iron and Wittenoom Formations can also have good aquifer potential.

3.4. Local Hydrostratigraphy

The predominant aquifer units hosting groundwater resources at West Angelas comprise, from oldest to youngest (Figure 6-5):

- Marra Mamba Formation: MacLeod and Mount Newman Members
- Wittenoom Formation: West Angela Member
- Detritals: alluvium and colluvium
- Calcrete: this usually sits near the base of the Detrital aquifer.

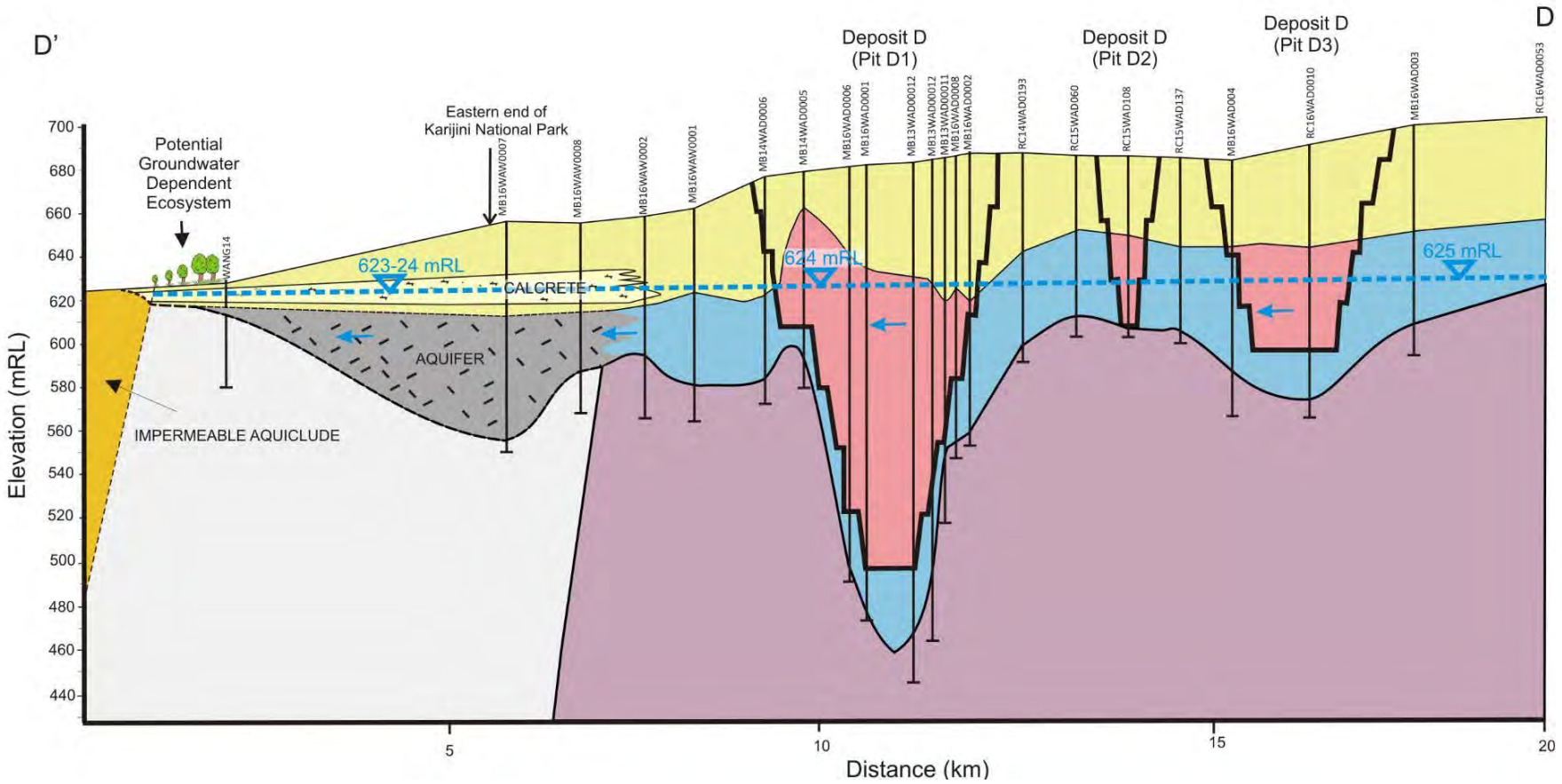
Figure 6-6 and Figure 6-7 show the extents of the Detrital and Calcrete aquifer units as obtained from RTIO's Leapfrog model of the study area. A large proportion of groundwater flow is thought to occur via the weathered upper portion of the Wittenoom Formation (R. Milton, pers. Comm, 12th Nov 2019). There is sparse data available to construct a regional-scale map of the thickness / lower boundary of the weathered Wittenoom Formation. Consequently, RTIO have developed such a map using the data available and the assumption that deeper weathering occurs beneath existing drainage lines (R. Milton, pers. comm. 20th April 2020) (Figure 6-8).

3.5. Groundwater Levels and Flow

The main aquifers that transmit groundwater in the study area comprise the mineralized zones of the Marra Mamba and Wittenoom Formations, the weathered upper portion of the Wittenoom Formation, and the Detritals/ Calcrete where these are saturated. Groundwater flows from east to west (Figure 6-9) and the groundwater system is conceptualized as being closed, with the southern and northern margins of the valleys formed by unmineralized Marra Mamba Formation and impermeable members of the Fortescue Group. In the east, northeast-southwest trending impermeable structures, thought to be dykes, form barriers to groundwater flow (Figure 6-6 to Figure 6-8) and Mount McRae Shale and Mount Sylvia Formation form an aquiclude to the west (Figure 6-5). The only inflow to the study area is therefore via rainfall recharge. Groundwater discharge is conceptualized to occur via evapotranspiration from shallow water tables at the potential GDE (Figure 6-5).

Some of the monitoring bores shown in Figure 6-10 were installed in 2013 and 2014, although the majority were installed between 2016 to 2019. Bore hydrographs have been provided and discussed by IGS (2020a). A summary is provided here. At bore WANG14, in Karijini National Park, there has been a gradual rise in groundwater levels over the period of record between 2012 and 2019. This is thought to be due to the occurrence of a period of below average rainfall between 1980 and 1995, followed by a period of above average rainfall since 1995 (Figure 6-3a). A rapid rise in groundwater levels of approximately 1.1 m occurred in early 2017, after which groundwater levels quickly receded. This rise is also observed in bores MB16WAW005 and MB16WAW007, located just east of the Park boundary. Here, the water table is in the Calcrete at a depth of approximately 19 m (MB16WAW0005) and 32 m (MB16WAW0007).

Between Deposits C and D and Karijini National Park (i.e. in the area of the proposed Stage 1 MAR scheme), the water table is in the Calcrete at a depth of 25 to 30 m (MB16WAW0006, MB16WAW0008), the Detritals (e.g. MB16WAW0002, MB16WAW0011) or top of the Mount Newman member (e.g. MB16WAW0001, MB16WAW0010). A rise in groundwater levels of approximately 20 to 30 cm occurred between 2016 and 2019, consistent with the long-term rise observed at WANG14 inside Karijini National Park. Seasonal responses to recharge of up to 25 cm are also observed in the area between Deposits C and D. A gentle rise in groundwater levels of between 20 and 30 cm also occurred in the Deposit C area, where depths to groundwater are around 55 m between 2015 and 2019.


D'
D
Deposit D (Pit D1)
Deposit D (Pit D2)
Deposit D (Pit D3)
Eastern end of Karijini National Park
Potential Groundwater Dependent Ecosystem
WANG14
MB16WAW0007
MB16WAW0008
MB16WAW0002
MB16WAW0001
MB14WAD0006
MB14WAD0005
MB16WAD0006
MB16WAD0001
MB13WAD00012
MB13WAD00012
MB13WAD00011
MB16WAD0008
MB16WAD0002
RC14WAD0193
RC15WAD060
RC15WAD108
RC15WAD137
MB16WAD004
RC16WAD0010
MB16WAD003
RC16WAD0053
623-24 mRL
624 mRL
625 mRL
CALCRETE
AQUIFER
IMPERMEABLE AQUICLUDE
Elevation (mRL)
700
680
660
640
620
600
580
560
540
520
500
480
460
440
5
10
15
20
Distance (km)

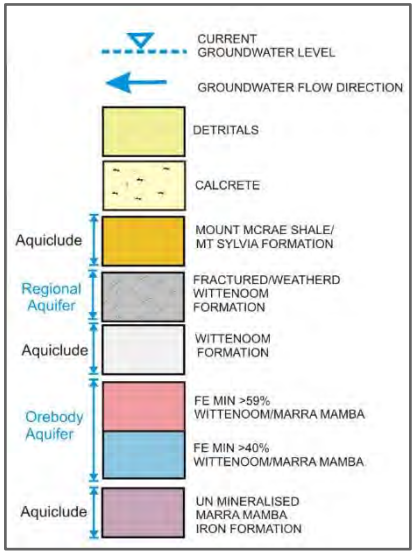
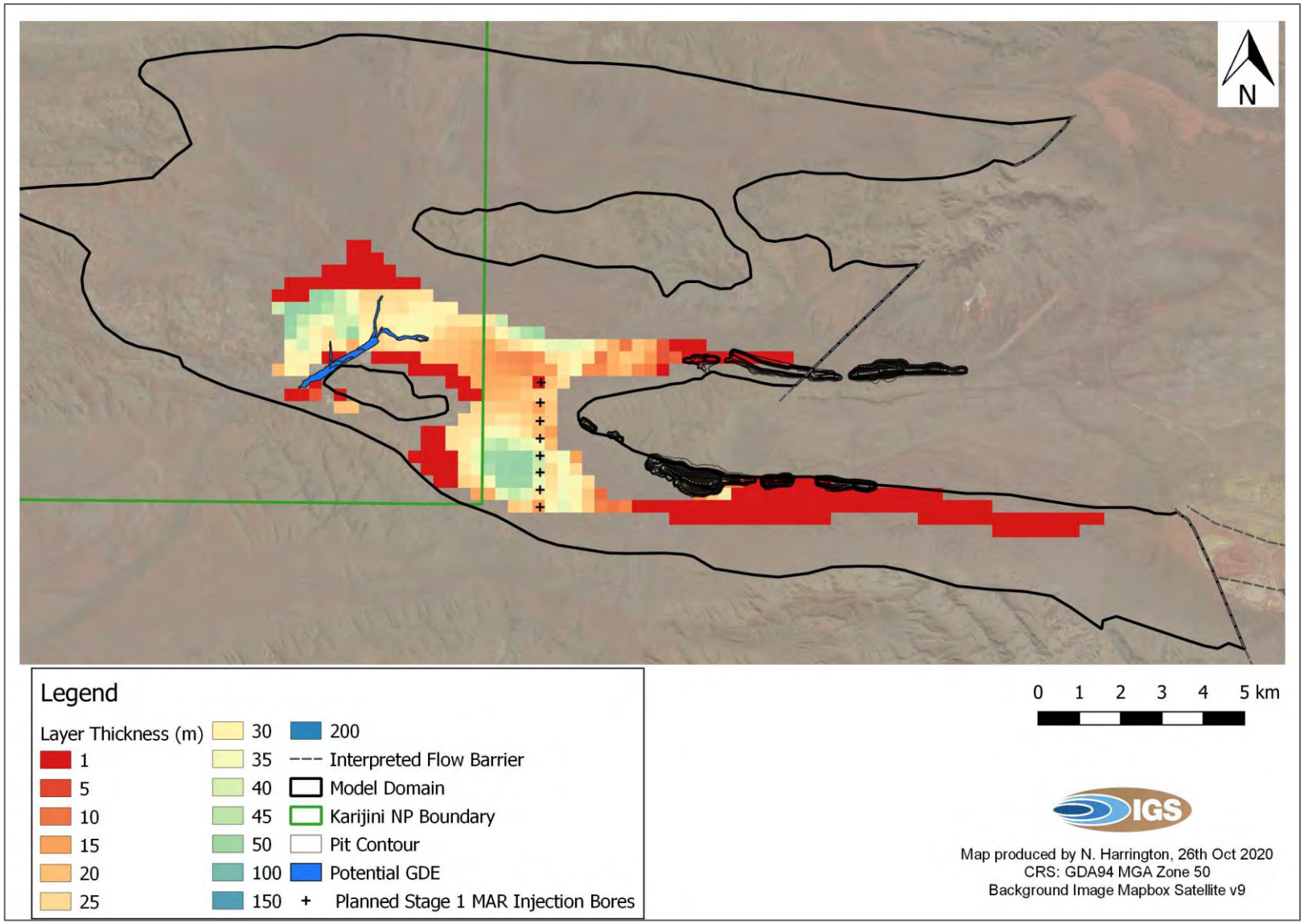


Figure 6-5. East-west hydrogeological cross section through Deposit D (RTIO).


N
Legend
Layer Thickness (m)
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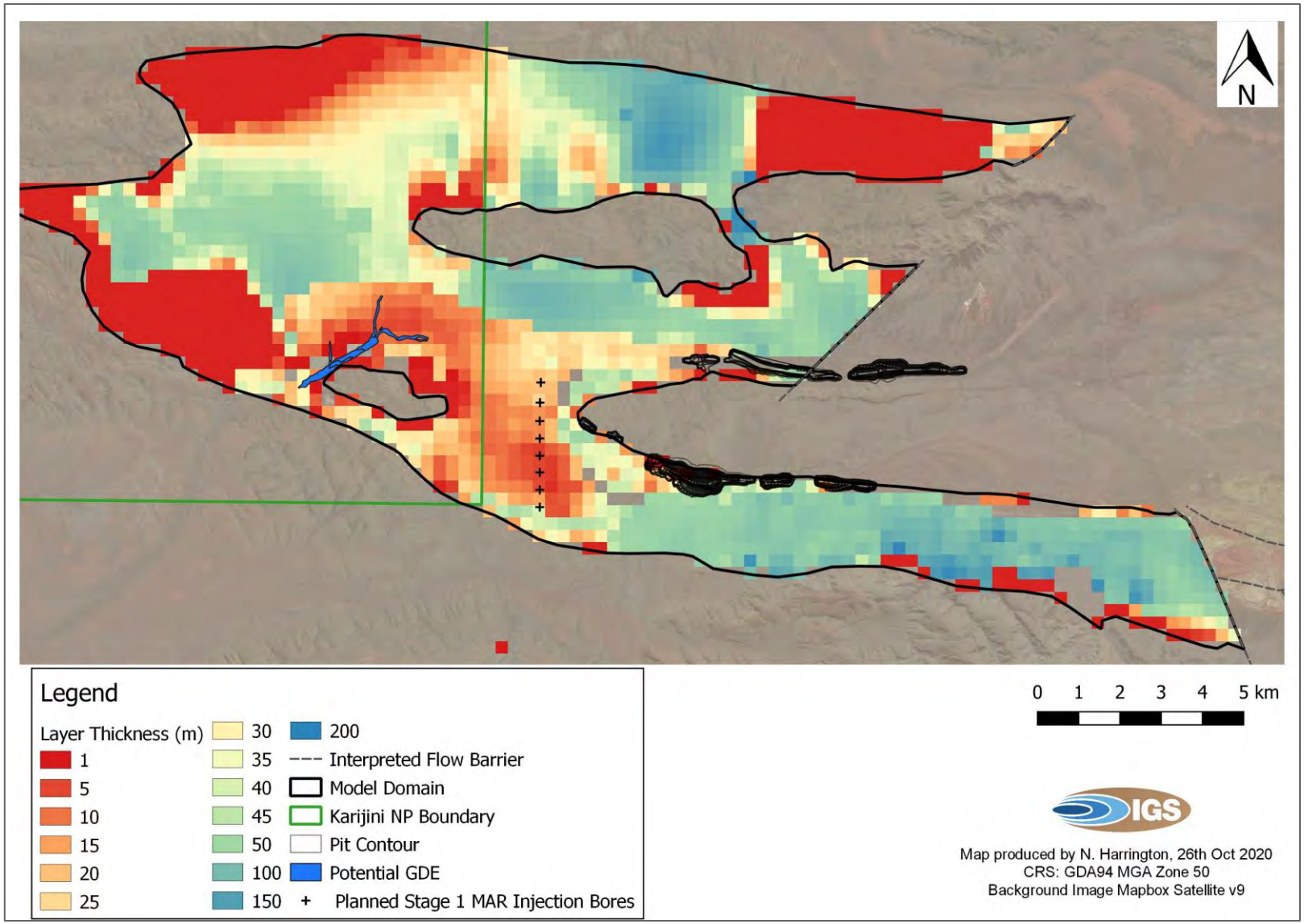
20
25
30
35
40
45
50
100
150
200
Interpreted Flow Barrier
Model Domain
Karijini NP Boundary
Pit Contour
Potential GDE
Planned Stage 1 MAR Injection Bores
0 1 2 3 4 5 km
IGS
Map produced by N. Harrington, 26th Oct 2020
CRS: GDA94 MGA Zone 50
Background Image Mapbox Satellite v9

Figure 6-6. Extent and thickness of the Calcrete Aquifer unit at West Angelas as obtained from RTIO's Leapfrog model.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Legend
Layer Thickness (m)
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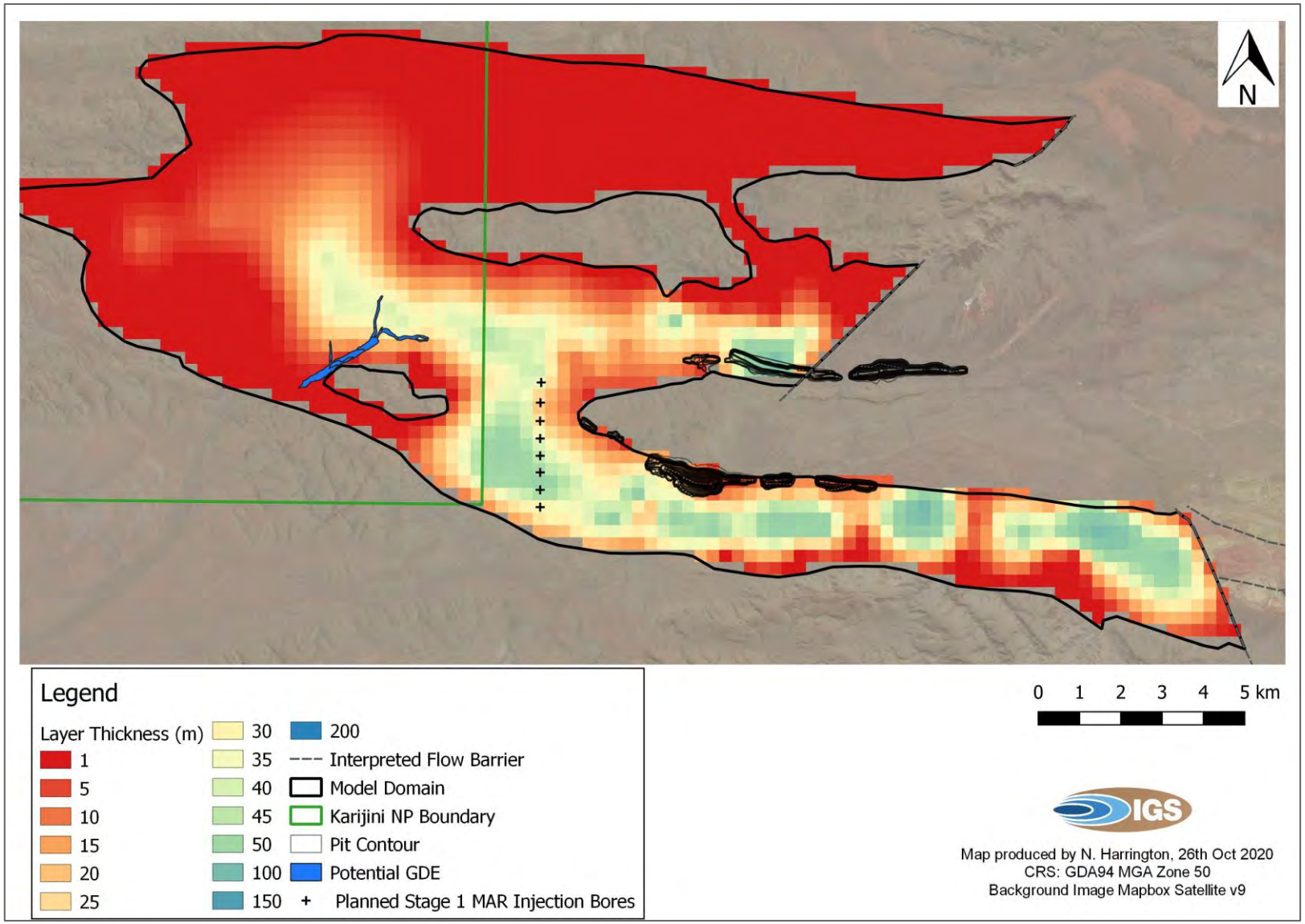
50
100
150
200
Interpreted Flow Barrier
Model Domain
Karijini NP Boundary
Pit Contour
Potential GDE
Planned Stage 1 MAR Injection Bores
0 1 2 3 4 5 km
IGS
Map produced by N. Harrington, 26th Oct 2020
CRS: GDA94 MGA Zone 50
Background Image Mapbox Satellite v9

Figure 6-7. Extent and thickness of the Detrital Aquifer Unit at West Angelas as obtained from RTIO's Leapfrog model.


N
Legend
Layer Thickness (m)
1
5
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200
Interpreted Flow Barrier
Model Domain
Karijini NP Boundary
Pit Contour
Potential GDE
Planned Stage 1 MAR Injection Bores
0 1 2 3 4 5 km
IGS
Map produced by N. Harrington, 26th Oct 2020
CRS: GDA94 MGA Zone 50
Background Image Mapbox Satellite v9

Figure 6-8. Thickness of weathered Wittenoom Formation used in the development of the regional groundwater flow model.

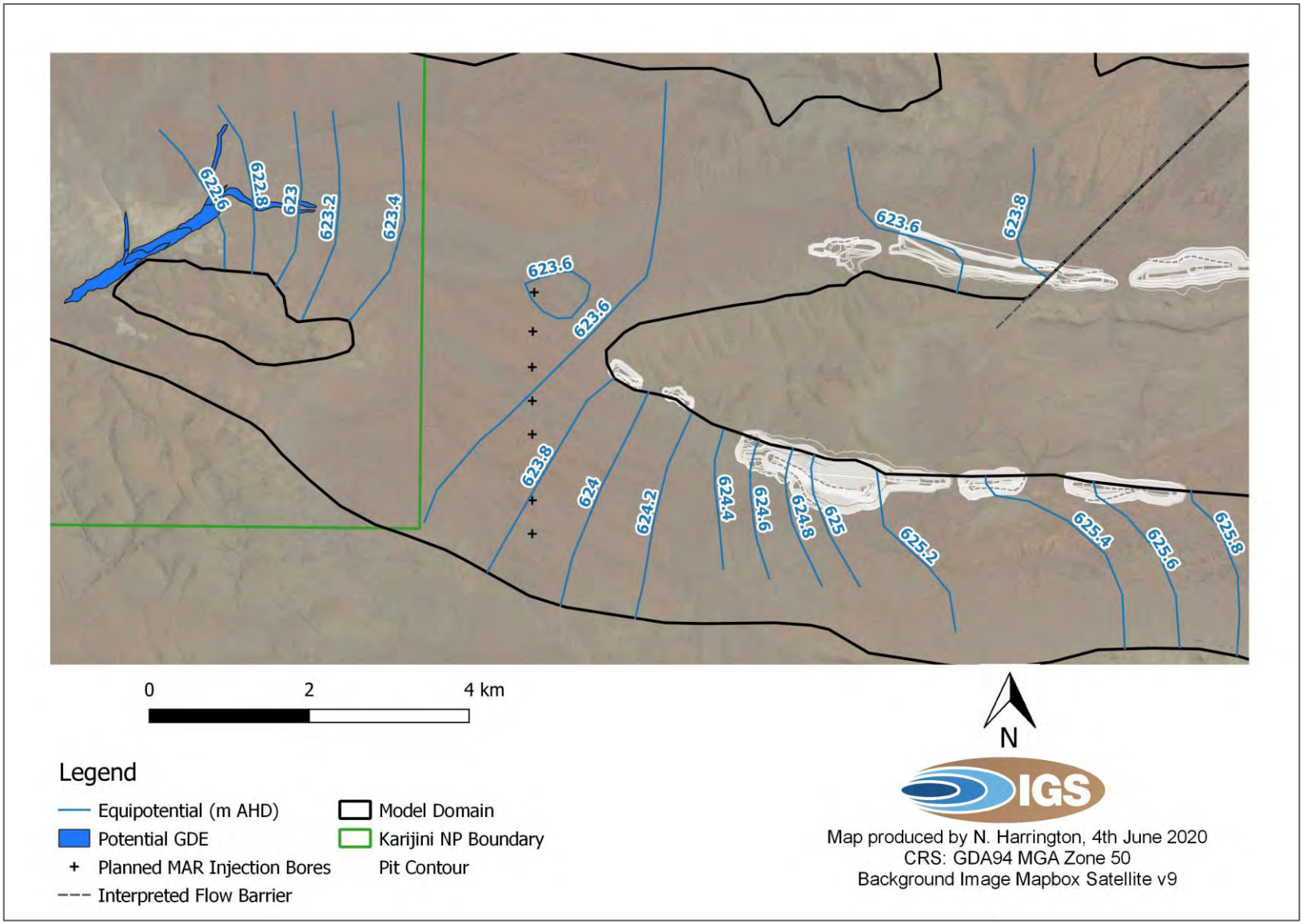
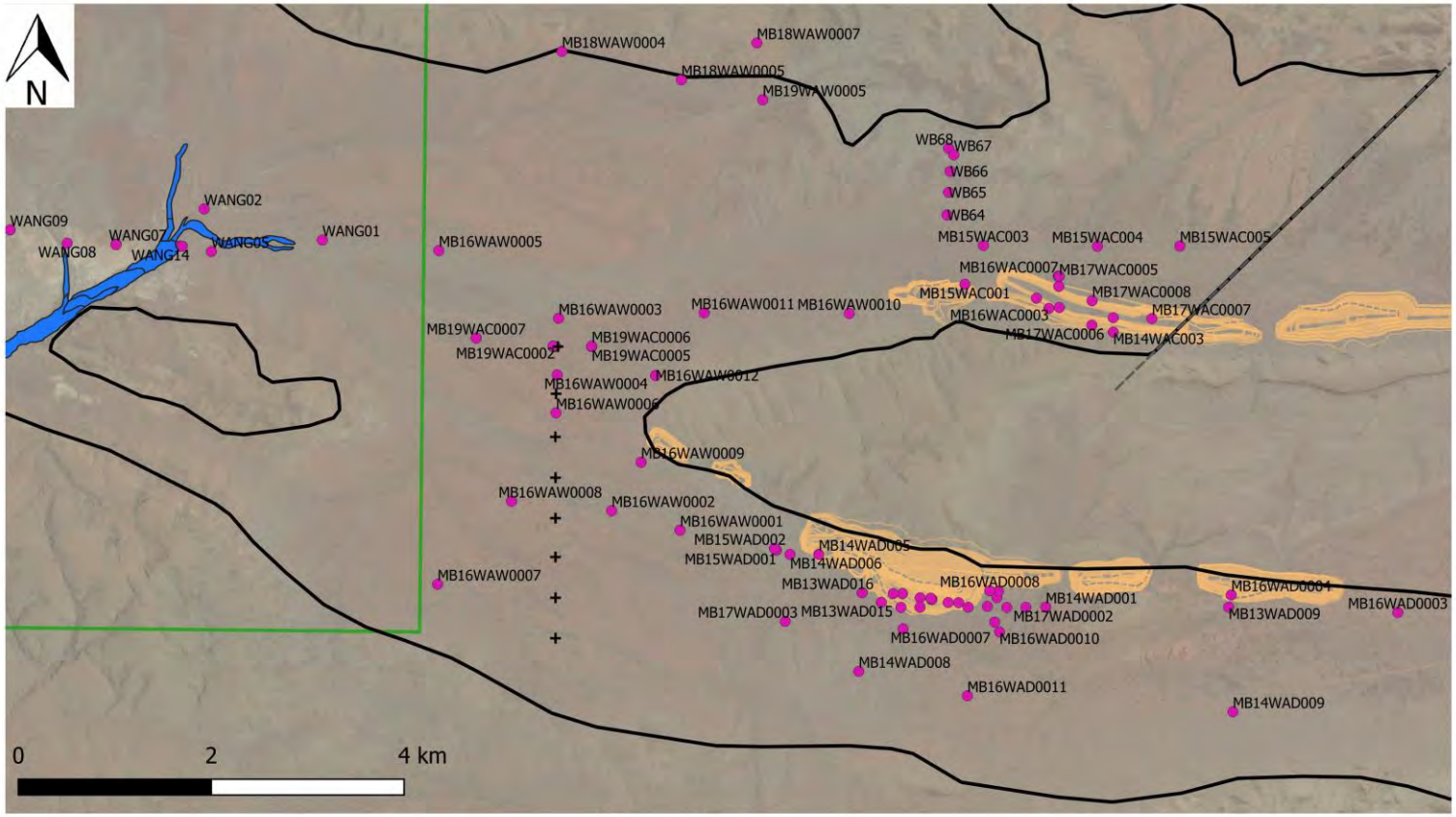

622.6
622.8
623
623.2
623.4
623.6
623.6
623.6
623.8
623.8
624
624.2
624.4
624.6
624.8
625
625.2
625.4
625.6
625.8
0
2
4 km
N
Legend
Equipotential (m AHD)
Potential GDE
Planned MAR Injection Bores
Interpreted Flow Barrier
Model Domain
Karijini NP Boundary
Pit Contour
IGS
Map produced by N. Harrington, 4th June 2020
CRS: GDA94 MGA Zone 50
Background Image Mapbox Satellite v9

Figure 6-9. Pre-mining steady state potentiometric surface developed using average pre-mining heads for each observation bore (locations shown in Figure 6-10).



Legend

- Potential GDE
- Planned MAR Injection Bores
- Interpreted Flow Barrier
- Model Domain
- Karijini NP Boundary
- Pit Contour

Bores

- Monitoring Bores

Map produced by N. Harrington, 20th November 2020
CRS: GDA94 MGA Zone 50
Background Image Mapbox Satellite v9

Figure 6-10. West Angelas monitoring bore locations.

A review of measured hydraulic gradients between monitoring bores MB16WAW0001 and MB16WAW0007 (Figure 6-11) shows that, most of the time, the hydraulic gradient is towards Karijini National Park (to the west). Occasionally the hydraulic gradient reverses, presumably due to recharge associated with the watercourse connected to the potential GDE located in Karijini National Park (see further discussion in Section 3.7).

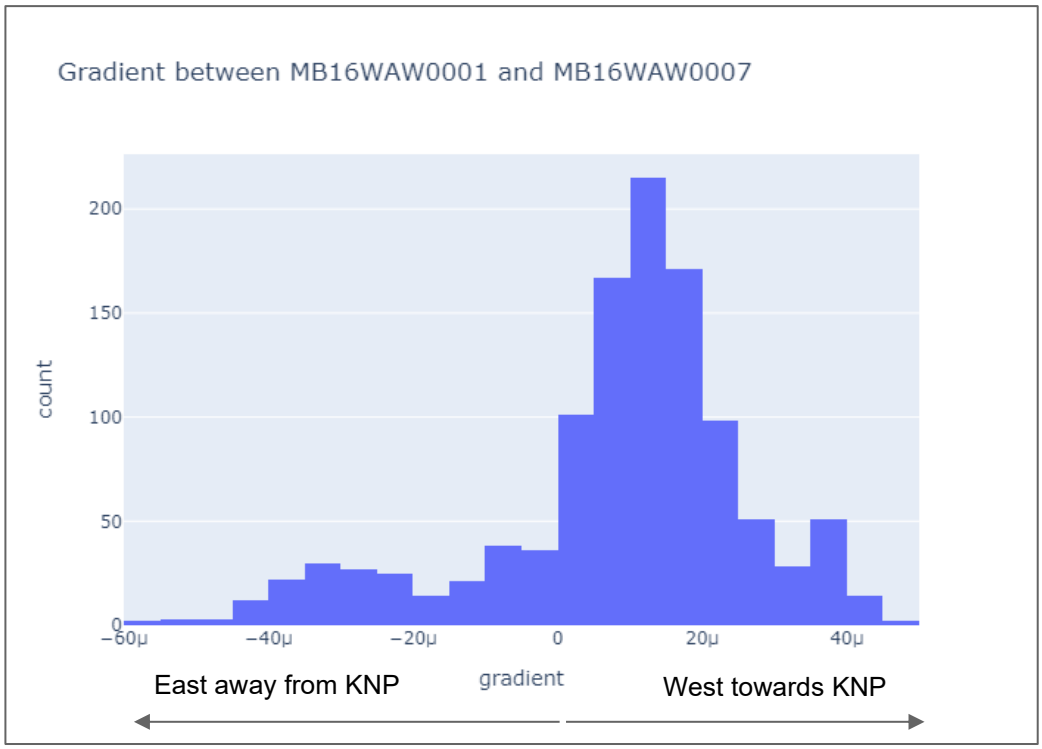


Figure 6-11. Histogram of observed hydraulic gradients between monitoring bores MB16WAW0001 and MB16WAW0007 for each time where there were head measurements available for both bores.

3.6. AQUIFER PROPERTIES

There is a paucity of field data available for aquifer properties across the West Angelas site (Table 3). Most of this data is concentrated around Deposits C and D and half of it relates to boreholes screened across multiple aquifers. The ranges shown in Table 3 indicate significant heterogeneity across individual units. Table 4 provides a broad comparison between aquifer property values obtained in Stage 1 through calibration of an Analytic Element Model (AEM) of the MAR Injection Trial (IGS, 2020b), the outcomes of the steady state regional flow model calibration (Section 4.2) and the available field data, noting again that much of the field data relates to bores screened across multiple aquifers.

Table 3. Existing field data on aquifer properties.

Aquifer	K (m/d)	S (-)	n
Detritals	26	0.02	1
Calcrete/Wittenoom	0.5	0.15	1
Wittenoom	0.3 to 5.1	0.001 to 0.005	3
Wittenoom / Mt Newman	0.7 to 3.5	0.0006 to 0.02	4
Mt Newman	0.75 to 9.5	0.0008 to 0.003	2

Detritals / Wittenoom / Mt Newman	0.9	0.003	1

Table 4. Comparison of aquifer parameter values determined through transient calibration of the AEM model using different methods, steady-state calibration of the initial (Stage 1) zoned regional groundwater flow model (IGS, 2020b), available field data and the values adopted as a starting position for pilot points in the updated (Stage 2) regional model.

	Field Data*	AEM Model	Regional Model Initial (Stage 1) Calibration		
	(see Table 3)	(various calibration methods)	Zones - Variable Weights	Zones - Tikhonov	Adopted Pilot Point Start Value
Single Layer Domain					
K_H (m/d)	-	19.6 – 39.0	-	-	-
K_V (m/d)	-	18.0 - 20.0	-	-	-
Sy (-)	-	0.15	-	-	-
Detritals	n=1				
K_H m/d	26		4.1	3.0	4.1
K_V m/d	-		8.6	1.5	8.6
Sy (-)	0.02		-	-	0.02
Above WT Calcrete					
K_H (m/d)	-	21.3 - 44.1	-	-	-
K_V (m/d)	-	40.0 - 44.1	-	-	-
Sy (-)	-	0.10 – 0.24	-	-	-
Below WT Calcrete	n=1				
K_H (m/d)	0.5?	100 – 134.1	9.4	18.6	9.4
K_V (m/d)	-	7.8 - 100	0.53	5.9	0.53
Sy (-)	0.15?	0.05 - 0.13	-		0.13
Weathered Wittenoom	n=7				
K_H (m/d)	0.3 to 5.1?	5.0 – 11.2	2.7	1.1	2.7
K_V (m/d)	-	4.7 – 15.0	5.3	1.5	5.3
Sy (-)	0.0006 to 0.02?	0.14 - 0.17	-		0.14

	Field Data (see Table 3)	AEM Model	Regional Model Zones – Variable Weights	Regional Model Zones – Tikhonov	Adopted Pilot Point Start Value
Unweathered Wittenoom	n=7				
K_H (m/d)	0.3 to 5.1?	-	0.17	0.17	0.17
K_V (m/d)	-	-	0.82	4.7	0.82
Sy (-)	0.0006 to 0.02?				0.02
Newman & McLeod	n=2				
K_H (m/d)	0.75 to 9.5		0.12	0.14	2.7
K_V (m/d)	-		0.30	1.5	5.3
Sy (-)	0.0008 to 0.003				0.01
Fortescue					
K_H (m/d)	-	-	100.0	0.01	0.01
K_V (m/d)	-	-	2.9	0.05	0.05
Sy (-)	-	-	-	-	0.01

*Question marks indicate that data relates to a bore screened over multiple hydrostratigraphic units or may not be relevant to the weathered or unweathered portion of the aquifer (see Table 3).

3.7. Recharge and Evapotranspiration

Both rainfall recharge and evapotranspiration are thought to be minor across the majority of the study area due to large depths to groundwater (> 20 m). This is supported by hydrographs of bores in and to the east of the Deposit D area, which show relatively constant groundwater levels over time prior to the commencement of groundwater pumping to the east of Deposit D in March 2016. As a consequence of this, a previous model of the West Angelas site implemented a low diffuse recharge rate of 0.5 mm/yr. across the study area (RTIO, 2017).

Preferential rainfall recharge can occur locally via surface drainage features during and immediately following periods of intense rainfall. Attempts were made to calibrate a variety of recharge models at locations in West Angelas that demonstrated macropore flow events following intense rainfall, evidenced as step increases in the hydrographs. This included a Berendrecht model (Berendrecht, 2006), a Flexmodel (Collenteur, in review) and PEST's new LUMPREM model (Doherty, 2020b). All were unsuccessful due to the inconsistencies between the hydrograph responses and rainfall and potential evaporation records.

A review of aerial photography and maps of major surface water features indicates that surface runoff in the study area is towards the potential GDE inside Karijini National Park, where water tables are less than 5 m deep. This is therefore likely to result in significant seasonal recharge in the vicinity of the National Park boundary and potential GDE. Seasonal variations in groundwater level within and to the east of the Karijini National Park boundary are evidence of this process (see Section 3.5). Occasional reversal of the normally western regional hydraulic gradient provides further evidence of significant recharge occurring periodically in the vicinity of the Karijini National Park (Section 3.5).

3.8. Managed Aquifer Recharge

Dewatering of Pits C and D is expected to cause drawdown extending to the Karijini National Park boundary. RTIO plan to mitigate this impact via operation of a Managed Aquifer Recharge (MAR) scheme between the deposits and the National Park. Stage 1 of the MAR scheme, which is designed to mitigate impacts from dewatering of Deposit D only, is the focus of the modelling described in this report. The planned configuration of the Stage 1 MAR injection bores is shown in Figure 6-10. It is expected that each injection bore will be screened across the Detritals, Calcrete and weathered Wittenoom Formation and will have an associated network of monitoring bores and Vibrating Wire Piezometers (VWPs). An injection trial was carried out on the northern bore (WB19WAC0001) between 20th February 2020 and 23rd March 2020. An overview of the injection trial and its outcomes are provided in IGS (2020b).

4. Regional Groundwater Flow Model Design and Calibration

4.1.1. Modelling Platform, Domain and Grid

The regional groundwater flow model is constructed in MODFLOW-USG (Panday et al., 2013) and adopts a Voronoi polygon grid (Figure 6-12). The domain boundary was provided by RTIO and comprises the valley area bounded by the Fortescue Group and the Brockman Iron Formation of the Hammersley Group. Development of the grid and initial simulation testing was performed in Algomesh (HydroAlgorithmics, 2016). Refinements were made to the grid in locations where stresses were likely to be implemented including injection and extraction wells, dewatered mine pits and the groundwater dependent ecosystem. The grid between the MAR injection bores and the Karijini National Park (KNP) boundary was also refined to facilitate better spatial and temporal resolution of drawdown impacts. Additionally, provision was made for the inclusion of dykes in a refined zone diagonally across the model, although these are not implemented in the present version of the model. The model was transferred to Groundwater Vistas (ESI, 2017) where further testing and refinements were made specific to optimising convergence and solution speed.

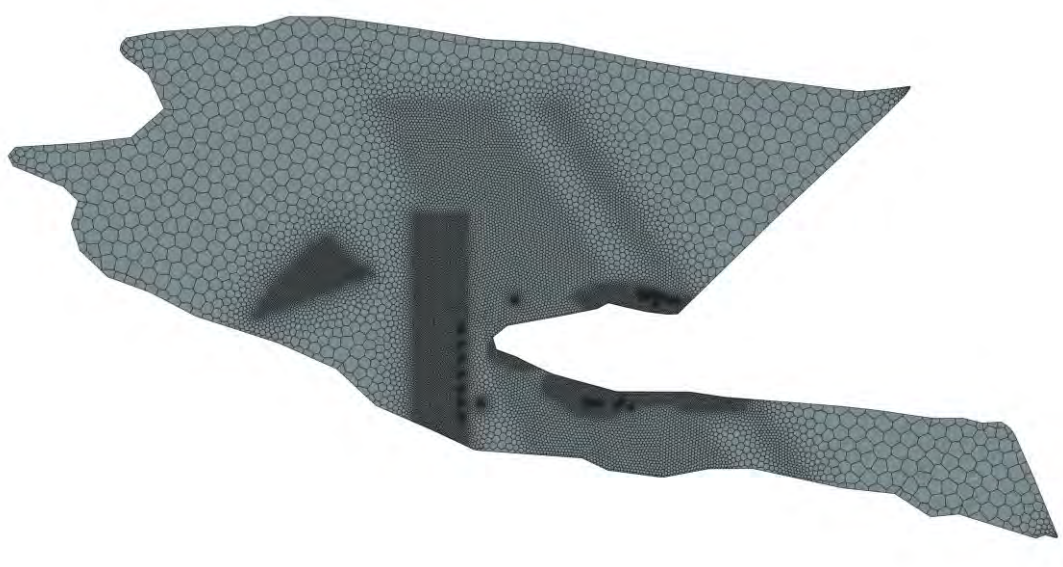


Figure 6-12 The grid developed for the West Angeles regional groundwater flow model

Initial model development included explicit representation of geological units from surfaces and thicknesses provided by RTIO's geological Leapfrog model of the area. According to the geological model, several units 'pinch out' within the model domain. However, incorporation of layer 'pinch outs' and lateral flow connections between pinched layers increased model run times and general instability. A continuous layered model was therefore developed, with zoned regions to represent the geological units.

The model comprises five layers, with many of the geological formations and their associated property zones spanning several layers. Accurate representation of the upper surface is not essential because there are no fluxes in the domain that are affected by surface elevation. The layer sequence follows

the uppermost major aquifer units and those expected to be impacted by future mine pit dewatering. Numbered according to layer, these are:

1. Detritals
2. Calcrete
3. Weathered Wittenoom Formation
4. Unweathered Wittenoom Formation
5. Combination of the Mt Newman and MacLeod Formations

The base of the model is defined by the upper surface of the Fortescue Group. However, a unit comprising a combination of upper Fortescue and the Nammuldi member of the Marra Mamba Iron formation was included as a zone that intersects all model layers. This inclusion simplified the model grid development process by keeping the same number of active nodes in each layer, which aids in simplifying scripted post processing. Surface elevations and lateral extents for geological units were obtained from RTIO and translated for input to the model via Golden Software's Surfer application.

4.1.2. Model Boundaries

The external model boundaries are all designated as no-flow. There are internal regions that are also implemented as inactive cells and these are projected through all model layers (Figure 6-13). Drain-type boundary conditions are used to represent the potential GDE located in Karijini National Park, which is conceptualized as the only discharge point in the system (Section 3.5). The elevation of the potential GDE is set at four metres below the surface elevation and its conductance is a calibrated model parameter. There are no permanent surface water features in the region and therefore these did not require representation in the model.

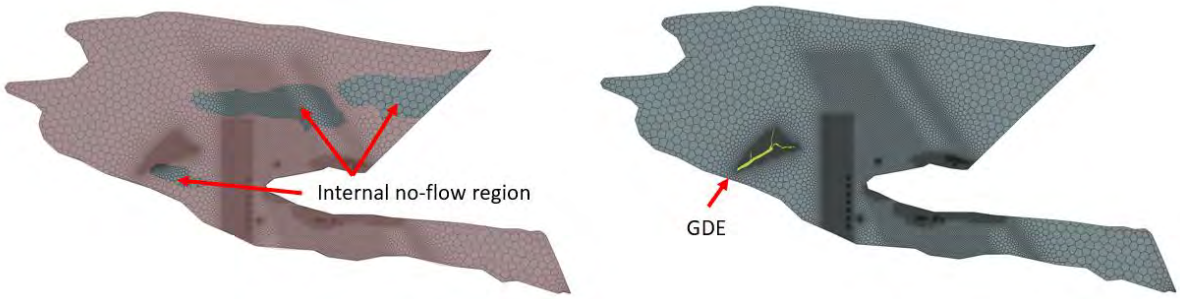


Figure 6-13 No-flow and potential GDE locations in the model domain

4.1.3. Recharge and Evapotranspiration

A spatially and temporally uniform recharge rate of 0.5 mm/yr. is applied to the model upper surface, representing the only source of water in the domain. This is considered to be a conservative value for recharge and the model does not account for episodic and spatially variable (preferential) recharge along surface drainage features. There is no data available on such recharge processes in the study area and therefore inclusion of spatially and temporally variable recharge would not add any additional confidence to model results (see Section 3.7 for details on assessment). Evapotranspiration is not implemented in the model due to large depths to groundwater across the majority of the model domain (Section 3.5). The major contributor to evapotranspiration is the potential GDE located in Karijini National Park, which is implemented as a drain (Section 4.1.2).

4.1.4. Aquifer Properties

The zones representing formations in each layer of the model are shown in Figure 6-14. These zones are assigned hydraulic properties based on values presented in Table 3 and Table 4. These include model- and field-derived values, as well as literature values where limited data is available. The results of the AEM analysis (IGS, 2020b) were used to inform the likely bounds on parameters during calibration and the subsequent MAR optimisation (Section 5). The aquifer properties assigned in the model are:

1. Horizontal hydraulic conductivity
2. Vertical hydraulic conductivity
3. Storage coefficient
4. Specific yield

There is no evidence of confining units or confined aquifer behaviour in the region. Consequently, specific yield estimates were used for the storage coefficient thereby ensuring unconfined storage behaviour irrespective of model cell confined/unconfined status. The weathered Wittenoom Formation did not feature in the geological model explicitly and was inferred from drill hole logs (R. Milton, pers. comm. 20th April 2020). The extent of this unit is mostly hypothesized in the northern parts model domain where it is relatively thin.

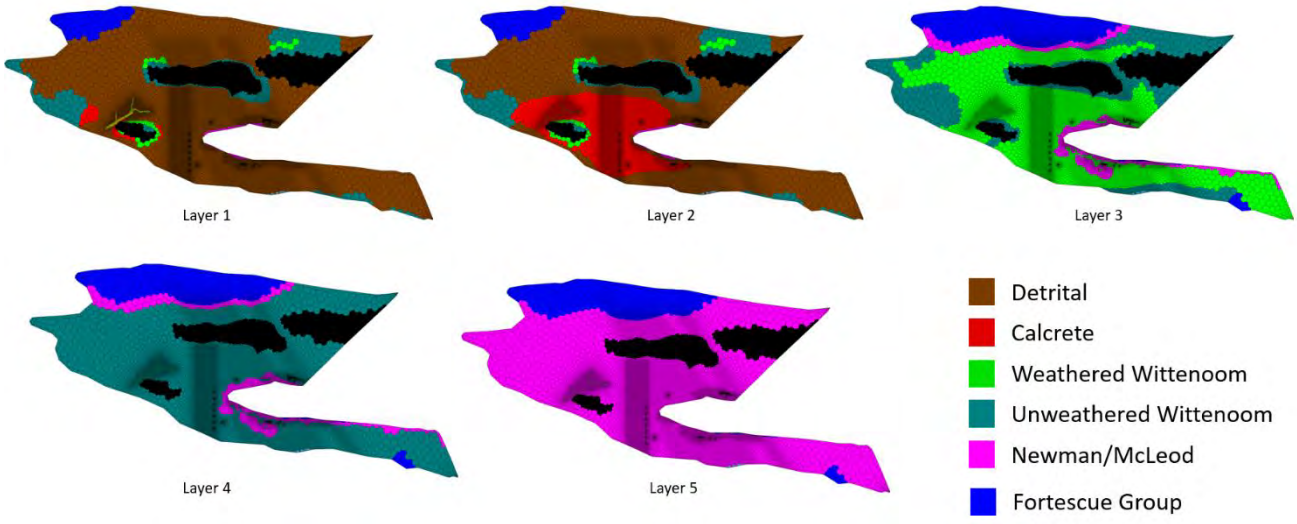


Figure 6-14. Zones representing formations in the regional groundwater flow model. Black zones represent inactive cells.

4.2. Steady-State Calibration

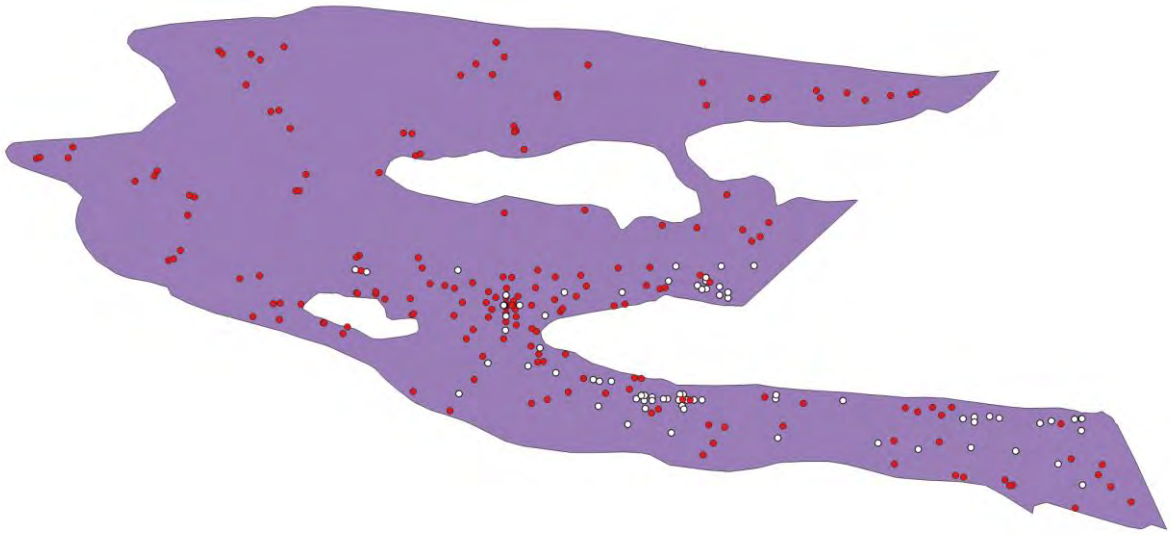
4.2.1. Calibration Methodology

Stage 1 of the model development utilized a combination of analytical element modelling (AEM) and a MF-USG model with zones based on known extents of geological formations. Steady-state hydraulic head values for monitoring locations in the region were provided by RTIO and used as observations for conditioning hydraulic properties of the model. The horizontal and vertical hydraulic conductivities for each zone and the potential GDE conductance were estimated using PEST (Doherty, 2020a) in estimation mode with the steady-state model. The initial approach used unit observation weighting

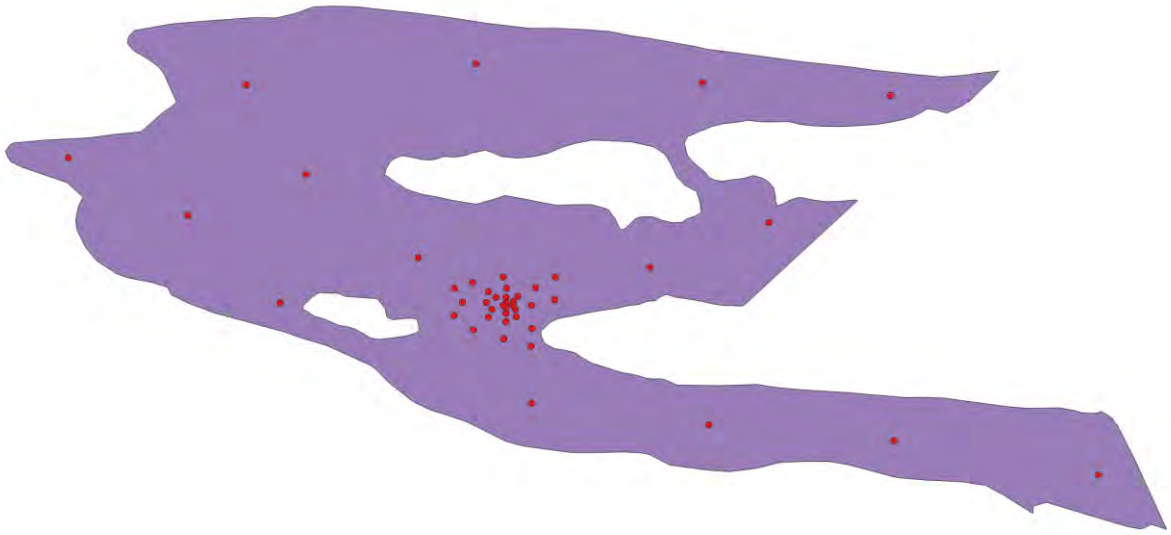
and parameter bounds spanning three orders of magnitude. Overall, a favourable match was produced. However, there remained several observations located in between the KNP, MAR site and future mine pits that demonstrated an unacceptable level of model to measurement misfit. Recognising that significant heterogeneity is likely across all units simulated, and that the use of single zones for all units is restrictive in allowing the calibration to arrive at representative aquifer parameters, the calibration strategy was focused on the key area of interest for the current model, between the pits, MAR scheme and KNP boundary. A weighting strategy was devised that sought to improve the match in this region. Observations pertinent to drawdown at the KNP boundary were grouped separately from the rest thereby facilitating a multicomponent objective function. Contributions of each group were then balanced before a four times multiplier was used on the group considered most influential to hydraulic behaviour between the KNP boundary and the MAR site.

Despite improvements to the calibration, eigenvalues reported in PEST output files indicated insensitivity in at least two directions of parameter space. The primary contributors were identified as the hydraulic conductivities for the combined Nammuldi/Fortescue Group zone. This prompted re-calibration using both Singular Value Decomposition and preferred value Tikhonov regularization for each zone based on field derived values (see Table 4).

In stage 2, further improvements to the steady-state model calibration were then obtained with a sparse irregular distribution of pilot points in each zone. Pilot points were located approximately midway between observations and then towards the outer edges of each zone (Figure 6-15). The initial values were set equivalent to the adopted zone values informed by the steady- state calibration of the regional model in Stage 1 (Table 4) and bounds within +/- one order of magnitude. Preferred value Tikhonov regularisation was used with weighting according to pilot point spatial distribution via 3D covariance matrices specific to the geological formations. The covariance matrices were developed using the *ppcov3d_sva* utility in PEST's groundwater utilities suite. Hydraulic conductivity fields were kriged using a combination of PLPROC's *calc_kriging_factors_auto_2D* and *krige_using_file* (Doherty, 2020d) functions with enforcement of maximum and minimum values. Zone boundaries were maintained throughout, that is, kriging across a zone boundary was prohibited during the estimation process. The best target measurement objective function was sought initially using a low value for PHIMLIM, which behaves as a user prescribed "level of fit" setting in the PEST control file. A very low value of PHIMLIM generally leads to over-fitting and amplification of measurement noise. The parameter estimation process was then repeated with PHIMLIM set at a value 10% greater than the previous minimum to reduce the propensity for fitting structural noise. This is the recommended strategy in the PEST manual to avoid overfitting when using pilot points.



(a)



(b)

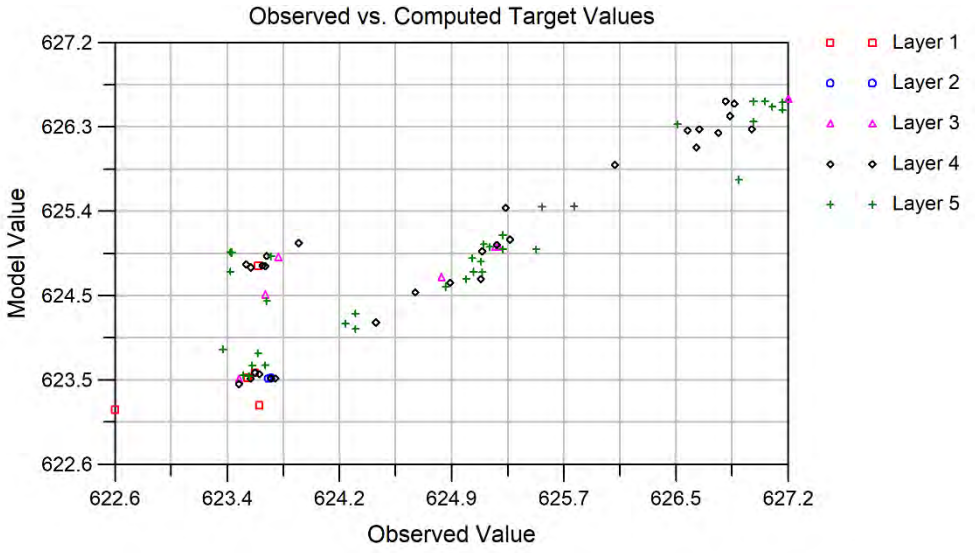
Figure 6-15. Pilot point distributions used in the regional groundwater flow model for (a) steady state calibration and (b) transient calibration to the MAR trial data. Red dots = pilot points (applied with same distribution in all model layers) and white dots = locations of steady state head data for all model layers.

4.2.2. Results

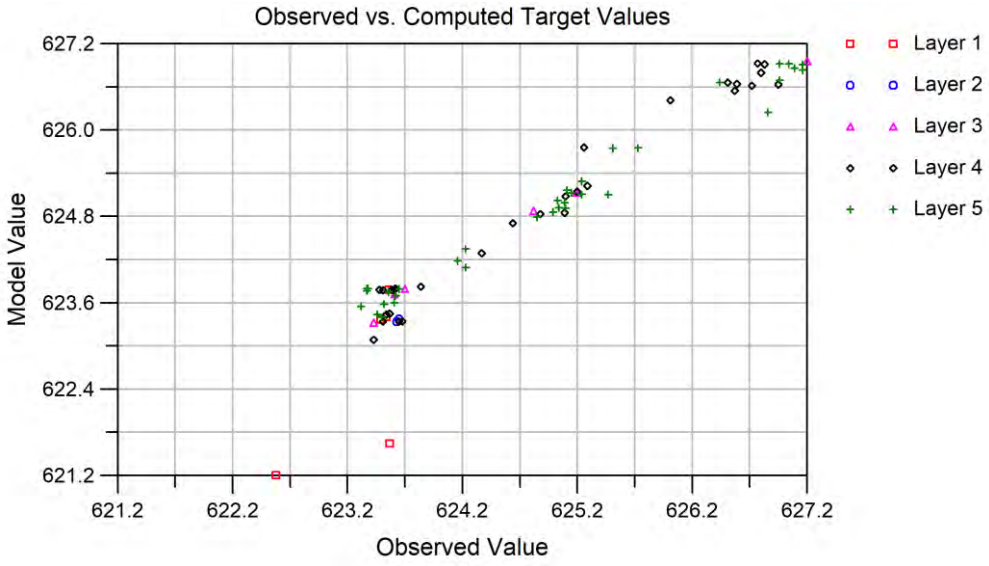
The parameter set results of the different zoned steady-state model calibration approaches carried out in Stage 1 are shown in Table 4. The adopted parameter set includes those parameters observed in all calibration attempts, including the AEM model, that are best aligned with field-tested values and most likely to be representative at the sub-regional to regional scale. Of note, vertical and horizontal hydraulic conductivity values for each unit are similar despite being calibrated as independent parameters. This is not a surprising result, given the relatively shallow gradient in the area, the small volume of recharge and that all aquifers are considered unconfined. The zone representing the

combined Nammuldi/ Fortescue Group was identified as insensitive during the parameter estimation process and was subsequently removed from further calibration with parameters fixed at the values presented in Table 4.

Figure 6-16(a) depicts the model to measurement misfit when using the best zoned parameter set. An SRMS error of 13% results from the 78 steady-state observations, which was considered acceptable given an associated RMSE of 0.6 m. The maximum and minimum residuals were 1.16 m and -1.56 m respectively.



(a)



(b)

Figure 6-16. Modelled heads (m) versus observed heads for the model using (a) the best zoned parameter set and (b) sparse pilot points.

The results of the steady state calibration with pilot points, using the preferred zone parameters as initial values, are presented in Figure 6-16(b). For this method, most of the domain has calibrated hydraulic conductivities between 0.1 and 1.0 m/d, with the exception of the calcrete and the Mt Newman/ Macleod Formations (Figure 6-17). An improved SRMS error of 7.3% was obtained. Two observations with the largest residuals in Layer 1 are located within the KNP near the potential GDE. The mismatch is considered acceptable given their distance from the area of interest. The spatial distribution of residuals is presented in Figure 6-18.

The raised hydraulic conductivity estimated for the Mt Newman/Macleod Formations in Layer 5 is explained by the over predictions of steady state heads observed in the zoned model (Figure 6-16a) which were translated to preferred values for the pilot points. Mineralization altering the formation properties could also be responsible for the estimated shift in conductivity but there is insufficient evidence to support this over a large area. Consequently, a review of the conceptual model and model design for the area around Deposit C is recommended prior to any simulation of drawdown or dewatering from this region.

The interpolated fields show some kriging artefacts in Layer 5 attributed to the sparse pilot point distribution, however this is unlikely to influence the results of the MAR simulations as these will primarily affect Layers 1, 2 and 3 that host the water table. Moreover, the resultant hydraulic conductivity fields presented below provide a suitable starting point for subsequent modelling experiments that will also account for, amongst other things, predictive uncertainty associated with uncertainty in aquifer parameters.

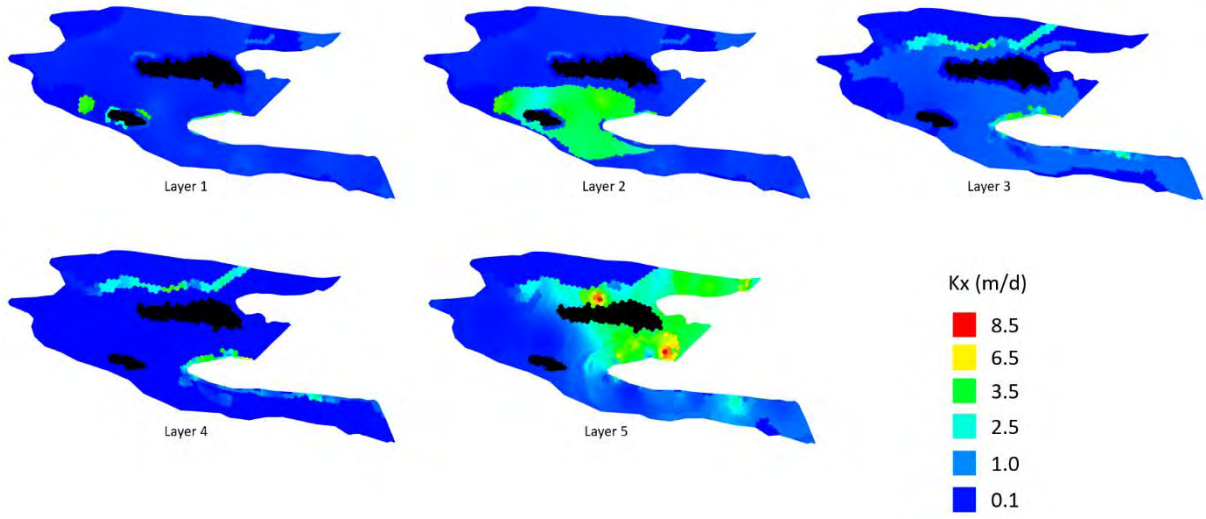


Figure 6-17 Steady-state calibrated horizontal conductivity fields derived using a sparse pilot point distribution and aquifer property zones.

The simulated steady-state water table contours depict a very shallow hydraulic gradient from east to west in both Deposit C and D regions (Figure 6-19). The hydraulic gradient in the area between the MAR and KNP boundary is even shallower. Model water balance comprises only rainfall recharge (2,495 kL/d) and discharge via the drains representing the potential GDE (2,495 kL/d).

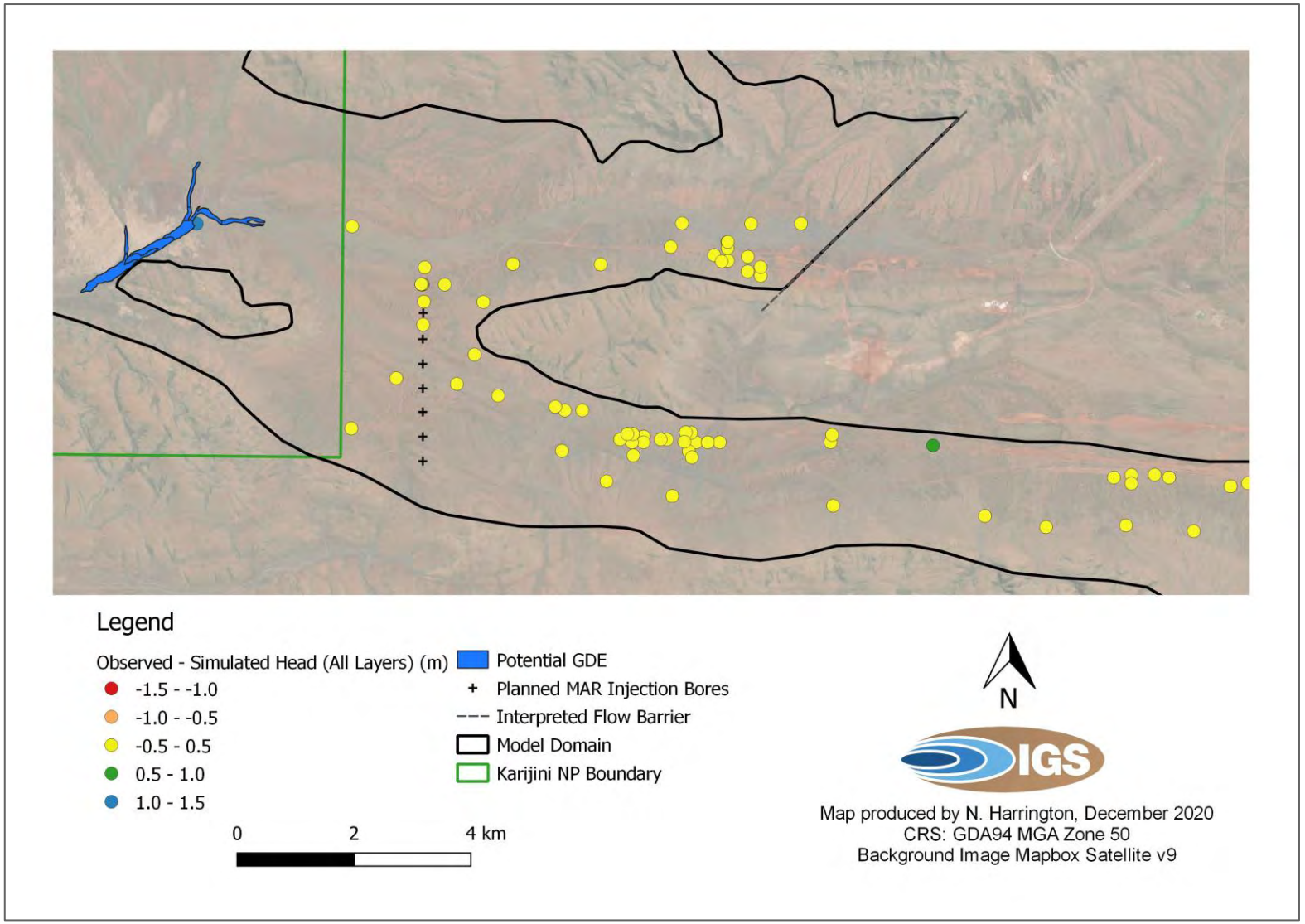


Figure 6-18. Simulated head residuals (observed head – simulated head) for the steady-state regional groundwater flow model using the hydraulic conductivity distributions shown in Figure 6-17.

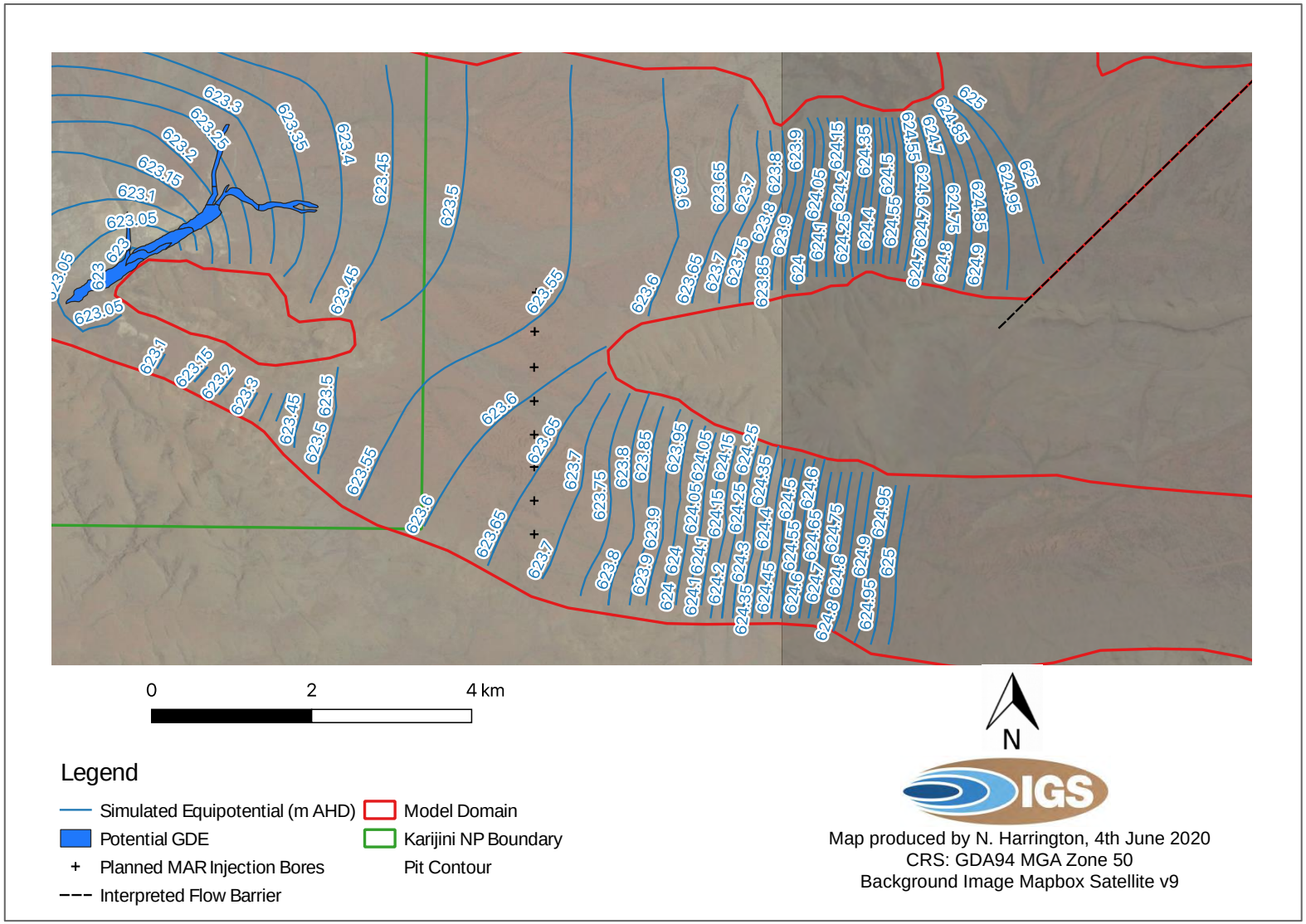


Figure 6-19. Steady-state water table elevation contours simulated using the calibrated steady state model.

4.3. TRANSIENT CALIBRATION USING MAR TRIAL DATA

4.3.1. Calibration Methodology

The steady-state regional model excludes any calibration of storage parameters, which is critical for predicting both drawdown from dewatering in Pit D and the likely response of the groundwater system to injection at the MAR bore locations. Additionally, drilling of the MAR injection bores and associated monitoring bores revealed extensive dissolution channel networks present in the calcrete above the water table (pers comm Rob Milton, RTIO). It is doubtful that uncertainty in the calcrete aquifer parameters obtained from the steady-state calibration accounts for these features, which will have a significant impact on the MAR injection. Capturing the plausible range of simulated hydraulic parameters for those formations in the MAR injection region is critical for performing a calibration-constrained optimisation of the injection rates.

Calibration of the AEM to MAR trial data in Stage 1 (IGS, 2020b) revealed that the hydraulic conductivity of the calcrete required to simulate water levels responses to the MAR trial needed to be much greater than the value obtained when performing a steady-state head calibration. Differences in structural uncertainty between the regional MODFLOW-USG model and the AEM precludes direct transfer of aquifer parameter ranges obtained through conditioning. This prompted a more robust interrogation of the MAR trial data by including it in a transient recalibration of the regional model. Details of the MAR trial, including location of the injection and monitoring bores, are provided in IGS (2020b).

The regional model MAR trial calibration adopted the resultant hydraulic conductivity distribution from the steady-state pilot-point calibration initially and featured an irregular array of pilot point multipliers (configured via PLPROC) in all layers. Pilot point placement density increased closer to the injection bore (Figure 6-15b). Starting storage parameters were uniform in each formation/zone with values based on either literature (Domenico and Schwarz, 1990) and/or pumping test values where appropriate. Preferred value Tikhonov regularisation was adopted with weighting provided by covariance matrices developed using *ppcov_sva* from PEST's groundwater utilities suite (Doherty, 2020c). PLPROC's radial basis function (*rbf_sda_interpolate_2d*) interpolator was used instead of kriging to facilitate the inclusion of anisotropy range and bearing in the calibration. A total of five parameters per pilot point were estimated including horizontal and vertical hydraulic conductivities, anisotropy range, anisotropy bearing and specific yield. Values for the storage coefficient in each cell were adjusted to reflect changes in specific yield via a PLPROC script.

The observation dataset comprised two groups of observations namely observed hydraulic heads and processed temporal head differences. Observation weighting was adjusted using PEST's *pwtadj1* utility (Doherty, 2020e) to ensure three-time greater weighting for temporal head differences, thereby focusing estimation on system response behaviour rather than absolute head observations.

4.3.2. Results

No changes to parameters were necessary for the Detritals, Wittenoom or Newman/McLeod formations. That is, multipliers remained at 1.0 or very close to it. Anisotropy bearing was also found to be insensitive. Consequently, all subsequent conditioning reverted to kriging as the interpolation method. The calcrete, present in Layer 2, required substantial increases in horizontal hydraulic conductivity for some pilot points (up to x100 multiplier) near the injection well (Figure 6-20). The weathered Wittenoom Formation, which comprises a large portion of Layer 3, required vertical

conductivity reductions (down to x0.2 multiplier near the injection well) for some pilot points (not shown). Storage parameters for both the weathered Wittenoom Formation (x0.5 to x1.5) and the calcrete (x0.2 to x1.0) were also altered in the vicinity of the injection well (Figure 6-21).

These results imply that the bulk of the uncertainty associated with MAR injection response can be attributed to the heterogeneity in model parameters representing the weathered Wittenoom Formation and the calcrete.

Good matches were obtained between observed and simulated heads and drawdowns for the observation bores monitored during the injection trial (Figure 6-22).

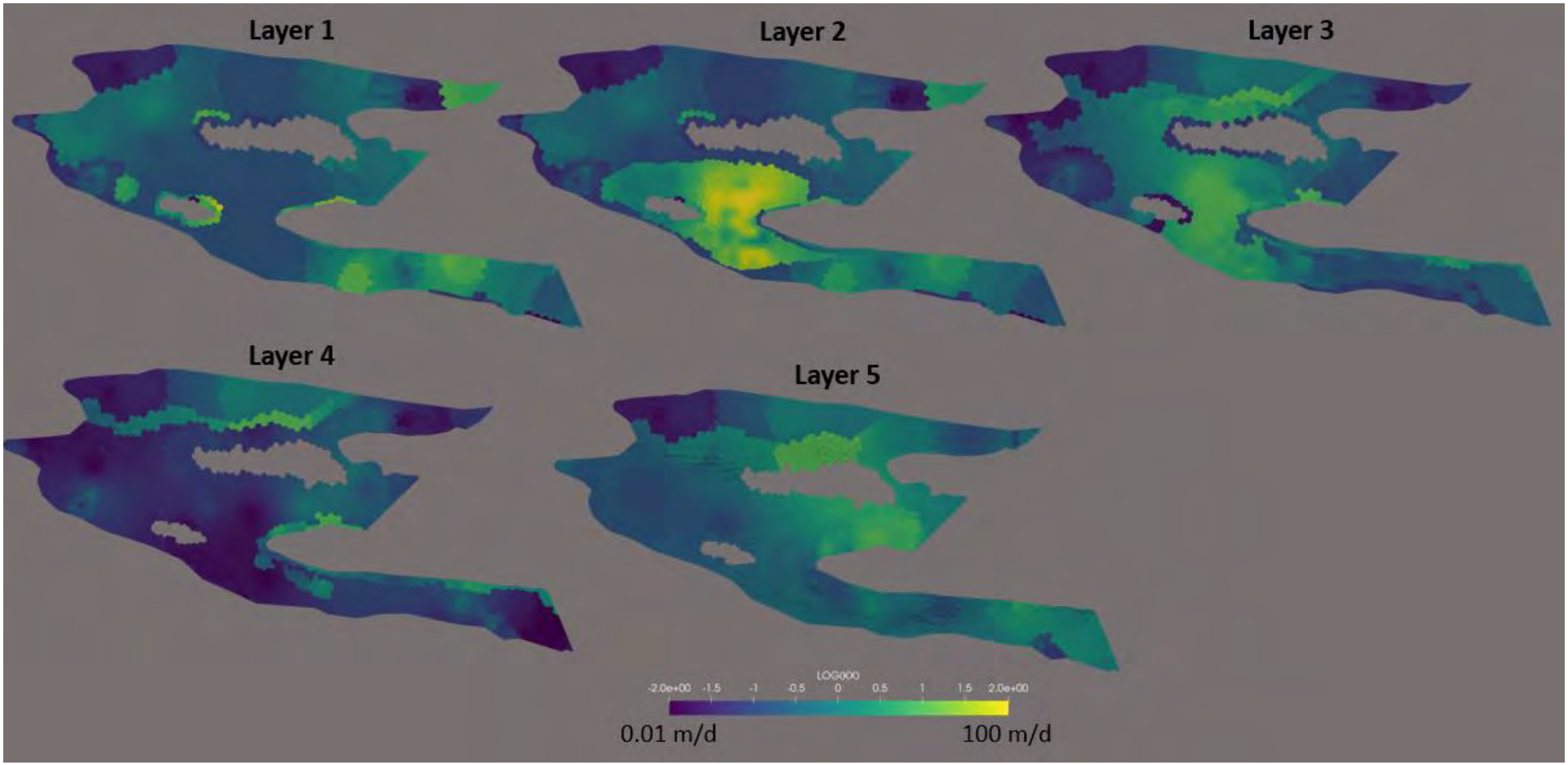


Figure 6-20. K_H distributions obtained following transient calibration of the regional model to the MAR trial data.

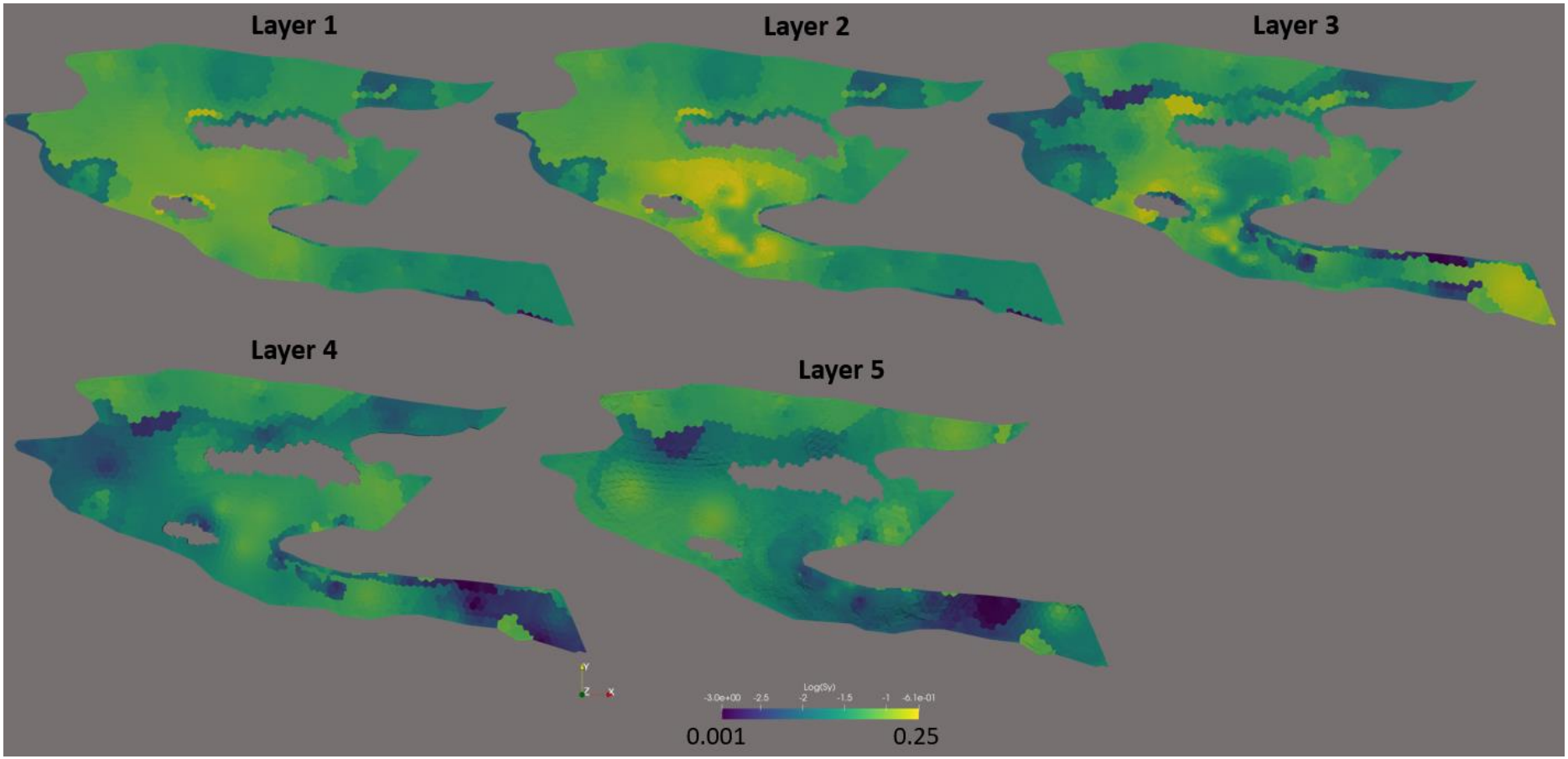


Figure 6-21. Sy distributions obtained following transient calibration of the regional model to the MAR trial data.

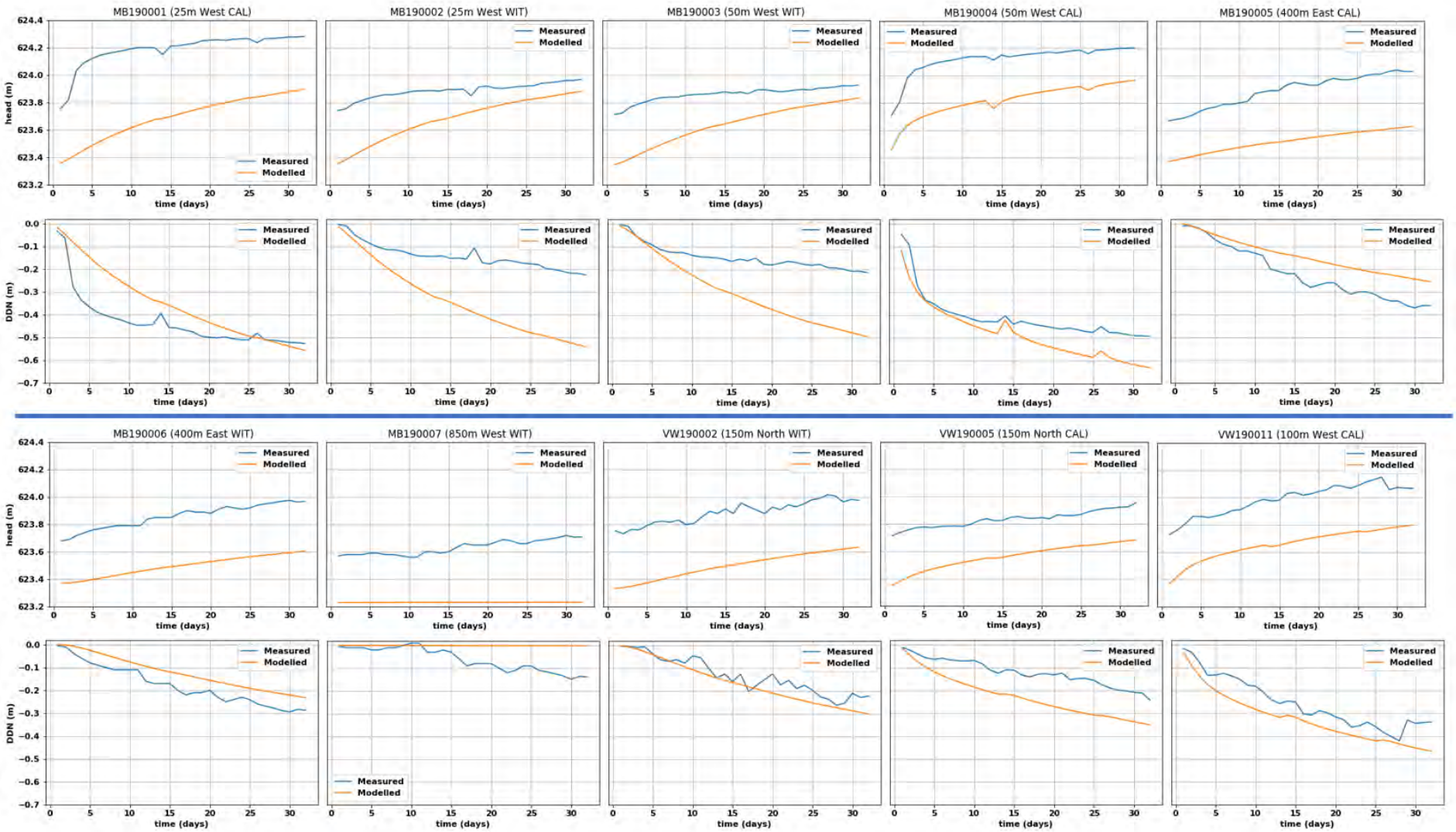

MB190001 (25m West CAL)
MB190002 (25m West WIT)
MB190003 (50m West WIT)
MB190004 (50m West CAL)
MB190005 (400m East CAL)
MB190006 (400m East WIT)
MB190007 (850m West WIT)
VW190002 (150m North WIT)
VW190005 (150m North CAL)
VW190011 (100m West CAL)
head (m)
DDN (m)
time (days)
Measured
Modelled

Figure 6-22. Observed and simulated head (m) and drawdown (DDN, m) for the MAR trial bores. Negative drawdown indicates impress. CAL and WIT are calcrete and weathered Wittenoom Formation. Distance from injection bore is noted in plot titles.

4.4. Conditioning an Ensemble Using Steady-State and MAR Trial Data

An ensemble of models featuring pilot point parameters was conditioned using PESTPP-IES (White, 2018, White et al., 2020). The objectives for developing the ensemble are to (1) assess the range of potential unmitigated drawdown at the KNP boundary from dewatering Pit D, and (2) use the ensemble with PESTPP-OPT (White et al., 2018, White et al., 2020) to obtain an optimised injection sequence for the MAR that also accounts for the uncertainty in the model predictions.

A model was configured with an initial steady-state stress period followed by 31 daily transient stress periods simulating the MAR trial injection. The steady-state dataset included absolute hydraulic head measurements, whilst the MAR trial dataset was converted to temporal difference head measurements minimising potential bias from boundary conditions. The pre-existing pilot point distribution used for the steady state calibration (Figure 6-15a) was augmented with a 500 m spacing uniform grid of pilot points in the area between the KNP boundary and Pit D (Figure 6-23).

A parameter uncertainty file comprising the standard deviation for probability of drain conductance and covariance matrices for pilot point parameter groups was included. Sill values for variograms in the pilot point statistical specification files used by *ppcov_sva* were set at log transformed variances corresponding to uniform probability distributions between parameter upper and lower bounds. This results in no increased likelihood for values between parameter bounds whilst maintaining geologically plausible pilot point parameter sampling by PESTPP-IES. Upper and lower bounds for parameters in both the calcrete and the weathered Wittenoom were extended to be commensurate with observed parameter ranges from the previous MAR trial calibration. Use of PESTPP-IES to condition an ensemble sampled in this manner accounts for both expert knowledge and historical system behaviour.

Zone boundaries were enforced by prohibiting kriging between the different geological formations represented in the model. Kriging of pilot point values to the model grid was performed by a combination of PLPROC's *calc_kriging_factors_auto2D* and *krig_using_file*. Conditioned parameters included drain conductance, horizontal and vertical hydraulic conductivity, and specific yield.

The optimum number of models for the ensemble was 558 identified through eigen analysis of a prior Jacobian matrix using the *matsvd* utility from the PEST suite (see Moore and Doherty, 2005).

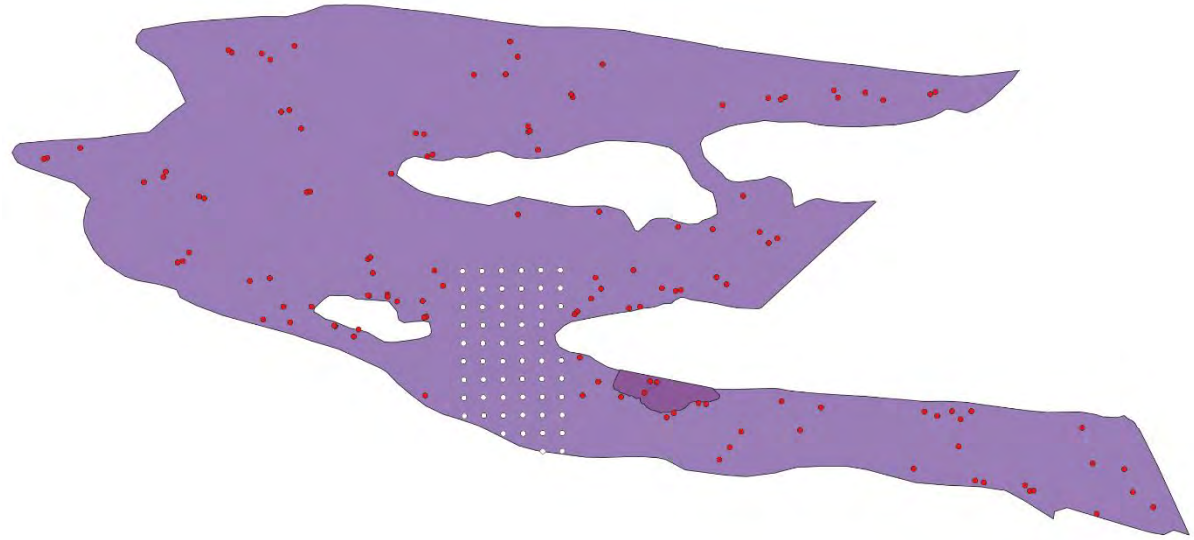


Figure 6-23 Pilot point distribution used in ensemble conditioning. Red – points from previous steady-state calibration. White – new grid of points added across MAR injection region.

Figure 6-24 and

Figure 6-25 summarise the ability of the ensemble of 558 models to simulate both the steady state head dataset and the transient heads and drawdown observed in the MAR injection trial. The range of steady state head values produced by the 558 models for each observation point was less than approximately 2 m (Figure 6-24). At least 50% of models simulated steady-state head values within 0.5 m of observed for the majority of observation locations. All simulated heads were within approximately 2 m of observed. The ensemble of models also simulates the impress observed at various observation locations during the MAR trial.

Figure 6-25 demonstrates that the transient system response behaviour, observed as the change in slope of the hydrograph with time, is captured reasonably well by the calibration. However, the absolute hydraulic head values show observation-simulation mismatches that range between 0.0 m and 0.3 m. Some mismatch is expected because higher weighting was given to temporal head differences over absolute hydraulic head for better storage parameter calibration. In addition, the spacing of some of the observation bores are close to a single model cell providing very little opportunity for parameter adjustments in the model to account for the effects of local scale heterogeneity

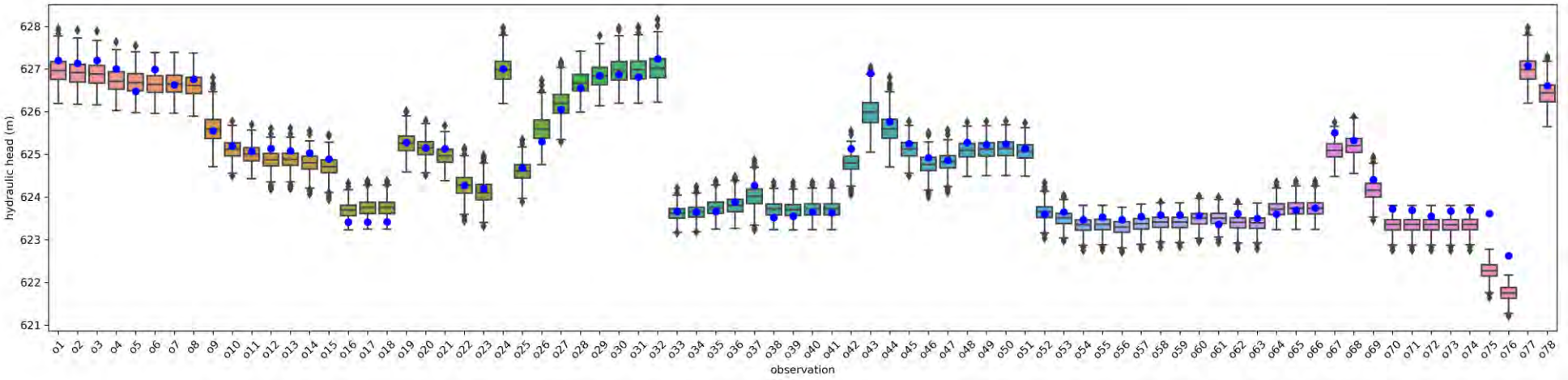


Figure 6-24. Box-and-whisker summary of steady state calibration results for the conditioned ensemble of 558 models. The blue dot represents the steady state head target. The box in the box and whisker plot represents 50% of the simulation results. The horizontal line represents the mean value for all simulations. The whiskers approximate 100% of all model results after assessing outliers.

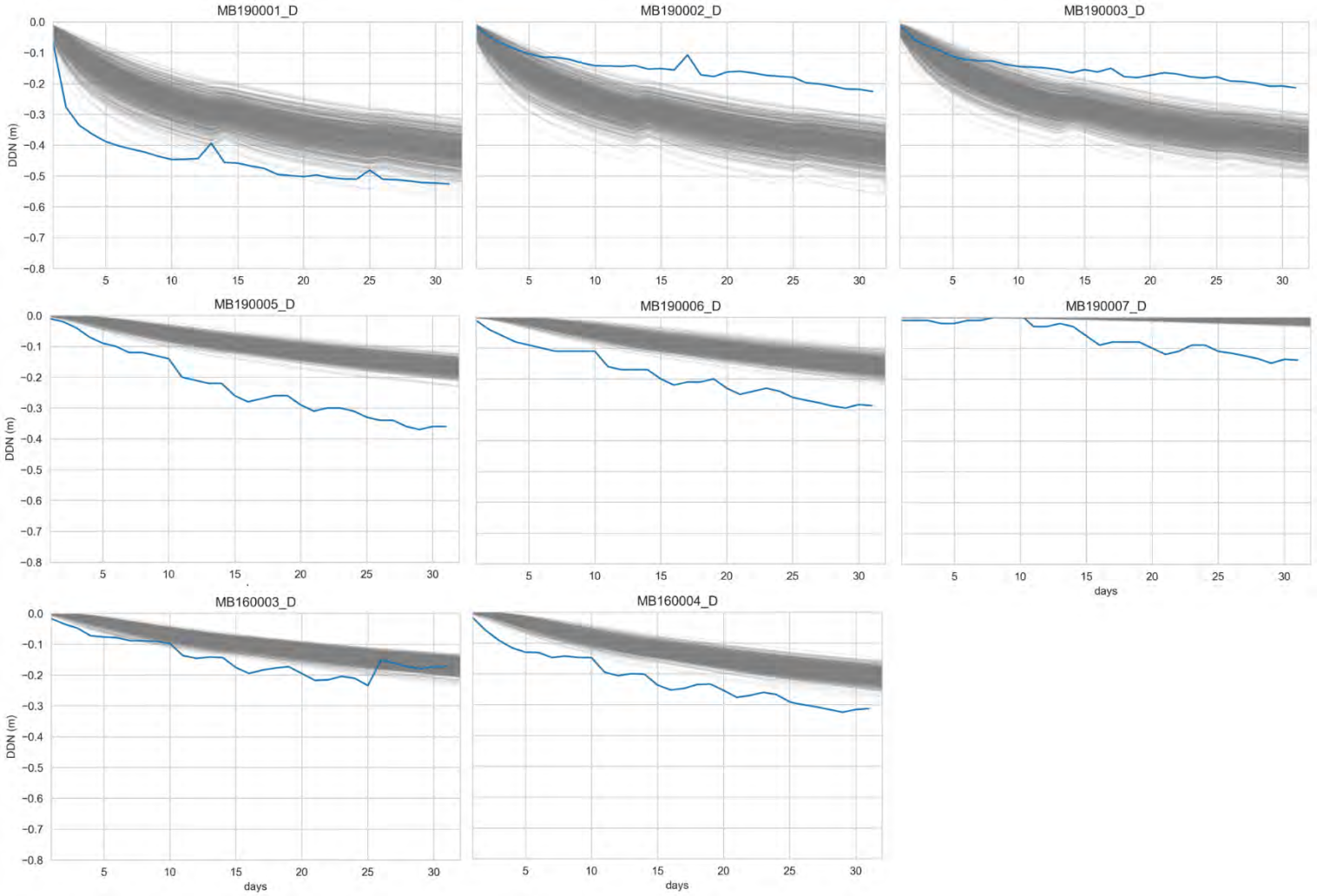


Figure 6-25. Comparison between observed impress (negative drawdown) during the MAR trial and impress simulated by the ensemble of 558 models.

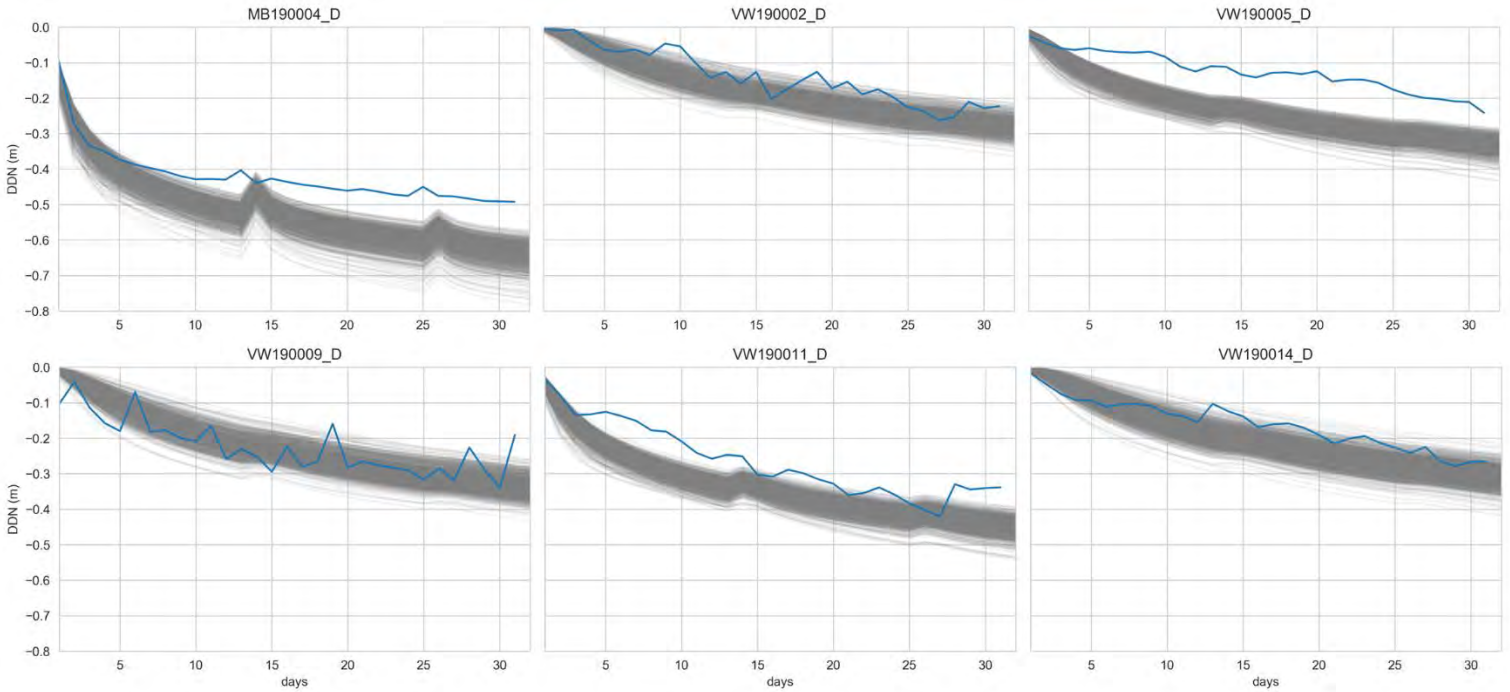


Figure 6-25 (continued). Comparison between observed impress (negative drawdown) during the MAR trial and impress simulated by the ensemble of 558 models.

5. Transient Simulation of Unmitigated Drawdown: Dewatering of Pit D1

The ensemble of models described in Section 4.4 were then used to simulate unmitigated drawdown impacts from Pit D1. Pit D1 is the current focus as it requires the greatest reduction in groundwater levels Dewatering is implemented in the model via drain cells over the maximum pit footprint.

Fixed fortnightly time steps were used and drain conductance for the pit was set at 100 m^2/d. Details of drain elevations are provided in IGS (2020a). The conductance was selected by trial and error seeking a sufficient rate of water table decline without excessive iterations from the solver or evidence of numerical instability.

Figure 6-26 shows simulated unmitigated drawdown at 15 different locations along the Karijini National Park boundary and Figure 6-27 to Figure 6-29 show contours of the simulated maximum unmitigated drawdown from the ensemble of 558 models at different times. Maximum impacts at the KNP boundary occur within 20 years post-mining (~35 years total simulation time) in the south but in the north, drawdown continues to increase with time beyond 85 years post-mining (100 years of simulation time).

Figure 6-26 shows that the conditioned ensemble comprises model realizations that simulate drawdown impacts in two distinct bands. The high impact band contains 126 models and the low impact band contains 432 models. This is thought to occur largely due to significant differences between the models in the properties of the Detrital aquifer surrounding the calcrete in Layer 2. The most notable differences are the horizontal hydraulic conductivity and specific yield of the Detrital aquifer adjacent to the calcrete (Figure 6-30).

Due to their mode of deposition, Detrital aquifers are very heterogeneous, and the prior parameter distribution implemented in PESTPP-IES for the Detritals was broad implying large uncertainty. Additionally, there are only two steady-state head observations in the Detritals and no transient observations from the MAR trial in this unit (the water table remained within the calcrete, which is extensive across the MAR area) to constrain its parameter distribution. Moreover, the lateral boundary between the calcrete and the Detrital aquifer and the degree of connectivity between these aquifers is unconstrained by drilling information.

The current model design features a discrete boundary between the calcrete and Detrital aquifer delineated according to RTIO's geological model. Aquifer properties are interpolated between pilot points within zones/formations only, which results in a number of calibrated models with a definite contrast in properties across the calcrete / Detrital boundary (Figure 6-30). The magnitude of this contrast influences drawdown propagation resulting in the bimodal distribution of unmitigated impacts observed in Figure 6-26. There was no indication of a bimodal distribution in the ensemble when assessing model behaviour with the observation dataset used in calibration. (Figure 6-24 and Figure 6-25). Regardless, the current model design honours the existing conceptual model, and the resulting two bands of unmitigated impacts provides an appreciation for the influence that uncertainty in Detrital properties has over model predictions.

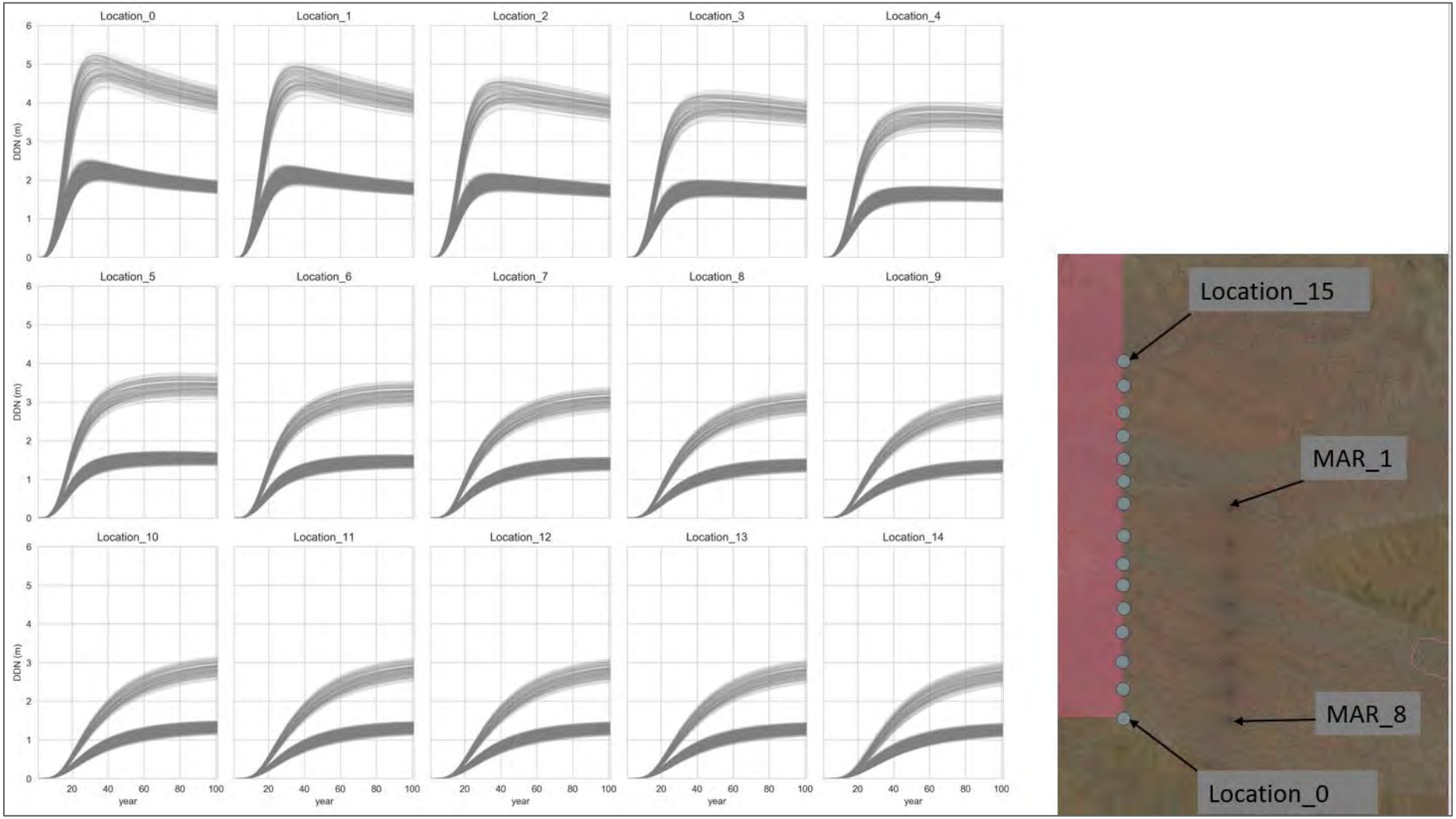
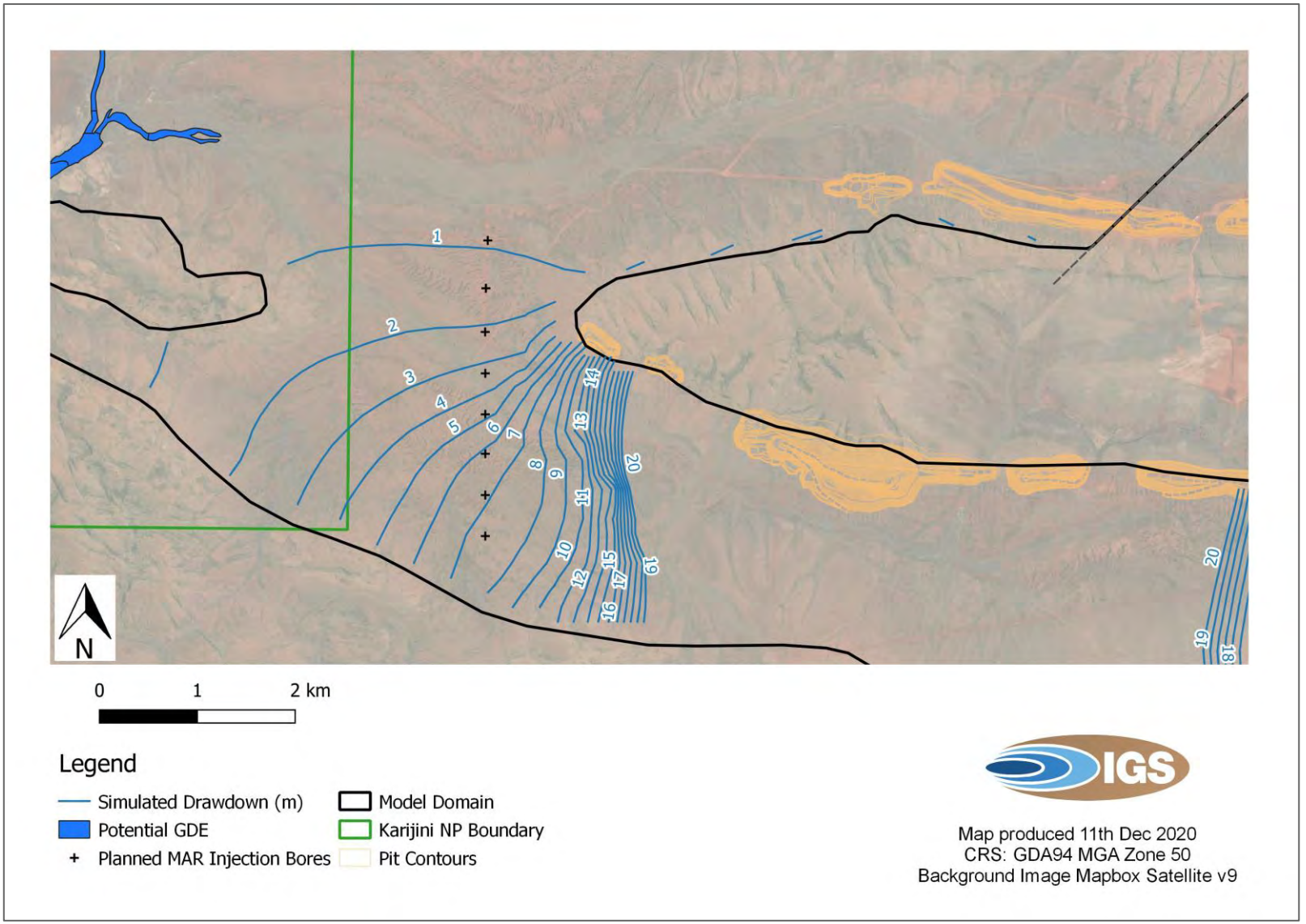

Location_0
Location_1
Location_2
Location_3
Location_4
Location_5
Location_6
Location_7
Location_8
Location_9
Location_10
Location_11
Location_12
Location_13
Location_14
DDN (m)
year
Location_15
MAR_1
MAR_8
Location_0

Figure 6-26. Simulated unmitigated drawdown at points along the Karijini National Park boundary using the ensemble of 558 models. Model observation locations are shown in the location map relative to the locations of planned MAR bores 1 to 8 (MAR_1 to MAR_8).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2 km
Legend
Simulated Drawdown (m)
Potential GDE
Planned MAR Injection Bores
Model Domain
Karijini NP Boundary
Pit Contours
IGS
Map produced 11th Dec 2020
CRS: GDA94 MGA Zone 50
Background Image Mapbox Satellite v9

Figure 6-27. Simulated maximum unmitigated drawdown from the ensemble of 558 models five years after the end of dewatering of Pit D1.

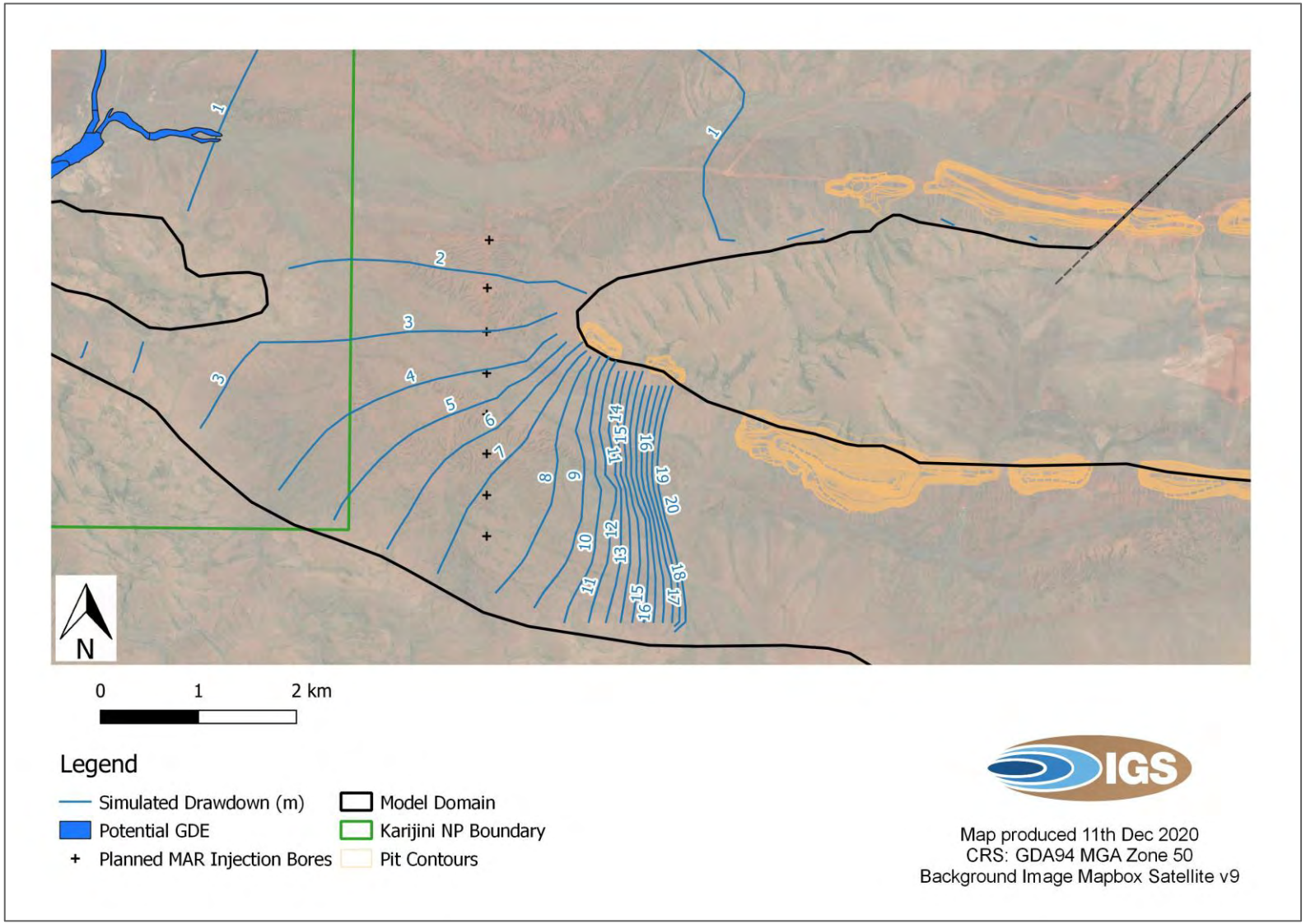


Figure 6-28. Simulated maximum unmitigated drawdown from the ensemble of 558 models 15 years after the end of dewatering of Pit D1

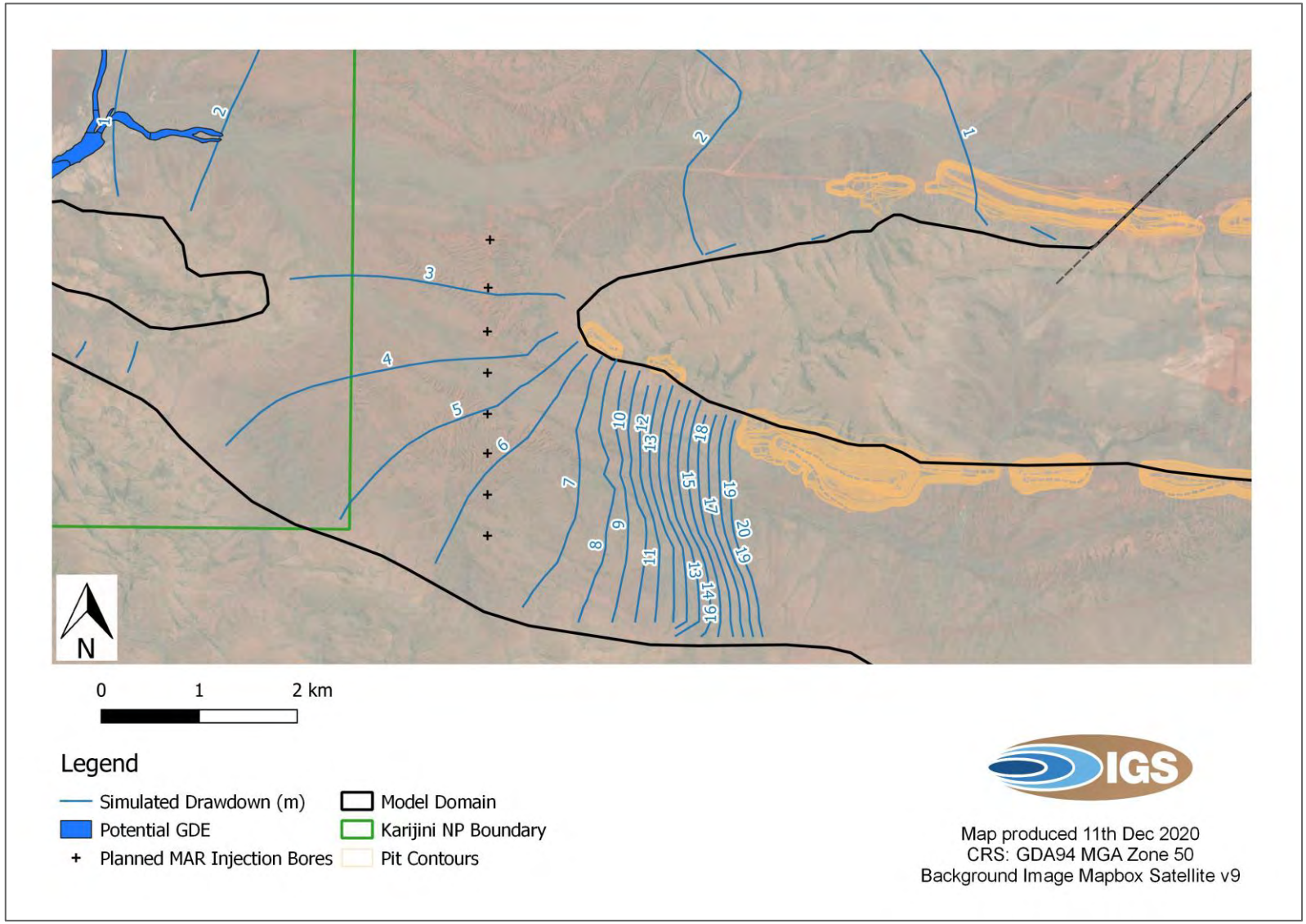


Figure 6-29. Simulated maximum unmitigated drawdown from the ensemble of 558 models 35 years after the end of dewatering of Pit D1.

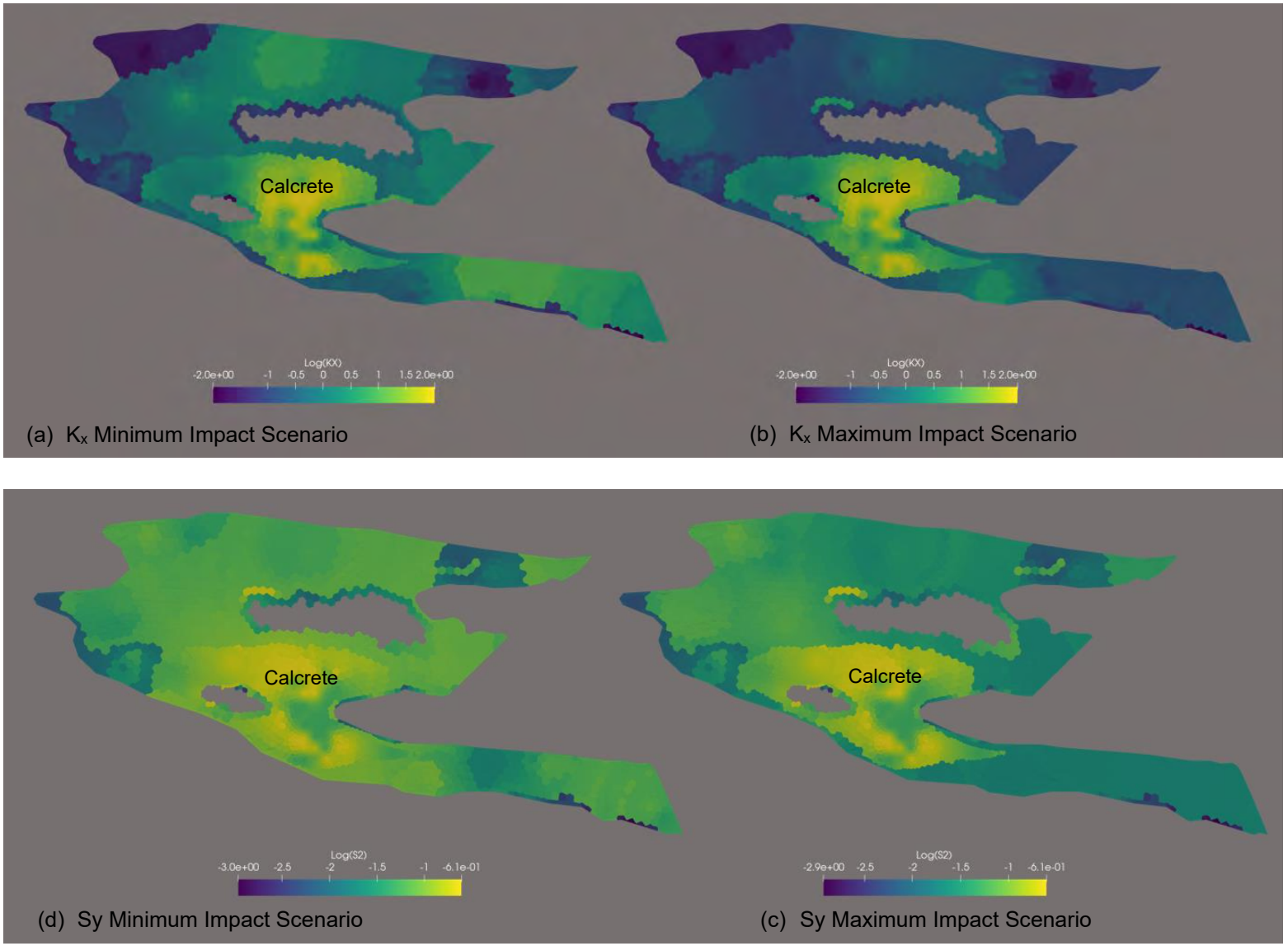


Figure 6-30. Differences in Kx and Sy for Layer 2 (Calcrete and Detritals) for the minimum and maximum impact scenarios shown in Figure 6-26.

6. Optimization of MAR Injection Rates

6.1. METHODOLOGY

The ultimate objective of the numerical studies described in previous sections was to achieve an appropriate ensemble of plausible models for use in a calibration-constrained optimisation of the MAR injection to achieve zero drawdown at the KNP boundary. PESTPP-OPT (White et al., 2018) was selected as the most suitable application to perform this analysis. The benefit of calibration-constrained optimisation over standard optimisation methods is the inclusion of predictive uncertainty, thus making it ideal for risk-based decision support. Confidence in resource management decisions can be explored with the numerical model synthesizing current system knowledge and behaviour.

A model capable of simulating mitigation of the drawdown via the MAR scheme was developed. It is identical to the model used for assessing unmitigated impacts but includes the MAR injection bores and has yearly stress periods. The approach implemented by PESTPP-OPT requires decision variables and observation constraints. For the present analysis, the decision variables are the injection rates at each MAR bore during each stress period. That is, eight injection rates for each of 100 yearly stress periods totalling 800 decision variables. Cost coefficients are assigned to the decision variables, weighting them according to stress period length. The coefficients are determined by dividing the stress period length of the decision variable by the total simulation time. This effectively creates a pseudo-volume since the decision variable rates are multiplied by coefficients that represent a time period. The optimisation therefore seeks to find the total minimum injection volume that also maintains adherence to the maximum number of observation constraints. Put another way, PESTPP-OPT minimises the cost (pseudo-volume) associated with the parameters (injection rates) while using the observation constraints as guides. This contrasts with a utility like PEST that adjusts the parameters (injection rates) to minimise the mismatch between simulation and observation constraints.

The observation constraints are configured as drawdown impacts at the KNP boundary that must be maintained within a specified margin. These constraints are set for the end of each transient stress period. Constraints of less than 0.1 m drawdown and greater than -1.0 m drawdown were set along the KNP boundary, thereby setting an acceptable water table change as the formal constraint. Note, negative drawdown at the KNP boundary represents an impress, which is implicitly minimised because PESTPP-OPT is targeting the minimum pseudo-volume. A range of injection rates between 0.0 and 40.0 L/s were provided for the decision variables based on advice from RTIO about maximum potential pump capacity. Extra observation constraints were added to (1) prevent the impress head from exceeding surface elevation near the injection bores, and (2) limit total injection within a year to be commensurate with existing capacity to deliver water to the MAR scheme. The latter was implemented to ensure the optimisation doesn't produce a solution that exceeds the volumetric capacity of the infrastructure piping water from the dewatering scheme to the MAR site. The maximum and minimum bounds on injection rates are also constraints on the solution but these are strictly enforced throughout the optimisation.

The optimisation strategy adopted a "stack based" approach for observation constraint uncertainty. This method assesses the uncertainty in observation constraints via a conditioned ensemble of models. Uncertainty in observation constraints is re-assessed by running the entire ensemble following each update to the decision variables (injection rates in this case).

The confidence percentage metric used by PESTPP-OPT's stack-based methodology is dependent on all the observations in the stack, that is, every observation in every stress period from each ensemble member. For example, a 70% confidence optimised solution translates to 70% of all constraints being respected across all models. This means that some models in the ensemble may, for example, not have any constraints respected, while other models may have all constraints respected. The bimodal distribution of unmitigated impacts (see Figure 6-26) reduces the feasibility of achieving a risk averse optimised solution (i.e., >50% confidence) and preliminary analysis revealed the full ensemble was only capable of achieving a feasible solution with maximum confidence of 61%. Consequently, the decision was made to split the conditioned ensemble into two separate groups and target two high-confidence risk-averse optimised injection sequences instead of a single low-confidence or potentially risk-tolerant (i.e., <50% confidence) solution. The groups were split according to their unmitigated impact predictions at the southern end of the KNP boundary. Models with drawdown impacts less than 4.0 m were grouped as Stack A (432 models), while those with greater impacts formed Stack B (126 models). Stack A achieved a feasible solution at 91% confidence while Stack B attained 93% confidence.

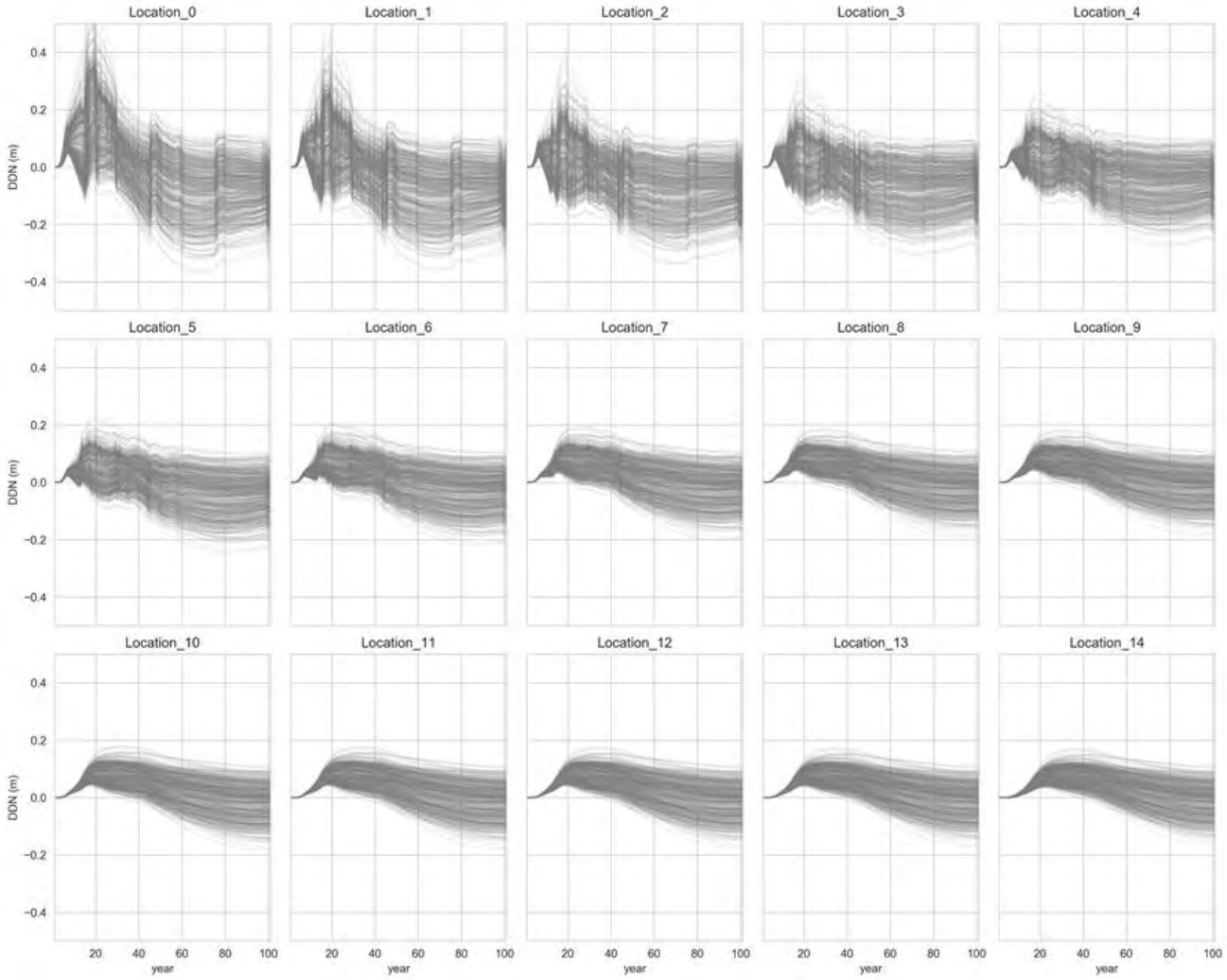
The solutions provided by PESTPP-OPT do not guarantee perfect adherence to observation constraints and are therefore unable to demonstrate with 100% confidence that the existing MAR infrastructure can prevent drawdown propagation into the KNP. Accordingly, an end member analysis was performed using the maximum and minimum unmitigated impact models of the complete ensemble (Figure 6-26). The covariance matrix adaptation evolutionary strategy (CMAES_P) global optimiser in the PEST (Doherty, 2020a) suite was used to obtain injection sequences that provide strict adherence to the impact constraints at the KNP boundary. In contrast to PESTPP-OPT, CMAES_P implements an objective function that is observation dependent. CMAES_P was selected because of the non-linear response to drawdown observations at the KNP boundary from injection at the MAR site. Unlike PEST, CMAES_P's performance is not dependent on derivatives of model outputs with respect to adjustable parameters. The decision to use CMAES_P was deemed appropriate when a trial run achieved solution in less than 800 model realisations, which is the minimum number of realisations PEST requires to build its initial sensitivity matrix. While observation constraints in PESTPP-OPT were configured as greater-than or less-than via the control file, producing equivalent constraints for CMAES_P required the use of PEST's observation post-processor, *obs2obs*. Observations were configured for zero contribution to the objective function unless the greater than or less than constraint was violated.

6.2. RESULTS

The optimised injection sequences are provided in IGS (2020a). Figure 6-31 shows the effects of the optimised injection along the KNP boundary for each member of the ensemble. The impress constraint at the KNP boundary is never transcended in any simulation but drawdown exceeds 0.1 m in all simulations most notably in the southern regions (locations 0 to 4). This is unsurprising given a less than 100% feasibility for the solution. Recall that PESTPP-OPT does not strictly enforce observation constraints but instead uses them to guide a solution and quantify feasibility. It is also seeking a single injection sequence that uses the least injection volume yet meets 91% of the prescribed constraints across all simulations in Stack A.

For Stack B drawdown constraints are exceeded in the southern region of the KNP albeit to a lesser extent and in later years than those observed in Stack A (Figure 6-32). However, impress along the entire park boundary is noticeably larger in the majority of simulations.

No constraint exceedances are observed for both CMAES_P solutions (Figure 6-33), which is unsurprising given the constraint focused objective function implemented in CMAES_P. Indeed, the drawdown constraint is maintained at almost 0.0 m for both solutions despite a threshold of 0.1 m. The integrated injection constraint associated with water delivery capacity to the MAR site remains unsurpassed throughout all solutions (conservatively set at 120 L/s).



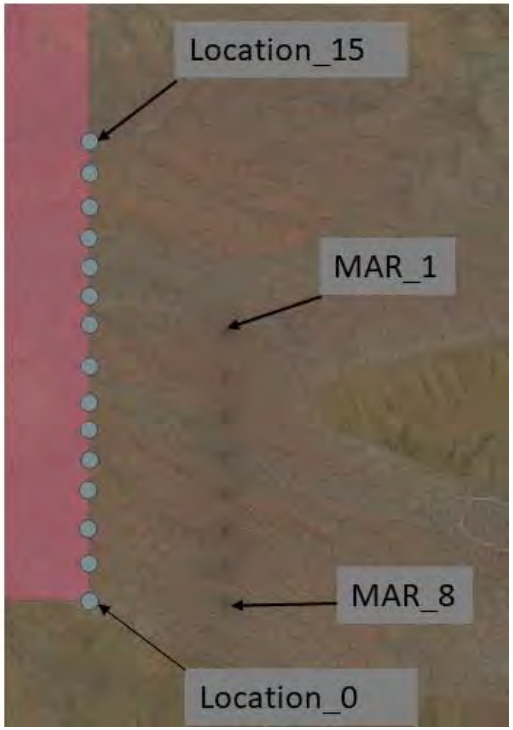
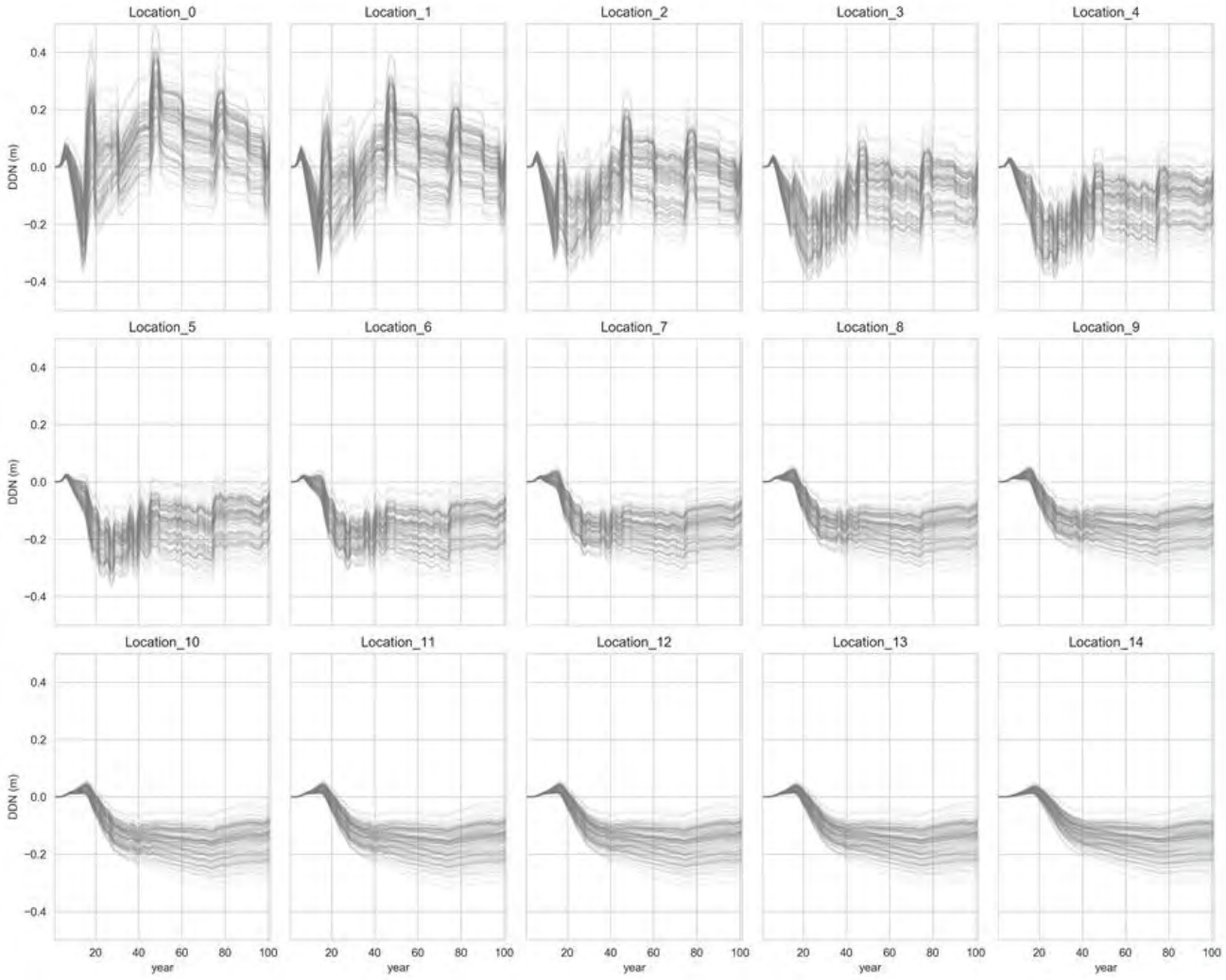


Figure 6-31. Stack A ensemble mitigated impacts along the KNP boundary. Note negative drawdown indicates impress.



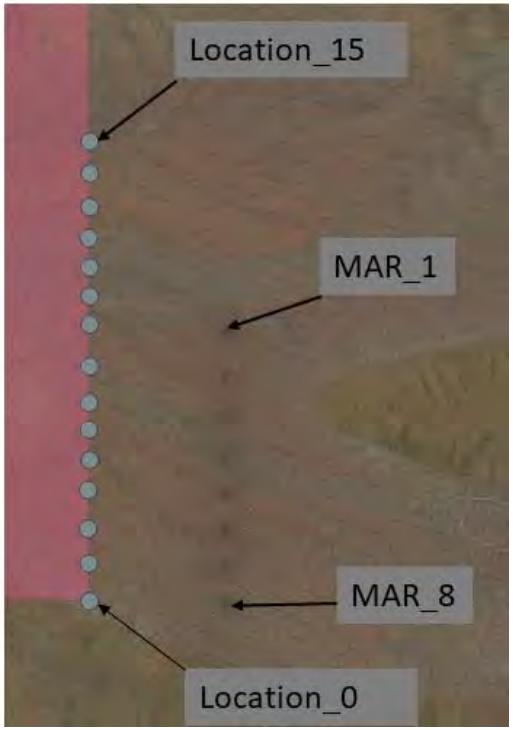
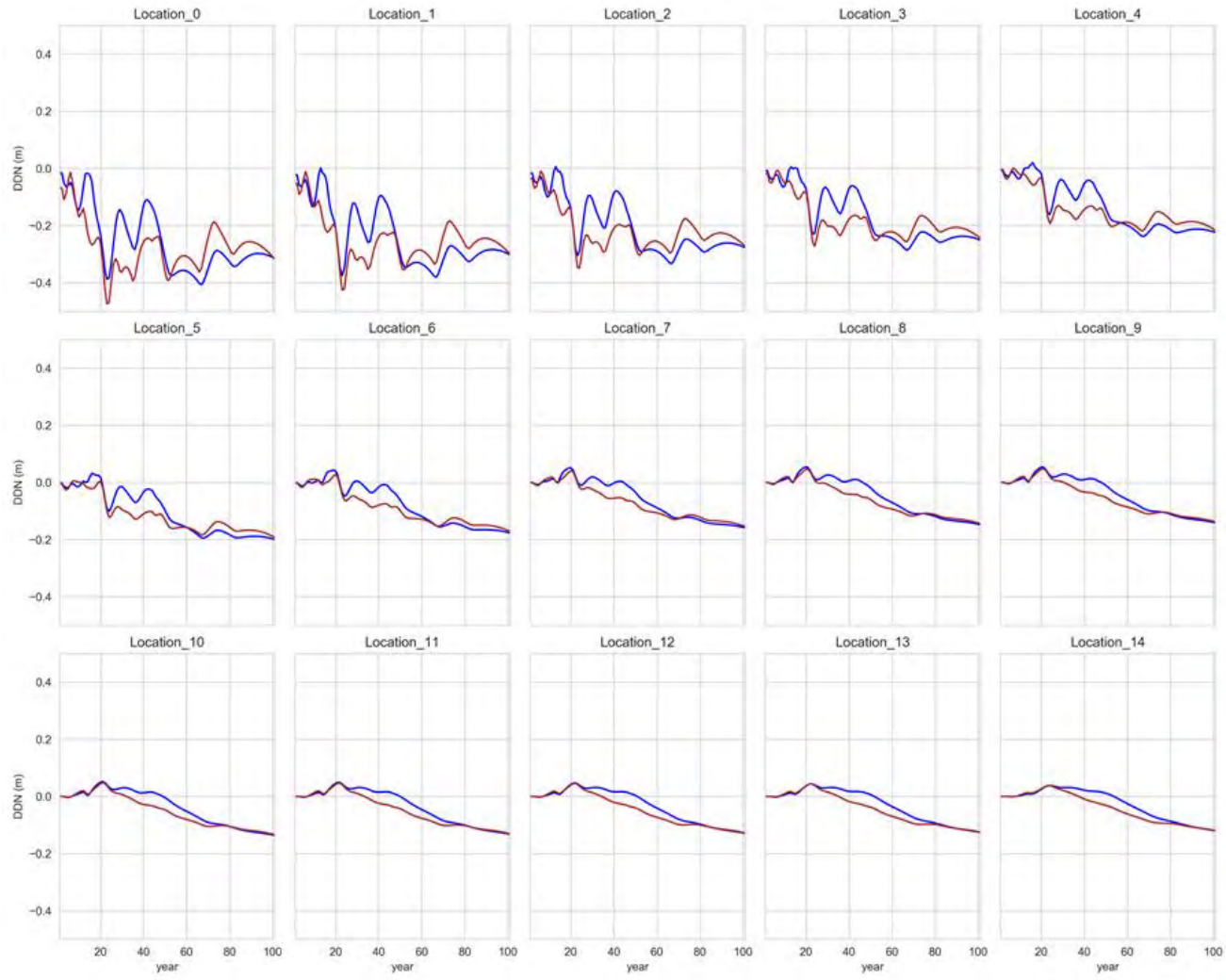


Figure 6-32. Stack B ensemble mitigated impacts along the KNP boundary. Note negative drawdown indicates impress.



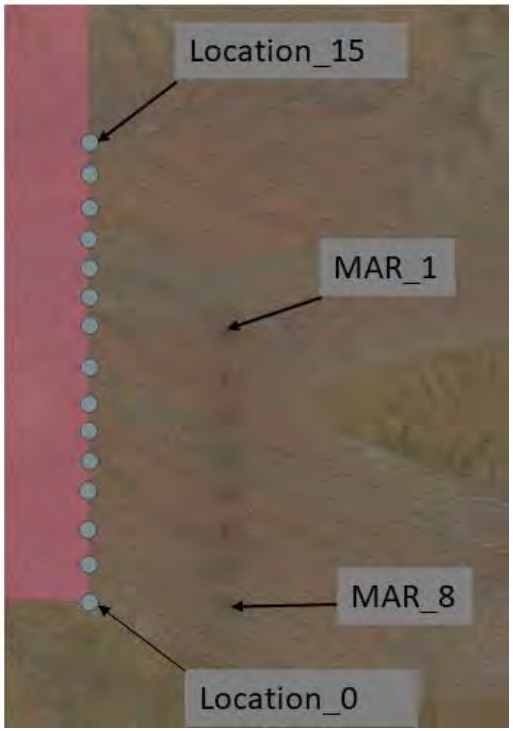


Figure 6-33. Maximum (red) and minimum (blue) mitigated impact model simulation results along KNP boundary. Note negative drawdown is an impress.

6.3. DISCUSSION

The end member analysis demonstrates the capacity for the present MAR infrastructure to mitigate the likely propagation of drawdown to the KNP boundary associated with dewatering in Pit D. The CMAES_P simulations implicitly account for uncertainty because they represent the two extreme impact prediction models derived from the conditioned ensemble. The differences in the solutions between CMAES_P and PESTPP-OPT are expected because of the differences in the objectives between the two methods. PESTPP-OPT accounts for uncertainty in its optimisation while simultaneously minimising the amount of injection required. CMAES_P solves the optimisation problem framed by the constraints for a specific model without accounting for uncertainty or seeking to minimise the total volume of injection. Nevertheless, the solutions share several common characteristics. The smaller impact models require a greater amount of injection over the peak period, which is likely related to the differences in parameters discussed previously (IGS, 2020a). High specific yield values combined with high hydraulic conductivity requires a greater volume to change hydraulic head. The larger impact models have the opposite combination of parameters that is lower specific yield and lower hydraulic conductivity, which increases the sensitivity of hydraulic head response to a given stress. The locations and timing of the peak injection is consistent across all models and solutions (IGS, 2020a). This reflects the results from the unmitigated impact simulations using the complete ensemble where drawdown was observed to propagate faster in the south than the north. The configuration of the numerical model is for a single injection rate per bore per year. In reality, this can be varied at a much smaller temporal scale. For example, injection rates at different bores can be varied fortnightly or monthly providing significantly finer control of mitigation measures. The implication here is that the simulated impacts are undoubtedly exacerbated due to the lack of fine temporal resolution in the simulated MAR operation. Additionally, the solutions are only representative of the plausible timing of injection volumes that will be required.

7. Preliminary Risk Assessment for Contaminant Transport to Karijini National Park

7.1. METHODOLOGY

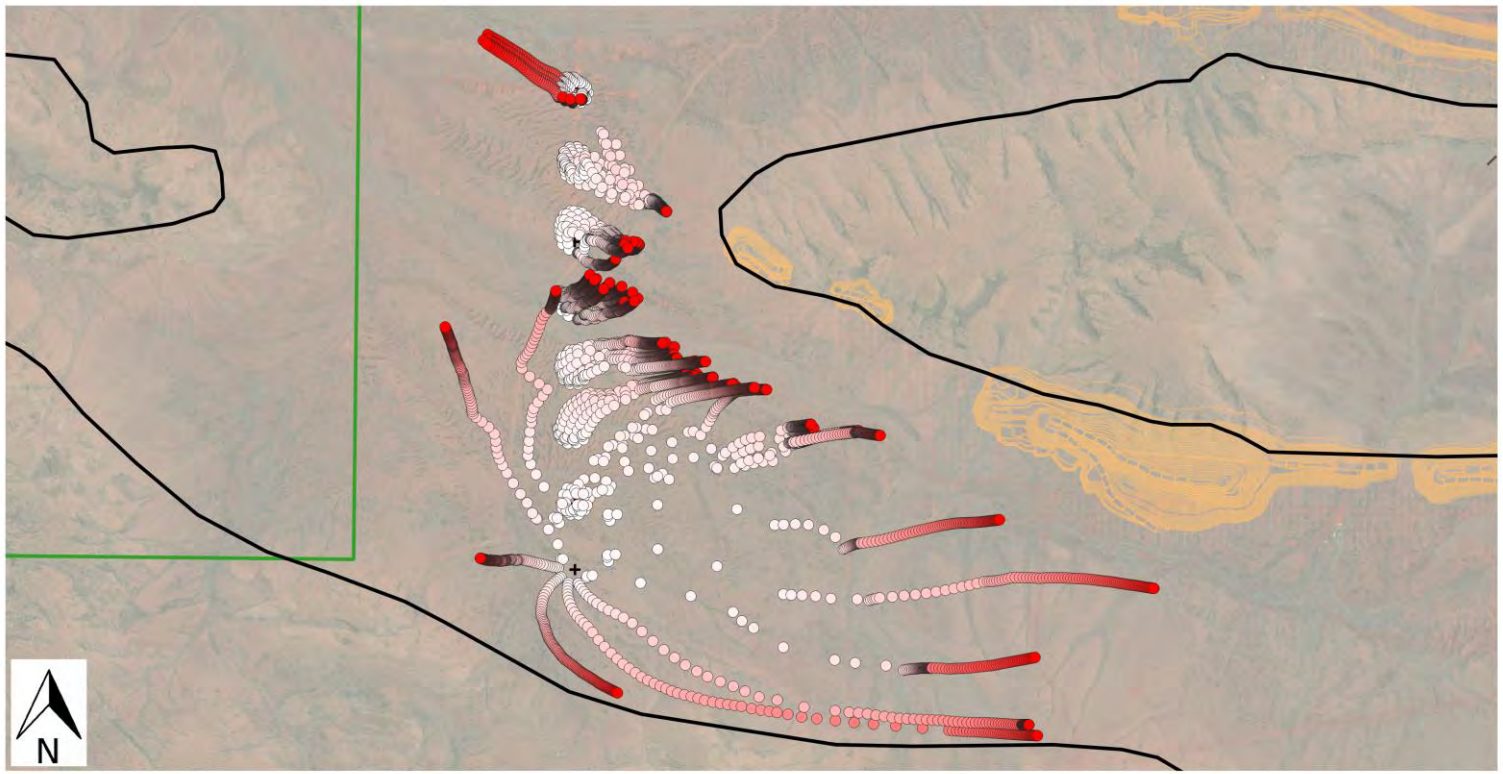
Particle tracking was implemented in forward mode with both the maximum and minimum CMAES_P models, which represent the end members of the conditioned ensemble. Forward particle tracking involves using particles placed in the aquifer at a specific time and tracing their movements forwards in time throughout the numerical simulation until they either reach a receptor or exit the model via an external boundary. The objective of this work is to assess the likely pathways and conservative travel times of injected water focusing on impacts at the KNP boundary. Accordingly, the particles are placed in the model at the screen locations of the MAR injection bores within the calcrete at the start of the simulation. The particle tracking code mod-PATH3DU (SS Papadopoulos and Associates, 2014) was selected for the analysis primarily because of its compatibility with MF-USG and the Voronoi grid used in the present model.

Both the maximum and minimum impact mitigated models featuring the injection sequence solutions from CMAES_P were used. Recall that both models demonstrate strict adherence to the impact thresholds with virtually zero drawdown and minimal impress impact at the KNP boundary over a 100-year period. Particle tracking results depict advective transport and are consequently dependent on the porosity or more specifically effective porosity, assigned to the aquifers. For the present analysis conservative values were selected that promote greater advection in the calcrete (porosity = 0.05)

and weathered Wittenoom Formation (porosity = 0.05) through which the particles flow. An effective porosity of 0.05 for the calcrete is very conservative (i.e., will result in most rapid particle migration in the aquifer) given the evidence for dissolution channels. This porosity is also conservative for the weathered Wittenoom Formation as it is less than half of the calibrated specific yield value (approximately 0.11) from the MAR trial.

7.2. RESULTS

Particles are plotted once every 365 days along their tracks with a graduated colour scheme starting at white for year 1 and finishing at red for year 100. Tracking in both simulations (Figure 6-34 and Figure 6-35) demonstrate that particles primarily migrate towards Pit D because of the gradient induced by dewatering, which is further enhanced at bores 7 and 8 when they are injecting. Accordingly, particles originating from those bores have the greatest travel distance over time. Both scenarios have little to no injection from the rest of the MAR scheme which results in significantly less particle advection from these locations. The migration of particles to the north-west from MAR bore 1 is consistent in both simulations and is representative of the prevailing flow field in this region and not a response to injection.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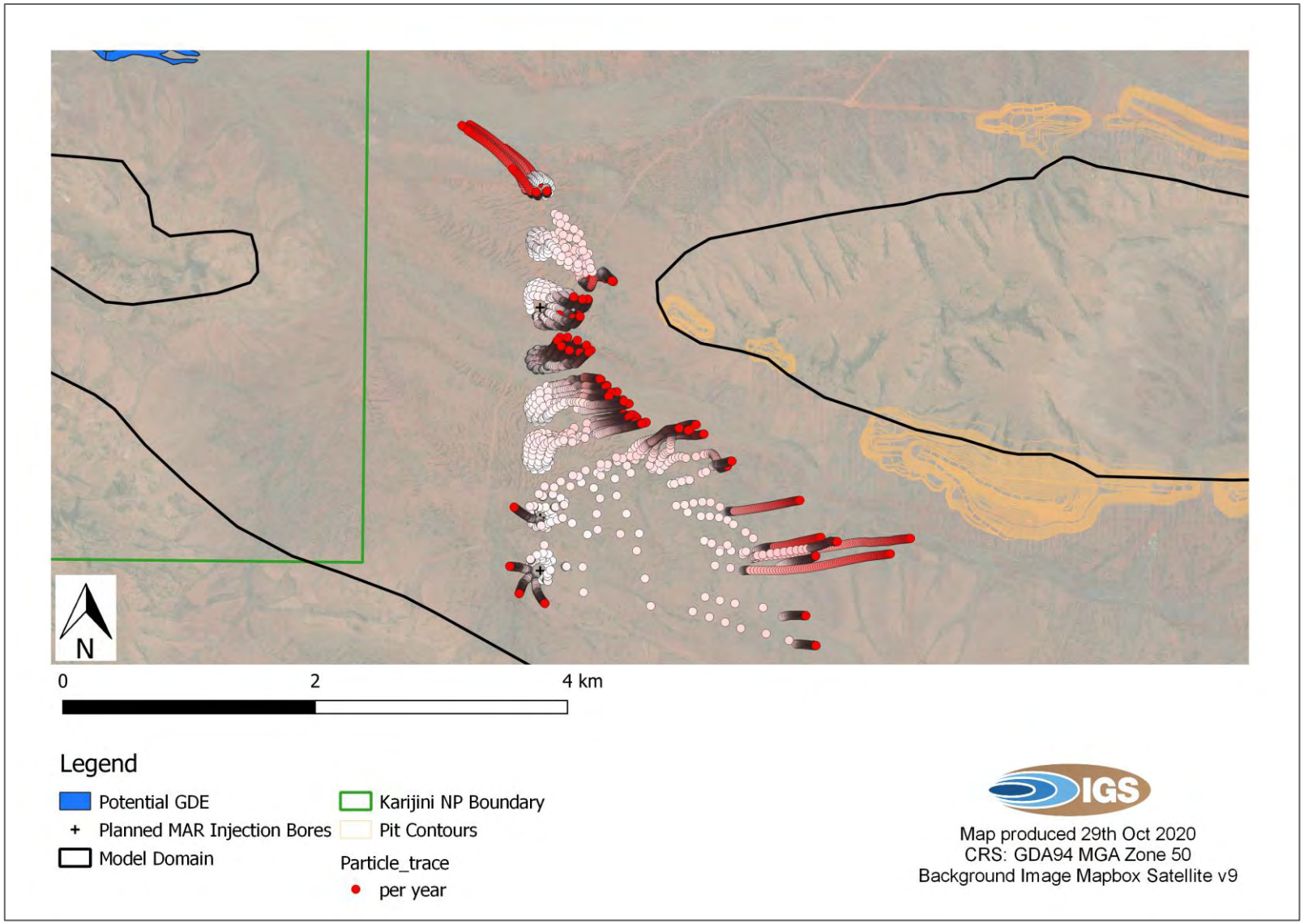
Legend
Potential GDE
Planned MAR Injection Bores
Model Domain
Karijini NP Boundary
Pit Contours
Particle_trace
per year
IGS
Map produced 29th Oct 2020
CRS: GDA94 MGA Zone 50
Background Image Mapbox Satellite v9

Figure 6-34 Particle tracking solution of mitigated maximum impact model for 100 years. Note each subsequent point is location after +1 year.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Pit Contours
Particle_trace
per year
IGS
Map produced 29th Oct 2020
CRS: GDA94 MGA Zone 50
Background Image Mapbox Satellite v9

Figure 6-35 Particle tracking solution of mitigated minimum impact model for 100 years. Note each subsequent point is location after +1 year.

7.3. DISCUSSION

The results of the particle tracking simulations suggest that water quality impacts at the KNP boundary are unlikely to occur as a result of injection at the MAR scheme. However, it should be noted that particle tracking represents the centre of mass of the injectant and thus does not include mechanical dispersion. On the other hand, use of overly conservative porosities greatly enhances the advective flow velocity, thereby potentially overestimating the migration of injectant centre of mass away from the MAR bores. Simulations featuring less conservative, more realistic porosities in conjunction with dispersive effects will still yield injectant fronts that migrate shorter distances than the centre of mass presented in the results.

8. Hydrograph Analysis and Grey Box Modelling to Support Trigger Development and Assessment

8.1. Observed Historical Ranges of Water Level Declines

In order to develop appropriate water level triggers for both operation of the MAR scheme and regulatory purposes, it is necessary to investigate the natural ranges of water level declines in the area around the proposed MAR scheme and Karijini National Park. This is important to ensure that water level declines that are caused by natural climatic factors and that fit within natural system behaviour are not attributed to mine impacts. The approach adopted here attempts to synthesize information contained in hydrographs by providing statistical metrics of “normal system behaviour”. The focus is on rates of water level decline because the primary concern is avoiding drawdown impacts at the KNP boundary associated with mine dewatering.

Declines in water level over specific time frames at each location and then between locations were recorded. For a single hydrograph the procedure was as follows:

1. Obtain water level of hydrograph on day 1
2. Skip forward a fixed number of days and obtain water level
3. If the difference is a decline, record the change/rate otherwise do nothing
4. Move to day 2 in the record and repeat steps 1 to 3 until the end of the record
5. Plot a histogram of the observed declines
6. Select new number of fixed days and repeat steps 1 to 5

The procedure was automated with a Python script using monitoring bore hydrographs with continuous records for the last four years. A similar Python script was developed to assess hydraulic gradients between monitoring bores across the West Angelas region. This required first developing a table of monitoring bore combinations and the distance between them. The assessment the procedure was as follows:

1. Obtain first monitoring bore combination
2. Get first recorded date in hydrograph of monitoring bore 1
3. Check for a record on the same date in hydrograph of monitoring bore 2
4. If there is a common date, calculate the gradient and record the value
5. Move on to the next date and repeat steps 3 and 4 until the hydrograph ends
6. Plot a histogram of the observed gradients
7. Move on to next monitoring bore combination and repeat steps 2 through 6.

It is considered that a head change of more than 10 cm could be confidently measured using standard monitoring techniques. Anything less than this could be attributed to equipment and/or human error. Statistics show that, for time periods less than approximately 60 days, most historical head declines recorded in the monitoring bores to the east of Karijini National Park (MB16WAW0001 to MB16WAW0010) have been less than 10 cm, i.e. within the range of possible error (IGS, 2020a). For time periods between 90 days and 360 days, head declines between 10 and 25 cm become more common. These trends are variable between bores and it should be noted that the analysis is based on approximately four years of data only.

Based on the above assessment, any observed head declines in the MB16-series monitoring bores of more than 10 cm over 30 to 60 days, or more than 25 cm over 90 to 360 days may warrant further investigation.

The above is also generally true for bore WANG14, which is situated adjacent a potential GDE within Karijini National Park. However, the hydrograph for this bore shows the occurrence of occasional rapid water level rises associated with preferential recharge due to surface water flow events. These rapid water level rises are also followed by rapid declines in water level, which correspond to water level declines of up to approximately 0.85 m over 30 to 360-day periods (IGS, 2020a). Therefore, any observed head declines up to 0.85 m (and greater) at this bore require confirmation that they are not associated with recovery of the water levels following a rapid recharge event prior to being attributed to mining impacts.

8.2. Historical Ranges of Hydraulic Gradients

As well as changes in water levels at individual points, mine dewatering impacts may be observed as an increase in hydraulic gradient towards the mine pit. Frequency analysis of hydraulic gradient between individual monitoring points have been developed. Historical measured hydraulic gradients between all MB16-series monitoring bores (for all times when there were head measurements available for both bores) range between -500μ and 450μ but are most commonly between -50μ and 50μ (IGS, 2020a) . Negative values indicate gradients approximately towards the pit, whilst positive values indicate gradients approximately towards KNP (i.e. depending on the orientation of the bore-pair). A value of 50μ corresponds to a gradient of 5 cm in 1 km. Historical gradients can be used to identify the magnitude of a negative gradient for each bore pair that would be considered outside the normal.

8.3. Grey Box Modelling to Assess Mine Contributions to Hydraulic Head Declines or Increased Hydraulic Gradients

8.3.1. Overview

Time series (TS) analysis of groundwater monitoring bore hydrographs can be used to assess the effects of climate variability, groundwater pumping, river stage variation and tides. It's application to identify the effect of land use change or engineering works has been minimal despite the development of sophisticated monitoring networks and analysis software. TS models are much simpler and give better fits than typical groundwater models. The inclusion of response functions with a TS model provides valuable insight into why heads vary at a specific location. This is preferable to using black-box modelling based on artificial intelligence. Accordingly, the term grey-box model is used synonymously with TS models that include response functions. Unlike the governing equations for a typical groundwater model (or white-box model), the response functions in a grey-box model do not explicitly represent physical processes. Nevertheless, there is always some physical basis for the inclusion of the response function/s. Grey-box modelling is therefore characterised as a semi-physical data-driven approach to find the relationship between input and output signals.

8.3.2. Methodology

The Pastas Python library (Collenteur et al., 2019) was used to perform the TS analysis and produce Grey Box models for a number of locations in the West Angelas region. Pastas is open source software for the analysis of groundwater time series and uses transfer function noise modelling to perform time series analysis. Inputs for the present analysis are:

1. an observation time series (usually the head observation hydrograph for a location)
2. stress time series such as precipitation, potential evaporation or pumping

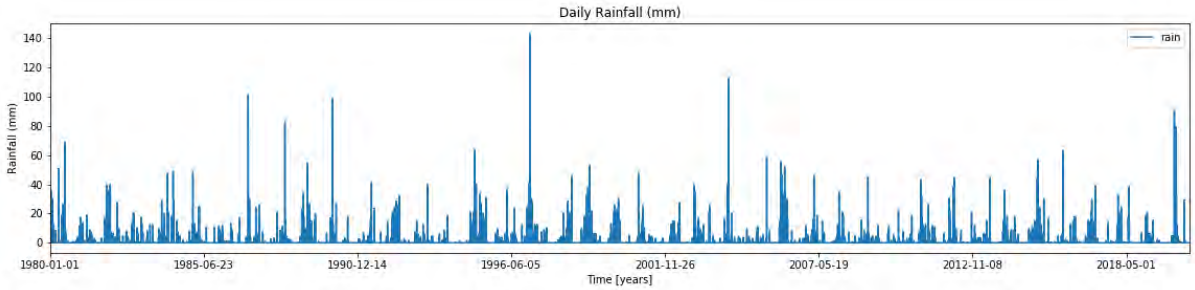
3. response functions assigned to the stresses (i.e., Gamma, Hantush or Exponential)

The Grey Box model parameters are then estimated using a non-linear least squares algorithm to minimize the sum of weighted squared noise. Models have been developed in this project for the following bores:

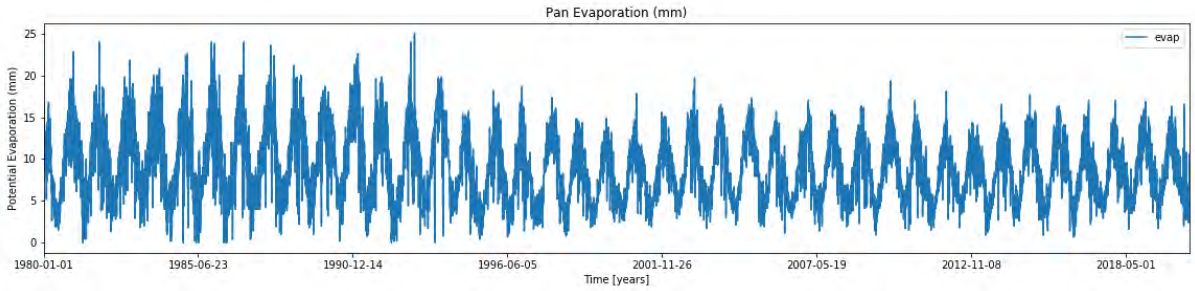
1. WANG14
2. MB16WAW0001 to MB16WAW00010

The input stresses comprise a combination of raw and processed rainfall and evaporation data from Paraburdoo weather station (

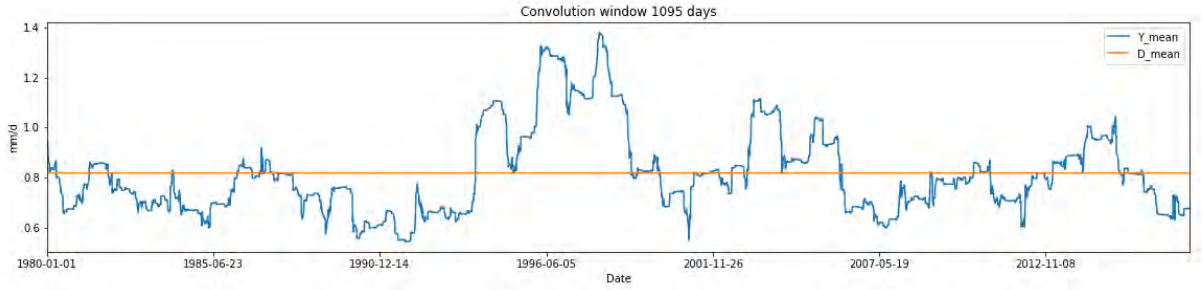
Figure 6-36). Response functions were trialed to ascertain those that produce the best fit to the observation datasets in each case. This includes multiple step functions for flow events in the ephemeral creek where groundwater levels are influenced by episodic recharge, and linear trends for wetter/dryer than long-term average periods (Figure 6-37). Steps and linear trends are linked to observations arising from processed rainfall data.



(a) Daily rainfall record.



(b) SILO interpolated pan evaporation data.



(c) 3-year rainfall running mean (blue line) compared to long-term mean (orange line).

Figure 6-36. Climate data for Paraburdoo (BoM station #7185).

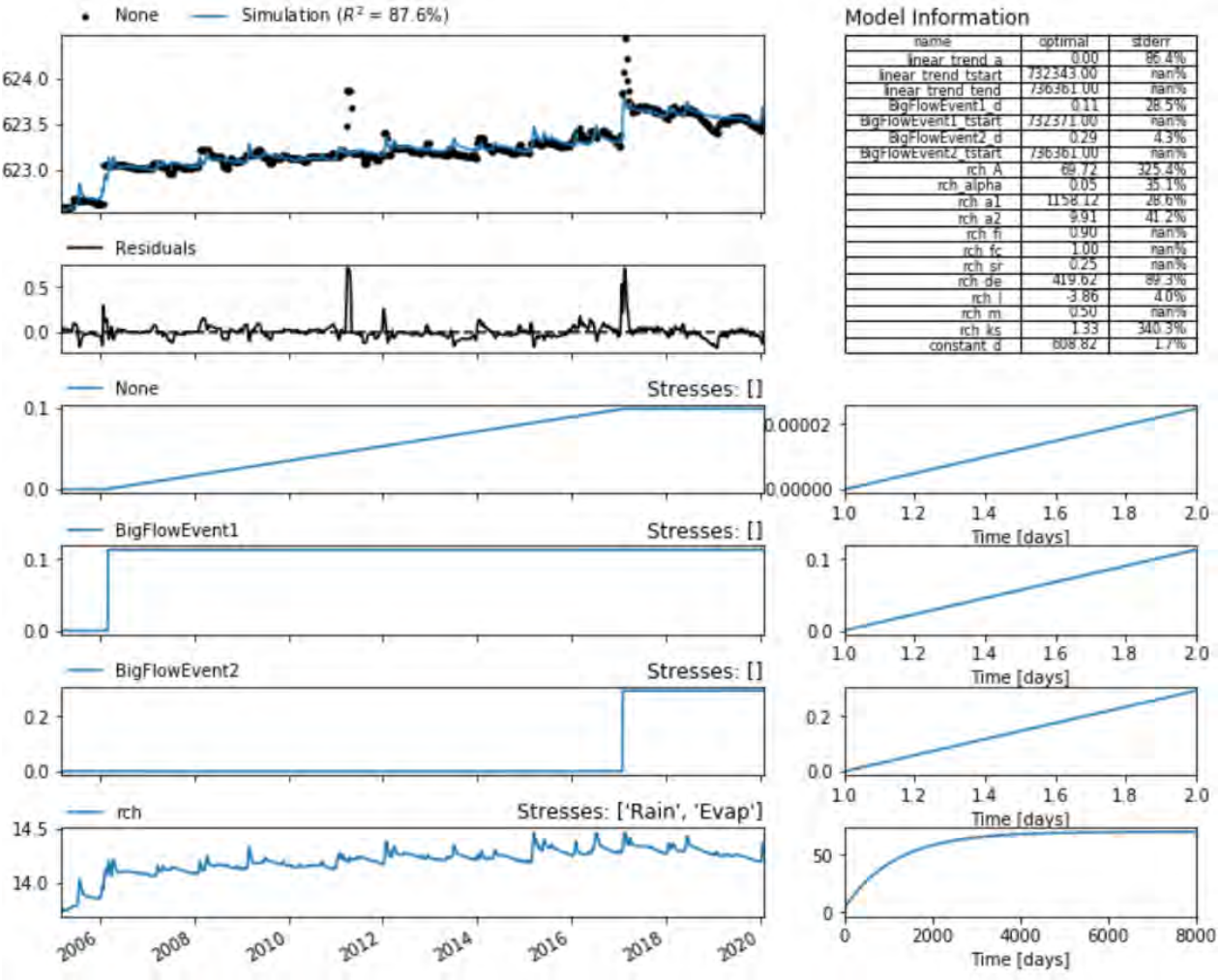


Figure 6-37. Examples of input stresses and final Grey Box Model (top graph) for observation bore WANG14, located near the potential Groundwater Dependent Ecosystem inside Karijini National Park.

8.4. RESULTS

The Grey Box Model developed for bore WANG14 is shown in Figure 6-37. Grey Box models have similarly been developed for bores MB16WAW0001 to MB16WAW0010 (IGS, 2020a). The graph plotted at the top of Figure 6-37 depicts the simulated (pale blue line) model results overlying the observation time series. An R^2 value of 87.6% was achieved with the parameter set listed in the model information table to the right of the plot. A plot of the residuals is located below the simulated output. The stresses used as inputs are then plotted sequentially below the residual plot. These include in descending order, a linear trend, two step stresses and a combined precipitation and potential evaporation stress (combined as precipitation subtract potential evaporation). To the right of each input stress is a plot of their calibrated response functions that ultimately translates the input stress to the simulated hydrograph. The step stresses were necessary to capture the effects of large macropore recharge events that result in long term increases to water table elevation. The combined precipitation and potential evaporation stress captures the increasing trend between 2006 and 2017 but to a lesser degree than what is observed in the hydrograph prompting the inclusion of a linear trend stress.

8.5. DISCUSSION

Once developed and calibrated, a Grey Box Model can be used as a tool to evaluate observed water levels against impact triggers / thresholds.

First, historical water level trends and historical maximum and minimum levels can be used to develop a set of early warning impact triggers and thresholds, whereby exceedance of these triggers would initiate a review of water level trends using the Grey Box model to determine the contribution of dewatering activities. The calibrated model parameters can be used throughout the life of mine to 'predict' water level responses as a result of trends in rainfall and evapotranspiration and therefore quantify the contribution of natural system responses to observed hydrographs. The Grey Box model is calibrated to natural head decline to assess and isolate non-natural decline associated with mine dewatering. Significant departure from the predicted system behaviour can be ascribed to anthropogenic influence triggering adjustments to MAR scheme operation. A second set of triggers specifically for mine-induced water level impacts would result in a management response.

9. Summary and Conclusions

A Managed Aquifer Recharge (MAR) Scheme is planned to offset drawdown impacts at Karijini National Park (KNP) as a result of dewatering West Angelas Deposits C and D. The West Angelas Groundwater Modelling project described herein includes several modelling tasks aimed at informing the design and operation of this MAR scheme, as well as the development of operational and management triggers. The major conclusions from the project are as follows:

Regional Model Development and Performance

A regional groundwater flow model has been developed to simulate both unmitigated drawdown impacts and the mitigation of these by the proposed MAR scheme.

Multiple calibration techniques were used in combination with both steady-state and transient water level datasets, including high-resolution temporal data from a MAR injection trial, to obtain a calibration-constrained ensemble of 558 plausible models that account for uncertainty in, amongst other things, aquifer hydraulic conductivity and storage properties.

In the ensemble of 558 models, 50% produced steady-state simulated head values within 0.5 m of observed values for the majority of observation locations. All simulated heads were within approximately 2 m of observed values.

The ensemble of models also simulates the system response behavior observed at various observation locations during the MAR trial with accuracy. Absolute hydraulic heads were not matched to the same degree, but this can be attributed to the weighting scheme adopted during the conditioning process and sub-optimal grid resolution between observation points.

Unmitigated Drawdown Impacts

Simulated drawdown impacts from dewatering of Deposit D travel more rapidly in the south of the model domain, reaching a maximum drawdown of between 1.9 and 5.2 metres within 20 years of the end of mining at the southern end of the KNP boundary. The impacts then migrate more slowly to the north, and drawdown continues to develop to more than 3.0 metres with time beyond 85 years post-mining at the northern end of the KNP boundary.

Although the water table occurs in the calcrete and weathered Wittenoom Formation across much of the study area, large uncertainty in the parameters and mode of connection of the Detritals with these formations appears to lead to large uncertainty in the simulation of drawdown impacts. This uncertainty is observed in the results of the current ensemble as two distinct groups of drawdown impacts, a low impact group (443 models) and a relatively higher impact group (115 models).

Simulation and Optimization of the MAR Scheme

The results from the unmitigated impact simulations using the complete ensemble (558 models) showed that drawdown propagates faster in the south than the north. The optimization solutions showed that the drawdown propagation can be mitigated with the southern-most bores providing the most effective use of injectant.

Because of the occurrence of two very distinct groups of 'impact' models, i.e. a 'low impact' and a 'higher impact' group, the ensemble of models was divided into these two groups for the purpose of optimization. This was done in order to achieve injection regimes that can address the full range of plausible scenarios with adequate confidence.

Two optimization methodologies were used to optimize MAR injection rates:

Method 1, PESTPP-OPT, attempts to minimise the injection volume, which is viewed in this method as a 'cost'. In doing this, the optimized injection regime does not always achieve drawdown less than the imposed constraint of 0.1 m at all observation points along the KNP boundary in all model realizations for the specified group. The optimization derived using Method 2, CMAES_P, which has a more constraint-focused objective function than PESTPP-OPT, resulted in no constraint exceedances. Rather than optimizing the full ensemble of models, this method was used to optimize MAR injection for the maximum and minimum impact models only, a simpler method that still captures the full range of potential impacts.

The bulk of the uncertainty associated with MAR injection response can be attributed to the heterogeneity in model parameters representing the weathered Wittenoom Formation and the calcrete.

The optimization simulations were implemented with annual stress periods in the interest of minimising computation times. However, in reality, injection can be varied at a much smaller temporal scale, e.g. fortnightly or monthly. Use of a finer temporal resolution would undoubtedly result in improved mitigation of drawdown impacts.

Risks of Water Quality Impacts to Karijini National Park

The results of the particle tracking simulations suggest that water quality impacts at the KNP boundary are unlikely to occur as a result of injection at the MAR scheme. While the particle tracking approach does not include the effects of dispersion, the adoption of conservatively low effective porosities for both the calcrete and weathered Wittenoom Formation means the predicted distances of injectant migration are likely overestimated and thus precautionary.

Tools for Accounting for Natural Climate Variability in Setting and Assessing Water Level Triggers

There is no data available on the episodic and spatially variable (preferential) recharge processes in the study area and therefore inclusion of spatially and temporally variable recharge in a numerical groundwater flow model is neither feasible nor would it add any additional confidence to model results. The regional model itself therefore uses a conservative value for long-term annual average recharge and does not account for these processes.

However, robust and scientifically defensible tools are required for assessing the contribution of natural climate variability to observed groundwater level declines in order to confirm the magnitudes of mining-related impacts that require mitigation.

Frequency analysis (histograms) of historical head declines for monitoring bores and historical hydraulic gradients for monitoring bore pairs are used to better understand the groundwater system behaviour and inherent variability. The histogram analysis has identified that any observed head declines in the MB16-series monitoring bores of more than 10 cm over 30 to 60 days, or more than 25

cm over 90 to 360 days may warrant further investigation using Grey Box models. These trends are variable between bores and it should be noted that the analysis is based on approximately four years of data only.

Once developed and calibrated, Grey Box Models similar to the ones described in Section 8.3 can be regularly updated with new data and used as tools throughout the life of mine to determine the relative contribution of mine dewatering to observed changes in groundwater level and/or hydraulic gradient. The Grey Box model is calibrated to natural head decline to assess and isolate non-natural decline from mine dewatering.

10. Limitations

During the process of the current project, the following key limitations of the regional groundwater flow model and MAR optimization have been identified:

Uncertainty in hydraulic properties of the Detritals: The current model design features a discrete boundary between the calcrete and Detrital aquifer delineated according to RTIO's geological model. Aquifer properties are interpolated between pilot points within zones/formations only, which results in a number of calibrated models with a definite contrast in properties across the calcrete / Detrital boundary (Figure 6-30). The magnitude of this contrast influences drawdown propagation resulting in a very large and bimodal distribution of unmitigated impacts as observed in Figure 6-26 and provides an appreciation for the influence that uncertainty in Detrital properties has over model predictions.

Dykes: The simulated region presently excludes any effects from intrusive dykes, which could potentially further inhibit drawdown propagation to the KNP boundary given their estimated strike and dip from exploration logs. There is existing evidence of dykes that are effective barriers to flow in the region (presently used as an external boundary in the model). However, the function of dykes as barriers in the region between Pit D and the KNP boundary remains unclear. A dyke may also act as a conduit for flow, but this is expected to have little impact between Pit D and the KNP because the dykes run perpendicular to the direction of drawdown propagation.

Uncertainty in Hydraulic Properties of the Weathered Wittenoom and Calcrete: The bulk of the uncertainty associated with MAR injection response can be attributed to the heterogeneity in model parameters representing the weathered Wittenoom Formation and the calcrete. Therefore, uncertainty in these parameters is a key component of the uncertainty in the optimization process.

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Appendix 4: Description of Zonal monitoring, data collection and analysis (Note: Red Text is subject to change as bore is yet to be drilled)

Monitoring Bore	Status	Total Cased Depth	Screened Interval	Screened Unit	Abstraction Volume	Injection Volume	Water Level	Water Quality frequency
Zone 1								
WB20WAD 0001	Drilled (Testing to be completed prior to Deposit D dewatering commencement)	72.4	14.2-68.2	Dolocrete/ Wittenoom Fm	Monthly meter reading	Monthly meter reading	NR	Quarterly Manual sampling (at end of Backflush)
WB20WAD 0002	Drilled (Testing to be completed prior to Deposit D dewatering commencement)	75.5	20.7-68.7	Dolocrete/ Wittenoom Fm	Monthly meter reading	Monthly meter reading	NR	Quarterly Manual sampling (at end of Backflush)
WB20WAD 0003	Drilled and Tested	89.7	22.8-82.9	Dolocrete/ Wittenoom Fm	Monthly meter reading	Monthly meter reading	NR	Quarterly Manual sampling (at end of Backflush)
WB20WAD 0004	Drilled and Tested	82	21.2-75.2	Dolocrete/ Wittenoom Fm	Monthly meter reading	Monthly meter reading	NR	Quarterly Manual sampling (at end of Backflush)
WB20WAD 0005	Drilled and Tested	59.5	22.7-52.7	Dolocrete/ Wittenoom Fm	Monthly meter reading	Monthly meter reading	NR	Quarterly Manual sampling (at end of Backflush)
WB19WAC 0001	Drilled and Tested	66	16.6-59	Dolocrete/ Wittenoom Fm	Monthly meter reading	Monthly meter reading	NR	Quarterly Manual sampling (at end of Backflush)
WB20WAC 0001	Drilled and Tested	93.3	20.4-86.5	Dolocrete/ Wittenoom Fm	Monthly meter reading	Monthly meter reading	NR	Quarterly Manual sampling (at end of Backflush)
20WAD-P05	To be drilled and tested prior to Deposit D dewatering commencement	*80*	*20-74*	Dolocrete/ Wittenoom Fm	Monthly meter reading	Monthly meter reading	NR	Quarterly Manual sampling (at end of Backflush)
Zone 2								
MB16WAW 0008	Drilled and Installed	87.5	33.5-81.5	Dolocrete/ Wittenoom Fm	NR	NR	Quarterly manual observation	Quarterly Manual sampling
MB19WAC 0007	Drilled and Installed	70	58-64	Wittenoom Fm	NR	NR	Quarterly manual observation	Quarterly Manual sampling
20WAD-M40	To be drilled and installed in 2021	*120*	*42-114*	*Wittenoom Fm*	NR	NR	Quarterly manual observation	Quarterly Manual sampling
21WAD-M01	To be drilled and installed in 2021	*120*	*42-114*	*Wittenoom Fm*	NR	NR	Quarterly manual observation	Quarterly Manual sampling
WAC_M28	To be drilled and installed prior to Deposit C dewatering commencement	*150*	*42-144*	*Wittenoom Fm*	NR	NR	*Once Drilled - Quarterly manual observation*	*Once Drilled - Quarterly Manual sampling*
WAW_M16	To be drilled and installed prior to Deposit C dewatering commencement	*150*	*42-144*	*Wittenoom Fm*	NR	NR	*Once Drilled - Quarterly manual observation*	*Once Drilled - Quarterly Manual sampling*
WAW_M17	To be drilled and installed prior to Deposit C dewatering commencement	*150*	*42-144*	*Wittenoom Fm*	NR	NR	*Once Drilled - Quarterly manual observation*	*Once Drilled - Quarterly Manual sampling*
Zone 3								
MB16WAW 0005	Drilled and Installed	88	34-82	Dolocrete/ Wittenoom Fm	NR	NR	Quarterly manual observation	Quarterly Manual sampling
MB16WAW 0007	Drilled and Installed	104	26-98	Dolocrete/ Wittenoom Fm	NR	NR	Quarterly manual observation	Quarterly Manual sampling
20WAD-M37	To be drilled and installed in 2021	*120*	*42-114*	*Wittenoom Fm*	NR	NR	*Once Drilled - Quarterly manual observation*	*Once Drilled - Quarterly Manual sampling*
20WAD-M38	To be drilled and installed in 2021	*120*	*42-114*	*Wittenoom Fm*	NR	NR	*Once Drilled - Quarterly manual observation*	*Once Drilled - Quarterly Manual sampling*
20WAC-M07	To be drilled and installed in 2021	*138*	*96-132*	*Wittenoom Fm*	NR	NR	*Once Drilled - Quarterly manual observation*	*Once Drilled - Quarterly Manual sampling*
21WAW-M03	To be drilled and installed prior to Deposit C dewatering commencement	*150*	*42-144*	*Wittenoom Fm*	NR	NR	*Once Drilled - Quarterly manual observation*	*Once Drilled - Quarterly Manual sampling*
21WAW-M02	To be drilled and installed prior to Deposit C dewatering commencement	*150*	*42-144*	*Wittenoom Fm*	NR	NR	*Once Drilled - Quarterly manual observation*	*Once Drilled - Quarterly Manual sampling*
WAW-M01	To be drilled and installed prior to Deposit C dewatering commencement	*150*	*42-144*	*Wittenoom Fm*	NR	NR	*Once Drilled - Quarterly manual observation*	*Once Drilled - Quarterly Manual sampling*
MB17WAW 0001	Drilled and Installed	130	106-124	Brockman Iron Fm	NR	NR	Quarterly manual observation	Quarterly Manual sampling

Monitoring Bore	Status	Total Cased Depth	Screened Interval	Screened Unit	Abstraction Volume	Injection Volume	Water Level	Water Quality frequency
Boundary Bores								
MB18WAW 0003	Drilled and Installed	80	59-77	Wittenoom Fm	NR	NR	Quarterly manual observation	Quarterly Manual sampling
MB19WAW 0006	Drilled and Installed	110	69-93	Wittenoom Fm	NR	NR	Quarterly manual observation	Quarterly Manual sampling
21WAD-M06	To be drilled and installed in 2021	*120*	*84-114*	*Brockman Iron Fm*	NR	NR	*Once Drilled - Quarterly manual observation*	*Once Drilled - Quarterly Manual sampling*
21TURB-M01	To be drilled and installed in 2021	*90*	*72-84*	*Brockman Iron Fm*	NR	NR	*Once Drilled - Quarterly manual observation*	*Once Drilled - Quarterly Manual sampling*
Karijini National Park Bores								
WANG14	Monitoring underway	25	22.5-25.5	Detritals/ Wittenoom Fm	NR	NR	Quarterly manual observation	*Once Accessible and Approved - Quarterly Manual sampling*
WANG07	To be accessed and telemetry deployed	65	30-50	Detritals/ Wittenoom Fm	NR	NR	NR	*Once Accessible - Quarterly Manual sampling*
WANG09	To be accessed and telemetry deployed	48	29-48	Detritals/ Wittenoom Fm	NR	NR	NR	*Once Accessible - Quarterly Manual sampling*
WANG10	To be accessed and telemetry deployed	53	46-52	Detritals/ Wittenoom Fm	NR	NR	NR	*Once Accessible - Quarterly Manual sampling*
Water Quality Control Bore								
MB16WAW 0005	Drilled and Installed	88	34-82	Dolocrete/ Wittenoom Fm	NR	NR	Quarterly manual observation	Quarterly Manual sampling
Backup Water Quality Control Bore								
MB16WAW 0007	Drilled and Installed	104	26-98	Dolocrete/ Wittenoom Fm	NR	NR	Quarterly manual observation	Quarterly Manual sampling

Appendix 5: Criteria, Monitoring Zones and Bore Summary

Monitoring zone	Bores	Groundwater Drawdown Criteria	Groundwater Drawdown Threshold	Groundwater Quality Criteria	Groundwater Quality Threshold
1	WB19WAC001	**Early Response indicator 1:** Injection bores non-operational outside of proposed plan for operation of the MAR scheme (more than 1 of a paired set of bores inoperable for more than 1 week).	NA	NA	NA
1	WB20WAC001				
1	WB20WAD003				
1	WB20WAD004				
1	WB20WAD002				
1	WB20WAD005				
1	20WAD-P05				
1	WB20WAD0001				
2	WAW_M17	**Early Response indicator 2:** Two consecutive monitoring periods of drawdown 25 cm greater than Grey Box level for modelled mitigation scenario in Zone 2 monitoring bores. **Criteria Level 1:** Two consecutive monitoring periods of drawdown 50cm greater than Grey Box level for modelled mitigation scenario.		**Early Response Indicator:** Long term pH trend in Zone 2 monitoring bores over two consecutive monitoring periods is not consistent with trend in control bore or proportional change in EC in Zone 2 bores is greater than 20% of proportional change in control bore EC over two consecutive monitoring periods. **Trigger Criteria Level 1:** Long term pH in Zone 2 monitoring bores is not between 6.5 and 8 for two consecutive monitoring periods and trend is not consistent with trend in control bore or proportional change in EC in Zone 2 bores is greater than 50% of proportional change in control bore EC over two consecutive monitoring periods.	
2	WAW_M16				
2	WAC_M28				
2	MB19WAC0007				
2	21WAD-M01				
2	MB16WAW0008				
2	20WAD-M40				
3	MB17WAW0001	**Management Target 2:** Water levels in Zone 3 monitoring bores and modelled are above or equal to rolling 3 year, seasonally adjusted water levels (mbgl). **Management Target 3:** Water levels in Zone 3 monitoring bores and modelled are above or equal to rolling 5 year, seasonally adjusted water levels (mbgl). **Management Target 4:** Water levels in Zone 3 monitoring bores and modelled are above or equal to rolling 10 year, seasonally adjusted water levels (mbgl). **Criteria Level 2:** Two consecutive monitoring periods of drawdown of 10 cm or greater than the Grey Box level for modelled mitigation scenario in Zone 3 monitoring bores or a single monitoring period of drawdown greater than 10cm in Zone 3 monitoring bores if Trigger Criteria Level 1 exceeded in the current or preceding monitoring period or a single monitoring period of drawdown greater than 10 cm or greater than the Grey Box level recorded in two or more adjacent monitoring bores	**Threshold**: Two consecutive monitoring periods of drawdown associated with the proposal of 20 cm or greater than Grey Box level for modelled mitigation scenario in Zone 3 monitoring bores or a single monitoring period of drawdown exceeding 20cm in Zone 3 monitoring bores if Trigger Criteria Level 2 exceeded in current or preceding monitoring period. or a single monitoring period of significant drawdown (over 40 cm drawdown) and the equipment is not damaged.	**Trigger Criteria Level 2:** Long term pH in Zone 3 monitoring bores is not between 6 and 8.5 for two consecutive monitoring periods and trend is not consistent with trend in control bore pH, or proportional change in EC in Zone 3 monitoring bores is greater than 50% of proportional change in control bore EC over two consecutive monitoring periods.	**Threshold Criteria:** Long term pH in Zone 3 monitoring bores is not between 6 and 8.5 for two consecutive monitoring periods and trend is not consistent with trend in control bore pH as a result of the action or proportional change in EC in Zone 3 bores is greater than 80% of proportional change in control bore EC over two consecutive monitoring periods as a result of the action.
3	WAW_M01				
3	21WAW-M02				
3	21WAW-M03				
3	MB16WAW0005				
3	20WAC-M07				
3	20WAD-M37				
3	20WAD-M38				
3	MB16WAW0007				
Boundary	MB18WAW0003	**Management Target 1:** Water levels in boundary bores to the south and north of the MAR scheme in areas outside of the regional aquifer are above or equal to rolling 3 year, seasonally adjusted water levels (mbgl).	NA	NA	NA
Boundary	MB19WAW0006				
Boundary	21WAD-M06				
Boundary	21TURB-M01				
KNP	WANG10	NA			
KNP	WANG09				
KNP	WANG07				
KNP	WANG14				