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**McArthur River Mine
Overburden Management Project**

Project Alternatives

Draft Environmental Impact Statement

5 Project Alternatives

5.1 Introduction

Chapter 3 – Project Description and Justification provides a description of the proposed Overburden Management Project (the Project) activities and infrastructure. A number of alternatives were considered and assessed for the various Project components. McArthur River Mining conducted a systematic analysis of those alternatives during the Project’s scoping and feasibility studies. The analysis of these alternatives was based on a number of criteria including environmental performance, technical feasibility (including constructability and maintenance), regulator acceptance, cost benefit analysis, cultural considerations and stakeholder benefits.

Project alternatives considered during the planning process included:

- Project versus No Project scenario;
- design alternatives for the north overburden emplacement facility (NOEF) and the tailings storage facility (TSF);
- mine layouts and configurations to improve Project outcomes, such as location of overburden emplacement facilities (OEFs);
- mine sequencing and scheduling;
- alternative processes, methods and lifecycles;
- closure and rehabilitation planning;
- consideration of alternative environmental management measures for key risks and impacts;
- various water infrastructure to capture and manage mine affected water;
- overburden and tailings disposal for long term, stable landforms; and
- final void management and closure.

The selection of the proposed development alternatives for each Project domain (refer to **Chapter 3 – Project Description and Justification**) considered leading industry practice for design, construction, operation, decommissioning and rehabilitation.

The process of selecting a preferred alternative is outlined in **Figure 5-1** below. A multi-criteria analysis (MCA) was undertaken on the key alternatives identified for the site domains. MCA is a well-researched technique that has been developed over the past number of decades to assist in evaluating alternatives against multiple criteria. It is especially useful where complex relationships exist and optimising a solution for one criterion may cause a reduction in the performance of another criterion. The development of scoring through the adoption of this approach has assisted McArthur River Mining in more informed decision making when selecting a preferred alternative (refer **Sections 5.5.2, 5.5.3 and 5.5.4** for details of the MCA of each Project domain). The preferred alternatives were then subject to further design development and impact assessment, prior to a final risk review.

In addition to identifying the preferred alternatives (presented in this chapter and discussed in detail in **Chapter 3 – Project Description and Justification**), this process has also facilitated identification of a range of other viable alternatives. These may be drawn upon by McArthur River Mining, should ongoing optimisation and performance monitoring identify a requirement or opportunity to apply adaptive management strategies or improve performance outcomes.

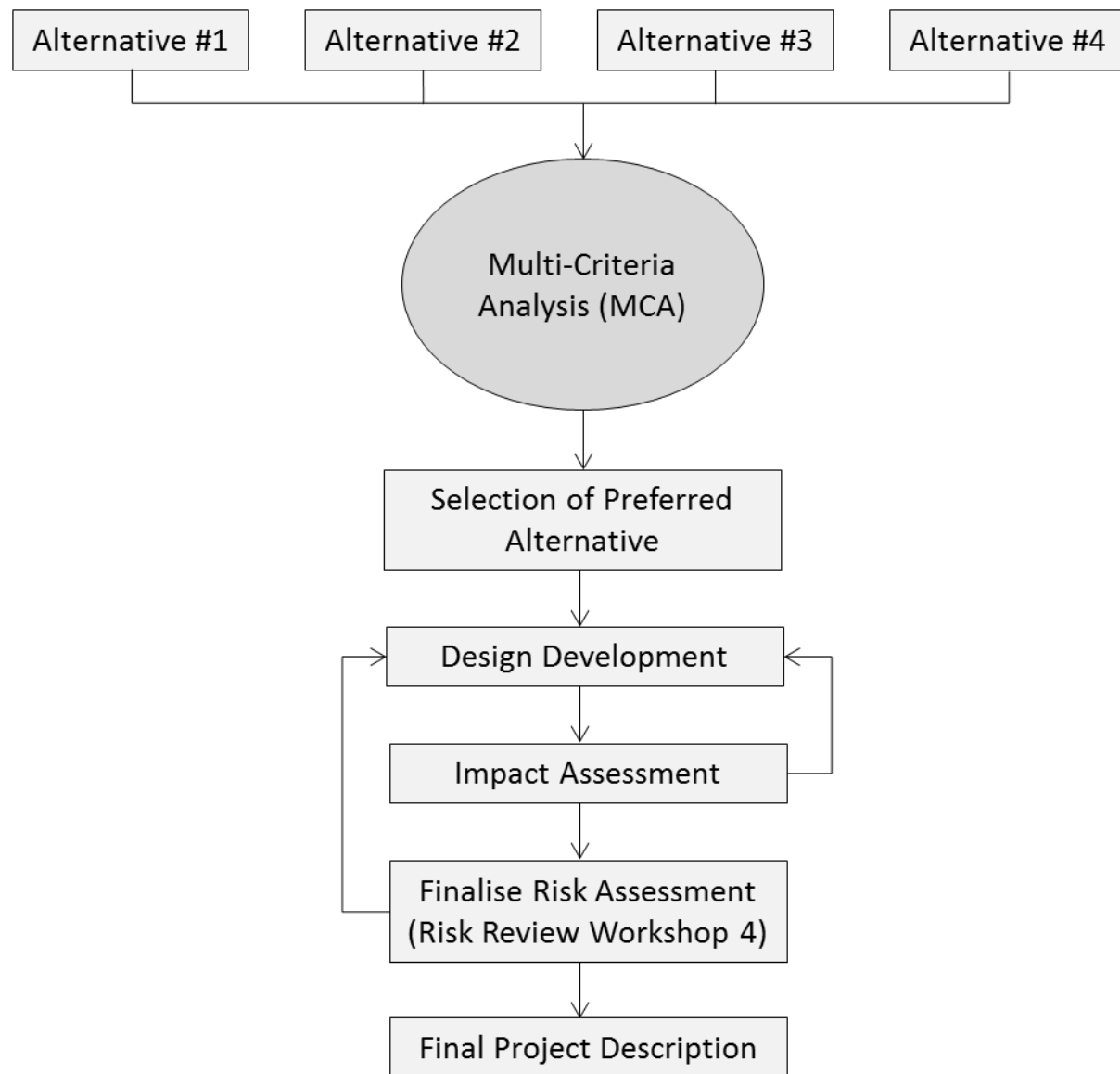


Figure 5-1 Preferred Alternative Selection and Assessment Process

5.2 Ecologically Sustainable Development

The concepts of ecologically sustainable development (ESD) are integral to the Project alternatives evaluation process, as required by the Project Terms of Reference (TOR).

Part 1 (Section 3A) of the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* provides the principles of ESD as:

- a) Decision making processes should effectively integrate long term and short term economic, environmental, social and equitable considerations.
- b) If there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation.
- c) The principle of inter-generational equity that the present generation should ensure that the health, diversity and productivity of the environment is maintained or enhanced for the benefit of future generations.
- d) The conservation of biological diversity and ecological integrity should be a fundamental consideration in decision-making.
- e) Improved valuation, pricing and incentive mechanisms should be promoted.

Glencore's Health, Safety, Environment and Community (HSEC) Committee Board establishes strategic direction for sustainability activities through policies and improvement programmes as well as HSEC assurance and sustainability. The board receives guidance from the Glencore plc Sustainability Team (the Team). The Team is dedicated to the:

- development and implementation of HSEC policies and improvement programmes, HSEC assurance and sustainability aspects of the code of conduct;
- catastrophic and fatal hazards management;
- identification of HSEC trends;
- analysis of stakeholder perceptions and understanding of the company; and
- reporting of progress against Key Performance Indicators (KPIs).

ESD principles are built into the standard operating processes and procedures for all Glencore operations. The consideration of ESD principles in the Project's planning and approval stages of the Project is further described below.

5.2.1 Integration of Economic, Environmental, Social and Equitable Considerations

Project decision-making and planning has addressed the principles of ESD by integrating the following:

- the findings of the MRM project risk assessment program;
- economic and financial modelling outputs;
- the findings of supporting environmental assessment studies; and
- outcomes of key stakeholder engagement programs.

These points have all been considered when conducting the MCA of the Project alternatives.

5.2.2 Precautionary Principle

McArthur River Mining has conducted a Project Risk Assessment (refer to **Chapter 7 – Project Risk Assessment**) to identify the hazards and risks associated with the preferred alternatives and to propose appropriate controls and mitigation measures where required. Design development and impact assessment have identified knowledge gaps, which have been addressed through various studies associated with the environmental impact statement (EIS).

5.2.3 Inter-generational and Intra-generational Equity

The principle of inter-generational equity requires the present generation to ensure that the health, diversity and productivity of the environment is maintained or enhanced for the benefit of future generations. Intra-generational equity refers to equity across communities within one generation.

As described in **Chapter 3 – Project Description and Justification**, both a short term (0-100 years) and long term (100-1,000 years) assessment of the Project has been undertaken. The potential social and economic benefits and impacts of the Project, along with mitigation measures, have been identified and quantified in **Chapter 12 – Socio-Economic Environment**.

5.2.4 Biodiversity Conservation

Conservation of biodiversity has been a fundamental consideration in Project decision-making. Existing nature conservation values have been identified and the potential impacts described and quantified in **Chapter 9 – Biodiversity**. From an ecological perspective, the Project will predominantly affect areas of remnant vegetation that have been disturbed by cattle grazing activities and localised areas of the on-lease surface water drainage system. A range of management and mitigation measures has been proposed to manage impacts on biodiversity values in order to reduce the residual risks to as low as reasonably practicable. These include rehabilitation for biodiversity conservation purposes and ongoing monitoring on-lease and off-lease as required as part of post-mining rehabilitation works.

5.2.5 Valuation Mechanisms

ESD requires that Project decision-making considers and internalises environmental costs, many of which currently fall outside the current market system. Refer to the Project economic assessment (**Chapter 12 – Socio-Economic Environment** and **Appendix Z – Economic Impact Assessment Report**) for further details.

5.2.6 Other Project Principles Supporting ESD

A number of other principles are being adopted as part of the Project development, which support and compliment the concept of ESD. These include:

- improved project design;
- adoption of a risk assessment approach to life of mine management; and
- addressing closure risk as part of design.

These principles are discussed further in the following sections.

5.2.6.1 Improved Project Design

A number of Project design related improvements are proposed, as detailed below.

5.2.6.1.1 Decreased Project Footprint in Vicinity of McArthur River

As a result of this Project the footprint of the mine at closure in close proximity to the McArthur River will be significantly less than the planned Phase 3 Development Project (Phase 3) EIS footprint due to the removal of the previously approved East OEF (EOEF) and South OEF (SOEF). **Chapter 3 – Project Description and Justification** provides further detail, including a comparison of the Project disturbance footprint between this Project and the previously approved Phase 3 EIS activities.

5.2.6.1.2 Flow through Mine Pit Lake

McArthur River Mining proposes to decommission and rehabilitate the open cut final void such that a self-sustaining flow through mine pit lake is created. It is anticipated that this alternative will gain a higher level of stakeholder acceptance than the the isolated void alternative originally proposed for the Phase 3 project. **Chapter 3 – Project Description and Justification** provides further details including the staged process to be adopted in order to achieve acceptable water quality conditions.

5.2.6.1.3 Removal of Entire TSF

Decommissioning and rehabilitation of the TSF will be undertaken to achieve the site closure objectives as detailed in **Chapter 4 – Closure, Decommissioning and Rehabilitation**. This will include removal of the entire TSF domain at closure, with all tailings to be rehandled back into the open cut final void. In addition, the TSF walls and buttress will be removed, the TSF footprint reshaped/re-contoured, a topsoil layer installed and a revegetation program undertaken. All borrow pits will also be topsoiled and revegetated.

It is anticipated that this alternative will gain a higher level of stakeholder acceptance than the alternative originally proposed for the Phase 3 project whereby all deposited tailings were to be retained at the TSF, with subsequent re-profiling of the TSF and capping with a benign cover. **Chapter 3 – Project Description and Justification** provides further details.

5.2.6.2 Risk Assessment Approach to Life of Mine Management

As detailed in **Chapter 3 – Project Description and Justification**, the Project will be developed in accordance with the Project design philosophy and closure objectives. The design philosophy is driven by the closure objectives, and focusses on managing and mitigating key long term environmental risks from the outset, as part of the Project design and operations phases. This approach reduces the reliance on the post-mining phase to address potential long term environmental risks.

The Project design philosophy includes implementation of a rigorous design program and (upon approval) implementation of comprehensive risk-based operational development and management. This includes a proposed staged management approach, which extends beyond the cessation of operations. The approach includes development of a number of stages within separate short term and long term timeframes, which include adaptive management as a short term management tool. Refer to **Chapter 3 – Project Description and Justification** for further details. The design process has also identified a number of alternatives and contingencies available to support the management of environmental performance. These will be drawn upon where monitoring indicates an altered approach to achieving the closure objectives is required.

5.2.6.3 Addressing Closure Risk as Part of Design

A number of planning and design related risk management measures have been adopted to support the preparation of this EIS. This has included several risk review workshops to assist with the planning of potential closure models and to inform preferred design selection. A number of Failure Modes and Effects Analysis (FMEA) workshops were initially held to identify the risks associated with design alternatives and potential mitigation measures. As reported by O’Kane Consultants (2016), the FMEA approach, which supported the McArthur River Mining risk management framework, is an engineering tool and can be used to inform and support the design process at any stage of a project. It is a top-down/expert-system approach, which systematically identifies risks, quantifies potential risk magnitude and prioritises risks that are identified. A final risk review workshop was held to consolidate all previous Project risk review findings. **Chapter 3 – Project Description and Justification** and **Chapter 7 – Project Risk Assessment** discuss the MRM risk identification, assessment and management approach in more detail.

5.3 Consideration of Matters of National Environmental Significance

Chapter 10 – Matters of National Environmental Significance provides a discussion of key Project alternatives and their impacts on relevant matters of national environmental significance. A more detailed assessment of the alternatives on broad environmental criteria is presented in this chapter.

5.4 Project vs No Project

As detailed in the Phase 3 EIS, the main consequence of not proceeding with the Project would be that a globally significant base metals resource would not be developed to its full potential, with associated socio-economic benefits unrealised. Local, regional, Territory and Australian economies would not benefit from the employment, trade and export opportunities that the Project provides in addition to the generation of significant government mining royalties and taxes.

The Project comprises one of the largest known zinc deposits in the world. The MRM site is an existing brownfield development that has been in operation for over 20 years. The operation is managed and regulated within a well-developed regulatory system, providing stringent controls on environmental and socio-economic performance. If this deposit is not developed, the existing market demand for zinc and lead will remain, and it could reasonably be expected that another mining operation (potentially located in a less regulated environment) will supply this market shortfall. From a net global perspective, this may lead to less favourable environmental, social and economic outcomes.

Existing approvals provide that the mine can continue, in its current form, until approximately 2020. However, should the Project not be approved, a revision to current operating plans would be evaluated. Any material changes to the Project may result in the loss of economic benefits for the Northern Territory and Commonwealth. With the proposed scale of the Project, it presents a rare opportunity to positively contribute to the community in an ongoing self-sustaining way across multiple generations. This will be achieved through provision of long term social initiatives including employment creation, skills development and improvements in health and education. The economic benefits associated with the Project are detailed in **Chapter 12 – Socio-Economic Environment**, and indicate that considerable benefits will not be realised should the Project not proceed.

Early closure of the operation (the No Project scenario) would also present an unfavourable environmental outcome. This EIS presents detailed closure proposals for the open cut, NOEF and TSF. The success of these proposals relies on the full development of the operation.

It is unlikely, considering Government positions on resource stewardship, that substantial quantities of fill would be placed in the open cut final void with a significant resource remaining within the deposit. This would preclude the preferred TSF solution of rehandling of tailings back into the open cut final void. It is more likely the site would have a prolonged period of care and maintenance waiting for management solutions or regulatory direction, which could delay the implementation of final closure works and hence increase the environmental risks during that period.

The closure of the NOEF is to be managed, in part, by the development of the future NOEF around the existing material, utilising improved design and construction methodologies. Early closure would limit the opportunities for implementation of these proposals.

5.5 Project Domain Alternatives

5.5.1 Introduction

The Project comprises three domains including the open cut, NOEF and TSF. A detailed description of these is provided in **Chapter 3 – Project Description and Justification**.

Key alternatives within each domain were subject to an MCA. This included alternatives for the following broad aspects:

- open cut final void closure and rehabilitation;
- NOEF design;
- NOEF cover systems;
- NOEF closure and rehabilitation;
- TSF design; and
- TSF closure and rehabilitation.

The analysis of each alternative was semi-quantitative in approach, and considered the following four equally weighted key criteria, which have been developed in accordance with the Glencore corporate risk framework and the principles of ecological sustainable development.

- Environmental Performance, the expected performance against both environmental regulatory compliance obligations and the site closure objectives;
- Constructability and Maintenance, the degree of construction and maintenance complexity, which can provide an indication of the level of confidence that the proponent can have in achieving the desired outcome at the forecast cost;
- Financial Cost, including consideration of budgeting and Project viability impacts; and
- Societal and Stakeholder Benefits, the degree to which the alternative impacts workforce numbers and/or planned community investment projects, services, taxes and royalties.

Table 5-1 below provides a general description of these assessment criteria, with **Table 5-2** providing further detail on how these criteria were individually defined in terms of effects. **Table 5-3** provides a summary of Project domain alternatives considered.

The scoring for each criterion was informed by the collective professional experience of MRM personnel and supporting technical specialists from the following organisations:

- MET Serve;
- WRM Water and Environment Pty Ltd;
- Klohn Crippen Berger Ltd;
- O’Kane Consultants Pty Ltd;
- GHD;
- Ecological Management Services;
- Indo Pacific Environmental;
- Tropical Water Solutions;
- University of Queensland;
- Todoroski Air Sciences;
- Creative Territory Pty Ltd;
- Aurecon; and
- RACAD.

Refer to **Appendix C – EIS Project Team** for further details.

The analysis included the assignment of scores to compare the alternatives in the context of the following effects, as per the TOR requirements:

- short term effects (0-100 years duration), including:
 - local level effects (within the mining lease); and
 - regional level effects (beyond the mining lease).
- long term effects (100-1,000 years duration), including:
 - local level effects; and
 - regional level effects.

Detailed analysis of alternatives was not considered necessary for some less significant Project alternatives, and hence an MCA was not applied. They were, however qualitatively assessed and have been discussed throughout this chapter. These included alternatives for:

- open cut expansion location;
- continuation of open cut mining versus reverting back to underground mining;
- location of the expansion of the NOEF;
- NOEF surface cover material selection;
- site-wide water management; and
- site-wide sourcing of benign materials.

The analysis of all alternatives was based on a series of assumptions, and these have been detailed throughout this chapter in the relevant sections. Note that some of the assumptions utilised in the assessment of alternatives were preliminary at the time of the MCA and were subsequently clarified through the technical assessment phase of the EIS.

Table 5-1 Assessment Criteria Definitions and Scoring

Assessment Criteria	Score Range	Description
Environmental Performance	5	Alternative is anticipated to have a low impact. No observable effect anticipated.
	4	Alternative is anticipated to have a minor impact, either localised (within the Project area) or short term (6-12 months).
	3	Alternative is anticipated to have a moderate impact, either localised, contained within the mining lease but have anticipated deleterious effects on valued ecosystem components, or off-lease, with deleterious effects on valued ecosystem components anticipated but for < 2 years duration.
	2	Alternative is anticipated to have a major impact, with extensive deleterious effects on valued ecosystem components anticipated, and medium-term (2-10 years) impairment of ecosystem function; including to the downstream catchment.
	1	Alternative is anticipated to have a catastrophic impact, with serious long term (> 10 years) impairment of ecosystem function anticipated; with off mine lease impacts anticipated to the downstream catchment.
	NA	A score cannot be reliably assigned to this criterion, either because it is not applicable or there would be no foreseeable difference in criteria scoring across each alternative.
Constructability and Maintenance	5	Construction or maintenance is of low complexity.
	3-4	Construction or maintenance may involve some complexity.
	2	Complex construction or maintenance.
	1	Construction or maintenance methodology excessively complex to justify alternative.
	NA	A score cannot be reliably assigned to this criterion, either because it is not applicable or there would be no foreseeable difference in criteria scoring across each alternative.
Financial Cost	5	Alternative can be funded within current budget, with no negative impact on Project viability.
	4	Alternative will have minor undesirable effects on company finances and budgeting, and pose minor restrictions on operations.
	3	Alternative will have moderate effect on company finances and budgeting, and poses moderate restrictions on operations, which could potentially lead to sub-optimal Project development.
	2	Alternative will have major effect on company finances and budgeting, and poses restrictions on operations, leading to sub-optimal Project development.

Assessment Criteria	Score Range	Description
Societal and Stakeholder Benefits	1	Alternative will have unsustainable effect on company finances and budgeting, and create inability to continue operations leading to Project closure.
	NA	A score cannot be reliably assigned to this criterion, either because it is not applicable or there would be no foreseeable difference in criteria scoring across each alternative.
	5	Alternative has a low impact, with no negative impact on workforce numbers and/or planned community investment projects, services, taxes and royalties.
	4	Alternative will have a minor impact, with minor influence on workforce numbers and/or planned community investment projects, services, taxes and royalties.
	3	Alternative will have a moderate impact, with moderate influence on workforce numbers and/or planned community investment projects, services, taxes and royalties.
	2	Alternative will have a major impact, with major influence on workforce numbers and/or planned community investment projects, services, taxes and royalties.
	1	Alternative will have a catastrophic impact, with a resulting cessation in employment and associated community investment projects, services, taxes and royalties.
	NA	A score cannot be reliably assigned to this criterion, either because it is not applicable or there would be no foreseeable difference in criteria scoring across each alternative.

Table 5-2 Criteria Definitions by Effect

Criteria	Effects			
	Local level	Regional level	Short term	Long term
Environmental Performance	Environmental compliance performance within the mining lease only	Environmental compliance performance beyond the mining lease	Environmental compliance performance within first 100 years of alternative implementation	Environmental compliance performance from 100-1,000 years after alternative implementation
Constructability and Maintenance ¹	Complexity of construction and maintenance and its impact within the mining lease	Complexity of construction or maintenance and its impact beyond the mining lease.	Complexity of construction and its impact within first 100 years of alternative implementation	Complexity of maintenance and its impact 100-1,000 years after alternative implementation
Financial Cost	Financial effects to MRM within the mining lease	Financial effects to MRM beyond the mining lease	Financial effects felt to MRM within first 100 years of alternative implementation	Financial effects to MRM felt 100-1,000 years after alternative implementation
Societal and Stakeholder Benefits	Level of benefits within the mining lease (e.g. MRM site workforce)	Level of benefits beyond the mining lease including off-lease purchase of goods and services and associated employment creation (e.g. in regional communities), investment in community infrastructure, payment of taxes and royalties.	Level of benefits expected within 100 years of alternative implementation	Level of benefits expected 100-1,000 years after alternative implementation

1. Assumes construction activities conducted in the short term, but these convert to maintenance activities in the long term

Table 5-3 Summary of Project Domain Alternatives Considered

Domain	Stage	Component	Preferred Alternative ¹	Other Alternatives Considered
Open cut	Closure and Rehabilitation	Closure Alternatives	Alternative 4 – Flow through mine pit lake as secondary path	Alternative 6 – Managed isolated mine pit lake Alternative 5 – Mine pit lake with backwater Interaction Alternative 3 – Flow through mine pit lake Alternative 1 – Isolated mine pit lake with passive filling (Phase 3 proposal) Alternative 2 – Isolated mine pit lake with active filling Alternative 8 – Partial backfill of final void Alternative 7 – Complete backfill of final void
NOEF	Design	Height, Footprint, Batter	Alternative 1b – 140 m height with trilinear batter configuration	Alternative 1c – 140 m height with 4h horizontal to 1 vertical (4H:1V) batter slopes Alternative 2b – 80 m height with trilinear batter configuration Alternative 2c – 80 m height with 4H:1V batter slopes Alternative 1a – 140 m height with 2.5H:1V batter slopes Alternative 2a – 80 m height with 2.5H:1V batter slopes Alternative 2d – 80 m height with steep (angle of repose) batter slopes Alternative 1d – 140 m height with steep (angle of repose) batter slopes
		Cover System	Alternative 3 – Oxygen barrier cover system ²	Alternative 5 – Bituminous geomembrane (BGM) Alternative 2 – Enhanced store-and-release cover system Alternative 4 – Two barrier layer cover system Alternative 1 – Store-and-release cover system
	Closure	Closure Alternatives	Alternative 1 – Retaining all deposited overburden in OEFs external to the open cut	Alternative 2 – Rehandle all material back into open cut Alternative 3 – Rehandle part of the material back into the open cut
TSF	Design and Construction	Tailings Disposal	Alternative 2 – Slurry tailings cells 1 & 2	Alternative 3 – Paste tailings cells 1 & 2 Alternative 2a – Slurry tailings cells 1 & 2 with mud farming Alternative 1a – Slurry tailings cells 2 & 3 with mud farming Alternative 1 – Slurry tailings cells 2 & 3 Alternative 5 – Filtered tailings co-disposal Alternative 4 – Filtered tailings

Domain	Stage	Component	Preferred Alternative ¹	Other Alternatives Considered
	Closure	Closure Alternatives	Alternative 3 – Tailings reprocessing, with in-pit placement of reprocessed tailings	Alternative 2 – Tailings directly back into open cut void Alternative 1 – Tailings to remain in-situ and TSF capped

1. The alternative was then subject to further design development and impact assessment, prior to a final risk review.
2. Alternative 5 initially scored higher, however it did present a number of risks. Alternative 5 may be considered further subject to confirmation of a number of risk issues.

5.5.2 Domain 1 – Open Cut

5.5.2.1 Design Alternatives

As the Project comprises a continuation of existing mining activities, the design of the open cut is influenced by the existing design and footprint (as detailed within the Phase 3 EIS), which has been dictated by the location and characteristics of the orebody.

Previous modelling of Project mining alternatives has been undertaken and has considered the following:

- site geology;
- ore quality;
- topography;
- production rates of various ore types;
- existing mining methods and extent of operations;
- ore processing methods;
- transportation needs; and
- potential environmental influence and impacts.

The geometry of the MRM deposit has the orebody dip predominantly in the range of 15 to 25 degrees. This range is highly unsuitable for underground mining because it is too steep for mobile vehicles to easily traverse and too flat for broken rock to be moved under gravity. In addition, there are multiple orebodies separated by intervening waste beds. The thickness of these waste beds is insufficient to allow for the effective extraction of the ore while leaving the waste behind without backfilling, but they are too thick to include with the ore and still be economic. These factors led to the underground mine being based on room-and-pillar mining in only two of the seven orebodies, with occasional bulk stopping where grades were higher and waste beds were thinner. These methods are intensive yet only allow an extraction rate of up to 40% of the available ore in those targeted beds. Studies undertaken from 2001 to 2003 examined backfilling options and higher mining rates but could not yield a feasible Project. Since the mine was converted to open cut mining and the underground operation terminated, the underground workings have been allowed to fill with water. This would rust the ground support that was installed in the tunnels, possibly flush out joints and generally reduce the stability of the rock mass.

Converting back to a solely underground mine raises some issues. Prior to re-opening of the underground mine, large scale backfilling of the underground voids would be required in order to stabilise the ground and re-distribute the rock stresses induced by open cut mining. Due to the extensive workings with flat dips, this operation would be technically difficult and expensive, requiring a large number of fill holes and complex fill distribution. Water would need to be released from the tunnels as they were filled, requiring additional drill holes. If water was trapped, there is the risk that it could be released in an outburst when nearby mining was recommenced, hence creating additional risks to worker safety.

The underground mine would require dewatering, and need to be maintained in a relative dry state. Underground personnel would also be exposed to the risks of water inrush from storm events. Regular disruptions could be anticipated in the wet season that would halt operations.

The production rate would be limited, and insufficient to match the capacity of the expanded plant. The resultant lower throughput would further reduce the economic viability of the operation.

All of these above considerations have rendered large scale underground mining technically challenging and economically unviable, although the potential for opportunistic, localised, small scale underground mining will be considered in the future. However, no such alternatives are presented in **Chapter 3 – Project Description and Justification**.

Open cut mining allows for efficient recovery of the in-situ resources within the open cut, including a number of orebodies that would be technically unviable by underground mining methods. Therefore, continuation of mining of the open cut is proposed.

5.5.2.1.1 Small Scale vs Large Scale Open Cut Mining

The feasibility of developing a smaller scale Project has also been considered. The original open cut project as planned prior to the Phase 3 project was a smaller scale open cut at a lower mining and processing rate. The current open cut has almost reached the previously proposed final extent of that initial phase. Hence, the small scale open cut alternative is almost complete.

The Phase 3 project sought to expand the size of the economic open cut (increasing the utilisation of the resource) by processing ore at a faster rate, which required a significant capital investment in infrastructure. In the long term, the improved economics of faster processing was forecast to pay off the capital investment and gain access to an advantageous natural geometric feature of the deposit. The eastern side of the ore deposit features a fold that results in a substantial increase in the quantity of ore available in the last and deepest open cut stage. This is what drives the size of the optimal open cut. Ceasing mining prior to completion of this stage would result in a significant reduction in ore reserves and financial output from the Project, while not avoiding the requirement to manage tailings and overburden in the long term. Thus, the management of environmental risks would still be applicable, though with substantially reduced financial resources to address them. A smaller open cut was therefore not considered any further.

5.5.2.1.2 Mining Sequencing and Scheduling

The sequencing and scheduling of mining activities has been refined via mine optimisation modelling. This has taken into consideration a number of input factors including the latest material classification data (as described in **Chapter 6 – Materials Characterisation**). Refer to **Chapter 3 – Project Description and Justification** for further details on mine sequencing.

5.5.2.2 Closure and Rehabilitation Planning

5.5.2.2.1 Key Alternatives

The key alternatives for open cut closure and rehabilitation planning include:

- in-pit dumping (IPD) of overburden versus no IPD, including high pyrite, potentially acid forming (high capacity) (PAF(HC)) material;
- in-pit tailings disposal versus tailings remaining within the TSF;
- active filling (with river water) of the open cut final void versus passive filling; and
- isolated mine pit lake versus various alternatives for interaction with the McArthur River.

5.5.2.2.1.1 In-Pit Dumping of Overburden vs No In-Pit Dumping

Three IPD alternatives were considered:

- no IPD;
- large scale IPD; and
- small scale IPD.

No IPD would require all the overburden material to be placed in external OEFs, with potential larger scale impact on land disturbance footprint and material transport and handling impacts.

Large scale IPD is a commonly used approach in strip coal mines and would minimise the need for external OEFs; however, this approach is not practical for the MRM open cut operation due to a number of factors.

The geometry of the deposit is not amenable to large scale dumping. The economic MRM orebodies extend to a depth of approximately 415 m below surface over a strike length of approximately 850 m, with a steep footwall (from 15° to 30°), whereas coal mines using the strip method are typically less than 100 m deep over a strike length of several kilometres and have gently dipping (less than 15°) footwalls. Previous planning undertaken on strip mining at MRM indicated in the order of 75% of the overburden would have to be mined before any substantial waste quantities could be placed in the open cut; thus, the method would still require a large external OEF. High seasonal rainfall and the geotechnical properties of the footwall cutback rock are further restrictions on the safe geometry of the IPD while operations were in progress. Therefore, this style of pit staging was not considered further. **Section 5.5.2.2.2.7** and **Section 5.5.2.2.2.8** provide further detail on assessment of these large scale IPD alternatives.

The opportunity exists to conduct small scale IPD over the last approximately six years of the mine life when the geometry of the open cut and safety conditions permit. Only limited overburden is required to be mined relative to ore quantities (refer to **Chapter 3 – Project Description and Justification**). This was the preferred alternative.

Two different IPD scenarios have been considered, with further investigation works planned on each concept as part of the detailed Project design. These include a larger IPD operated by tipping over the orebody footwall from the west (west IPD) for the last 10-12 years of operations, and a smaller IPD in the northwest corner of the final void (north IPD) operational for the final approximately six years of the mine life. The smaller IPD could also be located in the southwest corner of the final void if geotechnical and production issues indicated it to be preferred.

Figure 5-2 below provides details of the west IPD concept design. As the mining stages progress towards the east, the IPD would follow from the west. This would result in operations progressing down-dip (below) the advancing IPD.

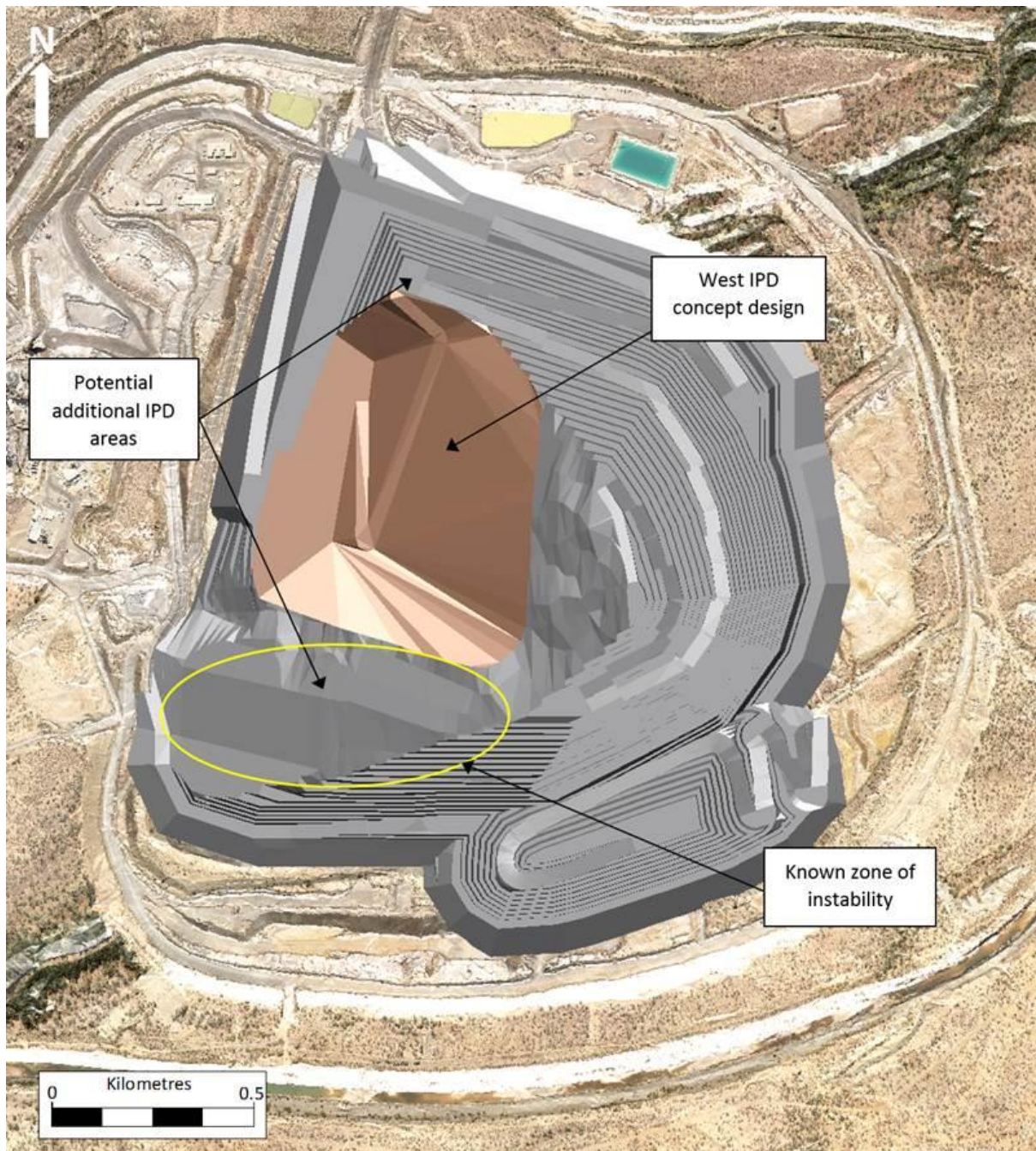


Figure 5-2 West IPD Concept Design

While the west IPD scenario would enable a significantly greater volume of overburden to be placed back into the open cut final void (approximately 20 million cubic metres (m^3) versus 8 million m^3 for the north IPD scenario), there are two major challenges to overcome before this alternative could be implemented: the stability of the footwall on which the IPD will be situated; and health and safety issues associated with working below the advancing IPD face, both in terms of geotechnical stability and gas production. Sections of the footwall exposed in the current mining stages, even after reducing their overall angle to 22° , continued to show signs of instability prior to mechanical stabilization.

The smaller north IPD scenario is the most advanced at this stage and has therefore been proposed as the preferred design within the EIS Project description. Refer to **Chapter 3 – Project Description and Justification** for a more detailed description of this north IPD scenario.

5.5.2.2.1.2 *In-Pit Disposal of High Pyrite Overburden vs Placement in the NOEF*

Overburden characterisation has identified discrete zones of PAF(HC) overburden with high pyrite grades that are scheduled to be mined in the latter years of mining (refer to **Chapter 6 – Waste Characterisation** for quantities and stratigraphic location). This small volume of material has the capacity to generate the largest amount of potential acidity of all MRM mined overburden. The optimal long term storage for this material (and PAF(RE)) would be sub-aqueous disposal, as it is highly effective in limiting oxidation. The only location for long term sub-aqueous disposal of this material is in the mine pit lake. While the mining schedule and quantities preclude PAF(RE) from being stored sub-aqueously in the mine pit lake, the limited volume and late mining of the high pyrite PAF(HC) overburden presents an opportunity to lower the environmental risk posed by this material, and thus lower the overall long term acid and metalliferous drainage (AMD) risk on site.

If the high pyrite material was to be stored in the NOEF, it would be placed in PAF(RE) cells using the same geometries, construction methods and layers, and be located in the core zone of the NOEF. This would provide effective containment in the long term.

Alternatively, temporary cells developed with the same principles as the PAF(RE) cells are proposed for part of the EOEF footprint (refer to **Chapter 3 – Project Description and Justification**). In order to limit oxidation of the material, this structure will need to be designed to manage the risk of spontaneous combustion and AMD during the time the overburden material is stored above-ground. The EOEF footprint will have a low permeability base directing seepage toward the open cut and collection drains. The cells will then be constructed on top of the base pad, and remain there during the rest of the mining operation. After the cessation of mining, during the tailings deposition phase, the stockpiles will be re-handled and placed into the final void to be permanently inundated.

Despite the extra costs of rehandling the high pyrite cells, the preferred alternative has been selected as short term (temporary) storage in the EOEF prior to longer term, sub-aqueous disposal in the final void after the cessation of mining.

5.5.2.2.1.3 *In-Pit Tailings Disposal vs Tailings Remaining within the TSF*

The Phase 3 EIS proposed to rehabilitate the TSF by:

- retaining the tailings within the existing TSF footprint;
- re-profiling the TSF to manage surface water runoff;
- constructing a cover layer to limit NP of rain into the tailings; and
- collecting and removing recoverable seepage water via recovery bores.

As detailed in **Chapter 3 – Project Description and Justification**, additional MRM planning and design work has identified a second alternative; that of in-pit tailings disposal (either via direct tailings rehandling or via the preferred alternative of initial reprocessing then disposal). This will involve the relocation of tailings (via hydraulic pumping) from the TSF to the open cut final void, either directly via a pipeline, or via initial reprocessing through the on-site processing plant then subsequent pumping of the reprocessed tailings into the open cut. Reprocessing is the preferred case.

This in-pit tailings disposal alternative provides for an improved long term strategy and removes the requirement for long term maintenance and management of the TSF at closure.

With respect to this in-pit tailings disposal alternative, the tailings would not be displacing NOEF material (or even PAF(RE)) from the open cut final void. There is sufficient capacity within the final void to accommodate most of the NOEF material; however the financial cost associated with this would inhibit Project feasibility.

5.5.2.2.1.4 *Passive Filling Of the Open Cut Final Void vs Active Filling*

Passive filling of the open cut final void includes natural inflows from ground water recharge (including surface/paleochannel water) and direct rainfall and localised surface runoff. The slow rate of filling would create a longer timeframe for the exposed void walls to oxidise, and this could negatively impact on mine pit lake water quality. Similarly, the extended timeframe allows more evapo-concentration of the waterbody; contributing to poorer mine pit lake water quality.

The preferred alternative of active filling of the open cut final void would include accelerated recharge from the McArthur River via pumping. This alternative would reduce oxidation rates of the final void walls and any materials stored in the void, resulting in a significantly improved void water quality and/or reduce the need for mitigation of water quality after the open cut is water-filled.

5.5.2.2.1.5 *Isolated Mine Pit Lake vs Alternatives for Interaction with the McArthur River*

The isolated mine pit lake alternative comprises the establishment of mine pit lake conditions where there is minimal mine pit lake water connection to the external drainage network (in this case the McArthur River and Barney Creek Channel). This would be achieved through maintaining the existing mine levee wall around the open cut, and maintaining the water level in the mine pit lake below the level where permeable pathways to external waters exist.

The preferred alternative of interacting with the McArthur River comprises breaching one or multiple sections of the mine levee wall to facilitate interaction with the McArthur River system under a variety of flow regimes.

5.5.2.2.2 *Closure Alternatives*

A total of eight closure alternatives were evaluated, as outlined below, with the preferred being Alternative 4 (flow through mine pit lake as secondary path). Each of these alternatives has considered the five key components as identified above.

For each closure alternative considered, a common assumption was that mine pit lake water could be transported in groundwater in the palaeochannel and shallow weathered bedrock zones; with the key difference between the alternatives being the quality of that water and the likelihood of it being transported.

5.5.2.2.2.1 *Alternative 1 – Isolated Mine Pit Lake with Passive Filling*

This alternative maintains an intact mine levee wall, with minimal surface water connection to the external flood waters (refer **Figure 5-3**). However it is assumed that there is still a connection between external surface water and inflows to the mine pit lake through groundwater. The final void is allowed to flood through groundwater seepage and rainfall recharge.

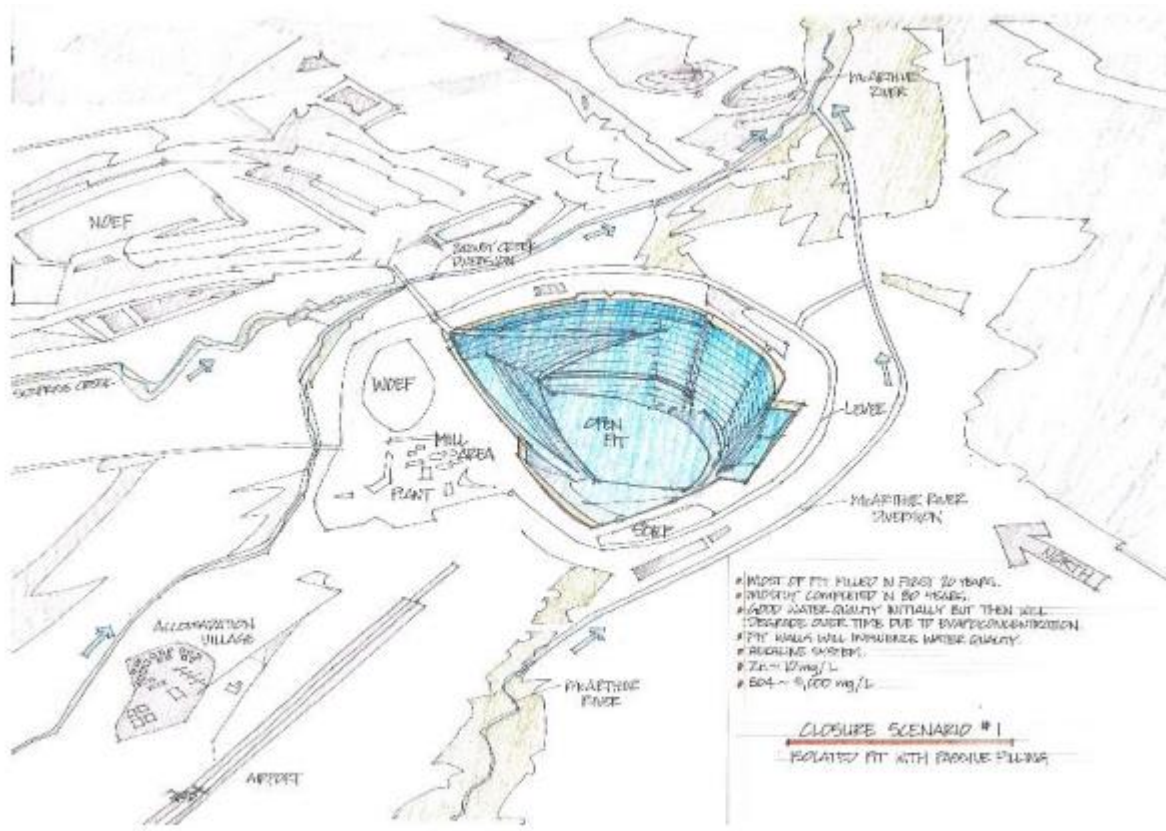


Figure 5-3 Alternative 1 – Isolated Mine Pit Lake with Passive Filling

The key assumptions for this alternative include the following:

- groundwater and rainfall recharge of the open cut final void;
- the filling rate would see most of the final void filled in the first 20 years, and complete filling by 80 years;
- the mine levee wall remains intact and maintained (levee design for 1 in 500 flood level plus freeboard);
- surface water inflows from external sources to inside the mine levee wall will occur when greater than 1:500 year flood events occur;
- mixing of upper mine pit lake layers will occur during filling;
- stratification of the mine pit lake is influenced by temperature of inflows and low total dissolved solids (TDS);
- the mine pit lake will exhibit enhanced thermal stratification due to warmer weather resulting in a warmer top layer in the water column;
- standard rehabilitation techniques would be applied to the pit edge (e.g. scaling and battering, abandonment bunding and signage); and
- no water treatment.

In Alternative 1, connectivity remains between the mine pit lake and McArthur River via palaeochannels and other potential flow paths. The final water level in the mine pit lake will be similar to the river water level. This would place it in the alluvium zone of the open cut, above the rock interface in most areas, so on-going oxidation of final void walls would be limited. This water level would result in intermittent exchange of mine pit lake water and groundwater in the upper levels.

The key advantages of this alternative include:

- low capital cost; and
- infrequent interaction with McArthur River.

The key potential risks identified for this alternative include:

- contamination of the mine pit lake water from the final void walls, overburden backfill and tailings material placed in the base of the open cut due to the extended length of time taken to cover these and reduce oxidation;
- water quality will decrease over time until large floods overtop the mine levee wall;
- illness or death of fauna coming into contact with the long term mine pit lake water if long term water quality is poor;
- water could soften the joints of rock, wash out infill clays and lead to instability or further oxidation pathways for water and air (this is mainly relevant to W-Fold shale on the west wall), increasing the risk of wall failure;
- prolonged exposure of the final void walls to weathering above the mine pit lake level will reduce wall stability;
- potential for a sudden wall failure leading to a tsunami effect in the mine pit lake;
- mine levee wall failure or overtopping, allowing release of poor quality water to the receiving environment; and
- requirement to maintain (longer than 100 years) the mine levee wall.

The Black Bituminous Shale (BbH) exposed in the wall could have a heightened risk of spontaneous combustion, which could in turn cause the walls to fail. This is not considered to be a significant risk as the BbH is exposed in the northern face, where the bedding is into the wall, so the jointing reduces the risk of large scale failures.

5.5.2.2.2 *Alternative 2 – Isolated Mine Pit Lake with Active Filling*

This alternative would involve the open cut deliberately being filled using external river water during wet season flooding to rapidly fill the final void to the modelled stable water level (refer **Figure 5-4**). Filling would be at a rate and time such that minimum required environmental flows were maintained in the McArthur River.

Key assumptions for this alternative include:

- stratification of the mine pit lake is expected to be the same as Alternative 1 due to similar water densities and water temperatures;
- reduced exposure of final void walls to oxidation and rinsing by rain;
- timeframe to demonstrate performance of the mine pit lake reduced;
- wall stability issues are abated with reference to Alternative#1; and
- no long term water treatment.

Water quality is expected to be initially acceptable, but estimated to deteriorate over time due to evapo-concentration, except when large floods overtop the mine levee wall. The water level is expected to remain at the level of the river due to interconnection, placing it in the alluvium zone of the open cut final void. This would limit further oxidation of the final void walls; however it would result in exchange of waters through palaeochannels and the weathered bedrock.

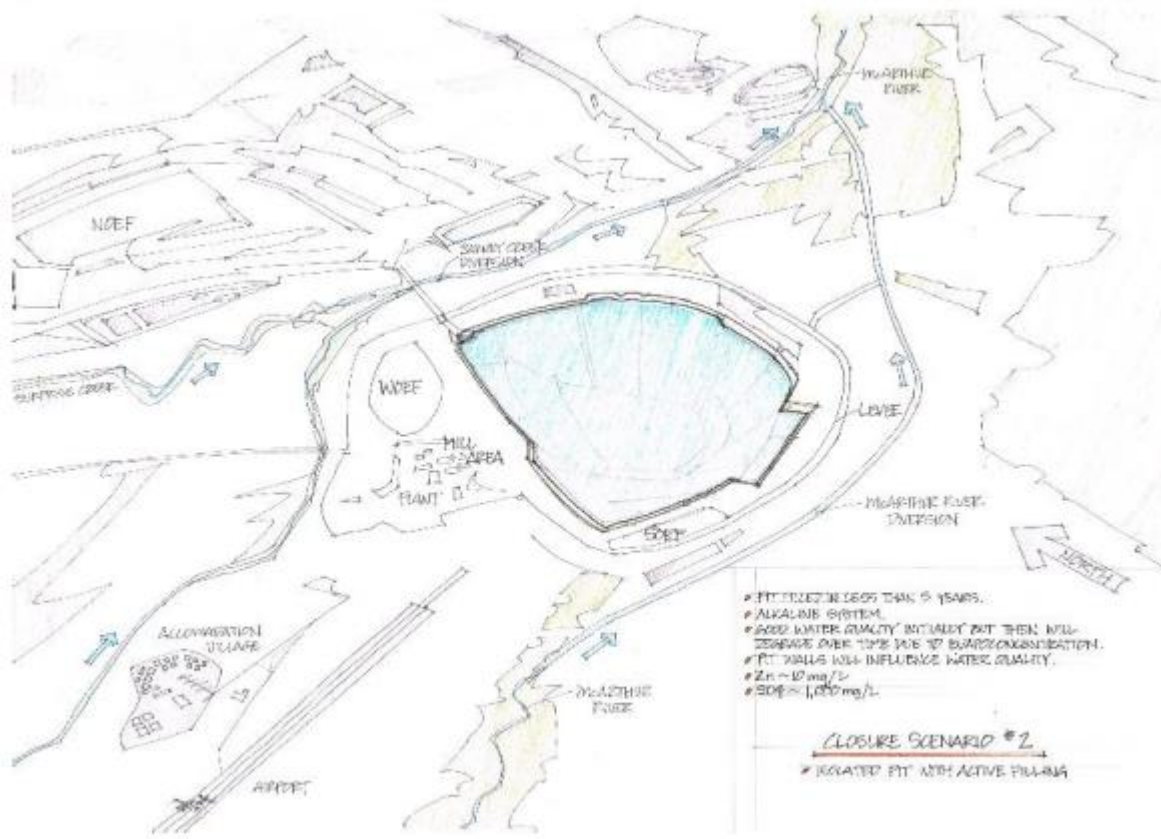


Figure 5-4 Alternative 2 – Isolated Mine Pit Lake with Active Filling

The key advantages of this alternative include:

- low capital cost;
- infrequent interaction with McArthur River; and
- improved initial water quality (compared to Alternative 1), due to reduced final void wall exposure timeframe.

The key potential risks identified for this alternative include:

- water quality is initially acceptable, but decreases over time due to evapo-concentration and limited fresh water input;
- rapid filling is planned to only occur when flows in the river are above the minimum environmental flows. Therefore the duration of filling relies on suitable successive wet season flows in the McArthur River;
- successive wet years and intense storms could raise water levels sufficiently to recharge shallow palaeochannels, though the water quality of the mine pit lake associated with such events may be reasonable due to large inputs of fresh water at rates in line with permeability as defined in EIS groundwater studies completed;
- the need to treat large volumes of water if the potential for unacceptable environmental harm is found to exist due to seepage from the mine pit lake into the receiving environment;
- illness or death of fauna coming into contact with the mine pit lake water if long term water quality is poor;
- mine levee wall failure or overtopping, allowing release of poor quality water to the receiving environment until it is repaired; and
- requirement to maintain (longer than 100 years) the mine levee wall.

5.5.2.2.3 Alternative 3 – Flow through Mine Pit Lake

Alternative 3 involves the mine levee wall being breached at the upstream and downstream ends, with the diversion becoming the secondary flow channel. Thus, the main flow path would be through the mine pit lake with only intermittent high flows through the diversion channel (refer to **Figure 5-5**). Some engineering will be required to enable flow through the old (original) channel. The excavated mine levee wall material could be used as a source of clean fill in rehabilitating other areas.

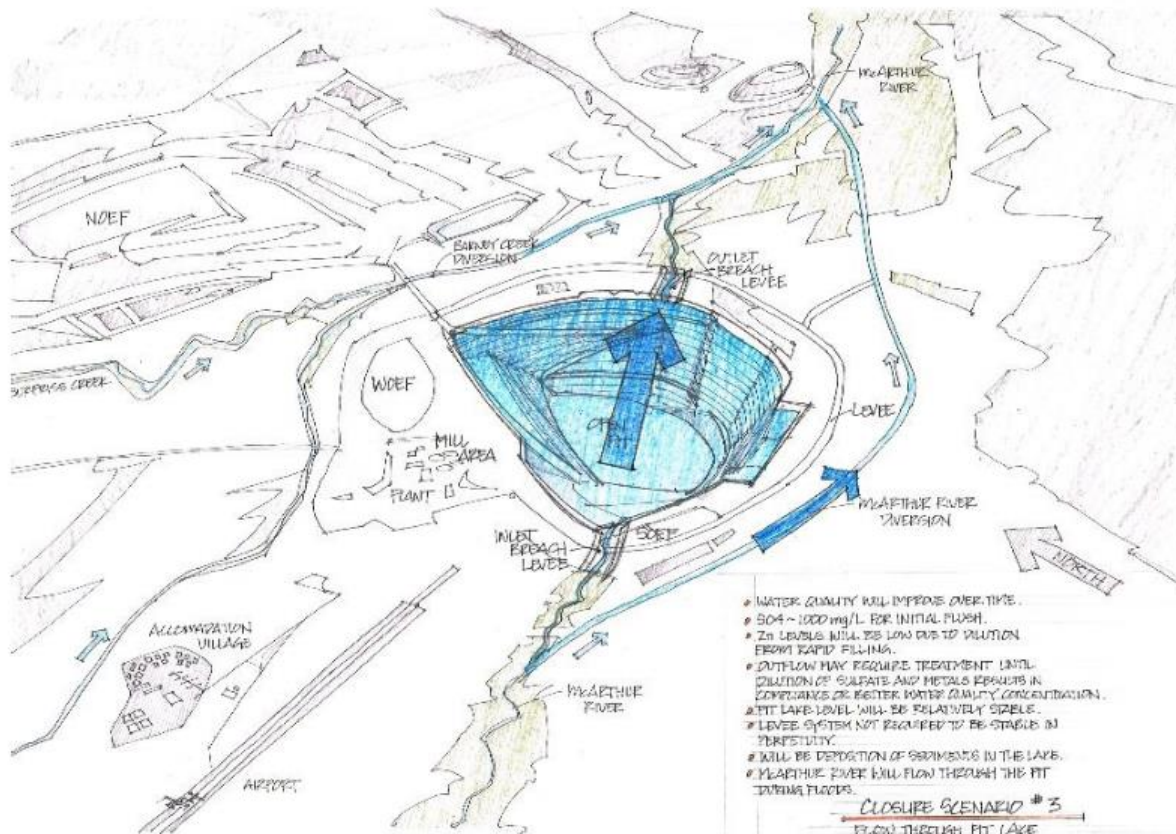


Figure 5-5 Alternative 3 – Flow through Mine Pit Lake

Key assumptions for Alternative 3 include:

- mine pit lake water level will be relatively stable;
- upon initial opening, there would be significant deposition of river-borne sediment in the final void, until the void was largely filled; and
- McArthur River will flow through the diversion channel during higher flow events.

Water quality will improve over time. It is estimated that sulphate concentrations will be approximately 1,100 milligrams per litre during the initial flushing stage. Zinc levels will be low due to rapid filling. The outflow may require treatment until water quality (specifically sulphate and selected metals) meets acceptance criteria.

The key advantages of this alternative include:

- improved water quality;
- the mine levee wall system will not need to be functional after breaching;
- higher degree of acceptance to stakeholders; and

- self-sustaining from a mine pit lake water quality perspective, therefore only minor ongoing maintenance anticipated.

Water quality will improve over time (compared to Alternatives 1 and 2); due to frequent interaction with McArthur River providing regular recharging and flushing of the pit void water. Frequent interaction with McArthur River will lead to a more diffuse release of contaminants. The excavated levee material could be used as a source of clean fill in rehabilitating other areas.

The key potential risks identified for Alternative 3 include:

- mine pit lake water quality not complying with surface water quality discharge criteria: with a subsequent impact on the receiving environment;
- mechanical turbulence of floodwaters entering the mine pit lake, thereby increasing the risk of the mine pit lake strata being disrupted, leading to poor quality water entering the receiving environment;
- water column mixing permanently or seasonally and exposing poor quality waters at the surface;
- amount of water treatment required is unknown at present, including whether treatment needs to vary with the seasons and/or climate cycles, or as the mine pit lake water depth changes due to sediment deposition;
- West OEF (WOEF) would be exposed to flood waters not envisaged in the original design, thereby requiring a suitably designed cover and flood protection system;
- WOEf cover system runoff and seepage interaction with surface water;
- power station is exposed to flooding without the additional construction of a flood protection levee;
- aquatic fauna impacts such as trapping of fish within the mine pit lake during the dry season and falling injuries as initial floodwaters breach the inlets when there is a water level differential between the lake and river;
- riparian vegetation in the diversion channel could potentially be negatively impacted due to reduced water flows, therefore requiring a revised rehabilitation strategy (using non-riparian species); and
- alteration to McArthur River sediment transport characteristics in the vicinity of the mine, impacting river morphology and energy inputs to the downstream ecosystem.

5.5.2.2.2.4 *Alternative 4 – Flow through Mine Pit Lake as Secondary Path (Preferred Alternative)*

The preferred Alternative 4 includes maintaining the McArthur River diversion as the primary flow path with only intermittent high flows through the mine pit lake (refer to **Figure 5-6**). Interaction with the mine pit lake would be maintained via a nominated flood event, which has been set at an approximate annual basis. This event would overtop engineered inlets through the mine levee wall at both upstream and downstream locations.

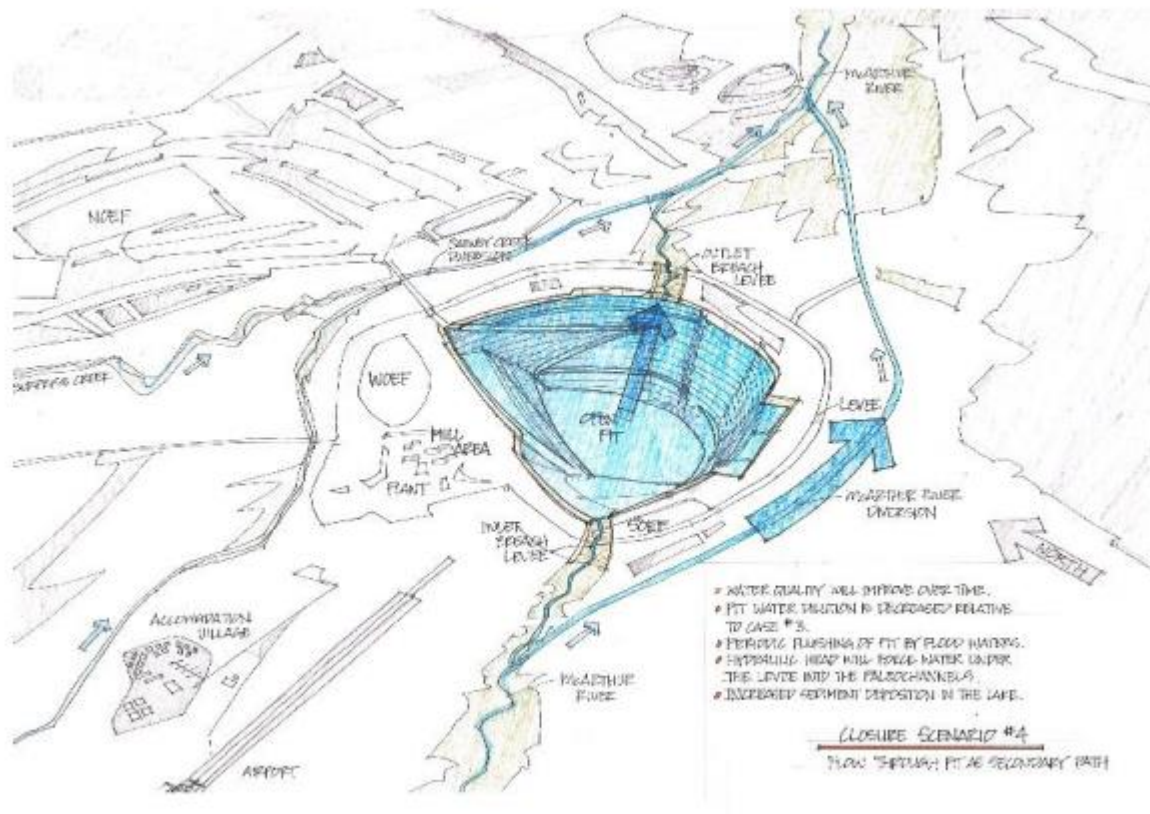


Figure 5-6 Alternative 4 – Flow through Mine Pit Lake as Secondary Path

Key advantages for Alternative 4 include:

- mine pit lake water dilution is decreased (relative to Alternative 3), with periodic flushing of the mine pit lake by flood waters only;
- mine pit lake water level will be relatively stable, though not as stable as Alternative 3 in low flow years;
- reduced sediment deposition in the mine pit lake as compared to Alternative 3;
- engineered inlets on the upstream and downstream side of the mine pit lake can be constructed and maintained to function as intended;
- the bulk of the mine levee wall would not need to be functional after breaching;
- the excavated levee material could be used as a source of clean fill in rehabilitating other areas;
- higher degree of acceptance to stakeholders;
- self-sustaining; and
- under low-flow conditions, evaporative loss from the mine pit lake does not limit downstream flows in the McArthur River (compared to Alternative 3).

The key potential risks identified for Alternative 4 include:

- mine pit lake water quality not complying with surface water quality discharge criteria, with a subsequent impact on the receiving environment;
- mechanical turbulence of floodwaters entering the mine pit lake, thereby increasing the risk of the mine pit lake strata being disrupted, leading to poor quality water discharging to the downstream receiving environment (although this risk is reduced compared to Alternative 3);
- water column mixing permanently and/or seasonally and exposing poor quality waters at the surface;

- amount of water treatment required is unknown at present, including whether treatment needs to vary with the seasons or climate cycles, or as the mine pit lake water depth changes due to sediment deposition;
- designing control measures to manage the mine pit lake as an effectively functioning secondary channel (the inlets, though not the whole mine levee wall, would need to be stable in the long term);
- the WOEF would be exposed to flood waters not envisaged in the original design, thereby requiring a suitably designed cover and flood protection system;
- the WOEF cover system runoff and seepage interaction with surface water;
- power station is exposed to flooding without the additional construction of a levee wall;
- aquatic fauna impacts such as trapping of fish within the mine pit lake during the dry season and falling injuries as initial floodwaters breach the inlets when there is a water level differential between the lake and river; and
- alteration to McArthur River sediment transport characteristics in the vicinity of the mine, impacting river morphology and energy inputs to the downstream ecosystem (though not as significant as Alternative 3).

5.5.2.2.2.5 *Alternative 5 – Mine Pit Lake with Backwater Interaction*

Alternative 5 includes establishing the mine pit lake as a backwater by breaching the mine levee wall on the downstream end only. The integrity of the diversion channel will need to be maintained such that the McArthur River is kept a suitable distance from the mine pit lake (refer to **Figure 5-7**).

Key assumptions for Alternative 5 include:

- mine pit lake water dilution is decreased (relative to Alternative 3), with periodic flushing of the mine pit lake by flood waters;
- mine pit lake water level will be relatively stable, though not as stable as Alternative 3 in low flow years;
- reduced sediment deposition in the mine pit lake compared to Alternative 3; and
- engineered inlet on the downstream side of the mine pit lake can be constructed and maintained to function as intended.

The key advantages of this alternative include:

- water quality will improve over time (compared to Alternatives 1 and 2);
- frequent interaction with McArthur River, leading to a more diffuse release of contaminants;
- reduced mechanical turbulence of floodwaters entering the mine pit lake, thereby reducing the risk of the mine pit lake strata being disrupted;
- reduced impact on the McArthur River natural sediment loading rates, compared to Alternatives 3 and 4; and
- under low-flow conditions, evaporative loss from the mine pit lake does not limit downstream flows in the McArthur River (compared to Alternative 3).

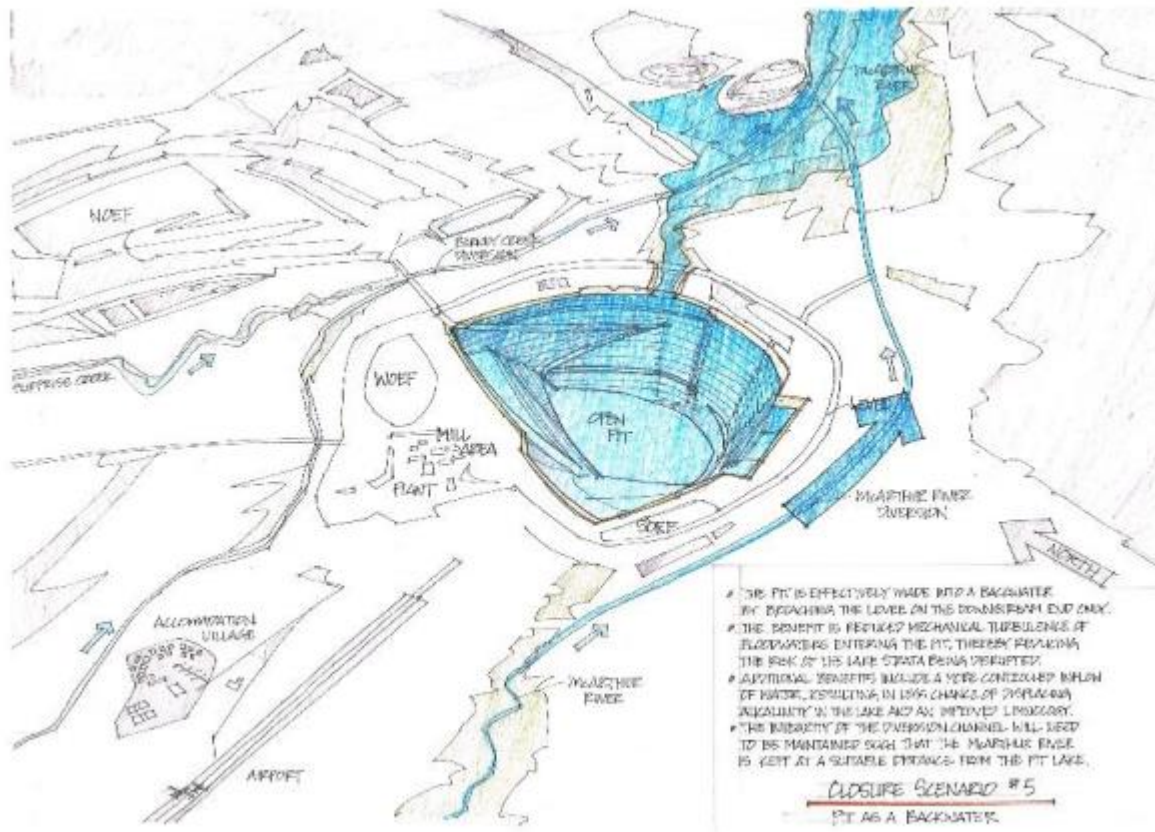


Figure 5-7 Alternative 5 – Mine Pit Lake with Backwater interaction

The key potential risks identified for Alternative 5 include:

- the mine pit lake water quality not complying with surface water quality acceptance criteria, with a subsequent impact on the receiving environment;
- water column mixing permanently and/or seasonally and exposing poor quality waters at the surface;
- amount of water treatment required is unknown at present, including whether treatment needs to vary with the seasons and/or climate cycles, or as the mine pit lake depth changes due to sediment deposition;
- need to maintain function of the upstream mine levee wall (e.g. manage in response to flood forces and/or subsequent erosion impacts);
- the WOEF would be exposed to flood waters not envisaged in the original design, thereby requiring a suitably designed cover and flood protection system;
- aquatic fauna impacts such as trapping of fish within the mine pit lake during the dry season and falling injuries as initial floodwaters breach the inlets when there is a water level differential between the lake and river;
- alteration to McArthur River sediment transport characteristics in the vicinity of the mine, impacting river morphology and energy inputs to the downstream ecosystem; although these would not be as significant as in Alternative 3 or 4;
- the WOEF cover system runoff and seepage interaction with surface water; and
- power station is exposed to flooding.

5.5.2.2.6 Alternative 6 – Managed Isolated Mine Pit Lake

Alternative 6 involves actively managing the water level in the mine pit lake so that the mine pit lake level is below the palaeochannels and other permeable pathways to the external waters at all times. The rationale for this alternative is the removal of a potential pathway for contaminants seeping from the isolated mine pit lake through the shallow groundwater system where it can enter the surface water system (refer to **Figure 5-8**).

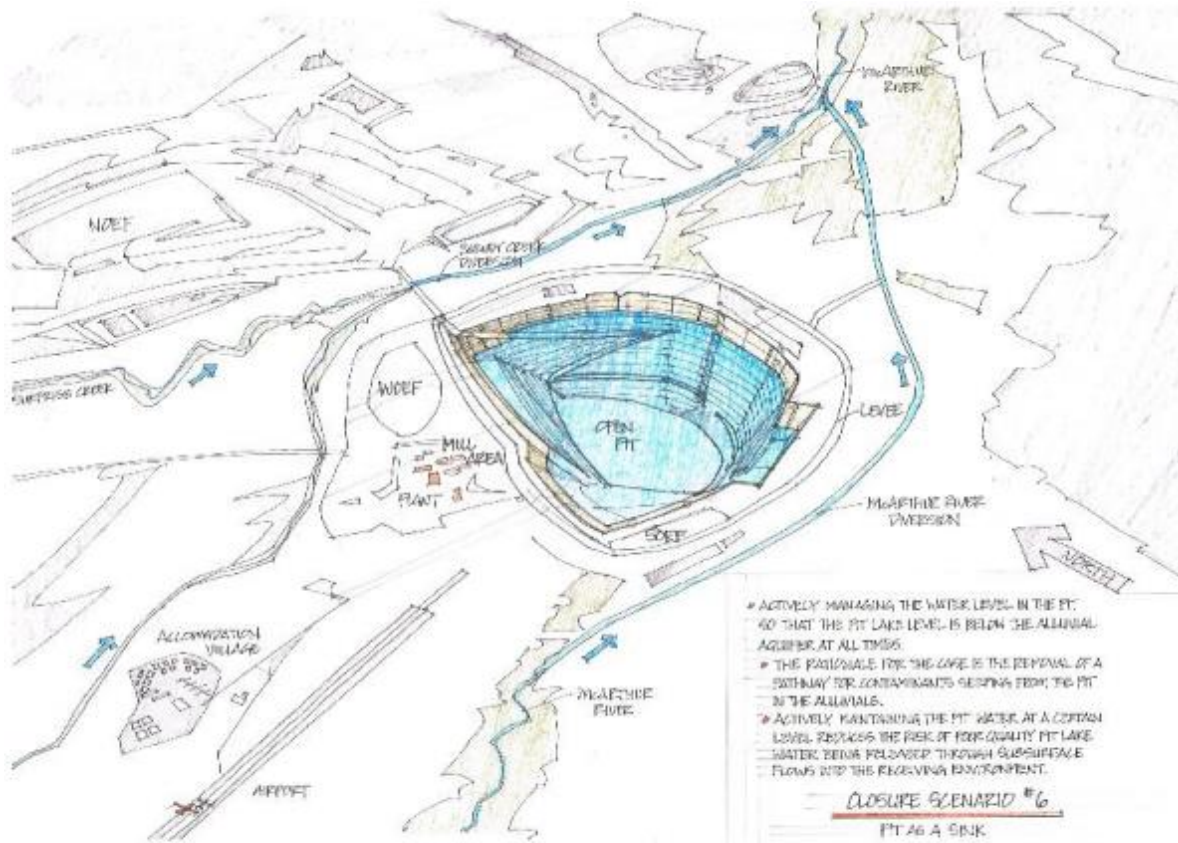


Figure 5-8 Alternative 6 – Managed Isolated Mine Pit Lake

Key assumptions for Alternative 6 include:

- active management of the mine pit lake water level in the foreseeable future; with the possible requirement to manage the catchment as well;
- mine pit lake would be subject to inflows from rainfall and groundwater, and be subject to evaporation and treated water losses;
- water removed from the mine pit lake would be treated to discharge quality (water quality committed to at the compliance point of the Waste Discharge License (SW11)) before being released to the environment, or blended into the external floodwaters at an appropriate dilution ratio when flow conditions permit; and
- the contaminants from any water treatment would be either disposed of in suitable land-based facilities, or deposited deep in the mine pit lake water column where stratification would prevent their mixing with upper level waters.

The key advantages of Alternative 6 include:

- reduced mine pit lake water interaction with McArthur River via palaeochannels, compared to Alternatives 1 and 2;

- actively maintaining the mine pit lake water below the critical level where interaction with the external environment occurs reduces the risk of poor quality water being released through subsurface flows to the receiving environment;
- WOEF flood protection is provided by the mine levee wall;
- power station is protected by flooding to a 1:500 year event;
- no aquatic fauna issues in the mine pit lake from entry to the open cut;
- no sediment deprivation of the McArthur River;
- deeper seepage under the southern parts of the NOEF may be drawn into the mine pit lake rather than the Barney Creek diversion; and
- anticipated wide-spread acceptance from external stakeholders.

The key potential risks identified for Alternative 6 include:

- mine levee wall must be maintained in perpetuity;
- will likely require water treatment and storage dams;
- maintaining power supply of suitable capacity to manage the water level and quality;
- medium capital cost, with higher operating costs expected (than Alternatives 1 and 2);
- management of flood levels greater than 1:500 year flood;
- extended drawdown may only be possible if the connection between surface floodwaters and mine pit lake through unknown groundwater connections is shut down; and
- uncertainty surrounding operating levels to allow for mine pit lake inflows from the catchment and groundwater and extent of the mine pit lake drawdown.

5.5.2.2.2.7 Alternative 7 – Complete Backfill of Final Void

Alternative 7 involves rehandling of NOEF overburden material into the final void. The rationale is to fully remove overburden material from the NOEF to reduce potential contaminant pathways from the NOEF to surface and groundwater systems, and place the overburden inside the mine levee wall where the perception is it will have a lower risk of impact on the external environment. **Figure 5-9** and **Figure 5-10** provide indicative sketches of this alternative. The key assumptions for Alternative 7 are discussed below.

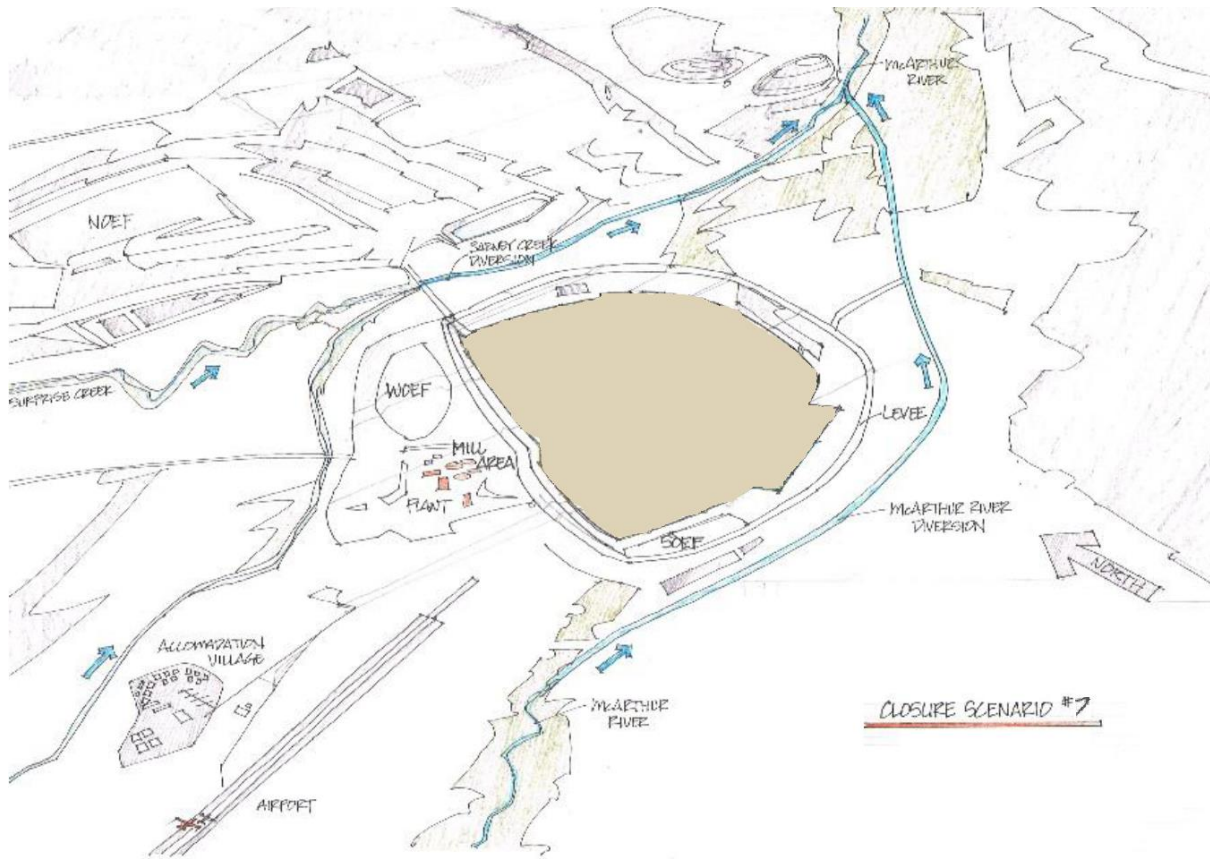


Figure 5-9 Alternative 7 – Complete Backfill of Final Void

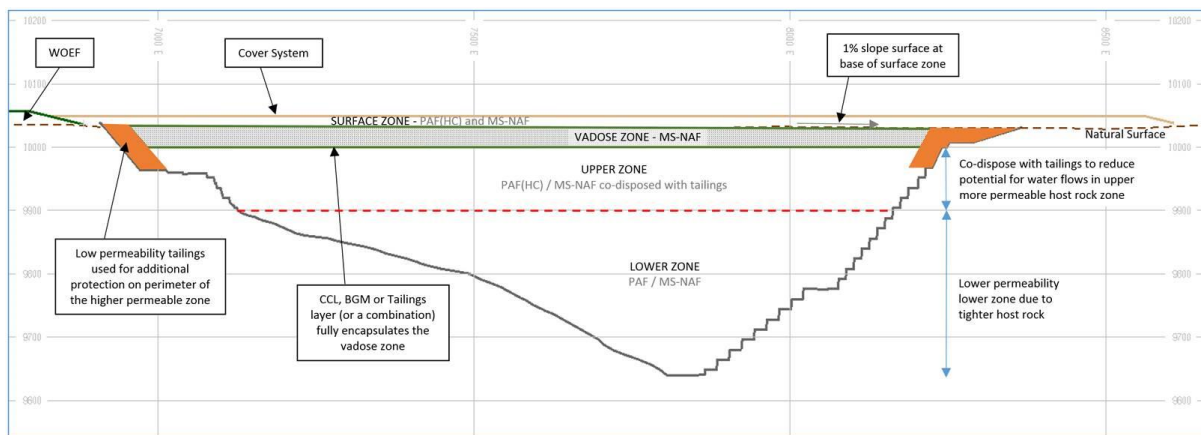


Figure 5-10 Indicative Cross-Section of Open Cut Complete Backfill Alternative

Not all NOEF material can be accommodated below the natural surface level in the final void. Due to the material swell factor in the order of 25-35%, excess NOEF overburden would need to be placed in a specially constructed OEF. This would be approximately 20 m in height and would need to be constructed over the backfilled open cut final void, extending from the WDEF to the mine levee wall.

Priority would be placed on returning potentially reactive overburden to the final void; therefore the majority of the tailings will remain in a surface storage facility so as not to consume final void capacity for the replaced overburden.

Replaced material would contain stored oxidation products resulting from approximately 30 years of surface storage that are soluble and immediately available to the environment.

There would be virtually no ongoing oxidation occurring in rock stored below the permanent groundwater table due to sub-aqueous storage following groundwater table recovery. Some connectivity would remain between the open cut final void and McArthur River via palaeochannels and shallow groundwater systems.

The permeability of the host rock and orebody reduces with depth; so below a certain depth the load transfer will be slow and the likelihood of water migrating away laterally would be very low. However, the upper zone (with moderate permeability but below the permanent water table) would have some risk of connection with the regional groundwater, and the vadose zone (in the region of fluctuating water table and variable permeability) is very likely to contain pathways of higher permeability.

It is not possible to only store benign material in the more permeable upper zone and vadose zone where oxidation and migration of products is more likely. Given these assumptions, the concept for full backfill is as follows.

The lower zone has the lowest risk of contaminants escaping the final void, so it is the target for the most reactive potentially acid forming (reactive) (PAF(RE)) material in the NOEF. Rehandling of the NOEF overburden would have to be coordinated to remove this reactive PAF(RE) material early and place it in this zone. PAF(HC) material and metalliferous saline non-acid forming (MS-NAF) material would also be placed in this zone.

In the upper zone, PAF(HC) material and MS-NAF material will also be placed. It is proposed to co-dispose this overburden with selected rehandled tailings to create a low permeability mass with a lower risk of contaminant migration and oxidation. In the upper benches with identified zones of moderate (or higher) permeability, tailings would be placed around the perimeter to form a low permeability barrier to groundwater flow.

The Vadose zone comprises the zone in soil or rock where groundwater and atmosphere are in contact, or where the water table pressure equals that of atmospheric. This zone generates both anoxic and oxic conditions depending on the depth to the water table and to a lesser extent the medium. For this zone, where groundwater tables could fluctuate, and in the unconsolidated alluvial material where palaeochannels are prevalent, a barrier layer (comprising a compacted clay liner (CCL), BGM or tailings or a combination of the three) would be constructed to fully encapsulate the materials placed inside.

The low permeability barrier layer on top of the vadose zone is also at the base of the surface zone, sloped towards the original McArthur River channel in the northeast, where seepage flowing through the above ground OEF on top of the open cut could be directed to a collection point for management.

The surface zone would be constructed from PAF(HC) material, MS-NAF material and benign NAF material in a similar manner to the proposed NOEF, with a core, halo and cover zones. The cover system would incorporate surface drainage to enable water to be directed to water management structures inside the levee wall for the required construction period, and then directed to drain over the levee wall through sediment traps once runoff water quality would meet the external discharge quality requirements.

Ongoing maintenance of the McArthur River diversion channel and the mine levee wall would be required and a network of monitoring bores around the mine levee wall would be installed to detect contaminated seepage originating from the facility. Mitigation strategies such as cut-off trenches, permeable reactive barriers, recovery bores and recovery trenches may be required to meet the environment objectives of the system.

Key advantages of this alternative include:

- complete removal of the NOEF, including the existing NOEF, with simpler rehabilitation and long term maintenance for the NOEF domain;
- storage of the most reactive materials in a sub-aqueous setting with a low risk of further oxidation and contaminant transport once deposited and inundated;
- a lower final NOEF landform with consequent reduction in erosion risk and visual impact; and
- highly engineered zones in the upper levels of the final void where risks of oxidation and transport are higher.

The key potential risks identified for Alternative 7 include environmental, financial and health and safety risks. These are discussed below.

The NOEF core, after being encapsulated for up to 20 years, would be re-exposed to advection and diffusion, potentially increasing the oxidation rates risking the release of additional contaminants. The original contaminant load, plus the increased load, would then be placed into the final void and overlying OEF and would require ongoing management.

The oxidation products will include soluble contaminants with a high potential for bioaccumulation. This would require large scale water treatment during the backfilling process to remove these contaminants from the water. Despite water treatment and barrier layers, there would still be oxidation products stored in zones with potential connections to the external receiving environment to be managed.

Direct rainfall and surface water runoff accumulating inside the mine levee wall would not have an escape pathway to the outside environment. This water would either have to be pumped back out over the mine levee wall or left to infiltrate into the ground (e.g. via palaeochannels under the mine levee wall). Pumping would be required for the foreseeable future, while infiltration increases the risk of the water becoming contaminated and entering the downstream environment.

The mine levee wall would require perpetual maintenance. The risks associated with undertaking another mining activity (NOEF back into open cut) with associated impacts of logistics, noise, dust and fuel consumption (and greenhouse gas emission (GHG)) also bear consideration.

With the re-exposure of overburden material this increases the risk of generation of (and subsequent exposure of people to) sulphur dioxide and spontaneous combustion, posing a health and safety risk to sensitive receptors (refer to **Chapter 13 – Air Quality**).

This alternative would represent the greatest cost to McArthur River Mining, rendering the project uneconomic and unviable. Thus, no further operations would occur, with a consequent cessation in employment and associated community investment projects, services, taxes and royalties.

5.5.2.2.2.8 Alternative 8 – Partial Backfill of Final Void

Alternative 8 involves rehandling a portion of the NOEF overburden material back into the final void, so that it fills the final void to below the vadose zone (i.e. to below the unconsolidated alluvial material), but retains an approximately 30 m deep final void that can be partially or wholly filled with water (refer **Figure 5-11**). The rationale is to partially remove overburden material from the NOEF to reduce potential contaminant pathways from the NOEF to surface and groundwater systems, but (unlike Alternative 7) avoid placing contaminated materials in the highest risk zone of the final void. Key assumptions for Alternative 8 are discussed below.

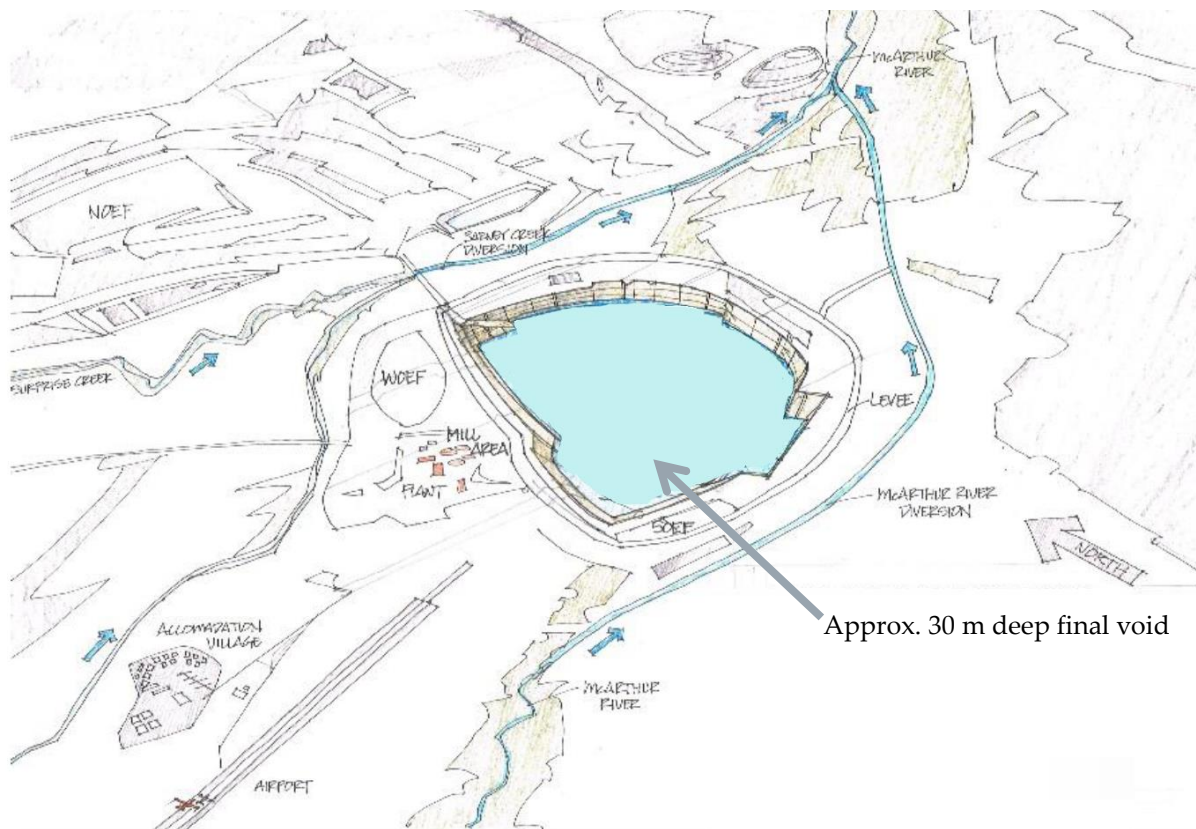


Figure 5-11 Alternative 8 – Partial Backfill of Final Void

Replaced material will contain stored oxidation products resulting from approximately 30 years of surface storage that are soluble and immediately available to the environment, hence requiring mitigation during relocation or placement. Limited ongoing oxidation would occur in overburden stored below the permanent groundwater table due to sub-aqueous storage following groundwater table recovery.

Some connectivity remains between the open cut final void and McArthur River via paleochannels and shallow groundwater systems. The permeability of the host rock and orebody reduces with depth; so below a certain depth the load transfer will be slow and the likelihood of water migrating away laterally would be very low.

This alternative would require the backfill of the final void to below the vadose zone then capping with a cover system (CCL, alluvial material and low salinity non-acid forming (high capacity) (LS-NAF(HC)) material). Backfilling of PAF(RE) overburden, hanging wall pyrite overburden and the existing NOEF would need to be prioritised and placed into the lower parts of the final void where the country rock is less permeable. This could be practically achieved with three large mining fleets over 7-10 years.

Priority will need to be placed on returning potentially reactive overburden to the final void, therefore the majority of the tailings will remain in a surface storage facility, so as not to consume final void capacity for the overburden.

In the upper zone, PAF(HC) material and MS-NAF material will also be placed. It would be proposed to co-dispose this overburden with selected rehandled tailings to create a low permeability mass with a lower risk of contaminant migration and oxidation. In the upper benches with identified zones of moderate (or higher) permeability, tailings would be placed around the perimeter to form a low permeability barrier to groundwater flow.

A 1 m thick CCL would be placed over the tailings, just below the level of the natural interface of rock and alluvium, followed by 4 m of LS-NAF(HC) rock. This would increase the backfilled level to approximately 16 m below the original ground surface, so only benign materials would be in the alluvial strata where higher groundwater flows and movement are likely. The volume above this level could seasonally fill with water from rainfall and shallow groundwater inflows, particularly via the paleochannels.

Once the surface water quality in the shallow final void is stabilised, the downstream levee could be broken so that flushing waters could flow in during times of flood, and more alluvial sediments could be deposited over the backfilled final void.

Not all NOEF material can be accommodated in the final void due to material swell factor in the order of 25-35%. Therefore, a smaller NOEF with an area of approximately 300 ha (similar to the existing footprint) and 80 m high would remain to the north of the current NOEF, further away from the sensitive receptors. It would contain PAF(HC) overburden and MS-NAF overburden in the core, MS-NAF material in the base and halo, and LS-NAF(HC) material as well as clay and alluvial material in the cover.

Ongoing maintenance would be required of the McArthur River diversion channel and the bulk of the mine levee wall.

A network of monitoring bores around the mine levee wall would be installed to detect contaminated seepage originating from the facility. Mitigation strategies such as cut-off trenches, permeable reactive barriers, recovery bores and recovery trenches may be required to meet the environment objectives of the system.

The key advantages of this alternative include:

- rehandling of the worst quality overburden from the NOEF back into the open cut final void, which may significantly reduce the NOEF long term management requirements;
- storage of the most reactive materials in a sub-aqueous setting with a low risk of further oxidation and contaminant transport once deposited and inundated;
- a lower risk of contaminant transport from the final void due to only benign materials being placed in the upper vadose zone;
- reduced erosion risk of the NOEF due to the lower height compared to a 140 m high NOEF;
- reduced NOEF visual impact, as a result of reduced height;
- less complex NOEF water management requirements; and
- potential for reducing the requirement for clean/benign capping and cover materials.

The key potential risks identified for Alternative 8 include environmental, health and safety and cost risks, as discussed below.

Environmental Risks

The NOEF core, after being successfully encapsulated for up to 20 years, would be re-exposed to possible advection and diffusion, thereby increasing the oxidation rates (i.e. contaminant loads) in the overburden that must be managed. The original contaminant load, plus the increased load, would then be placed into the final void and overlying OEF; and would require ongoing management.

The oxidation products will include soluble contaminants with a high potential for bioaccumulation. This would require large scale water treatment during the backfilling process to remove these contaminants from the water. Despite water treatment and barrier layers, there would still be oxidation products stored in zones with potential connections to the external receiving environment to be managed.

It is possible that insufficient LS-NAF(HC) material would be available to backfill the entire open cut final void through the vadose zone, retaining a shallow lake. This would encourage surface water to percolate through the profile unless it was able to drain freely through the paleochannels or through a break in the mine levee wall.

The NOEF would need to be constructed almost as two separate facilities comprising a:

- temporary section (around the existing NOEF) designed to be rehandled with no subsequent permanent cover system; and
- permanent section designed to remain on Emu Plains in the foreseeable future with an appropriately designed full cover system.

This adds complexity to the NOEF. Any cover system installed over the temporary section would perform worse than a permanent cover, increasing seepage in the short term.

To enable rehandling of overburden while maintaining a stable landform, the NOEF would need to be constructed to a lower height; hence the disturbance footprint would be greater than if the NOEF was constructed as a permanent facility to the preferred 140 m height. A larger footprint would create more ground disturbance, and the remaining NOEF still has a large footprint with the potential for net percolation (NP) and subsequent seepage.

Risks associated with undertaking another mining activity (NOEF back into open cut) with associated impacts of logistics, noise, dust, fuel consumption (and GHG emission).

Health and Safety Risks

With the re-exposure of overburden this increases the risk of generation of (and subsequent exposure of people to) sulphur dioxide and spontaneous combustion.

Cost Risks

Very high costs associated with the creation of a large footprint, low height OEF during operations, followed by the rehandling of a large portion of this overburden material (and combined with the rehandling of tailings material). This would render the Project uneconomic and unviable. No further operations would occur with a consequent cessation in employment and associated community investment projects, services, taxes and royalties.

5.5.2.3 Multi-criteria Analysis

A summary of the MCA outcomes for each of the above eight open cut closure and rehabilitation alternatives is provided in **Table 5-4**. A supporting discussion of these outcomes is provided following the table.

Table 5-4 Multi-criteria Analysis of Open Cut Domain Closure and Rehabilitation Alternatives

# Alternative		Short Term Effects ¹								Long Term Effects ²								Total %	
		Local effects ³				Regional effects ⁴				Local effects ³				Regional effects ⁴					
		Environmental Performance	Constructability ⁷	Financial Cost ⁵	Societal and Stakeholder Benefits ⁶	Environmental Performance	Constructability ⁷	Financial Cost ⁵	Societal and Stakeholder Benefits ⁶	Environmental Performance	Maintenance ease ⁷	Financial Cost ⁵	Societal and Stakeholder Benefits ⁶	Environmental Performance	Maintenance ease ⁷	Financial Cost ⁵	Societal and Stakeholder Benefits ⁶		
1	Isolated mine pit lake with passive filling	3	5	5	3	4	NA	NA ⁸	3	3	3.5	3	3	3	NA	NA ⁸	2	40.5	68
2	Isolated mine pit lake with active filling	3.5	4	5	4	4	NA	NA ⁸	3	3	3.5	3	3	3	NA	NA ⁸	2	41	68
3	Flow through mine pit lake	4	3.5	4	4	3	NA	NA ⁸	3	4	5	5	4	4	NA	NA ⁸	2	45.5	76
4	Flow through mine pit lake as secondary path	5	3	4	5	5	NA	NA ⁸	3	5	4.5	4.5	4.5	5	NA	NA ⁸	2	50.5	84
5	Mine pit lake with backwater interaction	4	3.5	4.5	4	4	NA	NA ⁸	3	5	4.5	4.5	4.5	5	NA	NA ⁸	2	48.5	81
6	Managed isolated mine pit lake	5	4	3	4.5	5	NA	NA ⁸	4.5	5	3	3	5	5	NA	NA ⁸	3.5	50.5	84
7	Complete backfill of final void	4	1	1	4.5	4	NA	NA ⁸	1	4	4.5	4.5	1	5	NA	NA ⁸	1	35.5	59
8	Partial backfill of final void	4.5	2	1	4	4.5	NA	NA ⁸	1.5	5	4	4	1.5	5	NA	NA ⁸	2	39	65
Maximum Possible Score		5	5	5	5	5	NA	NA	5	5	5	5	5	5	NA	NA	5	60	100

1 0-100 year timeframe
2 100-1,000 year timeframe
3 On-lease
4 Off-lease
5 Financial cost to McArthur River Mining and its impact on Project viability.
6 Includes benefits in terms of employment creation and planned community investment projects, services, taxes and royalties.
7 Assumption is that construction costs apply in the short term, but these transfer to maintenance costs in the long term.
8 All financial costs to McArthur River Mining are assumed to be incurred on-lease (therefore local effect only).

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5.5.2.3.1 Alternative 1 – Isolated Mine Pit Lake with Passive Filling

Total Score: 40.5/60 (68%)

5.5.2.3.1.1 Short Term Effects

Environmental Performance

Local effect was considered to be moderate (3). As the open cut final void filled slowly, there would likely be deterioration in water quality due to oxidation on the open cut walls, overburden and tailings washing into the mine pit lake water body, and evapo-concentration of the water body.

The regional effect was allocated a higher score (4) as the water level would likely be below the weathered rock and palaeochannel zone, thus confining the poor quality water to the open cut itself or very deep cracks and faults with limited transmissivity.

Constructability

Constructability was scored high locally (5) as it would be limited to the management of wall stability.

Financial Cost

Local Effects were scored 5 due to limited intervention required. A lack of a water treatment plant saves costs. Note that this assumes that there is no remediation of the river system in the event of contaminated water discharges – if this were required, the financial cost could drop to 1.

Stakeholder and Societal Benefits

Stakeholder and Societal Benefits were scored as a 3 both locally and regionally, as few workers would be impacted positively or negatively due to the time delay of filling to levels where contamination could occur.

5.5.2.3.1.2 Long Term Effects

Environmental Performance

Environmental Performance was considered moderate (both locally and regionally) due to the assumptions that:

- there would be some level of open cut water stratification which would trap poorer quality water in the lower layers;
- the open cut water level would eventually stabilise to approximately the palaeochannel level, enabling upper water layers which may be contaminated above the discharge criteria to migrate into the wider environment; and
- a greater than 1:500 year flood event, which would overtop the mine levee wall, would likely have limited environmental impact due to the large volumes of diluting waters available in such an event.

Maintenance Ease

Ease of maintenance was judged as moderate and involving some complexity, predominantly associated with maintenance of the mine levee wall and river channel, and implementation of any required environmental mitigation controls.

Financial Cost

Financial Costs are considered maintenance-related as described above.

Stakeholder and Societal Benefits

A moderate influence on local workforce with ongoing resourcing required to maintain this alternative, although regional benefits would be expected to decrease over the long term.

5.5.2.3.2 Alternative 2 – Isolated Mine Pit Lake with Active Filling

Total Score: 41/60 (68%)

5.5.2.3.2.1 Short Term Effects

Environmental Performance

The local effect was considered to be moderate (3.5) in the short term due to the reduced timeframe associated with filling the open cut, which would limit oxidation inside the final void relative to Alternative 1.

The regional effect was scored slightly higher due to the likely reasonable water quality in the lake in this timeframe seeping out at low rates and mixing with external waters.

Constructability

Constructability was scored high as a (4), being relatively simple. Readily available large pumps would be required to actively fill the final void but would require some level of management of the start and stop features to:

- control the risk of the pump jamming from debris; and
- limit the risk and erosion of the open cut walls from high volume water inflows.

Financial Cost

Financial Cost was scored high (5) locally in line with the relatively simple construction costs anticipated.

Stakeholder and Societal Benefits

Stakeholder and Societal Benefits was scored higher (4) locally due to the workforce resourcing required; however, it was scored slightly lower (3) regionally as majority of benefits would be felt on-site.

5.5.2.3.2.2 Long Term Effects

Environmental Performance

Environmental Performance was considered to be the same as Alternative 1, as both alternatives would create similar standing water levels, and in the long term would lead to similar water qualities due to ongoing evapo-concentration. This assumes the recovered water level is above the weathered rock zone where higher exchange of groundwater could be reasonably expected to occur.

Ease of Maintenance

Ease of Maintenance was considered to be the same as Alternative 1 (3.5 locally).

Financial Cost

Financial Cost was scored as a 3, reflecting that moderate amounts of ongoing spending on maintenance would be required including maintain the levee wall and ongoing environmental management and mitigation measures.

Stakeholder and Societal Benefits

As for Alternative 1, a moderate influence on local workforce would be anticipated with ongoing resourcing required to maintain this alternative, although regional benefits would be expected to decrease over the long term.

5.5.2.3.3 Alternative 3 – Flow through Mine Pit Lake

Total Score: 45.5/60 (76%)

5.5.2.3.3.1 Short Term Effects

Environmental Performance

The local effect is expected to be favourable as the McArthur River waters would dilute the open cut lake waters. Increased turbidity may be experienced due to the high volume of water flowing through the mine pit lake area.

On a regional scale, while the water quality flowing through the open cut lake may be acceptable, the deep and wide mine pit lake would be expected to reduce flow velocities, causing sediment to be deposited in the mine pit lake. It could be anticipated that the downstream river environment would be deprived of its natural sediment loads. This is assumed to have a negative environmental impact due to the aquatic ecosystems that would have historically adapted to this environmental condition. It is assumed that it would take decades for the open cut final void to fill up.

Constructability

Constructability was scored as moderate (3.5) as it would involve some complexity to construct the inlet and outlet for the initial filling. If water was harvested using pumps or siphons before opening the levee, this score could be increased.

Financial Cost

Financial Cost was assessed as minor locally (4) in line with the moderate level of construction complexity anticipated.

Stakeholder and Societal Benefits

As for Alternative 2, a moderate influence on local workforce would be anticipated with ongoing resourcing required to maintain this alternative, although regional benefits would be expected to decrease as the majority of benefits would be felt on-site.

5.5.2.3.3.2 Long Term Effects

Environmental Performance

Once the mine pit lake had silted up and the McArthur River natural sediment flows had returned to pre-development levels, then it is expected that this alternative would create a long term environmentally stable situation, both locally and regionally.

Maintenance Ease

The maintenance requirements were scored highly (5) as there is no mine levee wall to maintain, it has been assumed no water treatment would be required, and the geomorphology of the McArthur River and the mine pit lake would be self-managing and subject to natural processes.

Financial Cost

There should be low on-going costs associated with managing the mine pit lake if this alternative works as anticipated.

Stakeholder and Societal Benefits

A minor influence on local workforce would be anticipated with ongoing resourcing required to maintain this alternative, although regional benefits would be expected to decrease over time.

5.5.2.3.4 Alternative 4 – Flow through Mine Pit Lake as Secondary Path

Total Score: 50.5/60 (84%)

5.5.2.3.4.1 Short Term Effects

Environmental Performance

Environmental performance is expected to be high (5) both locally and regionally, assuming the water quality is maintained as per modelling results.

Constructability

Constructability was scored as moderate (3) as it is expected that construction of the inlet and outlets for the initial filling will be technically challenging. If water was to be harvested using pumps or siphons before opening the mine levee wall, then this score could be increased.

Financial Cost

This alternative would be expected to impose only minor effects on company finances, and not likely to impact on Project viability.

Stakeholder and Societal Benefits

In line with the financial scoring, this alternative would not be expected to negatively impact on site workforce numbers, although regionally some moderate influences would be expected, as the majority of benefits would be felt on-site.

5.5.2.3.4.2 Long Term Effects

All criteria have been scored based on the expectation that performance will be moderate to high in the long term, with the exception of stakeholder and societal benefits, which would be expected to decrease regionally in the longer term.

5.5.2.3.5 Alternative 5 – Mine Pit Lake with Backwater Interaction

Total Score: 48.5/60 (81%)

This alternative has been scored relatively similar (although slightly lower) to Alternative 4. The short term environmental performance rankings have been scored slightly lower due to the expectation that there would be less mixing of water within the mine pit lake.

5.5.2.3.6 Alternative 6 – Managed Isolated Mine Pit Lake

Total Score 50.5/60 (84%)

This alternative (along with Alternative 4) potentially poses the lowest environment risk as the water levels and water quality will be managed until such parameters have stabilised to an acceptable level. Short term constructability is anticipated to be of relatively low complexity, although on-site financial costs are expected to be moderate including costs associated with operating and maintaining water treatment plants and other water management system components including the mine levee wall. Societal benefits were assumed higher due to on-going water treatment requiring labour, utilities and consumables, all of which would require investment in the economy.

5.5.2.3.7 Alternative 7 – Complete Backfill of Final Void

Total Score: 35.5/60 (59%)

5.5.2.3.7.1 Short Term Effects

Environmental Performance

Environmental performance is expected to be relatively high, however from both a local and regional effects perspective, poor quality groundwater from the stored load in the backfilled overburden has the potential to migrate into the external environment. This water would then likely express into surface water features. Also due to the above surface portion of the overburden in this scenario, it is still left with similar long term seepage issues as the existing NOEF, which requires management. While it is assumed this can all be managed effectively, it would come at a high cost.

Constructability

Constructability was scored low, due to the works required and complexities around safely deconstructing the existing NOEF, sealing up the more permeable upper zone in the final void, construction of the barrier layers to protect the vadose zone from flushing out oxidation products during the wet/dry season cycling and the fact that the co-disposal of tailings and overburden is a complex process.

Financial Cost

The very high costs associated with this alternative would inhibit Project feasibility.

Stakeholder and Societal Benefits

Stakeholder and Societal Benefits was scored based on the assumption that (due to the prohibitive financial cost) mining operations would cease in 2018, with a prolonged period of care and maintenance resulting. As there would be no mine production (ore), it is assumed that the Community Benefits Trust (CBT) would cease in the short term, thus community investments not realised.

5.5.2.3.7.2 Long Term Effects

The rationale behind scoring of the long term effects was similar to the rationale of the short term scoring, although there would be improvement from an environmental perspective as the stored load would be reduced.

5.5.2.3.8 Alternative 8 – Partial Backfill of Final Void

Total Score: 39/60 (65%)

5.5.2.3.8.1 *Short Term Effects*

Environmental Performance

Environmental performance is expected to be relatively high due to the avoidance of placing contaminated fill in the vadose zones, and sealing off the fill beneath with a cover system and a shallow water body.

Constructability

Constructability was scored as low as per Alternative 7, for the same reasons as Alternative 7.

Financial Cost

The very high costs associated with this alternative would inhibit Project feasibility.

Stakeholder and Societal Benefits

Societal and Stakeholder Benefits was scored based on the assumption that (due to the prohibitive financial cost) mining operations would cease in 2018, with a prolonged period of care and maintenance resulting. As there would be no mine production (ore), it is assumed that the CBT would cease in the short term, thus community investments not realised.

5.5.2.3.8.2 *Long Term Effects*

The rationale behind the scoring of long term effects was generally similar to the short term scoring rationale.

5.5.2.4 **Preferred Alternative for the Open Cut Domain**

Details of the preferred alternative for the open cut domain are contained in **Chapter 3 – Project Description and Justification**, with the key features summarised below.

The open cut will be sequenced with conventional pit staging progressing from west to east and shallow to deep, with a slightly revised concept for the last two pit stages to enable some limited IPD during the last six years (approximately) of mining.

High pyrite PAF(HC) material would be stored during the open cut operations phase in engineered cells in the EOEF footprint. Rehandling of the EOEF high pyrite overburden and non-benign portions of the SOEF after mining is completed with placement in IPDs for inundation and permanent sub-aqueous storage.

The entire tailings mass would be hydraulically mined from the TSF footprint after the cessation of open cut mining, with reprocessing then deposition within the open cut final void. The excess water and liberated pore water in the open cut would be reclaimed for use in the tailings mining and reprocessing works, with water treatment as required to manage water quality. The open cut filling operations would be expected to leave a final void of approximately 175 m deep.

Batter works, topsoiling and revegetation of the upper benches of the open cut, including placement of structural debris for future aquatic habitat would be undertaken.

Re-shaping and construction of a benign cover system would occur, with low to very low NP over the WOEF. Construction of flood proofing barriers to a 1:500 year flood level for the WOEF and power station would occur.

The selected closure alternative for the open cut would then be a staged transition between several of the alternatives comprised of the following steps.

Initial active filling of an isolated mine pit lake (Alternative 6), with water treatment as required. Water within the mine pit lake would be expected to experience stratification, with better quality water in the upper strata. The mine levee wall would be required to maintain full function throughout this period. Once confirmation of water quality within the various strata is within the expected bounds, progress would occur to the next stage.

A mine pit lake with backwater interaction (Alternative 5) would be implemented, whereby a part of the downstream mine levee wall would be removed, and engineered inlets between the McArthur River and mine pit lake constructed. This would enable floodwaters in the McArthur River above a nominal event (assumed to be annual flooding) with associated sediments and small aquatic fauna to migrate inside the mine levee wall, mixing with the mine pit lake water body, and providing a periodic flush of the mine pit lake. Large fauna, such as the Largemouth Sawfish (*Pristis pristis*), would be discouraged from entering the mine pit lake by the structure of the inlets. The water would remain at similar levels to the external river, with a riparian zone being established around its shores.

Upon confirmation that the water quality is meeting expectations under a variety of conditions, the decision to proceed to Alternative 4 (Flow through Mine Pit Lake as Secondary Path) would be made. A similar engineered inlet would be created at the upstream portion of the mine levee wall, turning the mine pit lake into a full flow-through water body, except with the water body being the secondary flow branch after the existing McArthur River channel. Maintenance of the mine levee wall could be ceased upon successful commissioning.

5.5.2.5 Alternative Environmental Management Measures for Key Risks

Sections 5.5.2.2.2.1 through 5.5.2.2.2.8 above provide key assumptions, advantages, potential risks and selected management measures for each of the open cut domain closure and rehabilitation alternatives considered. For the preferred alternative (Alternative 4 – Flow through Mine Pit Lake as Secondary Path) proposed management measures have been summarised in **Section 5.5.2.4**, with further details provided in **Chapter 3 – Project Description and Justification**.

5.5.3 Domain 2 – NOEF

5.5.3.1 Location Alternatives

The Project includes the expansion of the existing NOEF to facilitate the storage of overburden material to be generated over the life of the mine. There are a number of site constraints which limit the direction in which the NOEF can be expanded including Surprise Creek and the Barney Creek channel to the south; Barramundi Dreaming (Mount Stubbs), a site of cultural significance, to the east; and the Carpentaria Highway to the west.

Expansion of the NOEF to the north is considered the most appropriate, and has been adopted in the preferred design for the Project. This is in-keeping with the Phase 3 EIS direction of NOEF approval.

5.5.3.2 Height and Footprint Considerations

A number of NOEF height alternatives were considered. The two most relevant height alternatives considered were 80 m and 140 m.

The Aboriginal Areas Protection Authority (AAPA) certification process associated with the original application for open cut mining specified an 80 m height limit for the NOEF to respect a cultural site on the adjacent ridge to the east of the NOEF. This height limit has been honoured by both the original NOEF design and the Phase 3 EIS.

An alternative maximum height limit of 140 m was nominated, taking into consideration indigenous cultural values, NOEF geometry, geotechnical, geochemistry, erosion and sediment control management, footprint constraints, visual amenity impacts and material transport and placement economics.

Given that a fixed quantity of overburden will need to be placed in the NOEF, there is a relationship between the maximum height of the NOEF and the resultant footprint. Note that support facilities including runoff dams and stockpiles are also required for both alternatives to enable the NOEF to be constructed and rehabilitated. **Figure 5-12** provides an indication of the NOEF footprint for both the 80 m height and 140 m height alternatives and provides a conceptual layout for supporting facilities for both height cases.

An indicative comparison of the key features of the 80 m height versus 140 m height NOEF alternatives is included below in **Table 5-5**.

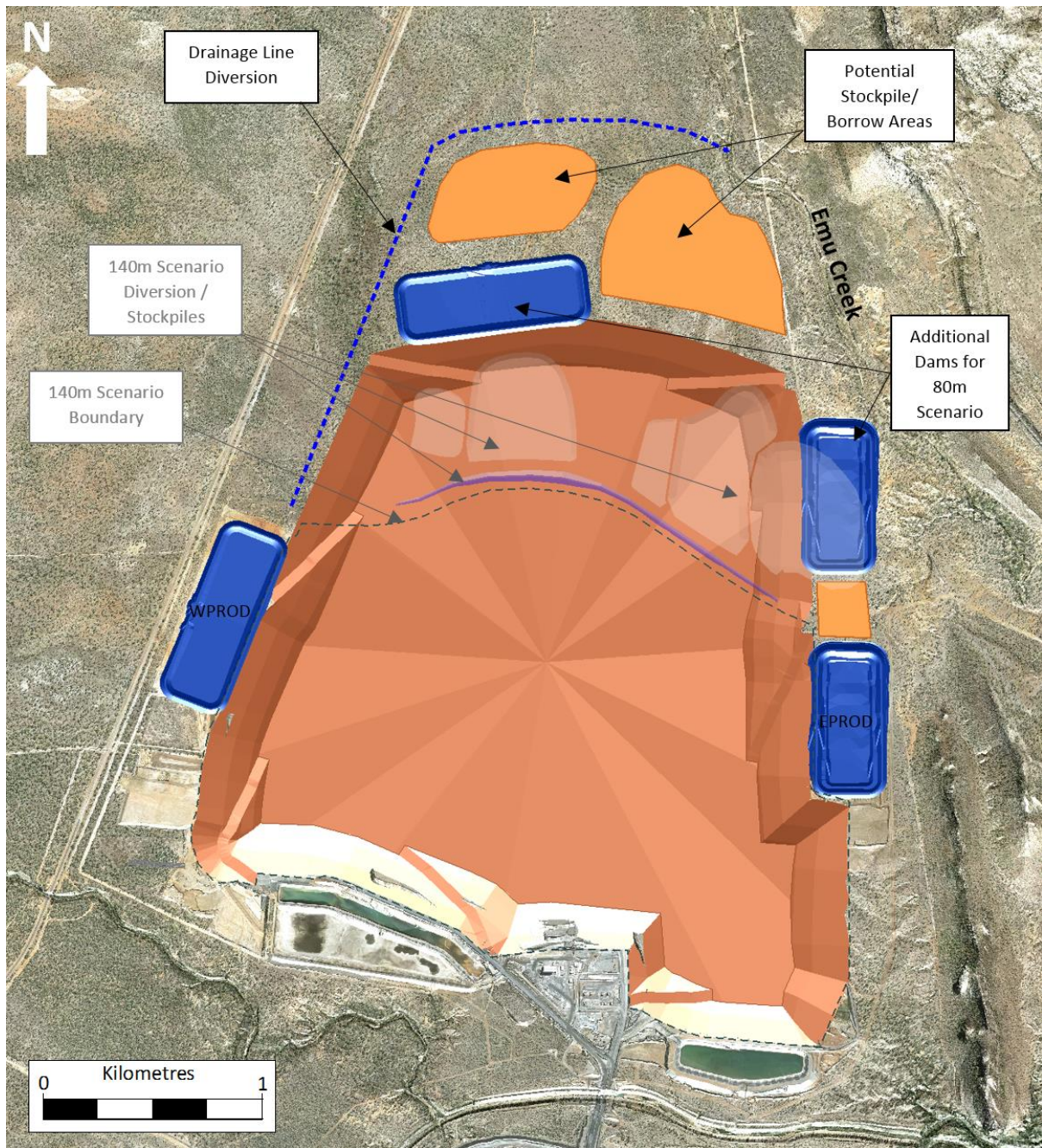


Figure 5-12 80 m vs. 140 m Design Footprint Conceptual Layout

Table 5-5 Indicative Comparison of Key Values for NOEF Height Alternatives

NOEF Feature	Unit	140 m	80 m	Balance	
Height	m	140	80	-60	-43%
Footprint in Barney Creek Catchment	ha	181	181	0	+0%
Footprint in Emu Creek Catchment	ha	330	513	183	+55%
Total footprint (excluding infrastructure, e.g. perimeter runoff dams stockpiles etc.)	ha	511	694	183	+36%
Core zone footprint (zone containing PAF(HC) material)	ha	451	621	170	+38%
Surface Area – Plateau	ha	128	462	334	+261%
Surface Area – Batter	ha	397	240	-157	-40%
Surface Area – Total	ha	525	702	177	+34%
Clay Required for CCL	million m ³	4.03	5.23	1.2	+30%
LS-NAF(HC) Required for Cover	million m ³	10.75	14.42	3.67	+34%
PAF Runoff Dams Required	#	4	6	2	+50%
Indicative Seepage Load	tonnes per day (SO ₄)	7.3	10.5	3.2	+44%

Key assumptions associated with the two height alternatives in addition to the above information include:

- the internal zones within the NOEF (base, core, halo, etc.) would use the same key design criteria for both height cases;
- the installed cover system would be based on a low to very low NP rate for both cases, with identical construction materials and specifications. Therefore, relative seepage rates are directly proportional to the footprint of the two alternatives;
- based on preliminary calculations, the 140 m height NOEF would result in an approximate 44% reduction in potential sulphate seepage from the facility;
- adjustments to the aerodrome Obstacle Limitation Surface (OLS) could be obtained from the Civil Aviation Safety Authority (CASA); and
- updated or new certificates for a higher NOEF limit could be obtained from AAPA.

The selection of the preferred height was undertaken in conjunction with the batter configurations and is presented after a discussion (below) of the batter alternatives.

5.5.3.3 Batter Configuration Alternatives

Four different batter (or slope) configurations were considered for the NOEF including:

- steep angle of repose (approximately 1V:1.3H);
- 1V:2.5H;
- 1V:4H; and
- trilinear concave, where the upper batters are 1V:2.5H, middle batters are 1V:3.5H, and the lower batters 1V:4.5H (therefore 1V:2.5/3.5/4.5H).

Factors considered in the selection and assessment of these alternatives is discussed below.

Visual Amenity

The natural topography around MRM features low rounded hills and higher rocky ridges with steep, sparsely vegetated upper slopes and flatter lower slopes with higher vegetation density.

Ratio of Plateau Area to Batter Area

It is generally more difficult to construct cover systems on batters compared to plateaus; however batters tend to have reduced NP compared to plateaus due to more positive drainage.

Influence on Total NOEF Area

An overall steeper profile will reduce the NOEF footprint for a given height, influencing disturbance, seepage quantities and rehabilitation material requirements.

Erosion Rates

In general for a given material, erosion rates increase as slope increases, although trilinear concave slopes are an exception to this rule as slope length is also influential, and steeper (angle of repose) slopes can remain relatively stable if end-tipped with coarse material being allowed to report to the outer part of the slope.

Modelling of erosion rates for comparison purposes has been undertaken as part of this assessment (refer to **Appendix K – Erosion Assessment for OEF Landform Configurations**).

Constructability

In general, tipping angle of repose slopes is a straightforward process for a mine, although different materials and tip heights can influence this angle. Flatter slopes require increasing amounts of earthworks (e.g. dozing) to produce the desired profile, although lift height can reduce this.

However, construction of cover layers increases in complexity as slope increases. From MRM site experience, the key limits associated with these works are:

- the maximum slope that a rubber tyred machine can operate on rock is approximately 1V:2.5H, while on CCL it reduces to 1V:3.0H; and
- the maximum slope that a tracked machine can operate on rock is approximately 1V:1.5H, although the limit at which rock can be pushed uphill by a dozer is 1V:2.5H. Due to grouser plates on the tracks, performance on CCL is unchanged.

Geotechnical Stability

The slope must be inherently stable under the expected range of conditions using the site materials intended for construction.

5.5.3.4 Height/Batter Combinations Assessment

The two NOEF height alternatives and four batter profile configurations were combined to create eight alternatives to be evaluated in an MCA. The alternatives are summarised in **Table 5-6** below.

Table 5-6 NOEF Height and Batter Slope Configuration Alternatives

Alternative	Height (m)	Batter Slope Configuration
1a	140	1V:2.5H
1b (preferred alternative)	140	Trilinear (1V: 2.5/3.5/4.5H)
1c	140	1V:4H
1d	140	Steep angle of repose (approx. 1V:1.3H)
2a	80	1V:2.5H
2b	80	Trilinear (1V:2.5/3.5/4.5H)
2c	80	1V:4H
2d	80	Steep angle of repose (approx. 1V:1.3H)

In assessing the NOEF alternatives, the following assumptions were made:

- all NOEF alternatives would have a cover system achieving a low to very low NP through the use of a barrier layer and benign growth media layer, with harder durable rock on the batters;
- drains and sediment control features would be designed to match the expected erosion rates before vegetation had time to establish;
- over the long term, all alternatives would require maintenance to manage erosion and cover integrity subject to performance monitoring outcomes;
- seepage mitigation installations and management would be installed and operated as required to meet the stated objectives; and
- the facility is part of the site-wide system that is aiming to achieve the sites Closure Objectives (refer to the **Chapter 4 – Decommissioning, Rehabilitation and Closure**).

The MCA scoring is shown in **Table 5-7**. The key results of the analysis are discussed below:

5.5.3.4.1 Alternative 1a – 140 m High, 1V:2.5H Batter Slope

Total Score: 43/60 (72%)

5.5.3.4.1.1 Short Term Effects

Environmental Performance

Total disturbance footprint favourable compared to 80 m height alternative, requiring relatively less seepage management. However, the steep batter slopes would require more controls to limit erosion and sedimentation impacts.

Constructability

Construction of the steep batter slopes would require the cover to be constructed in small lifts, which is a moderately complex and slower process.

Financial Cost

Moderately complex construction increases the construction cost, although the smaller footprint incurs lower costs associated with Perimeter Runoff Dams and total cover materials supply. The ongoing batter maintenance costs (even within the short term 100 year timeframe) would be higher than the alternatives with flatter batter slopes.

Societal and Stakeholder Benefits

A moderately complex construction would create a demand for specialised construction goods and services, although the increased cost associated with this could have a moderate impact on associated community investment projects.

*5.5.3.4.1.2 Long Term Effects***Environmental Performance**

Only minor impacts anticipated. This would be achieved through expenditure on ongoing maintenance and mitigation activities.

Maintenance Ease

It is possible for machines to access all areas across a 1V:2.5H batter slope. Erosion rates would be anticipated to be high due to a lack of vegetation growth on steep rocky batters, requiring more intervention.

Financial Cost

Reflective of the maintenance complexity, on-site financial costs would be major in the long term.

Societal and Stakeholder Benefits

Benefits still expected to be highly limited.

5.5.3.4.2 Alternative 1b – 140 m High and Trilinear (1V:2.5/3.5/4.5H) Batter Slope

Total Score: 46/60 (77%)

*5.5.3.4.2.1 Short Term Effects***Environmental Performance**

Total disturbance footprint is more favourable compared to 80 m height alternative. Trilinear slopes also:

- create breaks in batter overland flows, and improved ability to manage batter erosion and resulting sedimentation impacts; and
- more closely reflect the surrounding landform slope features, creating a less visually intrusive impact compared to other single sloped alternatives.

Constructability

The lower and mid slopes are able to be constructed along on the slope/contour, providing a more flexible and efficient approach to construction. The upper steeper slope is more complex and slower, but limited in quantity.

Financial Cost

Minor impact anticipated during initial construction as a result of the batter configuration and footprint, however maintenance costs in the shorter term are expected to be relatively low compared to the steeper battered alternatives.

Societal and Stakeholder Benefits

Construction costs initially would create a demand for specialised construction goods and services, with this increased cost having a moderate impact on associated community investment projects.

5.5.3.4.2.2 Long Term Effects

Environmental Performance

Improved slope water management would lead to a minor risk of erosion and resultant sedimentation of surface waterways, both on-lease and downstream.

Maintenance

Expected to comprise a low level of complexity and intervention to meet the performance criteria.

Financial Cost

Reflective of the low level maintenance complexity, on-site financial costs would be relatively minor in the long term.

Societal and Stakeholder Benefits

Benefits still expected to be highly limited.

5.5.3.4.3 Alternative 1c – 140 m High and 1V:4H Batter Slope

Total Score: 44.5/60 (74%)

5.5.3.4.3.1 Short Term Effects

Environmental Performance

Total disturbance footprint is more favourable compared to the 80 m height alternative and the relatively flatter slopes allow for improved erosion control compared to the steeper slope alternatives.

Constructability

Straightforward construction methodology, with batter slopes able to be constructed along the slope/contour, providing a more flexible and efficient approach to construction.

Financial Cost

Moderate impact anticipated during initial construction as a result of the increased footprint, CCL and cover material requirements (compared to the other 140 m high alternatives), however maintenance costs in the shorter term are expected to be relatively low compared to the steeper battered alternatives.

Societal and Stakeholder Benefits

Construction costs initially would create a demand for construction goods and services, with this increased cost having a moderate impact on associated community investment projects.

5.5.3.4.3.2 Long Term Effects

Environmental Performance

Improved slope water management would lead to a minor risk of erosion and resultant sedimentation of surface waterways, both on-lease and downstream.

Maintenance Ease

Expected to comprise some complexity and intervention to meet the performance criteria.

Financial Cost

Reflective of the level of maintenance complexity, on-site financial costs would be minor in the long term.

Societal and Stakeholder Benefits

Benefits expected to be highly limited on-site in the long term as workforce numbers would be small and engaged on an “as needed” basis from the regional community.

5.5.3.4.4 Alternative 1d – 140 m High and Angle of Repose Slope (1V:1.3H)

Total Score: 36.5/60 (61%)

5.5.3.4.4.1 Short Term Effects

Environmental Performance

Total disturbance footprint favourable compared to 80 m height alternative, resulting in relatively lower seepage mitigation controls to meet the required performance. Landform stability would need to be managed.

Constructability

Construction of the steep batter slopes would require liner and surrounding layers to be constructed in small lifts, which is a slower and more complex process.

Financial Cost

Although constructability is more complex, the reduced footprint (compared with the 1a, 1b and 1c alternatives) equates to a reduced need for basal CCL, cover materials and water management dams.

Societal and Stakeholder Benefits

More complex construction may result in more employment opportunities for a longer construction period.

5.5.3.4.4.2 Long Term Effects

Environmental Performance

The long term objectives could be achieved through continual maintenance of the cover system and seepage mitigation systems, although local impacts have been scored slightly lower than in the short term due to the ongoing maintenance complexities with respect to management of the cover system (and hence risk of erosion).

Maintenance Ease

Given the steep batter slopes and access restrictions, long term maintenance would continue to be problematic and costly. It would not be possible to repair any damaged liner in the cover system on the batters, hence there is a significant risk that a storm in excess of the design event would occur and irreparably damage the cover.

Financial Cost

Reflective of the maintenance complexity, on-site financial costs would be unsustainable in the long term.

Societal and Stakeholder Benefits

Benefits are expected to be highly limited on site as in the long term the workforce is likely to be sourced from the surrounding community (i.e. off-lease).

5.5.3.4.5 Alternative 2a – 80 m High and 1V:2.5H Batter Slope

Total Score: 41/60 (68%)

5.5.3.4.5.1 Short Term Effects

Environmental Performance

The low height creates a larger footprint, requiring more seepage mitigation controls. Additionally, the steeper batter slopes would require more controls to limit erosion and sedimentation impacts.

Constructability

Construction of the steep batter slopes would require the cover to be constructed in small lifts, which is a moderately complex and slower process.

Financial Cost

The larger footprint and steeper slopes increase construction and maintenance costs, and hence reduce the ranking of this alternative.

Societal and Stakeholder Benefits

Complex construction would create a demand for specialised construction goods and services initially, but the increased financial cost (compared to the 140 m alternative) would equate to slightly reduced stakeholder benefits compared to the 140 m alternative.

5.5.3.4.5.2 Long Term Effects

Environmental Performance

The increased footprint combined with the ongoing maintenance of slope stability (and associated erosion and sediment controls) will require ongoing controls and intervention to maintain downstream water quality, although slope stability would be expected to improve in the long term.

Maintenance

It is possible for machines to access the entire area of the batter slope, so ongoing maintenance as required is possible. Erosion rates would be high due to a lack of vegetation growth on steep rocky batters, thus requiring more intervention.

Financial Cost

Reflective of the maintenance complexity, on-site financial costs would be major in the long term.

Societal and Stakeholder Benefits

Benefits still expected to be highly limited.

5.5.3.4.6 Alternative 2b – 80 m Height and Trilinear Batter Slope (1V:2.5/3.5/4.5H)

Total Score: 44/60 (73%)

5.5.3.4.6.1 Short Term Effects

Environmental Performance:

The larger footprint would require more seepage interception controls and management to meet the MRM objectives; although trilinear slopes would:

- create breaks in batter overland flows, and improved ability to manage batter erosion and resulting sedimentation impacts; and
- more closely reflect the surrounding landform slope features, creating a less visually intrusive impact compared to other single sloped alternatives.

Constructability

The lower and mid slopes are able to be constructed on the slope, giving flexibility and efficiency. The upper steeper slope is more complex and slower, but of limited extent.

Financial Cost

The larger footprint increases the construction cost and seepage management costs, however landform maintenance costs in the shorter term are expected to be relatively low compared to the steeper battered alternatives.

Societal and Stakeholder Benefits

Construction costs initially would create a demand for specialised construction goods and services, with this increased cost having a moderate impact on associated community investment projects.

5.5.3.4.6.2 *Long Term Effects*

Environmental Performance

Improved slope water management would lead to a minor risk of erosion and resultant sedimentation of surface waterways, both on-lease and off-lease (downstream).

Maintenance Ease

Expected to comprise a low level of complexity and intervention to meet the performance criteria.

Financial Cost

While the landform maintenance costs would be low, the large footprint would require more on-going seepage management costs to manage the impacts and achieve the objectives.

Societal and Stakeholder Benefits

Benefits still expected to be highly limited.

5.5.3.4.7 Alternative 2c – 80 m High and 1V:4H Batter Slope

Total Score: 44/60 (73%)

5.5.3.4.7.1 *Short Term Effects*

Environmental Performance

Total disturbance footprint is greater than the 140 m high alternative with the same batter slope, so has been scored slightly lower.

Constructability

Straightforward construction methodology, with batter slopes able to be constructed along the slope, providing a more flexible and efficient approach to construction.

Financial Cost

Major impact anticipated during initial construction and has been scored lower (2) as a result of the increased footprint, CCL and cover material requirements (compared to the 140 m high alternative). Maintenance costs in the shorter term are expected to be relatively low compared to the steeper battered alternatives.

Societal and Stakeholder Benefits

Construction costs initially would create a demand for construction goods and services, and the resultant jobs this would create.

5.5.3.4.7.2 *Long Term Effects*

Environmental Performance

Improved slope water management would lead to a minor risk of erosion and resultant sedimentation of surface waterways, both on-lease and downstream.

Maintenance Ease

Expected to comprise some complexity and intervention to meet the performance criteria.

Financial Cost

Reflective of the level of maintenance complexity, on-site financial costs would be minor in the long term.

Societal and Stakeholder Benefits

Benefits expected to be highly limited on-site in the long term as workforce numbers would be small and engaged on an as needed basis from the regional community.

5.5.3.4.8 Alternative 2d – 80 m High and Angle of Repose Slope (1V:1.3H)

Total Score: 37.5/60 (63%)

5.5.3.4.8.1 Short Term Effects

Environmental Performance

This alternative has the smallest footprint of the 80 m height alternatives, though it is still larger than any of the 140 m height alternatives. This would require more seepage mitigation measures to meet the required performance objectives.

Constructability

Construction of the steep batter slopes would require liner and surrounding layers to be constructed in small lifts, which is a slower and more complex process.

Financial Cost

Complex construction would equate to a high up-front construction cost. Due to the steep slope, no access to the slope would be possible. Thus, maintenance of erosion could only be undertaken by tipping more material at the crest of the NOEF, relying on gravity to fill the gullies. This would require a higher volume of material and hence extra costs.

Societal and Stakeholder Benefits

Complex construction would create a demand for specialised construction goods and services, although this increased cost could have a moderate impact on associated community investment projects.

5.5.3.4.8.2 Long Term Effects

Environmental Performance

Ongoing maintenance of slope stability (and associated erosion and sediment controls) is anticipated to create a moderate to major environmental risk to downstream water quality.

Maintenance Ease

Given the steep batter slopes and access restrictions, long term maintenance would continue to be problematic and costly. It would not be possible to repair any damaged liner in the cover system on the batters, hence there is a significant risk that a storm in excess of the design event would occur and irreparably damage the cover.

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Table 5-7 Multi-criteria Analysis for NOEF Height and Batter Combinations

		Short Term Effects ¹								Long Term Effects ²									
#	Alternative	Local effects ³				Regional effects ⁴				Local effects ³				Regional effects ⁴				Total	%
		Environmental Performance	Constructability ⁷	Financial Cost ⁵	Societal and Stakeholder Benefits ⁶	Environmental Performance	Constructability ⁷	Financial Cost ⁵	Societal and Stakeholder Benefits ⁶	Environmental Performance	Maintenance ease ⁷	Financial Cost ⁵	Societal and Stakeholder Benefits ⁶	Environmental Performance	Maintenance ease ⁷	Financial Cost ⁵	Societal and Stakeholder Benefits ⁶		
1a	140 m high and 1V:2.5H batter slope	4	3	4	3.5	4	NA	NA ⁸	4	4	3	4	2	4	NA	NA ⁸	3.5	43	72
1b	140 m high and trilinear batter slope	4	4	4	3.5	4	NA	NA ⁸	4	4	5	4	2	4	NA	NA ⁸	3.5	46	77
1c	140 m high and 1V:4H batter slope	4	5	3	3	4	NA	NA ⁸	4	4	4	4	2	4	NA	NA ⁸	3.5	44.5	74
1d	140 m high and steep (angle of repose) batter slope	4	2	5	2	4	NA	NA ⁸	4	3.5	1	1	2.5	4	NA	NA ⁸	3.5	36.5	61
2a	80 m high and 1V:2.5H batter slope	3.5	3	3	3	4	NA	NA ⁸	4	4	3	4	2	4	NA	NA ⁸	3.5	41	68
2b	80 m high and trilinear batter slope	3.5	4	3	3	4	NA	NA ⁸	4	4	5	4	2	4	NA	NA ⁸	3.5	44	73
2c	80 m high and 1V:4H batter slope	3.5	5	2	4	4	NA	NA ⁸	4	4	4	4	2	4	NA	NA ⁸	3.5	44	73
2d	80 m high and steep (angle of repose) batter slope	3.5	2	4	3.5	4	NA	NA ⁸	4	3.5	1	2	2.5	4	NA	NA ⁸	3.5	37.5	63
Maximum Possible Score		5	5	5	5	5	NA	NA	5	5	5	5	5	5	NA	NA	5	60	100

1 0-100 year timeframe
2 100-1,000 year timeframe
3 On-lease
4 Off-lease
5 Financial cost to McArthur River Mining and its impact on Project viability.
6 Includes benefits in terms of employment creation and planned community investment projects, services, taxes and royalties.
7 Assumption is that construction costs apply in the short term, but these transfer to maintenance costs in the long term.
8 All financial costs to McArthur River Mining are assumed to be incurred on-lease (therefore local effect only).

This page has been intentionally left blank for consistency between printed and electronic versions of this document.

Financial Cost

Reflective of the maintenance complexity, on-site financial costs would be unsustainable in the long term.

Societal and Stakeholder Benefits

Benefits still expected to be highly limited.

5.5.3.4.9 Preferred Height and Batter Geometry Alternative

The overall MCA rankings show the top three to be:

- 1 Alternative 1b – 140 m high with trilinear slopes (1V:2.5/3.5/4.5H);
- 2 Alternative 1c – 140 m with 1V:4H slopes; and
- 3 Alternatives 2b and 2c (same scoring) – 80 m high, trilinear or 1V:4H slopes.

In addition to the MCA, the following issues were considered:

- the 1a and 2a alternatives with 1V:2.5H slopes would prove difficult to establish vegetative cover, and so would be subject to potential ongoing erosion and low visual amenity;
- the lower 80 m height alternatives would have final cover established on the plateau sooner, but similar exposures of non-benign working areas over the life-of-mine;
- the 80 m height alternatives would have less encapsulation around the existing NOEF;
- the 80 m height alternatives encroach on habitat of the Gouldian Finch to the north;
- drainage on the plateau and batters of the 1V:2.5H batters would need to be highly effective to avoid potential small scale geotechnical instability; and
- the inability to repair cover system barrier layers on the steep slopes beyond generous extra layers of end-tipped benign LS-NAF(HC) material was considered a fatal flaw, removing alternatives 1d and 2d from further consideration.

Considering this information, **the preferred alternative was 1b, a 140 m high NOEF with trilinear concave batters.**

5.5.3.5 Cover System Design

The primary role of the cover system in the context of OEFs at MRM is to limit the generation of oxidation products within the sulphidic materials stored within the inner zones of the OEF, and to limit transport mechanisms that may mobilise contaminants in those inner zones. The transport mechanisms and contaminants include water mobilising soluble contaminants, water mobilising physical sediment particles, and advective gas currents mobilising noxious gases. In completing these roles, the cover must possess the following inherent properties:

- long term physical stability;
- long term geochemical stability; and
- ability to form a suitable substrate in order to establish vegetation on, and subsequently provide a rehabilitated landform that satisfies the final land use and closure objectives (as defined in **Chapter 4 – Decommissioning, Rehabilitation and Closure**).

5.5.3.5.1 Design Alternatives

Analysis of five different types of cover systems was undertaken to determine the most appropriate design. The cover systems considered during the assessment are detailed below. **Figure 5-14** provides a diagrammatic representation of these cover system alternatives.

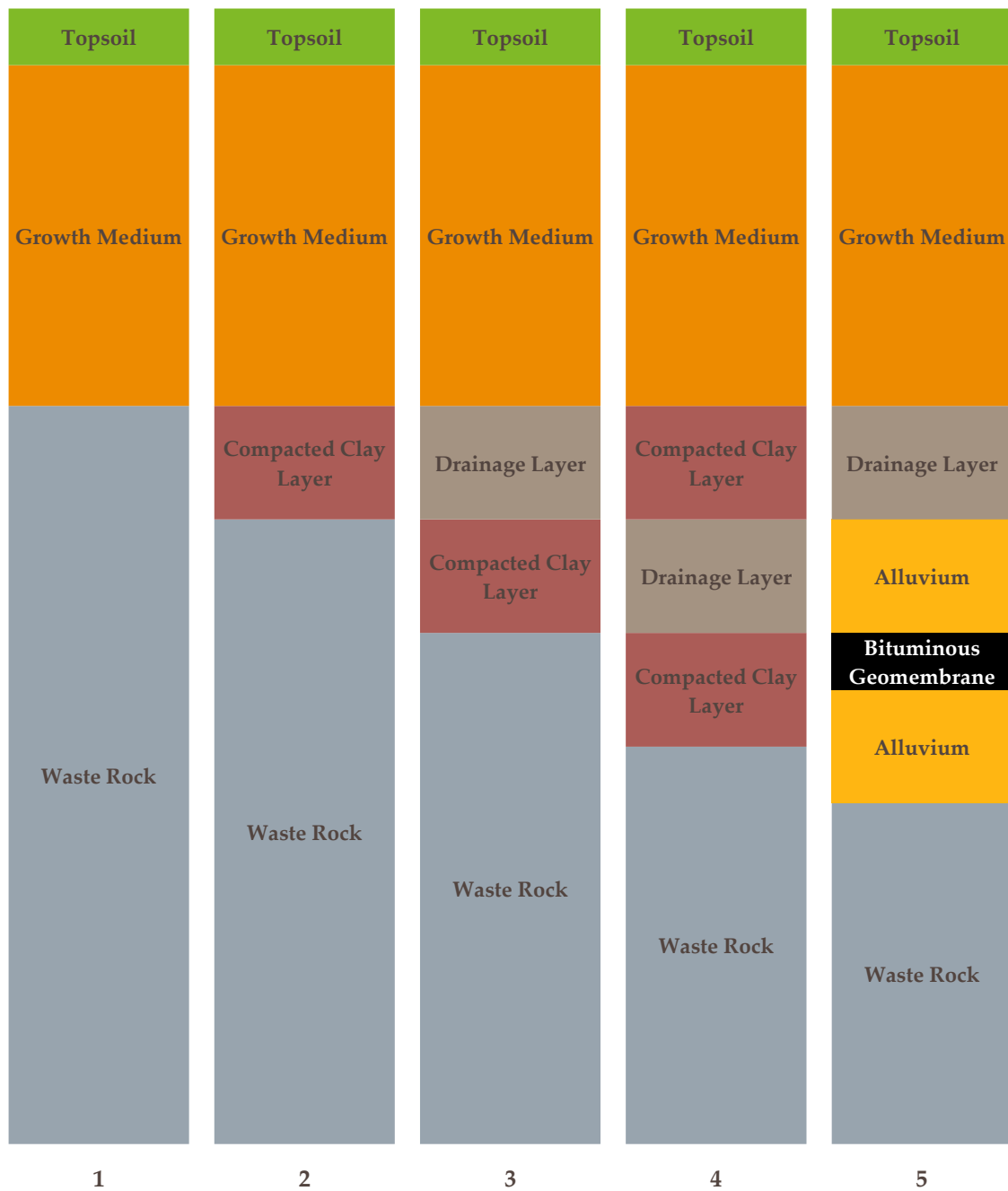


Figure 5-13 NOEF Cover System Design Alternatives (not to scale)

Design alternatives are:

1. store-and-release cover system;
2. enhanced store-and-release cover system;
3. oxygen barrier cover system;
4. two barrier layer cover system; and
5. BGM system (similar to alternative 3, except the CCL is replaced with a barrier comprised of a BGM with protective alluvium layers above and below.)

A description of each alternative is provided below.

5.5.3.5.1.1 *Alternative 1 – Store-and-Release Cover System*

A store-and-release cover system relies primarily on the store-and-release concept to reduce NP into the underlying overburden; i.e. infiltrating water is stored within the rooting zone of the cover system (the growth media, or growth medium (GM) layer) so it can be subsequently released via evapotranspiration (ET) between rainfall events. The objective of a store-and-release cover system is to reduce deep percolation by returning most of the infiltrating waters from storage to the atmosphere via transpiration. Limiting oxygen ingress is not achievable with this cover system design.

5.5.3.5.1.2 *Alternative 2 – Enhanced Store-and-Release Cover System*

This cover system design also utilises the store-and-release concept to meet most of the cover system objectives, but includes an additional reduced permeability barrier layer that results in a textural and hydraulic discontinuity. This discontinuity slows NP, which results in water being retained in the cover system for longer; allowing more time for its removal via evapotranspiration. The CCL barrier layer also provides the potential for a tension saturated layer to limit oxygen ingress.

5.5.3.5.1.3 *Alternative 3 – Oxygen Barrier Cover System (Preferred Alternative)*

The oxygen barrier cover system features a drainage layer of coarser rock between the GM and CCL layers. This enhances drainage of excess water from above the CCL, reducing NP. However, it also forms a capillary break between the growth medium and CCL to uncouple the underlying CCL barrier from the influences of vegetative water demands and atmospheric forces. As a result, drying of the CCL barrier is mainly due to a weak downward hydraulic gradient into the underlying material. Therefore, the CCL barrier is more capable of maintaining tension-saturated conditions, which results in reduced oxygen ingress via diffusion.

5.5.3.5.1.4 *Alternative 4 – Two Barrier Layer Cover System*

The two barrier layer cover system utilises a CCL barrier between the growth medium and drainage layers to reduce NP (similar to the enhanced store-and-release cover system) and a second CCL barrier below the drainage layer to provide a further barrier to oxygen and NP ingress (similar to the oxygen barrier cover system).

5.5.3.5.1.5 *Alternative 5 – Bituminous Geomembrane Cover System*

This alternative is a modification of Alternative 3 (oxygen barrier cover system) whereby the barrier layer function is provided by a BGM. Thin layers of fine-grained alluvium are placed below and above the BGM for physical protection of the BGM from puncture by rocks. This BGM is a manufactured product consisting of non-woven geotextile and glass fleece layers encapsulated in elastomeric bitumen, with a sanded upper surface for enhanced friction and an anti-root layer on the bottom (refer **Figure 5-14** below). The geotextiles dictate the mechanical properties of the BGM, while the bitumen binder provides waterproofing, chemical resistance and protection from ageing. The BGM alternative could be applied on the NOEF batter slopes and/or the NOEF plateau.

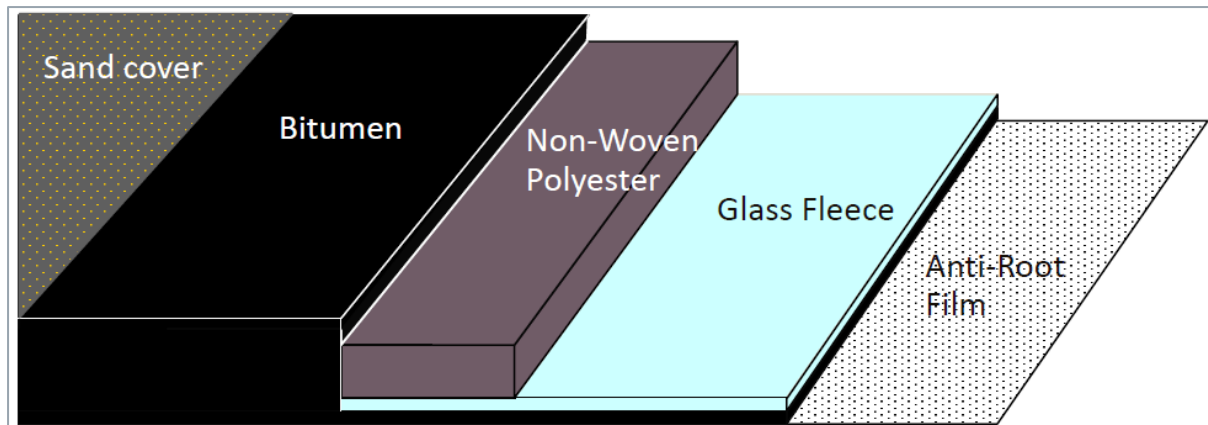


Figure 5-14 Coletanche BGM structure

5.5.3.5.2 Assessment of Cover Alternatives

An MCA was undertaken on the alternatives to provide a relative score for each alternative against the objectives of the cover system. **Table 5-8** presents the MCA scores, while the sections for each alternative provide more detail on the basis for the scores.

In assessing the cover alternatives, assumptions were made and discussed below.

The geometry of the NOEF is assumed to remain the same for all cases. The internal architecture of the NOEF is the same, which features a basal CCL to direct a significant proportion of seepage to collection points, compacted materials and/or regular advection barriers throughout the core to limit oxidation, and a lower reactivity halo.

Drains and sediment control features would be designed to match the expected erosion rates before vegetation had time to establish.

The GM layer on the batters would be suitably rocky and vegetated approximately 20 years into the adaptive management phase to resist erosion in regular wet season events.

Over the long term, all alternatives will require maintenance to manage erosion and cover integrity subject to performance monitoring outcomes. The frequency of maintenance may differ between alternatives, which would be reflected in the Financial Cost and Maintenance Ease assessments.

Seepage mitigation installations and management would be required for all alternatives to manage site performance during the construction phase to meet the stated objectives. So the presence and extent of these systems is assumed to be common to all cases. However, the difference in NP and oxidation rates of the various cover systems would affect the size of pumps, pipes and water treatment plants, and how long they were required for. This would be reflected in the 'Financial Cost' and 'Maintenance Ease' assessments.

The effectiveness of the seepage mitigation installations would be reasonable. Systems such as seepage interception trenches, recovery bores and barriers are widely used around the world in similar settings as the NOEF for similar purposes. However, they are not perfect. Therefore, minor differences in environmental performance have been factored in to differentiate between alternatives with better source control (i.e. reduced NP and oxidation through the cover system) from alternatives which rely more on secondary controls (e.g. seepage recovery and management).

The facility is part of the site-wide system that is aiming to achieve the site closure objectives (refer to **Chapter 4 – Decommissioning, Rehabilitation and Closure**).

Table 5-8 Multi-criteria Analysis of NOEF Cover System Alternatives

		Short Term Effects ¹								Long Term Effects ²									
#	Alternative	Local effects ³				Regional effects ⁴				Local effects ³				Regional effects ⁴				Total	%
		Environmental Performance	Constructability ⁷	Financial Cost ⁵	Societal and Stakeholder Benefits ⁶	Environmental Performance	Constructability ⁷	Financial Cost ⁵	Societal and Stakeholder Benefits ⁶	Environmental Performance	Maintenance ease ⁷	Financial Cost ⁵	Societal and Stakeholder Benefits ⁶	Environmental Performance	Maintenance ease ⁷	Financial Cost ⁵	Societal and Stakeholder Benefits ⁶		
1	Store-and-release	3	4	4	3	3.5	NA	NA ⁸	3.5	3	3	2	4	3.5	NA	NA ⁸	3	39.5	66
2	Enhanced store and release cover system	4	3.5	4	4	4	NA	NA ⁸	3.5	3.5	4	4.5	3	4	NA	NA ⁸	3	45.0	75
3	Oxygen barrier cover	4	3	3.5	4	4.5	NA	NA ⁸	3.5	4	4	4	3	4.5	NA	NA ⁸	3	45.0	75
4	Two barrier layer cover system	4.5	2	1.5	4	5	NA	NA ⁸	3.5	5	3.5	4	3	5	NA	NA ⁸	3	44.0	73
5	Bituminous Geomembrane (BGM) cover system	5	2.5	2	4	5	NA	NA ⁸	3.5	5	4	4	3	5	NA	NA ⁸	3	46.0	77
Maximum Possible Score		5	5	5	5	5	NA	NA	5	5	5	5	5	5	NA	NA	5	60	100

1 0-100 year timeframe
2 100-1,000 year timeframe
3 On-lease
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5 Financial cost to McArthur River Mining and its impact on Project viability.
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5.5.3.5.2.1 *Alternative 1 – Store-and-Release*

Total Score: 39.5/60 (66%)

The driver of the scores for this alternative is the lack of a barrier layer in the cover. This would enable oxidation of the halo zone, before being restricted by advection barriers in the core. However, the halo would be constructed out of MS-NAF material with lower reactivity than the PAF material.

The lack of a barrier layer also would see the store-and-release capacity of the cover system regularly exceeded by the high intensity storms that are prevalent at the site. When this occurs, higher NP would result, providing a transport mechanism for mobilising products of oxidation. Thus, intermittent periods of higher toe and basal seepage would be a feature of this alternative.

As the period for NP to migrate through the full NOEF profile and then report to groundwater and likely surface water could be highly variable, there is no guarantee that this would occur in the wet season when higher levels of dilution occur. Therefore, a comprehensive network of seepage detection and recovery systems would be required to enable this system to meet the Closure Objectives. However, given the basal CCL and drainage incorporated into the foundation, and the presence of only three major drainage lines under and around the NOEF where seepage would report to, it is assumed that extra capacity would need to be added into the seepage management system rather than additional installations.

So while the environmental performance could be satisfactory (with possible intermittent breaches), the required capacity and cost of construction and maintenance of the seepage mitigation system is assumed to be higher than alternatives with less seepage.

Environmental Performance

Consistent seepage could be expected, with intermittent fluctuations corresponding to wetter years. Seepage recovery systems installed locally around the NOEF would likely intercept and recover the majority of this seepage, however Barney Creek and Emu Creek may be subject to local impacts in the dry season. Due to dilution from additional catchments, the regional impact would be lessened relative to the local area. Similar performance would be expected in the long term due to on-going provisions for maintaining facility performance.

Constructability and Maintenance

While the cover itself is the most straightforward to construct and maintain and may warrant a score of '5', the seepage recovery systems and subsequent treatment and/or storage systems would create added complexity. Source control is usually easier, cheaper and more effective than mitigation strategies and systems in the long term.

Financial Cost

This score reflects the high cost of mitigation strategies, with a lower capital or initial construction cost of the cover itself but higher on-going costs to manage extensive seepage. It is assumed that in the long term, other alternatives with less seepage could foreseeably have seepage treatment systems decommissioned, but this alternative is likely to require intermittent collection and treatment (following wetter wet seasons) into the foreseeable future.

Societal and Stakeholder Benefits

The scores reflect a relatively straightforward initial site construction program, but on-going requirements for seepage management. Regional effects are not anticipated to differ from other alternatives.

5.5.3.5.2.2 *Alternative 2 – Enhanced store and release cover system*

Total Score: 45/60 (75%)

Environmental Performance

The addition of a CCL barrier reduces oxidation of the halo MS-NAF material, and reduces NP compared to Alternative 1. However, during larger and/or more intense rainfall events, there may be insufficient drainage capacity and evapotranspiration to remove all the water, therefore higher NP is anticipated to occur.

This would be relatively infrequent, and would be largely recovered by the seepage management system in the short term, so the additional impacts are minor.

It is assumed that there would be insufficient seepage in the long term to justify having extensive facilities in place rather than deposition of collected seepage into the mine pit lake, and so it is assumed there would be periodic minor water quality fluctuations on both the local and regional scales after rain events beyond the design event.

Constructability and Maintenance

The addition of a CCL increases the complexity of construction. Based on the assumption of no long term water treatment requirement, maintenance is relatively straightforward.

Financial Cost

The addition of a single specialty layer in the cover results in additional construction costs compared to Alternative 1, however these costs would be less than the other more complex versions. In the long term, there is no water treatment required to add costs, and repair of the simple cover system would be relatively straightforward.

Societal and Stakeholder Benefits

There is limited difference in impacts on employees or the wider community between this and other complex covers.

5.5.3.5.2.3 *Alternative 3 – Oxygen Barrier Cover System*

Total Score: 45.0/60 (75%)

Environmental Performance

This cover features additional drainage capacity, reducing the expected NP in higher magnitude storm events. This would reduce the reliance on imperfect seepage collection and mitigation compared to Alternative 2, resulting in a higher score in the long term.

Constructability and Maintenance

The drainage layer requires materials with a specific size range, plus a means to manage the risk of finer particles from the GM layer clogging up the drainage layer over time. This adds to the complexity of construction, but was not expected to materially impact on long term maintenance issues due to an established vegetation cover.

The relative simplicity of the layers means replacement of sections of the cover during the adaptive management phase would be reasonably straightforward.

Financial Cost

These scores reflect the construction complexity relative to the other alternatives.

Societal and Stakeholder Benefits

There is limited difference in impacts on employees or the wider community between this and other complex covers.

5.5.3.5.2.4 Alternative 4 – Two Barrier Layer Cover System

Total Score: 44.0/60 (73%)

Environmental Performance

This system would provide a high level of performance, with both oxygen and NP well controlled. Only the complexity of construction and associated quality assurance/quality control (QA/QC) affected the short term local performance, as some initial performance issues could be expected.

Constructability and Maintenance

This is the most complex cover, with multiple specialty layers. The risk of piping failure of the top CCL into the drainage layer would require installation of an intervening filter layer or geotextile. The complexity to repair the sequence in the long term caused a score reduction for maintenance.

Financial Cost

In line with construction complexity, this alternative is anticipated to have a major impact on company budgeting. The cost would be incurred during construction of the cover, but also in sourcing and then rehabilitating the extra clay borrow sources required.

Societal and Stakeholder Benefits

There is limited difference in impacts on employees or the wider community between this and other complex covers.

5.5.3.5.2.5 Alternative 5 – BGM Layer Cover System

Total Score: 46.0/60 (77%)

Environmental Performance

The BGM cover system is expected to perform to a high standard, with very low levels of NP and oxygen ingress, both in the short term and long term.

No long term requirement for seepage management is anticipated.

Constructability and Maintenance

As the BGM is an engineered product, the QA/QC of the construction material itself is less complex. QA/QC of the construction process would be relatively straightforward once the procedures were developed and became routine.

Allowance for gas venting and settlement would be required, adding to complexity;

Care would be required to limit the movement of the product down the batters as the overlying layers were placed, and to limit accidental puncturing of the product; and

It is anticipated that, due to the repeatable process of its installation, construction would become less complex over time.

Financial Cost

Major cost implications are anticipated due to the high capital expenditure for the geomembrane material and complex installation process, however, the relative simplicity to repair sections compared to CCL aids its long term cost score.

This score assumes the product integrity will be maintained through the 1,000 year assessment period in the cover system environment.

Societal and Stakeholder Benefits

There is limited difference in impacts on employees or the wider community between this and other complex covers.

5.5.3.5.3 Selection of Preferred Cover Alternative

The overall MCA scores for all of the cover systems with a barrier layer were comparable, with the top three scores as follows:

- 1) Alternative 5 – BGM cover system 46.0/60 (77%);
- 2) Alternative 3 – Oxygen barrier cover 45.0/60 (75%); and
- 3) Alternative 2 – Enhanced store and release cover system 45.0/60 (75%).

The highest score was attained by the BGM cover system. The high environmental performance of this alternative is due to anticipated very low NP and oxygen ingress rates, whilst moderate construction complexity and relatively high cost did not penalise the scoring significantly. However, there are a number of risks associated with this cover system design including:

- the durability has been rated very highly in the nuclear industry, however their emplacement conditions are expected to be materially different to the interior of the MRM OEFs;
- no construction trials have been undertaken at MRM or by McArthur River Mining, leading to a higher uncertainty in this area; and
- the risks of a limited friction angle and high runoff rates in high rainfall events may present a risk of geotechnical instability of the cover layer on the steeper upper batters of the NOEF.

The durability has also been rated highly in buried applications, however the number and duration of testing is limited compared to geomembranes such as high-density polyethylene (HDPE). No site specific testing has been completed on the product for the expected MRM application.

For these reasons, it was felt prudent to defer selection of this cover system until the confidence in these areas can be increased through site specific trials. The perceived additional performance of this cover will make it preferred for OEF areas of higher risk (such as where larger stored loads may be expected) if trials prove its capabilities.

Cover Alternatives 2 (Enhanced store and release) and 3 (Oxygen barrier cover) could not be differentiated based on their total MCA scores; however, the manner in which they achieved this total score was different. Alternative 2 has a lower effectiveness as a source control of potential contamination, but compensates for this due to the perceived small incremental extra cost to manage the slightly higher seepage quantities in years of heavier rainfall. Conversely, the addition of the drainage layer in Alternative 3 incurs a higher construction cost; however this is anticipated to be recouped in lower ongoing seepage management costs, and slightly improved environmental

performance in wetter years. The equal total ranking indicates that on a cost-benefit basis, the extra performance of the drainage layer is not expected to be a clear advantage.

McArthur River Mining recognises that there are inherent risks and uncertainties in the performance of the NOEF. In the hierarchy of controls, source control is the preferred approach compared to adoption of secondary or mitigation controls. Therefore, until as-built performance is verified by comprehensive monitoring data as matching or exceeding the conceptual model and computer modelled performance, an increased investment in source control and reduced reliance on secondary or mitigation controls is considered the most appropriate risk management approach. Hence, the **preferred alternative for the cover system is Alternative No. 3, the Oxygen barrier cover system.**

5.5.3.6 Construction and Operational Alternatives

As part of MRM Project planning phase, and its focus on the effective placement of non-benign overburden into the NOEF, a number of different NOEF overburden placement alternatives have been considered. This has formed part of McArthur River Mining's strategy to place this material within the NOEF so that oxidation of sulphide minerals can be managed during overburden placement, and therefore limit the potential for stored oxidation products within the NOEF. By achieving this, McArthur River Mining aims to reduce the long term reliance on the cover system as the sole means of managing contaminant loads from the NOEF, and hence support its Project design philosophy to reduce the risk of environmental harm (refer to **Chapter 3 – Project Description and Justification** for further details).

5.5.3.6.1 Alternative Construction Practices Considered

The alternatives considered have included the following methods of material placement:

- paddock dumping (nominal 2 m lifts);
- end tipping (nominal 5 m lifts);
- paddock dumping with advection barriers (nominally 2 m lifts with the placement of an interim alluvial cover to restrict gas flux); and
- end tipping with advection barriers (comprising two 5 m lifts within an approximate 50,000 square metre cell with the placement of an interim alluvial cover material to limit gas flux).

Refer to **Appendix P – NOEF Assessment for Waste Placement Report** for further details on these above four alternatives.

In addition, McArthur River Mining has also considered a fifth alternative, that of a 7.5 m lift scenario. This would comprise the following:

- lift height of 7.5 m comprising a 2 m thick paddock dumped base layer and an overlying 5.4 m thick tip head;
- 100 millimetre (mm) thick compacted alluvium sheeting applied on the horizontal surface every 7.5 m lift;
- 1.5 m thick alluvium layer on inter-stage slopes; and
- 100 mm to 200 mm thick, compacted alluvium layer on all inter-stage roads.

This 7.5 m lift scenario is described in further detail in **Appendix I – 7.5 m Advection Cover Lift Height Assessment**.

5.5.3.6.2 Assessment of Alternatives

Modelling of potential oxidation product generation associated with these alternatives has been undertaken through various studies (refer **Appendix J – NOEF Cover System and Landform Design** and **Appendix P – NOEF Assessment for Waste Placement, Footprint Seepage and Water Quality** for further details). A number of conclusions have been drawn from this modelling work and have informed design development, including:

- compaction of the overburden will limit oxygen availability and therefore oxidation;
- low lifts reduce particle segregation and prevent the formation of preferential pathways for the ingress of oxygen deeper into the overburden material;
- the capping of overburden with fine-grained, moisture conditioned and suitably compacted materials (forming an effective air advection barriers) will also limit oxidation;
- placement of advection barriers as soon as practicable after placement of overburden will limit oxidation; and
- combining all practices will enhance limitation of oxidation.

The selection of lift height, compaction, use of advection barriers, and the timing of their placement (influenced by scheduling and NOEF cell sizes) can be managed by MRM operations to suit operational factors present at the time of placement. These issues include dozer availability, mining rates, NOEF stage geometry and availability of suitable barrier materials.

5.5.3.6.3 Preferred Construction Practices

Chapter 3 – Project Description and Justification describes the construction methods adopted for the preferred alternative, including:

- the structure of the PAF(RE) material cells, which need to contain the highly reactive overburden, is based on the optimum style construction of paddock dumping in small cells with regular advection barriers (refer to **Chapter 3 – Project Description**); and
- the structure of the core zone is based on 7.5 m lifts with advection barriers (refer to **Chapter 3 – Project Description**), it is expected to give performance equivalent to, if not better than, paddock dumping of the overburden.

5.5.3.7 Closure and Rehabilitation Planning

5.5.3.7.1 NOEF Closure Alternatives

The three closure and rehabilitation alternatives considered as part of the Project planning phase have included:

- Alternative 1 – Retaining all deposited overburden in OEFs external to the open cut;
- Alternative 2 – Rehandling of all overburden back into the open cut final void, and subsequent rehabilitation of the former NOEF site; and
- Alternative 3 – Rehandling of a part of the overburden back into the open cut final void, and subsequent re-profiling of the NOEF.

5.5.3.7.1.1 *Alternative 1 – Retaining All Overburden in External OEFs (Preferred Alternative)*

This alternative would comprise capping the NOEF with a benign cover as each stage is completed. The revegetated cover would limit the generation and transport of oxidation products to a rate within the receiving environments assimilative capacity, without loss of agreed function as per McArthur River Mining's closure objectives. On-going maintenance would be undertaken as required to enable the facility to continue to meet the objectives in the long term.

McArthur River Mining focuses on managing and mitigating key long term environmental risks from the outset, as part of Project design and operations. This approach limits the reliance on the post mining phase to address such risks. The assessment of NOEF design alternatives will influence the closure and rehabilitation alternatives to be adopted. For example, the selection of batter slope configuration and cover system will drive the rehabilitation planning phase including associated water management and revegetation activities.

5.5.3.7.1.2 Alternative 2 – Rehandling of All Overburden Back Into the Open Cut Final Void

This alternative would apply should open cut closure Alternative 7 (complete pit backfill) be implemented. Rehandling of the stockpiled overburden back into the open cut final void would equate to the excavation and replacement of approximately 360 million m³ of overburden material back into the original open cut final void. **Section 5.5.2.2.2.7** and **Section 5.5.2.3.7** (within the open cut closure and rehabilitation section above) discuss the assumptions, risks and assessment outcomes of this alternative. Note that due to the swell factor of the excavated material, not all the overburden would be able to be replaced in the open cut final void below the original ground surface, requiring the construction of a new OEF over the top of the backfilled open cut final void. The 360 million m³ of material would comprise both the backfilled void material and the material within this new OEF.

5.5.3.7.1.3 Alternative 3 – Rehandling of a Part of the Overburden into the Open Cut Final Void

This alternative would apply should open cut closure Alternative 8 (partial pit backfill) be implemented. Rehandling of the stockpiled overburden back into the open cut final void would equate to the excavation and replacement of approximately 235 million m³ of overburden material back into the original open cut final void, with an approximate 30 m deep void left in the upper section of the open cut. **Section 5.5.2.2.2.8** and **Section 5.5.2.3.8** (within the open cut closure and rehabilitation section above) discuss the assumptions, risks and assessment outcomes of this alternative. Note that this alternative would require the existing NOEF to still be expanded in a northerly direction in order to accommodate the surplus overburden that would not be placed back in the final void.

5.5.3.7.2 Assessment of Closure Alternatives

A summary of the MCA outcomes for the closure and rehabilitation alternatives is provided in **Table 5-9**. A supporting discussion of these outcomes is provided following the table. These scores consider the NOEF domain only, not the open cut domain.

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Table 5-9 Multi-criteria Analysis of NOEF Closure and Rehabilitation Alternatives

		Short Term Effects ¹								Long Term Effects ²									
#	Alternative	Local effects ³				Regional effects ⁴				Local effects ³				Regional effects ⁴				Total	%
		Environmental Performance	Constructability ⁷	Financial Cost ⁵	Societal and Stakeholder Benefits ⁶	Environmental Performance	Constructability ⁷	Financial Cost ⁵	Societal and Stakeholder Benefits ⁶	Environmental Performance	Maintenance ease ⁷	Financial Cost ⁵	Societal and Stakeholder Benefits ⁶	Environmental Performance	Maintenance ease ⁷	Financial Cost ⁵	Societal and Stakeholder Benefits ⁶		
1	Retaining all overburden in external OEFs	4	5	5	3.5	4	NA	NA ⁸	3.5	4	5	4	3.5	4	NA	NA ⁸	3.5	49	82
2	Rehandling of all overburden back into the open cut final void	4	3.5	1	1	5	NA	NA ⁸	1	5	5	5	1	5	NA	NA ⁸	1	37.5	63
3	Partial rehandling of overburden into the open cut final void	4	2.5	1	1	4	NA	NA ⁸	1	4	5	5	1	4	NA	NA ⁸	1	33.5	56
Maximum Possible Score		5	5	5	5	5	NA	NA	5	5	5	5	5	5	NA	NA	5	60	100

1 0-100 year timeframe
2 100-1,000 year timeframe
3 On-lease
4 Off-lease
5 Financial cost to McArthur River Mining and its impact on Project viability.
6 Includes benefits in terms of employment creation and planned community investment projects, services, taxes and royalties.
7 Assumption is that construction costs apply in the short term, but these transfer to maintenance costs in the long term.
8 All financial costs to McArthur River Mining are assumed to be incurred on-lease (therefore local effect only).

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5.5.3.7.2.1 *Alternative 1 – Retaining all overburden in external OEFs*

Should this alternative be implemented, it would closely reflect the NOEF preferred design alternative of 140 m high with trilinear batters.

Total Score: 49/60 (82%)

Short Term Effects

Environmental Performance

The preferred design of the NOEF has mechanisms and mitigation measures in place to meet the closure objectives. This includes base preparation, internal NOEF structure, cover system, seepage management system, and on-going maintenance.

Constructability

Retaining all overburden in place would lead to a straight forward rehabilitation process. The NOEF would be constructed to a high level of performance initially, avoiding the need for rehandling and its complexities of managing gas and water and extra oxidation products.

Financial Cost

In line with the limited construction complexity, the cost of implementing this alternative would not be anticipated to have any negative effects on Project viability.

Societal and Stakeholder Benefits

There would be moderate resourcing required to implement this alternative.

Long Term Effects

Environmental Performance

The adaptive and reactive management phases would enable the NOEF to meet its performance objectives in the long term.

Maintenance Ease

Maintenance is expected to be straightforward, with only a low level of complexity and intervention anticipated to meet the performance criteria.

Financial Cost

Reflective of the low level maintenance complexity, there will only be minor level of on-site financial costs in the long term.

Societal and Stakeholder Benefits

Societal and stakeholder benefits are expected to be moderate in the long term.

5.5.3.7.2.2 *Alternative 2 – Rehandling of All Overburden Back Into the Open Cut Final Void*

The following scoring has assumed a scenario in line with the open cut closure Alternative 7 (complete backfill) where all overburden would be relocated from the NOEF back into the open cut final void, with any excess material (as a result of material swell factors) to be placed over the top of the final void footprint in a newly constructed OEF within the mine levee wall.

Total Score: 37.5/60 (63%)

Short Term Effects

Environmental Performance

As this alternative would involve the complete removal of overburden from the current NOEF site, there could be expected to be short term, local minor environmental impacts associated with dust, gas generation and runoff from temporarily exposed surfaces. In addition, the essential “re-mining” of the NOEF would require use of considerable fuel to run the plant and equipment fleet.

Constructability

Scored as having some complexity as there would need to be strict sequencing of activities to manage the placement of overburden back into the open cut, and in managing spontaneous combustion and water as PAF(RE) material cells were re-opened to the external environment.

Financial Cost

In line with the open cut “complete backfill” alternative, the very high costs associated with this alternative would inhibit the Project’s feasibility.

Societal and Stakeholder Benefits

McArthur River Mining and its employees, goods and services providers, the Borroloola community and the wider community would not receive the investment benefits that this Project is expected to provide due to its early termination.

Long Term Effects

Environmental Performance

With the NOEF completely removed and the site rehabilitated, this alternative is not anticipated to have an observable impact in the long term.

Maintenance

The site would likely be rehabilitated to a self-sustaining condition, so the maintenance requirements in the long term are anticipated to be straight forward.

Financial Cost

Little to no ongoing financial costs are anticipated given the long term status of the site.

Societal and Stakeholder Benefits

Little to no maintenance effort in the long term equates to little to no ongoing investment opportunities.

5.5.3.7.2.3 Alternative 3 – Rehandling of Part of the Overburden Back Into the Open Cut Void

The following scoring has assumed a scenario in line with the open cut closure Alternative 8 (partial backfill) where overburden would be relocated from the NOEF back into the open cut final void but only to a level up to the vadose zone. Excess material would remain in a modified NOEF footprint.

Total Score: 33.5/60 (56%)

Short Term Effects*Environmental Performance*

As this alternative would involve the removal of the majority of overburden from the current NOEF site, there could be expected to be short term, local minor environmental impacts associated with dust, gas generation and runoff from temporarily exposed surfaces. In addition, the essential re-mining of the NOEF would require use of considerable fuel to run the plant and equipment fleet.

Constructability

Slightly more complex than the complete relocation alternative as there would be a need to remove part of the NOEF to the final void while retaining a fully functional (albeit smaller) NOEF on site.

Financial Cost

The very high costs associated with this alternative would inhibit the Project's feasibility.

Societal and Stakeholder Benefits

McArthur River Mining and its employees, goods and services providers, the Borroloola community and the wider community would not receive the investment benefits that this Project is expected to provide.

Long Term Effects*Environmental Performance*

Considered similar to Alternative 1.

Maintenance

Expected to be straightforward, with only a low level of complexity and intervention anticipated to meet the performance criteria.

Financial Cost

Reflective of the low level maintenance complexity, on-site financial costs would be minor in the long term.

Societal and Stakeholder Benefits

Little to no maintenance effort in the long term equates to little to no ongoing investment opportunities.

5.5.3.7.3 Preferred NOEF Closure and Rehabilitation Alternative

The relative rankings of the MCA conducted for this case appear closer than they really should be, due to the lack of weighting on the various assessment criteria. The financial costs to implement Alternatives 2 and 3 would inhibit Project viability, with the subsequent loss of most of the Project's socio-economic benefits.

Consequently, the **preferred NOEF closure and rehabilitation alternative is Alternative 1, retaining all overburden in external OEFs.**

5.5.3.8 Alternative Environmental Management Measures for Key Risks

Sections 5.5.3.2 to 5.5.3.5 provide details on NOEF design (including height, footprint, batter configuration and cover system), construction/operations and closure/rehabilitation alternatives including objectives and required properties, assumptions, factors considered and selected management measures.

For the preferred alternatives for design, construction/operations and closure/rehabilitation the proposed management measures have been detailed in **Chapter 3 – Project Description and Justification**.

McArthur River Mining has developed a number of NOEF seepage management contingencies (refer to **Appendix Q – NOEF Mitigation Options Report**). These are proposed to be further developed and implemented subject to NOEF environmental performance monitoring outcomes in reference to the closure objectives.

5.5.4 Domain 3 – TSF

5.5.4.1 Design Alternatives

McArthur River Mining prepared a TSF Life of Mine (LOM) assessment outlining a concept for future tailings management. This comprised identification of a range of tailings disposal alternatives including use of paste, filtered tailings (dry stacking) at the current site or as co-disposal with overburden at the NOEF. Order of magnitude capital expenditure (CAPEX) and operational expenditure (OPEX) estimates, combined with an MCA of non-cost items was undertaken on each alternative.

5.5.4.1.1 TSF Alternatives Considered

The alternatives considered included:

- 1 slurry tailings cells 2 & 3;
- 1a slurry tailings cells 2 & 3 with mud farming;
- 2 slurry tailings cells 1 & 2;
- 2a slurry tailings cells 1 & 2 with mud farming;
- 3 paste tailings cells 1 & 2;
- 4 filtered tailings; and
- 5 filtered tailings co-disposal.

These alternatives are described in further detail below.

5.5.4.1.1.1 Alternative 1 – Slurry Tailings Cells 2 & 3

As described in the current TSF LOM Plan, this alternative continues to use conventional slurry tailings disposal and upstream raise construction to complete the current TSF cell 2 then develop cell 3 (the current Water Management Dam).

5.5.4.1.1.2 Alternative 1a – Slurry Tailings Cells 2 & 3 (with Mud Farming)

This alternative continues to use conventional slurry tailings disposal and upstream raise construction to complete the current TSF Cell 2 then develop cell 3 (the current Water Management Dam). However, mud farming is included to improve the tailings properties and reduce the requirements for stabilising earthworks as the TSF is raised.

5.5.4.1.1.3 *Alternative 2 – Slurry Tailings Cells 1 & 2 (Preferred Alternative)*

This alternative comprises a conventional slurry disposal using cells 1 and 2 at the existing TSF site, and encompassing the expansion of Cell 2 to Cell 1 to allow development of the total LOM operations within the current footprint.

5.5.4.1.1.4 *Alternative 2a – Slurry Tailings Cells 1 & 2 (with Mud Farming)*

This alternative comprises a conventional slurry disposal using cells 1 and 2 at the existing TSF site, and encompassing the expansion of Cell 2 to Cell 1 to allow development of the total LOM operations within the current footprint. However, mud farming is included to improve the tailings properties and reduce the requirements for stabilising earthworks as the TSF is raised.

5.5.4.1.1.5 *Alternative 3 – Paste Tailings Cells 1 & 2*

This includes paste thickening and deposition of tailings at the current TSF, most likely using cells 1 and 2.

5.5.4.1.1.6 *Alternative 4 – Filtered Tailings*

This includes dry stacking of filtered tailings at the current TSF using a pressure filter plant, with a fleet of trucks and dozers used to transport and spread the tailings.

5.5.4.1.1.7 *Alternative 5 – Filtered Tailings Co-Disposal*

This includes dry stacking and co-disposal of tailings at the NOEF. The pressure filter plant would be located at the NOEF and a fleet of trucks used to transport the filtered tailings to the core of the NOEF to be spread along with the overburden by dozers.

5.5.4.1.2 *Assessment of TSF Alternatives*

Given the TSF Design is only for an approximate 20 year operational life, the long term effects of this design were not considered relevant as the facility will be decommissioned and rehabilitated within the nominated short term timeframe (0-100 years). The long term effects of the facility have been assessed as part of **Chapter 8 – Water Resources** and have subsequently been considered and assessed as part of TSF Closure and Rehabilitation (refer to **Section 5.5.4.2**).

In assessing the TSF the following assumptions have been made:

- TSF design is only applicable for the 20 year construction and operational life of the facility, after which the facility will be decommissioned and rehabilitated;
- over the long term, the in-situ alternative will require maintenance to manage erosion and cover integrity subject to performance monitoring outcomes. This requirement is reflected in the Financial Cost and Maintenance Ease assessment; and
- in the short term, seepage mitigation would be implemented as required to meet the stated objectives, including:
 - the decant pond would be kept small, which acts as a source control for seepage; and
 - cut-off trenches, interception trenches and recovery bores would act as secondary controls.

A summary of the MCA outcomes for the TSF design alternatives is provided in **Table 5-10**.

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Table 5-10 Multi-criteria Analysis of TSF Design Alternatives

#	Alternative	Short Term Effects ¹								Long Term Effects ²								Total	%
		Local effects ³				Regional effects ⁴				Local effects ³				Regional effects ⁴					
		Environmental Performance	Constructability ⁷	Financial Cost ⁵	Societal and Stakeholder Benefits ⁶	Environmental Performance	Constructability ⁷	Financial Cost ⁵	Societal and Stakeholder Benefits ⁶	Environmental Performance	Maintenance ease ⁷	Financial Cost ⁵	Societal and Stakeholder Benefits ⁶	Environmental Performance	Maintenance ease ⁷	Financial Cost ⁵	Societal and Stakeholder Benefits ⁶		
1	Slurry tailings cells 2 & 3	3.5	2	3	3	4	NA	NA ⁹	2.5	NA ⁸	NA ⁸	NA ⁸	NA ⁸	NA ⁸	NA ⁸	NA ⁸	NA ⁸	18	60
1a	Slurry tailings cells 2 & 3 (with mud farming)	3.5	2.5	3	3	4	NA	NA ⁹	2.5	NA ⁸	NA ⁸	NA ⁸	NA ⁸	NA ⁸	NA ⁸	NA ⁸	NA ⁸	18.5	62
2	Slurry tailings cells 1 & 2	3.5	3	4	2.5	4	NA	NA ⁹	2	NA ⁸	NA ⁸	NA ⁸	NA ⁸	NA ⁸	NA ⁸	NA ⁸	NA ⁸	19	63
2a	Slurry tailings cells 1 & 2 (with mud farming)	3.5	3.5	4	2.5	4	NA	NA ⁹	2	NA ⁸	NA ⁸	NA ⁸	NA ⁸	NA ⁸	NA ⁸	NA ⁸	NA ⁸	19.5	65
3	Paste tailings cells 1 & 2	4	3.5	4	2.5	4	NA	NA ⁹	2	NA ⁸	NA ⁸	NA ⁸	NA ⁸	NA ⁸	NA ⁸	NA ⁸	NA ⁸	20	67
4	Filtered Tailings	4	3	1	1	4	NA	NA ⁹	1	NA ⁸	NA ⁸	NA ⁸	NA ⁸	NA ⁸	NA ⁸	NA ⁸	NA ⁸	14	47
5	Filtered Tailings Co-disposal	5	3	2	1.5	5	NA	NA ⁹	1.5	NA ⁸	NA ⁸	NA ⁸	NA ⁸	NA ⁸	NA ⁸	NA ⁸	NA ⁸	18	60
Maximum Possible Score		5	5	5	5	5	NA	NA	5	5	5	5	5	5	NA	NA	5	60	100

1 0-100 year timeframe
2 100-1,000 year timeframe
3 On-lease
4 Off-lease
5 Financial cost to McArthur River Mining and its impact on Project viability.
6 Includes benefits in terms of employment creation and planned community investment projects, services, taxes and royalties.
7 Assumption is that construction costs apply in the short term, but these transfer to maintenance costs in the long term.
8 TSF design is only applicable for the (approximate) 20 year construction and operational life of the facility, which is defined as a short term timeframe.
9 All financial costs to McArthur River Mining are assumed to be incurred on-lease (therefore local effect only).

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5.5.4.1.2.1 *Alternative 1 – Slurry Tailings Cells 2 & 3*

Total Score: 18/30 (60%)

Environmental Performance

The local environmental performance effect was scored as minor to moderate in the short term due to the potential seepage risks from the facility, although regional effects were considered minor due to the proposed seepage interception controls.

Constructability

Constructability was rated as complex (2) due to the anticipated complexity associated with future lined storages, underdrains and ongoing buttresses required for the raising of Cell 2. In addition, if Cell 3 was used for tailings storage then an additional water management storage dam would need to be constructed outside the existing facility's footprint.

Financial Cost

Based on CAPEX and OPEX cost estimates prepared as part of the development of the LOM Plan, this alternative has been scored as a 3 (moderate impact on company finances).

Stakeholder and Societal Benefits

In line with the financial costs and associated impacts on company finances, the impact on workforce numbers and community investment is expected to be moderate with respect to on-site job creation opportunities, although there will be a demand for labour to construct the lined facilities and drainage networks. There would be expected off-lease (regional) investment, although at a lower scale compared to on-site job creation opportunities.

5.5.4.1.2.2 *Alternative 1a – Slurry Tailings Cells 2 & 3 (with Mud Farming)*

Total Score: 18.5/30 (62%)

Environmental Performance

The local environmental performance effect was scored as minor to moderate in the short term due to the potential seepage risks from the facility, although regional effects were considered minor due to the proposed seepage interception controls.

Constructability

Constructability was rated as slightly less complex (2.5) compared to Alternative 1. Despite the additional mud farming activities, wall raising and buttressing requirements would be reduced due to the increased stability of the deposited tailings.

Financial Cost

Based on CAPEX and OPEX cost estimates prepared as part of the development of the LOM Plan, this alternative has been scored as a 3 (moderate impact on company finances).

Stakeholder and Societal Benefits

Alternative 1a is expected to create a broadly similar level of local and regional stakeholder benefits as does Alternative 1 (for similar reasons).

5.5.4.1.2.3 *Alternative 2 – Slurry tailings cells 1 & 2*

Total Score: 19/30 (63%)

The local and regional environmental performance effects were scored the same as Alternative 1, although (compared to Alternative 1) Alternative 2 also provides:

- improved surface water management practices as a result of the increased dimensions of the operating cell allowing a longer beach, increased fall across the beach and an improved storage volume characteristic (allowing improved short term storage and a lower risk of stormwater ponding);
- increased tailings density; and
- a reduction of closure surface area; and reduced earth borrow requirements (estimated at approximately one million cubic metres less than Alternative 1).

Constructability

Constructability was rated as involving some complexity, particularly in re-establishing cell 1. However, only the first two years are considered to be the most complex, with construction becoming relatively straightforward after this.

Financial Cost

Based on CAPEX and OPEX cost estimates prepared as part of the development of the LOM Plan, this alternative has been scored as a 4 (minor impact on company finances), mainly due to the anticipated capital expenditure cost savings compared to Alternative 1.

Stakeholder and Societal Benefits

In line with the financial costs and associated impacts on company finances, the impact on workforce numbers and community investment has been scored as moderate to major.

5.5.4.1.2.4 *Alternative 2a – Slurry Tailings Cells 1 & 2 (with Mud Farming)*

Total Score: 19.5/30 (65%)

Environmental Performance

The local and regional environmental performance effects were scored the same as Alternative 2.

Constructability

Constructability was rated as slightly less complex (3.5) compared to Alternative 2. Despite the additional mud farming activities, wall raising and buttressing requirements would be reduced due to the increased stability of the deposited tailings.

Financial Cost

Based on CAPEX and OPEX cost estimates prepared as part of the development of the LOM Plan, this alternative has been scored as a 4 (minor impact on company finances), mainly due to the anticipated capital expenditure cost savings compared to Alternative 1.

Stakeholder and Societal Benefits

Alternative 2a is expected to create a broadly similar level of local and regional stakeholder benefits as does Alternative 2 (for similar reasons).

5.5.4.1.2.5 *Alternative 3 – Paste Tailings Cells 1 & 2*

Total Score: 20/30 (67%)

Environmental Performance

The local and regional environmental performance effects were scored as minor in the short term due to reduced potential for seepage risks from the facility.

Constructability

Constructability was rated as involving some level of complexity, although the thicker paste tailings would be expected to provide a lower level of complexity compared to the slurry tailings approach.

Financial Cost

based on CAPEX and OPEX cost estimates prepared as part of the development of the LOM Plan, this alternative has been scored as a 4 (minor impact on company finances).

Stakeholder and Societal Benefits

In line with the financial costs and associated impacts on company finances, the impact on workforce numbers and community investment is expected to be moderate with respect to on-site job creation opportunities. There would be expected off-lease (regional) investment, although at a lower scale compared to on-site job creation opportunities.

5.5.4.1.2.6 *Alternative 4 – Filtered Tailings*

Total Score: 14/30 (47%)

Environmental Performance

The local and regional environmental performance effects were scored as minor in the short term due to the lower potential for seepage risks from the facility compared to Alternative 1 and 2.

Constructability

Constructability was rated as involving some level of complexity, with minimal earthworks but complex drainage requirements.

Financial Cost

Based on CAPEX and OPEX cost estimates prepared as part of the development of the LOM Plan, this alternative has been scored as a 1 (an unsustainable effect on company finances).

Stakeholder and Societal Benefits

In line with the financial costs and associated impacts on company finances, the impact on workforce numbers and community investment is expected to be catastrophic and negatively impact on Project feasibility.

5.5.4.1.2.7 *Alternative 5 – Filtered Tailings Co-Disposal*

Total Score: 18/30 (60%)

Environmental Performance

The local and regional environmental performance effects were scored as low in the short term due to the lower potential for seepage risks from the facility compared to Alternatives 1 and 2, plus the fact that tailings would be placed into the NOEF.

Constructability

Constructability was rated as involving some level of complexity.

Financial Cost

Based on CAPEX and OPEX cost estimates prepared as part of the development of the LOM Plan, this alternative has been scored as a 2 (a major effect on company finances). Due to poor availability of the complex filter plants, mill output would likely be intermittently curtailed, leading to economic losses.

Stakeholder and Societal Benefits

In line with the financial costs and associated impacts on company finances, the impact on workforce numbers and community investment is expected to be major with limited opportunities, both on-site and regionally.

5.5.4.1.3 Preferred TSF Design

Many scores in the MCA were similar, and could be considered within the margin of error of the estimate. The selected **preferred alternative is Alternative 2 Slurry tailings cells 1 & 2**. The basis for this selection is as follows:

- mud-farming has not been successfully trialled on site, and may not be possible;
- once the water management and spillway requirements are considered, consolidating cells 1 and 2 (and enabling cell 3 to be used for water management purposes) is a preferred alternative due to less total disturbance and material borrow requirements; and
- updated operating practices in combination with proposed mitigation measures around the perimeter of the TSF will limit on-going impacts to Surprise Creek.

5.5.4.2 Closure and Rehabilitation Planning

5.5.4.2.1 TSF Closure Alternatives Considered

The three closure and rehabilitation alternatives considered as part of the Project planning phase included:

- 1 retaining all deposited tailings at the TSF, with subsequent re-profiling of the TSF and capping with a benign cover (likely a very low NP cover using material sourced from local LS-NAF(HC) material and clay sources, and possibly a BGM barrier layer). This alternative (with a CCL barrier) was proposed in the Phase 3 EIS;
- 2 rehandling of all tailings back into the open cut using a hydraulic mining method, with subsequent re-profiling and rehabilitation of the TSF site. Removing the tailings from the surface would eliminate potential long term risks associated with seepage, settlement, tailings geochemistry and stability; and
- 3 reprocessing of all tailings with deposition into the open cut as per point 2 above (preferred alternative).

5.5.4.2.2 Assessment of Alternatives

Table 5-11 details the assessment scoring for the TSF closure alternatives. Explanatory text is provided following the table.

In assessing the TSF closure alternatives, the following assumptions were made:

- a hierarchy of potential mitigation measures can be applied to manage off-site seepage impacts;
- adoption of source controls is the preferred management measure, involving (in order of preference):
 - removal of tailings from the TSF (applicable to Alternatives 2 and 3); and/or
 - installation of a cover system over the tailings that creates low NP and oxidation conditions (applicable to Alternative 1);
- adoption of secondary controls is the next preferred management measure, involving installation of recovery bores or trenches (potentially applicable to all three alternatives); and
- adoption of tertiary controls is the least preferred management measure.

This would potentially involve off-site recovery activities such as pumping from adjacent surface water systems (e.g. Surprise or Barney Creeks).

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Table 5-11 Multi-criteria Analysis of TSF Closure and Rehabilitation Alternatives

#	Alternative	Short Term Effects ¹								Long Term Effects ²								Total		%	
		Local effects ³				Regional effects ⁴				Local effects ³				Regional effects ⁴							
		Environmental Performance	Constructability ⁷	Financial Cost ⁵	Societal and Stakeholder Benefits ⁶	Environmental Performance	Constructability ⁷	Financial Cost ⁵	Societal and Stakeholder Benefits ⁶	Environmental Performance	Maintenance ease ⁷	Financial Cost ⁵	Societal and Stakeholder Benefits ⁶	Environmental Performance	Maintenance ease ⁷	Financial Cost ⁵	Societal and Stakeholder Benefits ⁶				
1	Tailings to remain at the TSF with cover system installed	4	2.5	3.5	3	4	NA	NA ⁸	2.5	4	4	4	3	4.5	NA ⁹	NA ⁸	2.5	41.5	69		
2	Re-handle tailings back into final void	4.5	4	2	3.5	4	NA	NA ⁸	3	5	5	5	2	5	NA ⁹	NA ⁸	2	45	75		
3	Reprocessing of tailings then rehandling back into final void	4.5	4	5	5	5	NA	NA ⁸	5	5	5	5	2	5	NA ⁹	NA ⁸	2	52.5	88		
Maximum Possible Score		5	5	5	5	5	NA	NA	5	5	5	5	5	5	NA	NA	5	60	100		

1 0-100 year timeframe
2 100-1,000 year timeframe
3 On-lease
4 Off-lease
5 Financial cost to McArthur River Mining and its impact on Project viability.
6 Includes benefits in terms of employment creation and planned community investment projects, services, taxes and royalties.
7 Assumption is that construction costs apply in the short term, but these transfer to maintenance costs in the long term.
8 All financial costs to McArthur River Mining are assumed to be incurred on-lease (therefore local effect only).
9 TSF design is only applicable for the (approximate) 20 year construction and operational life of the facility, which is defined as a short term timeframe.

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5.5.4.2.2.1 Alternative 1 – Tailings to Remain at the TSF with Cover System Installed

Total Score: 41.5/60 (69%)

Short Term Effects

Environmental Performance

Environmental Performance effects, both locally and regionally, were rated as minor (4) as:

- the tailings will not acidify if they retain moisture, which would be anticipated to occur when encapsulated in an engineered cover system with a capillary break layer;
- a very low NP cover could be constructed over the TSF to limit oxidation and NP;
- seepage monitoring and recovery systems would limit the groundwater and surface water impacts to meet the objectives; and
- ongoing adaptive and reactive management would maintain the landform in the short term and long term.

Constructability

Constructability at a local scale was rated 2.5 due to the additional complexity of designing and constructing the cover to cope with tailings consolidation and to swap from a central decant pond to a domed shedding surface.

Financial Cost

Financial Cost would create minor to moderate effects on company finances and budgeting.

Stakeholder and Societal Benefits

Generally in line with financial costs, it is anticipated that there would be a moderate impact on job creation.

Long Term Effects

Environmental Performance

Long term local and regional environmental performance effects were still rated relatively highly (i.e. minor to low effects scoring 4 to 4.5) considering the cover material and seepage interception controls proposed.

Constructability

Ease of maintenance was anticipated to include some complexity (4) associated with the ongoing maintenance and management of the facility including cover layer integrity, erosion and sediment controls and ongoing requirements associated with interception trench and seepage bore management and maintenance.

Financial Cost

In line with maintenance complexity, there is only anticipated to be minor effects on company finances and budgeting.

Stakeholder and Societal Benefits

Post-site closure it is anticipated that only a small workforce would be required to maintain and monitor the TSF, therefore the impacts on workforce number and associated benefits have been scored as moderate – major.

5.5.4.2.2.2 Alternative 2 – Re-Handle Tailings Back Into Open Cut Final Void

Total Score: 45/60 (75%)

Short Term Effects

Environmental Performance

The local impact was rated highly, scoring 4.5 (minor to low effect) due to:

- complete removal of potential contaminant sources (tailings) from the facility;
- significant reduction in potential for seepage of contaminants off-site, with a lowering of the risk of impacts to Surprise Creek; although the scoring has reflected an acknowledgement this there could be potential localised short term residual groundwater impacts as a result of legacy seepage;
- rehandling tailings back into the open cut final void via hydraulic mining and pumping will greatly reduce the ongoing risk of dust generation and potential tailings oxidation;
- no requirement to source additional cover material, therefore development of new clay borrow areas will not be required; and
- re-contouring of the land back to pre-mining landform, with subsequent installation of a topsoil layer and revegetation program.

At a regional level, the performance would also be considered to be high (i.e. minor effect), due to the reduction in the source load of potential contaminants that could negatively impact on downstream water quality.

Constructability

Constructability was rated as high as the hydraulic mining and rehandling of tailings back into the open cut final void is a known technology, although there may be some complexity with mine pit lake water treatment.

Financial Costs

This has been rated to have a major effect on company finances and budgeting due to the extended (nominally 10 year) period where hydraulic mining and material rehandling will be undertaken with no revenue stream, resulting in major operating losses. Due to a lack of weighting, the impact of these losses is understated in this MCA.

Stakeholder and Societal Benefits

This has been rated to have a minor to moderate impact on site workforce numbers and regional community investment associated with the 10 year mining and rehandling program.

Long Term Effects

Environmental Performance

Long term local and regional environmental performance effects were rated to have a low impact (5) as all tailings will have been removed from the TSF footprint, the site rehabilitated and seepage mitigation controls should have come into full effect.

Maintenance Ease

Ease of maintenance was rated high locally due to the removal of the requirement for long term maintenance and management of the facility including cover layer integrity and erosion and sediment controls. There is expected to be some on-going requirements associated with interception trench management, however this is anticipated to reduce significantly over time.

Financial Costs

Both the local and regional financial costs were rated as having no negative impact on company finances in accordance with the long term maintenance obligations listed above.

Stakeholder and Societal Benefits

This has been rated to have a major impact on site workforce numbers and regional community investment as there would be little need for long term resourcing apart from limited monitoring and maintenance.

5.5.4.2.2.3 Alternative 3 – Reprocessing Of Tailings and Placement Back into Open Cut Final Void (Preferred Alternative)

Total Score: 52.5/60 (88%)

Short Term Effects

Environmental Performance

As per Alternative 2, the local impact was rated as high, scoring 4.5 (minor to low effect) due to:

- complete removal of potential contaminant sources (tailings) from the facility;
- significant reduction in potential for seepage of contaminants off-site, with a lowering of the risk of impacts to Surprise Creek, although the scoring has reflected an acknowledgement this there could be potential localised short term residual groundwater impacts as a result of legacy seepage;
- hydraulic mining, reprocessing and ultimately placing tailings back into the open cut final void will greatly reduce the ongoing risk of dust generation and potential tailings oxidation;
- no requirement to source additional cover material, therefore development of new clay borrow areas will not be required; and
- re-contouring of the land back to pre-mining landform, with subsequent installation of a topsoil layer and revegetation program.

At a regional level, the effect would also be scored highly, due to the reduction in the source load of potential contaminants that could negatively impact on downstream water quality.

Constructability

Constructability was rated as high as the hydraulic mining, reprocessing and subsequent replacement of tailings back into the open cut final void is a known technology. There may be some complexity with mine pit lake water treatment.

Financial Cost

Financial Cost was rated to not negatively impact on company finances due to the anticipated income generation from tailings reprocessing, which would off-set the costs of the approximate 10 year rehandling period (and associated extensive hydraulic mining and tailings pumping costs associated with this).

Stakeholder and Societal Benefits

Rated highly due to the employment and investment opportunities created for an additional 10 year period.

Long Term Effects

Environmental Performance

Long term local and regional environmental performance effects were rated to have a low impact (5) as all tailings will have been removed from the TSF footprint, the site rehabilitated and seepage mitigation controls should have come into full effect.

Maintenance Ease

Ease of maintenance was rated high locally due to the removal of the requirement for long term maintenance and management of the facility including cover layer integrity and erosion and sediment controls. There is expected to be some on-going requirements associated with interception trench management and maintenance, however this is anticipated to reduce significantly over time;

Financial Costs

Both the local and regional financial costs were rated as having no negative impact on company finances in accordance with the long term maintenance obligations listed above.

Stakeholder and Societal Benefits

This has been rated to have a major impact on site workforce numbers and regional community investment as there would be little need for long term resourcing apart from limited monitoring and maintenance.

5.5.4.2.3 Preferred TSF Closure and Rehabilitation Alternative

The MCA showed a clear **preferred case in 3, reprocessing of tailings then rehandling back into the open cut final void.**

5.5.4.3 Alternative Environmental Management Measures for Key Risks

Section 5.5.4.1 provides details on TSF design alternatives including assumptions and management approach. **Section 5.5.4.2** provides details on TSF closure and rehabilitation alternatives including assumptions and management approach.

For the preferred design and closure and rehabilitation alternatives the proposed management measures have been detailed in **Chapter 3 – Project Description and Justification.**

5.6 Site-Wide Alternatives

5.6.1 Water Management

Chapter 8 – Water Resources of the EIS includes the results of a site-wide water balance and details of McArthur River Mining’s existing and proposed water management strategy. This strategy comprises management of various water classes and McArthur River Mining’s waste discharge licence (WDL) release points and has considered a number of different key inputs, including:

- groundwater and surface water interaction;
- seepage modelling through the unsaturated zones of the NOEF and basal material;
- modelled estimates of NOEF toe and basal seepage and subsequent recharge of these waters to both surface and groundwater systems;
- potential TSF seepage pathways and loads;
- mine pit lake water quality, potential seepage pathways and loads; and
- modelled concentrations of contaminants of concern at the site’s downstream compliance point (SW11).

The management strategy has considered a number of different water management alternatives including:

- water retention in dams and resultant evaporation;
- water retention in dams and discharge to the environment under regulated conditions;
- water treatment with subsequent storage and evaporation;
- water treatment and discharge to the environment under regulated conditions; and
- water blending (via dams) and discharge.

The resultant strategy incorporates a combination of these alternatives. Refer to **Chapter 8 – Water Resources** for further details.

5.6.2 Sources of Benign Material

The sourcing of benign materials (including clay, alluvium, rock and topsoil) from within the MRM mining leases (as opposed to potential off-lease areas) provides the most cost-effective alternative to sourcing such material for use in the Project’s construction and rehabilitation programs. This is due to the reduced haulage distances between the borrow location and its ultimate destination.

The EIS groundwater impact assessment studies have included the conduct of a site-wide shallow hydrogeology and benign material investigation program. The findings of this investigation program are reported in Appendix 3 (EIS Hydrology Field Program Report) of **Appendix T – Groundwater Report**. Sufficient sources of benign material have been identified on-lease for McArthur River Mining’s purposes (refer **Chapter 6 – Material Characterisation**). No off-lease investigations have been considered necessary.

Where benign material borrow areas are required, they shall be developed in accordance with McArthur River Mining’s guidelines (refer **Appendix AG – Borrow Pit Design Process Guidelines**). These guidelines cover the process of site selection, determining design criteria and operational management, closure and rehabilitation protocols.

5.6.2.1 Clay, Alluvium and Topsoil Materials

These materials have been identified within the existing footprint of the TSF (e.g. within cell 3) and the proposed NOEF expansion footprint. In addition, clay deposits have also been identified in close proximity to the TSF and NOEF. Refer to **Chapter 3 – Project Description and Justification** for further detail.

5.6.2.2 LS-NAF(HC) Material

Low salinity non-acid forming (high capacity) or LS-NAF(HC) material is an environmentally benign material that is considered suitable for purposes where clean material is required (e.g. for use in construction of cover systems as well as flood protection levees, growth media and buttresses in environmentally sensitive areas). It is considered at low risk of generating AMD and therefore impacting on water quality; therefore does not require mitigation management apart from standard sediment controls. Refer to **Chapter 6 – Materials Characterisation** for further details on this material's characteristics.

Sources of this material have been identified in a number of locations on the mining lease including:

- adjacent to the open cut footprint (e.g. the Woyzbun Quarry on the southern edge of the open cut; and the footwall cutback); and
- radially around the TSF on selected higher ridgelines.

5.7 Summary of Preferred Alternatives

The results of the multi-criteria analyses undertaken for the various Project domain design, operations and closure and rehabilitation alternatives have been provided in the relevant summary tables and explanatory text in **Section 5.5**. The preferred alternatives may not necessarily equate to the highest assessment scores, due to the lack of weighting of the criteria, and different levels of confidence in the alternatives.

A summary description of the preferred alternative for each domain is discussed below. Note that further detail is provided in **Chapter 3 – Project Description and Justification**.

5.7.1 Open Cut

The details of the preferred alternatives for the open cut domain are contained in **Chapter 3 – Project Description and Justification**. Key features are summarised below.

The open cut will be sequenced with conventional pit staging progressing from west to east and shallow to deep, with a slightly revised concept for the last two pit stages to enable some limited IPD during the last six years (approximately) of mining.

High pyrite PAF(HC) material would be stored during the open cut operations phase in engineered cells in the EOEF footprint. There would be rehandling of the EOEF high pyrite overburden, and non-benign portions of the SOEF to IPDs for inundation and permanent sub-aqueous storage.

The entire tailings mass would be hydraulically mined from the TSF footprint after the cessation of open cut mining, with reprocessing then deposition within the open cut final void. The excess water and liberated pore water in the open cut would be reclaimed for use in the tailings mining and reprocessing works, with water treatment as required managing water quality. The open cut filling operations would be expected to leave a final void of approximately 175 m deep.

Batter works, topsoiling and revegetation of the upper benches of the open cut would be undertaken, including placement of structural debris for future aquatic habitat; The re-shaping and construction of a benign cover system with low to very low NP over the WOEF would occur. There would be construction of flood proofing barriers to a 1:500 year flood level for the WOEF and power station. The selected closure alternative for the open cut would then be a staged transition between several of the alternatives including:

- Initial active filling of an isolated final void (Alternative 6) would occur, with water treatment as required. Water within the resultant mine pit lake would be expected to experience stratification, with better quality water in the upper strata. The mine levee wall would be required to maintain full function throughout this period. Once confirmation of water quality within the various strata is within the expected bounds, progress to the next stage.
- A mine pit lake with backwater interaction (Alternative 5), whereby a part of the downstream mine levee wall would be removed, and engineered inlets between the McArthur River and open cut constructed. This would enable floodwaters in the McArthur River above a nominal event (assumed to be annual flooding) with associated sediments and small aquatic fauna to migrate inside the mine levee wall, mixing with the mine pit lake, and providing a periodic flush of the lake. Large fauna, such as the Largetooth Sawfish (*Pristis pristis*), would be discouraged from entering the mine pit lake by the structure of the inlets. The water would remain at similar levels to the external river, with a riparian zone being established around its shores.
- Upon confirmation that the water quality is meeting expectations under a variety of conditions, the decision to proceed to Alternative 4 (Flow through Mine Pit Lake as Secondary Path) would be made. A similar engineered inlet would be created at the upstream end of the mine levee wall, turning the mine pit lake into a full flow-through water body, except with the water body being the secondary flow branch after the existing McArthur River channel. Maintenance of the mine levee wall could be ceased upon successful commissioning.

5.7.2 NOEF

The details of the preferred alternatives for the NOEF domain are contained in **Chapter 3 – Project Description and Justification**. Key features are summarised below.

- the preferred location for the expansion of the NOEF is to the north of the existing NOEF;
- the preferred geometry of the NOEF is to construct it with a maximum height of 140 m, with trilinear concave batters;
- the preferred cover system is Alternative 3, the Oxygen barrier cover system. Although this was not the highest scoring alternative in the MCA (that being Alternative 5, the BGM cover system) there were a number of risks associated with Alternative 5 (refer **Section 5.5.3.5.3** for details);
- preferred construction methods would take into account the structure of the PAF(RE) material cells, which need to contain the highly reactive overburden, is based on the optimum style construction of paddock dumping in small cells with regular advection barriers;
- the structure of the core zone is based on 7.5 m lifts with advection barriers. It is expected to provide performance equivalent to, if not better than, paddock dumping of the overburden; and
- the preferred NOEF closure and rehabilitation alternative is Alternative 1, retaining overburden material in external OEFs with a constructed cover to mitigate oxidation of materials in the facility.

5.7.3 TSF

The details of the preferred alternatives for the TSF domain are contained in **Chapter 3 – Project Description and Justification**. Key features are summarised below.

Many scores in the TSF design MCA were similar, and could be considered within the margin of error of the estimate. The selected preferred design alternative is Alternative 2 – Slurry tailings cells 1 & 2. The basis for this selection is as follows:

- mud-farming has not been successfully trialled on site, and may not be possible;
- once the water management and spillway requirements are considered, consolidating cells 1 and 2 (and enabling cell 3 to be used for water management purposes) is a preferred alternative due to less total disturbance and material borrow requirements; and
- updated operating practices in combination with proposed mitigation measures around the perimeter of the TSF will limit on-going impacts to Surprise Creek.

The MCA of closure and rehabilitation alternatives showed a clear preferred case in Alternative 3 (Reprocessing of tailings then rehandling back into the open cut final void).