

## 7.0 Waste Management

### 7.1 Overburden Management – Existing Operations

As the existing mining operation is totally underground, there is no overburden produced. However, there is some rock between the various orebody layers (interburden) that requires disposal. Approximately 5% of the material handled underground is interburden and it is tipped into completed mining panels or into empty stopes. This activity requires the use of a low profile ejector tray truck, which can enter and tip in the room and pillar stopes. Due to the low volume of interburden generated, there is no shortage of disposal sites in the underground mine, which are usually close to the loading point.

There are also 4.3 ha of existing surface emplacements of overburden in the portal area cover. These emplacements were constructed from dolomitic siltstone and interbedded tuffs mined during the construction of the conveyor and main access declines in 1994. This will be the maximum area occupied by surface overburden pads under the existing operation, as all interburden produced by underground mining operations has been retained underground as fill.

During the 1994 construction activities, any overburden that was identified as having the potential to produce acid drainage was deposited within the tailings emplacement.

Whilst there is no formal interburden/overburden management plan in place, the system is low risk due to the retention of all interburden underground.

### 7.2 Overburden Management – Open Cut Operations

#### 7.2.1 Overview

Over the 25 year mine life for the open cut operations, approximately 183 million tonnes (Mt) of overburden waste rock will be mined from the pit. The majority of this material will be placed in the overburden emplacement facility (OEF), located to the north of the pit as shown on Figure 4.1. This location was selected after consideration of floodwater levels, surrounding topography, sacred sites, watercourse crossings, location of other infrastructure, and geotechnical issues. The footprint of the OEF will be approximately 255 ha. This is based on a swell factor of material from in-situ to the dump of 30%, and a final dump height of 50 m.

The overburden has been divided into the following categories to define its potential environment impact: Potentially Acid Forming (PAF) waste, Non-Acid Forming (NAF) and Acid Consuming (AC). PAF overburden has the potential, in the presence of air and water, to generate acid water, soluble metals and salts that could impact the environment. NAF overburden is chemically stable with low potential for generation of environmentally significant products. AC overburden has the capacity to neutralise runoff and seepage from PAF material. The available overburden characterisation data indicate that 11% of the total overburden could be PAF.

In the OEF, PAF overburden will be encapsulated within clay cells and layers of NAF/AC waste in the western zone of the OEF to ensure that there is no acidic seepage generated by the facility. Over the life of the OEF, seepage from the western zone will be contained within the site's water management system and transferred to the tailings storage facility (TSF) for recycling to the process plant. NAF overburden only will be used to construct the eastern zone of the OEF.

As part of the Test Pit project (Section 4.2.3), a small amount of overburden will be placed over the existing plant settling ponds and the original tailings dam located between Barney Hill and the open cut. This overburden emplacement facility will also be used for the balance of the Stage 1 overburden (ie. that not already removed by the Test Pit project) whilst the Barney Creek haul road crossing is constructed and the northern OEF site preparation is undertaken. As with the PAF material from the Test Pit, the Stage 1 PAF will be encapsulated in at least 1 m of clay and then surrounded by NAF/AC material. Once the northern OEF is operational, the Stage 1 overburden emplacement facility will be extended and used as the ore ROM stockpile by adding more NAF rock.

Additional small overburden emplacement facilities will be developed between the flood protection bund and the crest of the final open cut, as well as used as armouring for the bund. All of these emplacements will be constructed with NAF or AC materials only.

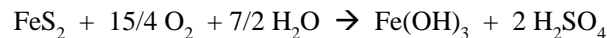
Wherever appropriate, NAF or AC overburden will also be used for construction and rehabilitation purposes on site.

## 7.2.2 Geochemical Nature of Overburden

An investigation into the geochemical characteristics of the overburden has been reported in "Geochemical Assessment of Overburden and Tailing Materials Including Conceptual Design of Overburden Emplacement Area" (URS, 2005a). This subsection summarises the results of the investigation.

Acid generation from mine materials is caused by the exposure of naturally occurring sulfide minerals, most commonly pyrite ( $\text{FeS}_2$ ), to atmospheric oxygen and water. Sulfur assay results are used to calculate the maximum potential acid (MPA) that could be generated by a waste, either directly from pyritic sulfur content, or by assuming that all sulfur not present as sulfate occurs as pyrite.

Pyrite oxidises to generate acid according to the following overall reaction:



While the above sulfide oxidation reaction generates acid, there is often a counterbalancing reaction from naturally occurring carbonate and silicate materials that can neutralise the acid generated. The interaction and overall mix of the acid generating and neutralising materials determines the amount and rate of any acid generation.

The net acid producing potential (NAPP) is used as an indicator of materials that may be of concern with respect to acid generation and represents the balance between the MPA and the acid neutralising capacity

(ANC) of the material. By convention, the NAPP result is expressed in units of kg of H<sub>2</sub>SO<sub>4</sub> (sulfuric acid) per tonne of overburden (kg H<sub>2</sub>SO<sub>4</sub>/t). If the ANC significantly exceeds the MPA, then the material is NAPP negative and likely to be NAF. Conversely, if the MPA significantly exceeds the ANC, the material is NAPP positive and likely to be PAF. The net acid generation (NAG) test has also been used to indicate the acid forming nature of mine materials.

McArthur River Mine materials contain reactive pyrite, but also contain a significant amount of ANC as well as non-reactive sulfides, such as galena (PbS) and sphalerite (ZnS) that do not generate acid. Hence, NAPP and NAG test data should be interpreted with caution. MRM conducted a geochemical assessment of overburden materials from the proposed open cut as part of an intensive exploration program carried out in the second half of 2002. The geochemical data were used to determine the geochemical characteristics of overburden likely to be generated from the proposed open cut and to develop management strategies for overburden placement.

URS (2005a) provides geochemical data obtained for 656 selected drill core samples (approximately 5 m depth intervals) from the exploration drill program completed in December 2002. The samples were selected to represent the various potential overburden rock types likely to be generated from the proposed open cut, from 35 drill holes in the immediate vicinity of the proposed pit. A cross-sectional representation of the main geological rock types (domains) located in the open cut is provided in Figure 7.1. The geochemical nature of the overburden materials is summarised in Table 7.1 below.

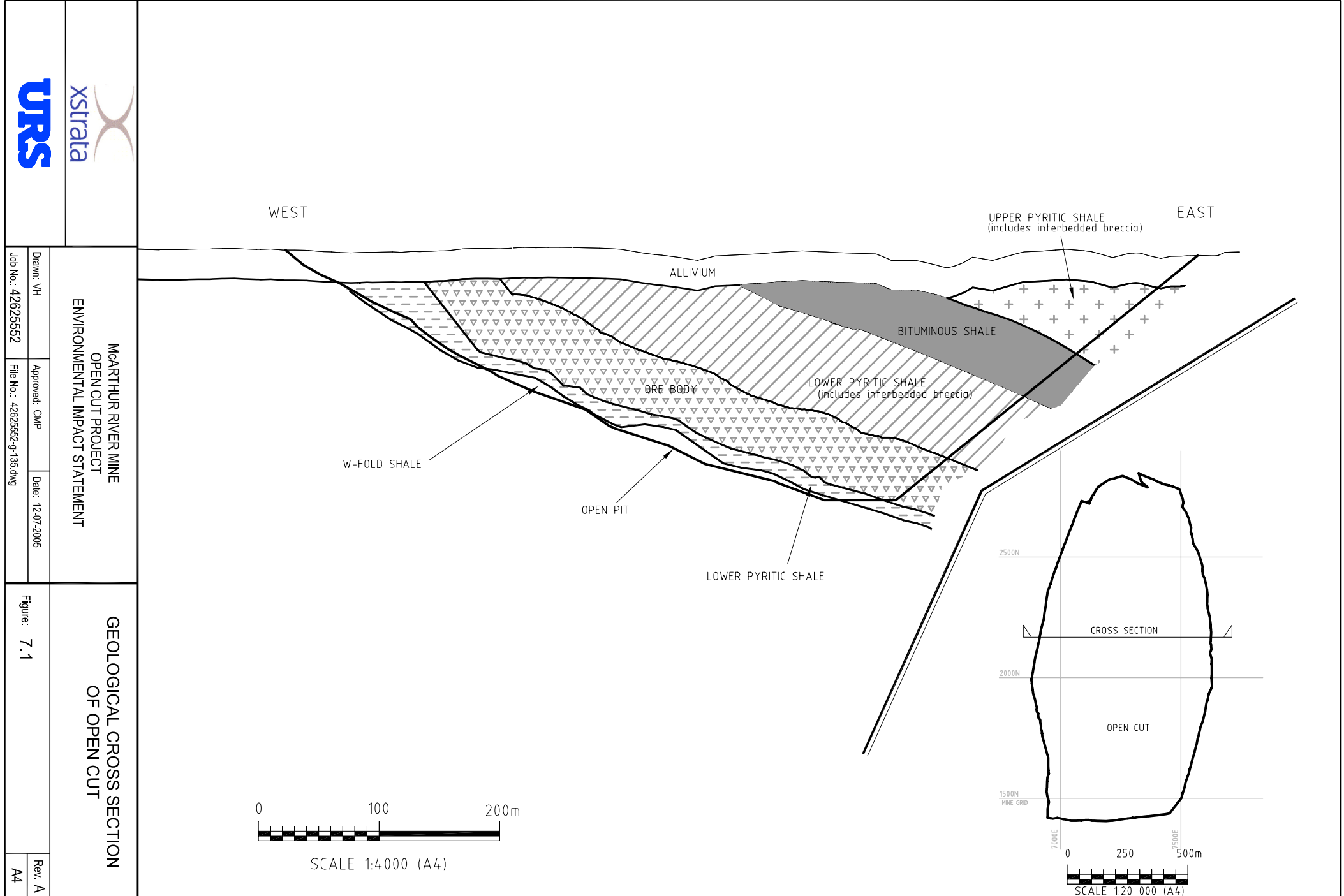
**Table 7.1**  
**Summary of Geochemical Nature of Overburden**

Rock Type	Upper Pyritic Shale	Lower Pyritic Shale and Bituminous Shale	Lower Dolomitic Shale	W-Fold Shale	Teena Dolomite	Total
Number of samples tested	36	309	50	231	30	656
% Total samples tested	5.5	47.1	7.6	35.2	4.6	100 %
Number of NAF samples	19	269	50	231	30	599
Number of PAF samples	17	40	none	none	none	57
% Sample rock type as NAF	53	87	all	all	all	
% Sample rock type as PAF	47	13	none	none	none	
% All samples tested as NAF	3	41	8	35	5	91 %
% All samples tested as PAF	3	6	none	none	none	9 %
% Total waste (from pit model*)	5	83	4	7	1	100 %

Notes:

NAF = Non-Acid Forming; PAF = Potentially Acid Forming

\* Proportion of each rock type expected to be mined as waste, based on the final pit design (AMDAD, May 2005).



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**McARTHUR RIVER MINE  
 OPEN CUT PROJECT  
 ENVIRONMENTAL IMPACT STATEMENT**

Figure: 7.1

**GEOLOGICAL CROSS SECTION  
 OF OPEN CUT**

Rev. A  
 A4

The results in Table 7.1 indicate that PAF materials are restricted to zones within the upper and lower pyritic shale rock types. The sulfur content of the pyritic shale can be high (up to 16.7%) and has the capacity to generate a significant quantity of acid drainage (up to 145 kgH<sub>2</sub>SO<sub>4</sub>/t as predicted in the NAG test). However, there is likely to be a period of time before acid conditions may become apparent in these materials (lag-period) due to high ANC content. Consequently, PAF shale materials will be selectively handled and encapsulated as part of the OEF management strategy.

The W-Fold Shale and Teena Dolomite rock types have a very low sulfur content and high ANC. These rock types are NAF and are also a potential source of highly acid consuming (AC) material. The lower dolomitic shales occasionally have a relatively high sulfur content, however all samples have a moderate to high ANC and a low (strongly negative) NAPP value. The geochemical data suggests that most of the dolomitic shale materials also have significant acid consuming characteristics.

Taking into account the geochemical characteristics above, the following proportions of NAF and PAF material expected to be mined over the 25-year life of the open cut pit (URS, 2005a). These results are based on an expected 183 Mt of waste rock to report to the OEF.

**Table 7.2**  
**Proportions of NAF and PAF Overburden Material from Final Pit Model**

Modelled Waste Type	% NAF	% PAF	Comments
Alluvials	12	none	No materials tested. All shallow weathered materials (generally <8 m below surface). All expected to be NAF.
Footwall Waste	12	none	Includes Lower Dolomitic Shale, W-Fold Shale and Teena Dolomite. All expected to be NAF.
Ore Zone Interburden	none	8	No materials tested. Conservatively assumed to be all PAF due to association with pyritic ore body.
Hangingwall Shales	65	3	Includes Upper and Lower Pyritic Shale and Bituminous Shale. Comprise the significant majority of all waste rock. Predominantly NAF.
<b>Total</b>	<b>89 %</b>	<b>11 %</b>	

Geochemical data will be used to determine the acid forming nature of overburden materials prior to mining using exploration drill core and/or active bench face samples. Acquired data will be used to block model overburden materials in advance of mining and to facilitate the implementation of proactive waste management strategies and procedures (i.e. selective handling, placement and clay encapsulation of PAF materials).

Flitch mapping, drill hole and grab sampling and assaying will be used to enable clear identification of the various material types within the open cut. Paint, tapes and spotters may be used to identify the various material types for operators.

### 7.2.3 Multi Element Nature of Overburden

#### ***Metal Concentrations***

Multi-element tests indicate that arsenic (As), cadmium (Cd), copper (Cu), manganese (Mn), lead (Pb), and zinc (Zn) are commonly present in most overburden rock types at elevated concentrations. Summary data from URS (2005a) are given in Table 7.3 and compare measured concentrations in the overburden with concentrations described in ANZECC (1992a) environmental investigation guidelines for the assessment and management of contaminated sites and NEPM (1999) health-based investigation guidelines for contaminated sites. The enrichment of these elements with respect to normal background concentrations is to be expected and simply reflects the natural geochemical enrichment that defines a mineral deposit.

**Table 7.3**  
**Metal Concentrations in Overburden**

<b>Element</b>	<b>Concentration Range in all Samples (mg/kg)</b>	<b>ANZECC Environmental Investigation Level for Soils (mg/kg)</b>	<b>NEPM Health-Based Investigation Level for Soils (mg/kg)</b>
As	0.3 to 800	20	200
Cd	0.005 to 236	3	40
Cu	100 to 979	60	2,000
Mn	143 to 15,700	500	3,000
Pb	100 to 13,300	300	600
Zn	100 to 108,800	200	14,000

The design of the OEF requires an outer layer of benign, inert overburden to provide the best physical and geochemical stability. Overall, the geochemical and multi-element results indicate that the W-Fold Shale and Teena Dolomite overburden materials are likely to be most suitable for forming the outer layers of the overburden emplacement facility (OEF). However, these materials are expected to comprise only 8 % of the total waste volume and may not be present in sufficient quantities to completely cover the outer layers of the OEF.

Other materials, such as hard breccias within the Upper and Lower Pyritic Shale domains, would have the physical durability to withstand weathering to make them suitable as a surface material. Assuming the breccias can be selectively handled, their function as a durable outer layer on the OEF will depend largely upon their geochemical characteristics. Of the 112 samples tested with greater than 50% of brecciated material, 110 were NAF and 2 are PAF (98 % and 2 %, respectively). Therefore, most breccia material is expected to be NAF and suitable for use as an OEF cover material. Furthermore, testwork on other rock types throughout the operation will be undertaken to identify alternative suitable rock from the shales to give more flexibility in the scheduling of placing the outer layers.

Background soil samples in the vicinity of the proposed OEF footprint will be tested for manganese and other metals to determine the significance of any enriched metals with respect to final rehabilitation. Rehabilitation of the OEF surface will be progressively undertaken and field trials will be conducted to determine any significant effects on rehabilitation success from any elevated metal concentrations in potential outer cover materials.

### **Leach Column Testing**

The above metals are bound in with the overburden and are not readily available to mobilise into the environment. Metal solubility is strongly pH dependent and a decrease in pH can significantly increase the solubility of environmentally important elements. If some of the PAF materials become acidic, acidic leachate may contain elevated concentrations of dissolved metals, sulfate, and salts, some of which may be greater than those recommended in ANZECC (2000)/NEPM (1999a) water quality guidelines.

To test if the metals can leach out of the overburden and mobilise, a series of long-term kinetic leach column tests was undertaken (URS, 2005a). These tests indicated the following:

- Seepage from PAF overburden materials can become acidic after a period of exposure to oxidising conditions. Seepage is likely to be brackish to saline and may contain elevated concentrations of soluble metals (generally Cd, Fe, Mn, Pb and Zn) and sulfate compared to relevant livestock drinking water quality criteria. It is for these reasons the all PAF material will be encapsulated by NAF and AC materials.
- Seepage from NAF overburden is likely to be pH neutral and generate excess alkalinity. It is expected to be slightly brackish and contain relatively lower concentrations of soluble metals, although soluble Mn (and occasionally some other metal concentrations) and SO<sub>4</sub> may exceed livestock drinking water quality criteria.
- The addition of NAF/AC overburden to PAF overburden is likely to significantly improve seepage quality from PAF overburden. The improvement in seepage quality is likely to be greatest when the layer width ratio of PAF to NAF/AC materials does not exceed 1:1.
- PAF and NAF overburden materials retain a high proportion of their inherent ANC after 18 months of exposure to oxidising conditions. The inherent ANC should continue to provide significant acid buffering for these materials, although for PAF materials the ANC may be sufficient to moderate but not prevent acid conditions.

The tests showed that soluble metals in runoff/seepage from overburden materials will remain within ANZECC (2000) /NEPM (1999a) concentration guidelines criteria for livestock drinking water under neutral or alkaline pH conditions.

## 7.2.4 Overburden Emplacement Facility

### *Design Concepts*

The OEF design is required to meet several objectives including:

- physical stability;
- chemical stability (prevent release of poor quality runoff and seepage);
- height consistent with local surrounds; and
- minimal dirty water catchment.

The design of the OEF has been developed to manage the key risks to the environment so that it will:

- Prevent the generation of acid from the PAF materials placed within the OEF.
- Prevent seepage of potentially acidic materials into the groundwater and surface water systems.
- Prevent erosion and sediment loss due to surface runoff and wind action.

The conceptual waste rock design comprises a “multiple lines of defence strategy” to reduce the risk of environmental harm from the OEF. The multiple lines of defence incorporated into the OEF design include the following:

- **Base Preparation:** The base of the OEF will be prepared, compacted and graded to ensure that any seepage through the OEF flows out through the toe to drainage collection facilities.
- **Construction:** The OEF will comprise an eastern and western zone. The western zone will contain Potentially Acid Forming (PAF) materials in clay encapsulated cells surrounded by Non-Acid Forming/Acid Consuming (NAF/AC) materials. The eastern zone will contain NAF/AC materials only.
- **Surface Water Management and Seepage Collection:** Surface water and seepage from the OEF will be contained within collection ponds. In the western zone, the pond will contain seepage and runoff that may have contacted PAF materials and this pond is referred to as the “PAF Pond”. In the eastern zone the pond will contain essentially “clean” runoff that may contain sediment and this pond is referred to as the “Sediment Pond”.
- **Final Rehabilitation:** The outer batters of the OEF will be designed to provide a final landform that is chemically and physically stable in the long term and limits erosion. Final rehabilitation of the OEF will include placing a surface cover on the crest of the OEF and on the intermediate benches across the outer slopes. This cover will support a vegetative cover of grasses. A surface water management system will be constructed across the OEF.

The concept design for the OEF is presented in Figure 7.2.

The construction of the OEF will extend over the life of the mine. It should be recognised that the level of knowledge regarding the materials used to construct the OEF will improve with time. Therefore



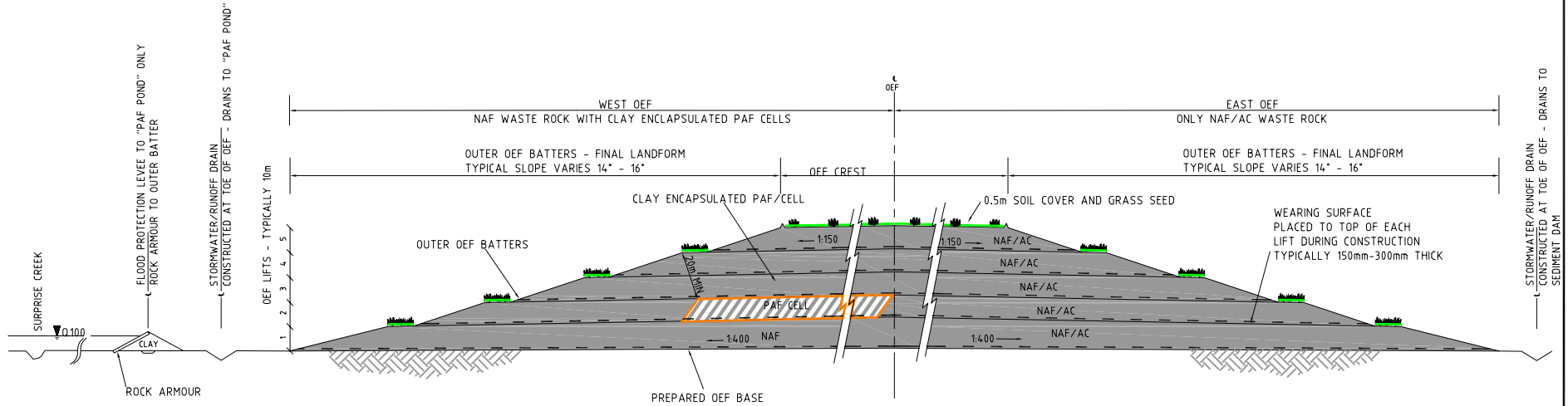
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



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Figure: 7.2

CONCEPTUAL OEF DESIGN

Rev. A  
 A4



- LEGEND**
-  Compacted Clay Seal Layer (0.6m)
  -  PAF Overburden Cell
  -  PAF Potentially Acid Forming Overburden
  -  NAF/AC Non Acid Forming/Acid Consuming Overburden
  -  Soil Cover
  -  Wearing Surface

NOT TO SCALE

changes to the design of the OEF may be required over the life of the facility to optimise the construction with current mine operations and to reduce the risk of environmental harm. Flexibility in the design approach is proposed to accommodate possible changes in the materials that are encountered during the mining operation, as well as to incorporate the results of performance monitoring and rehabilitation trials.

### **Base Preparation**

The proposed footprint of the OEF covers an area of approximately 255 ha, with the western zone occupying approximately 90 ha and the eastern zone occupying an area of approximately 165 ha. It will be constructed in stages as shown in Figure 7.3 and hence base preparation activities will be undertaken one stage at a time. The future stage will remain undisturbed until they are required.

The objective of the base preparation is to create a stable base layer to direct seepage and surface runoff from the OEF towards the perimeter/toe of the facility. The main activities will include the following:

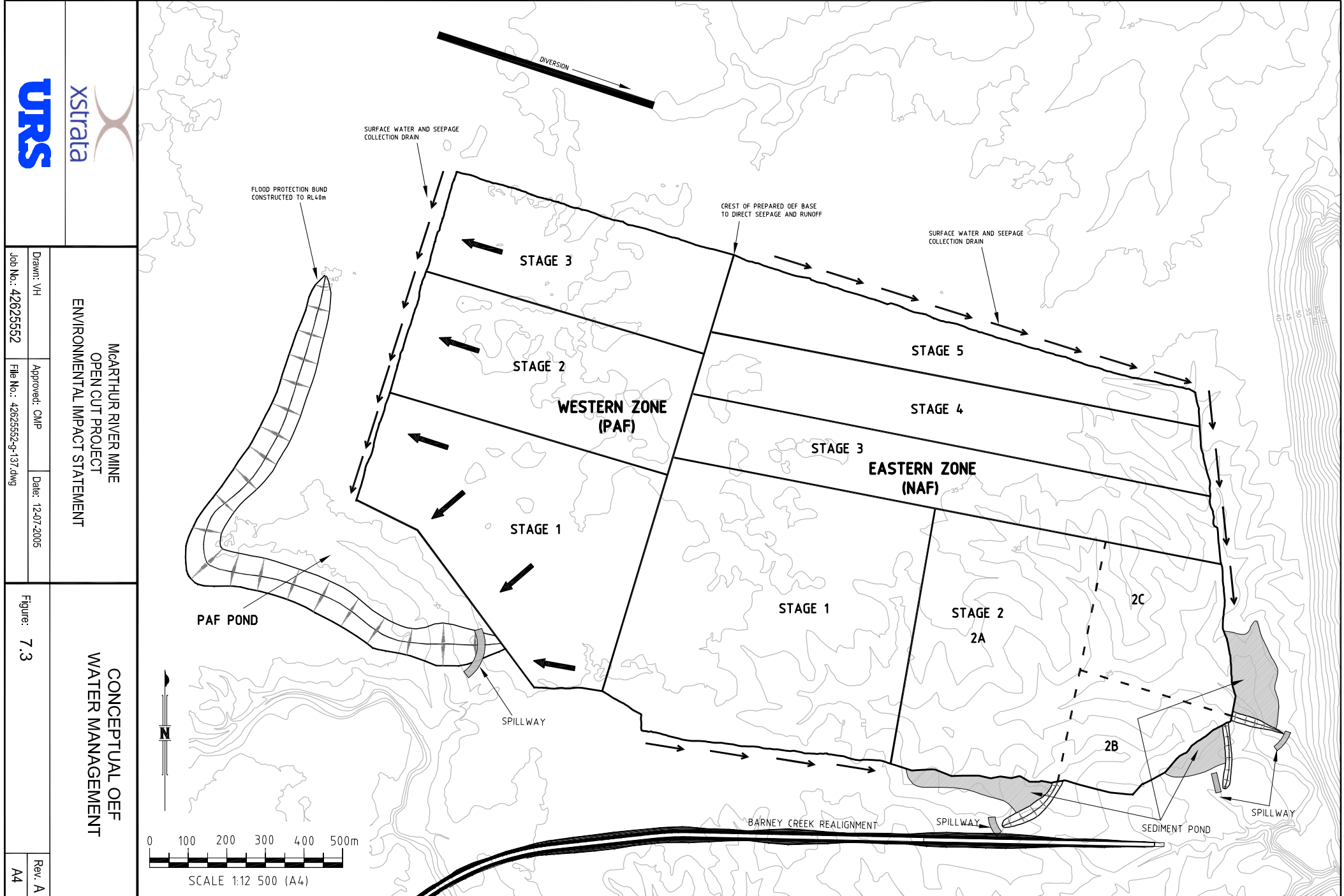
- **Stripping of vegetation and topsoil.** Each stage will be stripped of vegetation and topsoil. Stripped topsoil will be initially stockpiled for later use in rehabilitation works. However after the initial stripping operations, topsoil will be stripped and reused in progressive rehabilitation works on earlier stages where possible, to minimise stockpiling and doubling handling requirements.
- **Re-profiling the base of the OEF.** The base of the OEF will be re-profiled to a minimum slope of 400H:1V to drain seepage and runoff to the east and west of a central crest. The central crest will run in a north-south direction, splitting the western zone from the eastern zone.
- **Compaction of the base of the OEF.** The exposed surface areas of the OEF footprint in the western zone will be scarified to a depth of approximately 150 mm and compacted to achieve a low permeability base layer, with a typical permeability of  $10^{-8}$  m/sec. In the eastern zone compaction of the base will be undertaken to achieve a typical permeability of  $10^{-6}$  m/sec. Soft or weak areas and localised depressions across the OEF base will be over-excavated and replaced with compacted select clay fill material.

### **OEF Construction**

As discussed above, the OEF will be constructed in stages with two stages operational in the western zone and one in the eastern zone at any one time. The benefits of staged construction include:

- The area disturbed at any one time is reduced;
- The volume of surface water runoff that needs to be managed is reduced;
- The OEF will attain its full height progressively which will enable progressive rehabilitation to be undertaken; and
- It will enable rehabilitation trials to be undertaken early in the life of the OEF.

The OEF will be constructed in lifts that will be typically 10 m in height, extending to a nominal height of 15 m in some areas to achieve the desired surface gradient for each lift surface. Each lift will be



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Figure: 7.3

CONCEPTUAL OEF  
 WATER MANAGEMENT

Rev. A  
 A4

0 100 200 300 400 500m  
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constructed with an active tipping face across the full width of each stage of OEF construction, which will be selected to suit mining schedules and operations. This will provide flexibility in handling the various materials removed from the open cut.

PAF materials will be placed to the western zone only and will be encapsulated with clay to limit the risk of acid generation. Key features of the PAF cell construction include:

- **Initial Lift.** The first lift to the OEF will comprise NAF/AC overburden material that will be constructed by paddock dumping. The surface of the first lift will be graded to a minimum slope of 150H:1V to promote surface runoff to the PAF Pond. This lift will be constructed to a minimum elevation of RL 40 m AHD, such that the lowest level of the subsequent PAF cell will be above the 1 in 100 year ARI flood level.
- **Wearing Surface to Top of Lift.** A thin layer of fine grained material, typically clay materials sourced from the open cut will be placed across each lift surface to reduce tyre wear on the haul trucks.
- **Clay Base to PAF Cell.** A 0.6 m thick compacted clay layer will be placed on top of the initial lift to form a low permeability base for the PAF cell. The target permeability of this layer will be  $10^{-8}$  m/sec.
- **Clay Walls to PAF Cell.** The second lift will be constructed by end tipping NAF/AC materials from the outer areas of the OEF. The outer walls of the PAF cell will be constructed by tipping selected clay materials across the active tipping face to achieve a minimum placed width of 5 m. While initially loose, the clay will consolidate with time as additional overburden is placed above the clay walls to achieve a target permeability of  $10^{-6}$  m/sec. PAF materials will then be progressively tipped across the prepared clay base at a thickness of approximately 10 m. After completion of placement of PAF materials within the cell, another 5 m wide layer of select clay will be dumped to form the outer wall of the PAF cell. NAF/AC materials will be placed across the outer wall of the PAF cell to the outer perimeter of the OEF and will provide a minimum of 20 m between the clay wall of the PAF cell and the outer surface of the OEF.
- **Clay roof to PAF Cell.** A 0.6 m thick compacted clay layer will be placed on top of the PAF cell to form a low permeability surface above the PAF materials. The target permeability of this layer will be  $10^{-8}$  m/sec. This layer will be placed progressively to minimise the time that the PAF material is exposed to the atmosphere. The surface of the PAF cell's clay roof will be sloped to the west at a minimum gradient of 150H:1V, as per the initial lift, to reduce the risk of surface water ponding.
- **Additional OEF Lifts.** Subsequent lifts to the OEF will be constructed by end tipping NAF/AC materials. The additional lifts will also be graded to achieve a minimum slope of 150H:1V to the west of the OEF to direct surface runoff to the PAF pond. Each lift will include the wearing surface layer described above, which plays an important role in directing seepage within the OEF to the outer batters, providing a further line of defence against infiltration reaching the PAF cell.

Complete clay encapsulation of PAF materials will result in improved environmental performance of the OEF as it minimises the time that PAF materials are exposed to the atmosphere and therefore reduces the risk of environmental harm from the generation of acidic runoff. Constructing a clay lined PAF cell

within the OEF will also reduce the costs of final rehabilitation works, given that a low permeability cover will not be required across the surface of the OEF. This will limit the risk of cover failure associated with more traditional OEF designs (cover erosion, surface runoff ingress, localised cover failure through deep rooted trees, burrowing animals, uprooting of trees in storm events, etc).

Site investigations indicate that sufficient clay borrow material for encapsulation of the PAF overburden is present within the upper layers of the open cut.

The capacity of the PAF cells within each of the three stages of the western zone will cater for the all PAF materials likely to be generated throughout the 25 year mine life. The total amount of PAF to be produced is approximately 21 million tonnes (approximately 11 % of the total waste), although some of this material is close to the ore zone and may remain in the pit rather than be hauled to the OEF.

The eastern zone of the OEF will be constructed in a similar manner to the western zone but will cater for NAF materials only. There will be no PAF cell. The eastern zone will be constructed when excess NAF materials become available as the priority will be to ensure encapsulation of PAF materials in the western zone. The relatively small volume of PAF will result in construction of the eastern zone progressing faster than the west. Five stages of construction are proposed for the eastern zone.

### ***Surface Water Management and Seepage Collection***

As shown in Figure 7.4, during and after rainfall events water has the potential to flow along the following paths:

- Runoff from the surface of the OEF.
  - Runoff from the surface of the OEF will encounter NAF/PAF materials and therefore should be of an acceptable quality to be released into the environment, subject to appropriate sediment control, via a settlement pond, prior to establishment of vegetation.
- Infiltration within the OEF.
  - Water infiltrating the OEF will encounter the wearing surface layers placed at the top of each lift. The wearing surface will comprise a fine grained, lower permeability material that is expected to divert a significant portion of any infiltration along the wearing surface to the outer batters of the OEF.
  - Some infiltration through the wearing surface may occur, which could seep through subsequent layers of the OEF and potentially come in contact with the PAF cell.
  - Infiltration that comes into contact with the PAF cell could saturate and ultimately penetrate the clay surround to the PAF cell. The quality of any seepage from the PAF cell is also difficult to predict given that the surrounding NAF/AC materials surrounding the PAF cell have acid consuming potential that could neutralise acidic leachate. However, the seepage management strategy proposed has assumed that this seepage will be acidic and unsuitable for discharge to the environment.



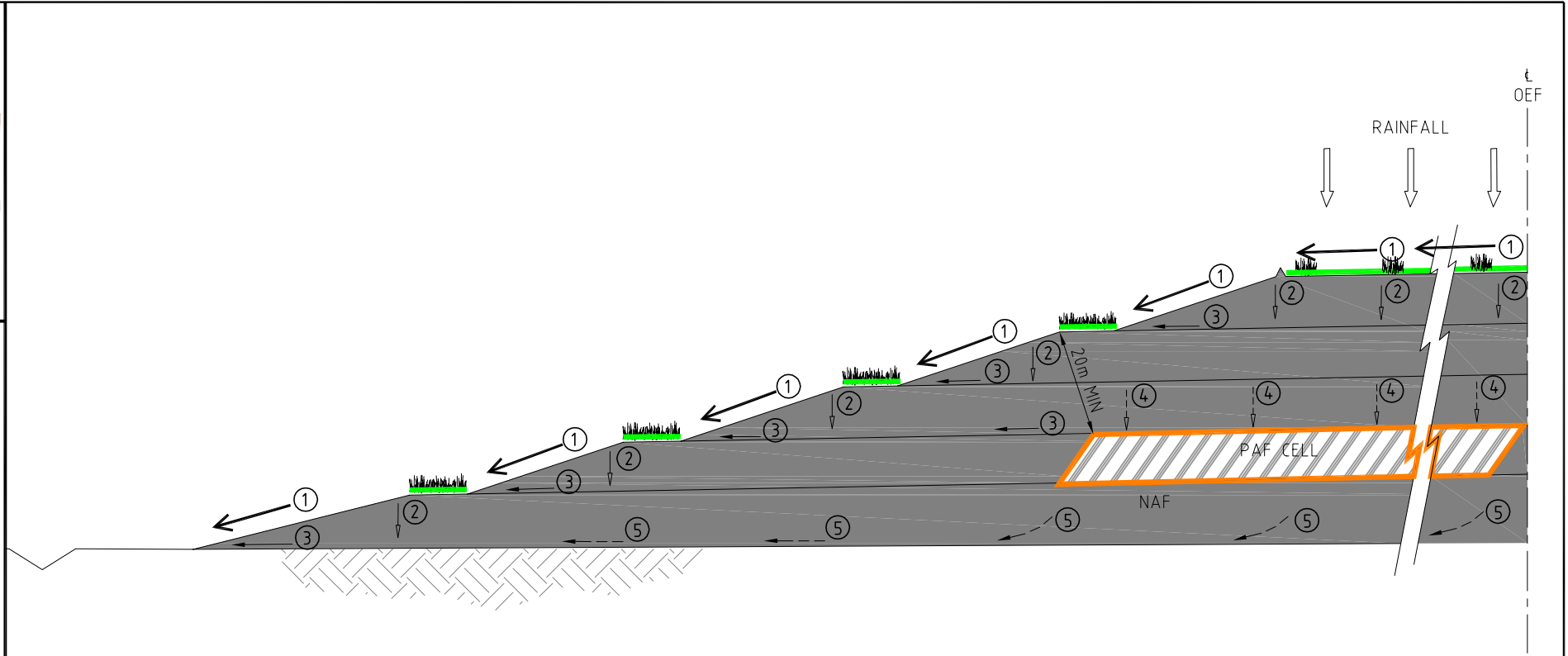
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 ENVIRONMENTAL IMPACT STATEMENT

Figure: 7.4

CONCEPTUAL OEF  
 WATER FLOW PATHS

Rev. B  
 A4



LEGEND

- ① → Runoff from OEF Surface
- ② ↓ Infiltration into OEF
- ③ → Infiltration diverted along wearing surface at each lift
- ④ - - ↓ Infiltration through OEF layers
- ⑤ - - → Potential flow path for leachate from PAF cell

NOT TO SCALE

Further detailed studies including site monitoring, geochemical testwork and mathematical modelling will be undertaken during the OEF construction when it will be possible to obtain more accurate information about the actual permeability characteristics of the constructed OEF layers, wearing surfaces, and the clay encapsulating the PAF cell.

All surface and seepage flows from the western zone will report to the PAF pond which will be designed to have a 1 in 100 Annual Exceedance Probability (AEP) of spilling (Figure 7.3). It will also be designed to exclude a 1 in 100 year ARI flood event by building the crest of the bund to RL 40 m AHD (1 in 100 ARI is between RL 38 m and RL 39 m). Water contained in the pond will be pumped to the water management dam at the tailings storage facility for reuse in the processing plant. The pond will be built in stages to match the staging of the OEF. Key design features of the PAF pond include the following:

- An impervious clay zone in the bund to limit infiltration – target permeability of  $10^{-8}$  m/sec.
- The base of the pond will be scarified to a depth of approximately 150 mm and compacted to achieve a low permeability base with a target permeability of  $10^{-8}$  m/sec.
- Erosion protection on the outside bund face to resist scour during flood events.
- An emergency spillway to discharge excess water in extreme rainfall conditions in order to protect against catastrophic failure of the bund.

As subsequent stages of the OEF are constructed and the earlier stages rehabilitated, surface water management systems will be constructed as part of the rehabilitation works. Given that the outer slopes of the OEF will comprise NAF/AC materials, surface water runoff from rehabilitated surfaces will be able to be discharged to the environment, subject to sediment control. A monitoring program will be implemented to determine when runoff from rehabilitated areas is acceptable for discharge.

All surface and seepage flows from the eastern zone will report to a sediment pond which will be designed to contain up to 50 mm of average erosion depth from the contributing catchment (approximately 1,000 t/ha/year). As there will be no PAF in the eastern zone, the only potential contaminant in the runoff will be sediment. The sediment pond will primarily function as flow-through structure designed to remove the majority of sediment load prior to it being discharged to downstream drainage (Barney Creek). As shown on Figure 7.3, there will be three sediment ponds constructed for the various stages of the eastern zone construction. Key design features of the sediment ponds include the following:

- A homogeneous clay embankment with a target permeability of  $10^{-6}$  m/sec.
- The outer batters of the bund will be capped with topsoil and vegetated with grass to reduce the risk of erosion.
- The overflow spillway will be able to discharge runoff waters (up to 1 in 100 year ARI events) without compromising the integrity of the embankment.
- An access ramp will be provided for periodic removal of captured sediment.

### ***Final Rehabilitation***

A detailed rehabilitation strategy will be developed during the construction of the OEF, including a series of trials of various landform profiles, outer batter material types, revegetation strategies and surface water management systems. The following discussion is provided to outline a general rehabilitation concept that will form the basis of future rehabilitation strategies and trials.

#### *Landform Design*

The OEF will be constructed with materials dumped at close to the angle of repose, which is expected to be approximately 35°, with 20 m wide benches at the top of each lift for vehicle access. This geometry will provide an overall outer batter slope of approximately 16°.

The final outer batter profile will depend upon the nature of the materials placed to the outer slopes. If sound, hard, durable waste rock is placed to the outer batters, then the local batters may be left at close to the angle of repose. However, it may be necessary to reduce the outer batter slopes to 3H:1V depending upon the quality of the materials available. This would be achieved by dozing the angle of repose slopes after construction of each lift thus reducing the bench width to 10 m resulting in an overall slope of approximately 14°. A bench width of 10 m for the final landform will be adequate to provide access for equipment to complete revegetation and drainage works.

The conceptual designs for both non-competent and durable rock types are shown on Figure 7.5.

The overburden materials that are expected to be available for use in the OEF construction include:

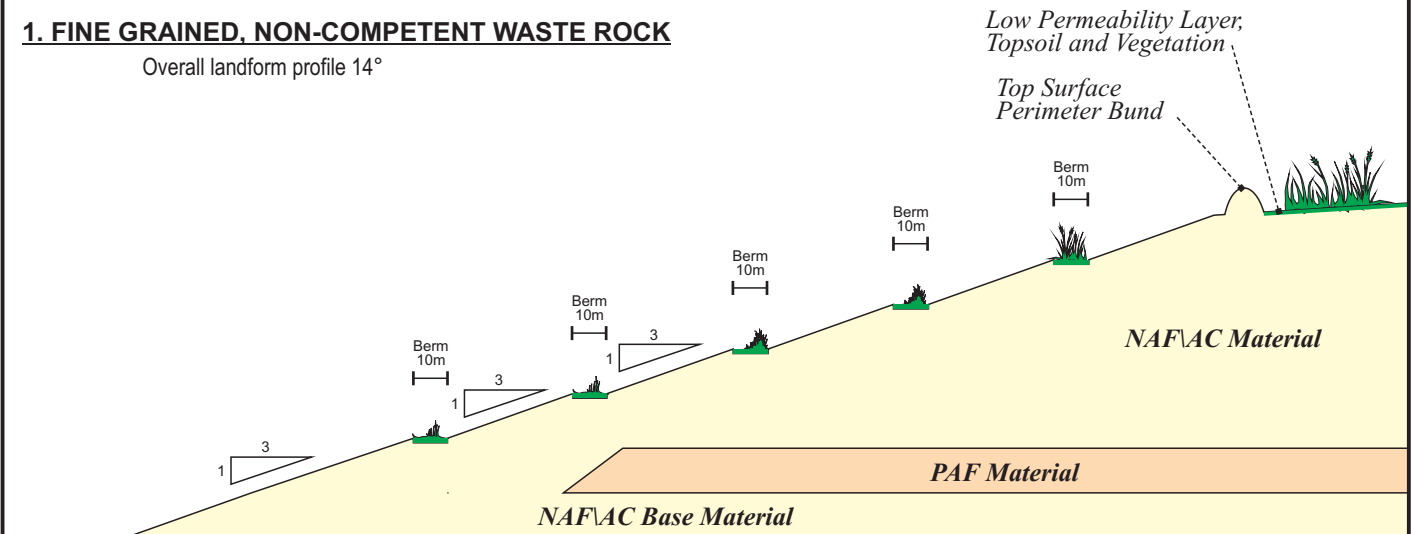
- Upper and Lower Pyritic Shale.
- Lower Dolomitic Shale
- W-Fold Shale.
- Teena Dolomite.

The geochemical and multi-element test results indicate that the W-fold Shale and Teena Dolomite overburden materials are likely to be the most suitable for forming the outer layers of the OEF. Furthermore, while experience indicates that shale materials will generally not have adequate long term durability and will break down with time due to weathering processes, the Lower Pyritic Shale geological domain includes a significant extent of breccia. The breccias have a very high strength and, subject to geochemical testing, could also be suitable as an outer batter material.

The crest of the OEF will be 50 m above the original ground surface, which is less than the height of the adjacent Mount Stubbs which has a maximum height of 80 m. The crest of the OEF will be graded to a maximum slope of 20H:1V from the centre to the outer slopes.

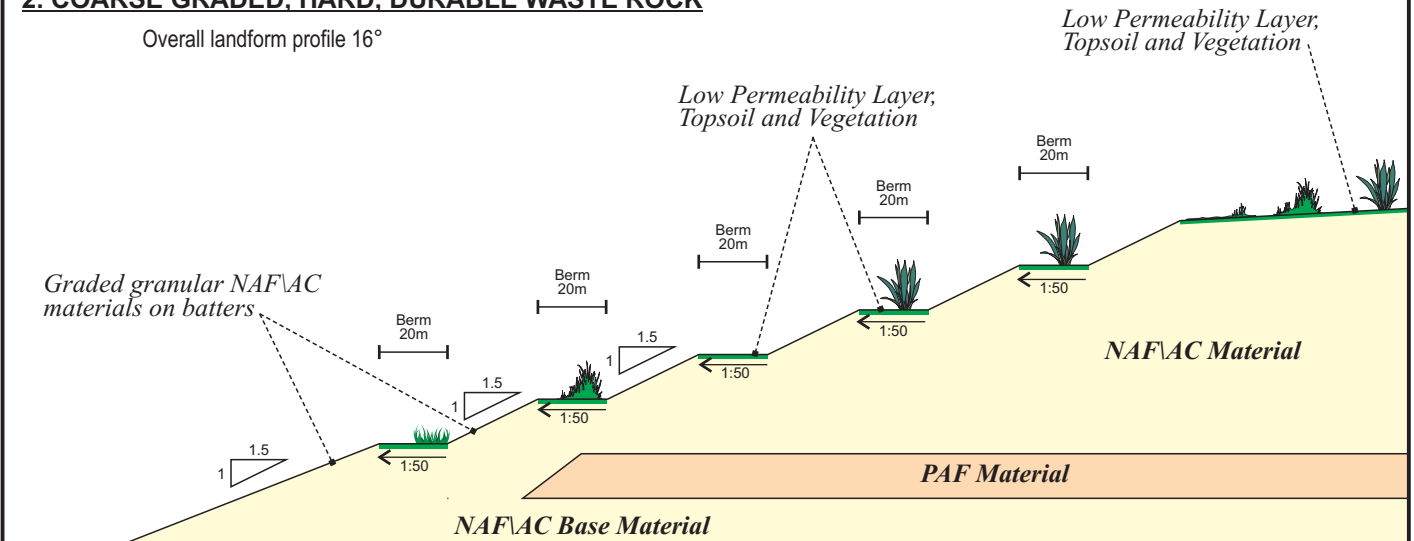
**1. FINE GRAINED, NON-COMPETENT WASTE ROCK**

Overall landform profile 14°





**2. COARSE GRADED, HARD, DURABLE WASTE ROCK**

Overall landform profile 16°



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 	McARTHUR RIVER MINE OPEN CUT PROJECT ENVIRONMENTAL IMPACT STATEMENT		<b>CONCEPTUAL OEF                  OUTER BATTER DETAILS</b>	
	Drawn: VH Job No.: 42625552	Approved: CMP File No. 42625552-g-139.cdr	Date: 12-07-05	Figure: 7.5

### *Revegetation*

The top of the OEF and the intermediate berms across the outer batter slopes will be rehabilitated progressively as sections of the OEF are completed. As discussed above, the final rehabilitation treatments will be selected based on the results of a series of field trials but conceptually will include:

- Final profiling of the surface to achieve the desired gradients.
- Placement of a 0.5 m nominal thickness of topsoil across the profiled surface.
- Contour ripping, seeding and fertilising to establish a grass cover.

Vegetation establishment on the crest and outer berms will improve the overall aesthetics of the OEF and will also minimise post rehabilitation maintenance costs by encouraging “self-healing” of minor erosion. A post-rehabilitation monitoring program will be implemented and should any significant erosion areas be identified, repairs would be carried out as required.

### *Surface Water Control*

The top of the OEF will be divided into a number of sub-catchments and surface water will be directed towards the outer batters, where engineered rock chutes will be provided to discharge the collected water in a controlled manner.

A series of detention banks will be constructed in a “herring bone” style across the top of the OEF to assist in the control of surface water flows. This surface profiling will allow rainfall from small rain events to be captured and utilised to sustain vegetation. The majority of runoff from larger storm events will be allowed to spill over the shallow surface undulations and be directed towards the engineered rock chutes located down the sides of the OEF. Surface runoff will be diverted from flowing over the outer batter slopes by perimeter bunds along the crest of the outer batters.

The engineered rock chutes will be designed to accommodate peak surface runoff flow from a 1 in 100 year ARI storm event. Preliminary surface hydrology assessment indicates that approximately six rock chutes will be required. Each chute will discharge into a sediment pond at natural surface level to limit the release of sediment to the downstream environment. The sedimentation ponds will be sized to provide 500 m<sup>3</sup> of sediment capacity for every hectare of contributing catchment. This will provide sufficient capacity to capture the equivalent of 50 mm erosion depth from the catchment surfaces.

The berms constructed at each lift will be used in the final landform to collect surface runoff. The berms shall be back graded from the outer slopes at an angle of 10H:1V and will direct runoff to the rock chute structures that drain the top of the OEF.

The conceptual design of the final surface drainage system at the OEF is shown in Figure 7.6.

Should the outer batters be constructed with coarse graded, hard, durable rock, the outer batter design as shown in Figure 7.5 may be built without the need for rock chutes. In this case surface water could be shed by sheet flow rather than by concentrating it in the rock chutes. The intermediate berms would be designed with a minimum forward slope of 1 in 50 to avoid concentrating the sheet flow.



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OPEN CUT PROJECT  
ENVIRONMENTAL IMPACT STATEMENT

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Job No.: 42025552

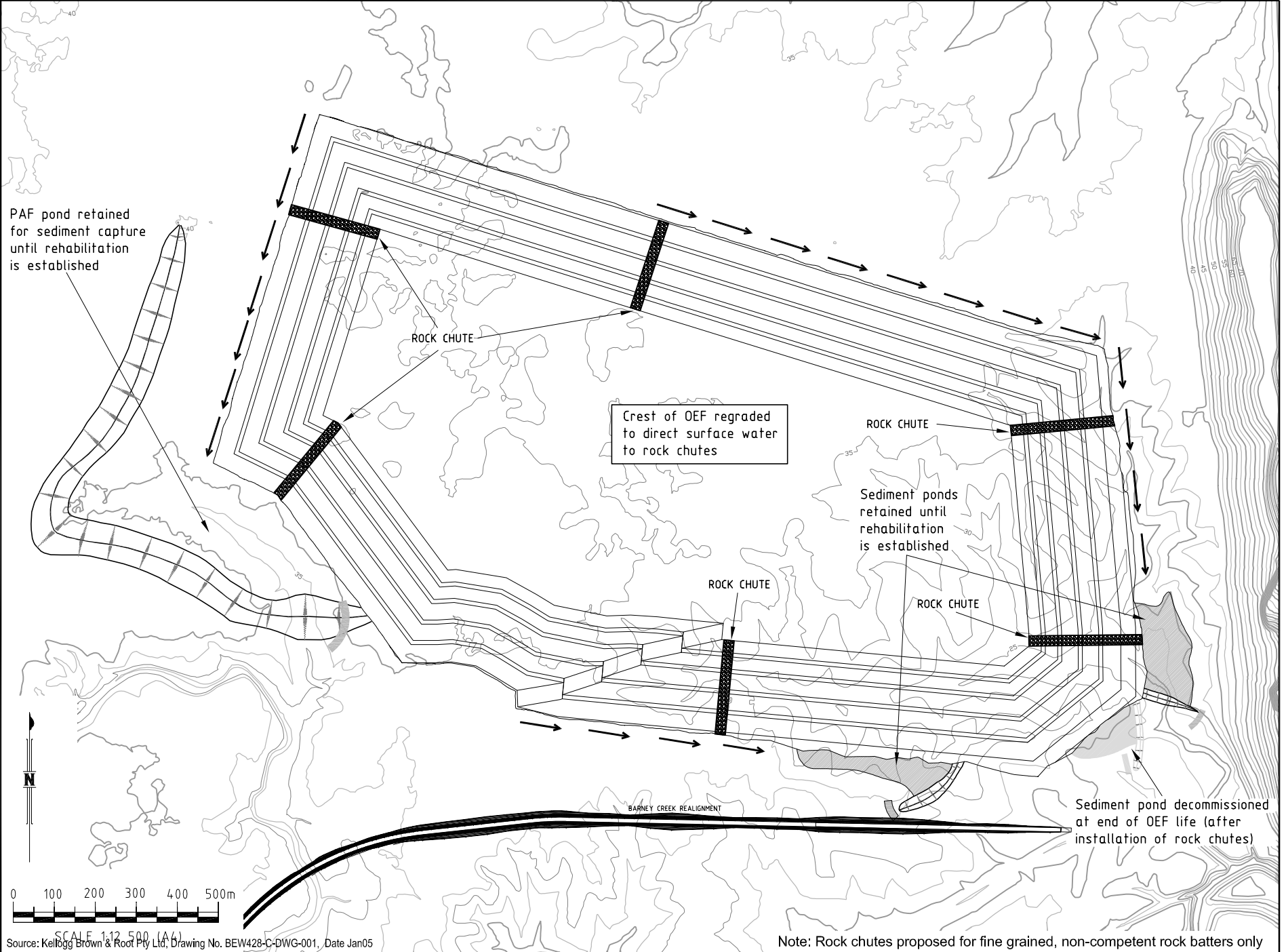
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Date: 12.07.2005

CONCEPTUAL OEF  
SURFACE WATER RUNOFF

Figure: 7.6

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### **7.2.5 Perimeter Overburden Emplacement Facility**

Overburden emplacement facilities have also been planned for the area in between the flood protection bund and the crest of the final pit. This provides a shorter haul, as well as some overburden emplacement capacity during times of flooding outside of the perimeter bund. These small dumps, in the order of 10 Mt capacity, would be used for NAF only. They will be sloped toward the pit to drain any dirty water runoff into the pit dewatering system. If any PAF is excavated during times of flooding, it will be stored in this area temporarily and then transferred to the main OEF once flooding subsides.

### **7.2.6 In-Pit Overburden Emplacement Facility**

The footwall of the lowest orebody is flat enough in some portions of the pit to potentially allow in-pit dumping of overburden. As portions of the pit walls contain mineralisation, these dumps can be used for PAF materials. They have the capacity for approximately 10 Mt of overburden. Larger in-pit dumps may be possible if geological conditions on the footwall are shown to be suitable.

## **7.3 Tailings – Existing Operations**

### **7.3.1 Overview**

As discussed in Section 3.4, concentrator tailing (process residue) is the material that remains after the mineral bearing component of the ore has been extracted during processing. The tailing is removed from the processing stream as slurry and pumped to the tailings storage facility (TSF) for storage. The thickened tailing slurry is pumped at high density, with a solids content of between 45% and 50%. The tailing is extremely fine, with more than 80% of the particles less than 7 µm in diameter.

This section summarises the results of a geochemical analysis of the tailings reported in URS (2005a).

### **7.3.2 Tailing/Decant Management**

The TSF is located adjacent to the western side of Carpentaria Highway south of Surprise Creek (Figure 1.2). It is divided into three cells: Cell 1 (83 ha), Cell 2 (56 ha), Cell 3 (62 ha) and the clean water dam area (115 ha) as shown in Figure 7.7. Cell 1 is the initial and current tailings impoundment area. Cells 2 and 3 were planned to store tailing materials once Cell 1 became full but they are currently used as an evaporation pond and dirty water dam, respectively.

The TSF operates with a central thickened discharge, with tailings deposited via an elevated riser into the centre of Cell 1 to form a cone of deposited tailings. The tailing cone is confined by the Cell 1 perimeter bund wall. Tailing bleed water and stormwater runoff flow down the beached tailing cone to the edge of the TSF. This flow is then directed either to the east or west (depending on the beach profile) to decant groynes and then via open channels to either the evaporation pond or the dirty water dam. The decant water may be held in the evaporation pond and allowed to evaporate if there is excess water, or allowed to

flow to the dirty water dam. From the dirty water dam it is either pumped through a series of sprinklers back to Cell 1 to enhance evaporation or returned to the processing plant for reuse.

The quality of the decant water is given in Table 7.4.

**Table 7.4**  
**Decant Water Quality**

Parameter <sup>3</sup>	ANZECC <sup>1</sup> / NEPM <sup>2</sup> Guidelines	Concentration
pH (no units)	-	7.0
EC (µS/cm)	-	1,880
Acidity (mg/L CaCO <sub>3</sub> )	-	49
Alkalinity (mg/L CaCO <sub>3</sub> )	-	21
<b>Major Elements</b>		
Ca	1,000	136
Mg	-	88
Na	-	198
K	-	66
SO <sub>4</sub>	-	983
Cl	-	111
<b>Minor Elements</b>		
Al	5	<0.01
As	0.5	0.012
Cd	0.01	0.017
Co	1	0.001
Cr	1	<0.001
Cu	0.5	0.03
Fe	1 <sup>2</sup>	<0.01
Hg	0.002	<0.0001
Mn	2 <sup>2</sup>	0.26
Ni	1	0.003
Pb	0.1	0.14
Sb	-	0.04
Se	0.02	<0.01
Ti	-	0.03
Zn	20	8.5

<sup>1</sup> ANZECC (2000a) – stock watering

<sup>2</sup> NEPM (1999) – groundwater investigation levels (irrigation)

<sup>3</sup> All units mg/L unless otherwise stated

- No level established

Decant liquor from the existing tailings is pH neutral and slightly brackish. The chemistry is dominated by the major soluble cations (Ca, Na, Mg and K) and anions (SO<sub>4</sub>). The concentration of soluble trace metals is relatively low and within relevant livestock drinking water guideline criteria (except for soluble Cd and Pb concentrations, which are marginally in excess of guideline criteria) (ANZECC, 2000a; NEPM, 1999).

A clean water dam is located to the south of Cell 3 and is used to collect storm water for future use. It may also be emptied and used to provide overflow storage in the event that excess dirty water is collected in the dirty water dam during the wet season.

### 7.3.3 Tailing Characterisation

Historical geochemical information for typical tailing material generated at MRM indicates that the tailing is reactive, but does not contain sufficient reactive sulfides to lower the pH of the material. Since 1998, tailings have been geochemically tested on a monthly basis using acid-base accounting and NAG tests and have generally been classified as NAF. The results in Table 7.5 summarise the geochemical characteristics of the tailings sampled from 1998 to 2003 (URS, 2005a).

**Table 7.5**  
**Geochemical Characteristics of MRM Tailings**

Value	Total Sulfur (%)	MPA <sup>1</sup>	ANC <sup>2</sup>	NAPP <sup>3</sup>	NAG <sup>4</sup>	NAG pH	Classification
		(kg H <sub>2</sub> SO <sub>4</sub> /t)					
Minimum	4.22	129	24	41	0	5.30	Non-Acid Forming
Maximum	15.46	473	202	393	45	7.50	Non-Acid Forming
Mean	10.32	316	107	209	6	6.74	Non-Acid Forming

<sup>1</sup>MPA = Maximum Potential Acidity

<sup>2</sup>ANC = Acid Neutralising Capacity

<sup>3</sup>NAPP = Net Acid Producing Potential

<sup>4</sup>NAG = Net Acid Generation.

Analysis of tailings samples taken from Cell 1 (URS, 2004) indicated that the tailings are currently pH neutral to slightly alkaline, brackish, and contain elevated concentrations of sulfate and some metals compared to relevant Australian water quality guidelines. The tailings also have high total sulfur content, although some is present in non-acid forming sulfide forms, and retain some potential to react if exposed to oxidising conditions. Most tailings have substantial acid neutralising capacity (ANC), which is likely to inhibit the onset of acid conditions for a significant period of time.

In spite of a strongly positive net acid producing potential (NAPP) result, tailings have historically been classified as NAF on the basis of NAG<sub>pH</sub> test data. However, recent research data indicate that the NAG test may not be reliable for determining the acid forming nature of waste materials with a high sulfur and high ANC content (Stewart *et. al.*, 2003). MRM tailings monitoring data indicate that the tailings NAPP value has been increasing since 1998, a trend that can be attributed to a higher sulfide content and lower ANC for ore reporting to the process plant, as the underground mining has progressed through different parts of the ore-body. The most recent geochemical tests on near-surface tailing samples at the TSF

indicate that some near-surface tailing materials are likely to be PAF if exposed to oxidising conditions for a significant period of time (URS, 2004).

Multi-element analysis of the tailing solids indicates the concentrations of major and minor elements in the tailings. The results of this analysis are given in Table 7.6.

**Table 7.6**  
**Multi-Element Analysis - Tailings**

Parameter <sup>3</sup>	ANZECC <sup>1</sup>	NEPM <sup>2</sup>	Concentration
pH (no units)	-	-	8.2
EC (µS/cm)	-	-	532
<b>Major Elements</b>			
Al	-	-	5,760
Ca	-	-	74.9 (g/kg)
Fe	-	-	40.6 (g/kg)
Mg	-	-	33.9 (g/kg)
Na	-	-	222
K	-	-	1,840
<b>Minor Elements</b>			
As	20	200	781
Cd	3	40	20
Co	2-170 (background)	200	13
Cr(VI)	50	200	24
Cu	60	2,000	322
Hg (inorganic)	1	30	0.2
Mn	500	3,000	2,400
Ni	60	600	12
Pb	300	600	8,460
Sb	20	-	8
Se	-	-	<1
Ti	-	-	33
Zn	200	14,000	7,390

<sup>1</sup> ANZECC (1992a) – environmental investigation level

<sup>2</sup> NEPM (1999) – soil investigation level (health based)

<sup>3</sup> All units mg/kg unless otherwise stated

- No level established

The data in Table 7.4 are compared with metal concentrations described in ANZECC (1992a) environmental investigation guidelines for the assessment and management of contaminated sites and NEPM health-based investigation guidelines for contaminated sites (parks and recreational open space), where they exist. The results indicate that some metals (As, Cd, Cu, Mn, Pb and Zn) can be present in

tailings materials at a concentration greater than the recommended ANZECC guidelines for these elements. Some metals (As and Pb) can be present at concentrations greater than the NEPM (1999) guidelines.

The above metals are bound in with the tailings and are not readily available to mobilise into the environment. To test if the metals can leach out of the tailings and mobilise, long-term kinetic leach column tests on the NAF tailing materials were undertaken (URS, 2005a). The tests indicated that leachate from the tailings may contain elevated soluble concentrations of Cd, Mn, Pb and SO<sub>4</sub> compared to ANZECC (2000a) and NEPM (1999) livestock drinking water guideline criteria. Mn and SO<sub>4</sub> are relatively soluble at neutral pH and would be expected to remain in solution and potentially impact upon the quality of any seepage from tailings materials. In contrast, Cd and Pb are sparingly soluble at neutral pH and are not expected to be mobile and should remain in the solid phase. Hence, it is expected that, at neutral pH, the concentration of the majority of soluble metals will remain within ANZECC (2000a) livestock drinking water quality guideline criteria.

#### 7.3.4 Seepage

The existing TSF was designed not to leak. The perimeter wall was constructed of local sandy clay and was designed to incorporate a cut-off trench in areas where sandy/gravelly lenses were encountered.

Early site investigation studies undertaken as part of the initial mine development indicate that the sub-surface conditions generally comprise an upper layer of sandy clay soils (low permeability) overlying weathered dolomitic siltstone. However, terrain analysis indicated that the footprint of TSF contained significant areas where the surface soils comprised “permeable sands and gravels”. Furthermore, *in situ* testing within the underlying weathered dolomitic siltstone indicated that the siltstone was relatively permeable and contained karst features, which together with other defects within the rock could provide preferential flow paths for seepage.

In June 1997 seepage was discovered in Surprise Creek adjacent to the TSF. Water in the creek was found to contain some sulfate (positive indication of tailings origin) but only background levels of lead and zinc (URS, 2004). Regular monitoring of the water in Surprise Creek indicated no or minimal transport of lead and zinc in the water from the tailings. Remedial actions taken as a result of the seepage included pumping of water from the creek back into the TSF, installing a cut-off trench between the TSF and the creek, reducing tailings accumulation in the section of the TSF nearest the creek, and instigation of a groundwater monitoring program.

Seepage analysis has been undertaken to model the likely groundwater levels within and around the TSF at various stages of development and to use this model to predict the likely future seepage performance of the TSF under a range of scenarios (URS, 2004). The results of the seepage modelling indicate that, for the current conditions at the site, some seepage is expected to occur under the perimeter embankment and flow to Surprise Creek within a few years of tailings placement. There is evidence to suggest that the sandy clay layer under the TSF footprint is not continuous, either due to zones of sandy gravels being present or the previous excavation of the sandy clay for construction of the TSF embankments. Modelling

indicates that seepage could extend for distances in excess of 200 m from the toe of the perimeter embankment.

A range of remedial works options was considered to minimise this seepage and the preferred method was to install a geopolymer barrier wall around the perimeter of Cell 1 fronting Surprise Creek. An aqueous geopolymeric solution is injected into the ground at nominated locations around the TSF perimeter. The solution initiates a hygroscopic reaction within the soil causing the bonding of soil particles together into a dense low permeability matrix. In early 2005, the first 700 m along the eastern end of the TSF perimeter was treated and the balance of the perimeter will be treated by the end of the third quarter 2005. The success of this treatment will be confirmed by the site's water quality monitoring program. In the unlikely event that ongoing seepage is detected, consideration will be given to alternative remedial works such as recovery bores.

It should be noted that with the open cut mine, a new TSF will be constructed (Section 7.4). This will eliminate the ongoing disposal of tailing materials to the existing TSF and will enable long-term rehabilitation to be undertaken. Once the existing TSF has been decommissioned and rehabilitated, the source of ongoing seepage will gradually reduce.

### **7.3.5 Groundwater Quality**

Geochemical and groundwater quality data indicate that seepage from the existing TSF is pH neutral to slightly alkaline (URS, 2004). However, elevated salinity levels and soluble sulfate concentrations can be greater than those recommended in relevant ANZECC (2000a) water quality guidelines. The elevated sulfate concentrations are probably due to sulfide oxidation in unsaturated surface tailings and are closely linked to elevated salinity levels.

Recent geochemical analysis indicated that the tailings retain a large ANC, which should provide acid buffering for a significant period of time. The underlying rock sequences at the TSF area are expected to have a significant ANC and may provide additional acid buffering capacity. In the longer-term, it is expected that rehabilitation (covering) of Cell 1 will limit sulfide oxidation, acid generation and potential for acid seepage.

Some metal concentrations (Cd, Cu, Fe, Mn, Pb and Zn) in seepage/groundwater can be greater than ANZECC (2000a) water quality guideline criteria for fresh water ecosystems, but are generally less than equivalent guideline criteria for livestock drinking water (URS, 2004). At neutral pH, most elevated metal concentrations are likely to be seasonal and associated with the solid phase ("colloidal" material). Hence, in the medium-term it is expected that, at neutral pH, the concentration of the majority of soluble metals in the groundwater will remain within ANZECC (2000a) livestock drinking water quality guideline criteria.

### **7.3.6 Cell 1 Closure Strategy**

The proposed Cell 1 TSF closure strategy includes the following tasks:

- Placement of tailings across the current TSF to achieve a target final landform profile.
- Placement of a capillary break layer (at least over the lower third of the tailings cone) to limit the risk of capillary rise of salts into the cover layer.
- Construction of a low permeability cover across the TSF surface. The cover will comprise a three layered system with a total thickness of 1.7 m to maximise the long-term sustainability and performance of the cover. The objectives of the cover are to:
  - reduce the potential for acid generation from oxidation of the tailings;
  - minimise the inflow of water into the tailings and therefore reduce the amount of water available to seep into the surrounding environment; and
  - stabilise the surface of the TSF.
- Construction of a surface water management system across the cover to limit surface erosion and collect surface water runoff. This would include a system of contour drains and rock-lined drainage channels and drop structures. The runoff collected from the revegetated surface will be discharged in a controlled manner to Surprise Creek.
- Revegetating the surface of the cover with native grasses and shallow rooted shrub species to stabilise the cover surface and to assist in the removal of water stored within the cover following extended wet periods.
- Continue the water monitoring program to confirm that ongoing seepage is not occurring into Surprise Creek.

## 7.4 Tailings – Open Cut Operations

### 7.4.1 Overview

The existing tailings storage facility (TSF) footprint will be utilised for the open cut operations. No additional land disturbance will be necessary. Tailings placement will shift west of the existing deposition location into the area currently used for the evaporation pond, the dirty water dam, and the clean water dam. This will enable the current cell to be decommissioned and rehabilitated.

Slurried tailings from the concentrator will be deposited within a bunded area and left to settle and consolidate in the same manner that is used for the existing TSF. The slurry water will flow to the low point in the tailings beach from where it will be decanted and flow to the water management dam. Water from the dam will be pumped back to the concentrator for reuse. As the tailings consolidate, new layers of tailings will be deposited on top of the old layers.

The layout of the new TSF is given in Figure 7.8.

Key design parameters for the new TSF include the following:

- Total tailings volume – 23 Mm<sup>3</sup>.



Source: Allen Watson Associates, Cad file 0102-AUS-001-008, Sept, 2003

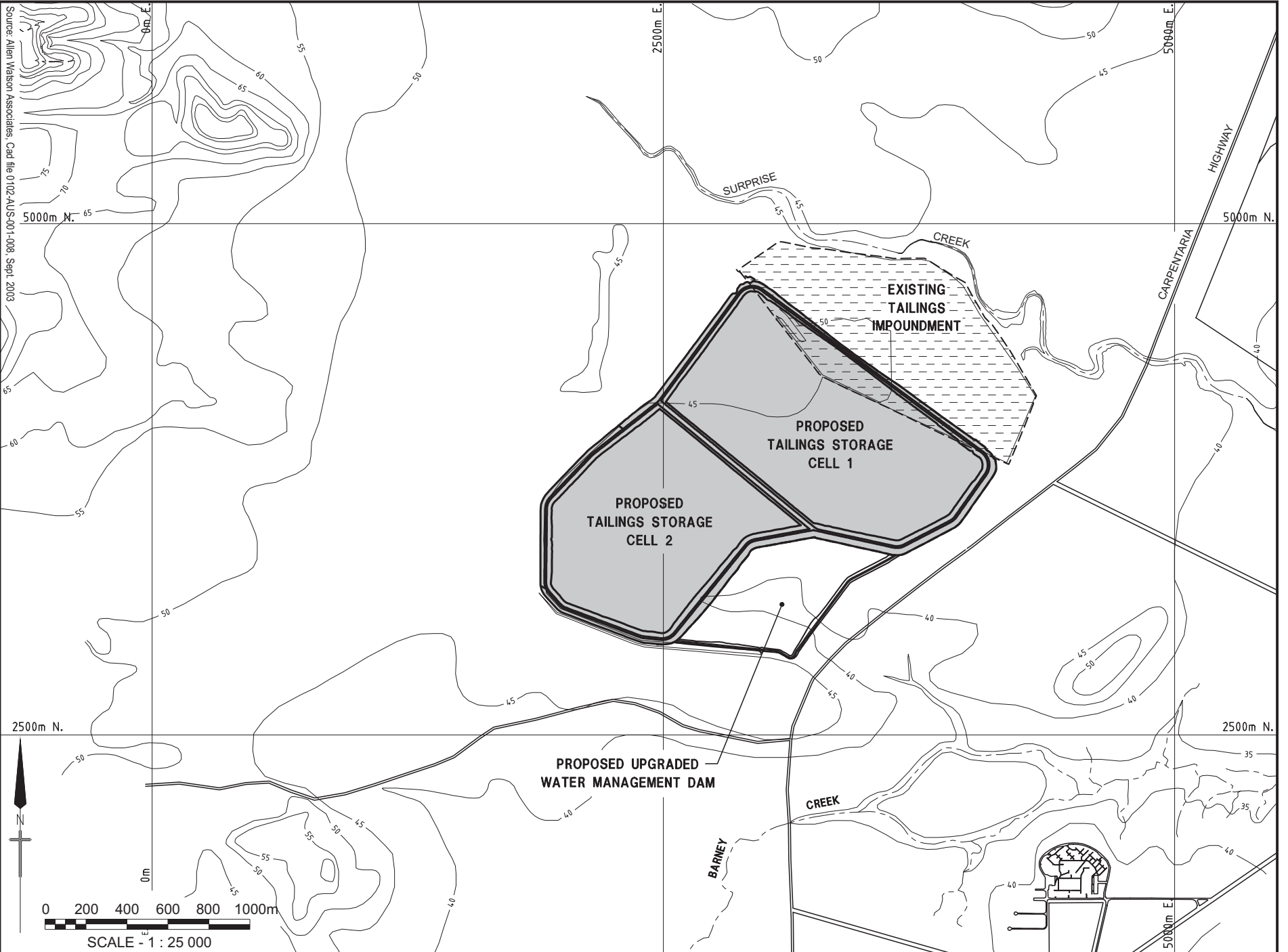
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Approved: OMP  
File No: 42625552-g-024b.cdr  
Date: 12-07-2005

McARTHUR RIVER MINE  
OPEN CUT PROJECT  
ENVIRONMENTAL IMPACT STATEMENT

Figure: 7.8

LAYOUT OF EXPANDED  
TAILINGS STORAGE FACILITY

Rev. B  
A4



- Two new cells proposed.
- Total surface area - 210 ha.
- Maximum surface level - RL 68 m.
- Maximum height of storage - 30 m .
- Runoff to water management dam.
- No additional land disturbance.

### 7.4.2 Tailings Deposition Method

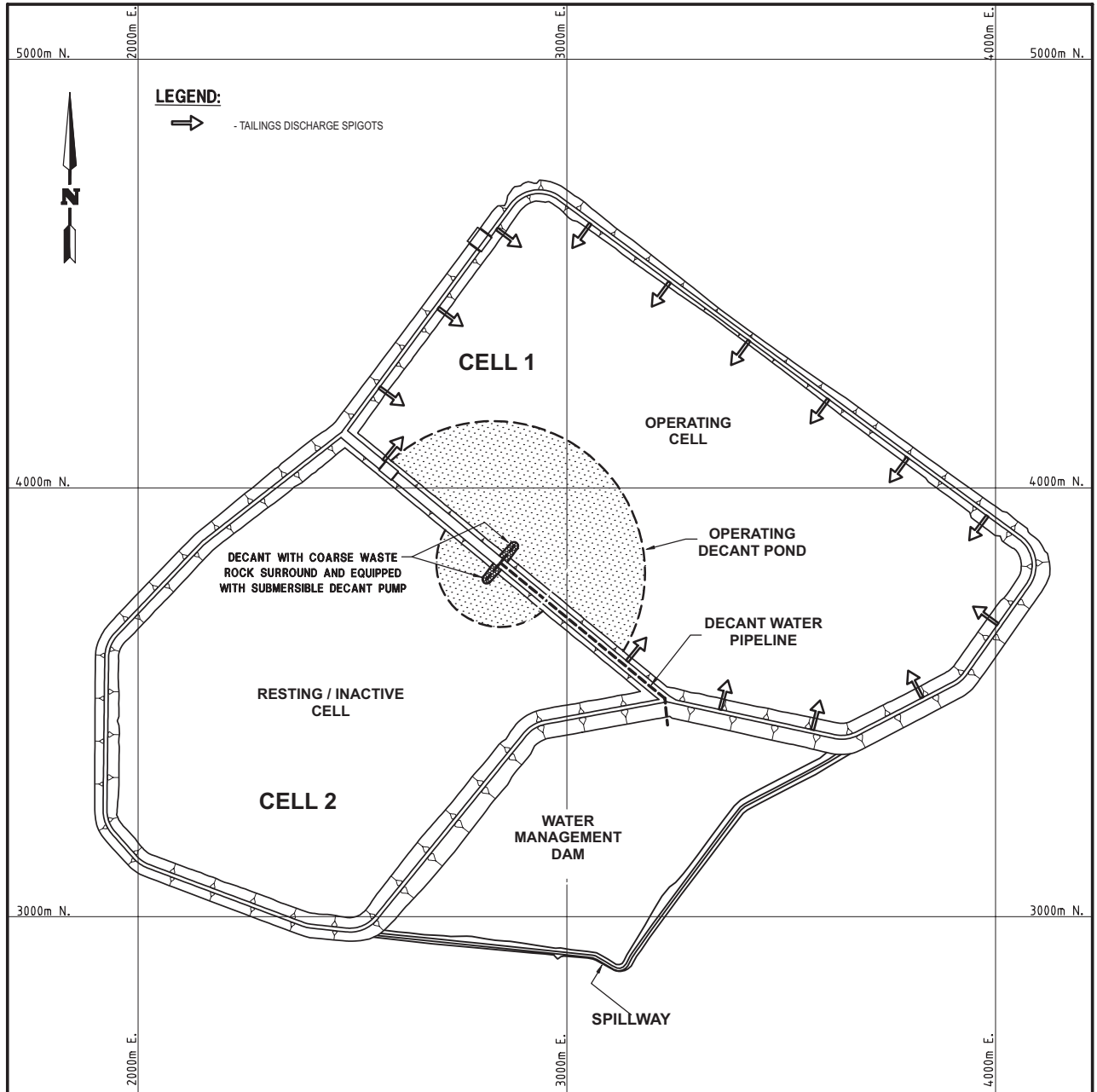
The general operational philosophy for the new TSF will be based on the use of sub-aerial techniques for tailings deposition. Sub-aerial deposition involves the discharge of tailings from multiple locations around the perimeter of the active cell. At each discharge location the tailings slurry will produce a near laminar flow over the gently sloping tails beach to enable segregation and deposition of tailings solids. Subsequent evaporation from the exposed beach surface areas will consolidate the tailings as a means of increasing *in situ* deposited densities and beach strengths. Water liberated from the tailings through the deposition phase and stormwater runoff will accumulate in a decant pond at the toe of the beach. From there the decant water will be pumped to the water management dam to be constructed on the southern side of Cells 1 and 2. Water from this dam will be returned to the concentrator for reuse. This arrangement for Cells 1 and 2 is shown in Figure 7.9.

The duration of a deposition cycle from a single deposition site and the associated rate of cycling around the storage will be subject to a number of issues including the following:

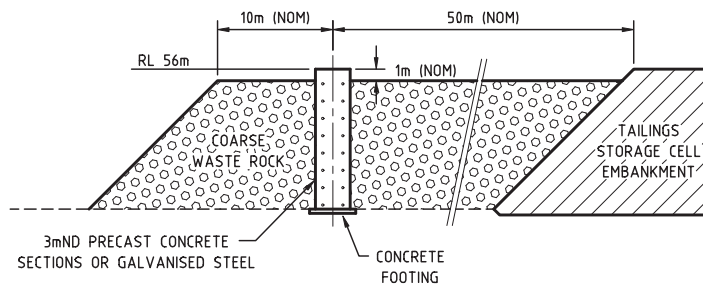
- Achieving high tailings densities such that the overall efficiency of the storage is maximised. This will be assisted by regular rotation of the use of the discharge spigots located around the cell to provide relatively thin tailings beach layers that can dry before subsequent placement of the next tailings layer.
- Achieving adequate strength and integrity of the tailings beach to enable future embankment lifting over the beach area and ultimate rehabilitation works.
- Obtaining an adequate rate of tailings water bleed from the beach surface such that recovery efficiencies can be maximised and the availability of water reporting as seepage can be minimised. As the head of water in the TSF is a key driver of seepage, the volume of water in the decant pond will be kept as small as possible and water will not be stored across the tailings surface.
- Maintaining a minimum moisture condition within the beach to inhibit the formation of oxidation products from drying tailings beaches and to prevent dust generation.

### 7.4.3 Design of the Tailings Storage Facility

The initial (starter) embankment of the TSF will be formed by earth and rock fill construction with the earth fill component being a centrally located core zone with rock fill embankment shoulders enhancing



SCALE 1:15000 (A4)



**DECANT CONCEPT**

SCALE 1:1250 (A4)

Source: Allen Watson Associates, Cad file 0102-AUS-001-010, Sept. 2003



McARTHUR RIVER MINE  
OPEN CUT PROJECT  
ENVIRONMENTAL IMPACT STATEMENT

**CONCEPTUAL TAILINGS  
STORAGE CELL OPERATION  
AND DECANT DETAILS (CELLS 1 & 2)**

Drawn: VH      Approved: CMP      Date: 12-07-2005  
Job No.: 42625552      File No. 42625552-g-025.cdr

Figure: 7.9

Rev. A  
A4

overall stability while providing flood erosion protection (1 in 500 year flood event). The earth fill core zone (clay/silt fraction greater than 20%) will incorporate a cut-off key, which will extend into competent basement material. It is anticipated that the earth fill for use in the embankment construction will be sourced from within the TSF storage area and rock fill (non-acid forming) will be sourced from the open pit. A cross section of the embankment is shown in Figure 7.10.

The TSF embankment will be coincident with the existing embankments. Their integrity will be confirmed by detailed investigations and depending on the results they will be either incorporated into the new embankments or removed to allow for the new construction. Where the northern embankment of Cell 1 overlaps the existing tailings impoundment, it will be constructed on the exposed tailings surface.

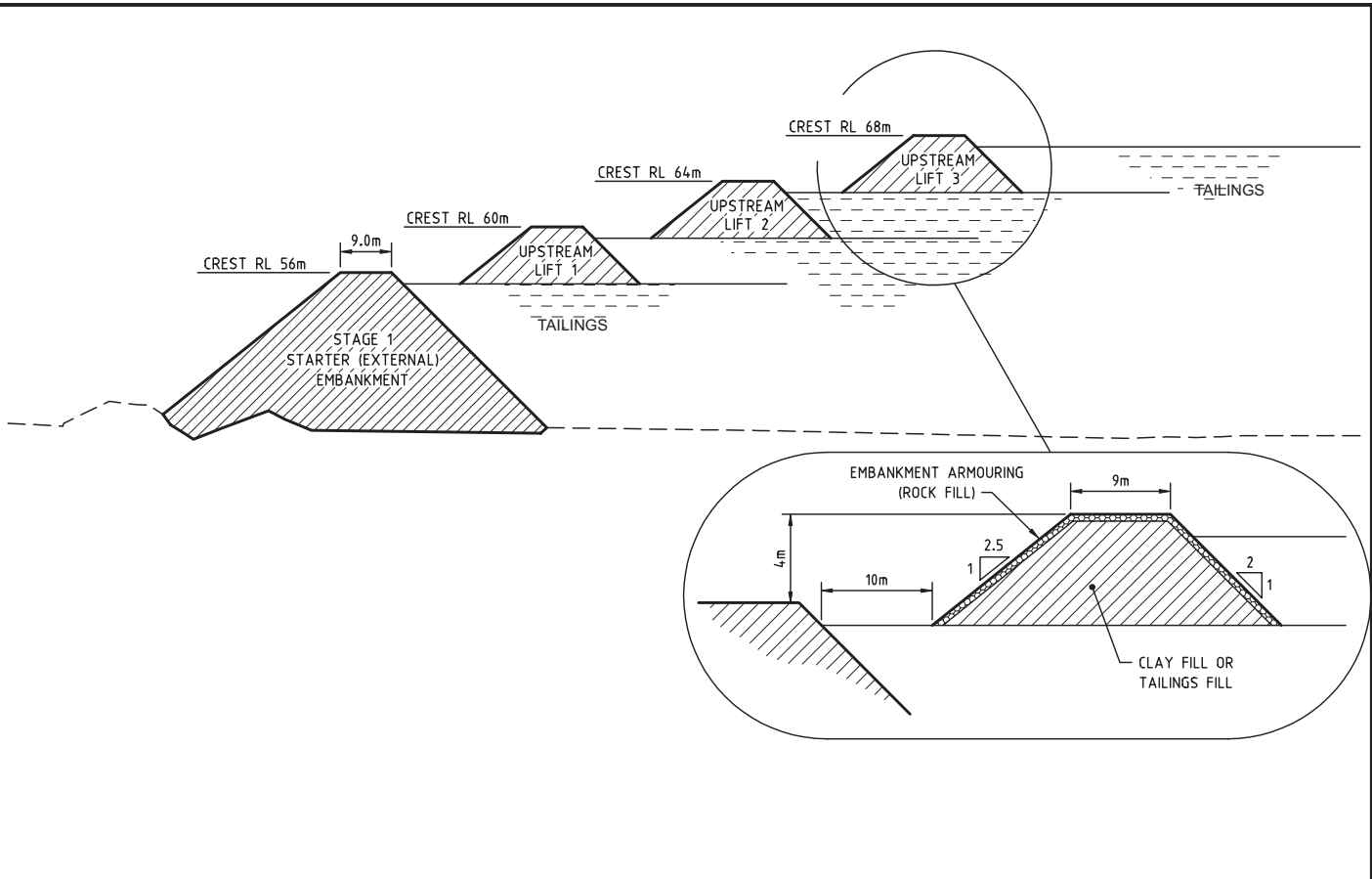
The new TSF will be designed to operate with a series of upstream lifts to maximise the capacity of each cell. Once the tailings in each cell reach the level of the perimeter embankment, a new embankment will be built upstream of the existing one to enable more tailings to be deposited over the old ones. The upstream lifts will be formed by constructing a new perimeter embankment over the exposed tailings beach of the full cell, upstream of the of the existing embankment crest. A typical cross section of the upstream lift technique is given in Figure 7.10.

To facilitate access to the tailings beach areas for the purpose of upstream lifting, the active tailings disposal system will use two cells at any one time, one cell for deposition with the second for resting/drying and subsequent upstream lifting. Deposition and lifting sequences would therefore alternate between cells.

As shown on Figure 7.10, the embankment will be constructed using a clay fill core to minimise seepage through the embankment and rock fill armouring to provide structural stability and erosion protection to the external face. Typical material specifications for these materials are as follows:

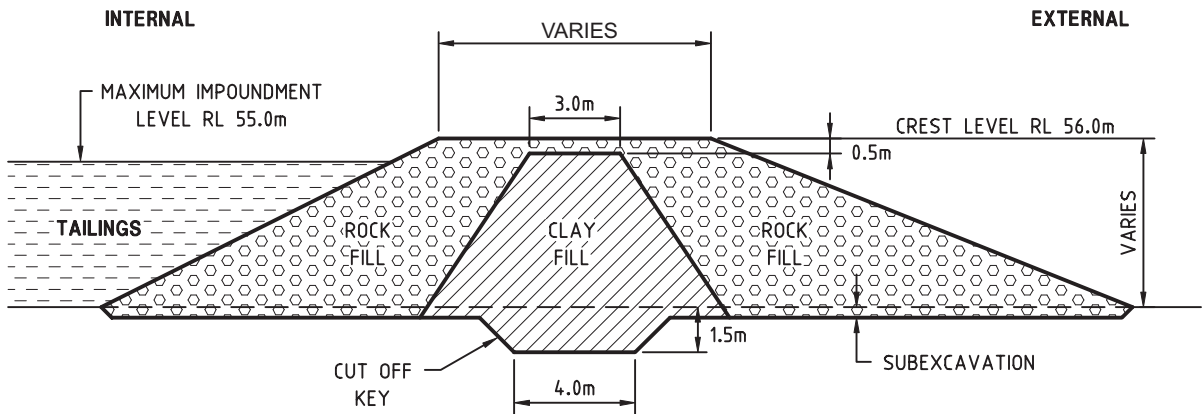
- Clay Fill
  - Clay/silt fraction greater than 20% and Liquid Limits ranging from 25% to 60%.
  - Undrained shear strength in excess of 50 kPa after compaction.
  - Achievable compacted permeability of less than  $10^{-8}$  m/s.
- Rock Fill
  - High load bearing capacity.
  - Physically stable and durable.
  - Geochemically stable (ie. non acid producing).

The embankments will be designed to meet the minimum factors of safety given in Table 7.7. A factor of safety for any structure needs to be greater than one before it can be considered to be safe.



**EXTERNAL EMBANKMENT LIFT CONFIGURATION**

SCALE HORIZ. 1:1250





**TYPICAL EMBANKMENT SECTION**

SCALE 1:250

Source: Allen Watson Associates, Cad files 0102-AUS-001-006 & 0102-AUS-001-010, Sept. 2003

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 	McARTHUR RIVER MINE OPEN CUT PROJECT ENVIRONMENTAL IMPACT STATEMENT			<b>TAILINGS STORAGE FACILITY                  EMBANKMENT CROSS SECTIONS</b>	
	Drawn: VH Job No.: <b>42625552</b>	Approved: CMP File No. 42625552-g-026.cdr	Date: 12-07-2005	Figure: <b>7.10</b>	Rev. A A4

**Table 7.7**

**Minimum Factors of Safety - Embankment**

Condition	Factor of Safety
Steady state (at maximum storage level)	1.5
Seismic condition	1.1
At closure	1.3
Rapid drawdown (subject of rapid dissipation of flood waters against downstream slope)	1.2

Water management design of the TSF will be based on the requirements of the Australian National Committee on Large Dams (ANCOLD, 1999). Using these criteria, the hazard category of the TSF is rated as high given the potential impacts from an uncontrolled release or embankment failure. By extrapolation of criteria from the Department of Mines and Energy (DME, 1995) for a high hazard category, the storage allowance will be based on a 1 in 200-year two-month duration wet season event.

An emergency spillway will be located in the north-west corner of Cell 2 to allow for overflows in extreme weather conditions. It will have a crest level of RL 55 m and will discharge to Surprise Creek. An overflow at RL 54.5 m will be provided between Cells 1 and 2 to enable Cell 1 to be serviced by the same emergency spillway. The spillway will be based on ANCOLD (1999) design conditions for a high hazard category and will incorporate the worst of the following:

- Probable maximum flood (PMF) on highest pond level in normal year; or
- Worst wet season on record less water returned to plant, plus 100-year average recurrence interval (ARI) storm plus waves.

#### **7.4.4 Water Management Dam**

The water management dam will be used to receive runoff and decant water from the tailings cells and to manage water flows between the Processing plant and the TSF.

The site water balance indicates that this dam requires a capacity of 2,500 ML. To achieve this, the existing embankment will be raised to a level of RL 47.5 m with the full supply level in the dam at RL 46.5 m. It is proposed to lift the embankment as well as to improve its seepage control by construction of an embankment upgrade formed on the upstream side of the existing embankment. This configuration would increase the capacity of the storage whilst enabling a seepage cut-off trench to be constructed. It will be designed to the same standards as the tailings storage embankments.

An emergency spillway at will be provided at the south-east corner of the dam. It will be designed to accommodate at least a 1 in 500 year event.

### 7.4.5 Decant Water Quality

The quality of the decant water in the new TSF is expected to be similar to the decant water quality in the existing TSF as discussed in Section 7.3.2.

To ensure that this quality is maintained, the following management measures will be implemented:

- Maintaining a large enough decant pond to enable sufficient residence time for the settlement of suspended solids prior to recovery.
- Maintaining an appropriate tailings deposition regime so that the potential for tailings to oxidise and release oxidation products is limited. Levels of saturation/moisture within the beach will be defined and maintained to inhibit oxidation. This practice will also significantly reduce the dusting potential of the tailings surface.

### 7.4.6 Seepage Water Quality

The quality of any seepage water from the new TSF is expected to be similar to the seepage quality at the existing TSF as discussed in Section 7.3.5. The main characteristics of this seepage are that it is pH neutral, slightly alkaline (soluble sulfate) and with no significant metal concentrations. To ensure that this quality is maintained, the measures described above to inhibit oxidation of the tailings will be implemented.

### 7.4.7 Seepage Analysis

#### **Geotechnical Conditions**

The soil profile across the TSF site is shallow colluvial outwash fan deposits and floodplain alluvium. The underlying basement sequences comprise predominantly dolomite and dolomitic siltstone. The engineering properties of the soil profile are as follows:

- Described as generally sandy/gravelly clay of medium plasticity.
- Below the topsoil horizon the soil profile is generally of high strength (inferred undrained shear strength of 100 kPa).
- Moderate *insitu* permeability in the range  $5 \times 10^{-6}$  to  $1 \times 10^{-6}$  m/s. Subject to reengineering the permeability can be increased to around  $5 \times 10^{-8}$  m/s.
- Soils are generally non-dispersive.

The permeability of settled tailings (at settled density of  $1.3 \text{ t/m}^3$ ) is  $5 \times 10^{-8}$  m/s.

#### **Design Objective**

The design objective of the TSF will be to prevent seepage from occurring. However, seepage from any tailings storage facility generally needs to be allowed for. If any seepage does occur, it is expected to

develop as a seepage plume. Initially the plume would migrate downwards into the foundation sequences below the TSF, then as the plume reaches the groundwater system, it will move laterally in the direction of groundwater flow. Experience with the existing TSF is that the seepage does occur and emerges as surface flow in Surprise Creek (Section 7.3.4).

ANCOLD (1999) does not provide quantitative design criteria for seepage from tailings dams. However it does provide the following guidance for the assessment of potential impacts of seepage:

- Seepage occurs from the base of all tailings storages and in many cases this seepage has no surface expression.
- It is part of the design and assessment process to consider the consequences of seepage and to include appropriate minimisation and management techniques in the design where necessary.
- Undesirable consequences of seepage include contamination of quality groundwater and elevation of the groundwater table leading to surface expression.

On the basis of ANCOLD (1999), the following design objectives have been adopted for seepage at the new TSF:

- Surface expression of seepage discharge downstream of the TSF should not occur.
- No significant impact should occur on the environmental quality of receiving waters.
- The potential beneficial uses of surface and groundwater downstream of the TSF should not be compromised.

### **Seepage Model**

Modelling of seepage from the new TSF has been undertaken to determine the potential extent of the seepage and to develop seepage control measures. The modelling was undertaken using the computer program SEEP/w version 4.23 (Geoslope, 1999).

The model assumed the following input conditions:

- The design of the TSF embankment and the subsequent upstream lifts are as shown on Figure 7.10.
- The sub-surface profile across the TSF footprint is a key input to the seepage analysis. The following two sub-surface profiles were developed to “bound” the likely seepage performance predictions based on the existing conditions in the area:
  - A “best case” profile comprising a 2 m thick layer of sandy clay soils overlying the weathered dolomitic siltstone.
  - A “worst case” profile comprising a 2 m thick layer of “permeable sands and gravels” overlying the weathered dolomitic siltstone.
- An initial groundwater level of RL 32 m was applied under the centreline of the proposed embankment.

### **Model Results**

The results of the seepage modelling for the TSF for the initial period prior to upstream lifting for the best-case and worst-case sub-surface conditions are presented in Figure 7.11. The model results show the following:

- For the best-case scenario, groundwater levels downgradient of the TSF rise only to a moderate extent over the initial four year operation period. There is no surface expression of seepage downgradient of the TSF.
- For the worst-case scenario, groundwater levels downgradient of the TSF rise at a much quicker rate and seepage is expressed at the ground surface at the downstream toe of the perimeter embankment after the first four years.

The model was also run for the case after 25 years of operation by which time all three upstream lifts will be in place. The model results are shown on Figure 7.12 and indicate the following:

- For the best-case scenario, elevated groundwater levels develop under the TSF and after approximately six years, the modelling indicates that seepage could express at the downstream toe of the perimeter embankment. At this time, upstream lift number one will have been constructed. As further lifts are added to the TSF, the area downgradient of the perimeter embankment that is impacted by the elevated groundwater levels will increase.
- For the worst-case scenario elevated groundwater levels develop under the TSF at a much quicker rate and after approximately four years, the modelling indicates that the seepage will express at the ground surface at the downstream toe of the perimeter embankment. As further lifts are added to the TSF, the area downgradient of the perimeter embankment that is impacted by the elevated groundwater levels will increase.

### **Seepage Controls**

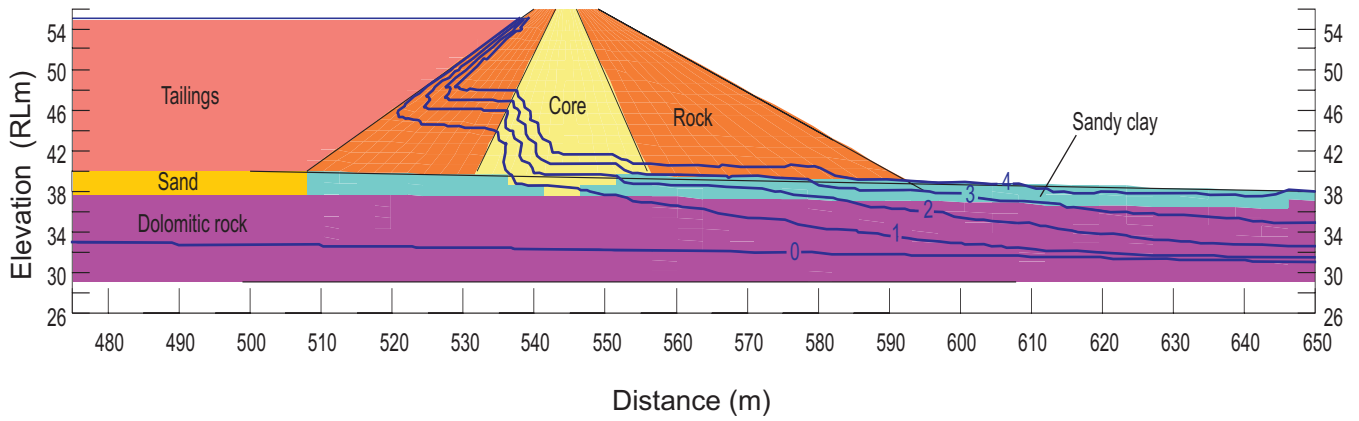
As the seepage model results discussed above indicate that seepage will be expressed at the surface downgradient of the TSF for both the best and worst-case scenarios, additional seepage control measures will need to be provided.

The following alternative control measures were modelled to gauge their effectiveness in reducing surface expression of the seepage:

- Providing a 1 m thick compacted clay layer below the tailings.
- Installing a network of recovery bores at the downstream toe of the perimeter embankment.

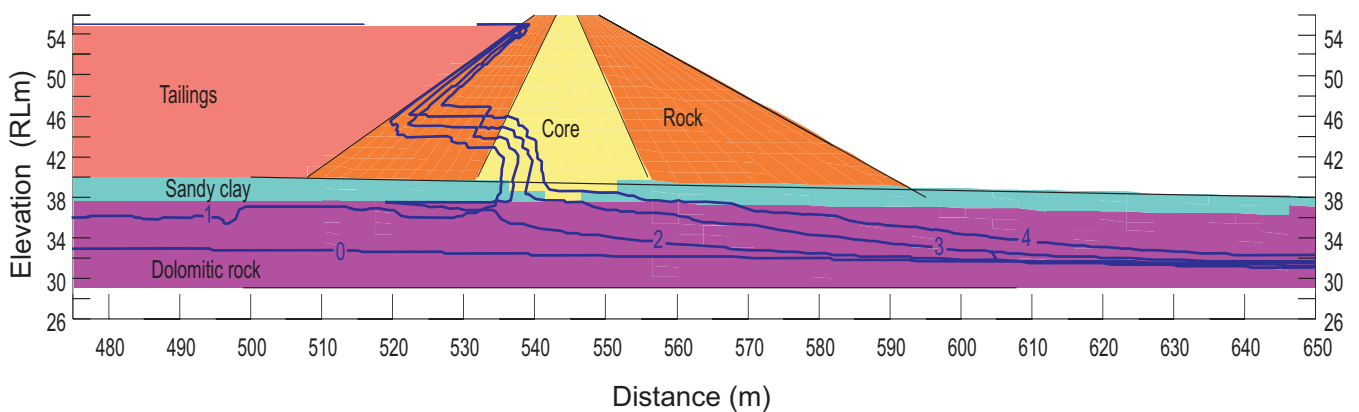
The model was run incorporating each of the above control measures for 25 years of operations. The predicted results which are shown on Figure 7.13 indicate the following:

- The provision of a 1 m thick compacted clay layer across the base of the TSF does not stop seepage but merely reduces the rate of groundwater rise. The modelling indicates that the groundwater level



**WORST CASE**

- Groundwater level
- 4— years after TSF operations commence



**BEST CASE**

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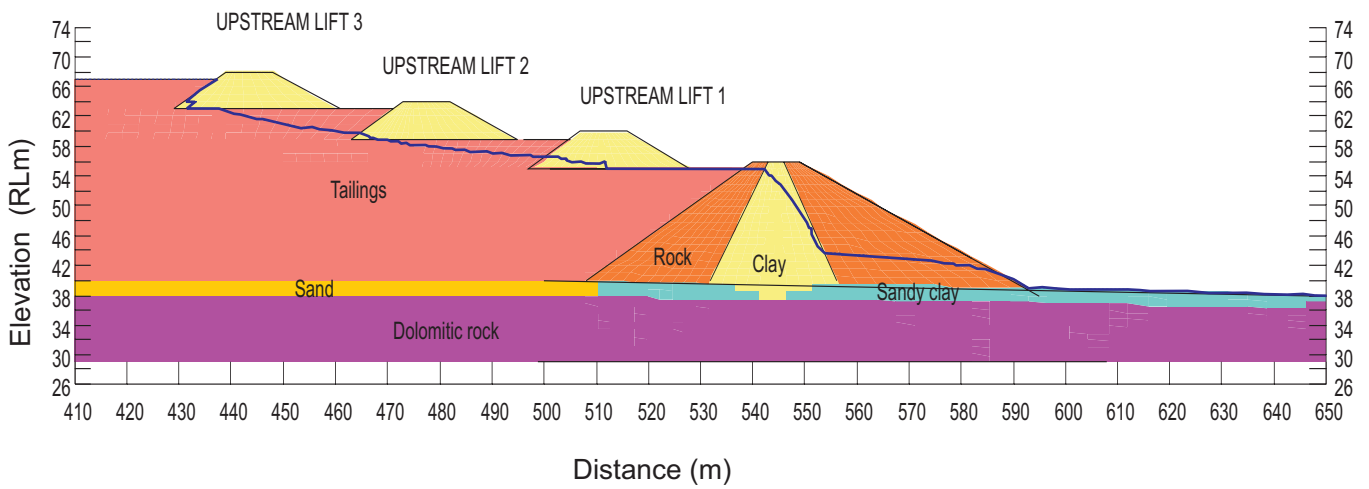
McARTHUR RIVER MINE  
OPEN CUT PROJECT  
ENVIRONMENTAL IMPACT STATEMENT

**TAILINGS STORAGE FACILITY  
SEEPAGE MODELLING  
PRIOR TO UPSTREAM LIFTS**

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Job No.: 42625552	File No. 42625552-g-027.cdr	

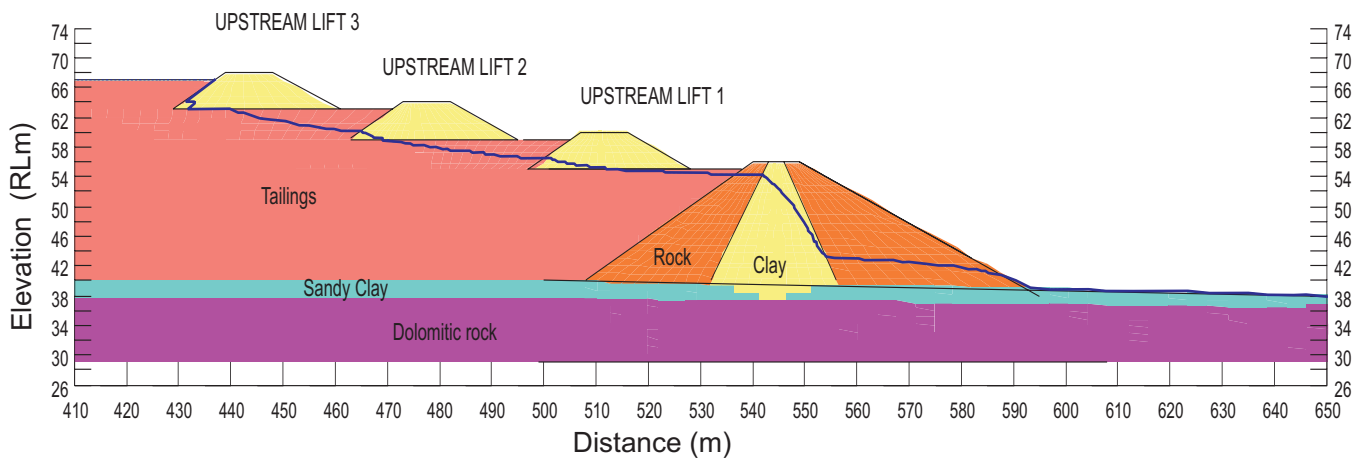
Figure: **7.11**

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**WORST CASE**

— Groundwater level in 2030



**BEST CASE**

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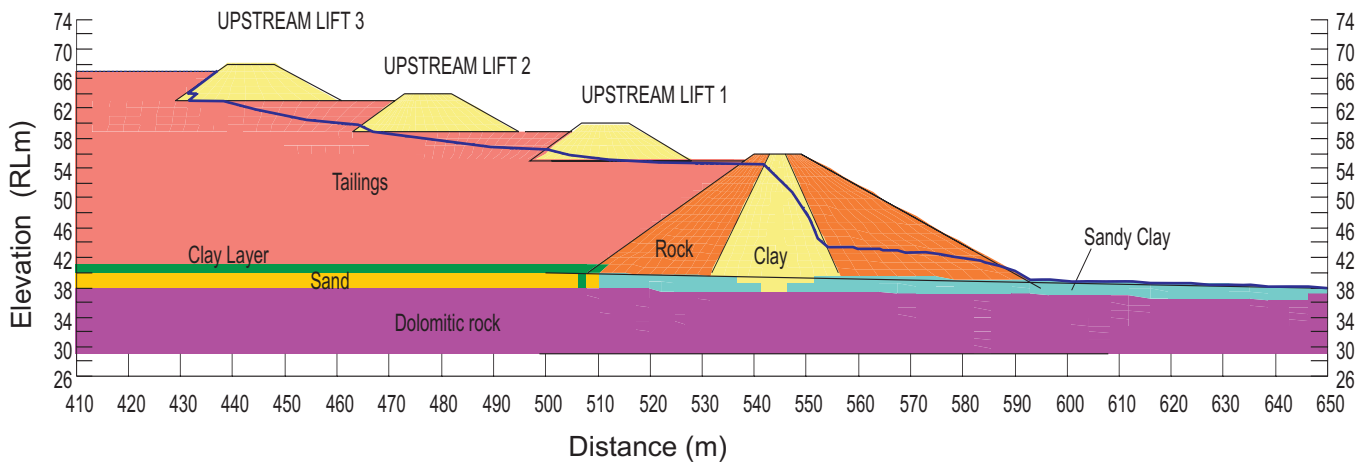
McARTHUR RIVER MINE  
OPEN CUT PROJECT  
ENVIRONMENTAL IMPACT STATEMENT

**TAILINGS STORAGE FACILITY  
SEEPAGE MODELLING  
AFTER UPSTREAM LIFTS**

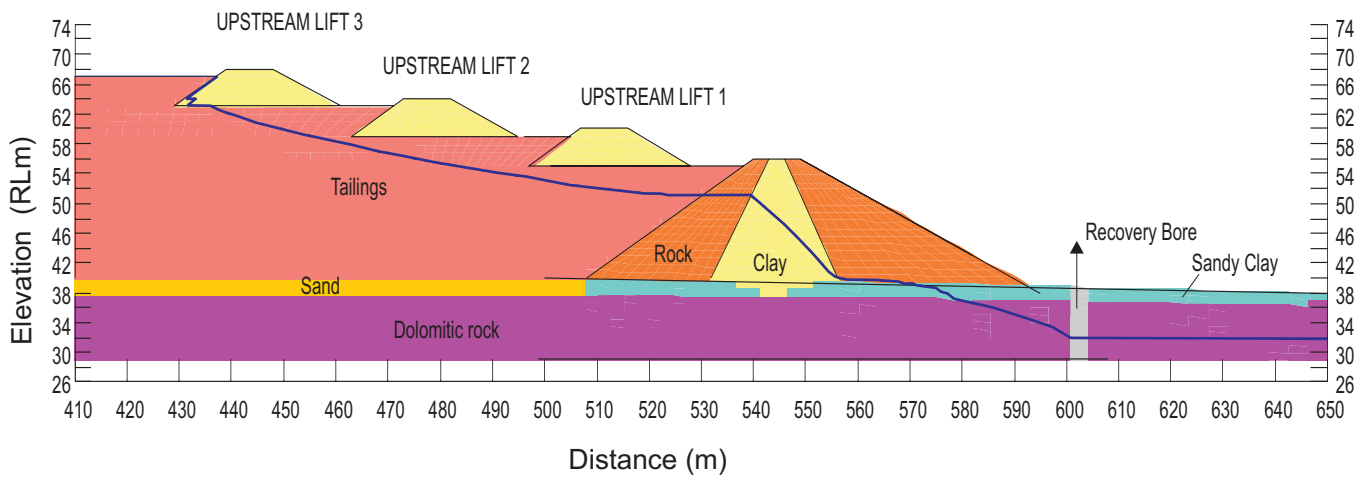
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Figure: **7.12**



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— Groundwater level in 2030



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 	McARTHUR RIVER MINE OPEN CUT PROJECT ENVIRONMENTAL IMPACT STATEMENT		<b>TAILINGS STORAGE FACILITY          SEEPAGE MODELLING          WITH SEEPAGE CONTROLS</b>	
	Drawn: VH Job No.: <b>42625552</b>	Approved: CMP File No. 42625552-g-029.cdr	Date: 12-07-2005	Figure: <b>7.13</b>

approaches the ground surface downgradient of the toe of the perimeter embankment within about six years of operation and will remain there for ongoing operations.

- The provision of a series of recovery bores along the downstream toe of the perimeter embankment prevents the surface groundwater levels from extending beyond the line of the recovery bores. However elevated groundwater levels will occur directly under the TSF footprint and the perimeter bund. The dewatering bores are equally as effective for either the best-case or worst-case sub-surface conditions.

On the basis of these modelling results, the preferred seepage control method is the installation of recovery bores. It is anticipated that the bores will be located around the downgradient (southern) side of the TSF at a spacing of approximately 50 m. They will be approximately 11 m deep which will be sufficient to intercept seepage through both the surficial sandy clay or sandy gravel layer and the underlying dolomitic sandstone layer.

Water from the recovery bores will be pumped to the water management dam from where it will be pumped to the concentrator for reuse.

#### **7.4.8 TSF Closure**

##### ***Rehabilitation Strategy***

At the completion of mining activities, the TSF will be decommissioned using a similar rehabilitation strategy to that given in Section 7.3.6 for the existing TSF. This will include:

- Re-profiling the surface to ensure incident rainfall runs off the TSF rather than seeps into the tailings.
- Placement of a capillary layer over the re-profiled surface to limit the capillary rise of salts into the cover layer.
- Placement of a low permeability cover over the capillary layer to prevent the oxidation of tailings, minimise the potential for seepage into the tailings, to stabilise the surface, and to provide a medium for vegetation growth.

The effect of this rehabilitation strategy will be to eliminate as far as possible additional water input into the tailings. In this way the head of water available to influence the seepage will be limited to what is in the tailings and will reduce over time as the seepage water is removed by the recovery bores.

### ***Seepage Recovery Timeframes***

Additional modelling was undertaken to assess the time that the recovery bores would need to operate after the TSF is rehabilitated until sufficient seepage water is removed so that no further surface expressions would occur. If the recovery bores are turned off immediately after the TSF is decommissioned, surface expressions of the ongoing seepage of the water retained within the tailings would appear downgradient of the perimeter embankment after approximately five years. Modelling has indicated that the recovery wells may need to be operated for a period of 30 years or longer after decommissioning to avoid surface expression of the seepage.

There are a number of variables that may affect the period that the recovery bores will need to be operated following decommissioning and an “observational approach” is proposed. This would include a series of monitoring bores that would be installed within the TSF, the perimeter embankment and the area downgradient of the TSF to monitor the level and quality of groundwater.

### ***Energy Source***

The operation of the recovery bores for the period following site closure when power is no longer readily available will be undertaken using alternate energy sources that could include either solar or wind powered pumps. The groundwater monitoring data collected during the operation of the TSF will be used to evaluate which system is most suitable. The recovery well system will be designed to have a much greater pumping capacity than theoretically required and it may be acceptable to have intermittent pumping from the bores particularly as the volume of seepage flows reduce with time. Monitoring of the performance of the recovery bores using alternate power sources will be undertaken to confirm that satisfactory performance can be provided.

### ***Seepage Water Disposal***

After mining activities have ceased, seepage water collected from the recovery bores will no longer be able to be reused in the concentrator. Instead it will be pumped to the mine pit void. Based on the modelling results, the volume of seepage that will be collected in a typical year after the TSF is decommissioned is of the order of 73,000 m<sup>3</sup> (200 m<sup>3</sup> per day). As discussed in Section 20.3.7, after site closure the pit void will be allowed to fill with groundwater inflow and flood flows. Discharging the TSF seepage water into the pit will increase the depth of water in the pit over a year by less than 10 cm which will be insignificant in a pit that will be over 215 m deep.

The quality of the seepage water collected from the recovery wells is expected to be better than the quality of water within the pit and should have no major impact on the pit water quality.

### 7.4.9 Monitoring

As discussed above, an “observational” approach will be taken in determining how long the recovery bores need to be operated following mine closure. Groundwater levels will be monitored within the TSF, the perimeter embankment, and the area downgradient of the TSF. During operation of the mine, personnel will be on site to oversee the groundwater and seepage monitoring program. After mining activities have ceased, an automated monitoring system will be installed. The automated monitoring system will store data at the site, which will be downloaded at regular intervals, either by personnel visiting the site or by a dial up connection.

## 7.5 General Operational Waste

### 7.5.1 Policy and Objectives

Waste management at McArthur River Mine is an integral component of the site’s environmental management system. Waste management practices aim to reduce waste production through recovery, re-use and recycling and through encouraging efficient utilisation of resources. MRM aims to promote best practice disposal of waste products both on-site through appropriate maintenance of waste disposal areas and off-site through utilising environmentally responsible waste disposal companies.

MRM’s Environmental Management Policy states that MRM will ensure “the efficient use of resources and minimisation of waste generation and disposal”.

In addition, MRM is a signatory to the Australian Minerals Industry Code for Environmental Management 2000, which includes waste management commitments.

MRM has prepared a waste management plan to assist in the implementation of the above policy. The objectives of the waste management plan are to:

- Identify and categorise all wastes produced across all leases.
- Identify and characterise disposal and storage areas for each waste category produced.
- Perform risk assessments on all storage, transport and disposal of all waste produced.
- Ensure appropriate maintenance of disposal areas.
- Ensure appropriate re-use and recycling of specific items.
- Identify feasible waste reduction strategies

### 7.5.2 Waste Management Strategies

The main elements of the site’s management strategies for general waste (other than tailings and waste rock which are discussed in Sections 7.1-7.4) are summarised in Table 7.8.

**Table 7.8**

**General Waste Management**

Waste Type	Amount	Disposal
Kitchen (putrescible) waste	600 m <sup>3</sup> /year	On-site refuse facility (incinerated)
Packaging, office and garden waste	2,000 m <sup>3</sup> /year	On-site refuse facility (buried)
Contaminated waste <sup>1</sup>	7,700 t/year	Designated section of tailings storage facility
Sludge from sewage treatment		Designated section of tailings storage facility
Laboratory waste	80 L/year	Via laboratory sink to concentrator runoff pond
Medical waste		Transported to Darwin Hospital for disposal in accordance with AS 3816:1998
Waste oil	50,000 L/year	Collected in 1,000 L dots for transport and disposal off-site
Waste cooking oil	4,200 L/year	Collected in 205 L drums and transported off-site for recycling
Aluminium cans	80,000/year	Given to Borroloola Community Government Council for recycling
Scrap metal		Transported off-site for recycling
Waste Jet A1 fuel	1,000 L/year	Reused in the on-site workshop as a cleaning fluid
Mill lubricant	16,500 L/year	Tailings storage facility
Batteries		Transported for off-site disposal
Tyres	200/year	Stockpiled pending development of an appropriate disposal strategy

<sup>1</sup> Waste that has come in contact with a contaminant generally from the mill, mine, workshops or concentrate storage shed and may include steel, reagent bags, wooden pallets and crates, workshop/hydrocarbon contaminated materials etc.

### 7.5.3 On-Site Waste Management

#### ***Tailings Storage Facility***

The current area in the tailings storage facility for the disposal of contaminated waste and mill lubricant is located on the eastern side of the tailings dam in Cell 2. The location of the waste disposal area and disposal locations is signed on-site. The planned procedure *ENV SOP 0054* explains how the tailings dam waste disposal area is managed.

In early 2005, the putrescible trench facility was relocated from the original 'site refuse facility' (see below) to an area in the south-east of the TSF. This relocation was to minimise the chance of birdstrike for planes landing at the airstrip, caused by the birds being attracted to the regular burn-offs.

The putrescible waste disposal area uses the trench method for disposal of waste. The refuse in the trench is burned once a week for health and safety reasons in accordance with the requirements of the NT Government. The catering contractor is responsible for the day to day collection of waste, however MRM staff are responsible for the maintenance of this area of the TSF.

### **Site Refuse Facility**

The site refuse facility is located approximately 500 m east of the accommodation camp. It was located there for the following reasons:

- The site is located above the 1 in 100-year flood level.
- The site is in a disused borrow pit that does not have a steep slope thereby reducing the risk of soil erosion.
- The site has clay rich soils, which are favourable due to their low permeability.
- The site has suitable all weather road access from the main entrance route from the highway to mine.

Currently there are two main disposal methods employed at the site refuse facility. The trench method and area fill method. Both these waste disposal areas are surrounded by a 2 m high mesh fence to minimise any material being blown out of the waste refuse facility.

The general (packaging, office and garden) waste disposal area uses the area fill method whereby waste is disposed on the existing ground level and then soil is placed over the top. This waste is pushed over the dumping face at fortnightly intervals and then covered with a minimum of 150 mm of soil. The Environmental Superintendent is responsible for the maintenance of this area. Signs identify the appropriate dumping area and clearly define the types of waste allowed to be disposed of (i.e. non-contaminated waste). The planned procedure *ENV SOP 0055* explains the steps associated with maintenance of the general waste disposal area.

### **7.5.4 Off-Site Waste Management**

Currently several waste types are transported off-site for disposal or recycling. Recycling is a key component of waste minimisation which is a concept MRM has committed to in the Mine Management Plan, the MRM Environmental Policy, and the Australian Minerals Industry Code for Environmental Management. Materials that MRM currently sends off-site for recycling or off-site disposals are:

- Aluminium cans
- Scrap steel
- Waste cooking oil
- Waste oil
- Batteries
- Medical waste
- Used printer and facsimile cartridges

All these wastes have relevant procedures for the collection, storage and dispatch. All items except aluminium cans are transported off-site. All material dispatched off-site travels via road transport except medical waste. Medical waste is transported via air to Darwin. Aluminium cans are either transported to

Borrooloola by the environment section or picked up by a representative from the Borrooloola Community Government Council. MRM has operating procedures that apply to the storage and transport of each of these waste types.

### 7.5.5 Asbestos

Removing and disposing of building waste containing asbestos fibres is required at MRM for some old offices and houses.

Building material from the mining camp has been sampled and positively identified as containing asbestos fibres. Further investigation into the extent of asbestos material found in the camp will be conducted prior to any future renovations.

Risks identified are adequately controlled by the implementation of the procedural requirements of the Asbestos Code of Practice Safe Removal of Asbestos (NOHSC, 2002 [1988]).

To dispose of the asbestos, the material is sealed, double bagged and clearly labelled. The sealed, industrial strength plastic bags are disposed in a 2 m deep pit and backfilled at a specially designated area at the site refuse facility. The area is signed and an asbestos disposal register is maintained. Site access is restricted and an adjacent pit at the same location will be used if more asbestos containing waste requires disposal.

Two campaigns of asbestos disposal were undertaken in 2002/2003, with pits dug and covered appropriately on each occasion.

## 7.6 Construction Wastes

The major solid waste streams likely to be generated during construction activities are as follows:

- Trees and other vegetation from initial clearing of the site;
- Soil and fill from excavation works for foundations;
- Timber from concrete formwork, boarding and associated waste;
- Scrap steel and offcuts, including weldmesh, conduit, pipework, nuts, bolts, concrete reinforcing rods, etc.;
- Concrete, plaster board and cement sheeting;
- Insulation materials;
- Plastics from conduit and pipework; and
- Miscellaneous wastes from a range of construction activities including:
  - General office refuse, paper, food scraps, food containers and wrappings;
  - Packaging materials from equipment, material, stores and spare parts;
  - Residues from painting, lubricating fluids and fuels for machinery.

Where possible, these wastes will be segregated to maximise potential re-use and recycling opportunities. It is expected that at least 10% of construction materials can be recycled.

The following are examples of how materials, identified as construction wastes, have potential for reuse or recycling:

- Where possible, tree wastes from site clearing will be chipped and stockpiled for future use on site landscaping and rehabilitation areas;
- Soil from excavation work will be stripped in layers, stockpiled and reused for contouring, landscaping and rehabilitation; and
- Recyclable building wastes will be collected separately and re-used or recycled, for example:
  - Timber from concrete formwork will be recovered and reused;
  - Scrap steel and offcuts will be recycled;
  - Plastics will be recycled; and
  - Oils will be collected and sent for recycling.

Details of the construction phase waste management plan are given in Section 21.3.1.

## 7.7 Risk Assessment

The assessment of all risk posed by the storage, transport and disposal of waste is a key component in the process of improving waste management at MRM. All waste management practices are assessed annually on their potential environmental risk.

In order to assess the environmental risk of each activity, it is necessary to identify the likelihood and the consequences of the storage, transport and/or disposal of each waste stream. Once the likelihood and consequences have been calculated, the risk of each activity can be ranked using the MRM risk ranking matrix (*MRM SOP 0026D*).

While assessing risk of waste management practices, all control strategies are taken into account. These control strategies reduce either the likelihood or the potential consequence of the risk. Control strategies may include implementation of procedures, adherence to guidelines, standards, legislation, routine maintenance, monitoring, and long-term mine planning.

The largest environmental risk associated with existing waste management practices is the disposal of tailings. This practice has resulted in the seepage of water with high concentrations of sulfates into the surrounding groundwater. This risk has been identified and current works are on going to remedy this impact. Management of this risk has been incorporated into the design of the tailings storage facility for the open cut operations (Section 7.4).

Disposal of waste rock from the current mining operations is not a high risk operation as the material remains underground. However, as the mine changes from underground to open cut mining, waste rock from the open cut mine will be stored on the surface. The geochemical nature of the waste rock is such

that there is a risk of acidic runoff being generated from the waste rock storage facility. To minimise this risk, the management measures discussed in Section 7.2 will be implemented.

All other risks associated with waste management have been ranked as low in the MRM risk ranking matrix. These risks are unlikely to cause environmental harm. Nevertheless some actions have been identified to further reduce the risk posed by these waste management practices. They mainly consist of the development and implementation of additional storage and transportation procedures and the construction of bunded areas for the storage of hazardous substances (i.e. hydrocarbons).