NEW HOPE GROUP PTY LTD

OAKLEIGH COAL MINE

Tailings Dam 1
Capping Options Study

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7. Geotechnical site investigation necessarily involves the investigation of the subsurface conditions at a site at a few isolated locations, and the interpretation and extrapolation of those conditions to elsewhere on the site not so investigated. This procedure has been adopted at the site that is the subject of this report and due care and skill has been applied in carrying out and reporting on the work. Thus the findings, conclusions and comments contained in this report represent professional estimates and opinions and are not to be read as facts unless the context makes it clear to the contrary. In general, statements of fact are confined to statements as to what was done and/or what was observed. Other statements have been based on professional judgement.

8. The scope of the work has been planned in the absence of any fore-knowledge of the site other than that stated in the report. Unless otherwise stated we consider that the number of locations investigated and the depths to which they have been investigated are reasonable bearing in mind the scale and nature of the project, and the defined purpose for which the investigation was undertaken.

9. We do not accept any responsibility for any variance between the interpreted and extrapolated conditions and those that are revealed by any means subsequently. Specific warning is also given that many factors, either natural or artificial, may render ground conditions different from those which pertained at the time of the investigation. Should there be revealed during the construction or at any other time any apparent difference from subsurface conditions described or assessed in this report, it is strongly recommended that such differences be brought to our attention so that its significance may be assessed and appropriate advice given.

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1 INTRODUCTION

1.1 Background

New Hope Group (NHG) has ceased operation at its Oakleigh Coal Mine, located north of Rosewood, 20km west of Ipswich in Queensland. As part of the Oakleigh operation, a tailings dam (referred to as Tailings Dam 1) was developed, sited within the former North Pit, on the eastern side of the Rosewood – Marburg Road.

Aerial photography for the site dating between 2009 and 2012 indicates that the exposed tailings beach within Tailings Dam 1 measures some 150m x 250m, sloping from west to east, with a decant/water pond formed on the eastern margin of the deposit. No tailings have been deposited since 2004; therefore, drying and consolidation of the beach is expected to have occurred. It is acknowledged that the extent of the beach may be greater than that currently observed, although 2003 photography shows deposition occurring from the western end of the storage, and over a similar footprint as shown in the later years. For the purpose of assessment of Tailings Dam 1, a total tailings surface area of some 4ha has been adopted.

It is understood that NHG is planning rehabilitation works for the Oakleigh site, and as part of future closure works, capping of Tailings Dam 1 will be undertaken. It is understood that the capping layer will primarily provide access across the exposed tailings surface, existing as a platform for rehabilitation works including final landform development and shaping (using mine spoil as fill), topsoil placement and revegetation.

To assist with rehabilitation planning, an options assessment for capping of Tailings Dam 1 is required. NHG has commissioned ATC Williams Pty Ltd (ATCW) to undertake this options assessment.

1.2 Study Scope and Approach

The scope of the Capping Options Study for Tailings Dam 1 is to identify an efficient and operationally effective strategy for capping of this storage, with a general objective being that this strategy will need to safeguard capping construction works, targeting critical loading conditions, comprising dead load and vehicle surcharge, based on the following scope of work:

- Conduct a site visit to confirm current conditions around the tailings dam and to recover samples of potential capping material for geotechnical analysis.
- Undertake a series of shear vane tests on the tailings crust around the facility sufficient to understand the insitu geotechnical properties of placed tailings within the tailings dam.
- Undertake a desktop study to evaluate options for safely capping the tailings dam, on the basis that the capping layer will support construction traffic associated with capping construction and additional fill placed to form a final rehabilitated landform.
- Prepare a report with the findings of the analysis and appropriate recommendations for a preferred capping approach.

1.3 Report Structure

The structure of the Capping Options Study report based on the scope and approach as described in **Section 1.2** is as follows:

Section 2.0: Provides a brief description of the Oakleigh Coal Mine project, including a brief history of the Tailings Dam 1.

Section 3.0: Identifies and justifies the capping options available for the Tailings Dam 1, and outlines the development works required for each option.

Section 4.0: Summarises geotechnical analyses completed in relation to the capping options, comprising geotechnical stability analyses and moisture infiltration estimates.

Section 5.0: Provides an assessment for all options with an overview/summary of the comparison between the options.

2 CHARACTERISATION OF SITE CONDITIONS

2.1 Description and History of Mine and Tailings Dam 1

As background to the capping options study for Tailing Dam 1, the development history for the tailings dam has been reviewed through discussions with NHG personnel, available technical reporting and related survey data provided by NHG.

Tailings Dam 1 is sited within the former North Pit (situated within the north eastern portion of the mining lease) and is located on the eastern side of the Rosewood-Marburg Road. The main pit associated with the project is located south west of Tailings Dam 1 across Rosewood-Marburg Road. The location of the storage within the site is shown on **Plate 1**.

Figure 1 shows the general layout of the tailings dam area.

Plate 1
General Location of Tailings Dam 1

Tailings Dam 1 was utilised for storage of tailings produced from the Oakleigh operation. The storage was formed within the completed North Pit. The deposition of tailings into Tailings Dam 1 was generally from the western edge of the storage via a single point discharge, forming a beach sloping towards the east, where a decant pond formed. It is understood that tailings deposition into the dam was completed around 2004.

NHG indicates that the base of the Tailings Dam 1 storage at its lowest point is around RL97.0m. With a current tailings beach level of RL147.0m (refer **Figure 1**), a maximum tailings thickness within the dam of approximately 50m exists. The level of the water at the decant pond (at the time of survey shown on **Figure 1**) is at RL 146.8m. The total volume of water estimated within the decant pond based on this level is some of 300ML.

The general condition of the tailings beach and decant pond within Tailings Dam 1 as at May 2014 is shown as **Plate 2**.

Plate 2
Tailings beaches (view towards north)

Decant Pond (view towards east)

Since decommissioning, NHG has indicated that a small depth of water within the decant pond has remained, and is recharged through rainfall. No spillway is currently in place, with any spillage/overflow of water from the decant area being directed into an adjacent water pond to the south (refer Figure 1). This pond is formed over a mine spoil area that was formed by backfilling within the southern portion of the North Pit. This area was isolated from the Tailings Dam 1 by a dividing wall constructed in an east-west direction.

2.2 Geotechnical Investigation

A geotechnical investigation was carried out by a Geotechnical Engineer from ATCW within the Oakleigh mine site on 8 May 2014. The investigation comprised two components as follows:

Part 1 - Investigation within Tailings Dam 1 to assess the strength profile within the deposited tailings beach.

Part 2 - Sampling and laboratory testing to characterise available site material for use in capping construction

The scope and results of these works are summarised in the following sections:

2.2.1 Tailings Beach Investigation

A vane shear test is an in-situ test which is one of the most commonly used methods for measuring the in-situ undrained shear strength of fine grained soils/tailings. The testwork for Tailings Dam 1 at Oakleigh Coal Mine was carried out using a hand-held GEONOR vane (Vane Tester H-60). The GEONOR H-60 consists of three exchangeable vanes, extended by 0.5m rods. The instrument covers three ranges of measurements, 0-50, 0-100, 0-200 kpa, depending on the size of vane used: 16x32 mm, 20x40 mm or 25.4x50.8 mm. The peak value is determined by means of the scale-ring, which has to be turned back to zero position before each measurement.

Vane shear testing is used to measure both peak and residual undrained shear strength. The test involves gently pushing a four-bladed vane into the undisturbed profile and slowing rotating it from the surface to determine the torsional force required to cause a cylindrical surface to be sheared by the vane; this force is then converted to a unit shearing resistance of the cylindrical surface. The friction of the rod is also measured using a blank stem (smooth rod with no blades) with the friction value subtracted from the vane shear strength to obtain the peak strength. Once the peak strength is obtained, the remoulded shear strength is then obtained by turning the vane (in the same position) about 10 to 20 times (NZ Geotechnical Society, 2001).

Hand augering within the tailings beach was undertaken at 0.5m intervals to facilitate vane shear testing. Sampling of tailings removed by augering was also undertaken for visual classification purposes.

The tailings beach investigation comprised a total of nine (9) vane shear tests over the existing tailings beaches, with tests extending to maximum depths of 2m, with readings of both the peak and residual shear strength obtained at 0.5m, 1.0m, 1.5m and 2.0m below ground level. Vane shear test locations are shown on **Figure 1**, with these locations concentrated around the central portion (Zone 2) of the tailings beach area, as near as possible to the decant pond edge.

Plate 3 shows the shear vane testwork carried out within the tailings beach.

Plate 3
Tailings Beach Strength Testing – Shear Vane Test

Graphed results from this testwork in the form of peak and residual shear strength are presented as **Appendix A.** These results have been used to develop a "characteristic" shear strength profile for the tailings beach as shown in **Plate 4**.

Plate 4
"Characteristic" Tailings Dam Beach Strength Profile

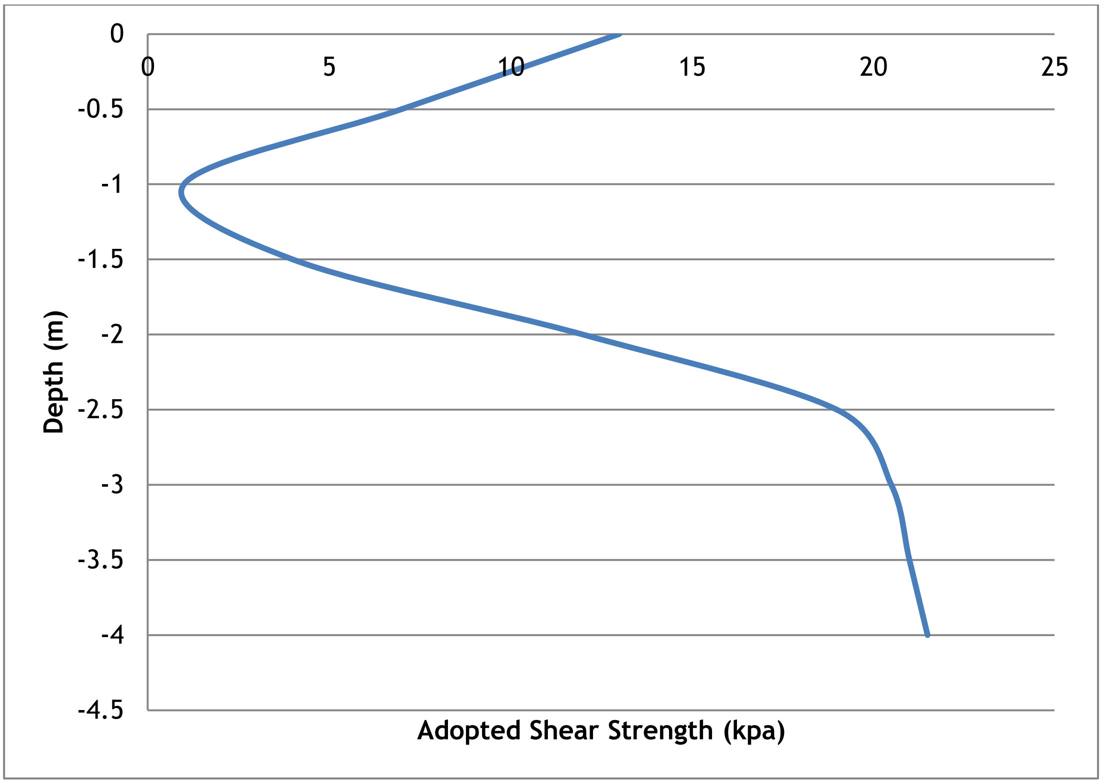


Plate 4 can be described as follows:

- Crust Zone:
  A surface crust can be observed, which has formed due to evaporation/desiccation. Vane shear results vary from 13kpa on the surface to approximately 7kpa at 0.5m.
- Tailings Mass
  Tailings directly below the crust (typically at 0.5m depth) is of low strength and in some of the test locations, the shear strength was not measurable with the equipment. A nominal shear strength of 1kpa at 1.0m has been adopted. Below this level, an increase in shear strength with depth occurs. From 0.5m to 2.5m depth, shear strength typically increased from 1kPa to 19kPa. Below a depth of 2.5m, it is expected that tailings strength becomes consistent, with no significant further strength increase. This condition has been conservatively adopted.

General interpretation of these test results in relation to observed site conditions would indicate that:

- **Plate 4** would be typical of conditions existing within the central portion of the tailings beach area (Zone 2), within the area where testing has occurred.
- Further to the west, towards the area of deposition (Zone 1), it is expected that higher beach strengths would exist, possibly of the order of the following:
  - Crust zone varying from 20kPa at the surface and 15kPa at 0.5m
  - Tailings mass increasing from 15kPa at 0.5m to 30kPa below 2.5m depth.
- Within the decant pond (Zone 3), it is expected that no crust zone will exist (while the pond exists or immediately following dewatering), with the following conditions assumed:

- Shear strength less than 1kPa to 0.5m
- Tailings mass increasing from 1kPa at 0.5m to 15kPa below 2.5m depth.

These characteristics of the tailings beach profile have been adopted for the purpose of this study.

2.2.2 Capping Construction Materials Investigation

Earthen fill materials available within the Oakleigh Coal Mine site and available for capping construction works include the following:

- Mine Spoil derived from the open cut mining operation, as overburden and interburden material.
- Coarse Reject derived from the coal handling and preparation plant (CHPP) during operation of the mine and typically co-disposed within spoil stockpiles.

These material sources were identified by NHG.

Bulk samples from the Mine Spoil stockpile located at the western side of the Tailings Dam 1 (refer **Figure 1**) and from the Coarse Reject stockpile located at the northern end of the main pit (across Rosewood-Marburg Road) were recovered as part of the geotechnical investigation. Three (3) samples of mine spoil and one sample of coarse reject were submitted to the NATA registered laboratory of Trilab, with testing undertaken in relation to the following test suite.

Test Procedure	Test Method
Atterberg Limits	
Liquid Limit	1289.3.1.1
Plastic Limit	1289.3.2.1
Plasticity Index	1289.3.3.1
Linear Shrinkage	1289.3.4.1
Moisture Content	1289.2.1.1
Emerson Class Number	1289.3.8.1
Particle Size Distribution	1289.3.6.1
Standard Compaction	1289.5.1.1
Coefficient of Permeability	1289.6.7.2

A summary of testwork results, and a geotechnical interpretation in terms of suitability for use as capping material is provided below:

2.2.2.1 Mine Spoil

Results of laboratory testing on mine spoil material recovered from a stockpile at the western side of the Tailings Dam 1 are presented in **Table 1** below:

Table 1
Results from laboratory testwork on mine Spoil/spoil

Test	unit	TP01	TP02	TP03
Material Description		CLAY with trace of Gravel	Clayey GRAVEL with Sand	Clayey GRAVEL with Sand
Atterberg Limits				
Liquid Limit	%	87	56	55
Plastic Limit	%	29	29	30
Plasticity Index	%	58	27	25
Linear Shrinkage	%	22	11.5	11.5
Moisture Content	%	15.2	12.1	9.6
Emerson Class				
Emerson Class Number		1	5	5
Particle Size Distribution (PSD)				
Passing 2.36mm	%	90	69	46
Passing 0.425mm	%	89	49	34
Passing 0.075mm	%	86	38	26
Standard Compaction				
Maximum Dry Density	t/m^3		1.46	
Optimum Moisture Content	%		22.7	
Permeability				
Coefficient of Permeability	m/s		4.5×10^{-10}	

Based on these test results, Mine Spoil material can be classified typically as ranging from CLAY with trace of Gravel (highly weathered spoil) to Clayey GRAVEL (less weathered Spoil), although with significant proportions of silt and clay. Site observations indicate that these materials are generally clay dominant, in either in situ or recompacted conditions. Test results indicate that low compacted permeability is achievable. In general, it is considered, based on these conditions, that select materials from within the site could achieve the following characteristics, being targeted for use in capping construction:

- able to create a fill layer that will achieve a low voids and geotechnically competent horizon and is geotechnically stable (i.e. not subject to significant vertical settlement under load based on the method of construction).
- possesses low permeability under controlled placement and compaction conditions.
- non-dispersive to the extent that soil-loss potential is low enough to avoid deep erosion gullying subject to a single storm event, in excess of 10 year ARI.

For the purpose of this study assessment, the following geotechnical properties for mine spoil have been assessed based on laboratory testwork:

Compacted Bulk Density	1.8 to 2.0 t/m^3		
Undrained Cohesion	5 to 10kPa	}	Partially Saturated Condition
Undrained Friction Angle	15 to 25 degrees		
Effective Friction Angle	28 to 35 degrees		
Permeability	10^{-8} to 10^{-10}m/s		

2.2.2.2 Coarse Rejects

Results of laboratory testing on coarse reject recovered from a stockpile to the north of the Wash Plant Dam are presented in **Table 2** below:

Table 2
Results from Laboratory Testwork on Coarse Reject

Test	TP04
Material Description	Clayey GRAVEL with Sand
Atterberg Limits	
Liquid Limit	48%
Plastic Limit	25%
Plasticity Index	23%
Linear Shrinkage	8.5%
Moisture Content	11.4%
Emerson Class	
Emerson Class Number	6
Particle Size Distribution (PSD)	
Passing 2.36mm	40%
Passing 0.425mm	29%
Passing 0.075mm	20%

These results indicate that the material possesses a maximum particle size of some 37.5mm, and a fines (-0.075mm) fraction of some 20%. It can be expected that a portion of these fines is fine silt and clay size (less than 0.01mm). Based on these conditions, and on further advice from NHG with respect to mining and processing conditions:

- The coarse reject can be classified as a fine to coarse grained SILTY/CLAYEY or SANDY GRAVEL.
- The constituents of the reject would comprise sandstone/siltstone fragments and reject coal, therefore a specific gravity (SG) of around 2.0 t/m^3 could be expected.
- The fines fraction will influence the permeability of the material, with permeability values between 10^{-5} and 10^{-7}m/s likely to exist, being in the moderate permeability range.
- Due also to the fines fraction, it is expected that the material would "bind" well, therefore would likely support construction traffic and achieve reasonable levels of compaction.

In summary, the behaviour that would be sought with the use of coarse reject, particularly being placed on a low strength tailings subgrade, would be to achieve a trafficable horizon by small construction plant, at relatively low thickness, and would allow upward drainage of tailings water into the material without loss of integrity, thereby eliminating high excess pore pressures. For the purpose of this study, the following geotechnical properties for coarse reject have been adopted:

Compacted Bulk Density	1.3 to 1.5 t/m^3
Effective Cohesion	0 kPa
Effective Friction Angle	22 to 28 degrees
Permeability	10^{-5} to 10^{-7}m/s

3 DESCRIPTION OF CAPPING OPTIONS

As outlined in **Section 1.2**, the key objective of this assessment is to identify options for safely capping Tailings Dam 1, on the basis that the capping layer will support construction traffic associated with capping construction and additional fill placed to form a final rehabilitated landform. The specific criteria for design of a capping layer to achieve this outcome are as follows:

(a) Creates a stable landform capable of supporting construction plant;
(b) Minimises the likelihood of any erosion occurring to either the final cover system, dumped soil material or deposited material.

It is recognised that to achieve these requirements, the adopted capping profile will include:

- A competent subgrade over which construction works can occur. Depending on existing tailings beach conditions, subgrade stabilisation works may be necessary, which may include any or a combination of the following:

  (i) Geosynthetic (geotextile and/or geogrid) layer
  (ii) Coarse reject

- An earthen capping layer (to achieve infiltration and erodability criteria)

Based on these aspects, a range of generic options for tailings surface capping have been identified and are listed as follows:

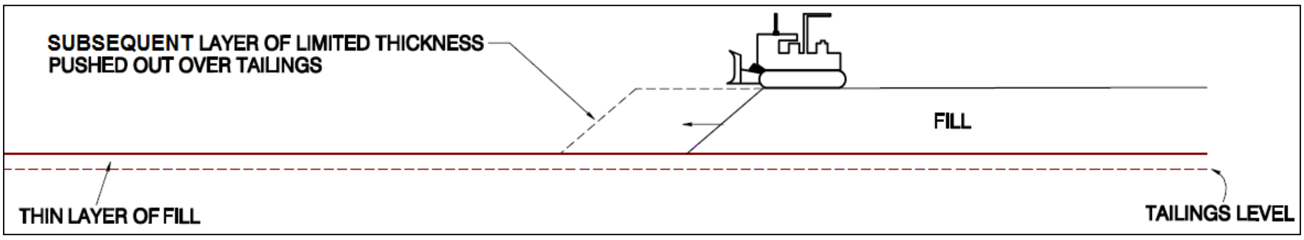
- Option 1: Direct Mine Spoil Placement (over existing tailings beach)
- Option 2: Geosynthetic Reinforcement (over existing tailings beach) overlain by Mine Spoil Capping
- Option 3: Coarse Rejects (or similar) Bridging Layer overlain by Mine Spoil Placement
- Option 4: Coarse Rejects (or similar) Bridging Layer, followed by Geosynthetic Reinforcement overlain by Mine Spoil

A description of each capping option is provided in the following sections.

3.1 Option 1: Direct Mine Spoil Placement

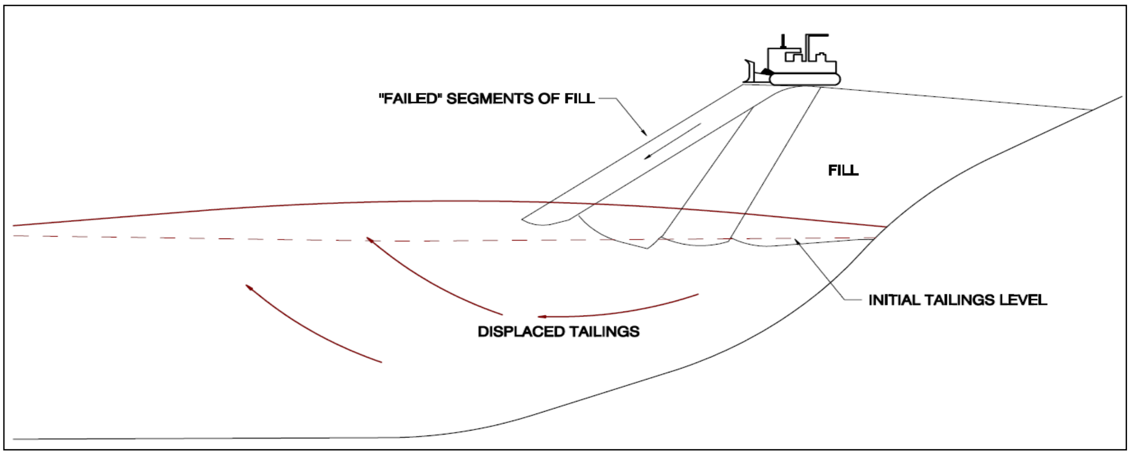
This option allows the placement of a relatively thin layer of Mine Spoil directly across the existing tailings beach using light equipment. This condition is shown on **Plate 5**.

Plate 5
Direct Mine Spoil Placement



In situations where the tailings strength is not able to support direct Mine Spoil placement, displacement of tailings can occur that is caused by the external force imposed by the fill creating “mud-waves” (refer **Plate 6**), which impedes capping works, and a potential loss of capping material into the tailings beach.

Plate 6
Mud-Wave Development on Capping Layer Placement

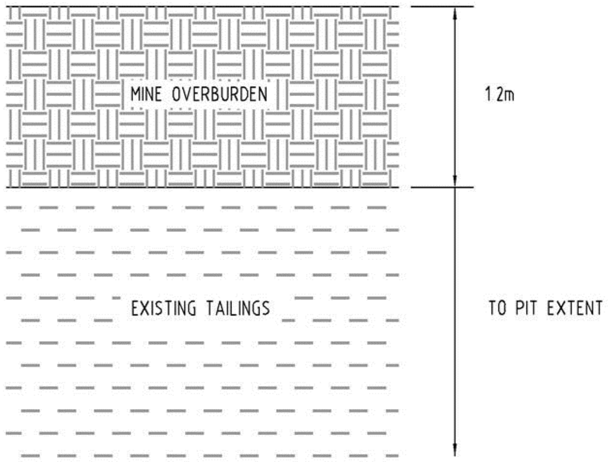


The key to success with this option is to minimise the thickness of Mine Spoil placement, as a balance between the mass of Spoil against the residual strength of the underlying tailings beach (It is noted that the fill thicknesses indicated in **Plates 5** and **6** are exaggerated.) Although this method has been broadly used, several shortcomings have been experienced, which relates to the low and variable strength of tailings, as follows:

- Safety risk of personnel and machinery while undertaking capping operations;
- Unpredictable fill quantities due to unexpectable displacements;
- Unknown duration to complete capping operations; and
- Difficulty of controlling final landform due to ongoing instability.

For the purpose of this capping options assessment, a maximum thickness of capping of 1.2m has been assumed (accepting that additional layers will be placed subsequently to achieve the overall landform for the area). The adopted capping profile to be considered for Option 1 is shown on **Plate 7**.

Plate 7
Adopted Capping Profile (Option 1)

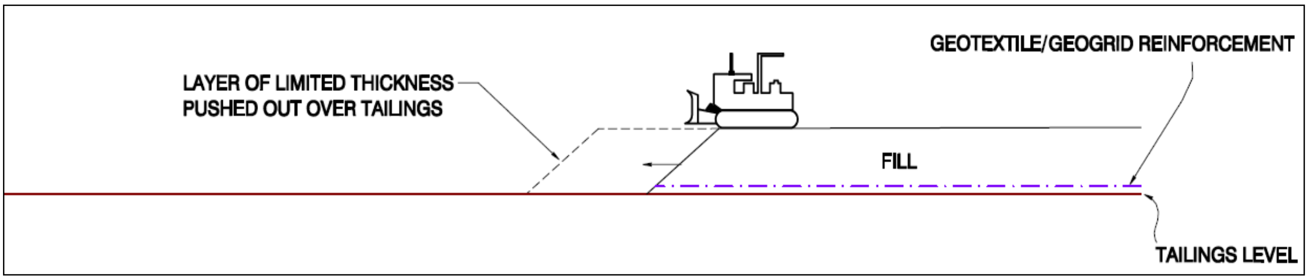


3.2 Option 2: Geosynthetic Reinforcement overlain by Mine Spoil Capping

This option allows the placement of a geosynthetic reinforcement layer (i.e. geogrid/woven geotextile) on the existing tailings surface, followed by placement of Mine Spoil as a capping layer. This condition is shown on **Plate 8** (although noting that the fill thickness indicated is exaggerated). The purpose of the geosynthetic reinforcement is to provide tensile support for placement of the Mine Spoil, as compensation for low and variable strength of the underlying tailings beach. Similar to Option 1, the key to success with this option is to minimise the thickness of Mine Spoil placement, as a balance between the mass of Spoil against the residual strength of the underlying tailings beach, which is enhanced by the geosynthetic. The potential shortcomings with this option are as follows:

- Accessibility for placing the geosynthetic reinforcement layer (with the typical approach being to initiate placement in exposed beach areas where the tailings strength is higher);
- Longer duration for capping construction works;
- Relatively higher capital costs, compared to a successfully implemented Option 1.

Plate 8
Geosynthetic Reinforcement with by Mine Spoil Capping



The procedure for placement of the capping layer under this option is controlled by the direction and the number of geosynthetic layers. A maximum of 2 layers (placed perpendicularly to each other) is typically adopted as a minimum requirement, thus enabling construction trafficking in multiple directions.

Experience indicates that the optimal approach for placement of geosynthetics is as follows:

- Step 1: Placement of first layer of geosynthetic longitudinally;
- Step 2: Rolling of second layer of geosynthetic with 12m spacing perpendicular to the first layer;
- Step 3: Placement of 300mm mine Spoil over the 2nd layer of geosynthetic therefore achieving 12m spaced filling operations (i.e. fingers);
- Step 4: Infill operations, between fingers;
- Step 5: Ongoing filling operations to achieve full earthen capping layer thickness (as described for Option 1 – refer **Section 3.1**).

This construction approach is shown in **Plate 9**.

Plate 9
Procedure for Geosynthetic Reinforcement and Mine Spoil Placement

(a) Steps 1, 2 and 3

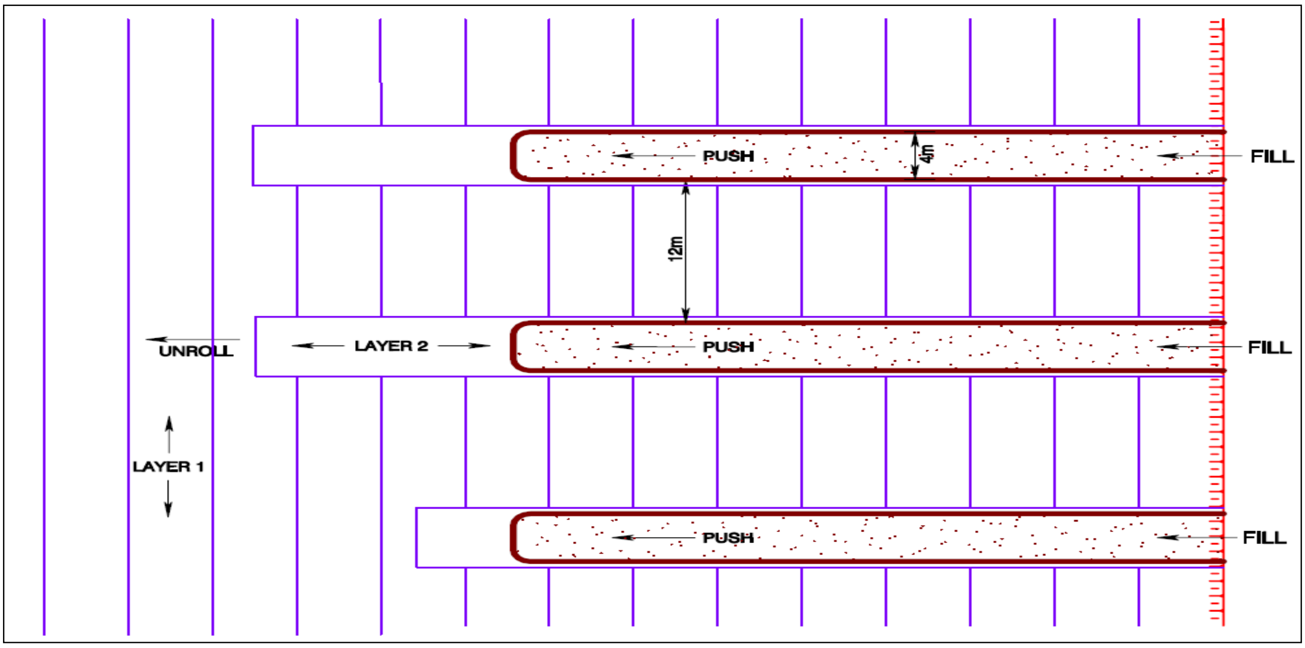
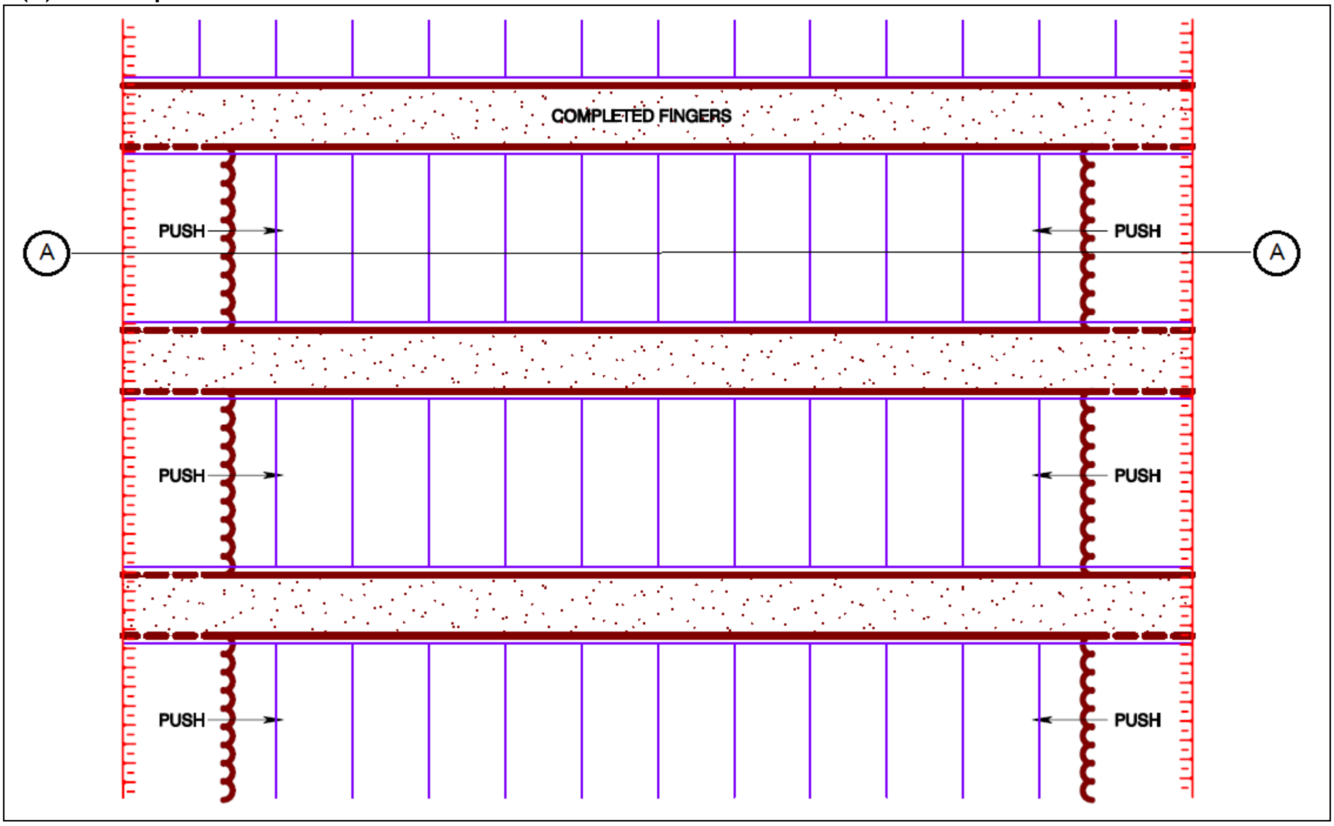


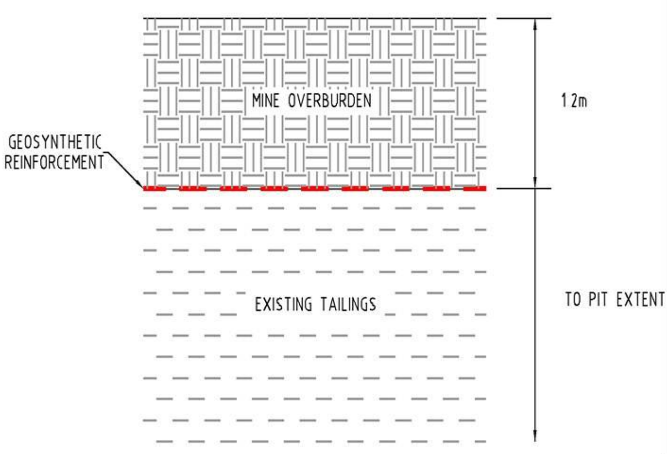
Plate 9
Procedure for Geosynthetic Reinforcement and Mine Spoil Placement (Cont'd)

(b) Step 4



For the purpose of capping options assessment, a maximum thickness of capping material of 1.2m has been assumed (similar to Option 1, and accepting that additional layers will be placed subsequently to achieve the overall landform for the area). The adopted capping profile to be considered for Option 2 is shown on **Plate 10.**

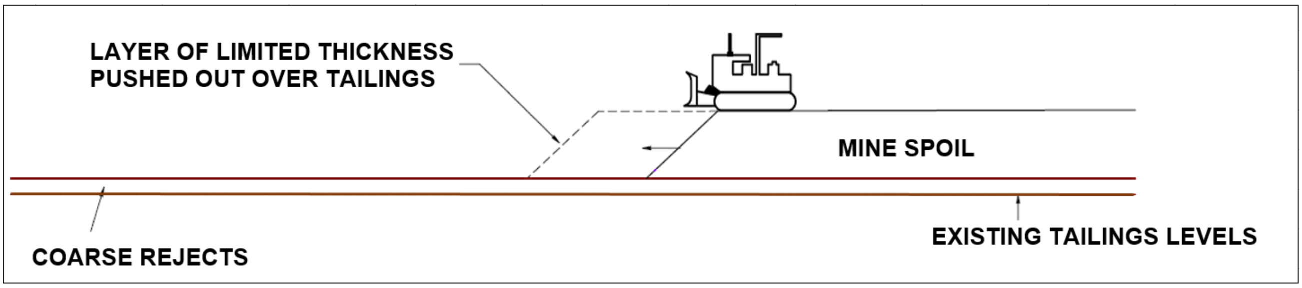
Plate 10
Adopted Capping Profile (Option 2)



3.3 Option 3: Coarse Rejects Bridging Layer overlain by Mine Spoil Capping

This option is similar to Option 2, with geosynthetic reinforcement replaced by Coarse Reject. Across the surface of the tailings, placement of a layer of coarse rejects (similar to Option 3) would occur, followed by placement of the mine spoil as a capping layer. This condition is shown on **Plate 11**.

Plate 11
Placement of Coarse Rejects with Mine Spoil Capping

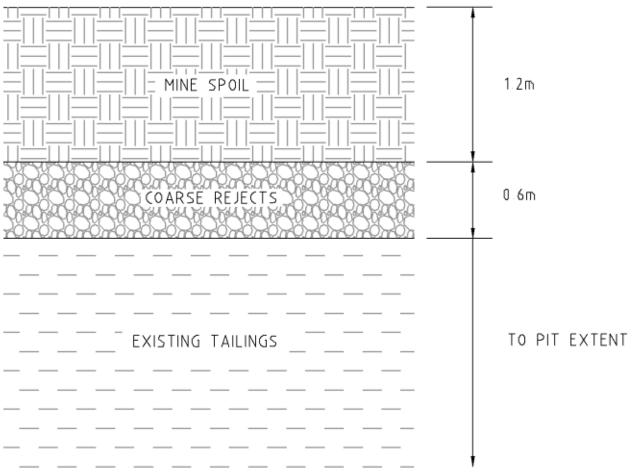


As outlined for Option 1, the key to success with this option is to minimise the thickness of Mine Spoil placement, as a balance between the mass of Spoil against the residual strength of the underlying tailings beach, which is enhanced by the coarse reject. The potential shortcomings with this option are as follows:

- The suitability of the coarse reject to form a bridging layer, relying on sufficient permeability to allow upward drainage of tailings water whilst maintaining a competent profile.
- Accessibility for placing the coarse reject layer, without increasing safety issues while undertaking these works.

For the purpose of capping options assessment, a minimum 0.6m thickness of coarse reject has been assumed (accepting that additional layers will be placed subsequently to achieve the overall landform for the area). The condition as described for Option 3 is shown on **Plate 12**.

Plate 12
Adopted Capping Profile (Option 3)



3.4 Option 4: Coarse Rejects Bridging Layer, followed by Geosynthetic Reinforcement

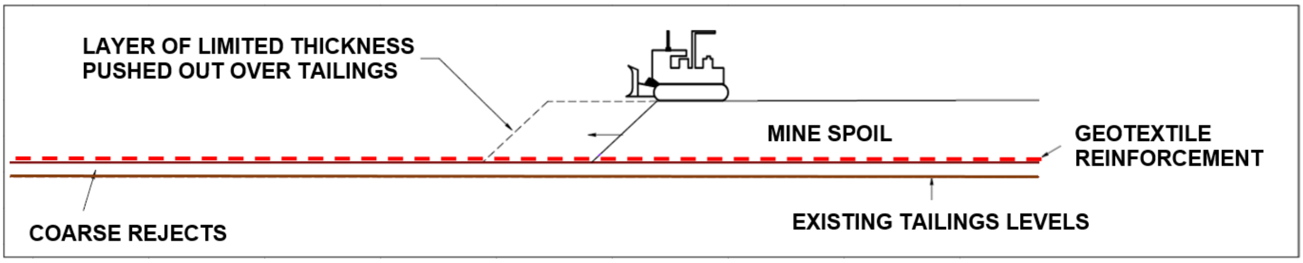
overlain by Mine Spoil Capping

This option would be achieved by placement of a coarse reject layer, overlain by geosynthetic reinforcement and followed by mine spoil placement. Across the surface of the reject, placement of geosynthetic reinforcement (similar to Option 2) would occur, followed by placement of the mine spoil as a capping layer. This condition is shown on **Plate 13**. As outlined for Option 1, the key to success with this option is to minimise the thickness of Mine Spoil placement, as a balance between the mass of Spoil against the residual strength of the underlying tailings beach, which is enhanced by the coarse reject. The potential shortcomings with this option are as follows:

- The suitability of the coarse reject to form a bridging layer, relying on sufficient permeability to allow upward drainage of tailings water whilst maintaining a competent profile.
- Accessibility for placing the coarse reject reinforcement layer, without increasing safety issues while undertaking these works.

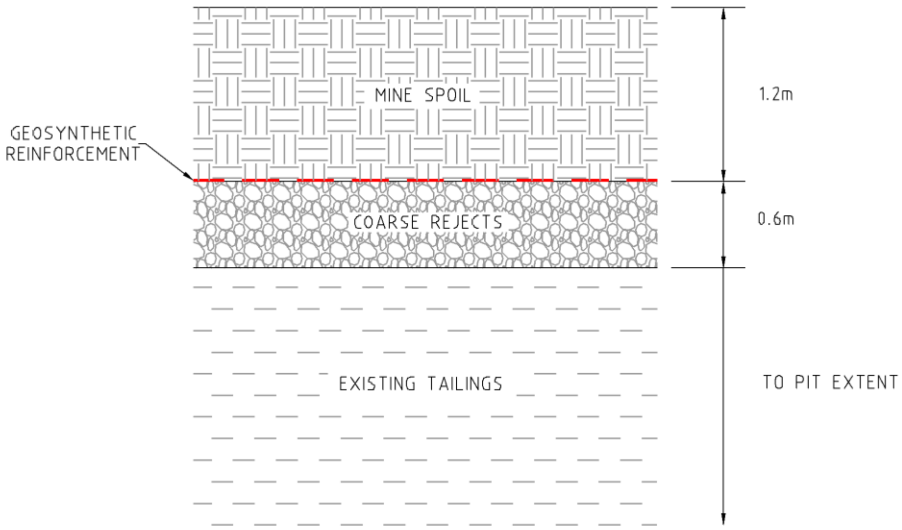
For the purpose of capping options assessment, a minimum 0.6m thickness of coarse reject has been assumed (accepting that additional layers will be placed subsequently to achieve the overall landform for the area). It is also assumed that the surface of the tailings does not possess any residual strength, as described in **Section 2.2.3**. The condition as described above for Option 3 is shown on **Plate 13**.

Plate 13
Coarse rejects bridging layer, followed by geosynthetic reinforcement overlain by mine spoil



The adopted capping profile to be considered for Option 4 is shown on **Plate 14**.

Plate 14
Adopted Capping Profile (Option 4)



4 GEOTECHNICAL ANALYSIS

The principle approach to assess each capping option as identified in **Section 3**, and for the purpose of options comparison, is geotechnical stability modelling, subject to traffic loading as a critical condition. A critical failure surface on the leading edge of capping layer placement is therefore to be expected. For the purpose of these analyses, a minimum factor of safety of 1.0 is to be achieved, which represents a condition of pseudo-equilibrium under the short term traffic loading.

Beyond the above design condition, a general check for long term serviceability subject to placement of a thicker earthen fill capping layer is required to ensure that potential settlements do not compromise overall performance of the capping layer.

Assessment for all options relevant to the Tailings Dam 1, covering stability and serviceability, is provided in the following sections.

4.1 Modelling Scope and Development

A geotechnical stability model in relation to the capping options for Tailings Dam 1 has been developed to assess and compare the geotechnical feasibility of each option. The stability model was developed using SLOPE/W numerical simulation software. The model uses a range of geotechnical parameters to represent the capping layer configuration and the underlying tailings profile. The model generates a series of slip surface iterations to evaluate the surface that provides a critical (minimum) Factor of Safety (FoS).

The objective required for the conditions to be assessed is not to produce a critical FoS of less than 1.0, subject to construction loading. For the purpose of modelling, a circular failure surface was adopted, simulating conditions occurring as described in **Section 3**

4.2 Material Properties

Geotechnical parameters adopted for stability modelling are described in **Section 2.2.1** for the insitu tailings beach and **Section 2.2.2** for available fill materials, with additional support from relevant geotechnical literature and product data for geosynthetics materials. These conditions are summarised in **Table 3**.

Table 3
Adopted Model Parameters

Material	Modelling Approach	Thickness	Tensile Capacity (kN/m)	Bulk Density	Total Stress Parameters		Effective Stress Parameters	
					Cohesion (c_u)	Friction Angle ($ø_u$)	Cohesion (c’)	Friction Angle (ø’)
Tailings Beach								
Insitu Condition (All Options)	Shear strength changing with depth	5m	N/A	$13.5kN/m^3$	13kPa at surface decreases linearly to 1.4kpa at 1m 1.4kpa at 1m increases linearly to 72kpa at 5m	0	N/A	N/A
Fill Materials								
Mine Spoil (All Options)	Mohr-Coulomb	0.6 to 1.2m	N/A	$18kN/m^3$	5kPa	20^o	0kPa	30^o
Coarse Reject (Options 3 and 4)	Mohr-Coulomb	0.6m	N/A	$14kN/m^3$	N/A	N/A	0kPa	25^o
Geosynthetic Reinforcement Material								
Geogrid or Woven Geotextile (Options 2 and 4)	Pull-out Resistance Factor	N/A	100	N/A	N/A	N/A	N/A	N/A

For modelling of capping options containing geosynthetic, a nominal tensile strength of 100kN was applied, based on product literature for commonly utilised geotextile and geogrid materials in similar applications. It is noted that this strength has been adopted as a representative conditions, with the geosynthetic product adopted to be refined in detailed design.

4.3 Modelling Conditions

The stability model has been undertaken applying a localised failure method (i.e. measuring the local effects on tailings beach stability subject to construction loading). As such, a per unit width section of the existing tailings beach has been modelled, with a model length of 50m and an adopted tailings thicknesses of 5m plus the thickness of capping layers.

Construction loads of either 20 tonne (being equivalent to the weight of an operating D6 swamp dozer) or 4.5 tonnes for a Hitachi DX 45 M Dozer (D4 equivalent) have been applied to represent the potential range of construction surcharges. These loads have been converted to equivalent surcharges applied over the 1m unit width for the model. This surcharge was applied at the leading edge of the capping layer, simulating a condition whereby the plant item would be working at this edge, placing fill, pushing fill material for extension of the platform, or fill compaction. A batter slope on the leading edge of 45 degrees has been adopted.

To simulate actual construction conditions, it has been assumed that the maximum thickness of capping material being placed along the leading edge of the fill batter would be 1.2m. The critical condition analysed has therefore been during the first 1.2m thickness of material to be placed.

Given the modelling approach, being to assess stability under construction conditions, total stress parameters were applied. This assumes that the tailings layers would remain saturated with the capping layer existing in a partially saturated condition (subject to moisture conditioning during placement).

4.4 Results from Stability Modelling

The results of the stability analysis are summarised below, with model output representing the critical stability condition being presented. Related analyses undertaken to provide output for additional analyses are provided in **Appendix B**. The scope and results of these sensitivity analyses are also presented in the following sections.

4.4.1 Option 1: Direct Mine Spoil Placement

Model output for the critical stability condition for Option 1, as described in **Section 3.1**, is presented in **Table 4**. Based on the adopted geotechnical parameters as outlined in **Section 4.2** and a maximum capping layer thickness at the leading edge of 1.2m, the calculated critical FoS is 0.4, which is less than the adopted critical/minimum FoS of 1.0. This condition is therefore considered to be geotechnically unstable, under a construction surcharge of 20 tonnes.

Model output for sensitivity analysis for Option 1 - Case 1a, shows that by reducing the Mine Spoil layer thickness from 1.2m to 0.6m, the FoS will increase to 0.6; however, this condition is still considered to be geotechnically unstable. Sensitivity analysis for Option 1 - Case 1b then shows that by using smaller plant (i.e. 4.5 tonnes Hitachi DX 45 M Dozer) the FoS will increase to 1.2, which is considered to be geotechnically stable. This suggests that direct placement of Mine Spoil over the existing tailings beaches would be feasible, only by placement of thin layers (i.e. 0.6m) of this material using a 4.5 tonnes dozer.

Table 4
Model output for the critical stability condition for Option 1

No.	Model Condition	Mine Spoil Thickness (m)	Construction Surcharge (tonnes)	FoS
1	Direct Placement of 1.2m thick Mine Spoil using 20 tonnes D6 Dozer	1.2	20	<u>0.4</u>
1a	Direct Placement of 0.6m thick Mine Spoil using 20 tonnes D6 Dozer	0.6	20	<u>0.6</u>
1b	Direct Placement of 0.6m thick Mine Spoil using 4.5 tonnes Hitachi DX 45 M Dozer	0.6	4.5	<u>1.0</u>

4.4.2 Option 2: Geosynthetic Reinforcement overlain by Mine Spoil Capping

Model output for the critical stability condition for Option 2, as described in **Section 3.2**, is presented in **Table 5**. Based on the adopted geotechnical parameters as outlined in **Section 4.2** and a maximum capping layer thickness at the leading edge of 1.2m, the calculated critical FoS is 0.6, which is less than the adopted critical/minimum FoS of 1.0. This condition is therefore considered to be geotechnically unstable, under a construction surcharge of 20 tonnes.

Model output for sensitivity analysis for Option 2 - Case 2a, shows that by reducing the Mine Spoil layer thickness from 1.2m to 0.6m, the FoS will increase to 0.8; however, this condition is still considered to be geotechnically unstable. Sensitivity analysis for Option 2 - Case 2b then shows that by using small plant (i.e. 4.5 tonnes Hitachi DX 45 M Dozer) the FoS will increase to 1.5, which considered to be geotechnically stable. This suggests that placement of Mine Spoil over the geosynthetic reinforcement would be feasible, only by placement of thin layers (i.e. 0.6m) of this material using a 4.5 tonnes dozer.

Table 5
Model output for the critical stability condition for Option 2

No.	Model Condition	Mine Spoil Thickness (m)	Construction Surcharge (tonnes)	FoS
2	Geosynthetic Reinforcement overlain by 1.2m of Mine Spoil Capping using 20 tonnes D6 Dozer	1.2	20	<u>0.6</u>
2a	Geosynthetic Reinforcement overlain by 0.6m of Mine Spoil Capping using 20 tonnes D6 Dozer	0.6	20	<u>0.8</u>
2b	Geosynthetic Reinforcement overlain by 0.6m of Mine Spoil Capping using 4.5 tonnes Hitachi DX 45 M Dozer	0.6	4.5	<u>1.5</u>

4.4.3 Option 3: Coarse Rejects Bridging Layer overlain by Mine Spoil Capping

For Option 3, as described in **Section 3.3**, two stages were modelled; the first stage for placement of the Coarse Rejects layer (nominally 0.6m thickness) over the existing tailings beach, and the second stage for placement of the Mine Spoil capping of an additional 1.2m thickness over the Coarse Rejects layer to provide an overall capping layer. Details of modelling in relation to these two stages, with the model output are provided in **Table 6**.

Based on the adopted geotechnical parameters as outlined in **Section 4.2**, the following results can be obtained from the modelling:

- Stage 1 - Placement of the Coarse Rejects Layer

  For a maximum coarse rejects layer thickness at the leading edge of 0.6m, using a 20 tonnes D6 dozer, the calculated critical FoS is 0.6, which is less than the adopted critical/minimum FoS of 1.0. This condition is therefore considered to be geotechnically unstable, under a construction surcharge of 20 tonnes.

Model output for sensitivity analysis for Option 3 – Stage 1a, shows that by using a small plant (i.e. 4.5 tonnes Hitachi DX 45 M Dozer) the FoS will increase to 1.5, which considered to be geotechnically stable. This suggests that placement of coarse rejects layer over the tailings beaches would be feasible, only by placement of thin layers (i.e. 0.6m) of this material using a 4.5 tonnes dozer.

- Stage 2 - Placement of the Mine Spoil Capping

  Model output for the critical stability condition for Option 3 – Stage 2, is also presented in **Table 6**. Based on the adopted geotechnical parameters as outlined in **Section 4.2** and a maximum capping layer thickness at the leading edge of 1.2m, the calculated critical FoS is 0.7, which is less than the adopted critical/minimum FoS of 1.0. This condition is therefore considered to be geotechnically unstable, under a construction surcharge of 20 tonnes.

  Model output for sensitivity analysis for Option 3 - Stage 2a, shows that by reducing the Mine Spoil layer thickness from 1.2m to 0.6m, the FoS will increase to 0.8; however, this condition remains geotechnically unstable. Sensitivity analysis for Option 3 - Stage 2b shows that by using small plant (i.e. 4.5 tonnes Hitachi DX 45 M Dozer) the FoS will increase to 1.2, which considered to be geotechnically stable. This suggests that placement of Mine Spoil over the coarse rejects layer would be feasible, only by placement of thin layers (i.e. 0.6m) of this material using a 4.5 tonnes dozer.

Table 6
Model output for the critical stability condition for Option 3

No.	Model Condition	Mine Spoil Thickness (m)	Construction Surcharge (tonnes)	Coarse Rejects Layer Thickness (m)	FoS
3-Stage 1	Placement of 0.6m Coarse Rejects Layer, using 20 tonnes D6 Dozer	-	20	0.6	<u>0.6</u>
3-Stage 1a	Placement of 0.6m Coarse Rejects Layer, using 4.5 tonnes Hitachi DX 45 M Dozer	-	4.5	0.6	<u>1.5</u>
3-Stage 2	Placement of 0.6m Coarse Rejects Layer, overlain by 1.2m Mine Spoil Capping using 20 tonnes D6 Dozer	1.2	20	0.6	<u>0.7</u>
3-Stage 2a	Placement of 0.6m Coarse Rejects Layer, overlain by 0.6m Mine Spoil Capping using 20 tonnes D6 Dozer	0.6	20	0.6	<u>0.8</u>
3-Stage 2b	Placement of 0.6m Coarse Rejects Layer, overlain by 0.6m Mine Spoil Capping using 4.5 tonnes Hitachi DX 45 M Dozer	0.6	4.5	0.6	<u>1.2</u>

4.4.4 Option 4: Coarse Rejects Bridging Layer, followed by Geosynthetic Reinforcement overlain by Mine Spoil Capping

For Option 4, as described in **Section 3.4**, two stages were modelled; the first stage for placement of the Coarse Rejects layer (nominally 0.6m thickness) over the existing tailings beaches, and the second stage for placement of the Mine Spoil capping of an additional 1.2m thickness to provide an overall capping layer over the geosynthetic reinforcement. Details of modelling in relation to these two stages, with the model output are provided in **Table 7**.

Based on the adopted geotechnical parameters as outlined in **Section 4.2**, the following results can be obtained from the modelling:

- Stage 1 - Placement of the Coarse Rejects Layer

  For a maximum coarse rejects layer thickness at the leading edge of 0.6m, using a 20 tonnes D6 dozer, the calculated critical FoS is 0.6, which is less than the adopted critical/minimum FoS of 1.0. This condition is therefore considered to be geotechnically unstable, under a construction surcharge of 20 tonnes.

  Model output for sensitivity analysis for Option 3 – Stage 1a, shows that by using a small plant (i.e. 4.5 tonnes Hitachi DX 45 M Dozer) the FoS will increase to 1.5, which considered to be geotechnically stable. This suggests that placement of coarse rejects layer over the tailings beaches would be feasible, only by placement of thin layers (i.e. 0.6m) of this material using a 4.5 tonnes dozer.

- Stage 2 - Placement of the Mine Spoil Capping

  Model output for the critical stability condition for Option 4 – Stage 2, is also presented in **Table 7**. Based on the adopted geotechnical parameters as outlined in **Section 4.2** and a maximum capping layer thickness at the leading edge of 1.2m, the calculated critical FoS is 0.9, which is less than the adopted critical/minimum FoS of 1.05. This condition is therefore considered to be geotechnically unstable, under a construction surcharge of 20 tonnes.

  Model output for sensitivity analysis for Option 4 - Stage 2a, shows that by reducing the Mine Spoil layer thickness from 1.2m to 0.6m, the FoS will increase to 1.0; therefore, this condition is considered to be geotechnically stable. Sensitivity analysis for Option 4 - Stage 2b also shows that by using a small plant (i.e. 4.5 tonnes Hitachi DX 45 M Dozer) the FoS will increase to 1.7, which considered to be geotechnically stable. This suggests that placement of Mine Spoil over the geosynthetic reinforcement which is installed over the coarse rejects layer would be feasible, only by placement of thin layers (i.e. 0.6m) of this material using either a 20 tonnes or a 4.5 tonnes dozer.

Table 7
Model output for the critical stability condition for Option 4

No.	Model Condition	Mine Spoil Thickness (m)	Construction Surcharge (tonnes)	Coarse Rejects Layer Thickness (m)	FoS
4-Stage 1	Placement of 0.6m Coarse Rejects Layer, using 20 tonnes D6 Dozer	-	20	0.6	0.6
4-Stage 1a	Placement of 0.6m Coarse Rejects Layer, using 4.5 tonnes Hitachi DX 45 M Dozer	-	4.5	0.6	1.5
4-Stage 2	Placement of 0.6m Coarse Rejects Layer, followed by Geosynthetic Reinforcement overlain by 1.2m Mine Spoil Capping using 20 tonnes D6 Dozer	1.2	20	0.6	0.9
4-Stage 2a	Placement of 0.6m Coarse Rejects Layer, followed by Geosynthetic Reinforcement overlain by 0.6m Mine Spoil Capping using 20 tonnes D6 Dozer	0.6	20	0.6	1.0
4-Stage 2b	Placement of 0.6m Coarse Rejects Layer, followed by Geosynthetic Reinforcement overlain by 0.6m Mine Spoil Capping using 4.5 tonnes Hitachi DX 45 M Dozer	0.6	4.5	0.6	1.7

4.5 Estimation of Settlement Potential

A simplified first principles (one-dimensional) analysis has been undertaken to estimate the magnitude of potential settlement within the existing tailings beach subject to capping layer construction. This analysis is intended to assess longer term (post-construction) conditions, subject to the expected full depth of capping. For the purpose of this analysis, a maximum capping fill thickness of 6m has been adopted. The settlement parameters for each significant layer within each capping configuration are adopted based on typical values obtained from literature and are summarised in **Table 8** below:

Table 8
Adopted Settlement Parameters

Significant Layer	Consolidation Potential	Coefficient of Volume Compressibility (m_v)
Existing Tailings Beach	High Compressibility	0.9 m^2/MN
Capping Layer (Mine Spoil)	Low Compressibility	0.075 m^2/MN

As reflected in the capping configurations, the effect of geosynthetics under Options 2 and 4, and the coarse reject placed under Options 3 and 4 was to reduce the thickness of existing tailings beach over which potential consolidation would occur. The effect of this reduced thickness, as well as varying capping layer thicknesses is therefore of significance to assess the potential surface displacement of a final landform over the tailings dam, and the potential impact on drainage characteristics. The basis of settlement analysis and calculated vertical settlements are presented in **Table 9**.

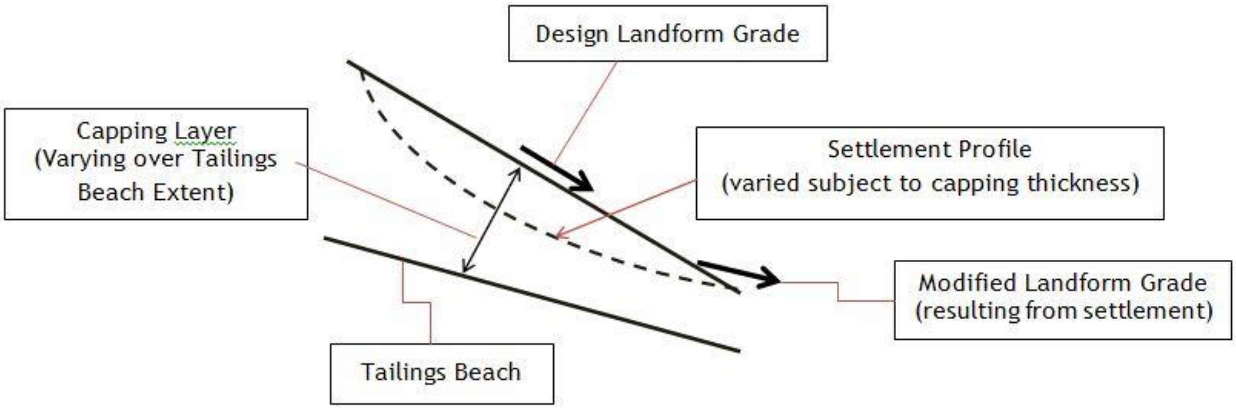
Table 9
Results of Settlement Analysis

Option No	Description	Estimated Settlement
1	Effective maximum tailings thickness 40m over which consolidation occurs	
	- Capping thickness 6m	1,600mm
	- Capping thickness 3m	800mm
2	Effective maximum tailings thickness 30m over which consolidation occurs, taking into account effect of geosynthetics	
	- Capping thickness 6m	800mm
	- Capping thickness 3m	400mm
3	Effective maximum tailings thickness 30m over which consolidation occurs, taking into account effect of geosynthetics with coarse reject	
	- Capping thickness 6m	800mm
	- Capping thickness 3m	400mm
4	Effective maximum tailings thickness 20m over which consolidation occurs, taking into account effect of coarse reject	
	- Capping thickness 6m	400mm
	- Capping thickness 3m	200mm

The key outcome from this analysis, based intuitively on effective depth over which tailings beach consolidation can occur, is that Option 4 provides the best outcome, with potential settlement being minimised under this configuration. Beyond this face-value assessment, the magnitude of estimated settlement influences the acceptable final grade for the landform, with a view to maintaining drainage. This condition is shown conceptually as **Plate 15**. The objective is to adopt a design landform grade that, subject to potential settlement, would maintain a positive drainage profile, thereby limiting the potential for surface water ponding.

A basic analysis undertaken, utilising settlement results presented in **Table 9**, and assuming a tailings dam width of some 300m indicates that a minimum design landform grade of at least 5% is required to maintain a positive drainage profile post-settlement for all options.

Plate 15
Conceptual Representation of Settlement Impact on Final Landform Surface



5 SUMMARY

5.1 Study Overview

The scope of the Capping Options Study for Tailings Dam 1 is to identify an efficient and operationally effective strategy for capping of this storage. The objectives of the final capping system are as follows:

(a) Creates a geotechnically stable landform;
(b) Minimises the likelihood of any erosion occurring to either the final cover system, dumped soil material or deposited material.

A range of generic options for tailings surface capping, listed as follows, have been assessed:

- Option 1: Direct Mine Spoil Placement (over existing tailings beach)
- Option 2: Geosynthetic Reinforcement (over existing tailings beach) with Mine Spoil Capping
- Option 3: Coarse Rejects (or similar) Bridging Layer overlain by Mine Spoil Placement
- Option 4: Coarse Rejects (or similar) Bridging Layer, followed by Geosynthetic Reinforcement overlain by Mine Spoil

The basis for assessment of these options has been as follows:

– Geotechnical stability modelling, subject to construction traffic loading of 20 tonne as a critical condition, with stability assessed at the leading edge of capping layer placement.
– A general check for long term serviceability following placement of the capping layer, ensuring that potential settlements do not compromise overall performance of the capping layer (with a focus on surface drainage).

5.2 Overview of Stability Analyses

Stability analyses described in **Section 4** were completed for all capping options by stability modelling for Zone 2, with model output comprising calculated factors of safety (FoS). The objective required for the conditions to be assessed is not to produce a critical FoS of less than 1.0.

The calculated FoS for Option 1 was very low (of the order of 0.4 for placement of 1.2m of Mine Spoil using a 20 tonnes dozer), therefore was critically unstable and unfeasible conditions. These results are to be expected however, given the low beach strength conditions currently observed, and large settlements and loss of fill expected based on settlement analysis in **Section 4.5**. the FoS for Option 1; however, can be increased to 1.0 by reducing the thickness of Mine Spoil to 0.6m and using a 4.5 tonnes dozer. This condition can be considered marginally stable; however, the settlement for such condition will be very large, based on the settlement analysis in **Section 4.5**.

The results of this analysis indicate that a “bridging” layer, placed between the existing tailings surface and the fill capping, is necessary. Principally this bridging layer would be formed by either a layer of geosynthetic or coarse reject. The stability modelling also indicates that stable conditions are likely achievable for Options 2, 3 and 4, all of which apply bridging layers comprising either geosynthetic or coarse rejects or both. The key observations from stability analysis on these Options for Zone 2 indicate the following:

- Option 2 may be feasible subject to reduced construction plant size and Mine Spoil thickness, although this condition is unable to comply with a requirement to withstand a 20 tonne loading condition. This approach would however have an impact on constructability/productivity.
- Option 3 presents a robust capping approach based on adopted conditions, although feasibility appears to be sensitive to thickness of the mine spoil layer. Additionally, coarse rejects layer needs to be placed using a small plant size (i.e. 4.5 tonnes dozer). To maintain feasibility, control on these factors would be necessary.
- Option 4 can be achieved feasibly by reducing mine spoil layer thickness, although this will depend on using small size dozer, provided that the coarse reject layer can be placed using a small plant size.

In summary, it is considered that to withstand the potential variability of conditions existing within the Tailings Dam 1, the viable capping approaches exist, as follows:

(i) Adopt Option 2 configuration, subject to:
   – limiting capping layer placement thickness to 600mm; and
   – using small plant size (4.5 tonnes dozer) for placement of mine spoil capping layer over the geosynthetic layer.
   – final selection of an appropriate geosynthetics reinforcement.

(ii) Adopt Option 3 configuration, subject to:
   – placement of the coarse reject layer using small plant (not exceeding 4.5 tonne mass);
   – limiting capping layer placement thickness to 600mm; and

(iii) Adopt Option 4 configuration, subject to:
   – placement of the coarse reject layer using small plant (not exceeding 4.5 tonne mass);
   – limiting capping layer placement thickness to 600mm.
   – final selection of an appropriate geosynthetics reinforcement.
   – using small plant size (4.5 tonnes dozer) for placement of mine spoil capping layer over the coarse rejects layer.

It can be concluded that:

- For Zone 1 (western portion of Tailings Dam 1), based on tailings beach characterisation described in **Section 2.2.1**, and on relevant site observation, the predicted beach strengths would support the use of Option 1 (i.e. direct mine spoil placement). This approach exists as the most cost-effective approach, being relevant for higher strength tailings beaches.
- For Zone 2 (central portion of Tailings Dam 1), engineering analysis indicates that Option1 would be unsuitable, being likely to experience failure under construction loading. To this end, Options 2, 3 and 4 would be necessary, providing that using small plant and limiting capping layer thicknesses are adopted.
- For Zone 3 (the eastern portion of Tailings Dam 1), with ponded water and a very low strength tailings beach, capping of the tailings surface is likely to be unfeasible. To enable such works to occur, dewatering of the surface would be required, with a stormwater management sump and pump structure formed to capture runoff during rainfall periods, and also to recover bleed water from the tailings beach as ongoing

consolidation occurs. This sump and pump would be operated to maintain a dry tailings beach surface, to encourage consolidation and strength gain through air-drying.

The timeframe required to achieve a surface suitable for capping works is difficult to predict, although a minimum period of 6 months following dewatering is considered reasonable from a planning perspective, anticipating that Options 2, 3 and 4 may be suitable for capping purposes. Any time beyond 6 months would achieve benefit in terms of further air-drying and beach strength gain, provided that dewatered conditions are maintained, although it is expected that a substantial timeframe (2 dry-season cycles or more) would be required to substantiate the use of a lower standard of capping (i.e. Option 1). Through this period, systematic insitu testing (e.g. vane shears) would be necessary to assess the rate of tailings beach strengthening, for projection of timeframe to achieve a beach strength necessary to adopt an Option 1 treatment. Otherwise, Options 2, 3 and 4 would be relied upon.

5.3 Overview of Potential Settlement

A simplified first principles (one-dimensional) analysis was undertaken to estimate the magnitude of potential settlement within the existing tailings beach subject to capping layer construction. This analysis assessed longer term (post-construction) conditions, subject to the expected full depth of capping. For the purpose of this analysis, a maximum capping fill thickness of 6m was adopted.

Analysis was undertaken in relation to Options 1, 2, 3 and 4, with settlements magnitudes varying between 400mm and 1,600mm for a capping layer thickness of 6m, and 200mm to 800mm for capping layer thickness of 3m. These settlements were used to assess a minimum surface profile that could be tolerated without influencing surface drainage potential. A grade of 5% (minimum) was estimated based on this assessment, and is recommended as a minimum criterion.

REFERENCES

[1] Department of Mines and Energy (1995), *Technical Guidelines for the Environmental Management of Exploration and Mining in Queensland;*

[2] ANCOLD (2012), Guidelines on Tailings Dams Planning, Design, Construction and Closure, May 2012;

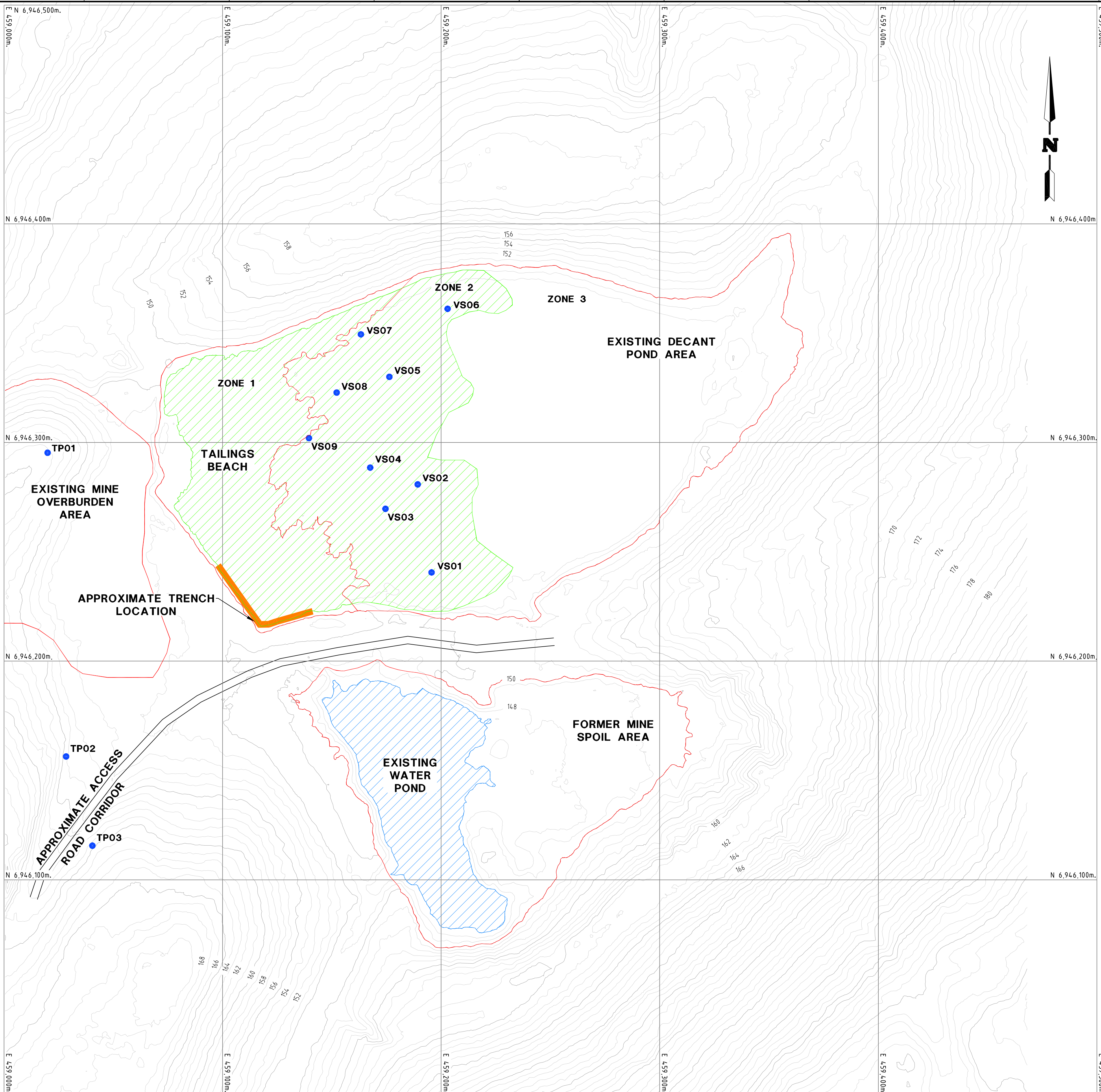
[3] DEHP (2013), Manual for Assessing Consequence Categories and Hydraulic Performance of Structures; November 2013.

FIGURES

VANE SHEAR TEST LOCATION			
PIT	EASTING	NORTHING	LEVEL
VS01	459,195.63	6,946,240.57	146.96
VS02	459,189.30	6,946,250.81	146.97
VS03	459,174.51	6,946,269.66	147.18
VS04	459,167.55	6,946,288.49	146.97
VS05	459,176.30	6,946,330.00	147.30
VS06	459,202.95	6,946,361.12	147.04
VS07	459,163.29	6,946,349.44	147.69
VS08	459,152.21	6,946,322.83	147.66
VS09	459,139.52	6,946,301.98	147.79

NOTES:

1. DATA SOURCE: NEW HOPE GROUP -MAY 2014
2. WATER LEVEL AT RL 146.83m AS AT 9TH MAY 2014
3. VS (VANE SHEAR TEST LOCATION)
4. TP (TEST PIT LOCATION FOR MINE SPOIL MATERIAL)



ISSUED FOR REVIEW

No.	DESCRIPTION	DATE	DRAWN	CHECK'D	APPR'D
A	ISSUED FOR REVIEW	19/05/14	CMA	TK	SP

SCALE:	1:
JOB No.	114021-01
DATE	19/05/14
DESIGN	CMA
DRAWN	CMA
CHECKED	TK
APPROVED	SP

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SHEET SIZE A3 Rev. A

SHEET 1 OF 1

APPENDICES

APPENDIX A

FIELD SHEAR VANE TEST

DATE : 8/05/2014

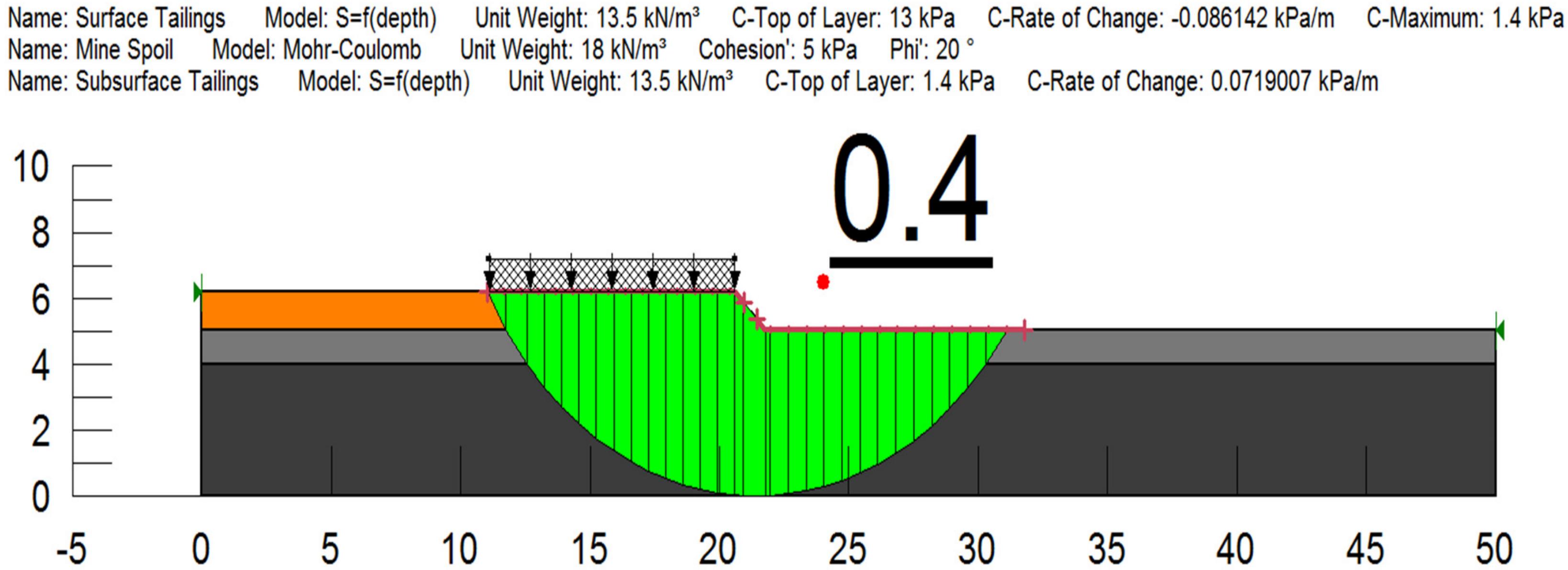
PROJECT : **Oakleigh Mine**
JOB No. : **11402-01** **TESTED : TK&MT**
CLIENT : **New Hope Group** **CHECKED : TK**

Test ID	Depth (*mbgl)		Vane Size	Dummy Reading	Shear Vane Reading	Remoulded VSR	Total Corrected Test	Vane Factor	Shear Strength (kPa)
1	-0.5	0.5	L	2	10	0	8	0.5	4
	-1	1	M	1	1	0	0	1	0
	-1.5	1.5	L	1	1	0	0	0.5	0
2	-0.5	0.5	L	0	2	0	2	0.5	1
	-1	1	L	1	4	1	4	0.5	2
	-2	2	L	2	16	10	24	0.5	12
3	-0.5	0.5	L	1	1	0	0	0.5	0
	-1	1	L		9		9	0.5	4.5
	-1.5	1.5	L	13	12	16	15	0.5	7.5
	-2	2	L	20	30	1	11	0.5	5.5
4	-0.5	0.5	L	1	8	1	8	0.5	4
	-1	1	L	6	1	1	-4	0.5	0
	-2	2	L	2	14	1	13	0.5	6.5
5	-0.5	0.5	L	28	52	22	46	0.5	23
	-1	1	L	39	6	15	-18	0.5	0
	-2	2	L	12	40	28	56	0.5	28
6	-0.5	0.5	S	12	8	8	4	2	8
	-1	1	S	12	8	4	0	2	0
	-2	2	S	9	8	8	7	2	14
7	-0.5	0.5	S	26/6	2	4	0	2	0
	-1	1	S	18/26	5	8	-13	2	0
	-2	2	S	54	10	25	-19	2	0
8	-0.5	0.5	S	12	3	3	-6	2	0
	-1	1	S	16	12	1	-3	2	0
	-2	2	S	16	11	6	1	2	2
9	-0.5	0.5	M	4	16	12	24	1	24
	-1	1	M	6	2	10	6	1	6
	-2	2	M	2	24	10	32	1	32

*mbgl - meters below ground level

Vane Size (Factor): S (2.0), M (1.0) , L (0.5)

APPENDIX B



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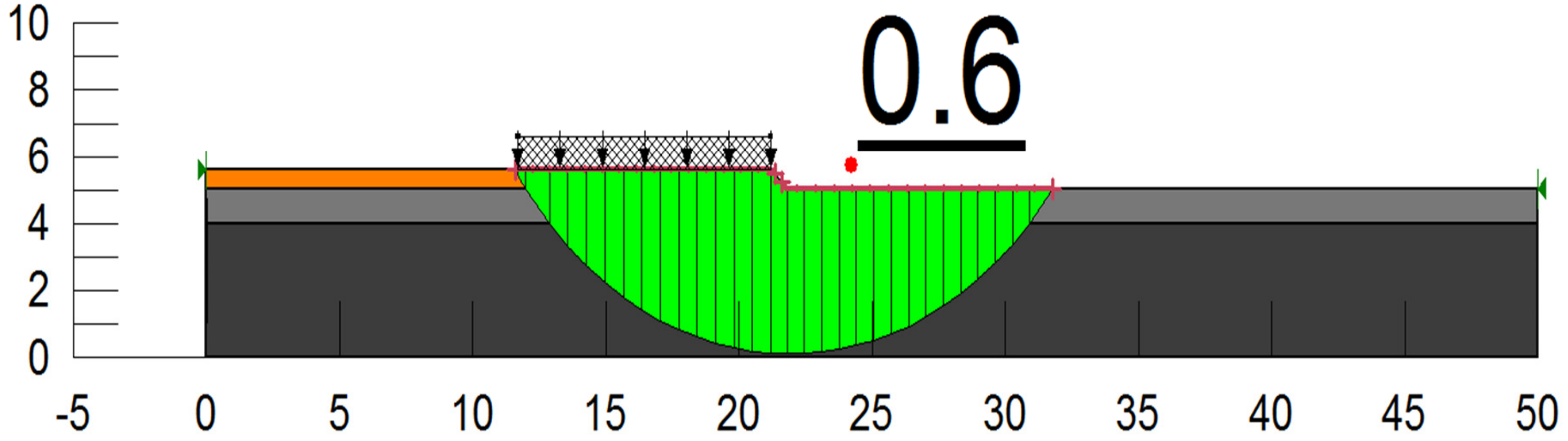
OAKLEIGH COAL MINE

TAILINGS DAM 1

STATIC STABILITY ANALYSIS (ENTRY AND EXIT METHOD): OPTION 1

Date:	23/07/2014	**Job No:**	114021.01	**Appendix B1**

Name: Surface Tailings Model: S=f(depth) Unit Weight: 13.5 kN/m³ C-Top of Layer: 13 kPa C-Rate of Change: -0.086142 kPa/m C-Maximum: 1.4 kPa
Name: Mine Spoil Model: Mohr-Coulomb Unit Weight: 18 kN/m³ Cohesion': 5 kPa Phi': 20 °
Name: Subsurface Tailings Model: S=f(depth) Unit Weight: 13.5 kN/m³ C-Top of Layer: 1.4 kPa C-Rate of Change: 0.0719007 kPa/m



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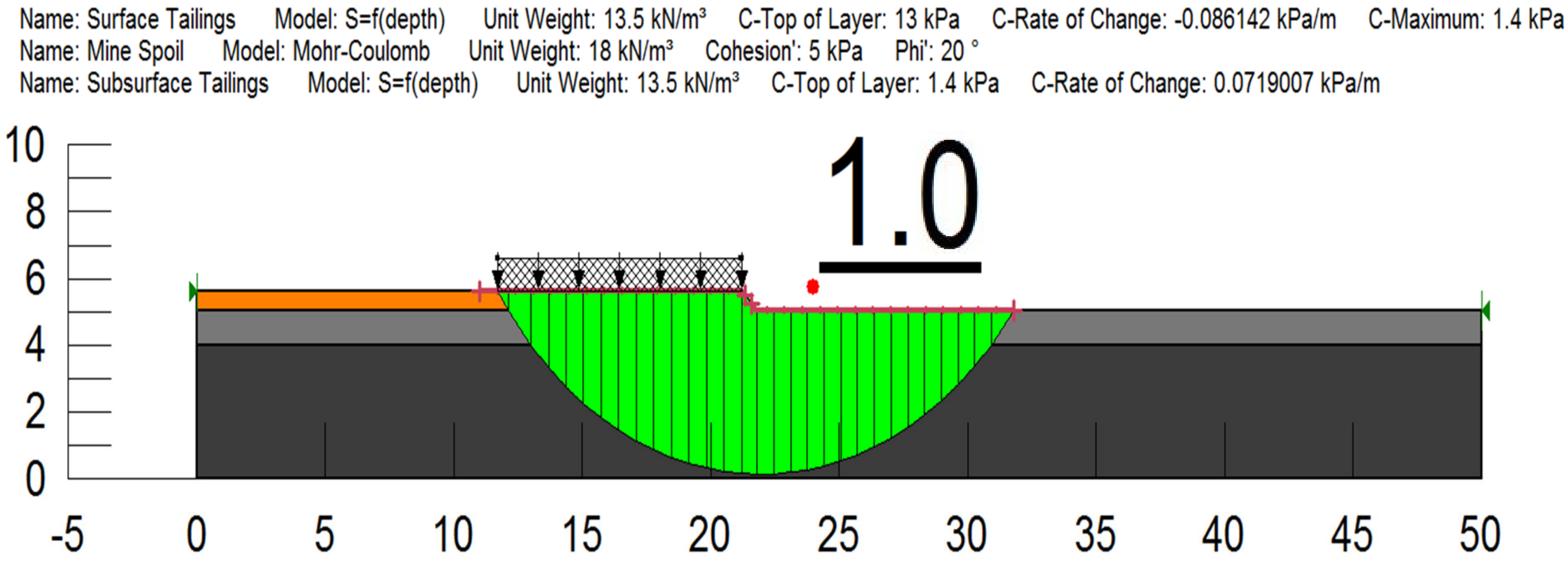
OAKLEIGH COAL MINE

TAILINGS DAM 1

STATIC STABILITY ANALYSIS (ENTRY AND EXIT METHOD): OPTION 1A

Date:	23/07/2014	**Job No:**	114021.01	**Appendix B2**



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OAKLEIGH COAL MINE

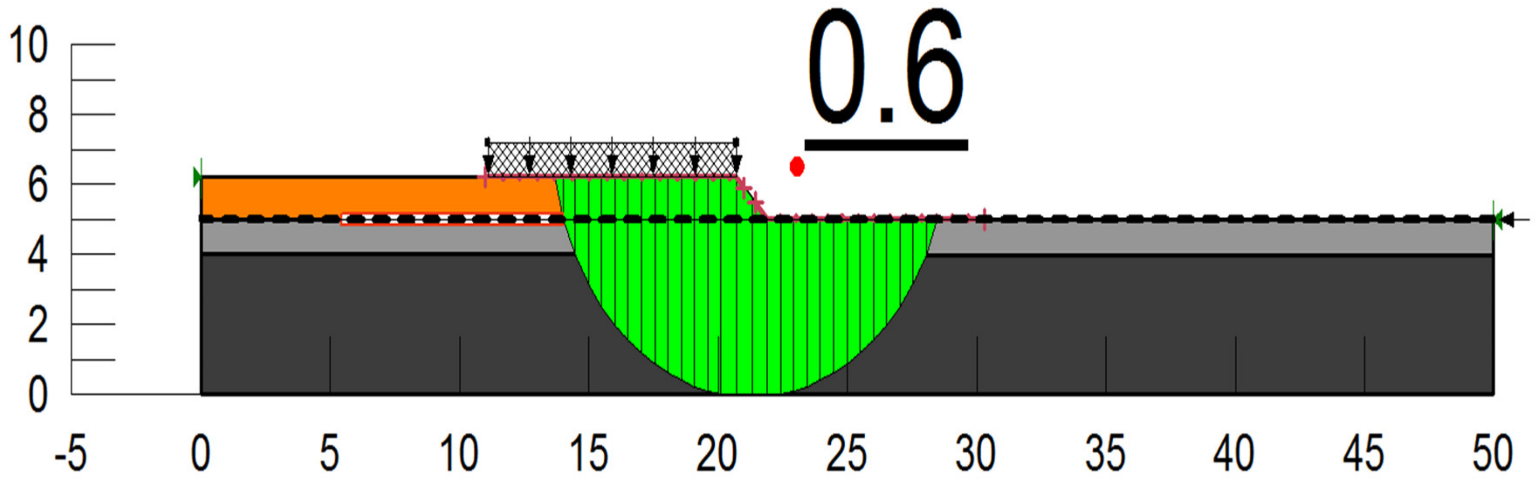
TAILINGS DAM 1

STATIC STABILITY ANALYSIS (ENTRY AND EXIT METHOD): OPTION 1B

Date: 23/07/2014 **Job No:** 114021.01

Appendix B3

Name: Surface Tailings Model: S=f(depth) Unit Weight: 13.5 kN/m³ C-Top of Layer: 13 kPa C-Rate of Change: -0.086142 kPa/m C-Maximum: 1.4 kPa
Name: Mine Spoil Model: Mohr-Coulomb Unit Weight: 18 kN/m³ Cohesion': 5 kPa Phi': 20 °
Name: Subsurface Tailings Model: S=f(depth) Unit Weight: 13.5 kN/m³ C-Top of Layer: 1.4 kPa C-Rate of Change: 0.0719007 kPa/m



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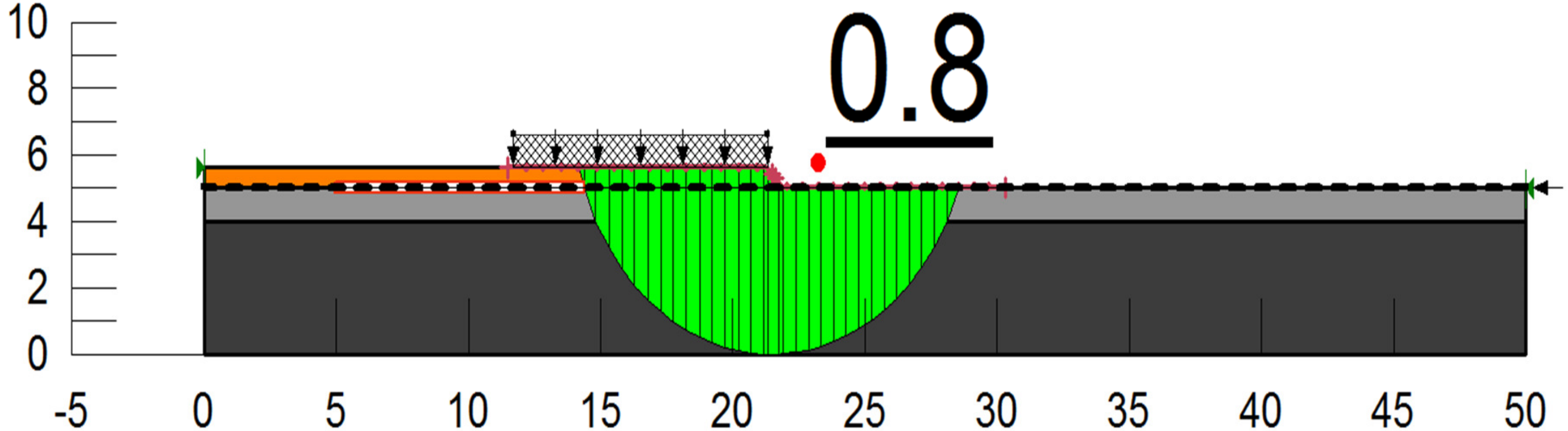
OAKLEIGH COAL MINE

TAILINGS DAM 1

STATIC STABILITY ANALYSIS (ENTRY AND EXIT METHOD): OPTION 2

Date:	23/07/2014	**Job No:**	114021.01	**Appendix B4**

Name: Surface Tailings Model: S=f(depth) Unit Weight: 13.5 kN/m³ C-Top of Layer: 13 kPa C-Rate of Change: -0.086142 kPa/m C-Maximum: 1.4 kPa
Name: Mine Spoil Model: Mohr-Coulomb Unit Weight: 18 kN/m³ Cohesion': 5 kPa Phi': 20 °
Name: Subsurface Tailings Model: S=f(depth) Unit Weight: 13.5 kN/m³ C-Top of Layer: 1.4 kPa C-Rate of Change: 0.0719007 kPa/m



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OAKLEIGH COAL MINE

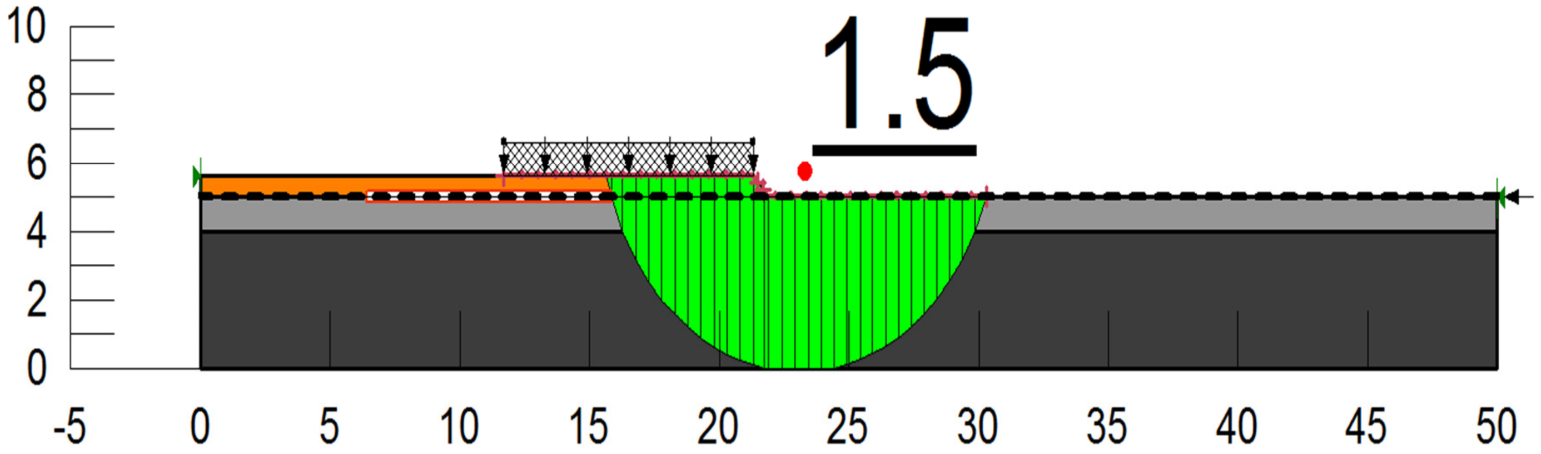
TAILINGS DAM 1

STATIC STABILITY ANALYSIS (ENTRY AND EXIT METHOD): OPTION 2A

Date: 23/07/2014 **Job No:** 114021.01

Appendix B5

Name: Surface Tailings Model: S=f(depth) Unit Weight: 13.5 kN/m³ C-Top of Layer: 13 kPa C-Rate of Change: -0.086142 kPa/m C-Maximum: 1.4 kPa
Name: Mine Spoil Model: Mohr-Coulomb Unit Weight: 18 kN/m³ Cohesion': 5 kPa Phi': 20 °
Name: Subsurface Tailings Model: S=f(depth) Unit Weight: 13.5 kN/m³ C-Top of Layer: 1.4 kPa C-Rate of Change: 0.0719007 kPa/m



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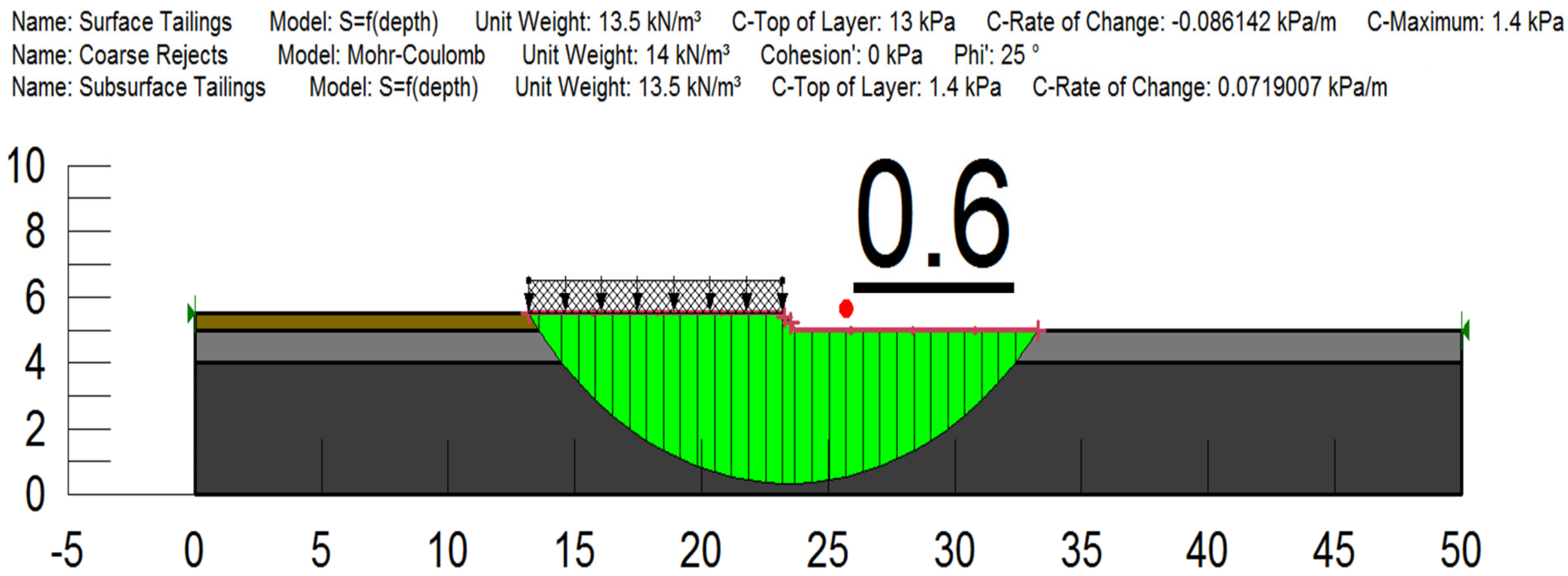
OAKLEIGH COAL MINE

TAILINGS DAM 1

STATIC STABILITY ANALYSIS (ENTRY AND EXIT METHOD): OPTION 2B

Date: 23/07/2014 **Job No:** #REF!

Appendix B7



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OAKLEIGH COAL MINE

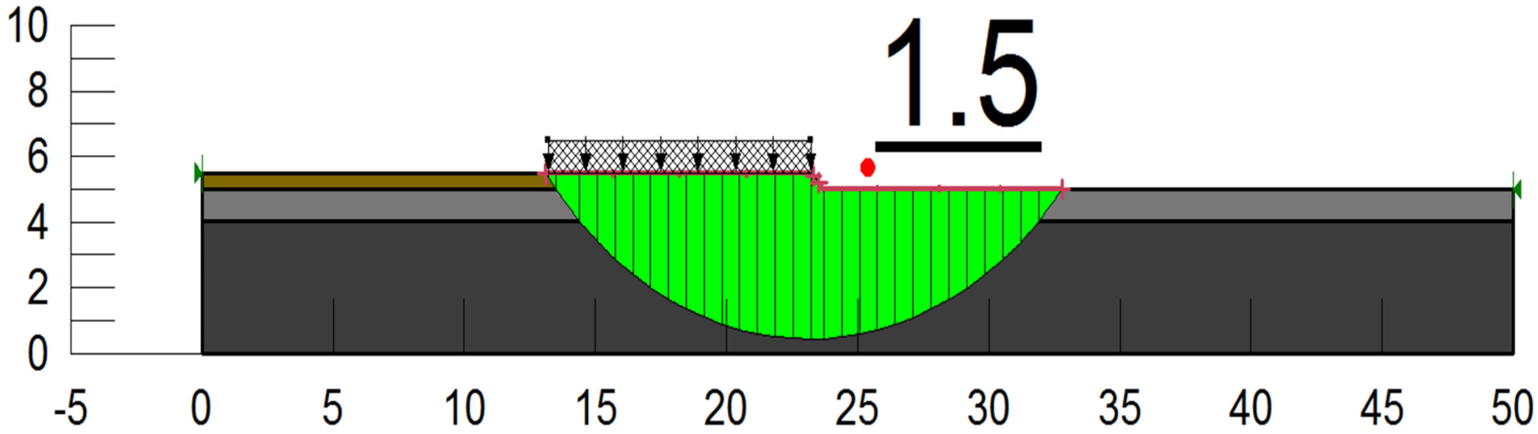
TAILINGS DAM 1

STATIC STABILITY ANALYSIS (ENTRY AND EXIT METHOD): OPTION 3 - STAGE 1

Date: 23/07/2014 **Job No:** 114021.01

Appendix B13

Name: Surface Tailings Model: S=f(depth) Unit Weight: 13.5 kN/m³ C-Top of Layer: 13 kPa C-Rate of Change: -0.086142 kPa/m C-Maximum: 1.4 kPa
Name: Coarse Rejects Model: Mohr-Coulomb Unit Weight: 14 kN/m³ Cohesion': 0 kPa Phi': 25 °
Name: Subsurface Tailings Model: S=f(depth) Unit Weight: 13.5 kN/m³ C-Top of Layer: 1.4 kPa C-Rate of Change: 0.0719007 kPa/m



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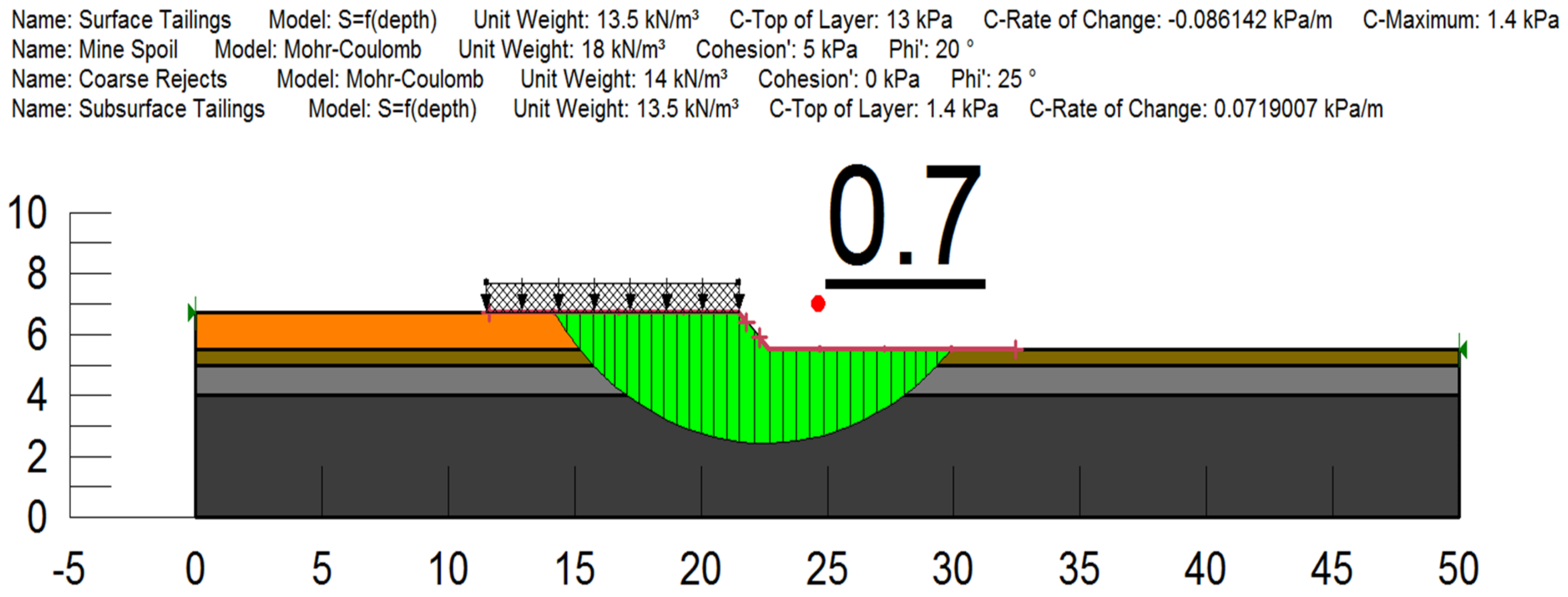
OAKLEIGH COAL MINE

TAILINGS DAM 1

STATIC STABILITY ANALYSIS (ENTRY AND EXIT METHOD): OPTION 3 - STAGE 1A

Date:	23/07/2014	**Job No:**	111320.05

Appendix B14



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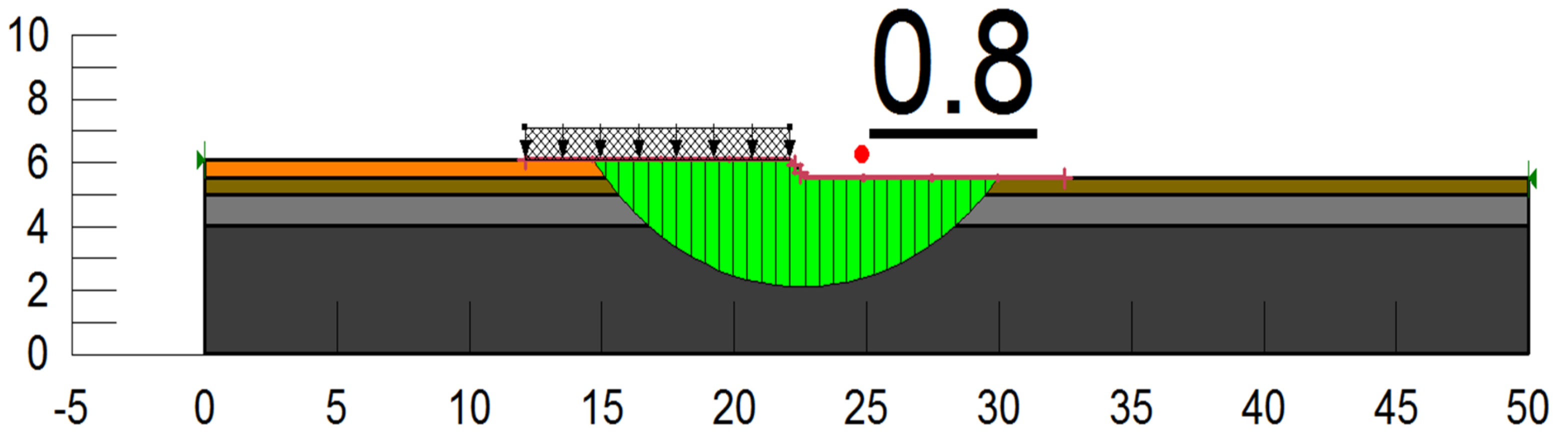
OAKLEIGH COAL MINE

TAILINGS DAM 1

STATIC STABILITY ANALYSIS (ENTRY AND EXIT METHOD):
OPTION 3 - STAGE 2

Date:	23/07/2014	Job No:	114021.01	Appendix B15

Name: Surface Tailings Model: S=f(depth) Unit Weight: 13.5 kN/m³ C-Top of Layer: 13 kPa C-Rate of Change: -0.086142 kPa/m C-Maximum: 1.4 kPa
Name: Mine Spoil Model: Mohr-Coulomb Unit Weight: 18 kN/m³ Cohesion': 5 kPa Phi': 20 °
Name: Coarse Rejects Model: Mohr-Coulomb Unit Weight: 14 kN/m³ Cohesion': 0 kPa Phi': 25 °
Name: Subsurface Tailings Model: S=f(depth) Unit Weight: 13.5 kN/m³ C-Top of Layer: 1.4 kPa C-Rate of Change: 0.0719007 kPa/m



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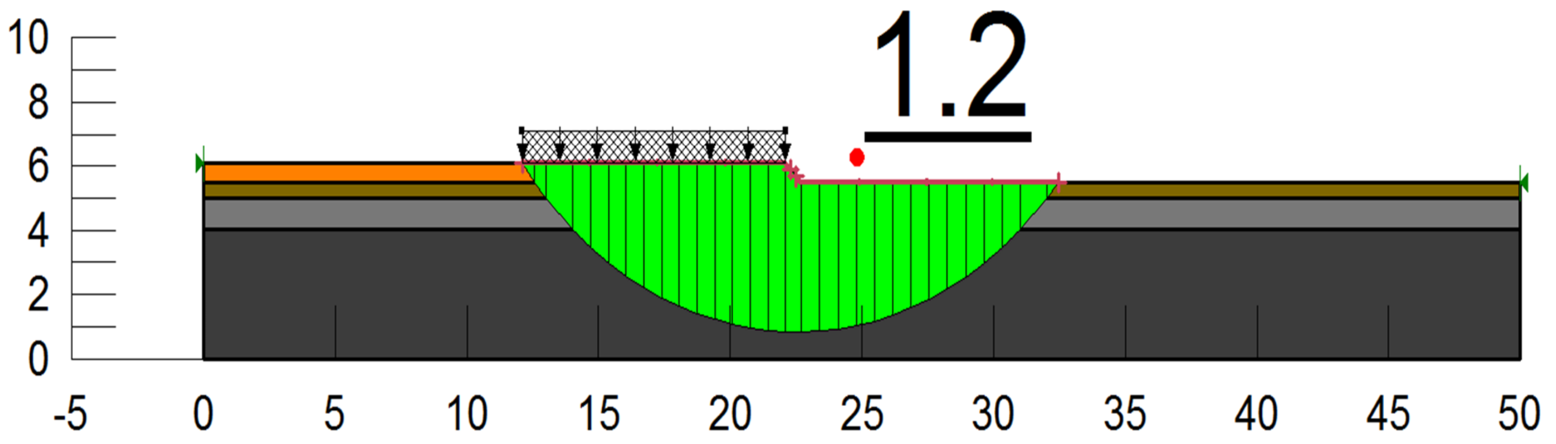
OAKLEIGH COAL MINE

TAILINGS DAM 1

STATIC STABILITY ANALYSIS (ENTRY AND EXIT METHOD): OPTION 3 - STAGE 2A

Date:	23/07/2014	**Job No:**	114021.01	**Appendix B16**

Name: Surface Tailings Model: S=f(depth) Unit Weight: 13.5 kN/m³ C-Top of Layer: 13 kPa C-Rate of Change: -0.086142 kPa/m C-Maximum: 1.4 kPa
Name: Mine Spoil Model: Mohr-Coulomb Unit Weight: 18 kN/m³ Cohesion': 5 kPa Phi': 20 °
Name: Coarse Rejects Model: Mohr-Coulomb Unit Weight: 14 kN/m³ Cohesion': 0 kPa Phi': 25 °
Name: Subsurface Tailings Model: S=f(depth) Unit Weight: 13.5 kN/m³ C-Top of Layer: 1.4 kPa C-Rate of Change: 0.0719007 kPa/m



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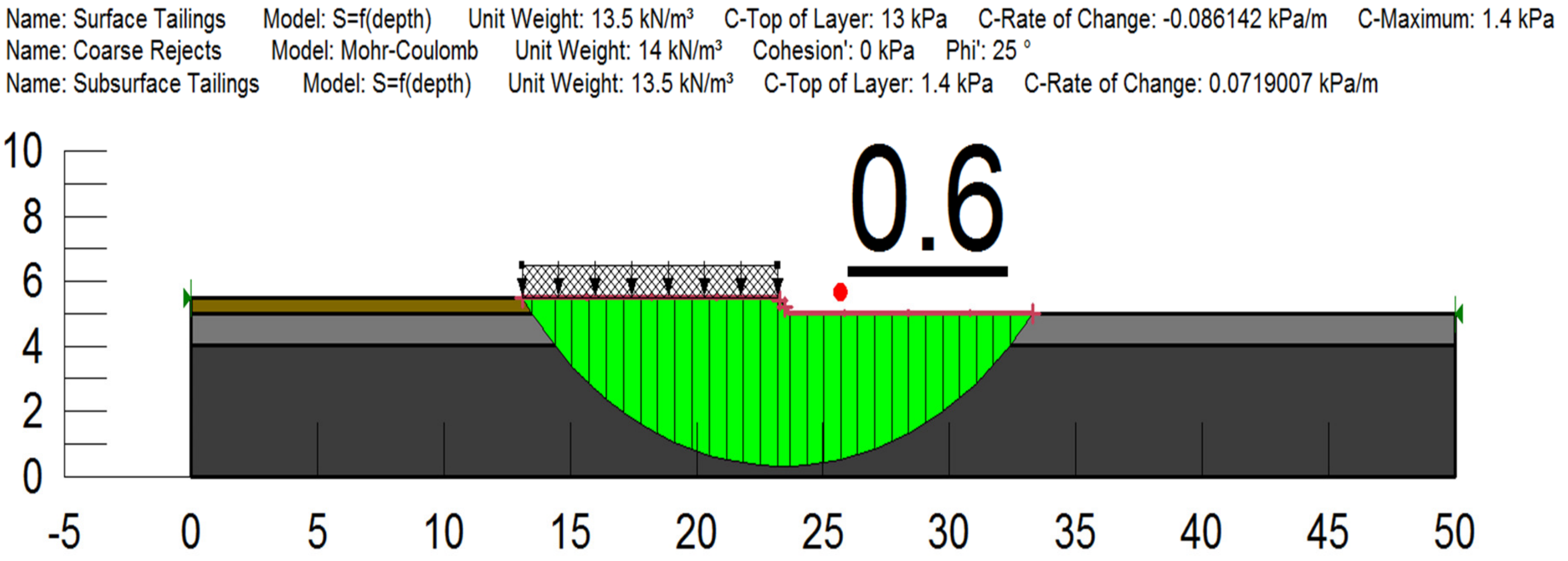
OAKLEIGH COAL MINE

TAILINGS DAM 1

STATIC STABILITY ANALYSIS (ENTRY AND EXIT METHOD): OPTION 3 - STAGE 2B

Date: 23/07/2014 **Job No:** 111320.05

Appendix B17



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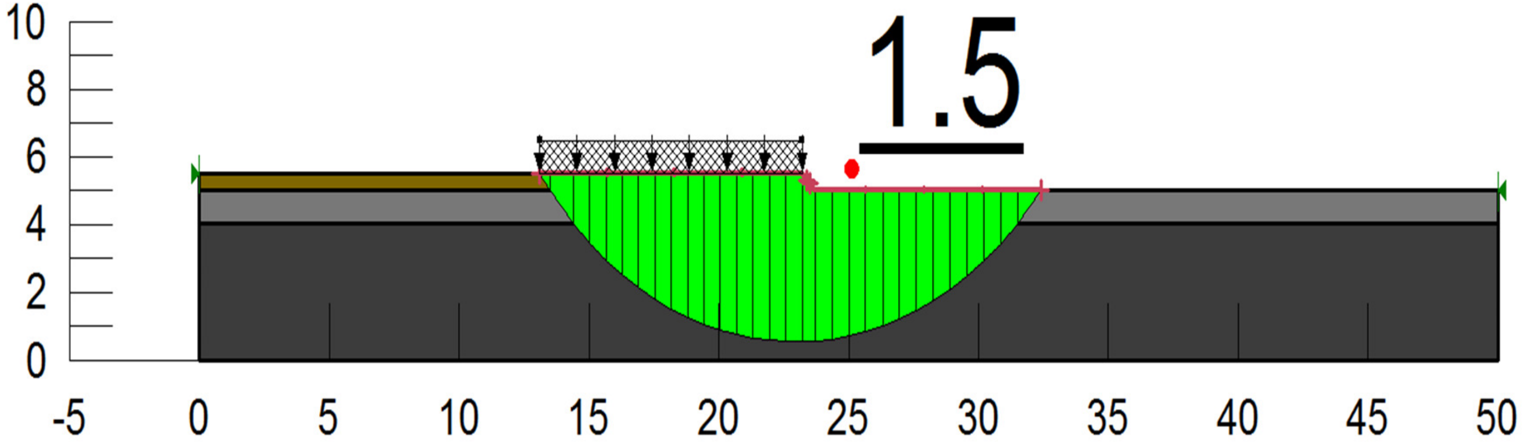
OAKLEIGH COAL MINE

TAILINGS DAM 1

STATIC STABILITY ANALYSIS (ENTRY AND EXIT METHOD): OPTION 4 - STAGE 1

Date:	23/07/2014	**Job No:**	#REF!	**Appendix B8**

Name: Surface Tailings Model: S=f(depth) Unit Weight: 13.5 kN/m³ C-Top of Layer: 13 kPa C-Rate of Change: -0.086142 kPa/m C-Maximum: 1.4 kPa
Name: Coarse Rejects Model: Mohr-Coulomb Unit Weight: 14 kN/m³ Cohesion': 0 kPa Phi': 25 °
Name: Subsurface Tailings Model: S=f(depth) Unit Weight: 13.5 kN/m³ C-Top of Layer: 1.4 kPa C-Rate of Change: 0.0719007 kPa/m



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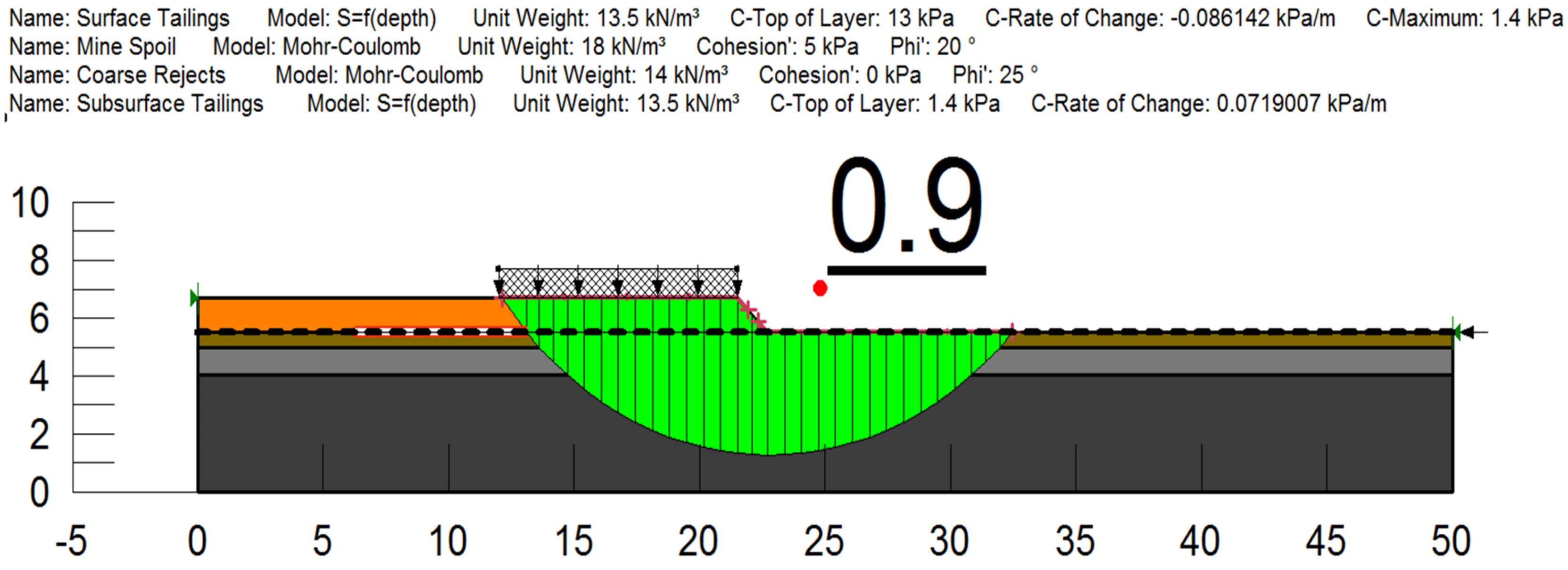
OAKLEIGH COAL MINE

TAILINGS DAM 1

STATIC STABILITY ANALYSIS (ENTRY AND EXIT METHOD):
OPTION 4 - STAGE 1A

Date:	23/07/2014	**Job No:**	111320.05	**Appendix B9**



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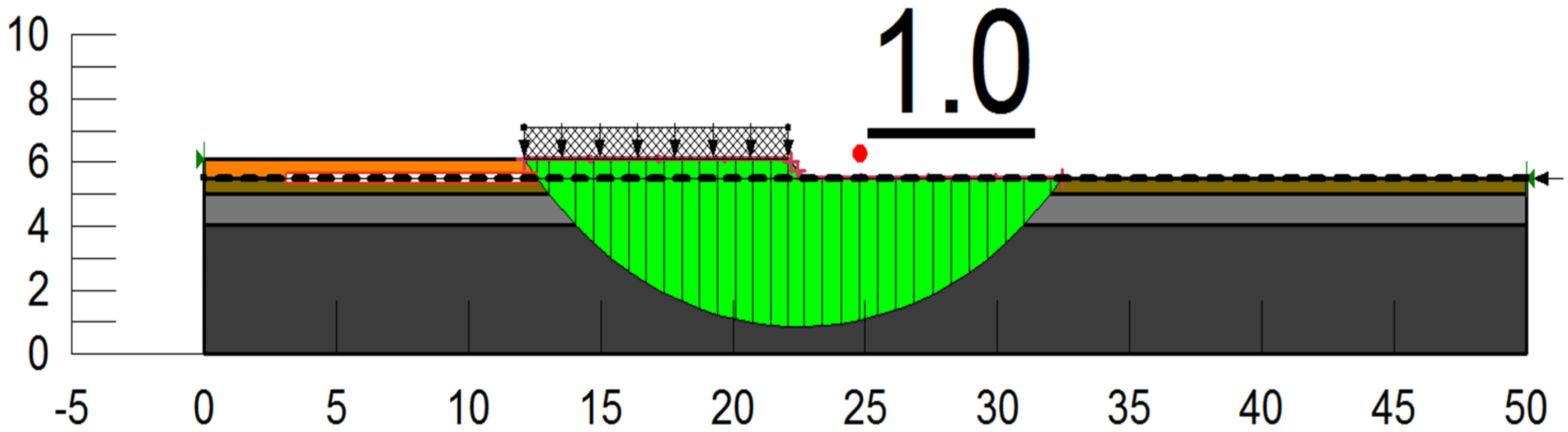
OAKLEIGH COAL MINE

TAILINGS DAM 1

STATIC STABILITY ANALYSIS (ENTRY AND EXIT METHOD):
OPTION 4 - STAGE 2

Date:	23/07/2014	Job No:	114021.01	Appendix B10

Name: Surface Tailings Model: S=f(depth) Unit Weight: 13.5 kN/m³ C-Top of Layer: 13 kPa C-Rate of Change: -0.086142 kPa/m C-Maximum: 1.4 kPa
Name: Mine Spoil Model: Mohr-Coulomb Unit Weight: 18 kN/m³ Cohesion': 5 kPa Phi': 20 °
Name: Coarse Rejects Model: Mohr-Coulomb Unit Weight: 14 kN/m³ Cohesion': 0 kPa Phi': 25 °
Name: Subsurface Tailings Model: S=f(depth) Unit Weight: 13.5 kN/m³ C-Top of Layer: 1.4 kPa C-Rate of Change: 0.0719007 kPa/m



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OAKLEIGH COAL MINE

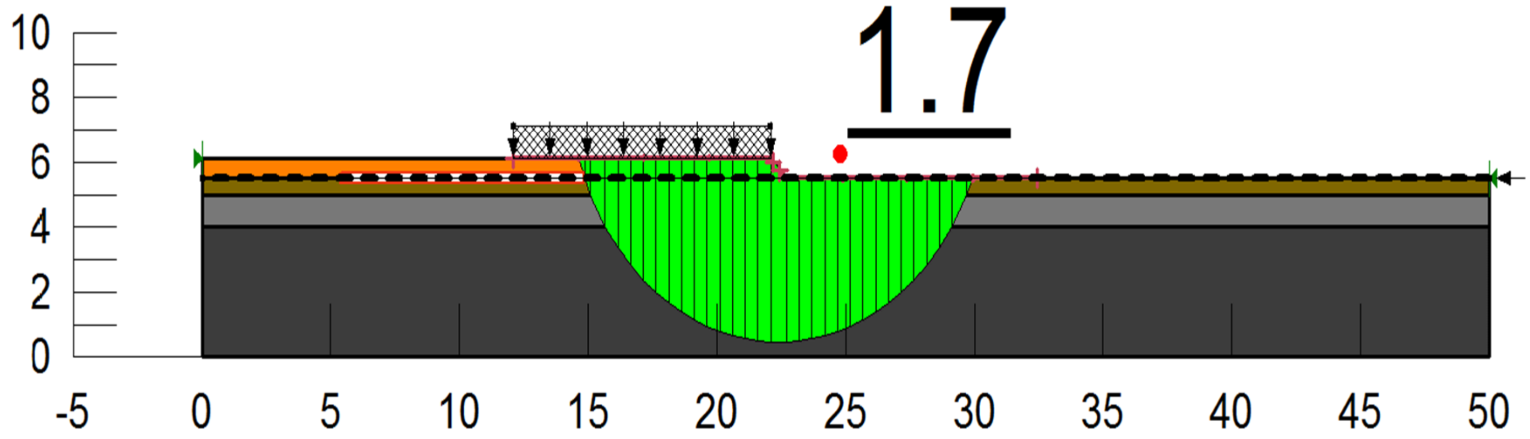
TAILINGS DAM 1

STATIC STABILITY ANALYSIS (ENTRY AND EXIT METHOD): OPTION 4 - STAGE 2A

Date: 23/07/2014 **Job No:** 114021.01

Appendix B11

Name: Surface Tailings   Model: S=f(depth)   Unit Weight: 13.5 kN/m³   C-Top of Layer: 13 kPa   C-Rate of Change: -0.086142 kPa/m   C-Maximum: 1.4 kPa
Name: Mine Spoil   Model: Mohr-Coulomb   Unit Weight: 18 kN/m³   Cohesion': 5 kPa   Phi': 20 °
Name: Coarse Rejects   Model: Mohr-Coulomb   Unit Weight: 14 kN/m³   Cohesion': 0 kPa   Phi': 25 °
Name: Subsurface Tailings   Model: S=f(depth)   Unit Weight: 13.5 kN/m³   C-Top of Layer: 1.4 kPa   C-Rate of Change: 0.0719007 kPa/m



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OAKLEIGH COAL MINE

TAILINGS DAM 1

STATIC STABILITY ANALYSIS (ENTRY AND EXIT METHOD): OPTION 4 - STAGE 2B

Date: 23/07/2014 **Job No:** 114021.01

Appendix B12