

**REQUIREMENTS OF PIT ABANDONMENT
AND DESIGN CHANGE ASSOCIATED
WITH THE GOLDEN PIKE CUTBACK

FOR

KCGM**

Prepared by:

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Date	July 2005

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1.0 INTRODUCTION

Kalgoorlie Consolidated Gold Mines Pty Ltd (KCGM) has been working on the pit abandonment issues for the eventual closure of the open pit, now projected to 2017 (Reference 1). This report has been prepared by BFP Consultants (BFP) to address the requirements of pit abandonment in the context of the Department of Industry and Resources (DoIR) guidelines (Reference 2), and a recent design change associated with the Golden Pike Cutback (Reference 3).

2.0 BACKGROUND

BFP has undertaken a geotechnical assessment for the proposed Golden Pike Cutback (Reference 3). The proposed cutback, shown in Figure 1, will impact on the location of any abandonment plans developed prior to this new design consideration.

KCGM plan to relocate the Environmental Noise-Bund (ENB) along the western side of the pit which is shown in Figure 2. This is a view of the pit looking north with the present ENB highlighted. The bund is approximately 20 m high, with a base width of approximately 100 m. A picture of the present ENB is shown in Figure 3. This is a substantial bund and significantly exceeds the requirements outlined in the DoIR Guidelines (Reference 2) which requires, as a minimum, a bund with:

- a height of 2 m, and
- a based with of 5 m.

Hence the ENB would replace the requirement for an abandonment bund.

The footprint of the proposed ENB is shown in Figure 4 with respect to the current proposed final pit wall incorporating the Golden Pike Cutback.

On this figure the location of the pit abandonment bund, developed in accordance with the DoIR guidelines, is shown as a dashed line. The figure also shows in the proximity of the ENB to the Golden Pike Cutback.

This report examines the geotechnical issues relating to the stability of the proposed pit abandonment taking into account the expected geotechnical parameters and the eventual condition of the pit after the groundwater has achieved its stable position.

3.0 DoIR ABANDONMENT GUIDELINES

The guidelines developed by the DoIR (Reference 2) provide that upon abandonment, a bund or fence will be established around the mine workings to minimise inadvertent public access. The bund should be constructed outside the area designated as being susceptible to wall collapse.

In the absence of any geotechnical investigations, the guideline establishes the location of the bund based on WA experience with abandoned pits. The guideline has established that a pit slope constructed in unweathered (fresh and slightly weathered) rock would be 45° from the toe of the slope to the top of the fresh rock. In weathered (distinctly to extremely weathered) rock, the slope angle would be 25° angle from the bottom of the weathered (oxidised) material to the ground surface. In the guidelines un-oxidised and oxidised rocks are defined as equivalent to unweathered and weathered rocks respectively. In compound slopes comprising both materials then the bottom of the weathered zone would coincide with the point at which the 45° line intersected this horizon. The guideline, as proposed by DoIR, is summarised in Figure 5.

The guideline identifies the appropriate geotechnical definition of weathering as presented in the Australian Standard for Geotechnical Site Investigations AS1726 - 1993 (Reference 4). However the guideline does suggest that weathered ground can be equated to oxidised ground. While this is a commonly assumed relationship in WA mining terminology, it can lead to confusion about the inferred properties of the rock mass as the two terms are not necessarily interchangeable.

Oxidised ground around mineralised deposits results from the percolation of surface water through the rock mass. In the process, sulphides are converted to oxides and carbonates. There is no geotechnical classification for oxidation and no direct relationship between oxidation and weathering. The process of oxidation has most relevance to the metallurgical properties of the rockmass rather than the geotechnical properties of the rock mass.

Fresh rock material with exposed sulphide will gradually decay and spawl with time due to the exposure of rock surfaces and oxidation. More exposure of surface areas expedite oxidation and partial weathering.

Weathering however is defined as the destructive process (or group of processes) by which soil and rock materials degrade. The process is both physical and chemical. It changes the colour, texture, composition, competency with little or no transport of the altered material (Reference 5).

The weathering classification used in this report is summarised in Table 1 derived from AS1726 (Reference 4). The base of oxidation has been taken as the bottom of the distinctly weathered horizon.

Experience at KCGM suggests that the process of degradation is very slow and can be inferred to be measured in years.

The DoIR guidelines provide a comprehensive list of issues to be addressed in determining the location of the abandonment bund as follows:

- The presence and orientation of major geological planes of weakness in the rock mass forming the pit walls,
- The strength of the rock mass within the pit walls,
- Variation in the strength of the rock mass with time,
- The geometry of the pit wall,
- The influence of groundwater and incident rainfall on pit walls, and
- The influence of seismic events.

These are addressed in the next section.

4.0 GEOTECHNICAL INVESTIGATIONS

The stability of the pit wall adjacent to the Golden Pike Cutback has been evaluated in Reference 3 which established that there were no kinematic failures that could be identified that would result in overall wall instability.

4.1 Review of Data

A review of the available data indicates:

- There are faults and shears which define the mineralisation at KCGM. It is possible that a fault could be present in the final wall; however the faults and shears within the west wall of KCGM are generally re-healed (Reference 3), (Figure 1).
- The fresh rock mass is very strong (Table 2).
- The weathering profile at KCGM along the western flank has been indurated with iron rich fluids leading to a laterite cap rock (comprising the oxidised and cemented material) with a variable thickness of 5 to 15 m.
- The base of oxidation in the vicinity of the Golden Pike Cutback has been identified by KCGM at -110 mRL. This also coincides with the base of the distinctly weathered horizon. The crest is located at -50 mRL.
- The materials forming the topographic highs around Kalgoorlie are resistant to erosion. These are generally oxidised.
- The pit geometry has been designed to take account of geological structures, previous underground workings, and safety of personnel taking account of seismic events and the groundwater regime.

4.2 Numerical Modelling

- A numerical analysis of the pit slope stability was undertaken using material properties developed from the Hoek-Brown criterion (Reference 7). Initially the 2D model was calibrated using the current pit monitoring (Figure 6). This represents the incremental displacement between 2001 and 2003 pits.
- The prism data presented in Figure 6 corresponds to prisms located at -90 mRL in the Stores Cutback (shown in Figure 2). The displacements show a trend of dilation of approximately 30 mm/year. This response is linear and therefore considered to be within the elastic range for calibration purposes. The stress regime used in the analyses has been measured at the Croesus waste dump and in the Chaffers shaft confirming the general trends previously established at Mt Charlotte (Reference 6). The results indicate that the stress ratio is as follows:
 - Sigma 1 (σ_1) = 3 times overburden (σ_v) and is oriented north-south,
 - Sigma 2 (σ_2) = 1.5 times overburden (σ_v) oriented east- west
 - Sigma 3 (σ_3) = Overburden ($\sigma_v = \gamma z$) and is sub vertical, where γ is the unit weight of the rock and z the depth below surface.
 - The rock density for the significant rock units (Golden Mile Dolerite, Williamstown Dolerite, and Paringa Basalt) is 2.9 t/m³.
- The numerical model used for the calibration is shown in Figures 7 to 10 which also show the material properties applied. These sections correspond to the status of the pit at the end of 2001 and 2003. The phreatic surface was modelled and then calibrated using known locations of the water surface within the underground workings and exploration drilling.
- The initial deformation properties of the rock mass have been determined from laboratory testing or BFP experience in similar materials.
- All stopes on the interpreted section have been assumed to be un-filled representing a worst case for stability.

- The rockmass properties have been determined using RocLab from RocScience. The results are presented in Table 2, with the calculation sheets presented in the Appendix.
- The position of the Environmental Noise Bund is shown to the west of the pit as a surcharge load.
- The total displacements calculated for mining to 2001 are shown in Figure 12. At -90 mRL, the displacement is calculated to be 170 mm.
- Each major mining step has been modelled as shown in Figure 9 at the end of 2001, Figure 10 for the proposed pit at end of 2003 and Figure 11 for the proposed final pit at end of 2017.
- The calibration runs compared the displacement at -90 mRL between 2001 and 2003. The actual displacement recorded was between 50 and 90 mm (i.e. relatively small displacement). The numerical model gives a relative displacement between the two stages of 60 mm as shown in Figure 14. This is comparable to the recorded displacement, giving confidence in the rock mass properties and stress regime adopted for this study. The faults have been assumed to be very stiff as shown in Table 2.
- The numerical analyses were then used to examine the rock mass behaviour with time and determine the effective factor of safety. The results of the analyses are presented in Figures 15 to 20. Three sections were examined 48700N, 48800N and an oblique section constructed normal to the wall. The location of these design sections are shown in Figure 1. The effective factor of safety (the term used in the stress analyses is Strength Reduction Factor (SRF)), has been calculated by progressively increasing or reducing the material parameters until plastic yield occurs within the model. It can be seen that, at the final pit shape, the factor of safety at 48700 mN, 48800 mN and the oblique section will be 4.54, 5.94 and 2.0 respectively. The oblique section has a much steeper overall slope than sections 48900 N and 4800 N contributing to the lower SRF calculated. These safety factors compare very favourably when compared to the DoIR guidelines of acceptable factors of safety in the range of 1.2 to 1.5 for commensurate pit wall designs.
- Seismicity occurs in the Kalgoorlie region; typically it is associated with the belt of mineralisation occurring between Norseman to the south and Wiluna to the north.
- Local seismic events have also been associated with mining at Mt Charlotte.. For design purposes the stability of the pit walls has been examined using a horizontal acceleration of 0.07g in accordance with local experience.
- The SRF calculated can then be compared to the factor of safety determined by a rotational analysis which assumes limit equilibrium (with and without seismic loading). These results are shown in Figures 21 and 22 and show that the expected seismic activity will have no detrimental effect on the pit wall stability.
- Groundwater will be allowed to infiltrate and eventually flood the pit void. The long term phreatic surface is anticipated to be located at -80 mRL allowing for 10 m of evaporation. The influence of rock exposure to water has not been specifically addressed (i.e. water will inundate all rock exposed in the pitwall and not just in the joints). The results of the analyses presented in this report however demonstrate that the stability of the ENB and abandonment bund is not compromised by flooding of the pit (Figures 23 to 31).
- The consequences of wave action on the weathered wall material in the flooded pit has not been addressed in this report. However the impact may be ameliorated by backfilling over the pit edge with fresh rock before the water level rises that high.

5.0 DISCUSSION

Mining at Kalgoorlie has been undertaken since the 1890's. There are extensive underground workings. The more recent underground mining has established very large voids. The stability of these voids has been excellent. The rate of deterioration of the fresh host rocks at Kalgoorlie is unknown, but likely to be extremely slow.

The factor of safety for the final pit wall stability is calculated to be in excess of 2 on a section constructed normal to the proposed final pit wall (Figures 19 and 20) and in excess of 4 for sections adjacent to the Golden Pike Cutback. These results are well above the limits suggested by the DoIR as design guidelines. On this basis (Figures 15 to 18) BFP consider that the fresh rock slopes are not at risk of overall failure and that the abandonment guideline of 45° is too conservative in this operation. It is therefore considered appropriate to site the location of the abandonment bund based only on the weathered horizon according to the DoIR Guidelines (1997).

To reduce the impact of weathering in the Golden Pike Cutback, it is proposed to backfill over the pit crest with fresh waste rock to minimise further deterioration by the eventual flooding of the pit and any subsequent wave action. The benefits of this approach can be seen in Figure 32 where the abandonment guideline would then be effectively located at the (former) pit crest.

Using an angle of 25° from the base of the distinctly weathered horizon, the position of an abandonment bund is shown in Figure 33.

6.0 RECOMMENDATIONS

No kinematic stability mechanisms have been identified for the western wall at the KCGM open pit in the area of the Golden Pike Cutback (Reference 2). Stress analyses resulted in a minimum factor of safety of 2 for the most aggressive slope adjacent to the Golden Pike Cutback, and circular failure analyses have provided a factor of safety of in excess 5 (through the weathered materials). Analysis undertaken with consideration of a flooded pit provided similar results.

Based on these analyses and the observation that the unweathered rock in the KCGM pit has shown no evidence of breakdown with time, BFP recommend that a 25° line be projected from the top of the unweathered rock at its exposure in the pit wall to the ground surface to determine the location of the safety bund wall, as shown in Figure 33. On this basis the proposed Environmental Noise Bund (ENB) will meet the DoIR guidelines and substantially exceed their requirements.

The ENB would therefore be suitable as a foundation for the proposed loop line assuming it is constructed with suitable materials and in accordance with the requirements of a railway embankment.

For and on behalf of
BFP CONSULTANTS
(a division of Coffey Geosciences Pty Ltd)



Phil Dight
Senior Principal

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3. Geotechnical Assessment of the Golden Pike Cutback for KCGM Pty Ltd. BFP Report, February 2004, 1803035
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TABLES

Table 1 - Rock Material Weathering Classification (AS1726)

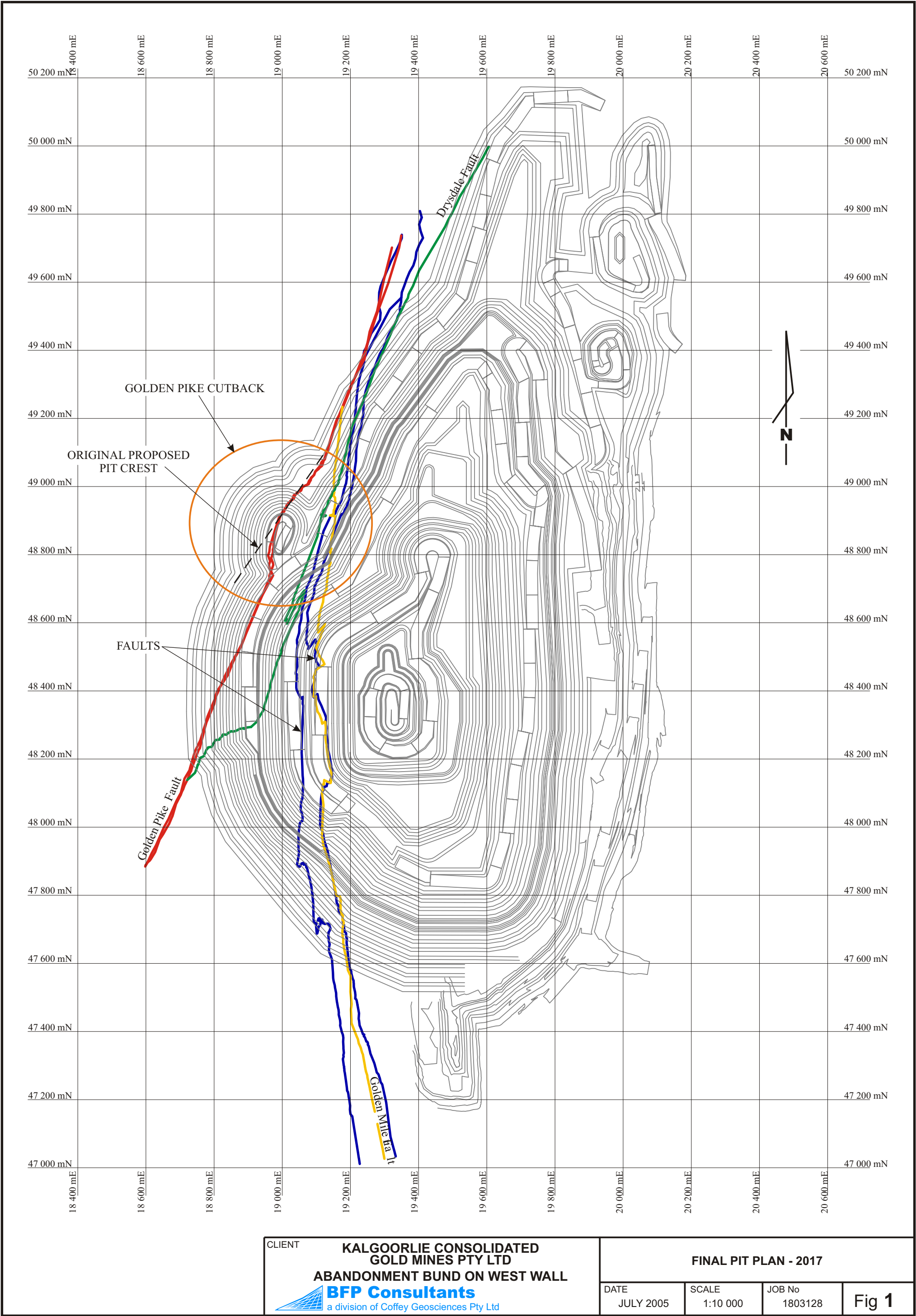
TERM	SYMBOL	DEFINATION
Residual Soil	RS	Soil developed on extremely weathered rock; the mass structure and substance fabric are no longer evident; there is a large change in volume but the soil has not been significantly transported.
Extremely weathered rock	XW	Rock is weathered to such an extent that it has 'soil' properties, i.e. it either disintegrates or can be remoulded in water
Distinctly weathered rock	DW	Rock strength usually changed by weathering. The rock may be highly discoloured, usually be iron staining. Porosity may be increased by leaching, or may be decreased due to deposition of weathering products in pores.
Slightly weathered rock	SW	Rock is slightly discoloured but shows little or no change of strength from fresh rock.
Fresh Rock	FR	Rock shows no sign of decomposition or staining.

Table 2 – Material Properties Used in Numerical Analyses


Rock Type	Unit Weight t/m ³	*GSI (=RMR ₈₉ -10)	m _i	m _b	s	c _i MPa	Φ Degree	E _i GPa	E _m GPa	σ _t MPa	σ _c MPa	ν
Williamstown Dolerite	2.91	52	16	2.881	0.0048	6.367	49.57	88.85	11.22	-0.556	22.46	0.42
Golden Mile Dolerite West	2.91	54	16	3.095	0.0060	8.396	35.76	72.60	10.48	-0.269	12.59	0.20
Golden Mile Dolerite East	2.91	58	16	3.570	0.0094	8.904	36.96	72.60	13.18	-0.330	15.85	0.20
Black Flag Beds	2.77	54	6	1.161	0.0060	8.879	27.39	68.00	12.6	-1.003	14.66	0.20
Paringa Basalt	2.90	67	25	7.690	0.0256	6.374	43.51	63.00	23.3	-0.256	12.23	0.25
Highly Weathered	2.7	25	16	1.1	0.0002	0.1	25	-	0.410	-	0.04	0.2
Slightly Weathered	2.7	44	16	2.165	0.002	0.37	45	-	3.0	-	0.8	0.2
		Normal Stiffness MPa		Shear Stiffness MPa								
Faults		100000		10000								

* Conservative correlation literature recommends GSI = RMR₈₉-5

FIGURES





CLIENT	KALGOORLIE CONSOLIDATED GOLD MINES PTY LTD			VIEW OF WEST WALL STORES CUTBACK BEING UNDERTAKEN IN FOREGROUND	
	ABANDONMENT BUND ON WEST WALL			DATE JULY 2005	SCALE NTS
 BFP Consultants a division of Coffey Geosciences Pty Ltd				JOB No 1803128	Fig 2



CLIENT

**KALGOORLIE CONSOLIDATED
GOLD MINES PTY LTD**
ABANDONMENT BUND ON WEST WALL



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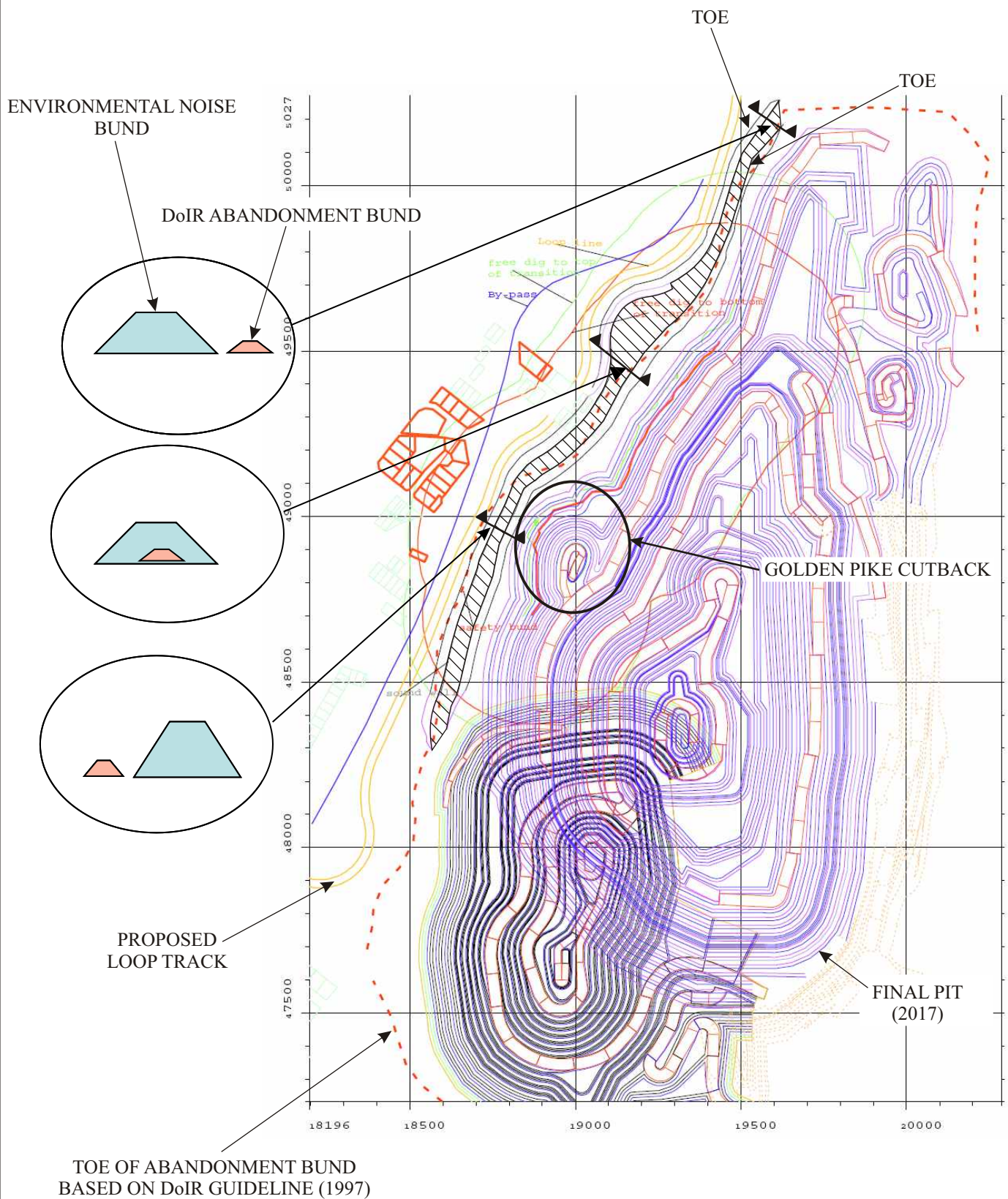
VIEW OF ENVIRONMENTAL NOISE BUND (ENB)

DATE
JULY 2005

SCALE
NTS

JOB No
1803128

Fig 3



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**KALGOORLIE CONSOLIDATED
GOLD MINES PTY LTD**
ABANDONMENT BUND ON WEST WALL

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**PLAN SHOWING LOCATION OF
NOISE ABATEMENT BUND &
ABANDONMENT BUND AFTER DoIR 1997**

DATE
JULY 2005

SCALE
AS SHOWN

JOB No
1803128

Fig 4

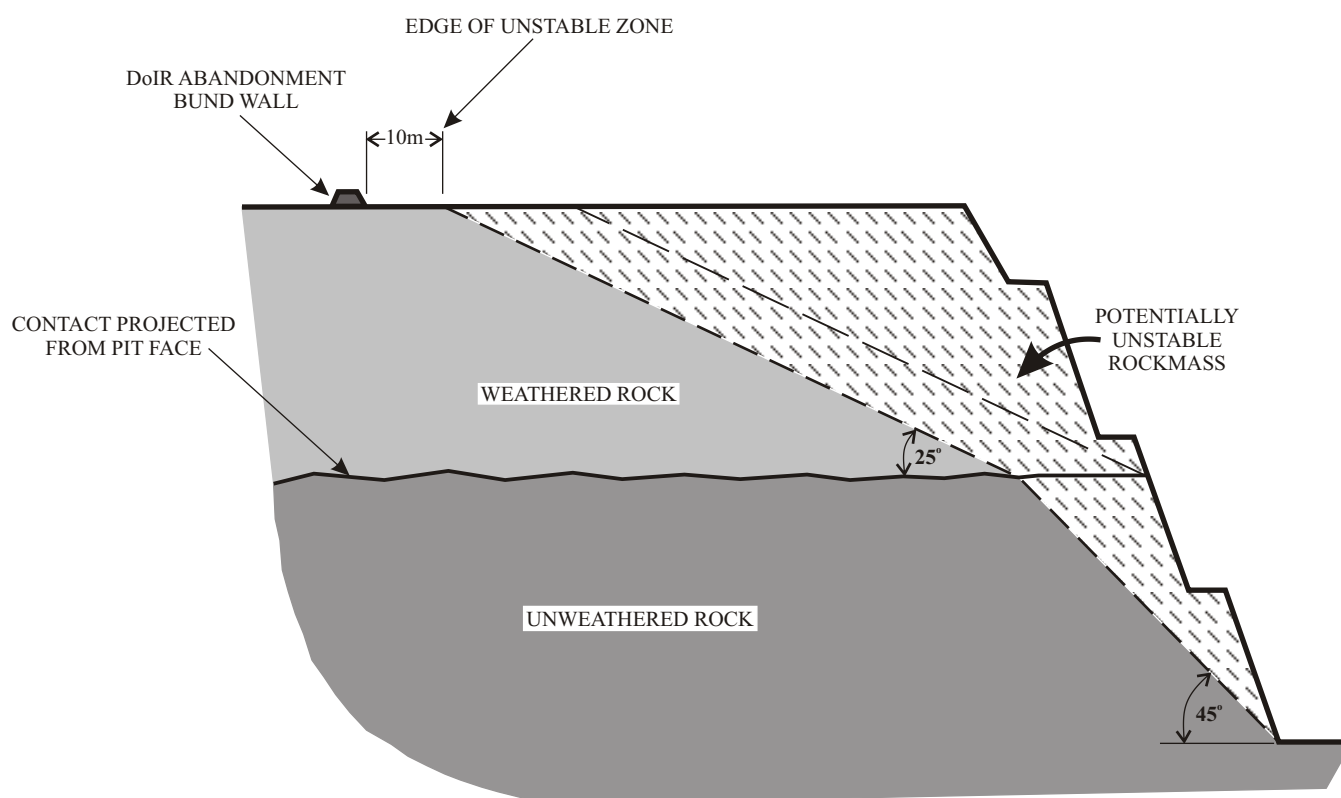


FIGURE SUPPLIED BY DoIR (1997)


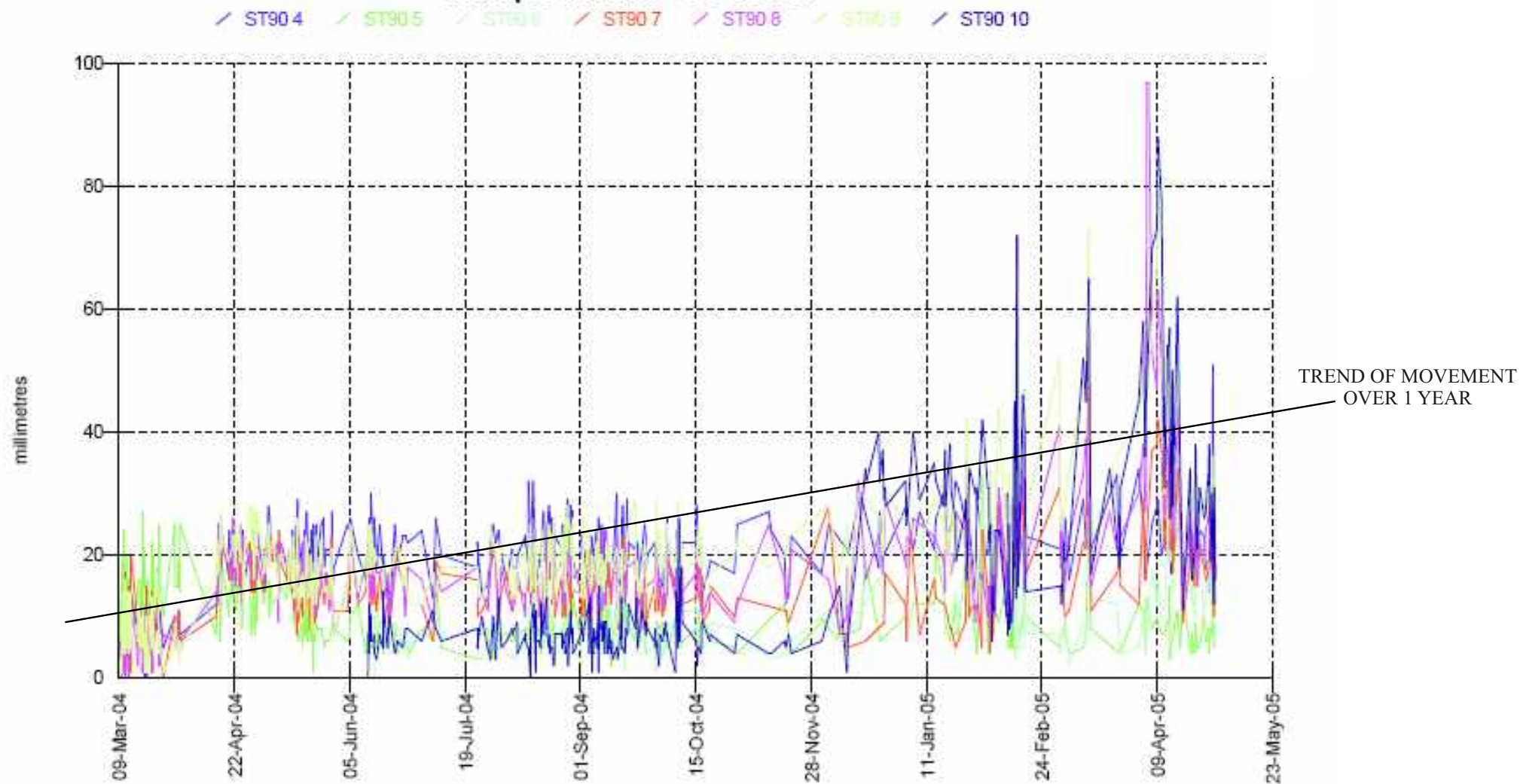
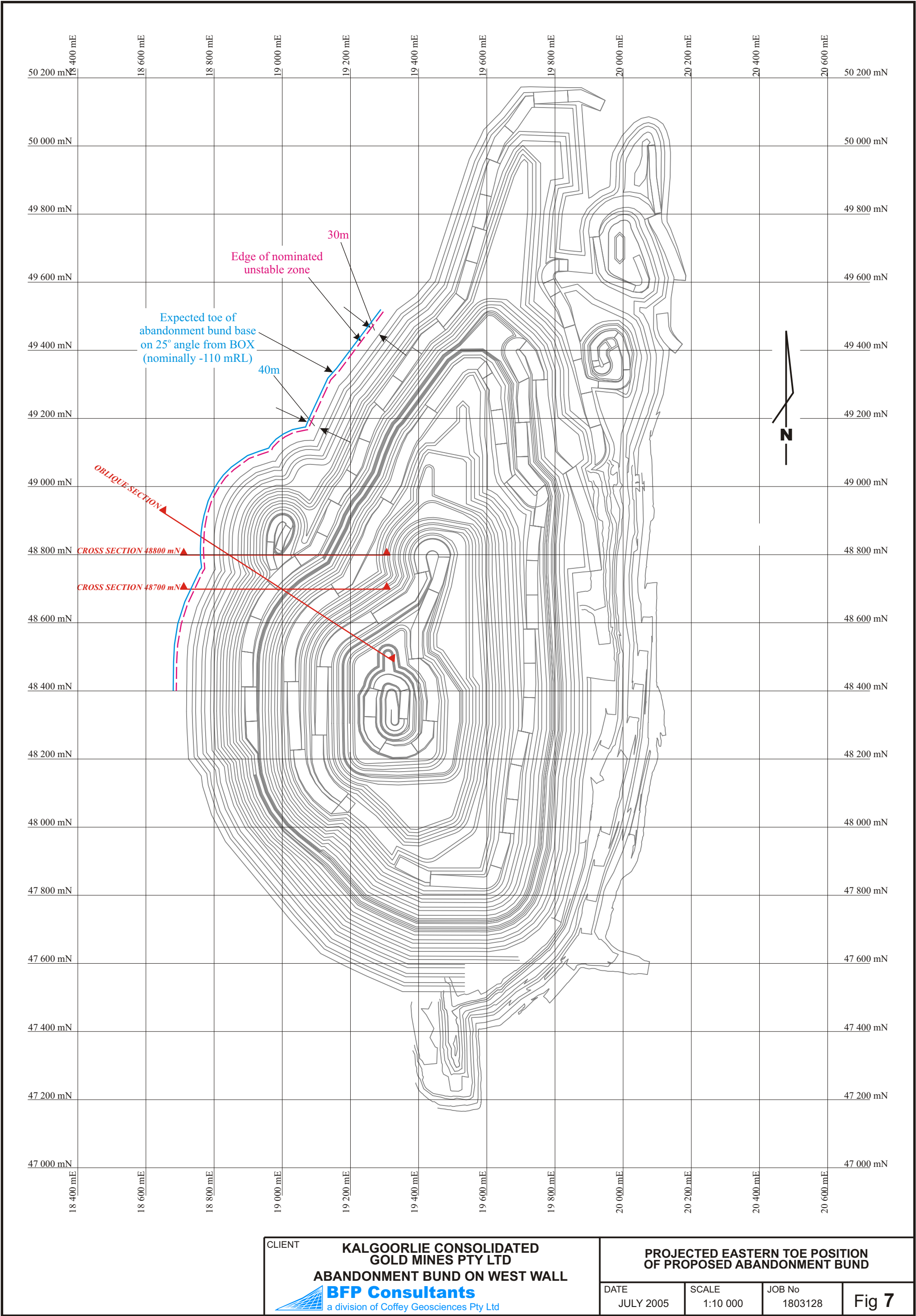
CLIENT KALGOORLIE CONSOLIDATED GOLD MINES PTY LTD ABANDONMENT BUND ON WEST WALL  BFP Consultants a division of Coffey Geosciences Pty Ltd	EXAMPLE OF ABANDONMENT BUND LOCATION		
	DATE JULY 2005	SCALE 1:1000	JOB No 1803128

Fig 5

Multiple Prisms - 3D vector



CLIENT		KALGOORLIE CONSOLIDATED GOLD MINES PTY LTD		PRISM MOVEMENT -90 mRL STORES CUTBACK, WEST WALL	
ABANDONMENT BUND ON WEST WALL		BFP Consultants		DATE	JULY 2005
a division of Coffey Geosciences Pty Ltd		SCALE		AS SHOWN	JOB No
					1803128
				Fig 6	



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ABANDONMENT BUND ON WEST WALL



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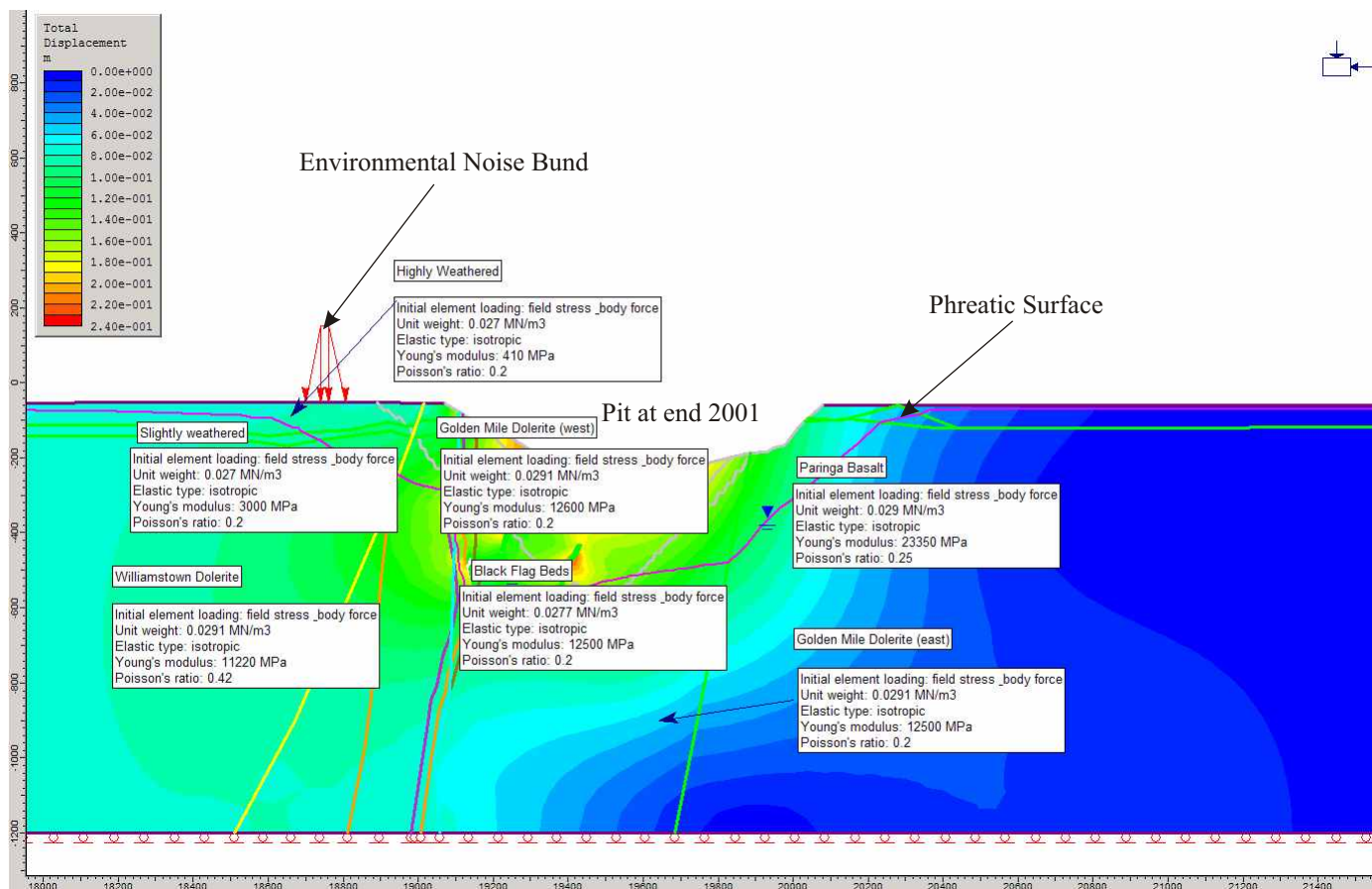
**PROJECTED EASTERN TOE POSITION
OF PROPOSED ABANDONMENT BUND**


DATE
JULY 2005

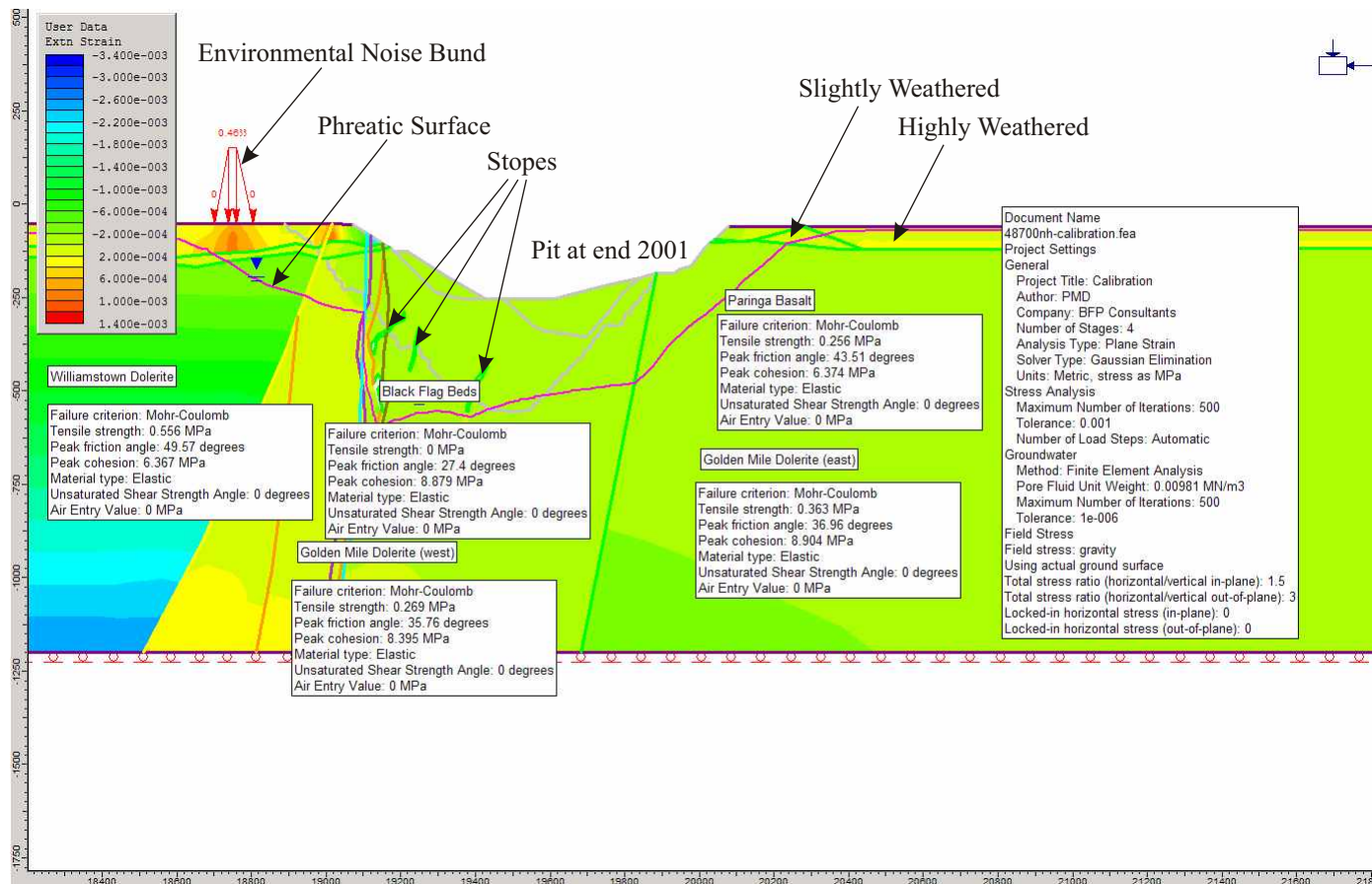
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JOB No
1803128

Fig 7



CLIENT KALGOORLIE CONSOLIDATED GOLD MINES PTY LTD ABANDONMENT BUND ON WEST WALL  BFP Consultants a division of Coffey Geosciences Pty Ltd	ELASTIC PROPERTIES PIT AT END 2001			
	DATE JULY 2005	SCALE 1:20 000	JOB No 1803128	Fig 8



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ABANDONMENT BUND ON WEST WALL



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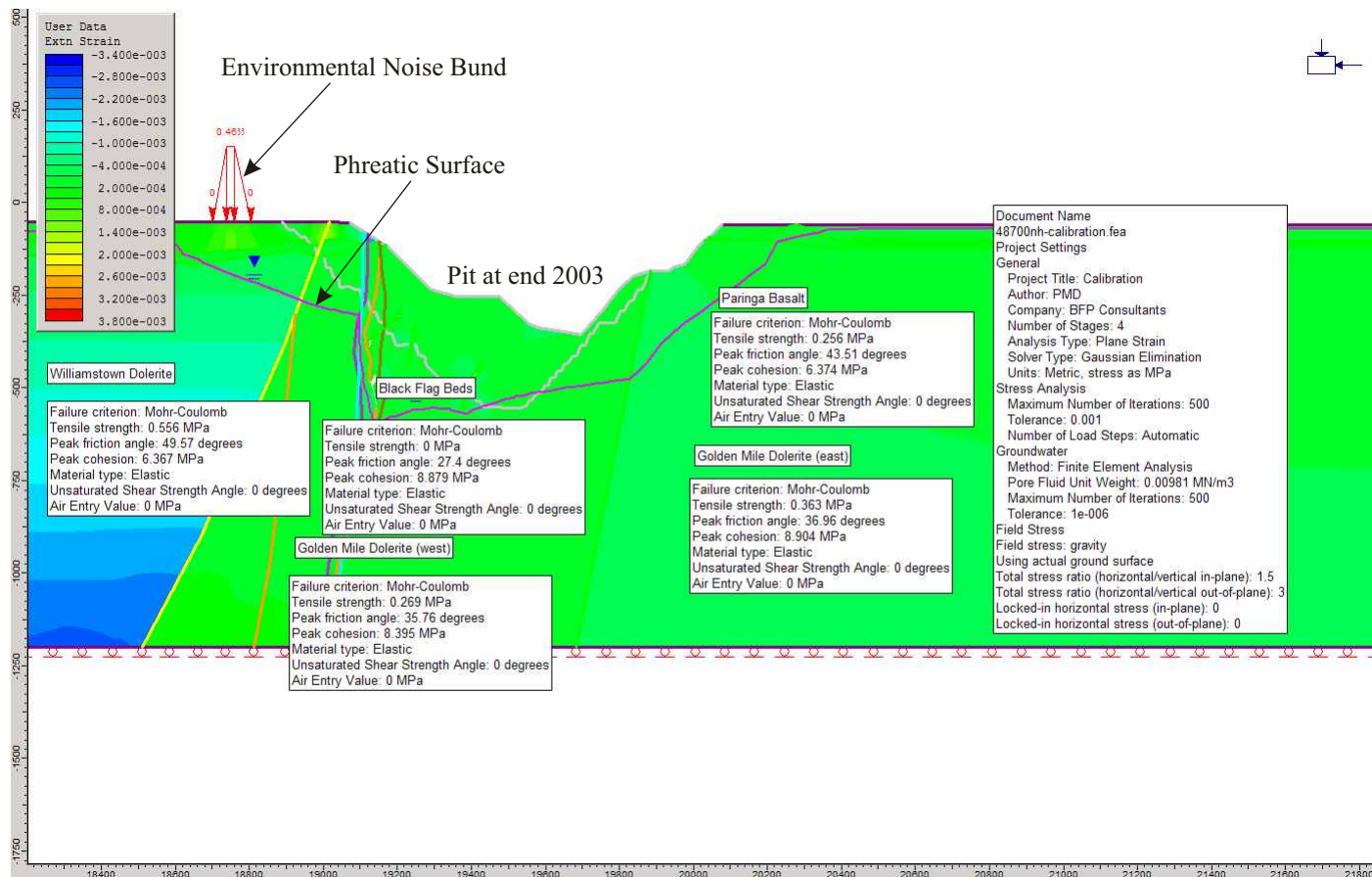
**MATERIAL PROPERTIES
PIT AT END 2001**

DATE
JULY 2005

SCALE
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Fig 9



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**KALGOORLIE CONSOLIDATED
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ABANDONMENT BUND ON WEST WALL



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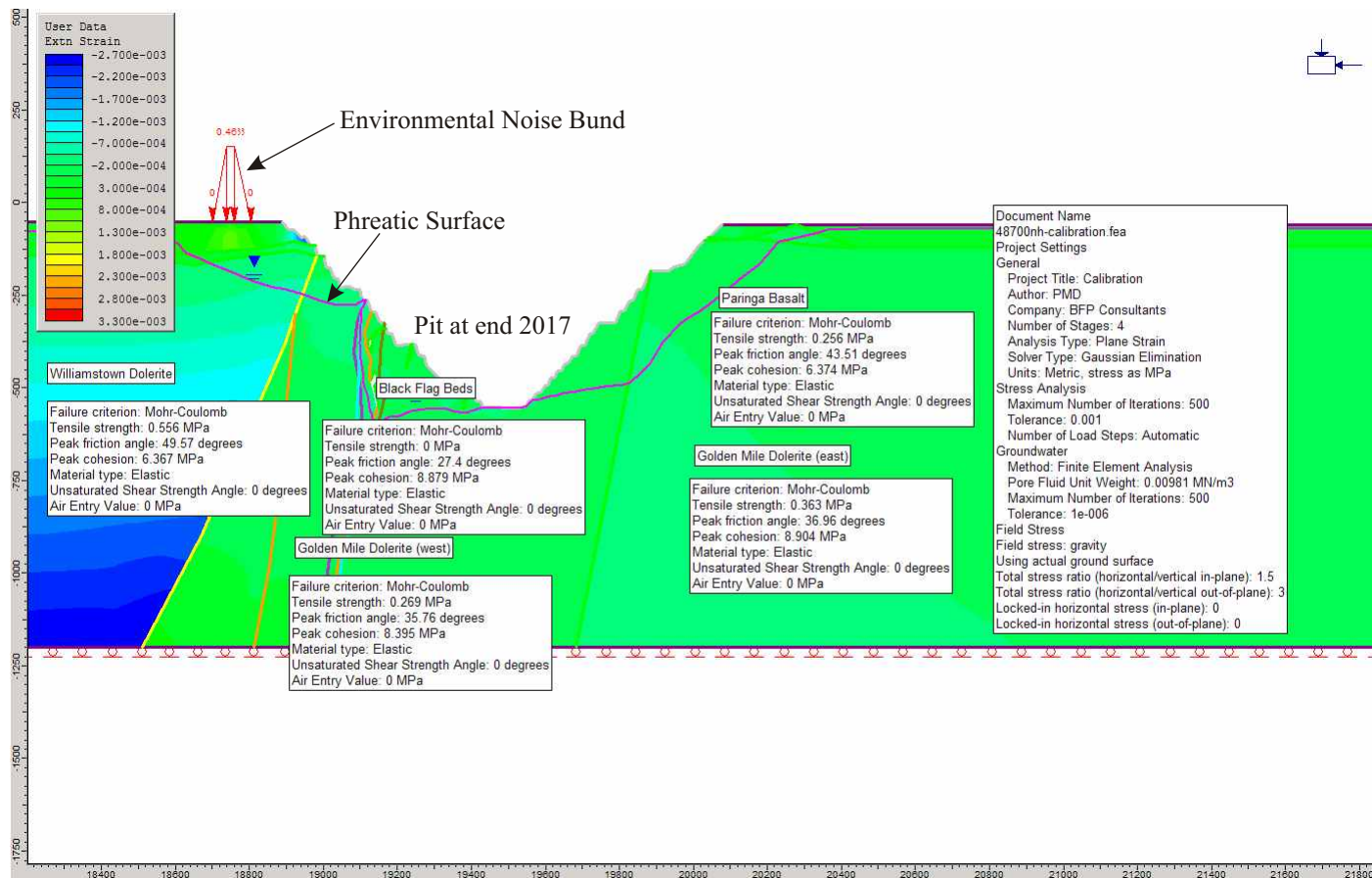
**ELASTIC PROPERTIES
PIT AT END 2003**

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JULY 2005

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Fig 10



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ABANDONMENT BUND ON WEST WALL



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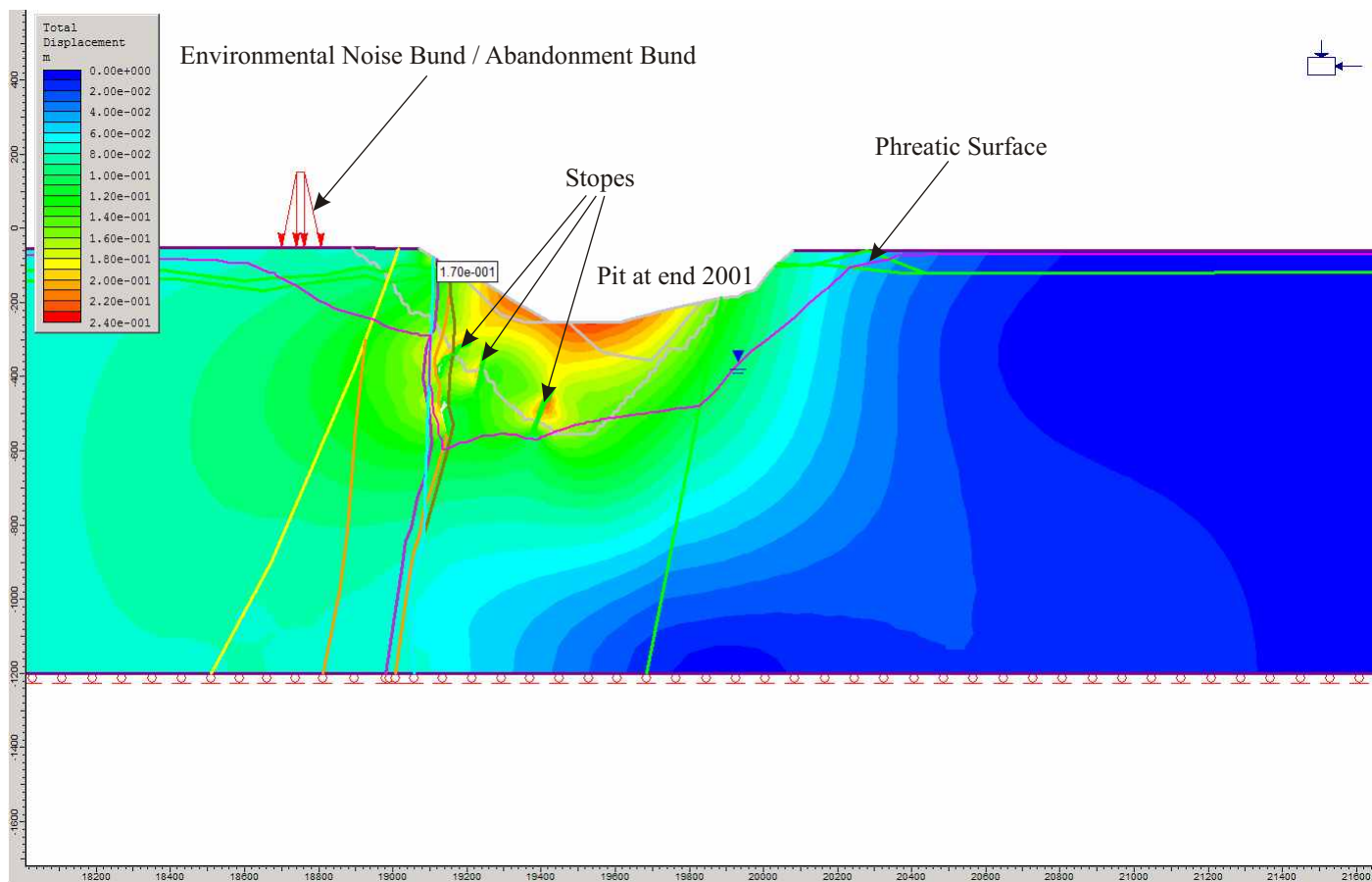
**MATERIAL PROPERTIES
PIT AT END 2017**

DATE
JULY 2005

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Fig 11



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ABANDONMENT BUND ON WEST WALL



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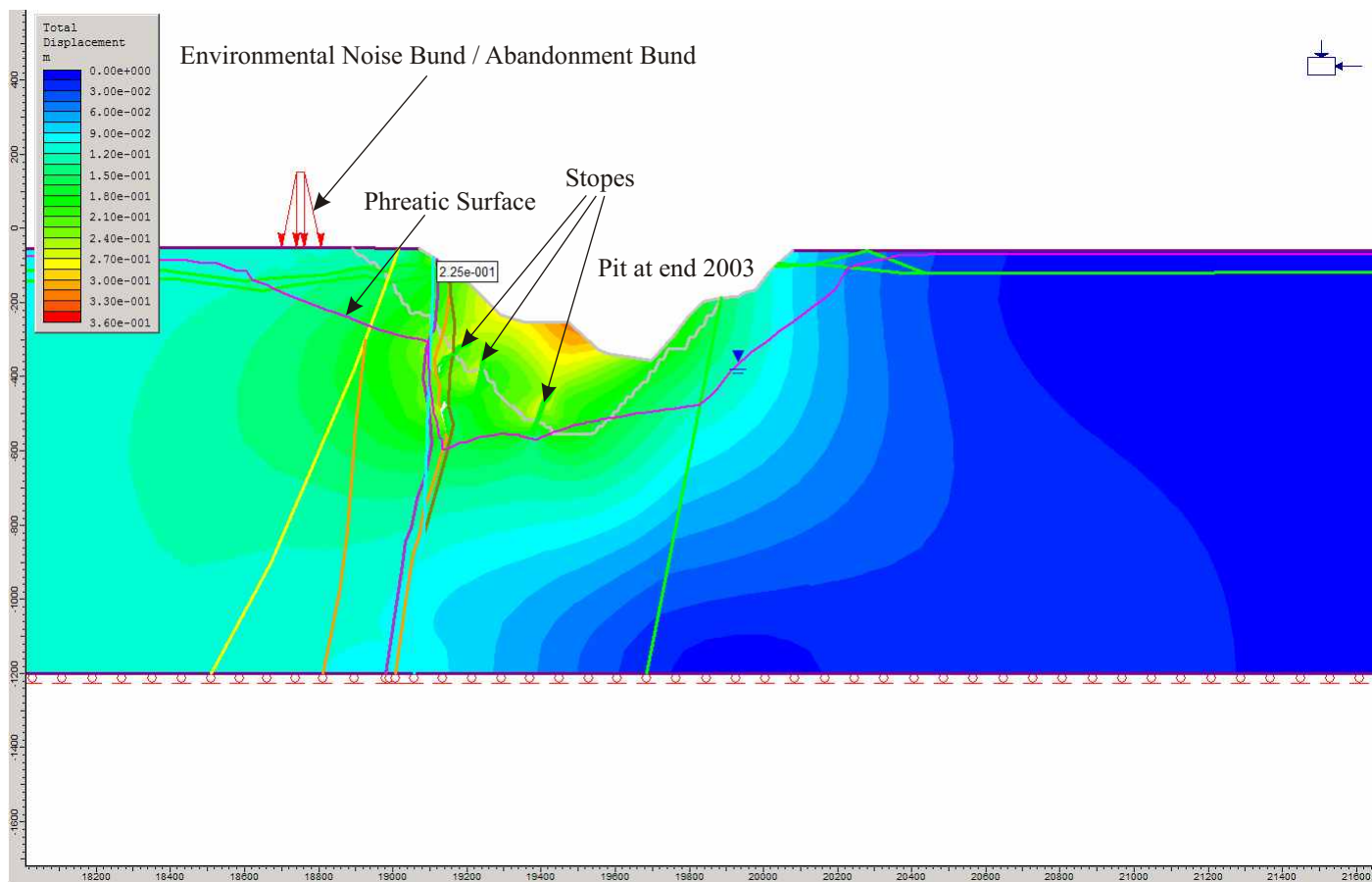
**TOTAL DISPLACEMENT AT END OF 2001
AT -90 mRL = 170mm**

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SCALE
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Fig 12



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ABANDONMENT BUND ON WEST WALL



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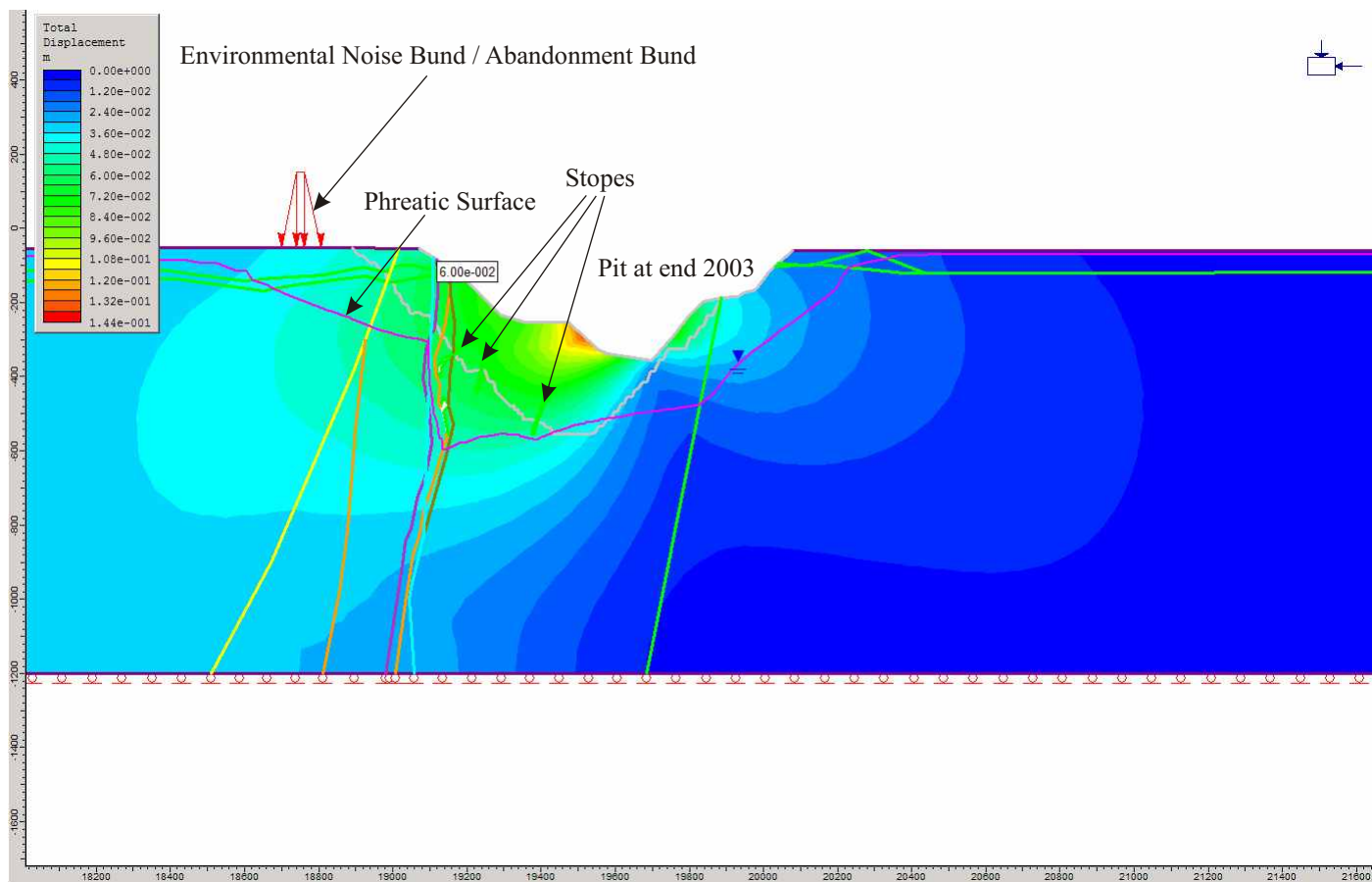
**TOTAL DISPLACEMENT AT END OF 2003
AT -90 mRL = 225 mm**

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SCALE
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Fig 13



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ABANDONMENT BUND ON WEST WALL



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CALCULATED DIFFERENTIAL DISPLACEMENT
AT -90 mRL = 60 mm
EQUATES TO PRISM MEASUREMENT OF 50 - 90mm

DATE
JULY 2005

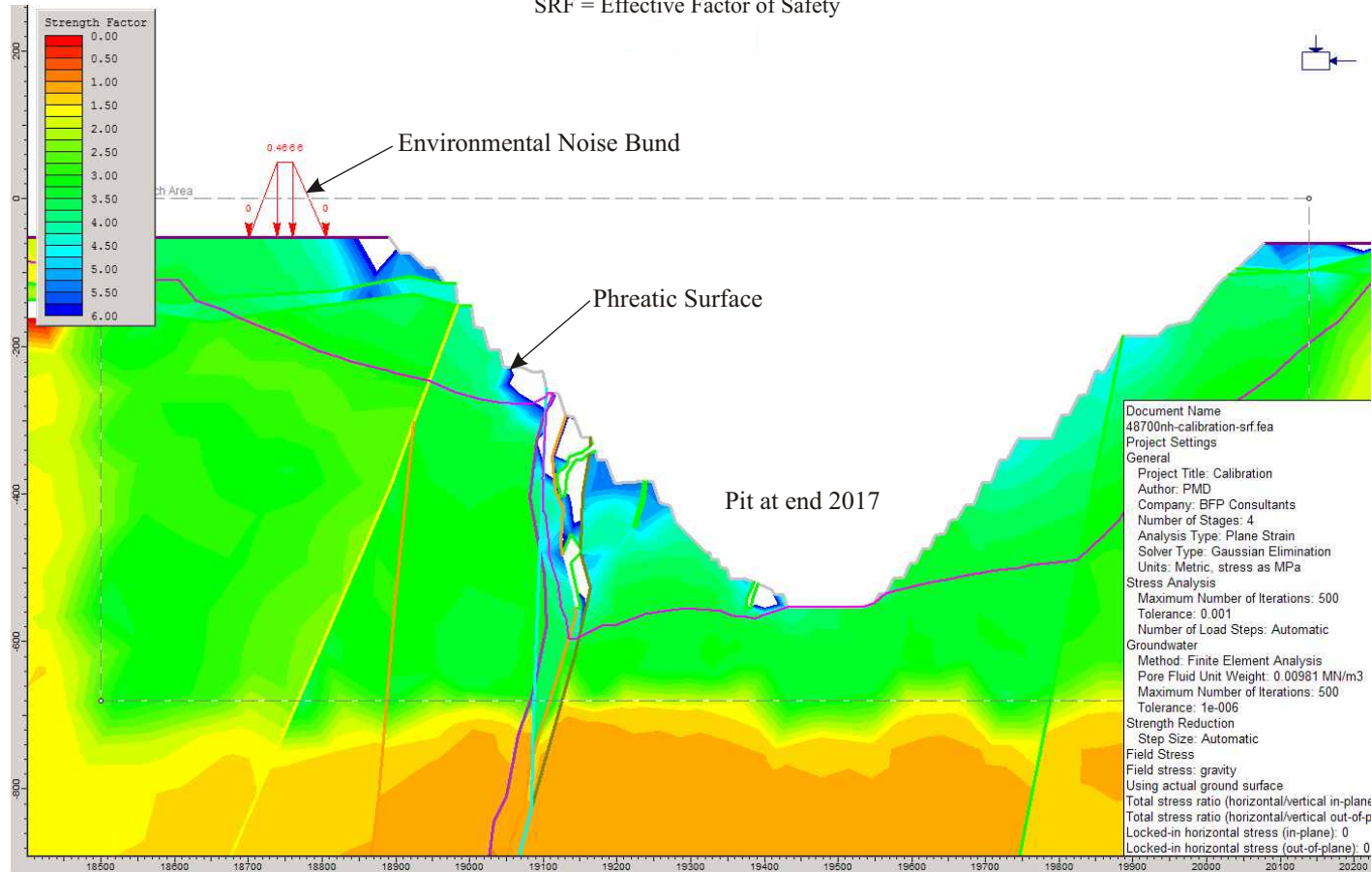
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Fig 14

Critical SRF = 4.54

SRF = Strength Reduction Factor
SRF = Effective Factor of Safety



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**END OF MINING
48700 mN - STRENGTH FACTOR**

DATE
JULY 2005

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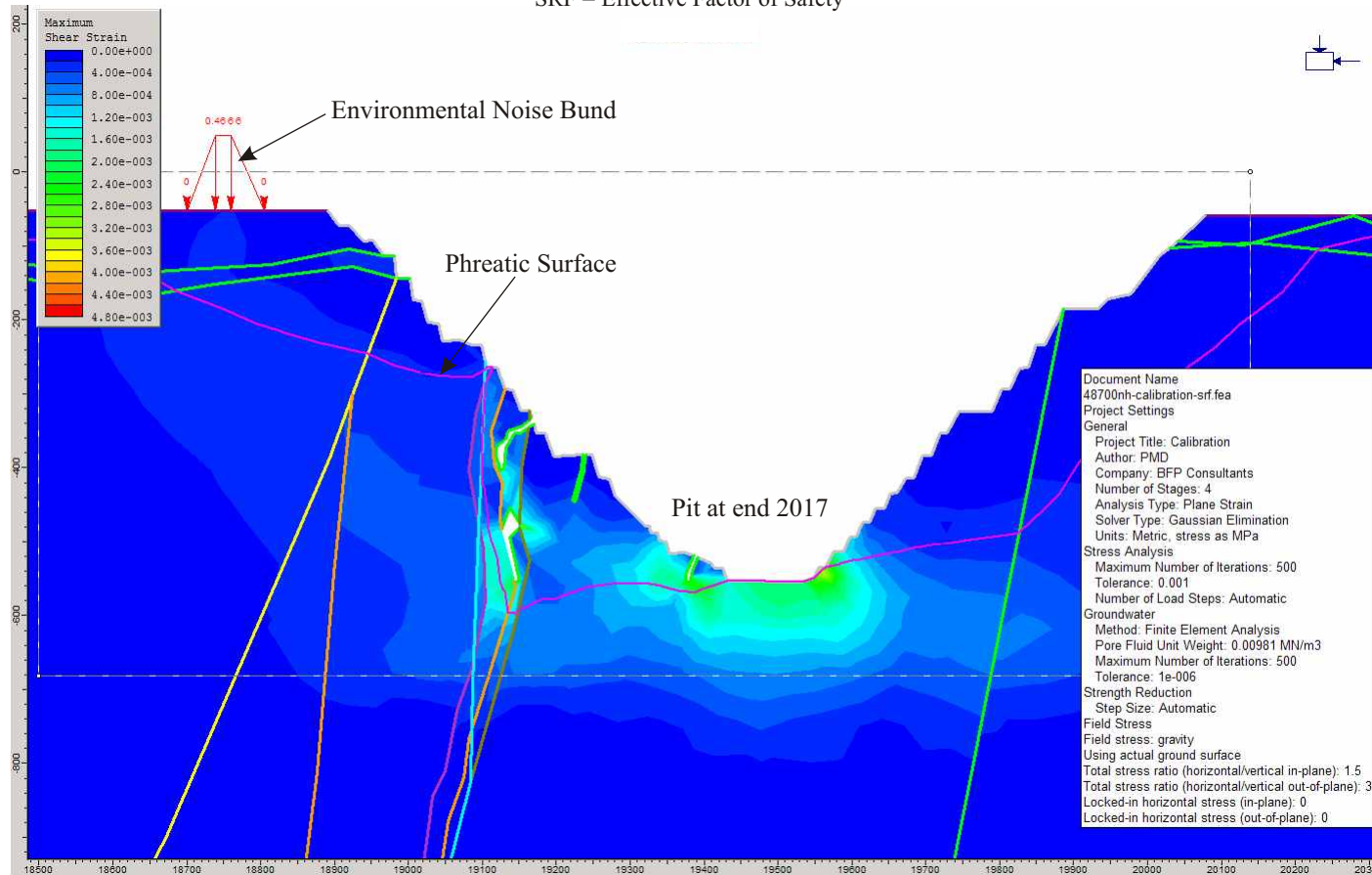
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Fig 15

Critical SRF = 4.54

SRF = Strength Reduction Factor

SRF = Effective Factor of Safety



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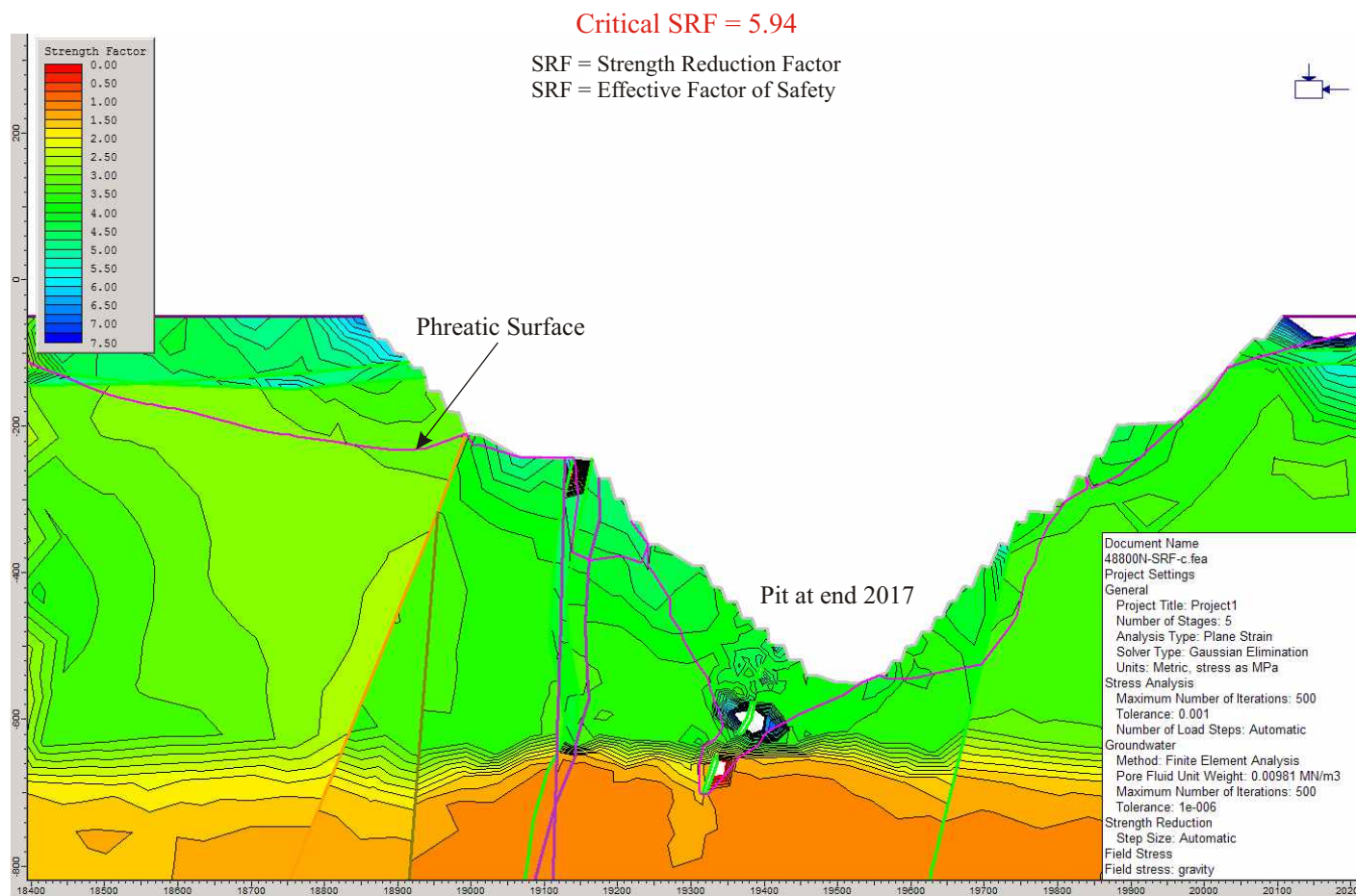
48700 mN - MAXIMUM SHEAR STRAIN

DATE
JULY 2005

SCALE
1:10 000

JOB No
1803128

Fig 16



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ABANDONMENT BUND ON WEST WALL



48800 mN - STRENGTH FACTOR

DATE
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SCALE
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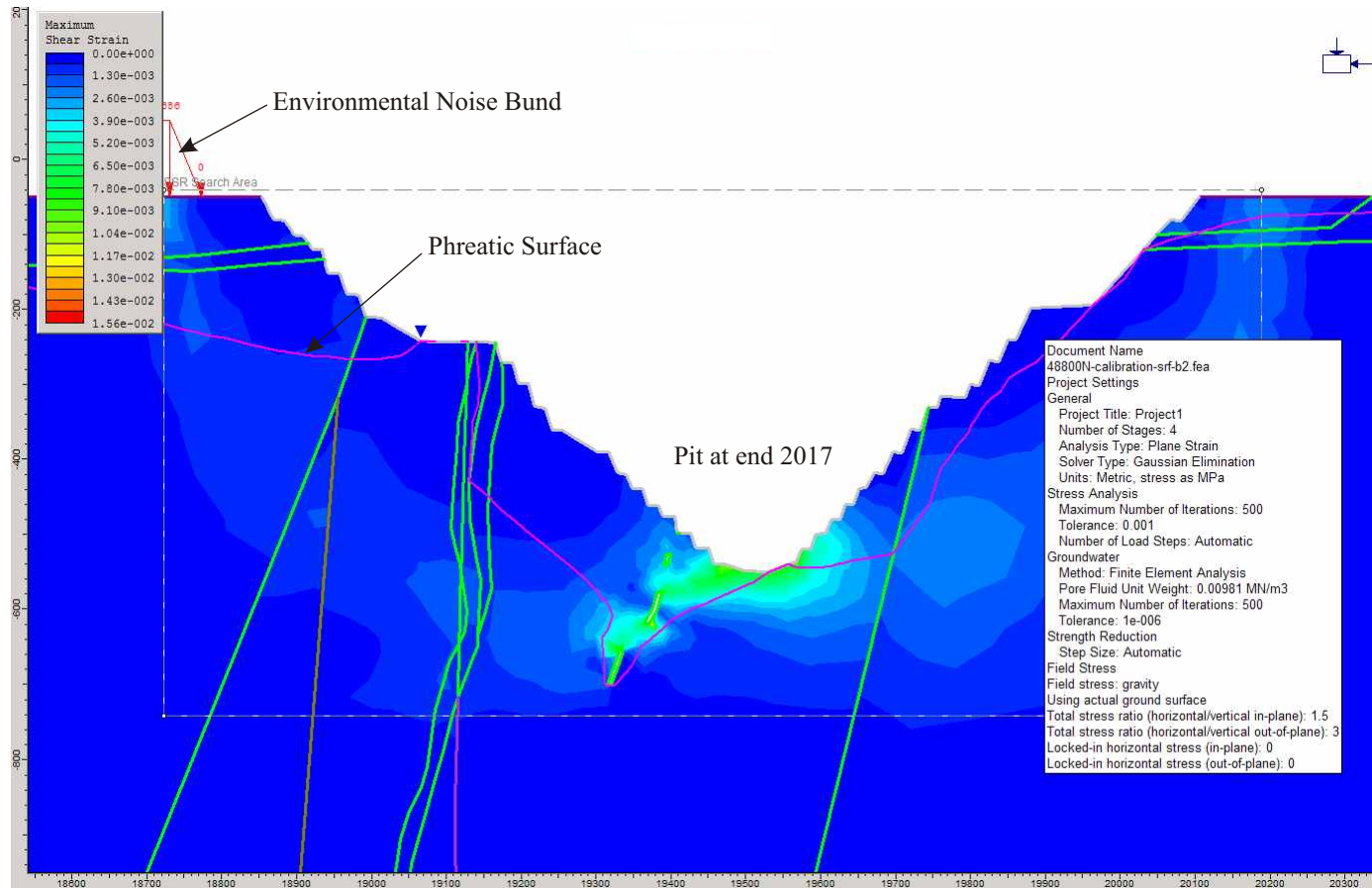
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Fig 17

Critical SRF = 5.94

SRF = Strength Reduction Factor

SRF = Effective Factor of Safety



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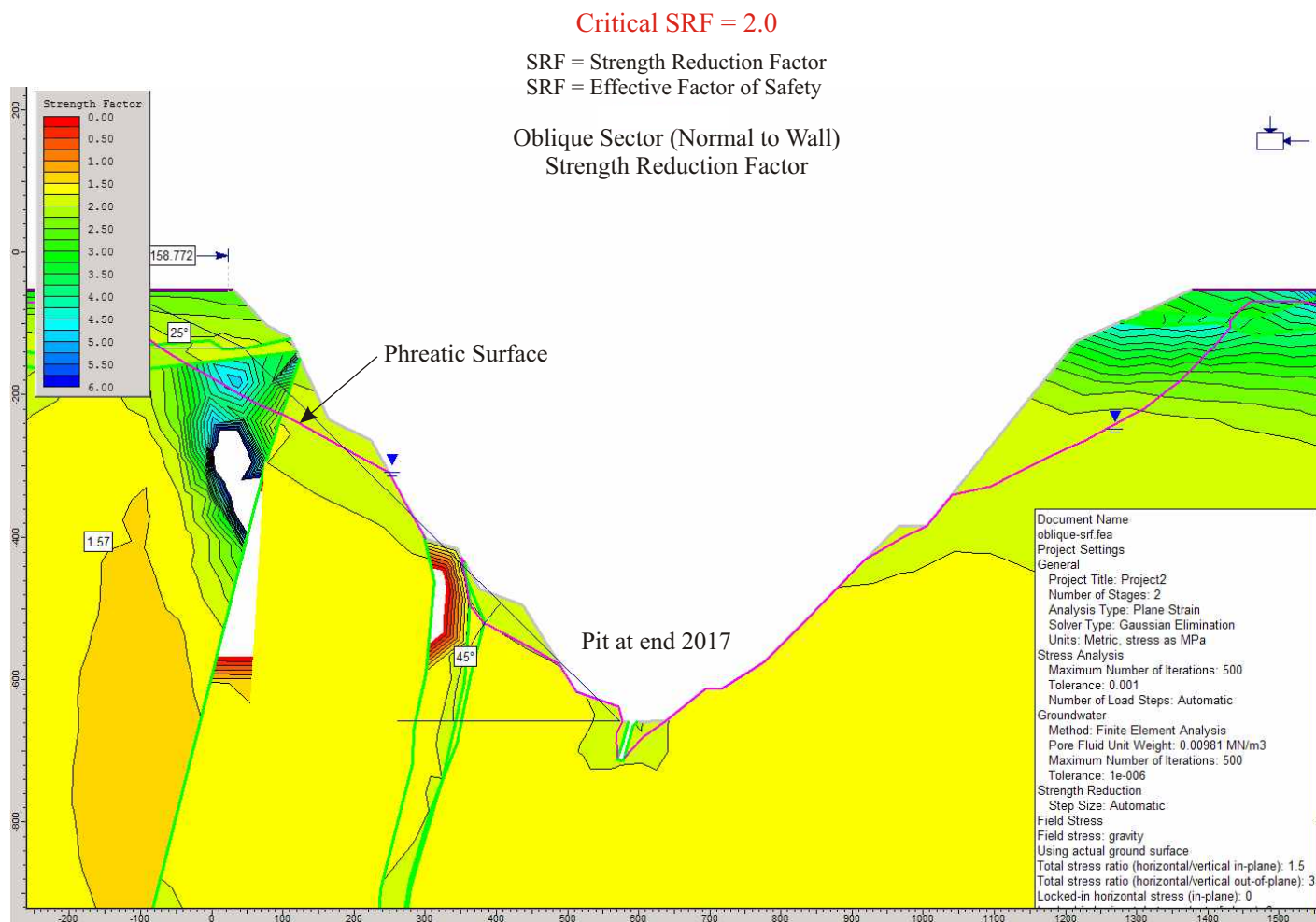
48800 mN - MAXIMUM SHEAR STRAIN

DATE
JULY 2005


SCALE
1:10 000

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Fig 18

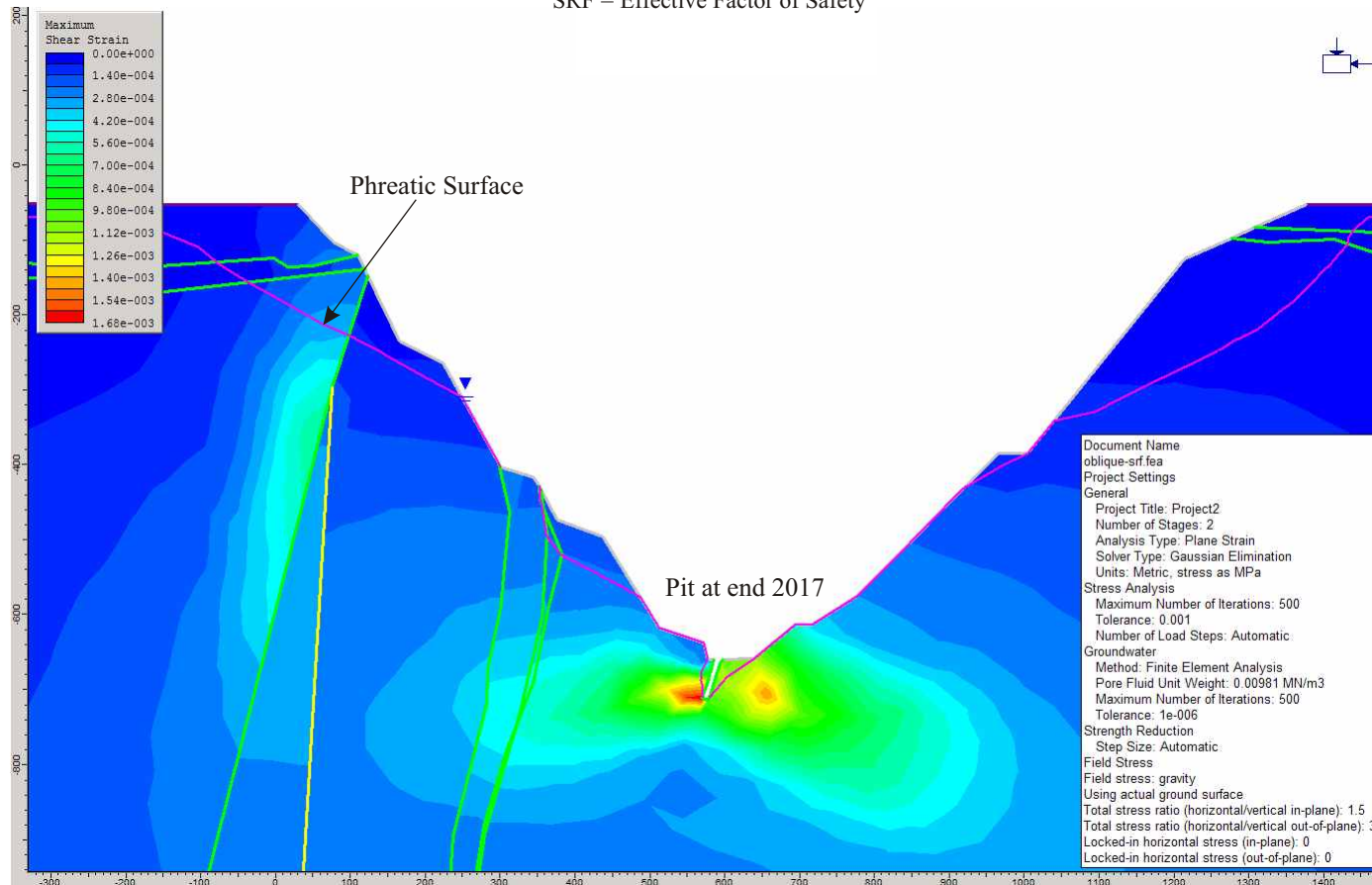


Note: No Section of Slope Has Failed

CLIENT	KALGOORLIE CONSOLIDATED GOLD MINES PTY LTD ABANDONMENT BUND ON WEST WALL  BFP Consultants a division of Coffey Geosciences Pty Ltd	END OF MINING OBLIQUE SECTION - STRENGTH FACTOR			
		DATE JULY 2005	SCALE 1:10 000	JOB No 1803128	Fig 19

Critical SRF = 2.0

SRF = Strength Reduction Factor
SRF = Effective Factor of Safety



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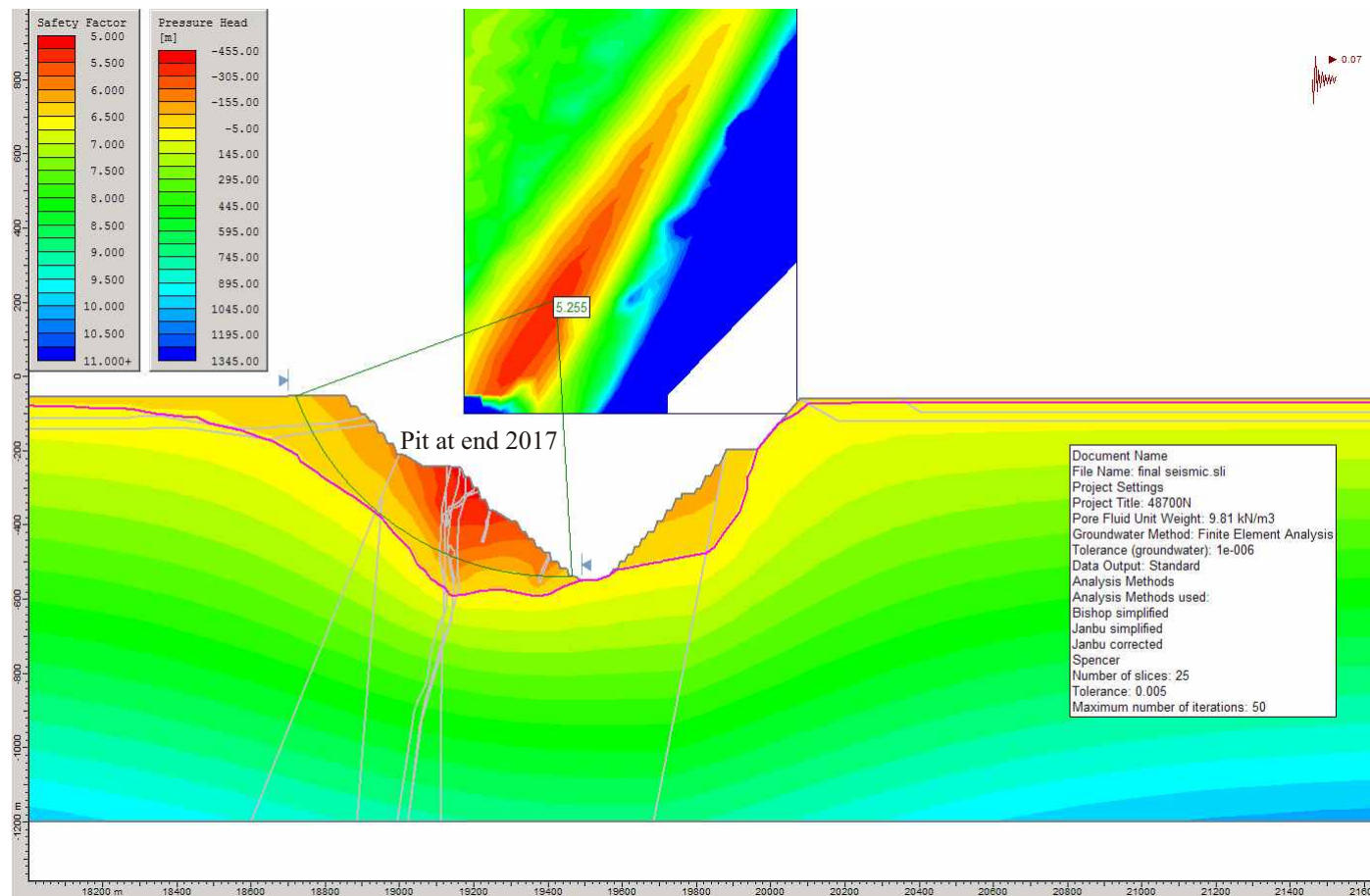
**END OF MINING
OBLIQUE SECTION - MAX. SHEAR STRAIN**


DATE
JULY 2005

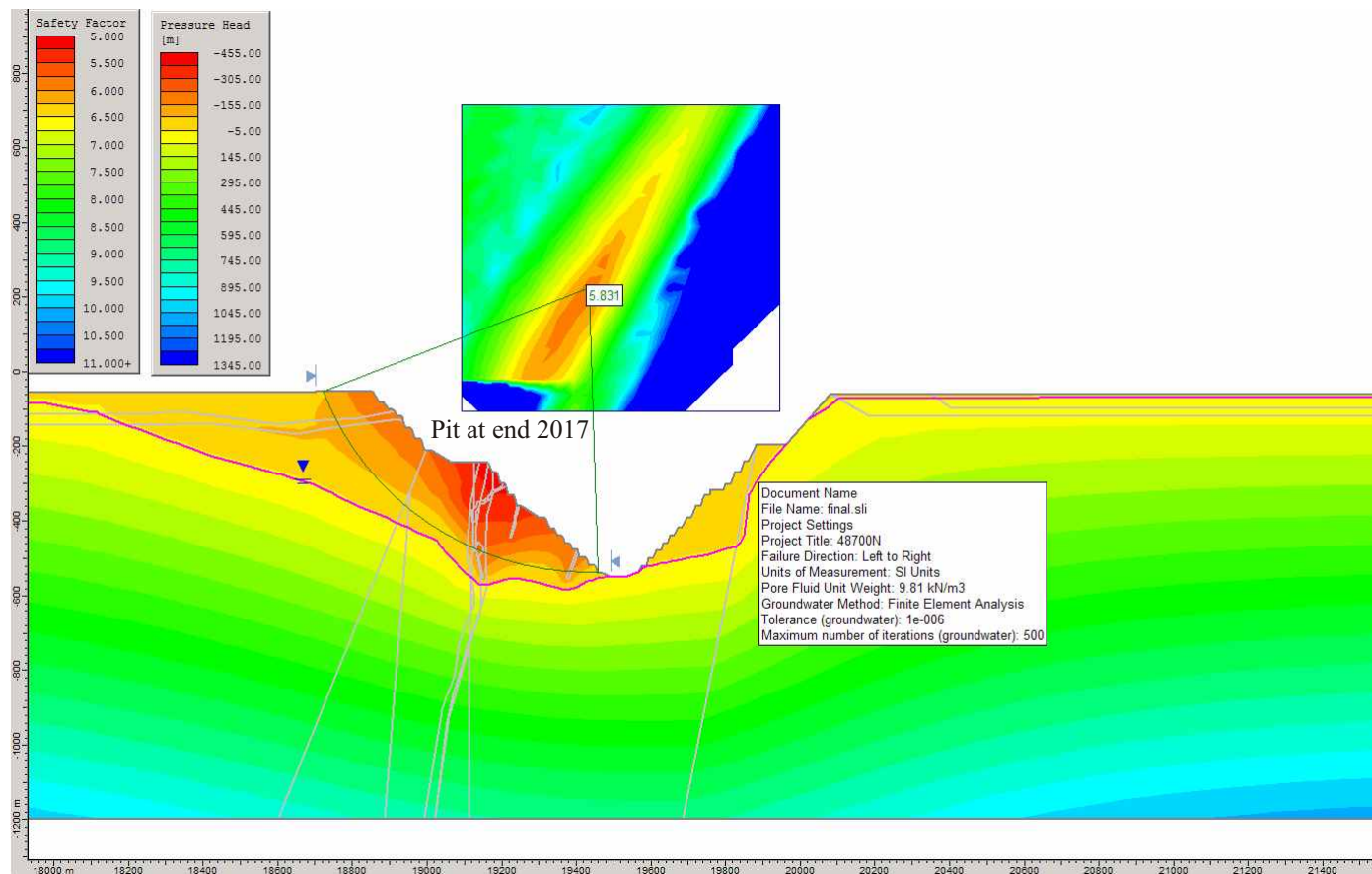
SCALE
1:10 000

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Fig 20



CLIENT KALGOORLIE CONSOLIDATED GOLD MINES PTY LTD ABANDONMENT BUND ON WEST WALL  BFP Consultants a division of Coffey Geosciences Pty Ltd	SLIDE ANALYSIS - 48700 mN INCLUDING SEISMICITY			
	DATE JULY 2005	SCALE 1:20 000	JOB No 1803128	Fig 21



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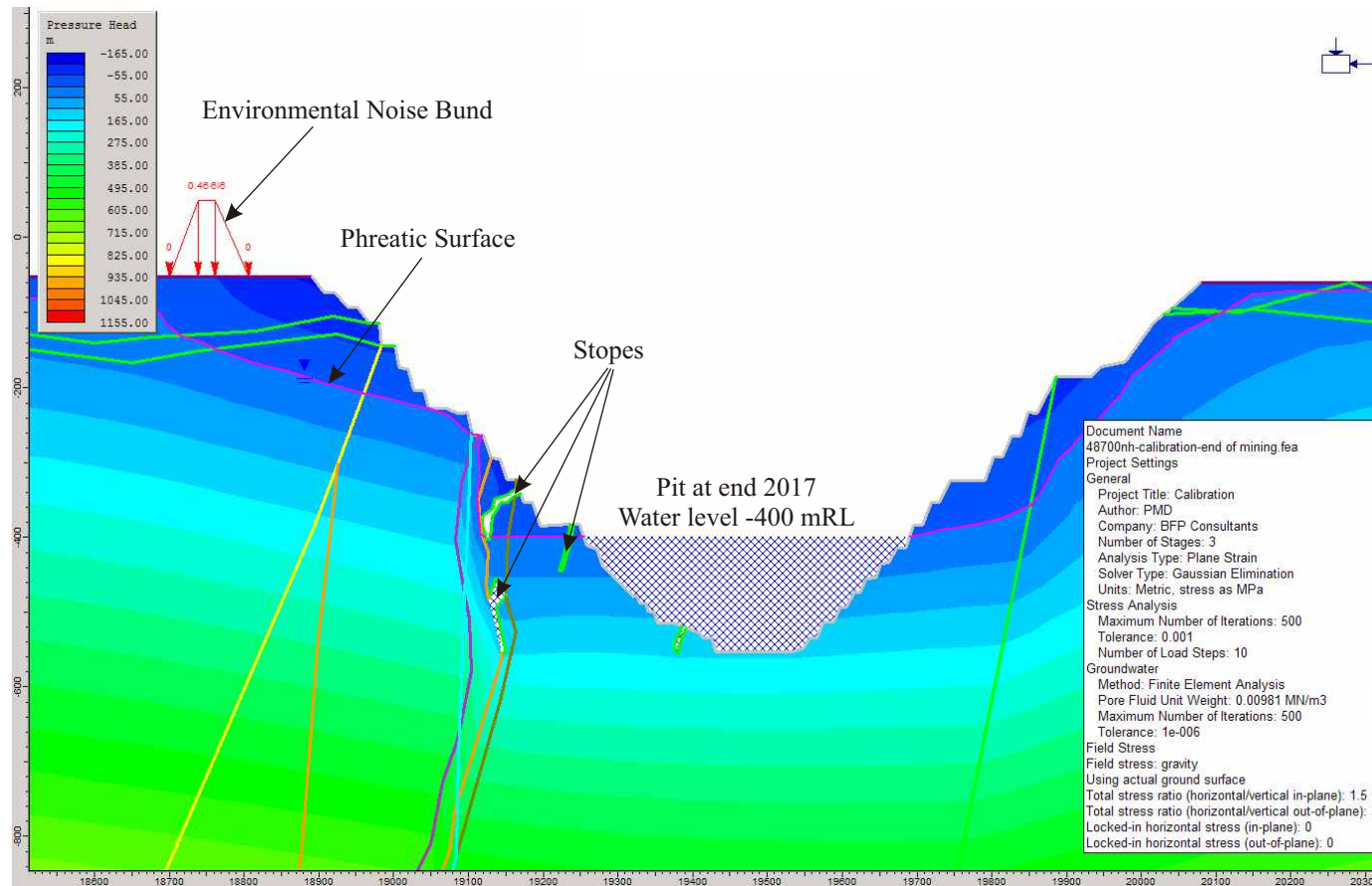
**SLIDE ANALYSIS - 48700 mN
WITHOUT SEISMICITY**

DATE
JULY 2005

SCALE
1:20 000

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Fig 22



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ABANDONMENT BUND ON WEST WALL



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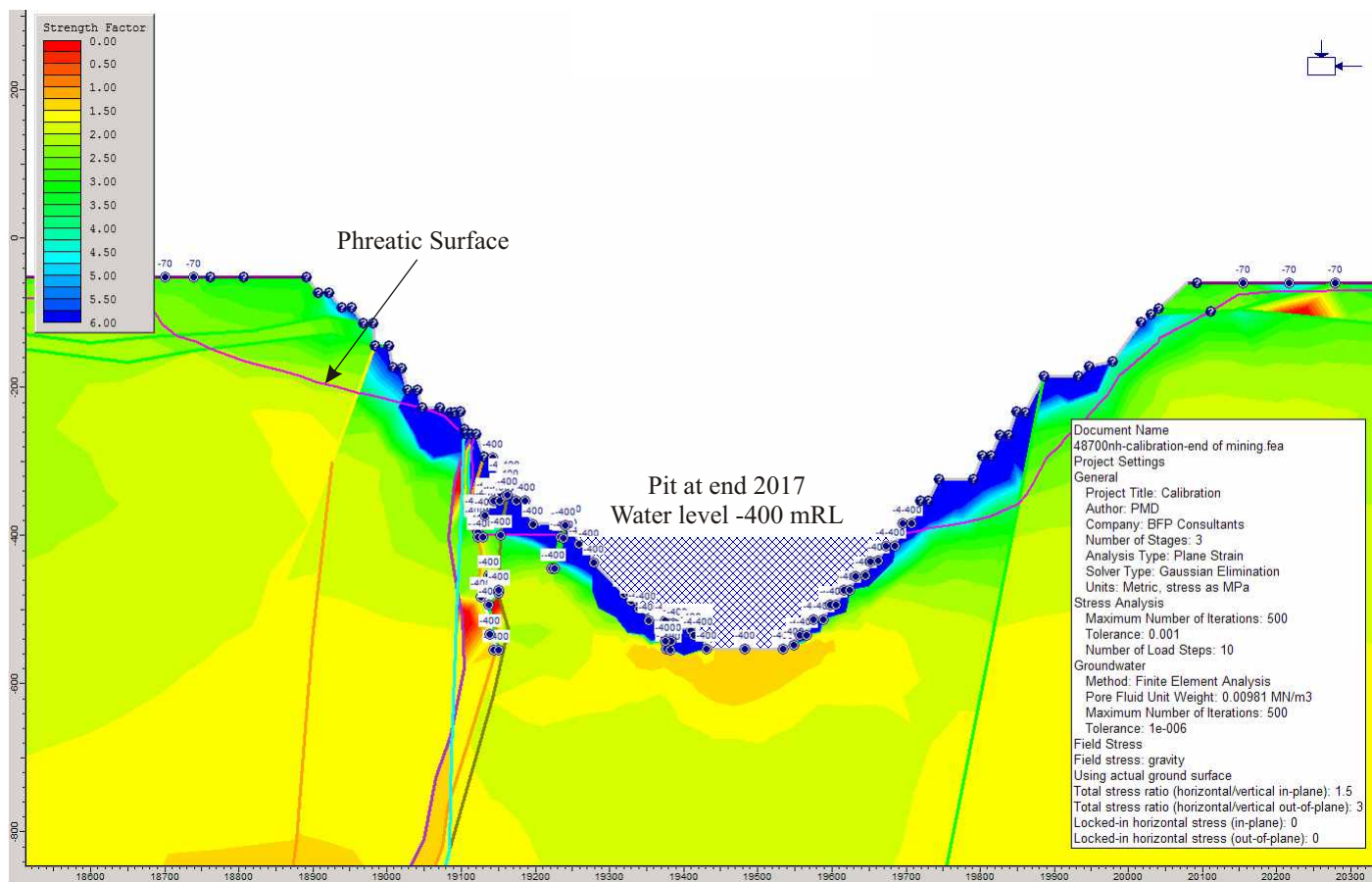
**WATER LEVEL -400 mRL
PRESSURE HEAD**

DATE
JULY 2005

SCALE
1:10 000

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Fig 23



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ABANDONMENT BUND ON WEST WALL



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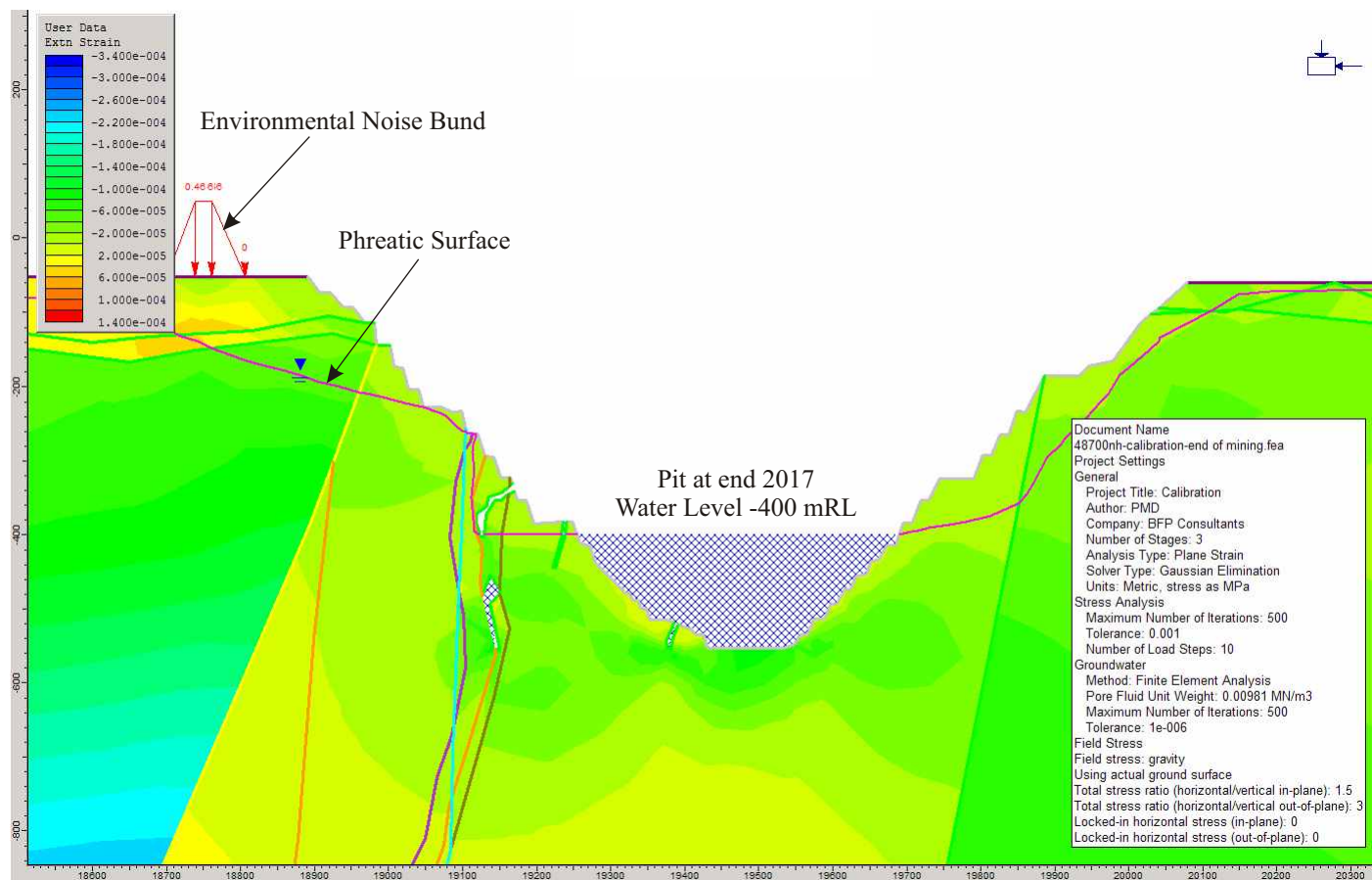
**WATER LEVEL -400 mRL
STRENGTH FACTOR**

DATE
JULY 2005

SCALE
1:10 000

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Fig 24



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ABANDONMENT BUND ON WEST WALL



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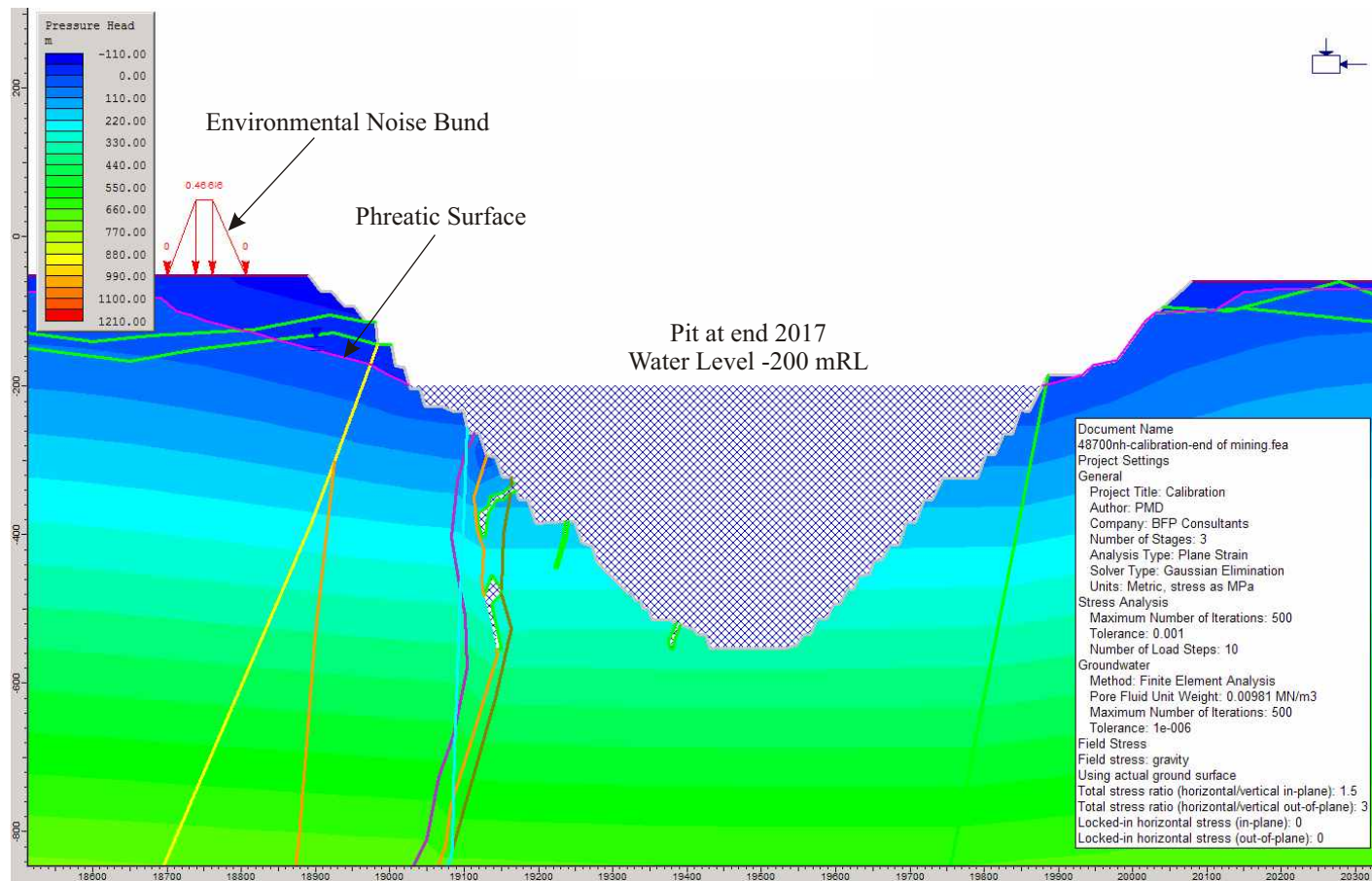
**WATER LEVEL -400 mRL
EXTENSIONAL STRAIN**

DATE
JULY 2005

SCALE
1:10 000

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Fig 25



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ABANDONMENT BUND ON WEST WALL



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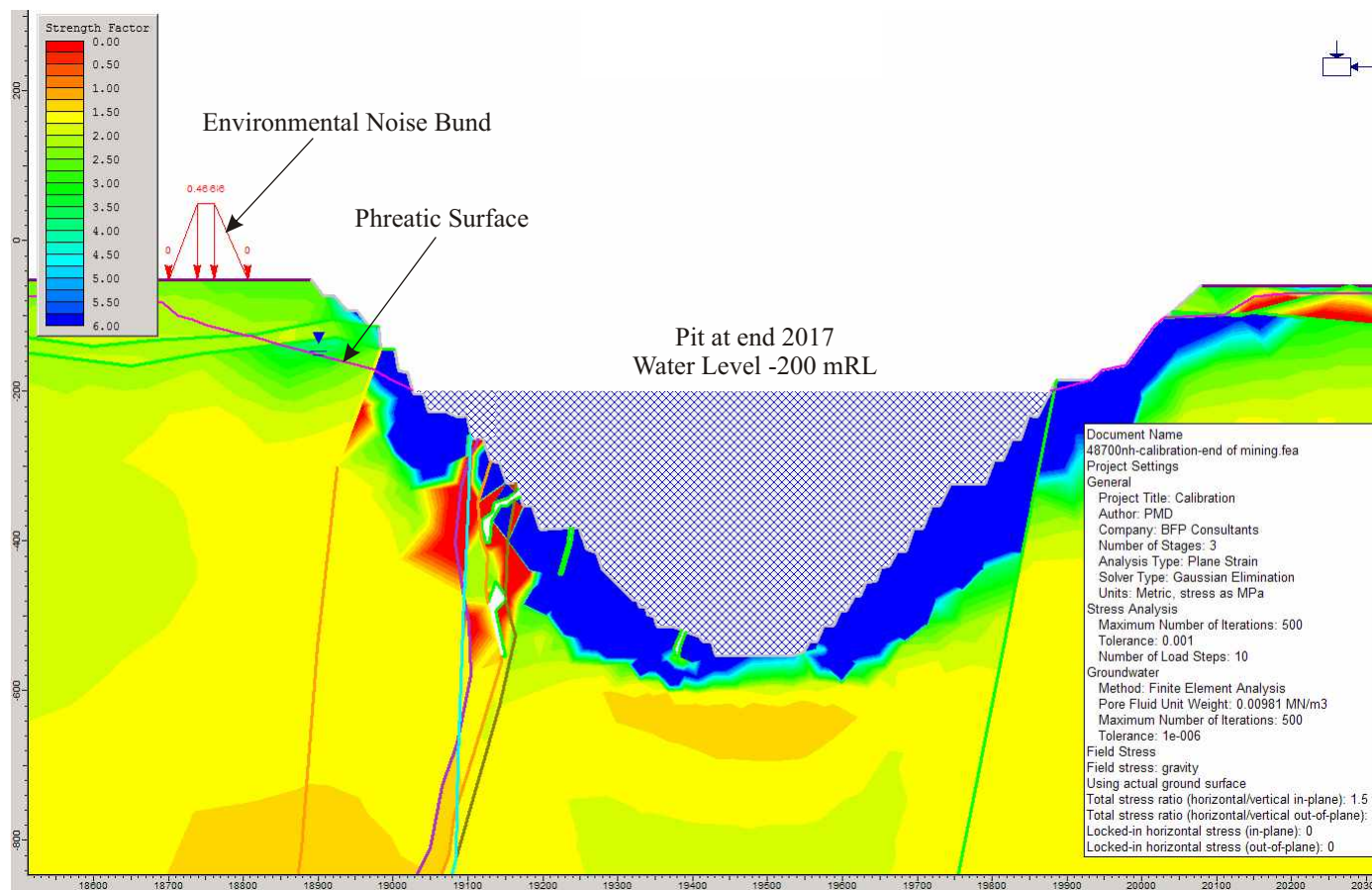
**WATER LEVEL -200 mRL
PRESSURE HEAD**

DATE
JULY 2005

SCALE
1:10 000

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Fig 26



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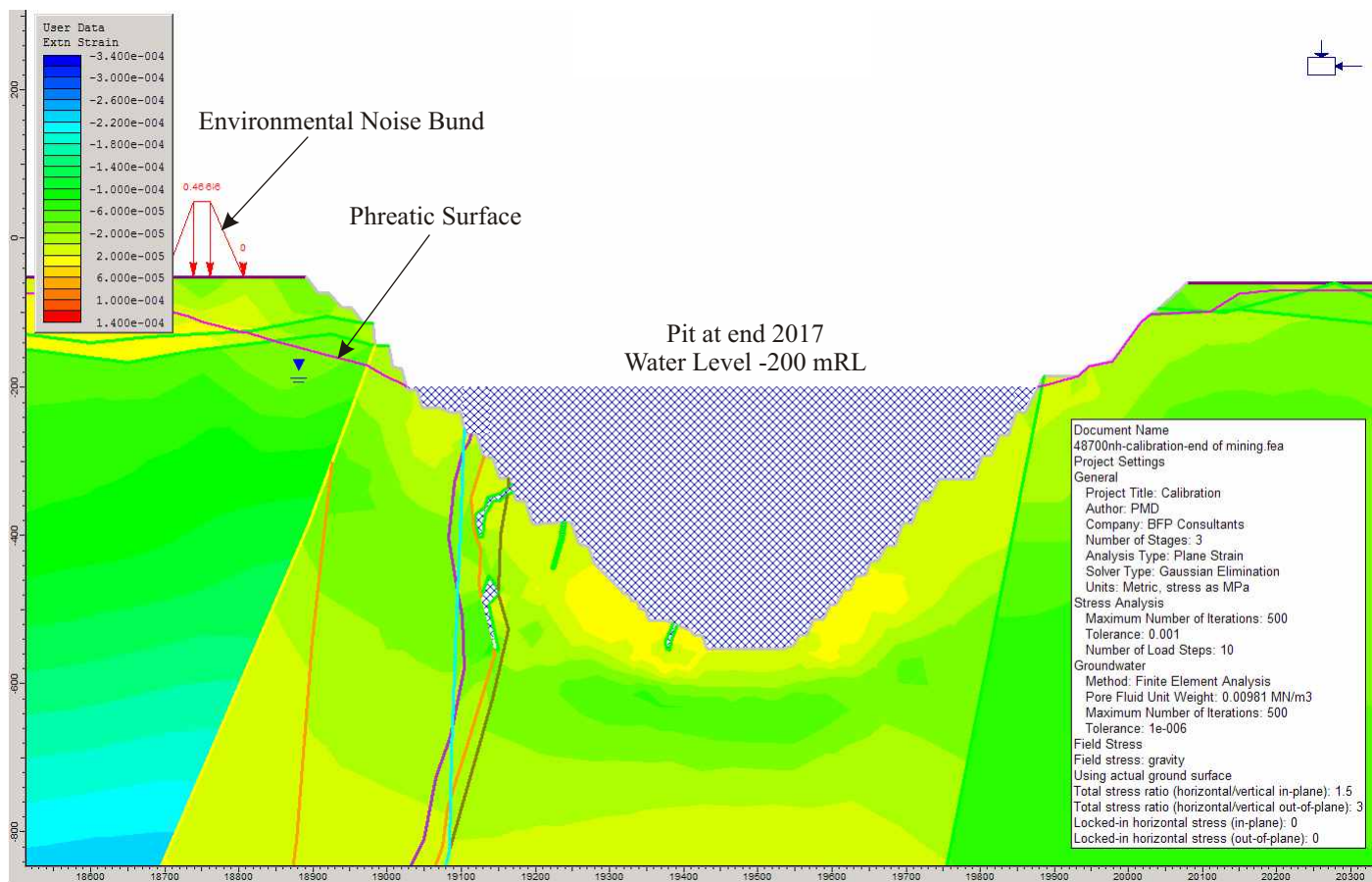
**WATER LEVEL -200 mRL
STRENGTH FACTOR**

DATE
JULY 2005

SCALE
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Fig 27



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ABANDONMENT BUND ON WEST WALL



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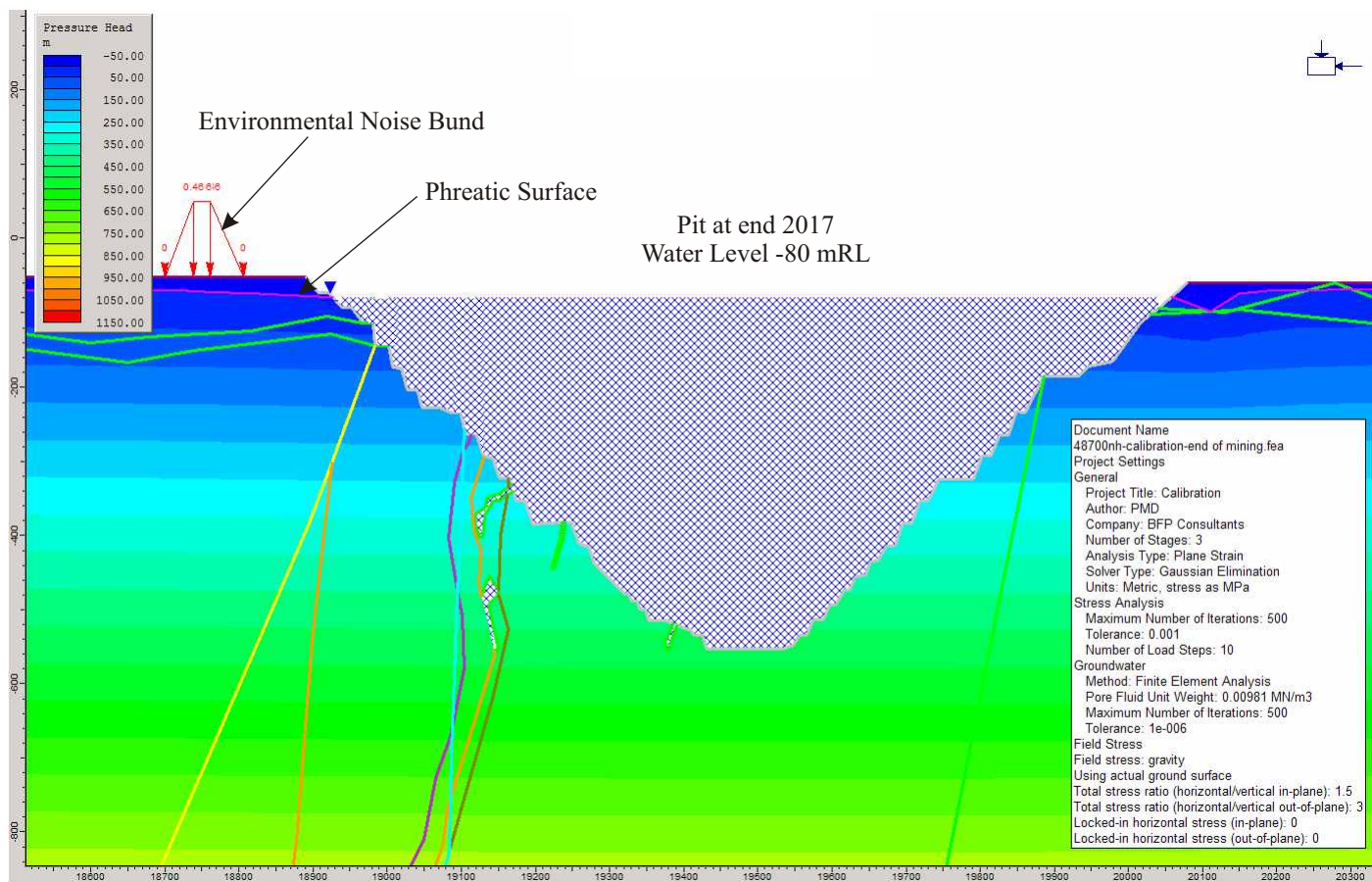
**WATER LEVEL -200 mRL
EXTENSIONAL STRAIN**

DATE
JULY 2005

SCALE
1:10 000

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Fig 28



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ABANDONMENT BUND ON WEST WALL



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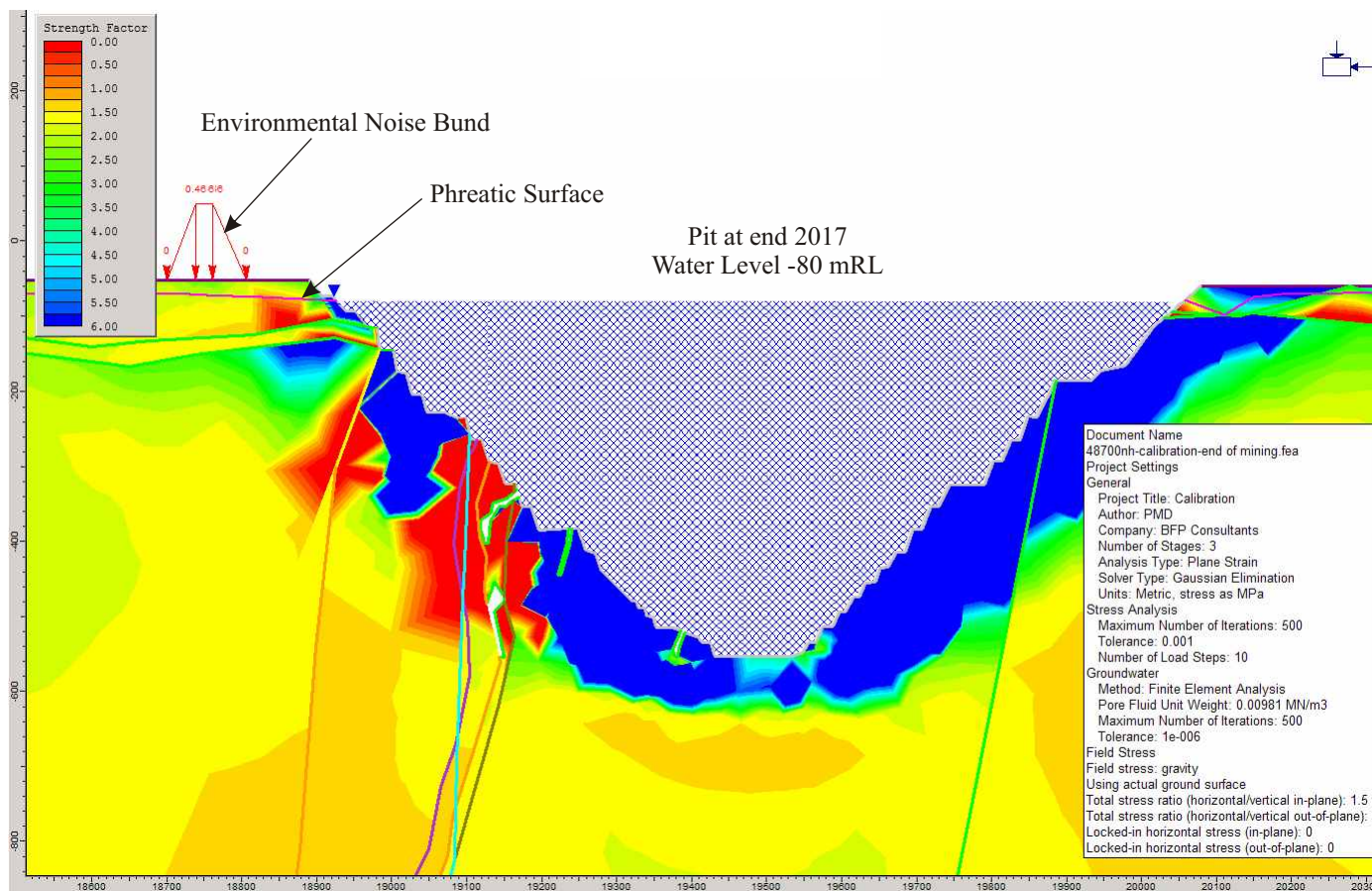
**WATER LEVEL -80 mRL
PRESSURE HEAD**

DATE
JULY 2005

SCALE
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JOB No
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Fig 29



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**KALGOORLIE CONSOLIDATED
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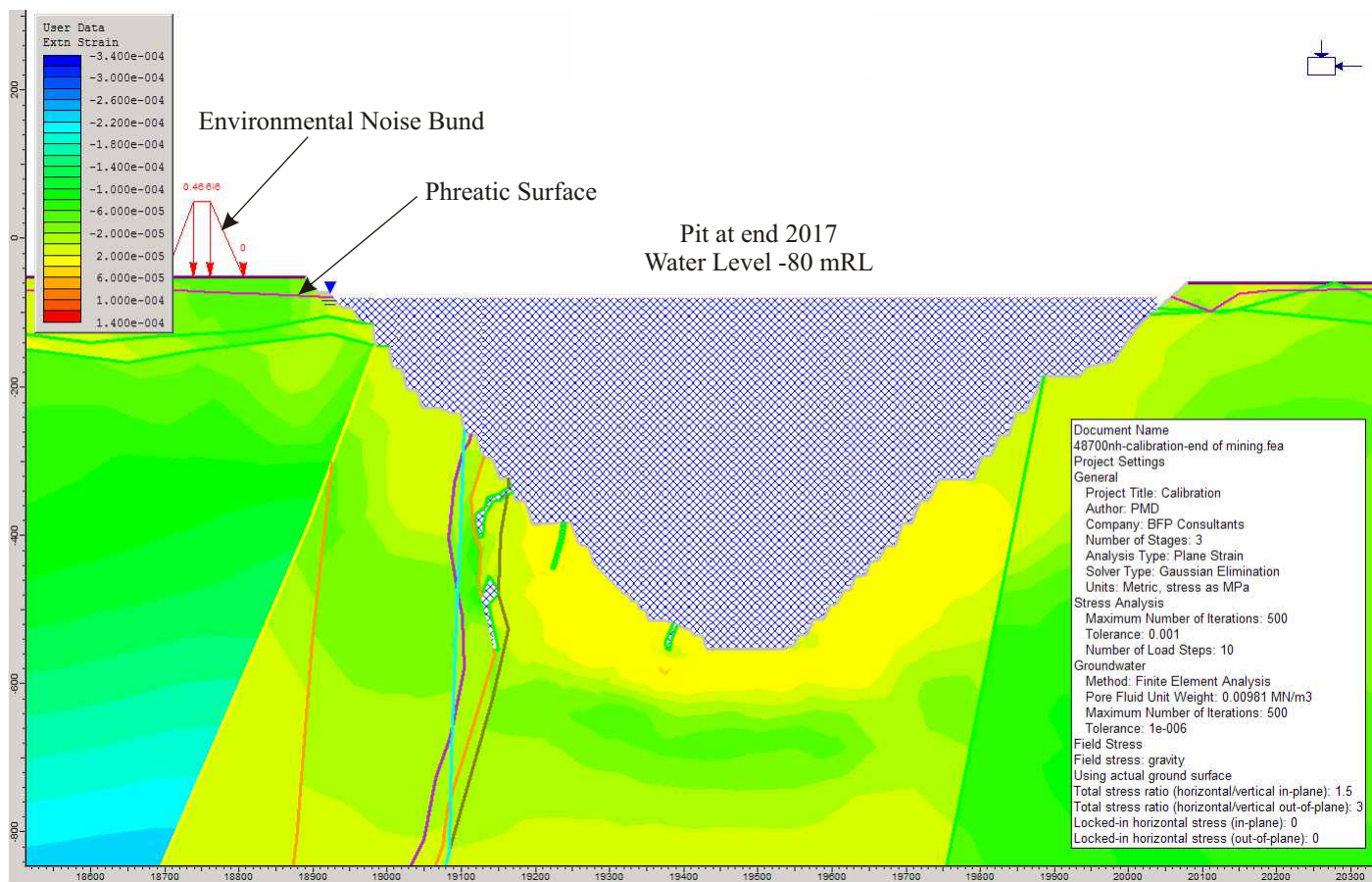
**WATER LEVEL -80 mRL
STRENGTH FACTOR**

DATE
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SCALE
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Fig 30



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ABANDONMENT BUND ON WEST WALL



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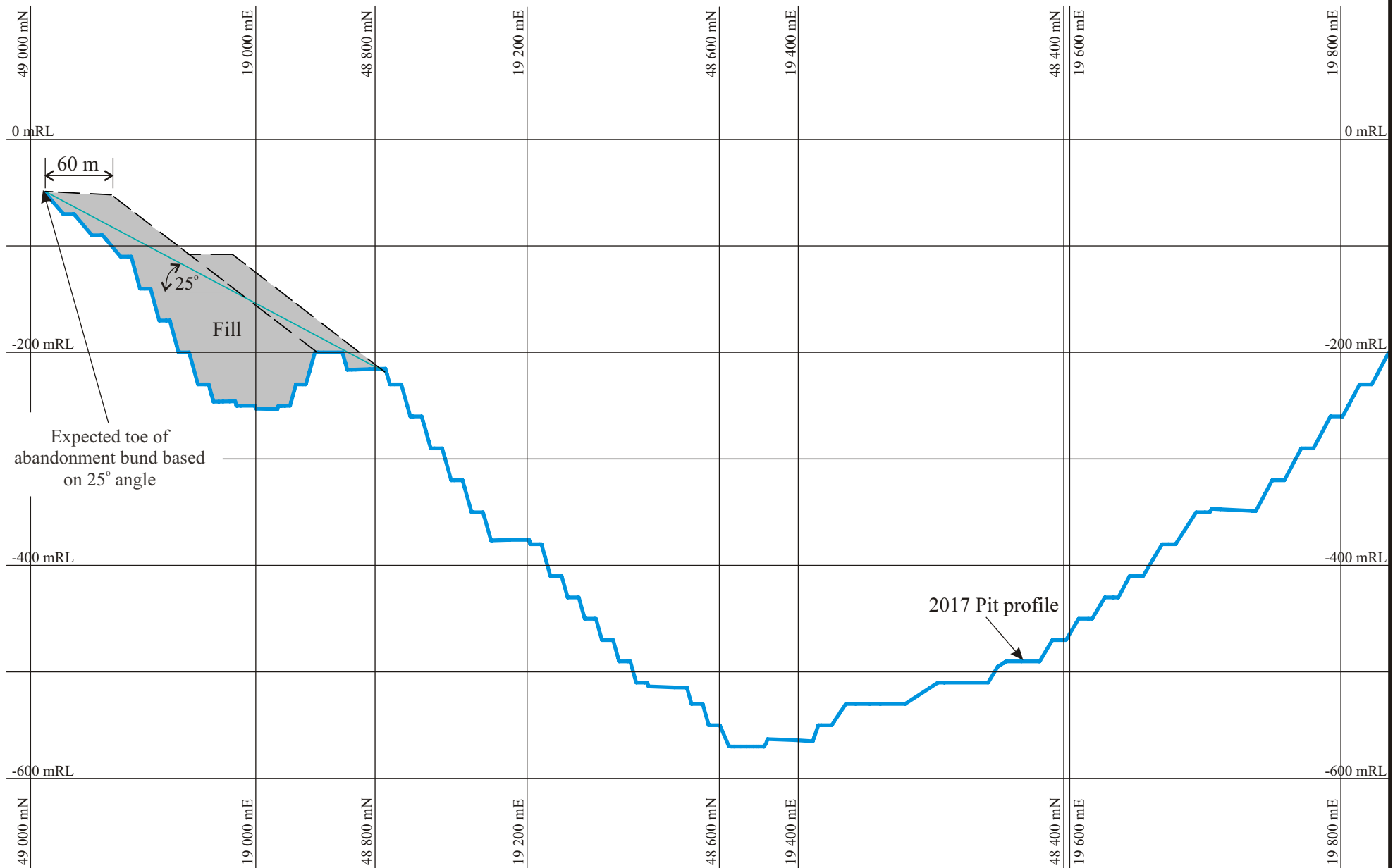
**WATER LEVEL -80 mRL
EXTENSIONAL STRAIN**


DATE
JULY 2005

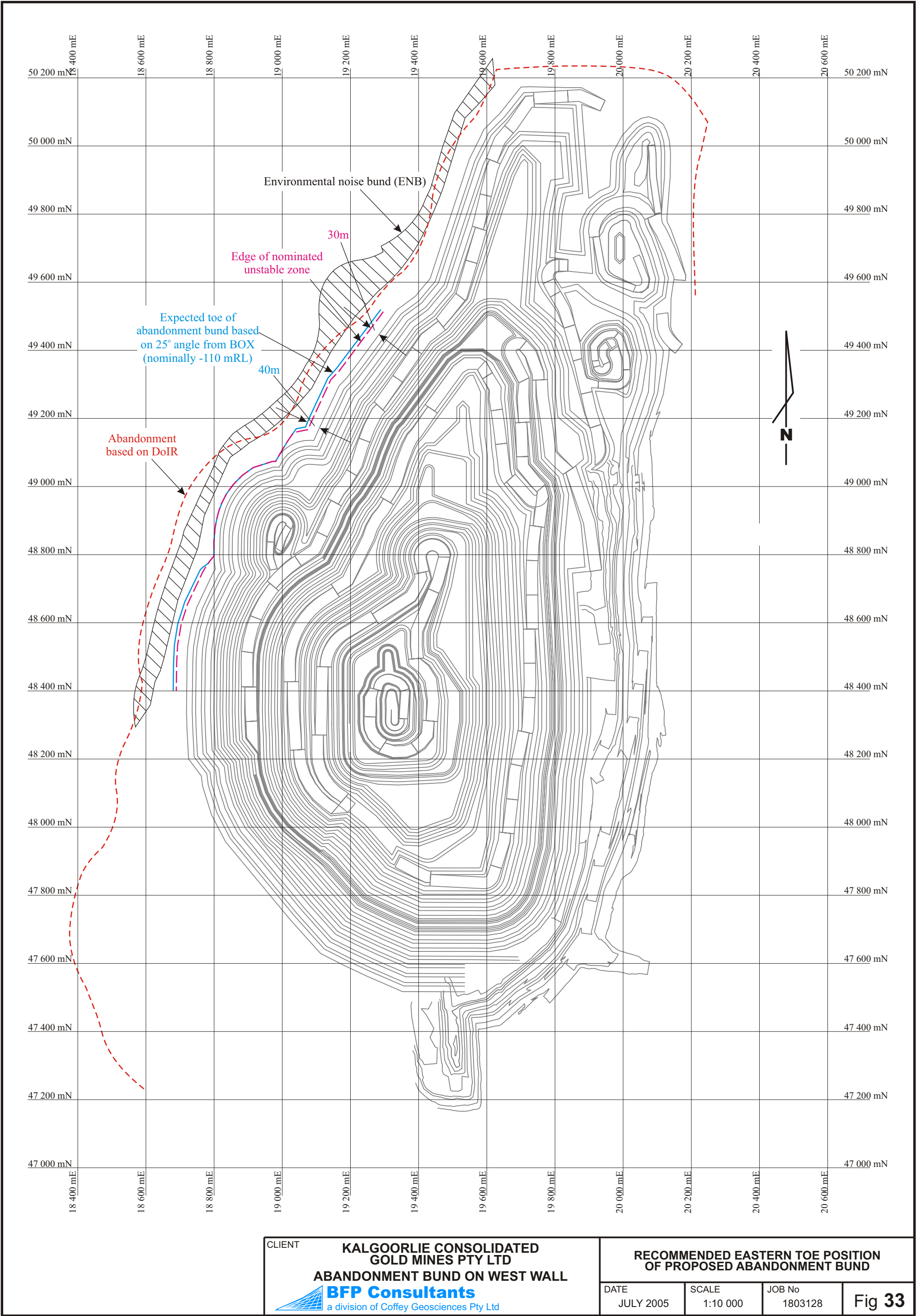
SCALE
1:10 000

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Fig 31



CLIENT		KALGOORLIE CONSOLIDATED GOLD MINES PTY LTD		GOLDEN PIKE BACKFILL	
		ABANDONMENT BUND ON WEST WALL			
 BFP Consultants a division of Coffey Geosciences Pty Ltd				DATE	JOB No
				JULY 2005	1803128
				SCALE	Fig 32
				1:5 000	



APPENDIX A

Golden Mile Dolertite (GMD) - West

Hoek-Brown Classification

intact uniaxial compressive strength = 138 MPa
GSI = 54 $m_i = 16$ Disturbance factor = 0

Hoek-Brown Criterion

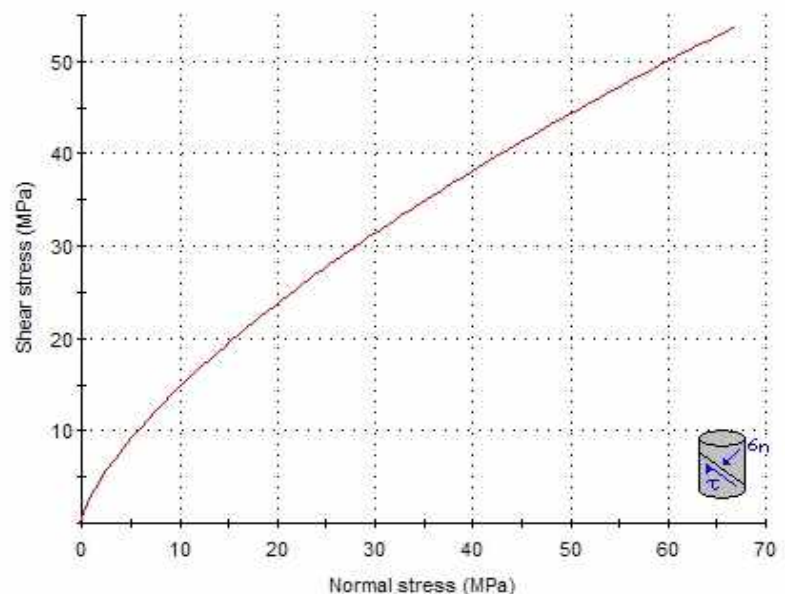
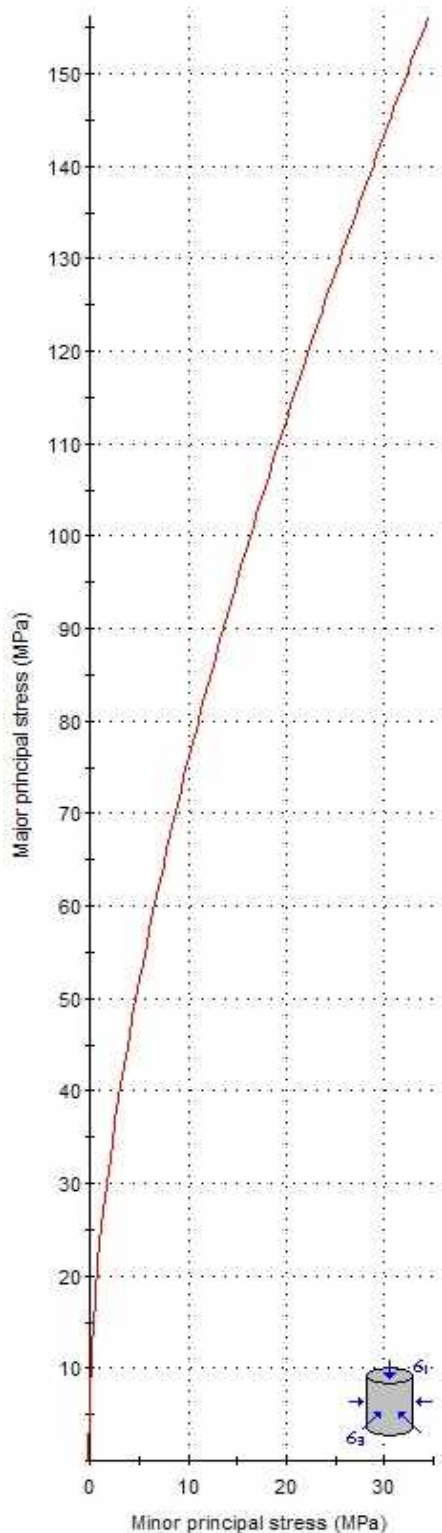
$m_b = 3.095$ $s = 0.0060$ $a = 0.504$

Mohr-Coulomb Fit

cohesion = 8.396 MPa friction angle = 35.76 d

Rock Mass Parameters

tensile strength = -0.269 MPa
uniaxial compressive strength = 10.480 MPa
global strength = 32.786 MPa
modulus of deformation = 12589.25 MPa



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**ROCLAB RESULTS
GOLDEN MILE DOLERITE (GMD) - WEST**

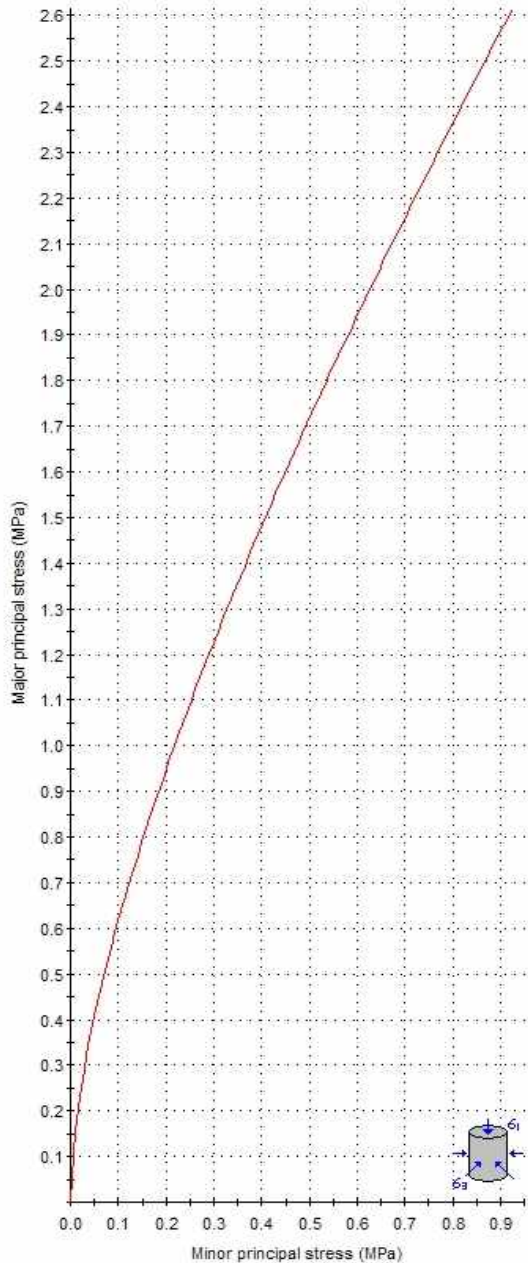
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Fig A1

Distinctly Weathered Williamstown Dolerite



Hoek-Brown Classification

intact uniaxial compressive strength = 3 MPa
GSI = 25 m_i = 16 Disturbance factor = 0

Hoek-Brown Criterion

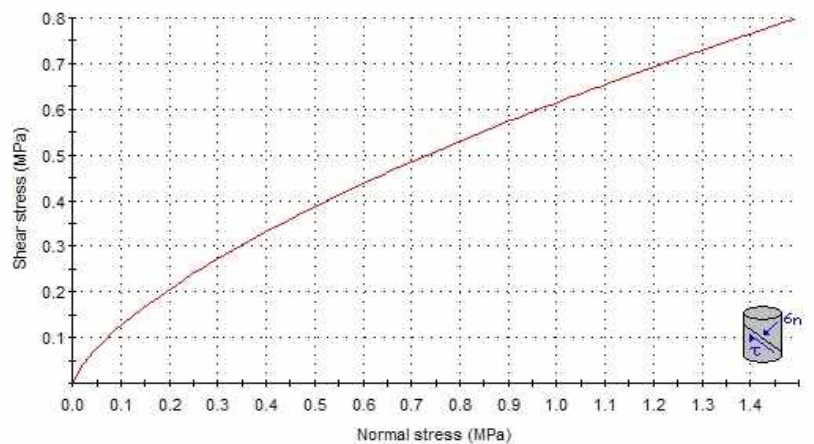
m_b = 1.099 s = 0.0002 a = 0.531

Mohr-Coulomb Fit

cohesion = 0.129 MPa friction angle = 25.38 deg

Rock Mass Parameters

tensile strength = -0.001 MPa
uniaxial compressive strength = 0.036 MPa
global strength = 0.366 MPa
modulus of deformation = 410.73 MPa



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**ROCLAB RESULTS
DISTINCTLY WEATHERED
WILLIAMSTOWN DOLERITE**

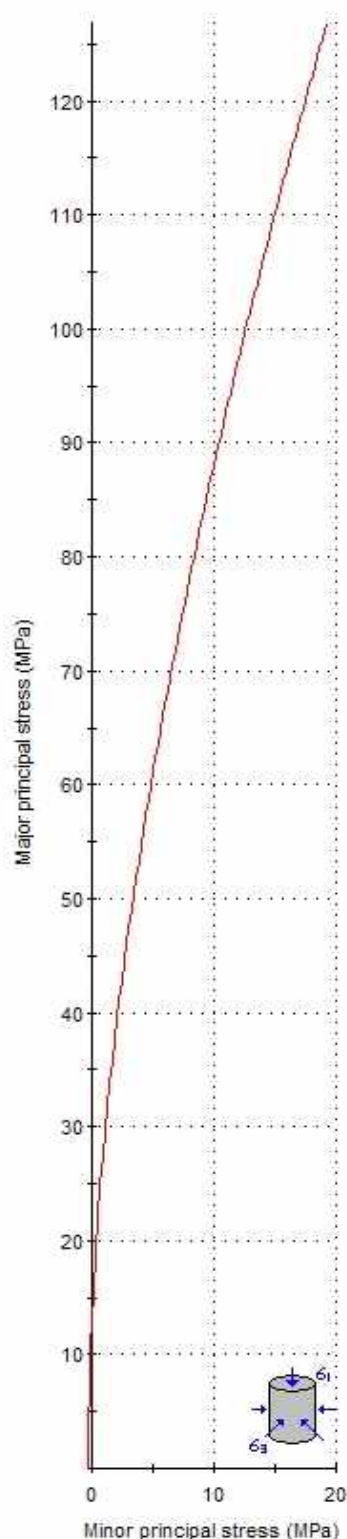
DATE
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Fig A2

Paringa Basalt



Hoek-Brown Classification

intact uniaxial compressive strength = 77 MPa
GSI = 67 m_i = 25 Disturbance factor = 0

Hoek-Brown Criterion

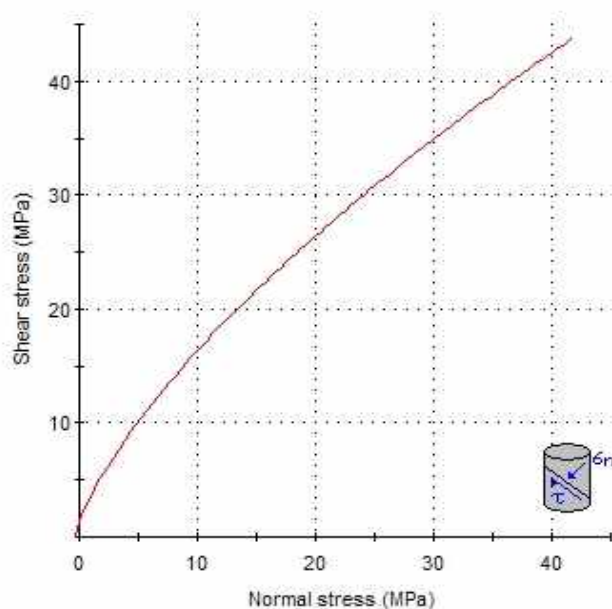
m_b = 7.693 s = 0.0256 a = 0.502

Mohr-Coulomb Fit

cohesion = 6.374 MPa friction angle = 43.51 de

Rock Mass Parameters

tensile strength = -0.256 MPa
uniaxial compressive strength = 12.234 MPa
global strength = 29.678 MPa
modulus of deformation = 23347.77 MPa



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**ROCLAB RESULTS
PARINGA BASALT**

DATE
JULY 2005

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Fig A3

Williamstown Dolerite

Hoek-Brown Classification

intact uniaxial compressive strength = 332 MPa
GSI = 52 m_i = 16 Disturbance factor = 0

Hoek-Brown Criterion

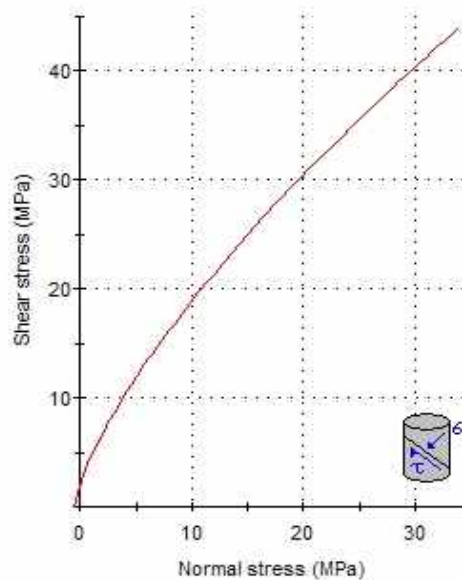
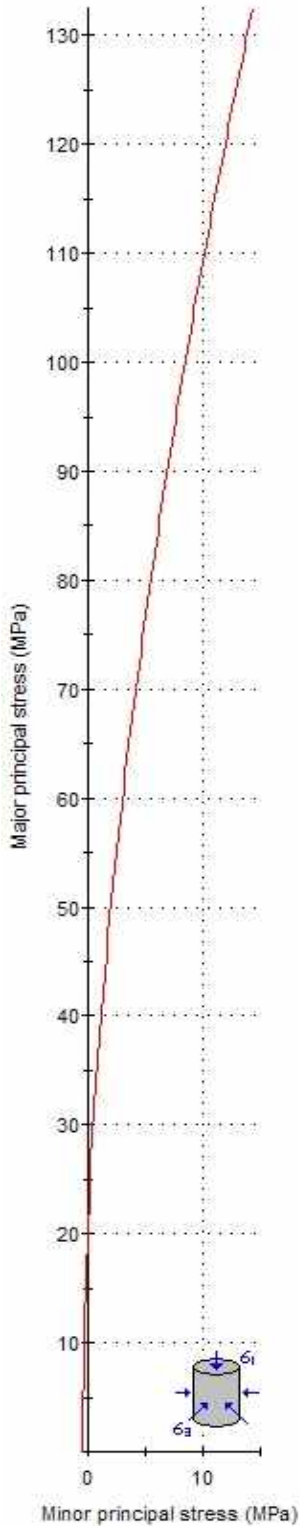
m_b = 2.881 s = 0.0048 a = 0.505

Mohr-Coulomb Fit

cohesion = 6.367 MPa friction angle = 49.57 deg

Rock Mass Parameters

tensile strength = -0.556 MPa
uniaxial compressive strength = 22.463 MPa
global strength = 75.637 MPa
modulus of deformation = 11220.18 MPa



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**ROCLAB RESULTS
WILLIAMSTOWN DOLERITE**

DATE
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Fig A4

Slightly Weathered Williamstown Dolerite

Hoek-Brown Classification

intact uniaxial compressive strength = 19 MPa
GSI = 44 mi = 16 Disturbance factor = 0

Hoek-Brown Criterion

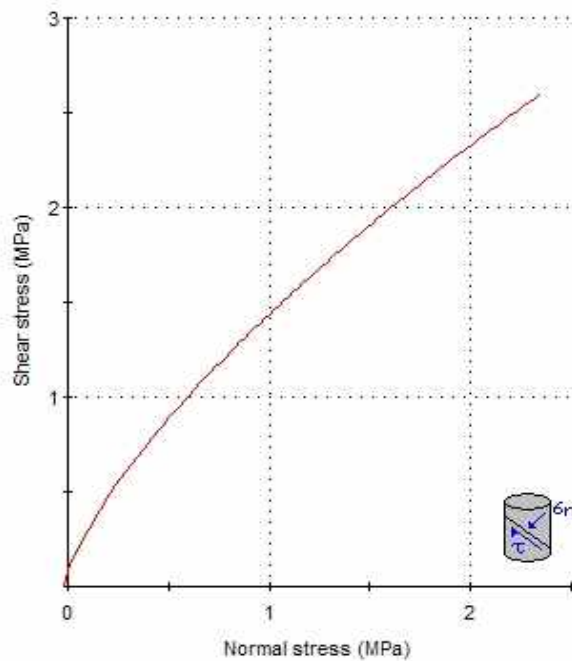
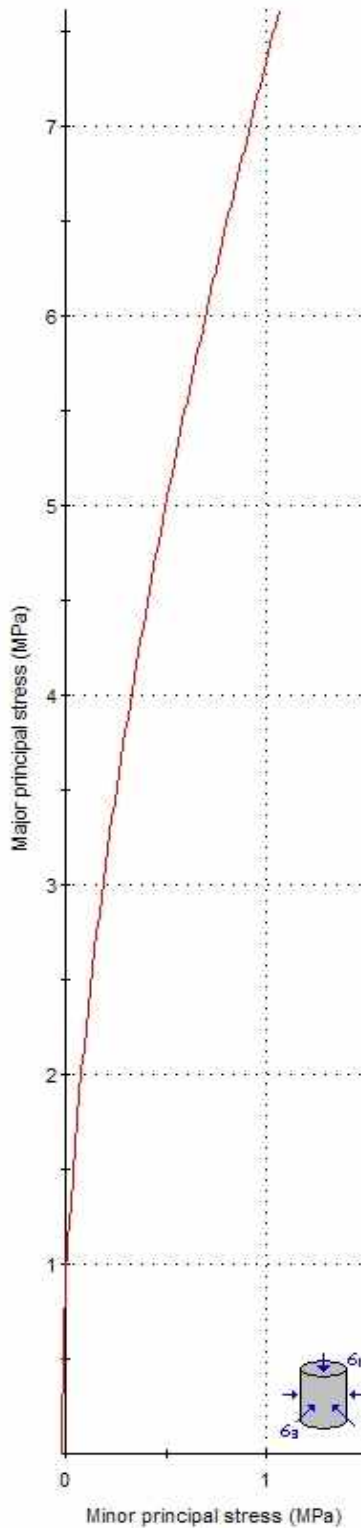
mb = 2.165 s = 0.0020 a = 0.509

Mohr-Coulomb Fit

cohesion = 0.368 MPa friction angle = 45.20 deg

Rock Mass Parameters

tensile strength = -0.017 MPa
uniaxial compressive strength = 0.802 MPa
global strength = 3.658 MPa
modulus of deformation = 3085.86 MPa



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ROCLAB RESULTS
SLIGHTLY WEATHERED WILLIAMSTOWN DOLERITE

DATE
JULY 2005

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Fig A5