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Robe Valley Deposits Façade Stand-Off Distance Memo

Executive Summary

The Robe Valley is located in the Pilbara region of Western Australia and contains numerous Pisolite Mesa formations (also known as Channel Iron Deposits (CID)), which are characterised by steep 20-30 m high cliffs (façades) and flat tops. A number of these deposits have been mined, are active operations or are proposed for mining.

In order to protect environmental, heritage and visual amenity values associated with Mesa's particularly the façade fronting the Robe River during mining operations, a safe stand-off distance (the distance between the crest of the pit and that of the mesa's natural slope) is required to be determined to ensure the long term stability of the facade.

Since 2007 several Geotechnical studies have been carried out on the facade stability including internal Rio Tinto studies and external Consultant studies. The previous façade stability studies have recommended stand-off distances ranging between 10m to 50m. However, the current review identified that these results were based on different levels of orebody and geotechnical knowledge. An attempt was made to simplify and determine the appropriate stand-off distance to the Mesa façade. The current review utilized the following approach:

1. A review relevant Geotechnical reports relating to the Mesa façade stability (Sections 1 through 5),
2. A review of the pit slope performance of as-built slopes (Section 6), and
3. A review of the façade stability during closure (Section 7)

The outcome of this report can be used as a guideline for current and future mining operations in Robe Valley region.

1 Introduction

The current and proposed pits at Robe Valley Mesa deposits are generally shallow and are above the water table. As such, geotechnical hazards pose a relatively low risk to mine operations. The key focus of the assessment is to ensure preservation of the majority of the Mesa façades to protect associated environmental, heritage and visual amenity values particularly the façade fronting the Robe River.

A stand-off distance (the distance between the crest of the pit and that of the mesa's natural slope) based on a geotechnical assessment is required to ensure that the façades can be preserved and also allow for resource recovery.

This memorandum aims to recommend the minimum stand-off distance by reviewing historical geotechnical studies and based on the current pit wall performance.

2 Geology

Robe Valley is located in the Western Pilbara region of Western Australia. Mining commenced in 1972 from Middle Robe Valley and were relocated to the west as mining progressed. The locations of all the deposits are shown in Figure 1.

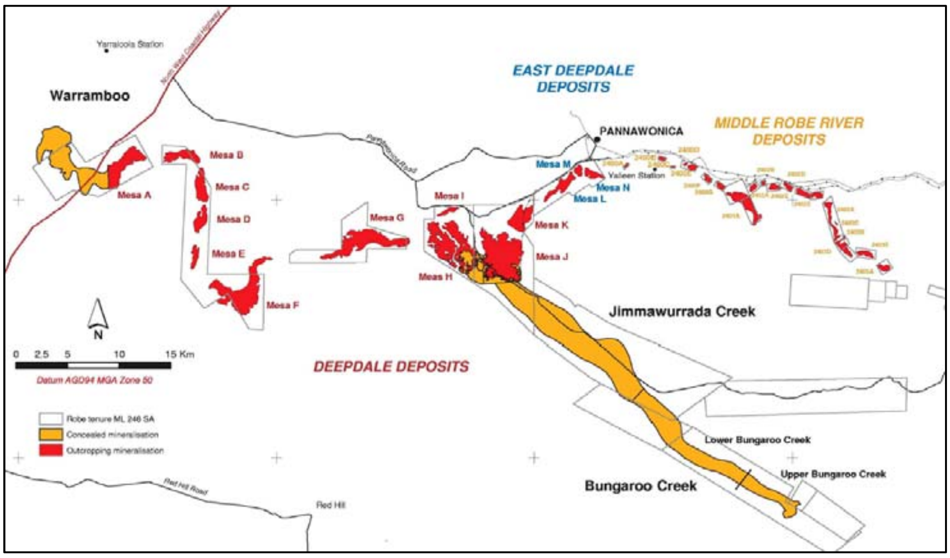


Figure 1. Location of Robe Valley Iron Ore Operations.

Mesa deposits are broad flat-topped hills with a number of deeply incised gullies. The deposit is bounded by 20-30 m high cliffs (façade). The channel at Mesa is incised through the Yarraloola Conglomerate into sediments interpreted to be part of the older Proterozoic Ashburton Formation, which forms the majority of the basement.

Mineralization within the Mesa deposits is generally hosted in the Tertiary Pisolite (TP) units. The TP has a pisolitic texture and is cemented together by a goethitic matrix. Internal zones of poorer quality material exist in the form of clay or as hydrated/denatured pisolite, but these are infrequent. Overlying the TP zone is the Semi-hardcap Tertiary Pisolite (HTP), which is a weathered/laterized form of the TP zone and contains secondary soils and silica. The transition between the HTP and TP is gradational and visually difficult to identify. Underlying the TP is the Mixed/Massive Sub-Grade Pisolite (TPM). This zone is also gradational from the TP. It is characterised by a limonitic, denatured/massive appearance and clay is common throughout. This contact is also visually difficult to identify due to its gradational nature. It is suggested that this zone has been subjected to a palaeo-water table, which has resulted in a significant hydration effects in comparison to the overlying TP.

The typical sequence of Mesa geological units are:

- Quaternary alluvium (variable thickness);
- HTP (Hardcap Tertiary Pisolite) (variable thickness);
- TPC (Tertiary Pisolites Clay) (variable thickness);
- TPM (Tertiary Pisolites Mixed) (variable thickness);
- TPH (Tertiary Pisolites Hard) (variable thickness); and
- TPB (Tertiary Pisolites Base) (variable thickness);

An in-situ geology sections and models are shown in Figure 2-5.

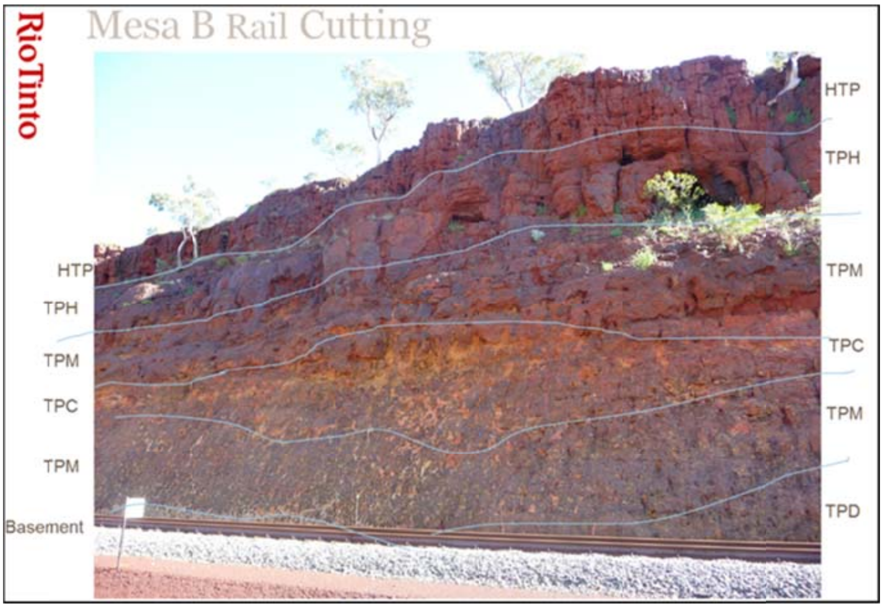


Figure 2. In-situ Geology Units Cross Section in Mesa B.

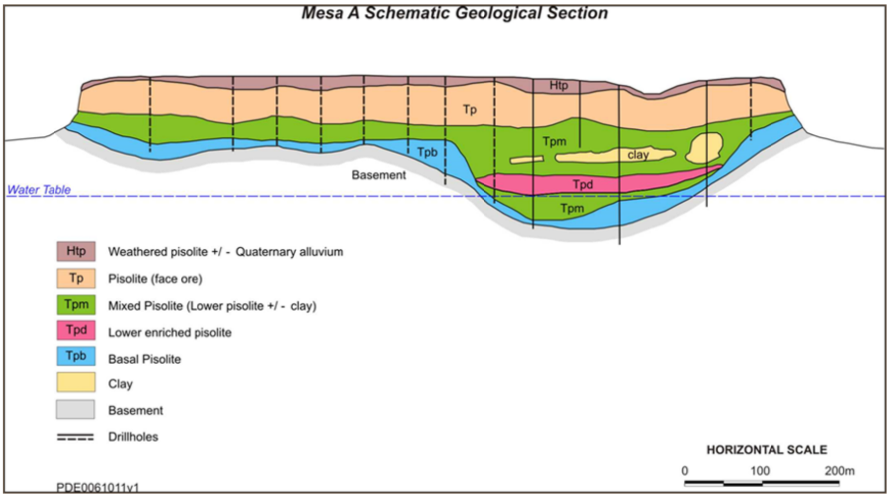


Figure 3. Geology Section of Mesa A.

Apart from other Robe Valley deposits, recent geology drilling indicated (refer Figure 4 and Figure 5) that unconsolidated alluvial cover (ALL) extends up to 15m in the upper most portion of the Mesa H and Mesa J deposit.

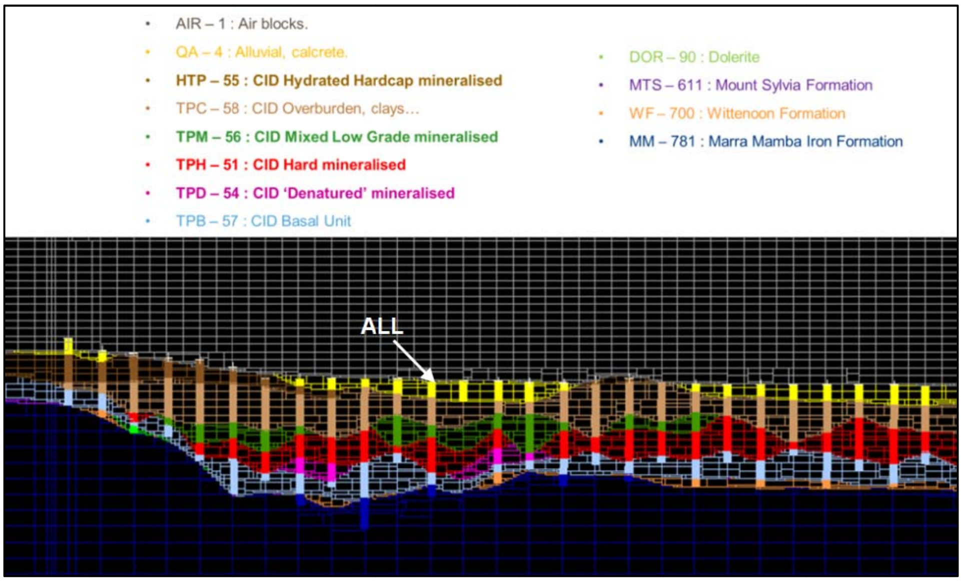


Figure 4. Mesa H Geology Cross Section.

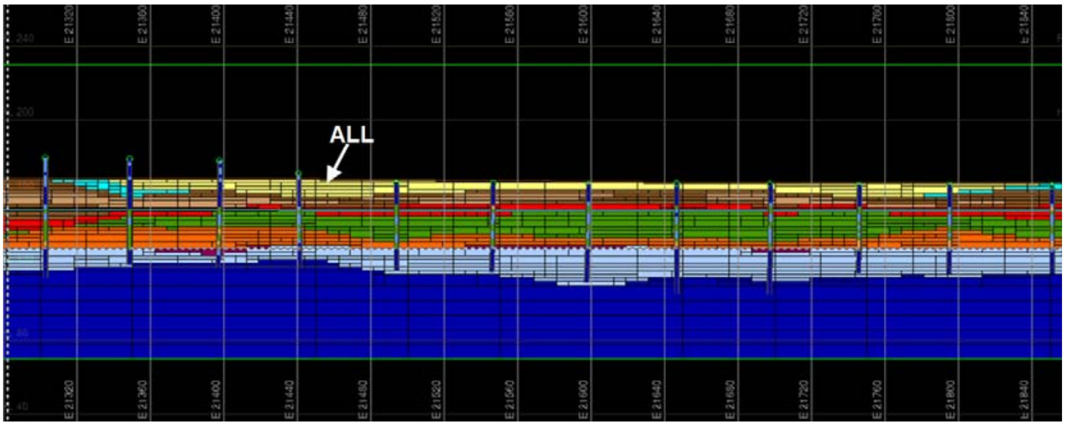


Figure 5. Mesa J Geology Cross Section.

3 Hydrology and Hydrogeology

Surface water and groundwater can impact the stability of façade. Most of the Robe deposits are above the groundwater table and the facade surrounding the Mesas further protect the mining operations from flooding of the Robe River.

3.1 Hydrology

The Robe Valley area is hot and persistently dry. Rainfall is also highly seasonal, with approximately 69% of the annual total occurring between December and April.

The Robe Valley deposits reviewed in this report are located on high ground, outside the 1% annual exceedance probability (AEP) floodplain of the Robe River. Riverine flooding of the deposits is not considered as a geotechnical issue. An example of the Mesa A, Mesa B, Mesa C, Mesa K and Mesa J 1% Annual Exceedance Probability (AEP) flood extent is shown in Figure 6, Figure 7 and Figure 8.

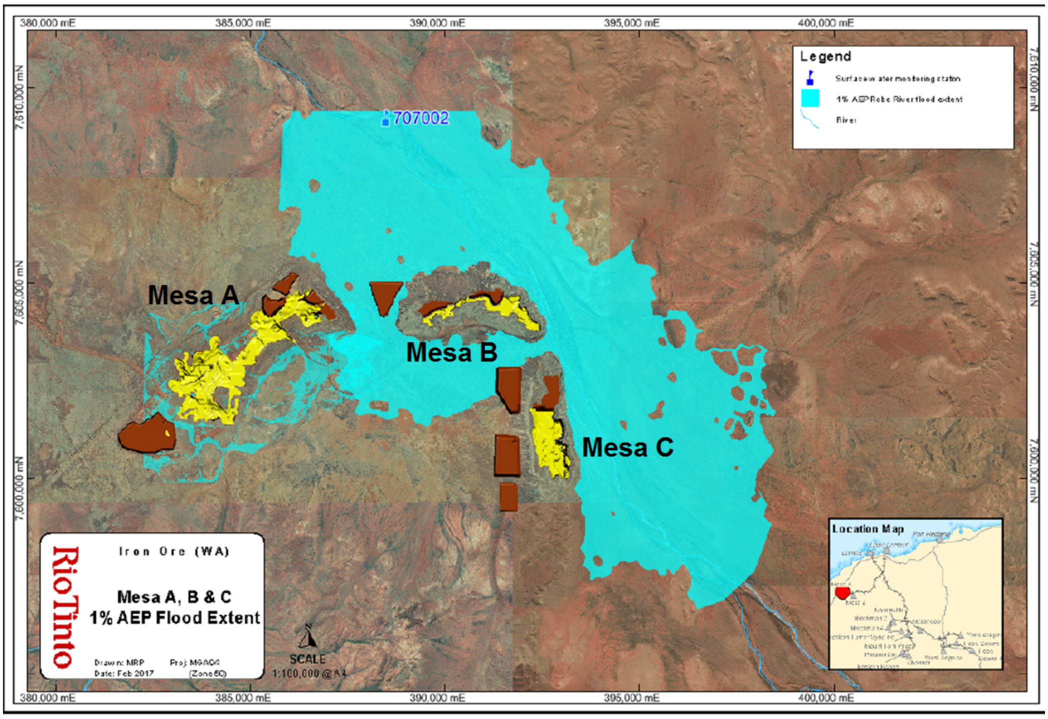


Figure 6. Mesa A, B and C Deposits in relation to the 1% AEP flood extent of the Robe River.

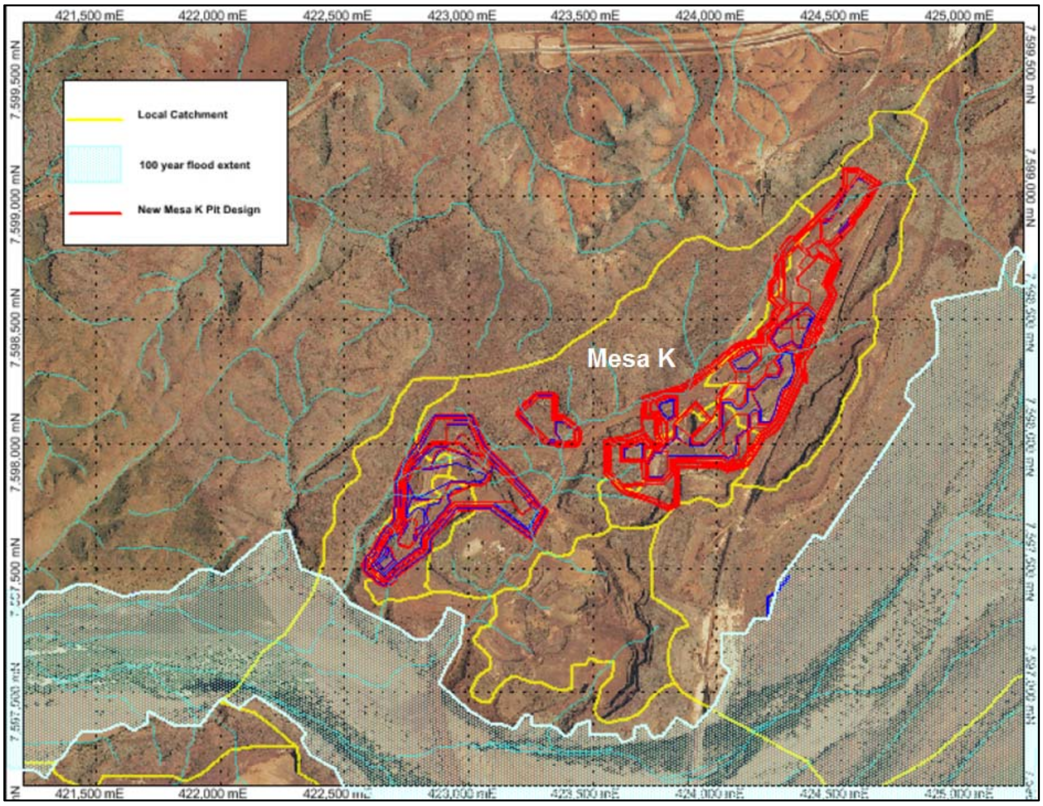


Figure 7. Mesa K Deposits in relation to the 1% AEP flood extent of the Robe River.

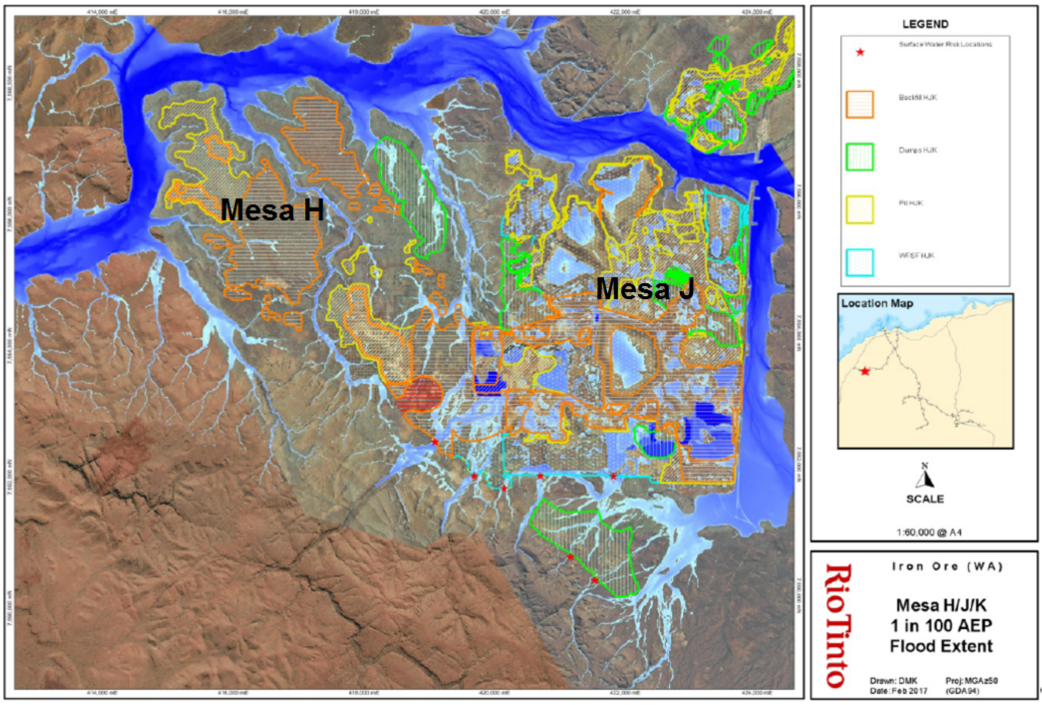


Figure 8.Mesa J and Mesa H Deposits in relation to the 1% AEP flood extent of the Robe River.

3.2 Hydrogeology

The key hydrogeological concepts at the Robe Valley are summarized based on groundwater investigations and groundwater modelling work summarised in Table 1: Dewatering is needed to mine the areas below pre-mining water table as shown from Figure 9 to Figure 13.

Table 1. Intersection Area between Robe Valley Pits and the Pre-Mining water Table.

Deposit	Pit Floor (mRL)	Benches	Pre-Mining Water Table (mRL)	Bench below Water Table
Mesa A	44	3	48.5	1
Mesa B	80	4	65	0
Mesa C	52	7	69	4
Mesa H	110	9	121	2
Mesa J	130	5	135	1
Mesa K	156	5	145	0
Warramboo	20	6	39	4

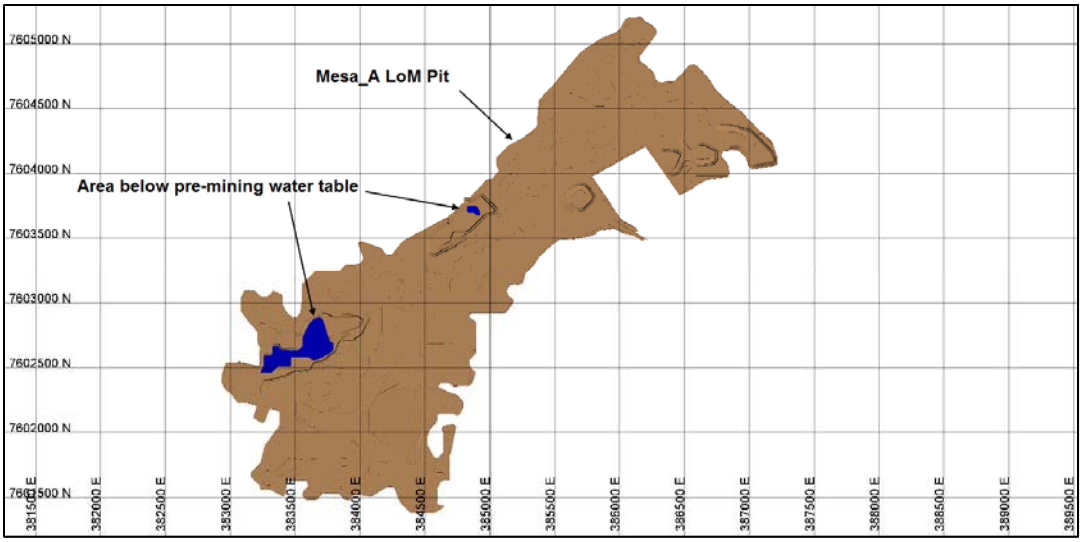


Figure 9. Areas in Mesa A Life of Mine (LoM) Pit Below Pre-mining Water Table.

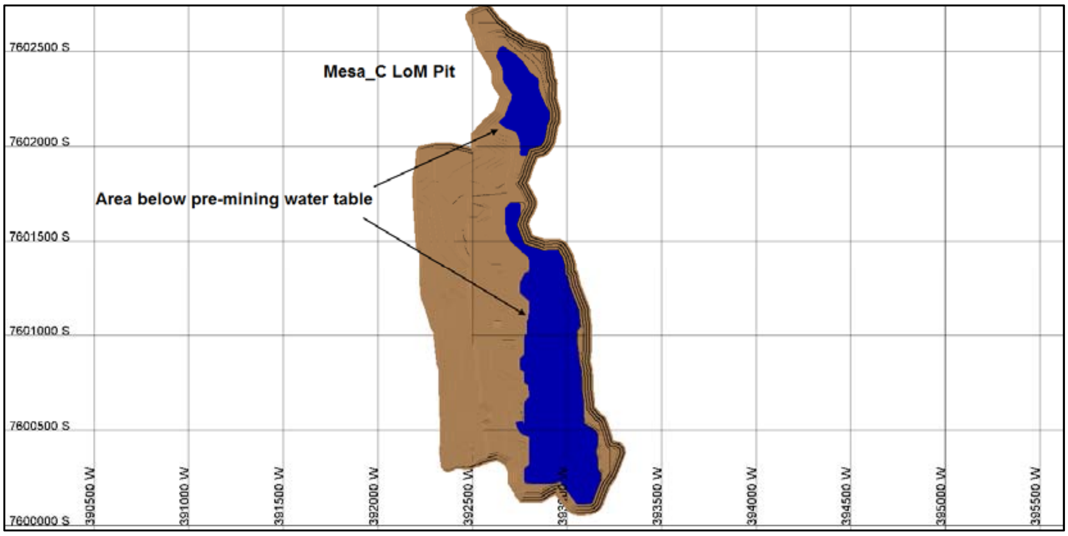


Figure 10. Areas in Mesa C Life of Mine (LoM) Pit Below Pre-mining Water Table.

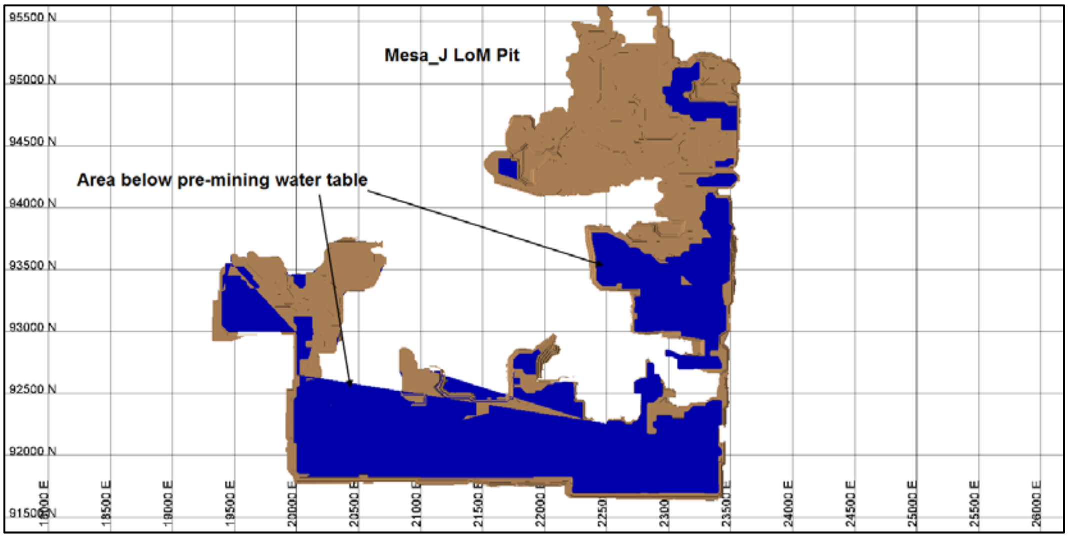


Figure 11. Areas in Mesa J Life of Mine (LoM) Pit Below Pre-mining Water Table.

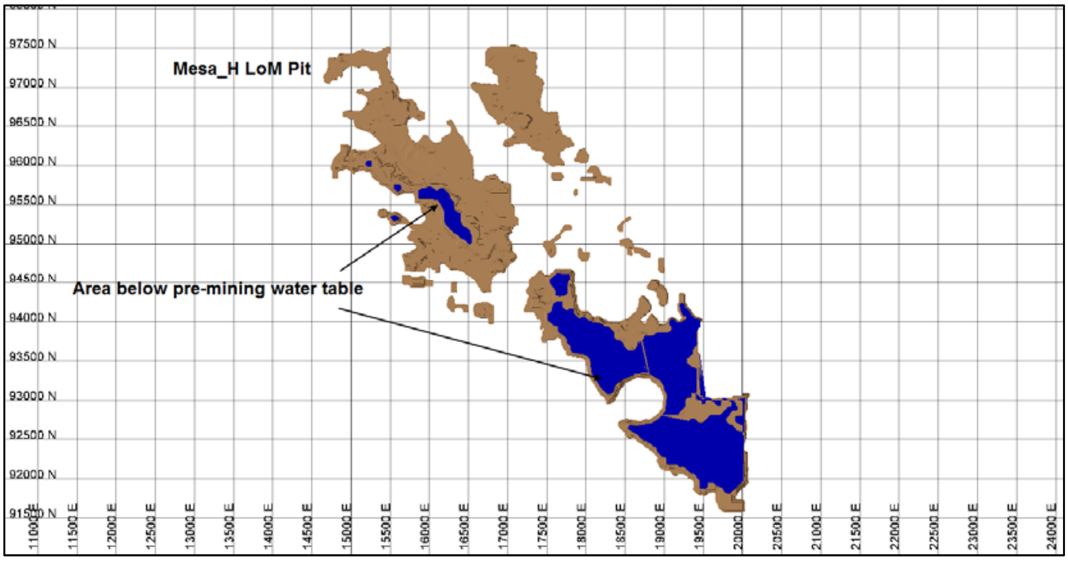


Figure 12. Areas in Mesa H Life of Mine (LoM) Pit Below Pre-mining Water Table

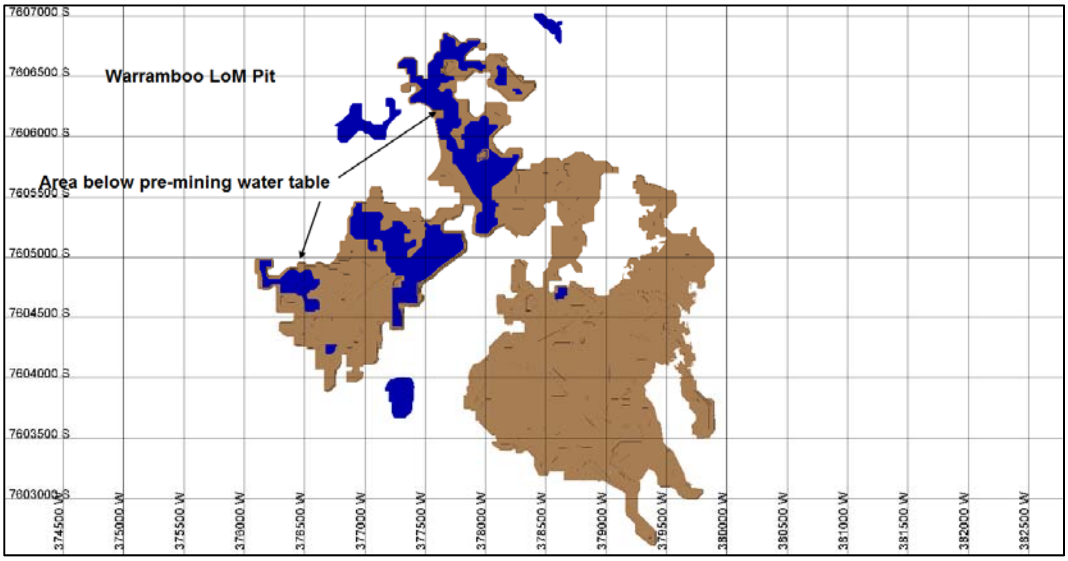


Figure 13. Areas in Warramboo Life of Mine (LoM) Pit Below Pre-mining Water Table

4 Geotechnical Field Investigation

The geotechnical site investigations have been undertaken at Robe Valley since 1999, Table 2 summarises all the completed geotechnical drilling to date and the drill hole locations are plotted in Figure 14, Figure 16, Figure 24, Figure 25 and Figure 26.

Table 2. Robe Valley Geotechnical Drilling Summary.

Year	Deposit	Drill Type	Actual Meters (m)	Number of Holes
1999	J	Diamond	129.8	3
2005	A	Diamond	182	6
2006	A	Diamond	195.5	5
2013	H	Diamond	486	10
2016	B	Diamond	230.1	4
2016	C	Diamond	749.7	10
2016	H	Diamond	900.1	12
Total			2873.2	51

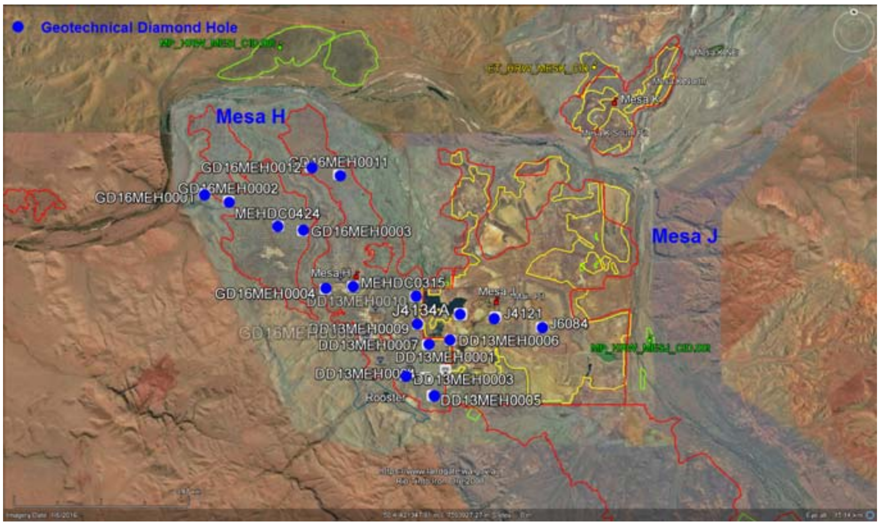


Figure 14. Historical Geotechnical Drill Holes in Mesa J and Mesa H.

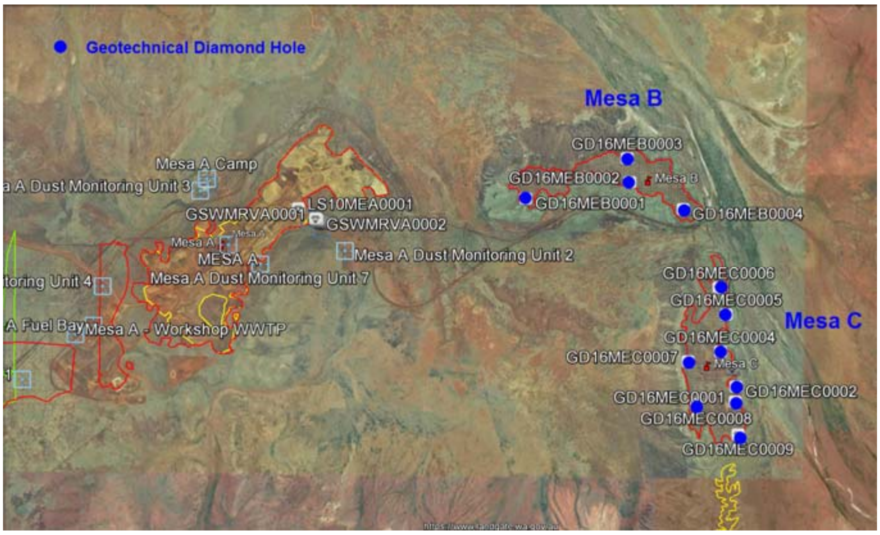


Figure 15. Historical Geotechnical Drill Holes in Mesa B.

5 Geotechnical Studies for Facades

Since 2007, several geotechnical studies were completed by Rio Tinto and external consultants, which included façade reviews. The results are summarised below.

5.1 Mesa A and Warramboo Geotechnical PFS (Snowden Mining Consulting, 2007)

Snowden undertook a review of the status of geotechnical knowledge and the proposed pit design criteria as part of the Warramboo and Mesa A pre-feasibility study (PFS) in 2007. This work was later substantiated by two programs of geotechnical investigations by PSM involving a total of 11 HQ3 diamond drill holes initially completed along the steeper and deeper sections of the proposed pit walls, and subsequently within the 50 m façade planned to be retained.

5.1.1 Site Investigation and Analysis Approach

Phase 2 of this project focused on investigating the stability of the 50 m wide façade. This program involved five vertical HQ3 diamond drill holes for a total of 195.52 m and was completed in December 2006 as shown in Figure 16.

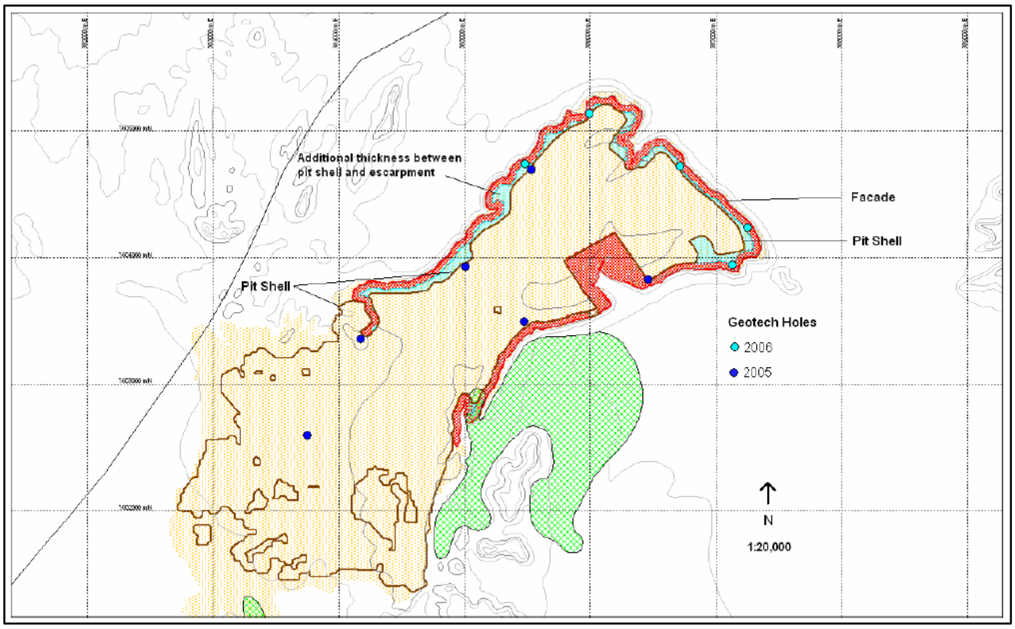


Figure 16. 2006 Snowden Façade Study Mesa A Geotechnical Drill Holes Locations.

The actual core data collection and collation was undertaken by Pells Sullivan Meynink Pty Ltd. Laboratory tests were carried out and the diamond cores were logged for geotechnical use. Snowden was engaged to undertake site visits to Mesa A, J, K and M to assess the conditions of natural and mined mesas in March 2007.

It was observed that visible blast damage typically extends 1 -2 m beyond the pit crest at Mesa J, K and M. Furthermore sections of 25-year-old remnant mesa only showed blast damage where the width of remnant façade was reduced to 15 m.

5.1.2 Results

- Mining operations adjacent to natural mesa facades have not caused large (face) scale instability of the natural slopes or escarpment at these sites;
- Visible damage from blast practices typically extends < 2m behind the slope crest; and
- Mesa A façade to have a probability of failure of 0.1%. It should be noted that none of the critical failure paths assessed involved the full 50m width of the façade.

5.2 Robe Valley Sustaining (Middle Robe, East Deepdale, Mesa B and Mesa C) Geotechnical Design Report (RTIO, 2015)

This report outlines the geotechnical slope design recommendations and mesa façade stand-off requirements associated with geotechnical risks.

5.2.1 Site Investigation and Analysis Approach

There was no specific geotechnical information, either measured or logged, for the Mesa B, Mesa C, East Deepdale or Middle Robe deposits and therefore for this study, geotechnical parameters were inferred from CID units found at Mesa A by Snowden in 2007.

To account for geological uncertainty and provide robust slope configurations, the entire slope was modelled using TPB/TPM strength parameters as a base case. A series of typical sections as shown from Figure 17 to Figure 20 were selected from Middle Robe, Deepdale, Mesa B and Mesa C for the 2D slope stability analysis.

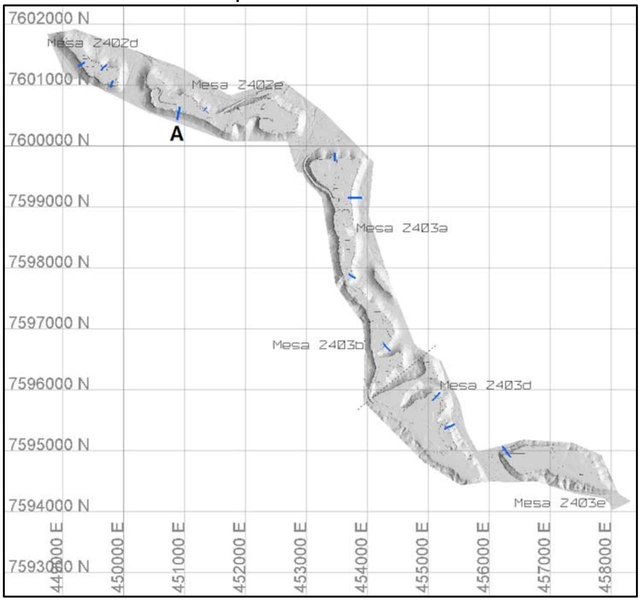


Figure 17. 2015 RTIO Robe Valley Pre-Feasibility Study (PFS) Middle Robe Section lines.

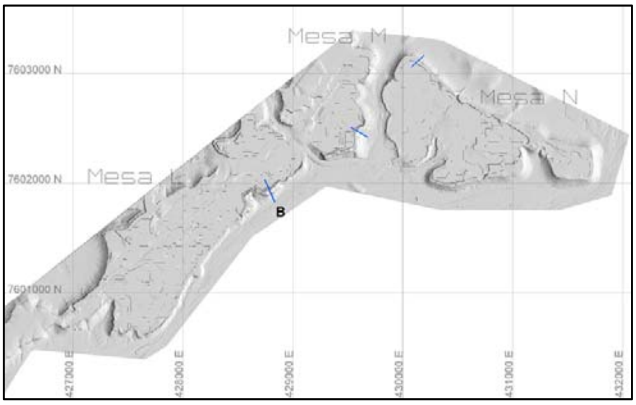


Figure 18. 2015 RTIO Robe Valley Pre-Feasibility (PFS) East Deepdale Section lines.

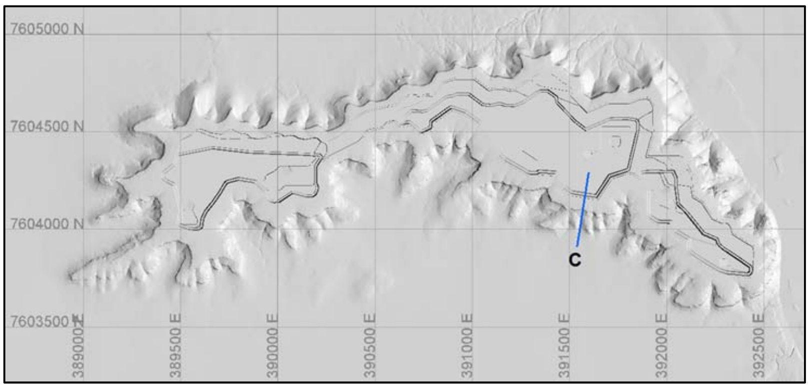


Figure 19. 2015 RTIO Robe Valley Pre-Feasibility Study (PFS) Mesa B Section lines.

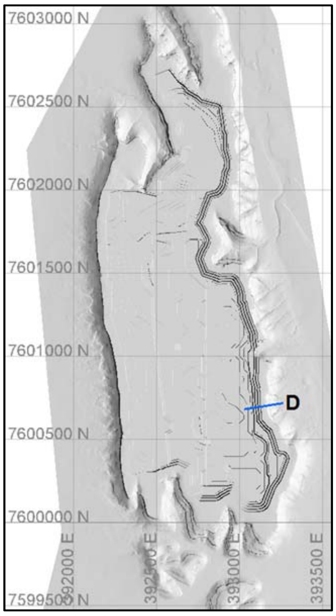


Figure 20. 2015 RTIO Robe Valley Pre-Feasibility Study (PFS) Mesa C Section lines.

5.2.2 Results

The façade stand-off distance recommendations were calculated based on the risk associated with different slope heights as outlined in Table 3.

Table 3. 2015 RTIO Robe Valley Slope Design Recommendations and Corresponding Minimum Mesa Facade Stand-Off Distance.

Deposit	Maximum Slope Height	Strand	Maximum IRA (°)	Maximum BFA (°)	Minimum Berm Width (m)	Max Bench Height (m)	Minimum Mesa Façade Stand-off (m)
Middle Robe / East Deepdale / Mesa B & C	20m high, AWT	HTP/ TPB/ TPM/ TPH/ TP	56	75	8	20	15
	40m high, AWT		56	75	8	20	20
East Deepdale	50m high, AWT		56	75	8	20	26
Mesa C	70m high, 13m BTW		52	75	10	20	35

5.3 Mesa H Pit crest/Façade Stand-off Distance Geotechnical Recommendations Update (RTIO, 2016)

A geotechnical assessment was undertaken in 2016 by Rio Tinto to review façade stand-off requirements.

5.3.1 Site Investigation and Analysis Approach

Review of the existing geotechnical data together with updated geological modelling and drilling data across the Robe Valley was undertaken and was analysed taking into consideration the distance to the 1.5 FOS failure surface in order to refine the stand-off distance from the pit crest to the mesa façade crests.

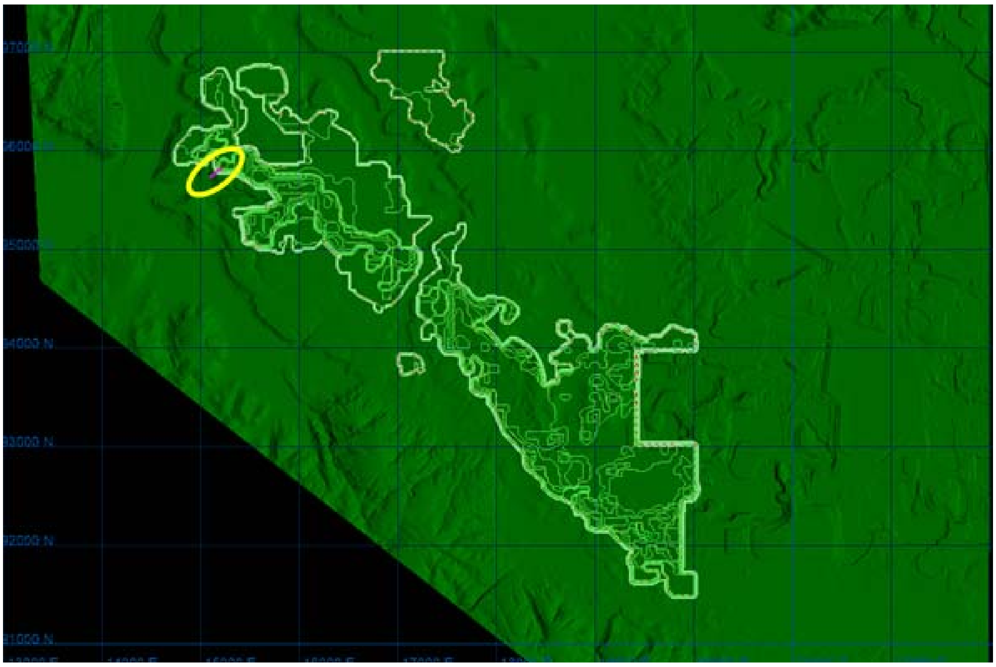


Figure 21. 2016 RTIO Mesa H Analysis Section.

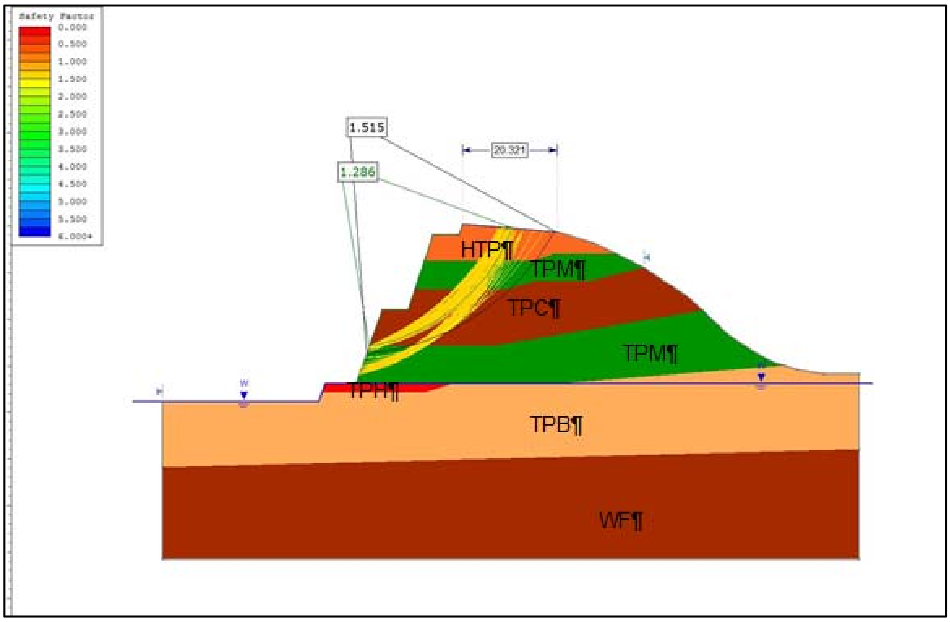


Figure 22. 2016 Mesa H Section Stability with 20m Stand-Off Distance on Pit Side (FoS=1.5).

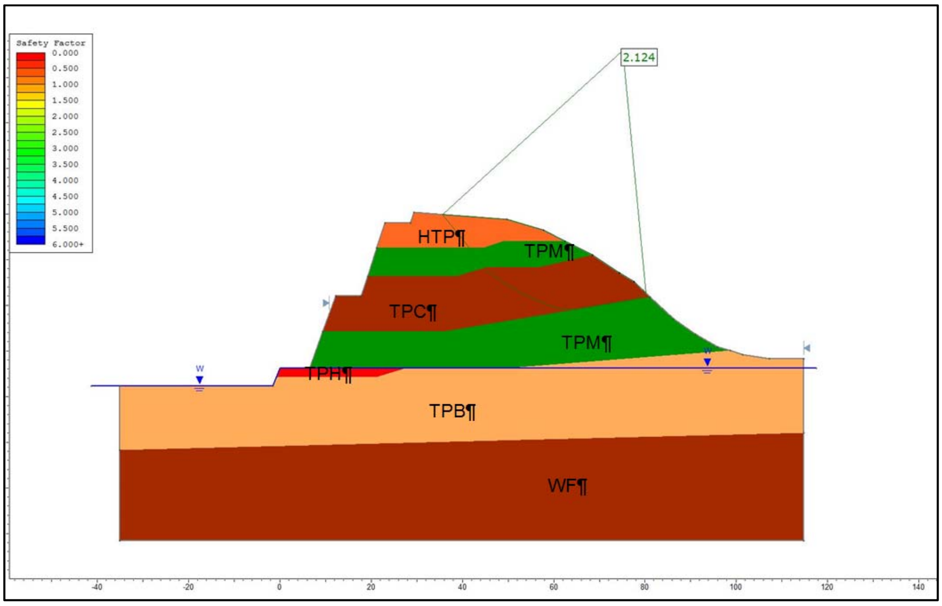


Figure 23. 2016 Mesa H Section Stability with 20m Stand-Off Distance on Façade Side (FoS>1.5).

5.3.2 Results

It was found that the FoS for the façade is below 1.5 using a 20m stand-off distance and above 1.5 with 30m stand-off distance. It was recommended that a minimum 30m stand-off is required between the Mesa H pit crest and façade crest.

5.4 Robe Valley mesa B, C and H Pits Geotechnical Feasibility Study, (3rd Rock Consulting, 2017)

3rd Rock Consulting (3RC) was commissioned to carry out a Life of Mine (LoM) geotechnical feasibility level design for Mesas B, C and H deposits.

5.4.1 Site Investigation and Analysis Approach

A total of 2690m of core were drilled and logged over seven drilling campaigns since 1999 with 1880m drilled in 2016 as shown in Figure 24, Figure 25 and Figure 26. A total of 435 geotechnical laboratory tests have been undertaken on core samples in the same period.

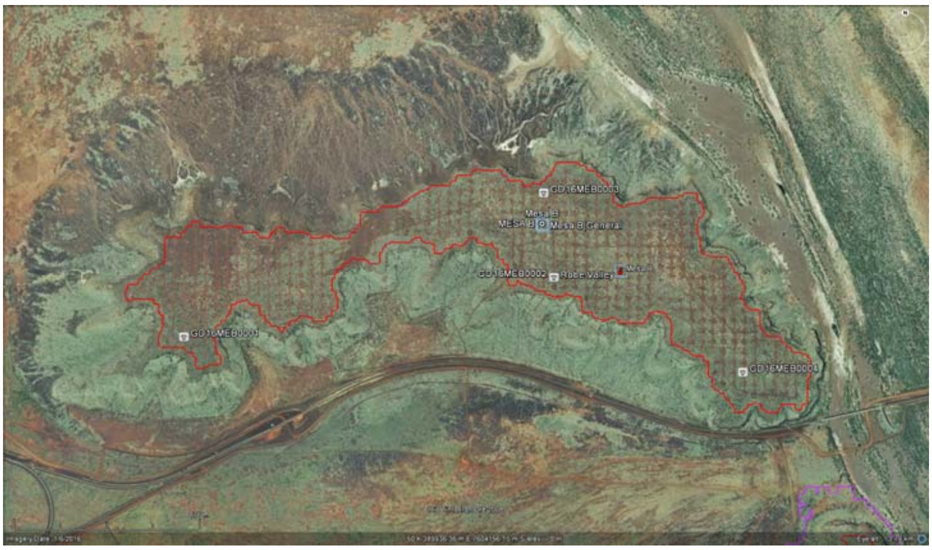


Figure 24. 2016 Mesa B Geotechnical Drill Hole Locations.

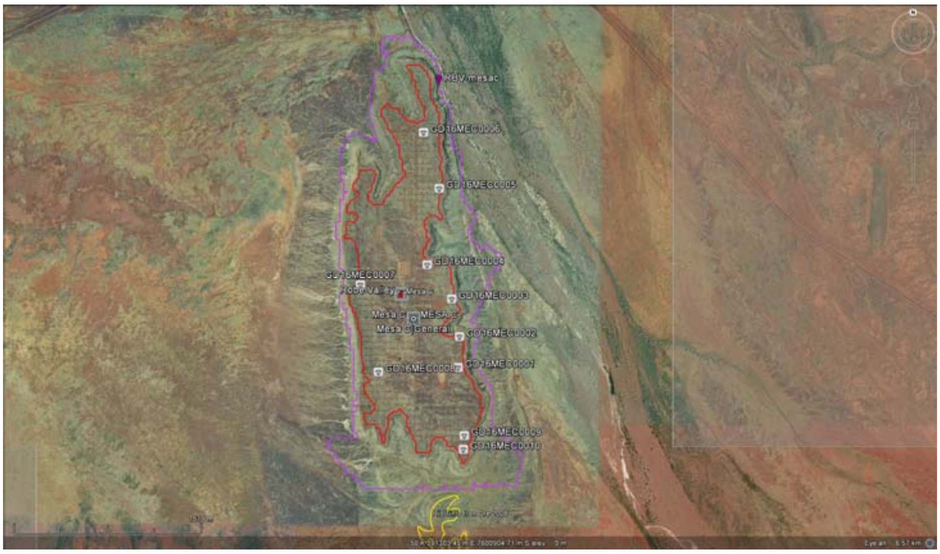


Figure 25. 2016 Mesa C Geotechnical Drill Hole Locations.

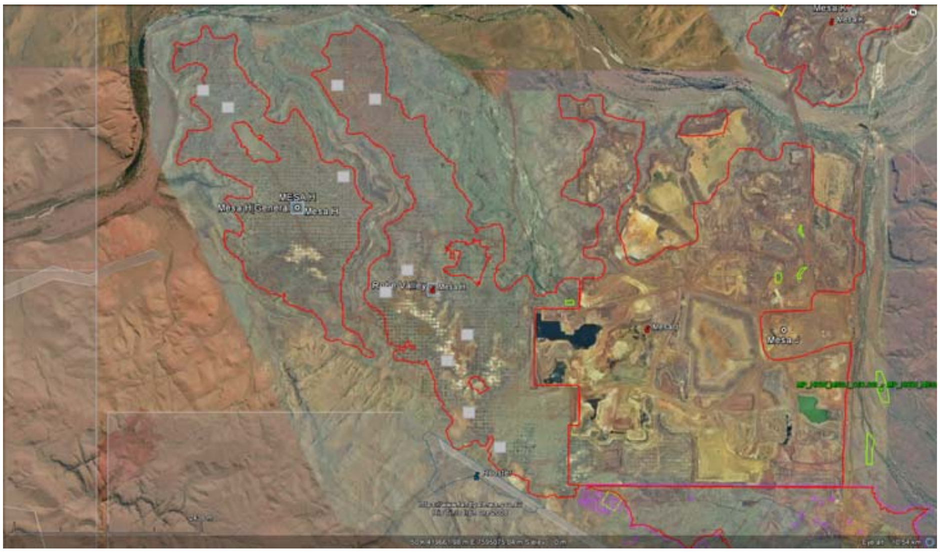


Figure 26. 2016 Mesa H Geotechnical Drill Hole Locations.

5.4.2 Results

3rd Rock developed material shear strengths which derived for both best-estimate and reduced (Lower Quartile) shear strengths for limit equilibrium stability analysis to meet Rio Tinto geotechnical Design Acceptance Criteria (DAC).

The SLIDE modelling results shown that the Factor of Safety meets the geotechnical DAC for both the estimated and lower quartile rock mass strength. The result also shows that the Factor of Safety of the façade is greater than 1.5 even with lower quartile rock mass strength and 30m stand-off distance as shown in Figure 27.

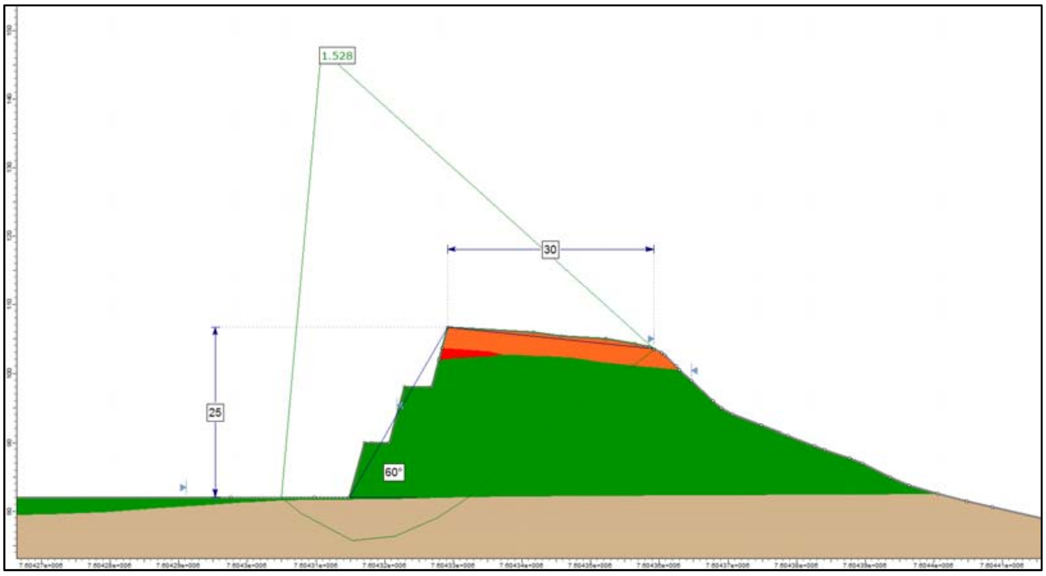


Figure 27. 2017 3rd Rock RV Study Mesa B Section A Facade Factor of Safety =1.53 with Lower Quartile Strength 30m from façade.

3rd Rock concluded:

- The slope stability results for Rio Tinto's designs for all three Mesas show that the Factor of Safety (FoS) for all sections are greater than Rio Tinto's Design Acceptance Criteria; in most cases significantly greater. This is because the final pit slopes are shallow and will perform well in competent cemented material; and
- The slopes were optimised in order to increase the overall slope angles and to reduce the façade width (that is the distance between the crest of the pit and that of the mesa's natural slope) to a minimum of 30m.

It has been implicitly assumed that best practise blasting methods will be used in order to minimise disturbance to the façade rock mass.

5.5 Robe Valley Operational Geotechnical Function Independent Review (Xstract, 2017)

Xstract Mining Consultants (Xstract) undertook an independent Operational Geotechnical review of the Mesa A and Mesa J mining areas at Robe Valley Operations in March 2017.

5.5.1 Site Investigation and Analysis Approach

This review mostly focused on the performance of the current slope, compliance to D3 standards by performing a desktop review, a site visit and discussion with key personnel.

5.5.2 Results

It was determined to be important to consider the likely depth of blast disturbance into the perimeter rock mass, behind the mined batters, which is generally taken as one to two mining bench heights but can be greater depending on the blasting methods used. Further, the impact of the blast disturbance on façade stability will be increased where the outer slope of the mesa forms a steep slope, forming a more slender perimeter "Pillar" as shown in Figure 28.

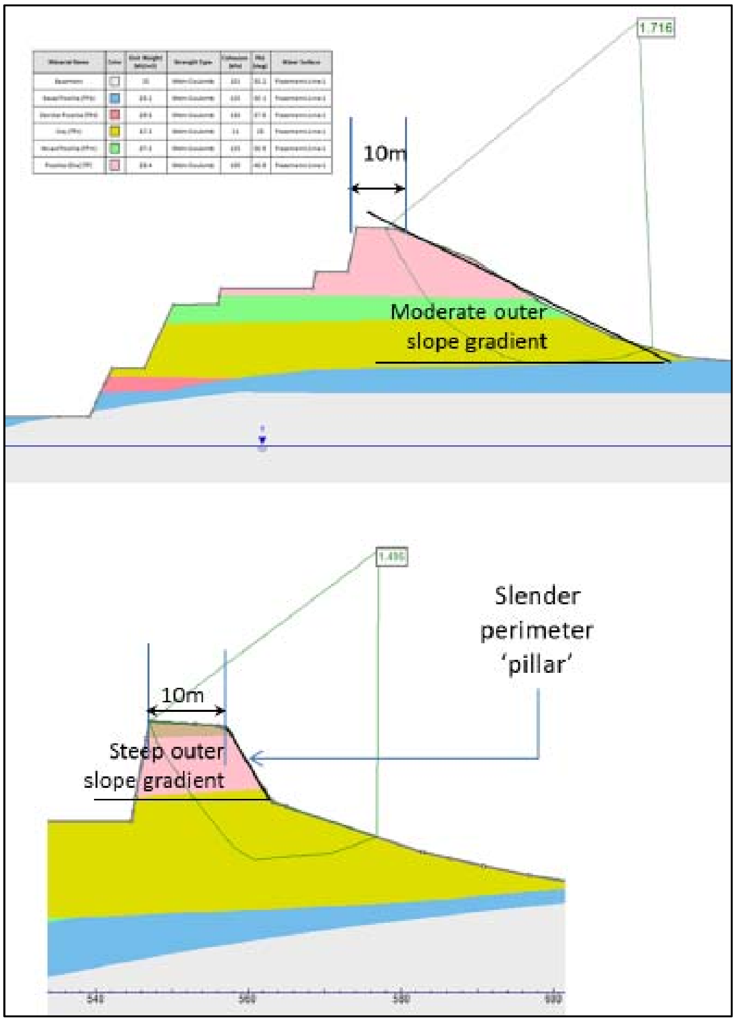


Figure 28. Example of Facade geometry in RTIO 2015 "Mesa B and C Façade Slope Stability Analysis for Closure" Report.

The long term stability of the mesa façade will be controlled, in part, by the level of blast damage and relaxation undergone by the perimeter material. Xstract recommended a minimum stand-off distance of 20m (i.e. approximately twice the standard mining bench height) be employed where the outer slope of the mesa is relatively steep (i.e. a 'slender' perimeter pillar may be formed).

6 Current Wall Performance

Current Mesa deposits wall performance was also evaluated to assist in deciding the minimum stand-off distance. The wall performance was evaluated in two ways:

- By reviewing wall condition utilizing UAV fly-over images (March, 2017) and
- By reviewing the prism monitoring data.

6.1 Wall Conditions

In Robe Valley, Mesa A, Mesa J and Warramboo are currently in an operational stage. Other deposits are currently under assessment. As there is no façade in Warramboo, only the current as-built slopes in Mesa A and Mesa J were reviewed. The existing walls have minimum stand-off distance of 50m as shown in Figure 29 and Figure 32.

In order to check geotechnical assumptions (design parameters) applied to the façade modelling, the installed prisms movements have been reviewed. The intent was to correlate the wall performance to the geotechnical parameters assuming the geotechnical parameters are not overly conservative.

The as-built wall conditions for Mesa A and Mesa J are shown in Figure 30, Figure 31, Figure 33 and Figure 34. Compared with Mesa J slope, the top benches in Mesa A demonstrated better performance. It was estimated that better wall performance in Mesa A contributed by more competent material intersected in the wall (HTP, TP TPM, and TPB). Mesa J has softer material (Alluvium and Colluvium) on the top benches. However, there were no indications that this condition has any impact on the façade.

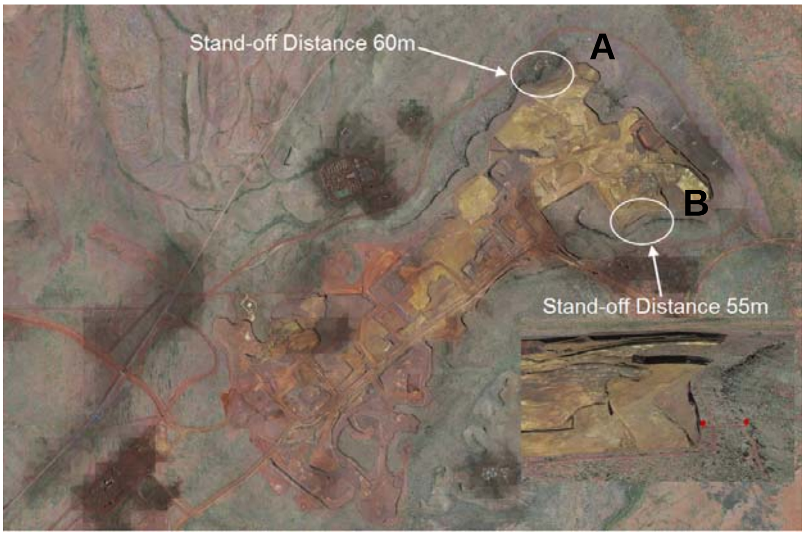


Figure 29. Mesa A As-Built Stand-Off Distance

Figure 30. Mesa A Area A Wall Conditions.

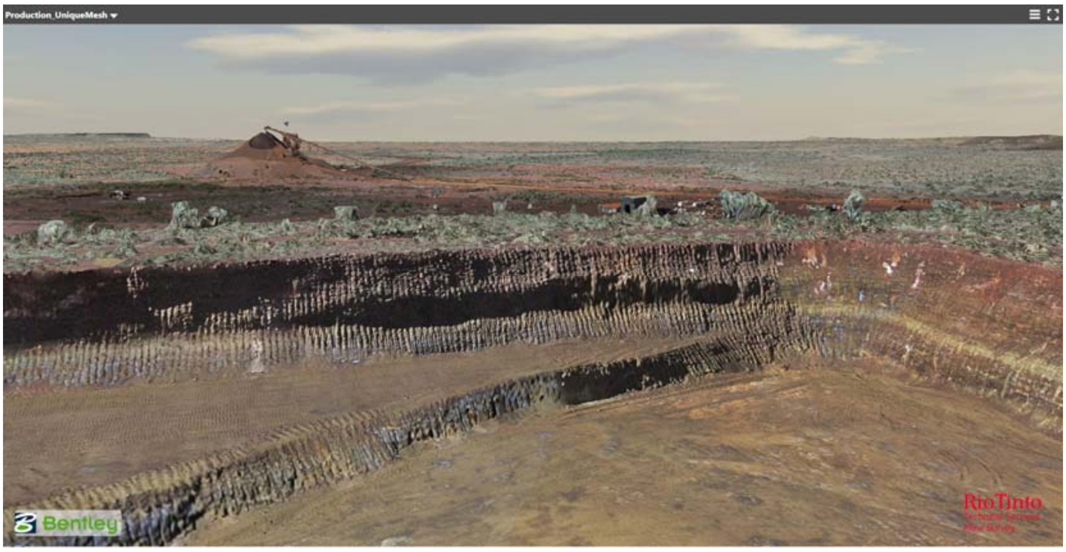


Figure 31.Mesa A Area B Wall Conditions.

Figure 32. Mesa J As Built Stand-Off Distance.

Figure 33.Mesa J Area A Wall Conditions.

Figure 34.Mesa J Area B Wall Conditions.

6.2 Prism Monitoring Data

Based on the geotechnical risk assessment, prisms have been installed in several areas in Mesa A and Mesa J to monitor the wall performance. The prisms are monitored manually on a fortnightly basis.

The prisms 3D movements were used to analyse the current as-built wall stability.

6.2.1 Mesa A Prisms

Eight prisms were installed on the cut slopes crest close to the façade in Mesa A Breach area (5 on the North wall and 3 on the South wall) as shown in Figure 35. A cross section of the slopes with the geological setting is shown in Figure 36. The wall in this area intersected HTP, TPH, TPM and TPB with 25m slope height. The Inter Ramp Angle (IRA) is 30 degrees in the north wall and 48 degrees in the south wall. Both are still below the maximum IRA recommended by Snowden in the 2007 report.

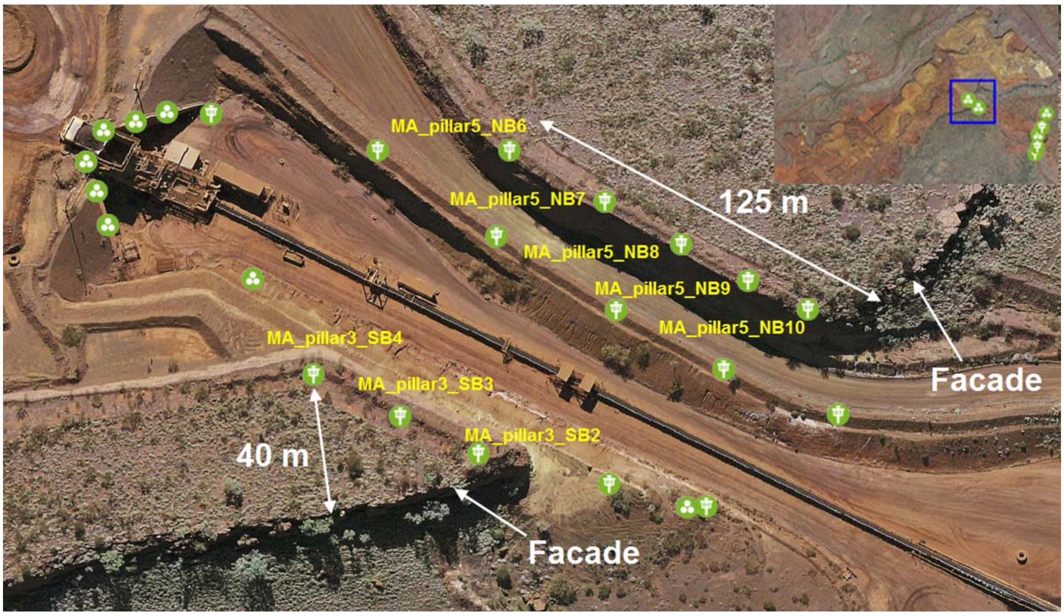


Figure 35. Prisms location in Mesa A Breach Area.

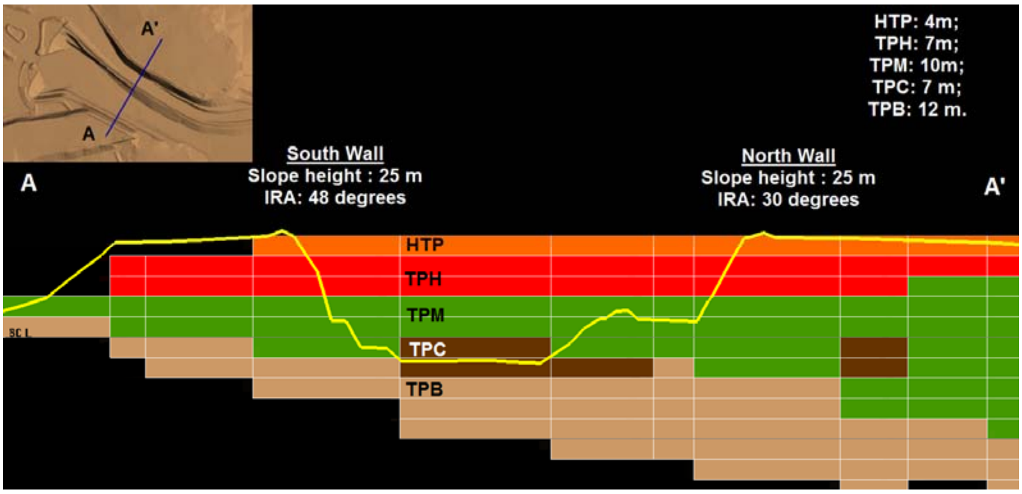


Figure 36. Mesa A Pit Cross Section where Prisms were installed.

The expected movement direction in the north wall prisms (NB6 toNB10) was south/south-west and north/north-east for the south wall prisms (SB2 to SB4). The prisms movements between May 2016 and April 2017 are summarized in Table 4.

Table 4. Mesa A Breach Area prisms movements summary

Deposit	Prism Name	3D Movement (mm/month)	Actual Movement direction	Expected movement direction	Note
Mesa A	SB2	-0.35	S-E	S / S-E / N / N-E / N-W	
Mesa A	SB3	-0.067	S-E	N-E / N / N-W	Invalid movement direction
Mesa A	SB4	0.00	N-E	N-E / N / N-W	
Mesa A	NB6	0.1	N	S / S-E / S-W	Invalid movement direction
Mesa A	NB7	0.00	N-W	S / S-E / S-W	Invalid movement direction
Mesa A	NB8	0.00	NA	S / S-E / S-W	
Mesa A	NB9	0.00	N-E	S / S-E / S-W	Invalid movement direction
Mesa A	NB10	0.00	N	S / S-E / S-W	Invalid movement direction

The recorded prism movement rates were minor. Five out of eight prisms movements also indicated invalid movement directions (moving towards the wall), possibly impacted by errors in the readings. Therefore, it was concluded that there was no apparent movement trend observed.
Mesa A prisms movement charts were included in Appendix A.

6.2.2 Mesa J Prisms

In order to check geotechnical assumptions (design parameters) applied to the façade modelling, the installed prisms movements have been reviewed. The intent is to correlate the wall performance to the geotechnical parameters assuming the geotechnical parameters are not overly conservative.

There is a Tailings Storage Facility (TSF4) behind the east wall of Pit 8 in Mesa J. The distance between the pit crest and the toe of TSF4 is around 25m. In total there are 17 prisms installed on the wall; 145mRL (prisms #17 and #18), 155mRL (prisms #10 to #16) and 161mRL (prisms 1 to 9) and monitored since February 2017 to monitor the impact of TSF4 to the pit 8 stability. The prisms locations are shown in Figure 37 and the as-built wall conditions are shown in Figure 38.

There is no façade near or might be impacted in this area. Monitoring results of this area is included to demonstrate stability of wall with worse conditions compared to most of the pit wall with façade in vicinity.

Prisms #1 to #9 are located in the tailing embankment to monitor the tailing slope stability. Therefore they were not included for analysing the slope stability. Only the prisms on the Pit 8 slope (#10 to 18) were investigated.

Figure 37. Mesa J TSF4 Prisms Locations.

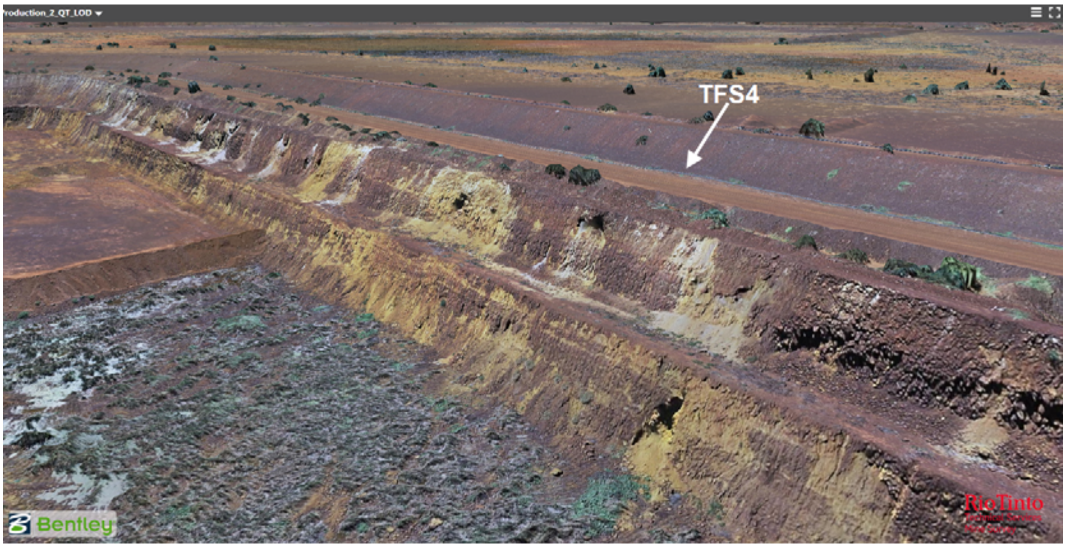


Figure 38. Mesa J Slope Under TFS4 Wall Conditions.

The slope intersected HTP (2m) and TPM (20m). The slope height is 25m with IRA 40 degrees as shown in Figure 39 which is lower than the maximum IRA recommended by 3rd Rock in their 2017 Mesa B, C and H FS report for similar material.

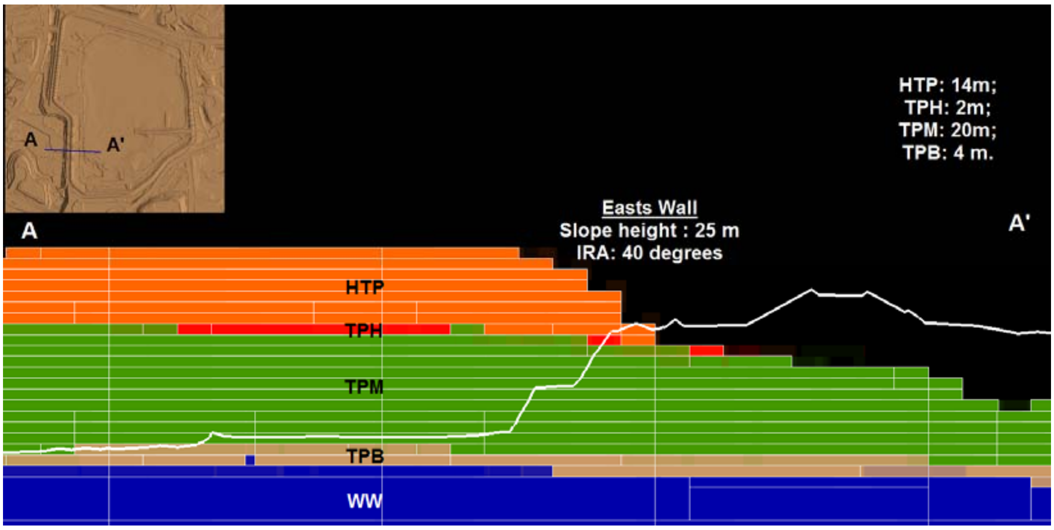


Figure 39. Mesa J South West Dump Cross Section Geology Setting.

Table 5.Mesa J TSF4 Area Prisms Movements Summary

Deposit	Prism Name	3D Movement (mm/month)	Actual movement direction	Expected movement direction	Note
Mesa J	10	1.40	S-E	W / N-W / N-E	Invalid movement direction
Mesa J	11	1.10	S-E	W / N-W / N-E	Invalid movement direction
Mesa J	12	0.00	N-E	W / N-W / N-E	No movement
Mesa J	13	1.10	S-E	W / N-W / N-E	Invalid movement direction
Mesa J	14	0.90	S-E	W / N-W / N-E	Invalid movement direction
Mesa J	15	1.20	S-E	W / N-W / N-E	Invalid movement direction
Mesa J	16	2.4	S-E	W / N-W / N-E	Invalid movement direction
Mesa J	17	1.80	S-E	W / N-W / N-E	Invalid movement direction

The recorded prism movement rates were minor with most of them showing invalid movement direction (moving towards the wall) Therefore, it can be concluded that there was no apparent trend of movement observed.

The Mesa J Pit 8 TFS4 prisms movement charts were included in Appendix A.

7 Façade Stability in Closure Stage

Stability of the mesa facades post closure had not been considered in historical Robe Valley Closure studies. There is a risk that the facade stability may be impacted if the water table returns to pre-mining levels. This risk must have been considered as part of the closure study.

7.1 Robe Valley Closure Plan

Closure studies have been completed for the Mesa A Hub (including Warramboo, Mesa A, B & C) and the Mesa J Hub (including Mesa J, K & H) by RTIO in 2017. The surface water, ground water and back fill plan are the factors which can affect the façade stability; therefore these parameters were reviewed in this report.

7.1.1 Surface Water

Flood modelling has been undertaken for the Robe Valley deposits as mentioned in Section 3.1. Mesa A and Mesa J hub deposits are not subject to riverine flooding from the Robe River. Waste Dumps currently proposed for a breakout flood area between Mesa A and Mesa B located in an area subject to infrequent and shallow flow. Flow velocities are less than 2 m/s and not expected to result in erosion of landforms (RTIO, 2017).

7.1.2 Ground Water

During mining, there will be a total of four deposits which will have the deepest part of their pit floors under the pre-mining ground water table level including: Mesa C, Mesa H, Mesa J and Warramboo. Predicted groundwater recovery levels and the modelled time to recovery are listed in Table 6.

Table 6. Predicted Ground water Level and Approximate time for Recovery (RTIO, 2017)

Deposit	**Pre-mining Water Level (mRL)**	**Estimated water table level at mining stage(mRL)**	**Estimated maximum drawdown level (mRL)**	**Estimated recovery level (mRL)**	**Time (years)**
Warramboo	25-50	18	18	25-50	100
Mesa A	48-50	No change-AWT mining	NA	NA	NA
Mesa B	55-58	No change-AWT mining	NA	NA	NA
Mesa C	67-70	47	20	TBC	TBC
Mesa H	120-144	110	34	120-144	30
Mesa J	142-155	110	45	142-155	30
Mesa K	144-146	No change-AWT mining	NA	NA	NA

7.1.3 Backfill Plan

The distribution of closure domains are illustrated in Figure 40, Figure 41 and summarized in Table 7.

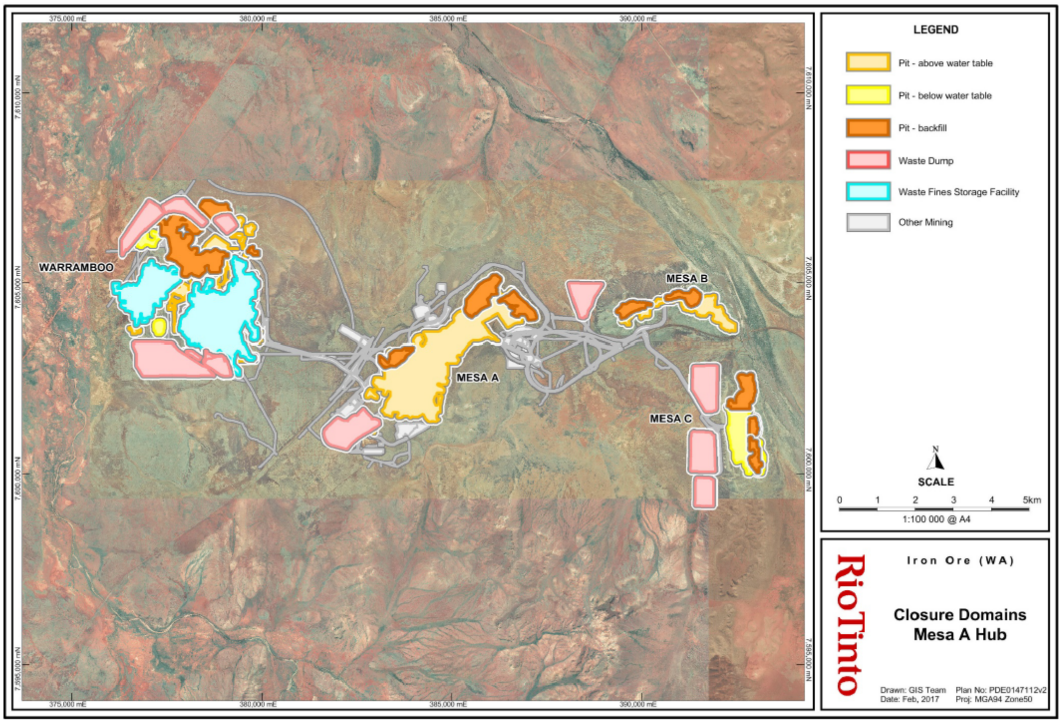


Figure 40. Robe Valley Mesa A, Mesa B, Mesa C and Warramboo Closure Domains.

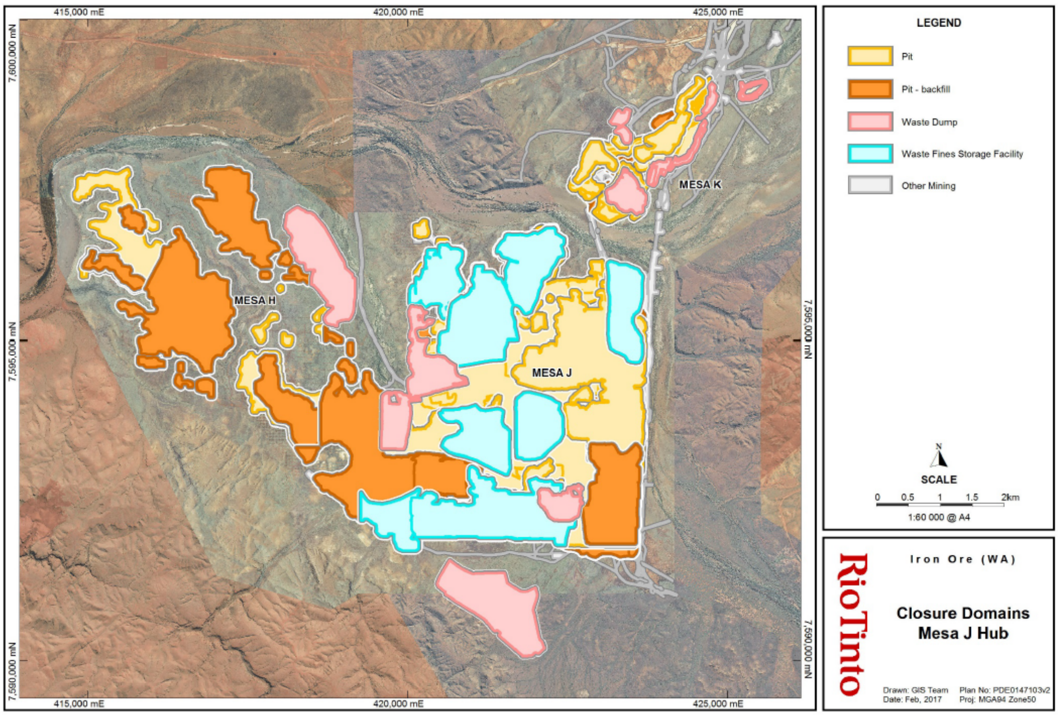


Figure 41.Robe Valley Mesa J, Mesa H and Mesa K Closure Domains

Table 7. Robe Valley Deposits Backfill Plan.

Deposits	Below/Above Water Table	Pits	Backfill Plan
Mesa J Mesa H Mesa K	AWT	Other pit except BWT pits	Pits may be partially backfilled
	BWT	Mesa H Pit 1 Mesa H Pit 3 Mesa H Pit 4 Mesa H Pit 5 Mesa H Pit 6 Mesa H Pit 7 Mesa J Pit 6 Mesa J Pit 11 Mesa J Pit 12 Mesa J Pit 15	Undertake opportunistic backfill during operations
		Mesa J Pit 15	Mesa J pit 15 will have an area partially left as a pit lake.
Mesa A Mesa B Warramboo	AWT	Other pits except BWT pits	Pits may be partially backfilled where possible to minimise the volume of waste in out of pit waste landforms
	BWT	Mesa C_pit01 Mesa C_pit02 Mesa C_pit03 Wboo_pit3	Undertake opportunistic backfill during operations

In order to assess the slope stability close the façade after ground water recovery, two sections were selected from Mesa C and Mesa H in the area where pit floors will be under the pre-mining water table as shown in Figure 42 and Figure 43. The pit floors will be 15m below pre-mining water table in section A Mesa C, and 10m below pre-mining water table in section J of Mesa H.

The closure plan has consequently prioritised these areas for backfill in the future. Additional stability analyses in these sections were intended to check the stability of the slopes prior to backfill.

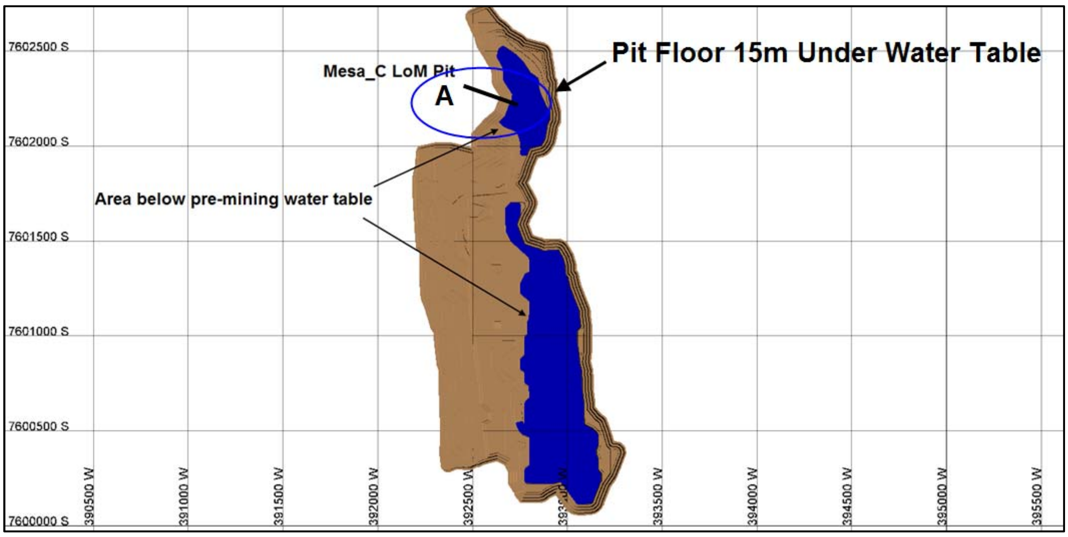


Figure 42. Closure Slope Stability Geotechnical Section in Mesa C.

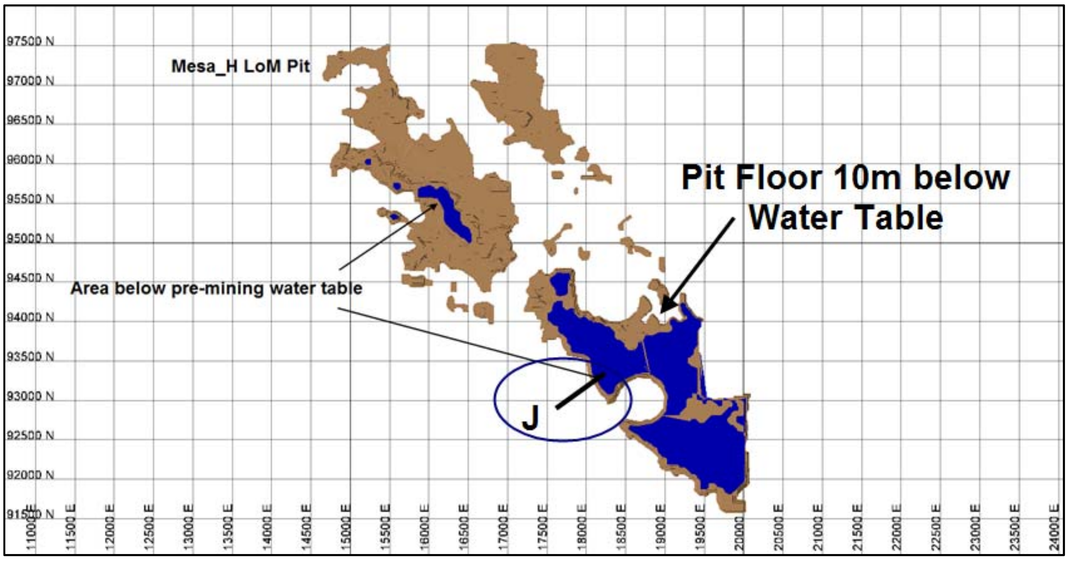


Figure 43.Closure Slope Stability Geotechnical Section in Mesa H.

The SLIDE models for the two sections used the rock mass parameters from 2017 3rd Rock study, and the pre-mining water table levels (69mRL in Mesa A and 135mRL in Mesa H). The results were plotted in Figure 44 and Figure 45.

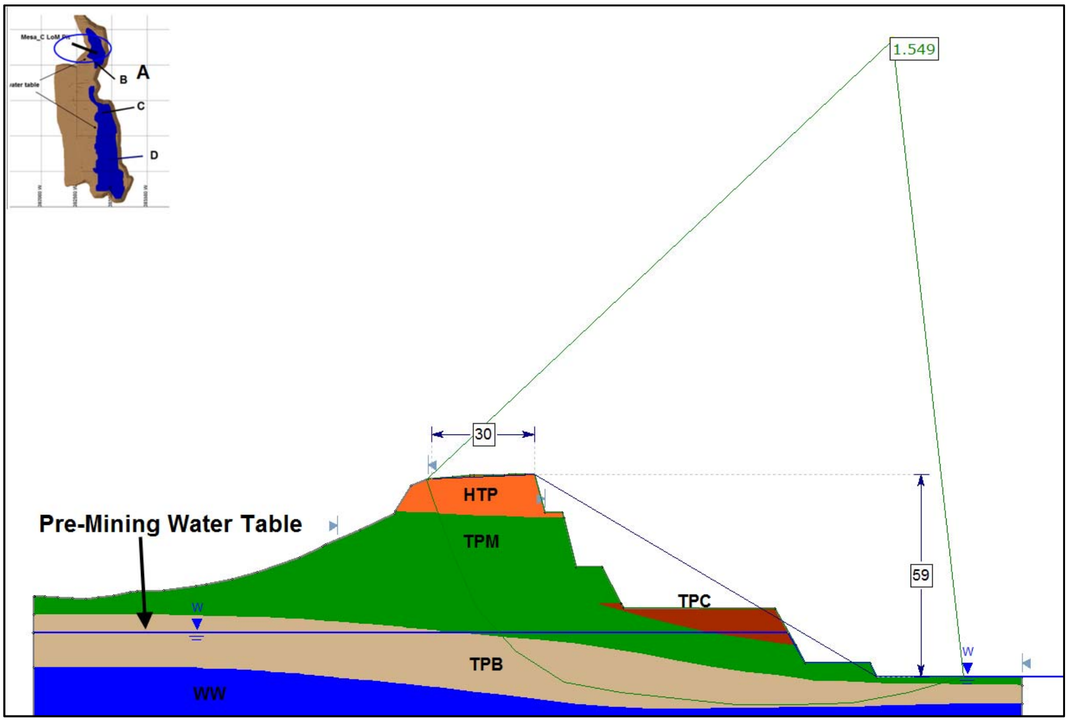


Figure 44. Section A Mesa C Slope Stability after Closure (FoS>1.5).

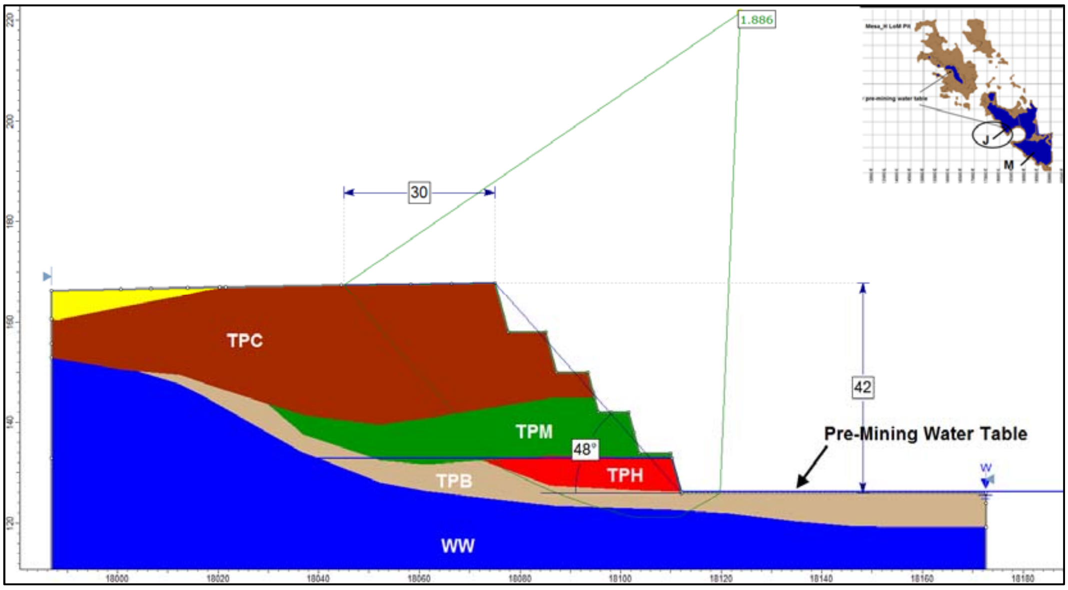


Figure 45.Section J Mesa H Slope Stability after Closure (FoS>1.5).

Both models show that the FoS in area within 30m from the pit crest were higher than Rio Tinto Design Acceptance Criteria (>1.5). Backfilling proposed in the closure plan will increase the wall stability. Therefore, it is concluded that a minimum 30m façade is considered as adequate from a stability perspective and to protect the identified environmental and heritage values.

8 Conclusions

The historical recommendations for the Robe Valley façade stand-off distances are summarized in Table 8.

Table 8. Recommendations for Facade Stand-Off Distance

Robe Valley Façade Stand-Off Distance Recommendation					
Report	**Completed by**	**Year**	**Geotechnical Drilling (m)**	**Number of used holes**	**Minimum Stand-Off Distance (m)**
Mesa A and Warramboo Geotechnical Review	Snowden	2007	507	14	50
Robe Valley Sustaining PFS Geotechnical Design Report	RTIO	2015	NA		15
Mesa H Pit crest/Façade Stand-off Distance Update	RTIO	2016	NA		30
Robe Valley Operational Geotechnical Function Independent Review	Xstract	2017	NA		20
Robe Valley mesa B, C and H Pits Geotechnical Feasibility Study	3rd Rock	2017	2873.2	51	30

Note. Snowden assessed stability for 50m stand-off distance but did not examine smaller distances (less than 50m).

Based on work undertaken in previous studies, and updated information available from new studies including: current wall performance and wall monitoring (with current prism monitoring data at Mesa A); additional drilling data; updated geological models; recent blasting data; and additional laboratory testing (including consideration of the lower quartile rock strength) have contributed to refining a minimum stable stand-off distance to protect the façade during mining operations and into closure.

From the work and studies undertaken to date, it is concluded that a minimum of 30m stand-off distance from the façade to the pit crest is adequate for maintaining the long term stability and integrity of the façade.

Sincerely,

Xuzheng Gao
Geotechnical Engineer
Mine Engineering Geotechnical, OKP

9 Reference:

1. Snowden, 2007. Mesa A/Warramboo Feasibility Study,< RTIO-PDE-0036381>

2. RTIO, 2007. Mesa K Pre-Feasibility Study, <Q:\Resource Planning\Geotechnical\01_Projects\11_Robe_Valley\07_Mesa K\8. Reports>

3. RTIO, 2016. Mesa H Pit crest/Façade Stand-off Distance Geotechnical Recommendations Update, <RTIO-PDE-0131352>

4. RTIO, 2015. Robe Valley Sustaining PFS (Middle Robe, East Deepdale, Mesa B and Mesa C) Geotechnical Design Report, <Q:\Resource Planning\Geotechnical\01_Projects\11_Robe_Valley\00_Robe Valley General\2. Reports\2015_RV_Sustaining_PFS\01_Report>

5. RTIO, 2015, Mesa B and C façade slope stability analyses,< RTIO-PDE-0131352>

6. RTIO, 2016. Mesa H Pit crest/Façade Stand-off Distance Geotechnical Recommendations Update, <Q:\Resource Planning\Geotechnical\01_Projects\11_Robe_Valley\15_Mesa H\8. Reports>

7. 3RD Rock Consulting, 2017. Robe Valley, Mesa B, C and H Pits Geotechnical Feasibility Study, <RTIO-PDE-0154264>

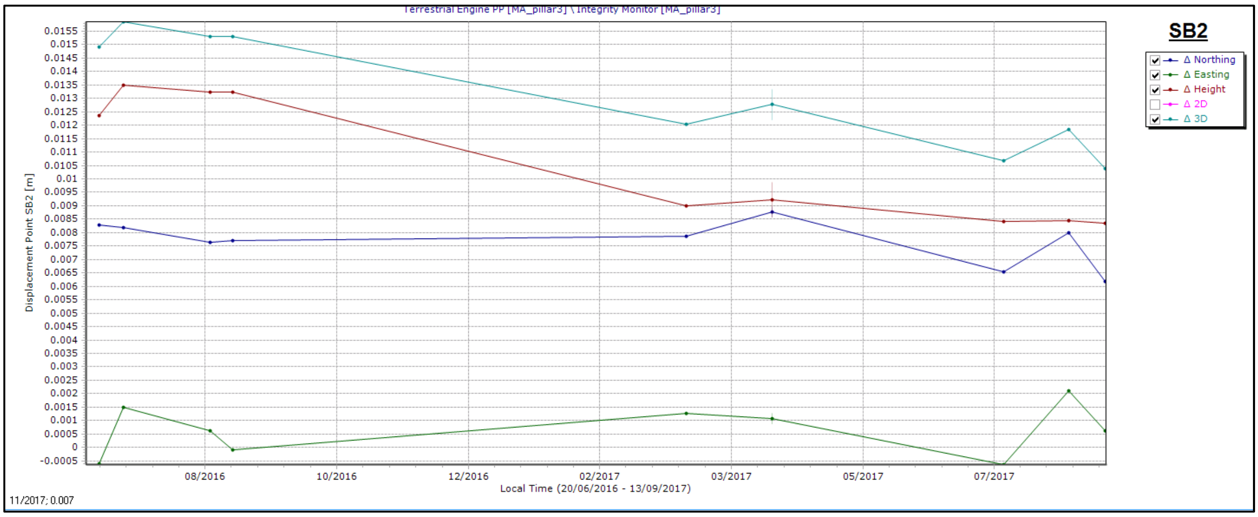
8. Xstract, 2017, Robe Valley Operational Geotechnical Function Independent Review, <RTIO-HSE-0304656>

9. RTIO, 2017, Mesa A Hub Closure Plan, <RTIO-HSE-0307626>

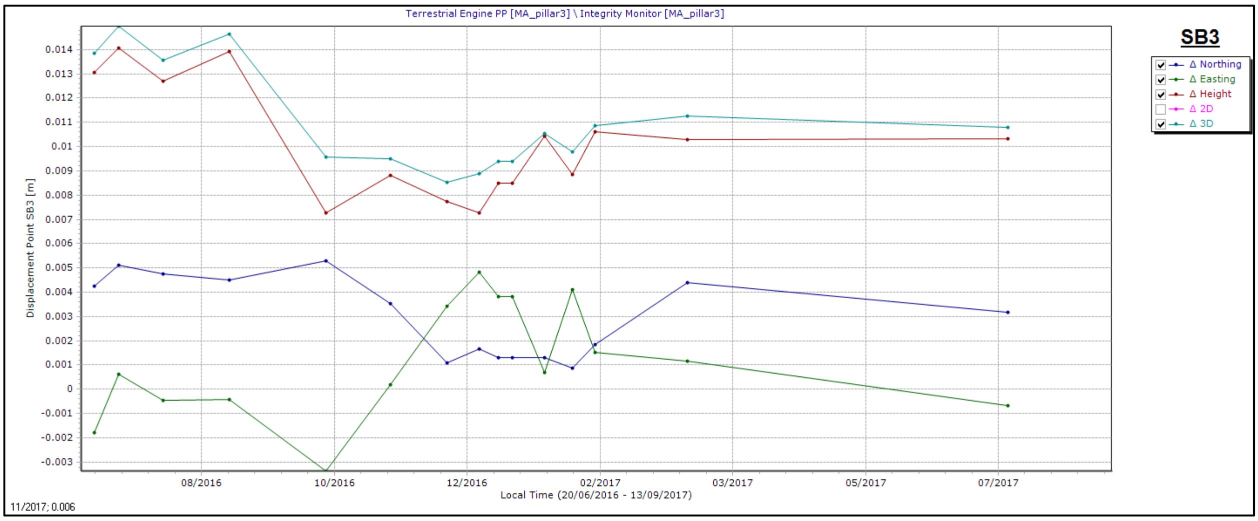
10. RTIO, 2017, Mesa J Hub Closure Plan, <RTIO-HSE-0168839 >

Appendix A – Prisms Displacement Monitoring Charts (Northing, Easting and 2D) vs Time

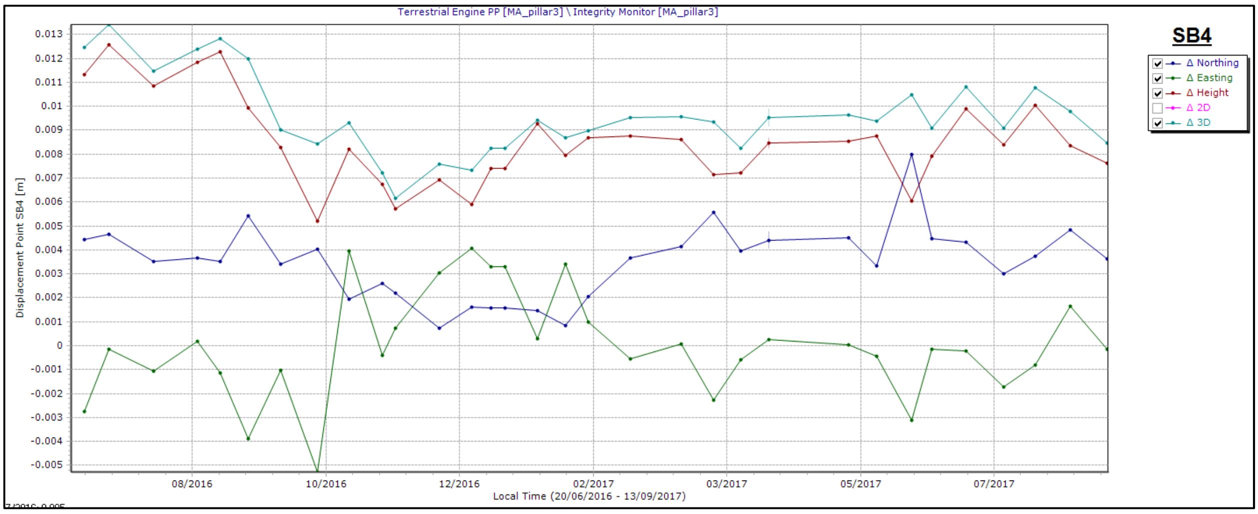
Mesa A Prisms (Breach Area)



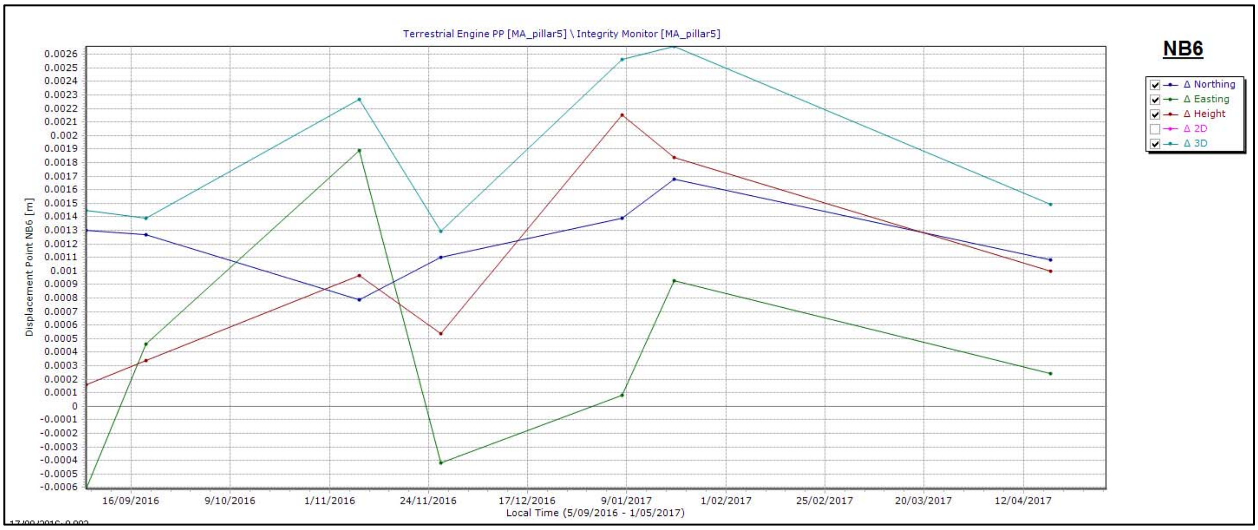
Mesa A Prism SB2



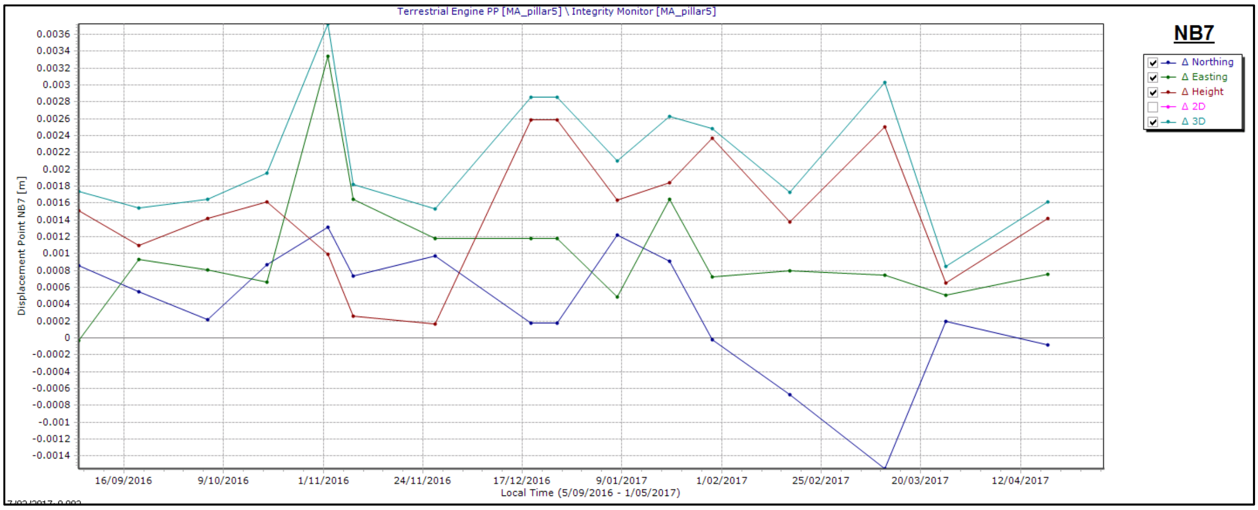
Mesa A Prism SB3



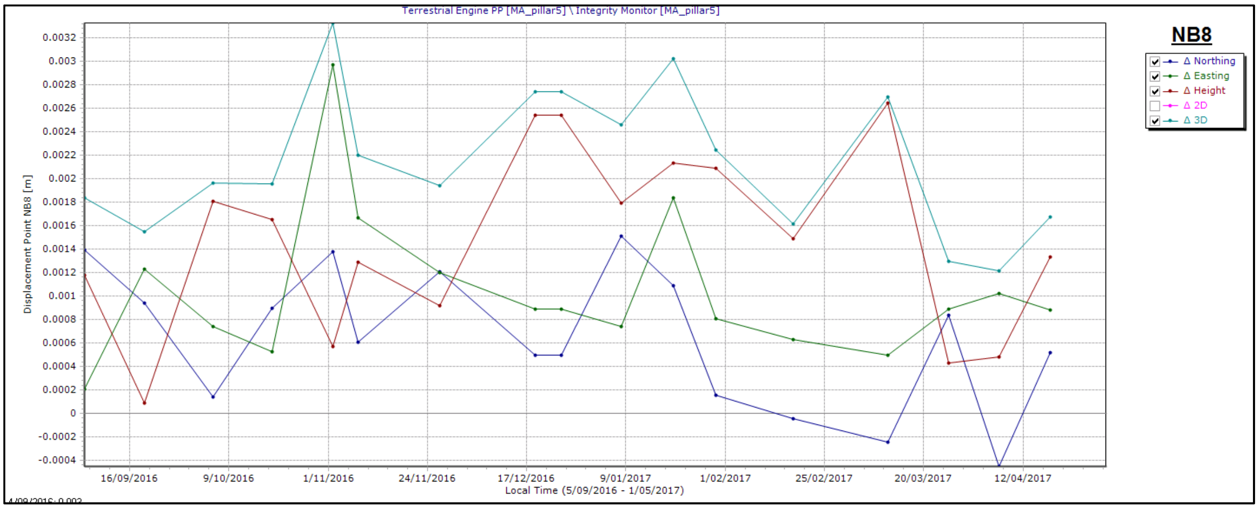
Mesa A Prism SB4



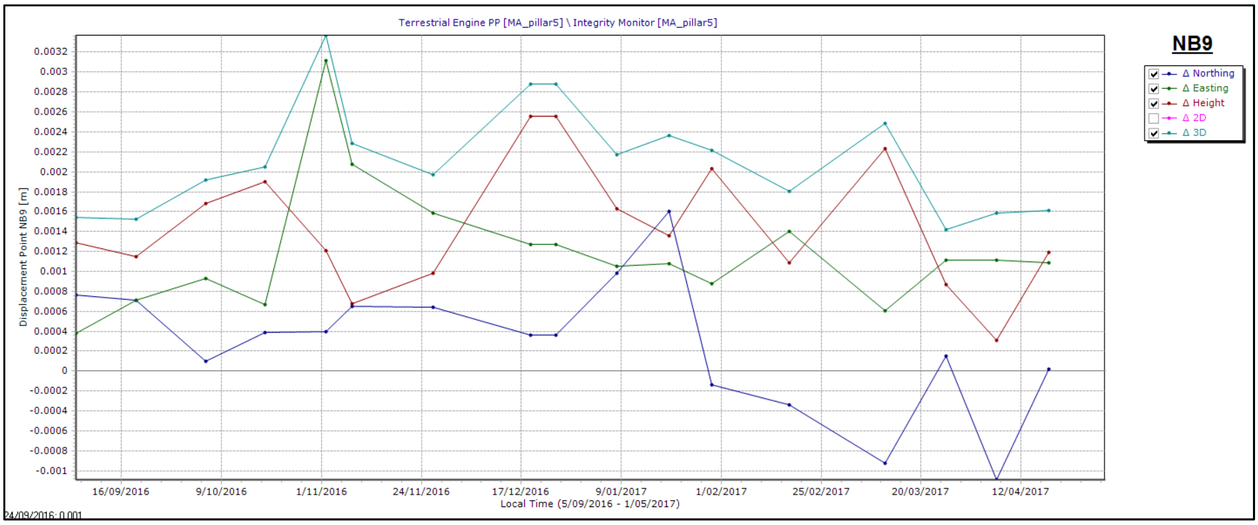
Mesa A Prism NB6



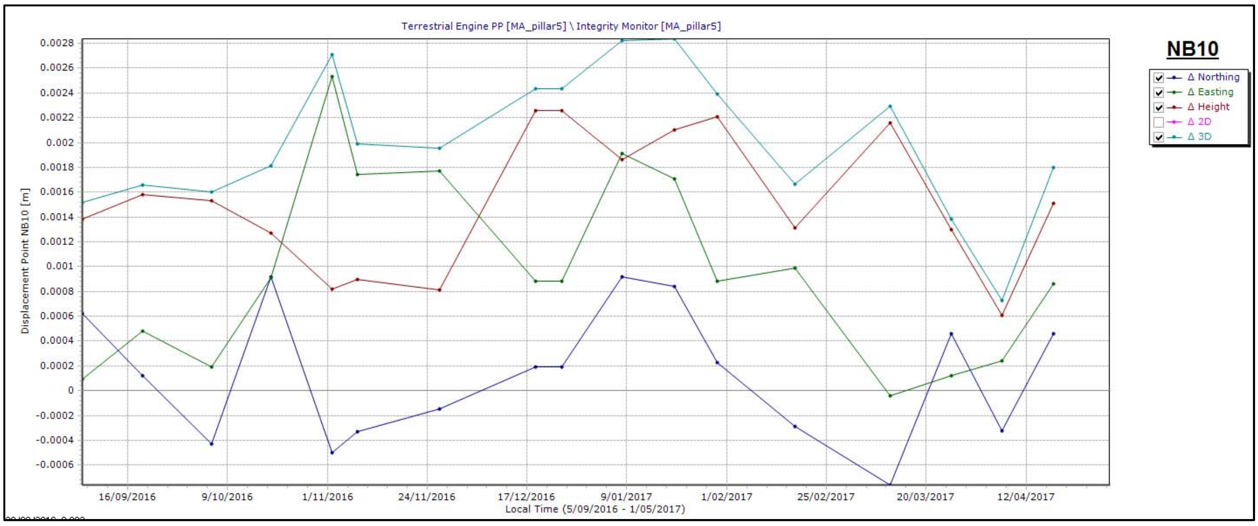
Mesa A Prism NB7



Mesa A Prism NB8

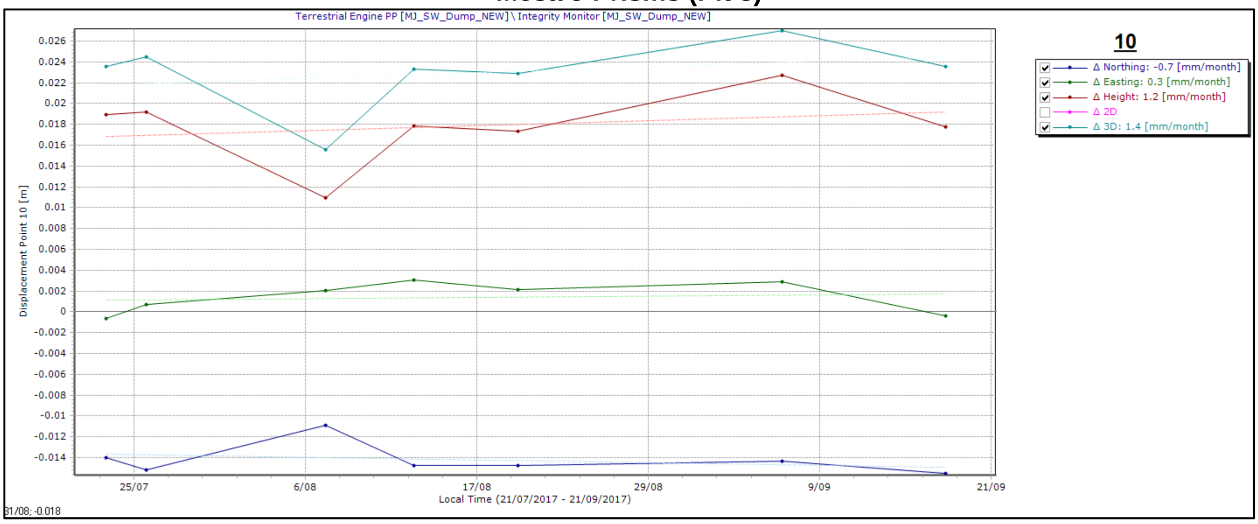


Mesa A Prism NB9

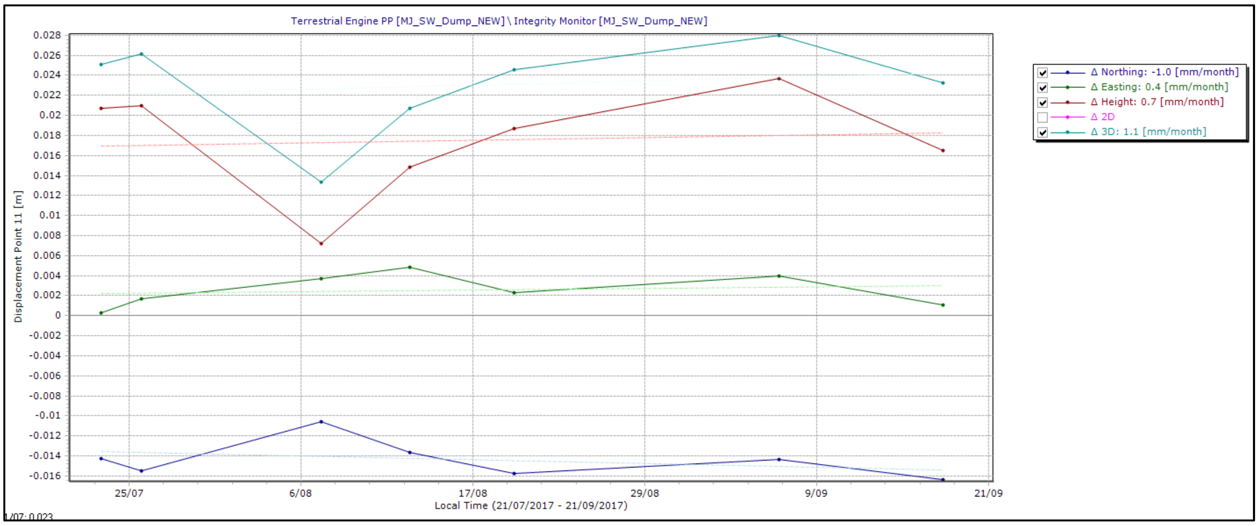


Mesa A Prism NB10

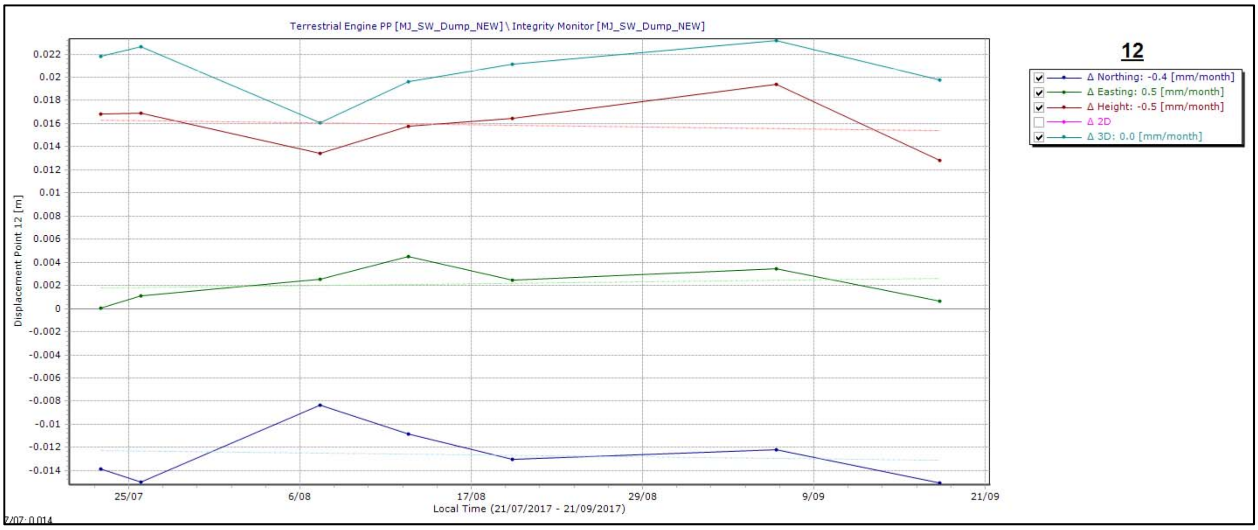
Mesa J Prisms (Pit 8)



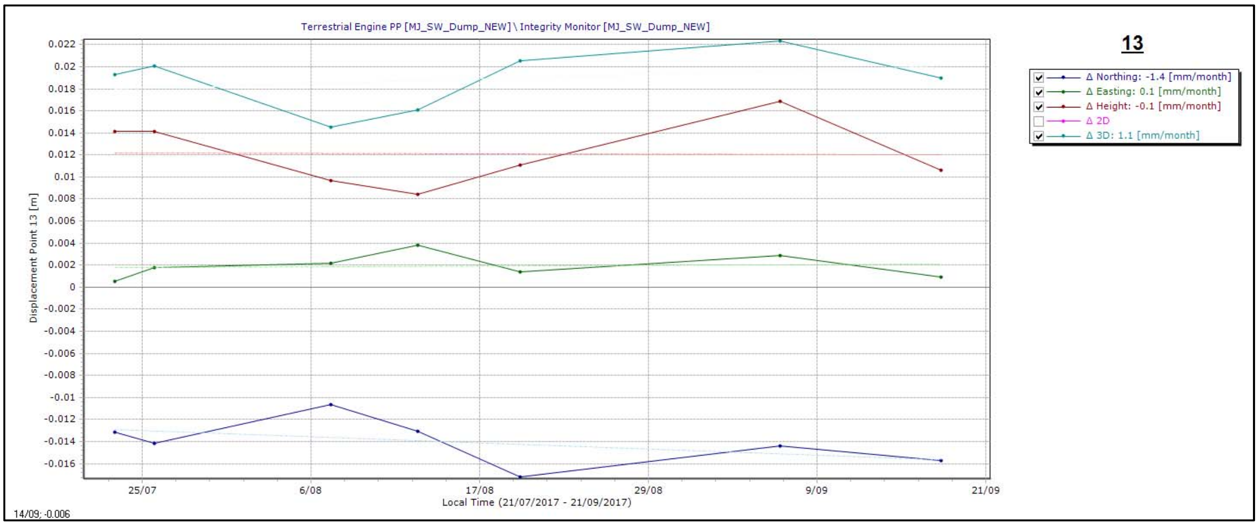
Mesa J Prism 10



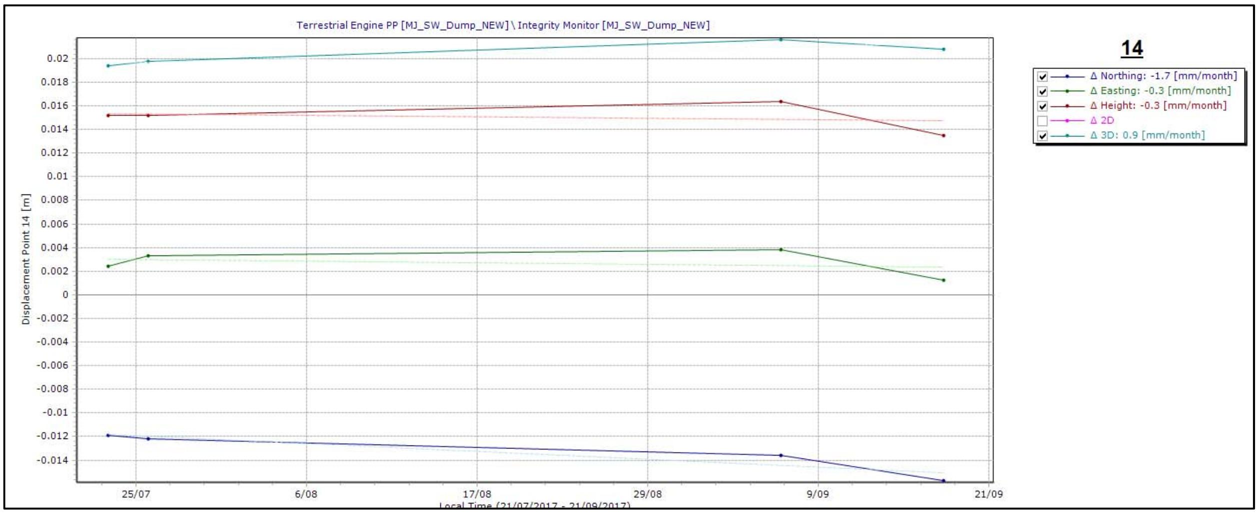
Mesa J Prism 11



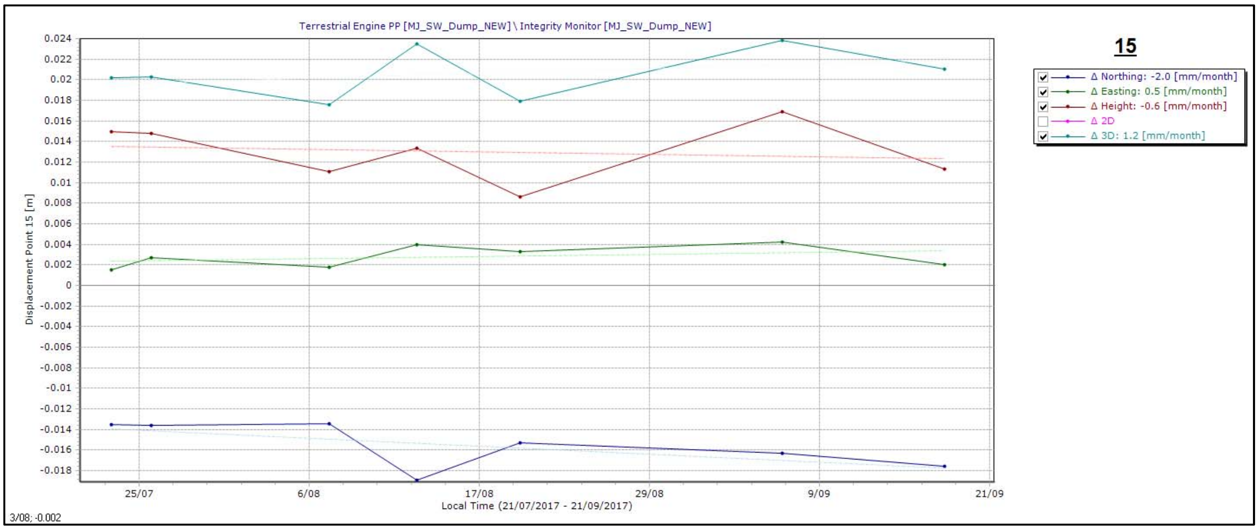
Mesa J Prism 12



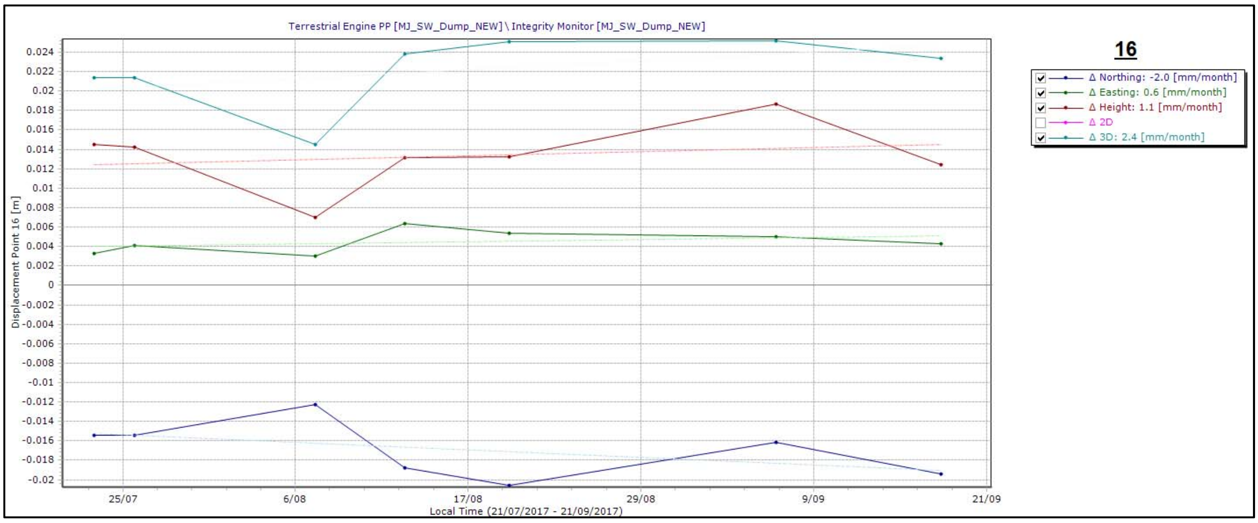
Mesa J Prism 13



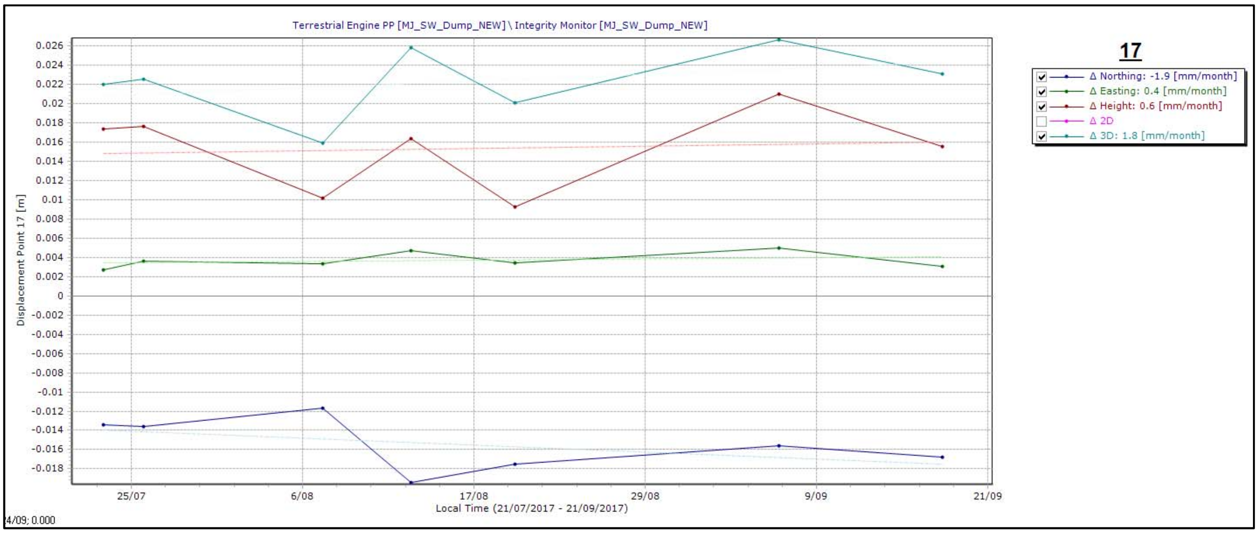
Mesa J Prism 14



Mesa J Prism 15



Mesa J Prism 16



Mesa J Prism 17