

Appendix 6.2-C

*Ajax Project Open Pit – Review of Open Pit Design Parameters
for Updated Hydrogeological Conditions*

AJAX PROJECT

**Environmental Assessment Certificate Application / Environmental Impact Statement
for a Comprehensive Study**

Ajax Project Open Pit

Review of Open Pit Design Parameters for Updated Hydrogeological Conditions

Report Prepared for

KGHM Ajax Mining Inc.



Report Prepared by



SRK Consulting (Australasia) Pty Ltd

KGH001

November 2014

Ajax Project Open Pit

Review of Open Pit Design Parameters for Updated Hydrogeological Conditions

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Executive Summary

SRK carried out slope stability analysis to assess slope parameters for the Ajax pit, during June 2014 (SRK, June 2014). At this time, there was limited information available on the hydrogeological conditions of the area and the level of drainage that the pit will generate; therefore, the pore water pressure distribution was assumed.

KGHM Ajax Mining Inc. (KGHM) has since provided SRK with new information about the hydrogeological conditions in the Jacko Lake vicinity. The information is in the form of results from 2D hydrogeological models produced by Klohn Crippen Berger (KCB, 2014). KCB has carried out preliminary analysis of the hydrogeology of the Jacko Lake area; these results can improve the assumptions made with regard to pore water distributions used in the previous analysis carried out by SRK (June 2014).

A new pit design, provided by KGHM, was used to carry out the revised analysis (interim mw final min waste clipped_july 2014.dxf). The main difference is the depth of the new pit; it is 40 m deeper on the West end and approximately 60 m shallower on the East end.

Summary and recommendations

The analysis carried out indicates that it is possible to increase the overall slope angle (OSA) in sectors 1, 2 and 6, provided that it is possible to achieve the drainage indicated in KCB's 2014 report.

For Sector 6, there was no new information about pore water distribution, but the new pit design is shallower than the pit design used previously (SRK, June 2014). The combination of reduced depth and less exposure of the weak Picrite (PICR) rock makes it possible to increase the OSA. It is important to recognise the sensitivity of the pit wall stability in Sector 6 to changes in design relative to the spatial distribution of weak rock.

Table ES-1 summarises the results of the analysis and recommendations based on the work presented in this report.

Table ES-1: Changes in OSA

Sector	Original Design (*)	Current Design (**)	Recommended
Sector 1	46°	43° – 45.3°	48°
Sector 2	46°	46.8°	48°
Sector 6	42°	40°	45°

(*) SRK June 2014

(**) June 2014 KGHM Mine Model

For completeness, the location of the sectors is shown in Figure ES-1 and the recommended slope parameters in Table ES-2. This table includes the same information shown in the SRK report of June 2014, although the OSAs for sectors 1, 2 and 6 have been updated.

It is recommended that if new information regarding pore water distribution is obtained, either due to re-analysis of the current 2D models or from new 3D models, the slope parameters recommended herein should be re-assessed to verify their validity.

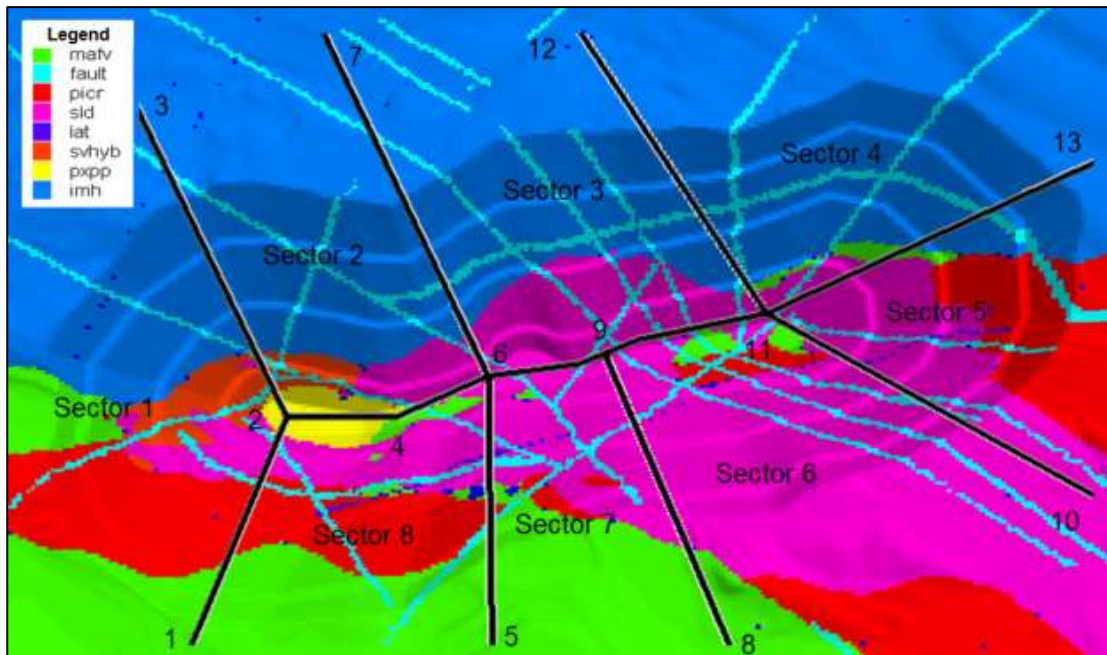


Figure ES-1: Location of Design Sectors 1 to 8

Table ES-2: Summary of recommended initial slope parameters (SRK, June 2014) and revised recommendations for sectors 1, 2 and 6 (SRK, November 2014).

Sector	Unit	Bench height, h (m)	BFA (°)	Berm B (m)	BSA (°)	IRA (°)	Geotech berm (m)(**)	Maximum OSA (°)
1	IMH/PXPP – LAT	30	75	17	54.2	50.2	25	48
	SLD	30	75	18	53.2	49.0	25	
	PICR (NVP)	30	65	16	48.2	45.0	25	
	MAFV (NVV)	30	65	16	48.2	45.0	25	
2	IMH/PXPP – LAT	30	75	17	54.2	50.2	25	48
	SLD	30	75	18	53.2	49.0	25	
3	IMH	30	75	17	54.2	50.2	25	50
	SLD	30	75	18	53.2	49.0	25	
4	IMH	30	75	17	54.2	50.2	25	53
	SLD	30	75	18	53.2	49.0	25	
5	IMH	30	75	17	54.2	50.2	25	53
	SLD	30	75	17	54.2	50.2	25	
	PICR (NVP)	30	65	16	48.2	45.0	25	
6	SLD (*)	30	70 (75)	20 (17)	48.1 (54.2)	44.1 (50.2)	40 (30)	45
	PICR (NVP) (*)	30	65	16.5	47.8	44.5	40 (30)	
7-8	SLD	30	75	17	54.2	50.2	25	52
	PICR (NVP)	30	65	16	48.2	45.0	25	
	MAFV (NVV)	30	65	16	48.2	45.0	25	
	SLD/PXPP – LAT	30	75	17	54.2	50.2	25	

(*) The slope design recommended has been adjusted to produce the OSA, which cannot be exceeded as explained in the text below; this applies only for the final pit wall. The numbers in brackets are the recommendations for any the interim pit walls.

(**) The geotechnical berm can be reduced to 20m in places were the combination of ramp and geotechnical berms push the OSA away from the maximum OSA indicated in the table.

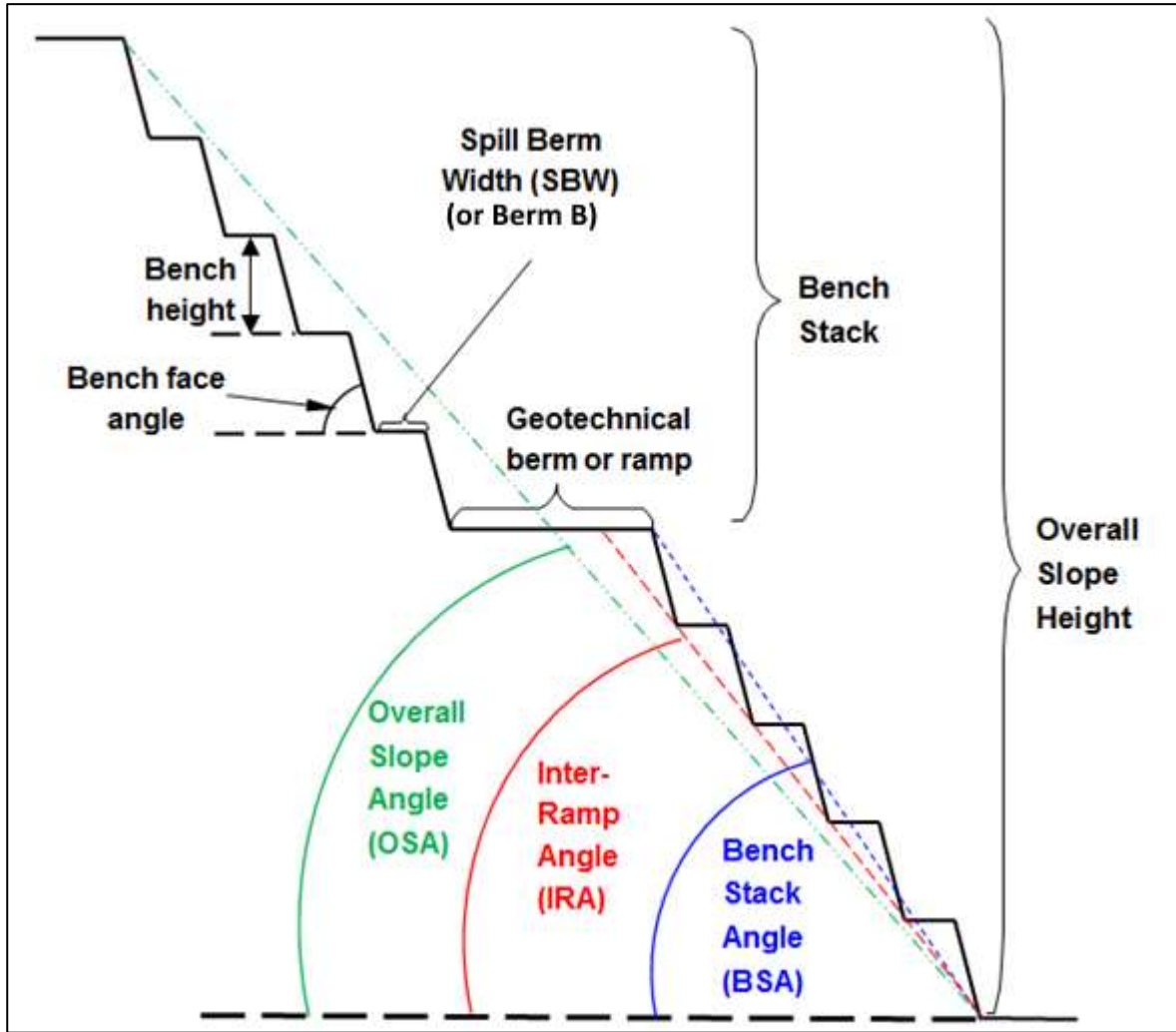


Figure ES-2: Naming convention for pit slope geometrical elements

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Disclaimer

The opinions expressed in this Report have been based on the information supplied to SRK Consulting (Australasia) Pty Ltd (SRK) by KGHM Ajax Mining Inc. (KGHM). The opinions in this Report are provided in response to a specific request from KGHM to do so. SRK has exercised all due care in reviewing the supplied information. Whilst SRK has compared key supplied data with expected values, the accuracy of the results and conclusions from the review are entirely reliant on the accuracy and completeness of the supplied data. SRK does not accept responsibility for any errors or omissions in the supplied information and does not accept any consequential liability arising from commercial decisions or actions resulting from them. Opinions presented in this Report apply to the site conditions and features as they existed at the time of SRK's investigations, and those reasonably foreseeable. These opinions do not necessarily apply to conditions and features that may arise after the date of this Report, about which SRK had no prior knowledge nor had the opportunity to evaluate.

1 Introduction and Scope of Report

SRK carried out slope stability analysis to assess slope parameters for the Ajax Open Pit during June 2014 (SRK June 2014). At the time, no information on the hydrogeological conditions of the area and the level of drainage that the pit will generate was available; therefore, the pore water pressure distribution was assumed.

KGHM Ajax Mining Inc. (KGHM) has provided SRK with new information about the hydrogeological conditions in the vicinity of Jacko Lake (Figure 2-1). The information is in the form of results from 2D hydrogeological models produced by Klohn Crippen Berger (KCB, 2014). KCB has carried out preliminary analysis of the hydrogeology of the Jacko Lake area; these results can improve the assumptions made with regard to pore water distributions used in the previous analysis carried out by SRK in June 2014.

A new pit design, provided by KGHM, was used to carry out the analysis (interim mw final min waste clipped_july 2014.dxf). The main difference is the depth of the new pit; it is 40 m deeper on the West end and approximately 60 m shallower on the East end.

Based on this information, KGHM requested SRK to review the slope parameters recommended for sectors 1 and 2 and consider alternative drainage conditions for Sector 6 (Figure 1-1). The requested analyses are described in Table 2-1.

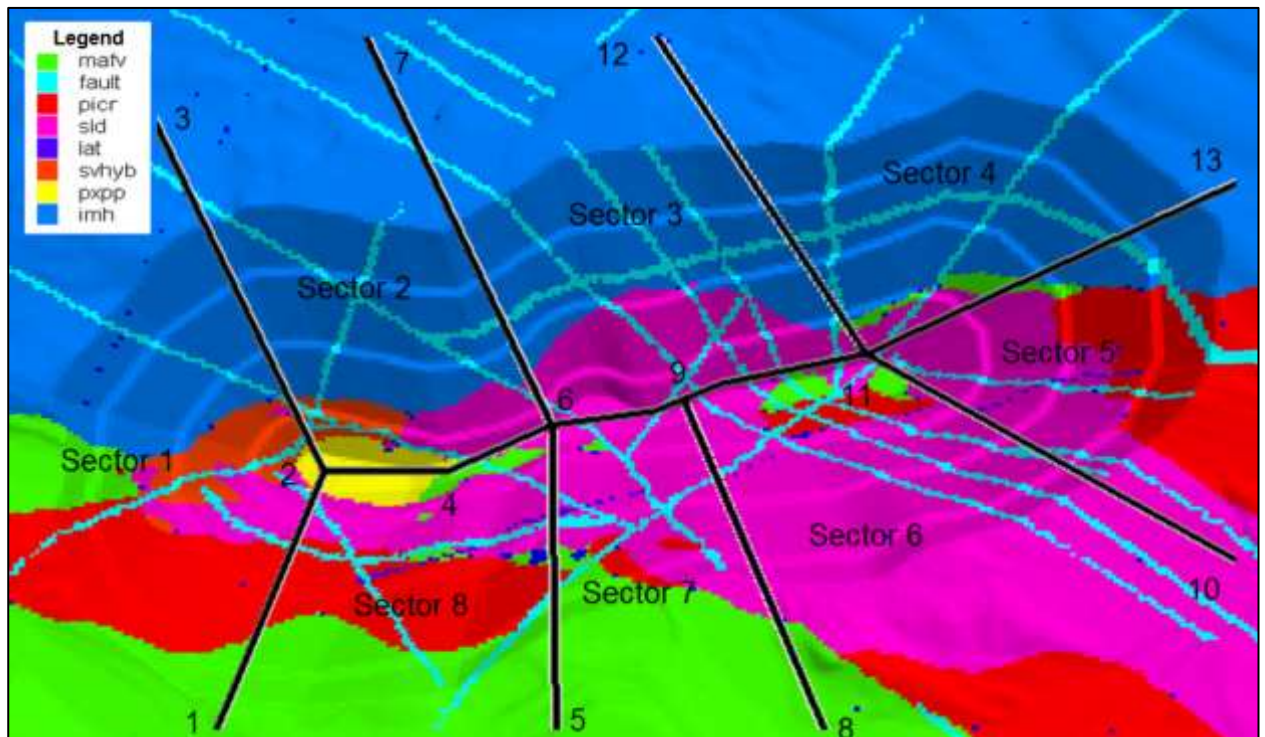


Figure 1-1: Pit design sectors (1 through 8) shown relative to approximate final pit shape, and lithology model

2 Programme Objectives and Work Programme

The objective of this work programme is to improve, when possible, the OSA parameters previously recommended, based on the new hydrogeological information. The bench slope angle and inter-ramp stability was analysed assuming drained conditions in the previous work undertaken by SRK; therefore, improvements in drainage will not have an impact on bench and inter-ramp scale, and the slope parameters recommended (SRK, 2014) are still valid. For completeness, the recommendations are repeated in Section 4 (Conclusions and Recommendations).

The analyses considered in this study are provided in Table 2-1. The discussion of the analyses carried out, along results, are organised following the descriptions (A to D) indicated.

Table 2-1: Analyses carried out for this Study

Analysis	A	B	C	D
Scenario description	Increase assumed active depressurisation from 125 m to 150 m for Sector 6. For sectors 1 and 2, Base Case and Sensitive 4 KCB results were used	No active depressurisation	West wall not affected by Jacko Lake	Use KCG findings for hydrogeological conditions located behind the pit wall and below Jacko Lake
Sectors affected	1, 2 and 6	1	1	1
Comments	On sectors 3, 4, 5, 7 and 8, OSA will not be improved by further active depressurisation	This considers only natural depressurisation (no drain holes)	Assumed the phreatic surface is located 100 m below surface level (currently assumed to be at ground surface)	Using most up-to date information

The main objective of these analyses is assessment of the impact of pore water pressures on some design sectors of the pit. SRK received several results of one 2D section analysed by KCB considering different scenarios, as listed in Table 2-2. The location of the 2D section is shown in Figure 2-1 (blue line).

SRK has assumed that the pore water pressure calculated by KCB for Sector 1 can be extrapolated to Sector 2.

Table 2-2: Scenario summary for 2D groundwater flow models (KCB July 2014)

Model setup	Base Case	Variation from Base Case
Base Case	Base Case	n/a
	Sensitivity 1	Lake Bed Sediment K increase to 1E-06 m/s
	Sensitivity 2	Till K increase to 6E-06
	Sensitivity 3	Base Case Sensitivity 1 and 2 combined
	Sensitivity 4	Bedrock K increase by one order of magnitude for all units
	Sensitivity 5	Base Case Sensitivity 3 and 4 combined
Mitigated	Sensitivity 6	Increased Lake setback to 210 m from Pit
	Base Case	150 m-long horizontal drains at ~100 m vertical spacing
	Sensitivity 1	Lake Bed Sediment K increase to 1E-06 m/s
	Sensitivity 2	Till K increase to 6E-06
	Sensitivity 3	Mitigated Sensitivity 1 and 2 combined
	Sensitivity 4	Horizontal drains at ~50 m vertical spacing

Model setup	Base Case	Variation from Base Case
	Sensitivity 5	Mitigated Sensitivity 3 and 4 combined
	Sensitivity 6	Mitigated Sensitivity 3 and 4 combined; addition of horizontal drain just below Overburden / Bedrock contact
	Sensitivity 7	50 m horizontal drain spacing; Overburden / Bedrock drain, Bedrock K increased by one order of magnitude for all units
	Sensitivity 8	Mitigated Sensitivity 6 and 7 combined
	Sensitivity 9	Mitigated Base Case with increased Lake setback to 210 m

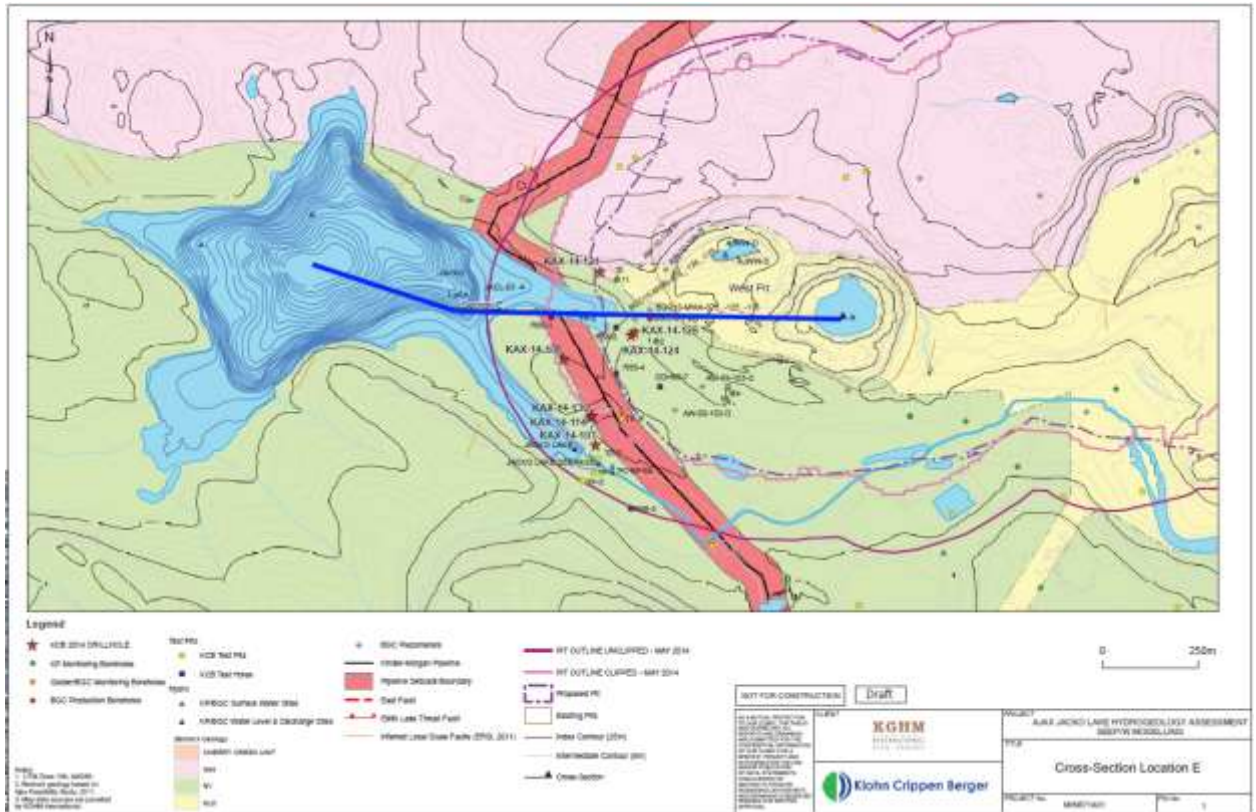


Figure 2-1: Location of section analysed by KCB (KCB July 2014)

Only transient pore water pressure results were considered for this stability analysis. The steady-state results are considered too optimistic, because although this is the best drainage condition possible, it may take a long period of time (years) to achieve. Furthermore, the pit wall may be exposed prior to realisation of a steady-state pressure regime.

Some of the scenarios analysed by KCB produce very similar pore water pressure distributions; for instance, the mitigated base case is very similar to sensitivity analyses 1, 2 and 3 – with the only variation on the upper part of the pit slope wall. Others are considered too optimistic for slope stability analysis, such as sensitivity analysis 7 where the water table is lower than the transient base case.

The pore water pressure distributions adopted in the stability analysis are therefore mitigated base case (shown in Figure 2-2) and mitigated sensitivity 4 (shown in Figure 2-3).

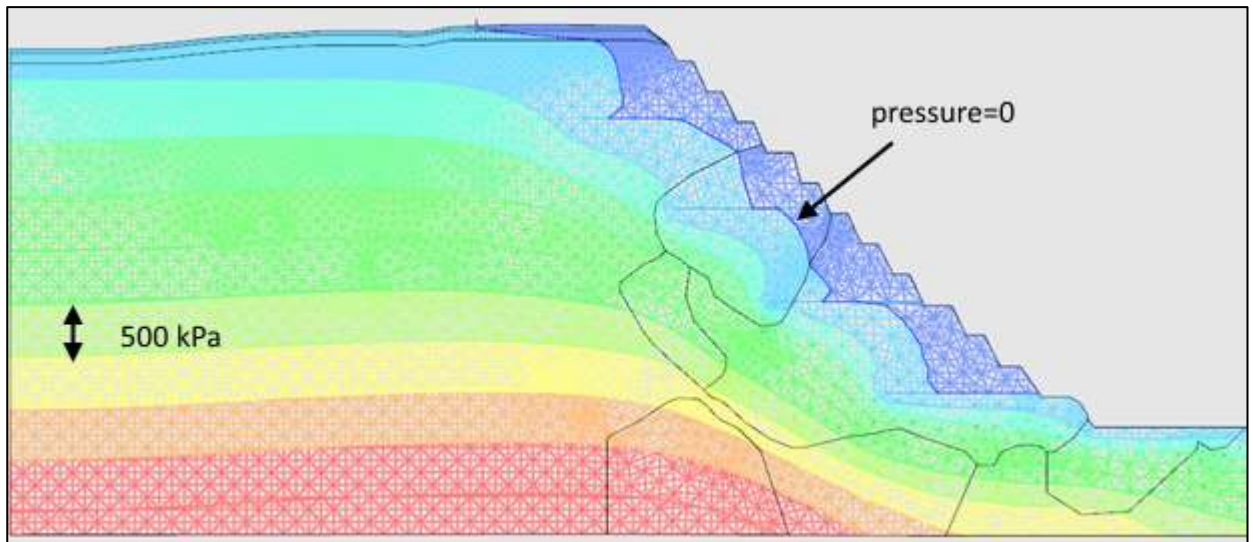


Figure 2-2: Pore water pressure distribution mitigated base case (transient) (KCB July 2014)

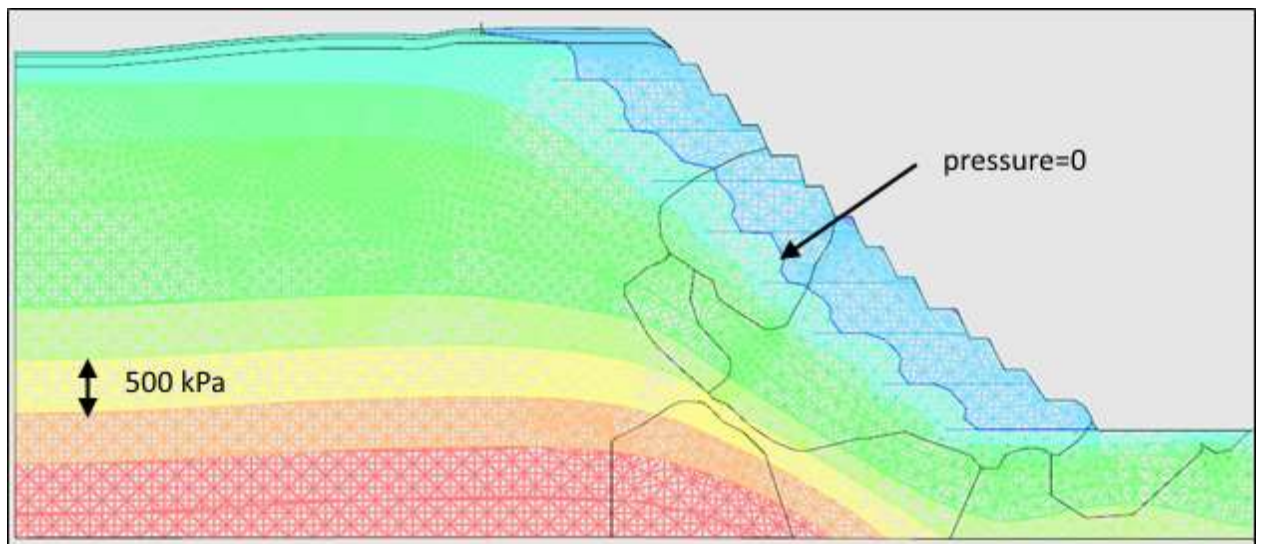


Figure 2-3: Pore water pressure distribution for mitigated case sensitivity 4 (transient) (KCB July 2014)

The water table considered for each analysis is detailed below.

Analysis A:

The water table defined in the present scope of work was stated as metres behind the wall (125 m and 150 m); this will be used for Sector 6 only. For sectors 1 and 2, the results provided by KCB will be used to model an improvement in water drainage conditions. SRK understands the idea of these analyses is a normal case (most probable) and an improved dewatering case. In order to do this, the normal case is considered the base case with drainage (Figure 2-2), while the improved case is presented as sensitivity 4 (Figure 2-3).

Analysis B:

The pore water distribution used for this analysis corresponds to the base case with no mitigation or drainage of any kind; the pore water pressure is shown in Figure 2-4. It is important to note the proximity of the water table to the surface of the design pit wall.

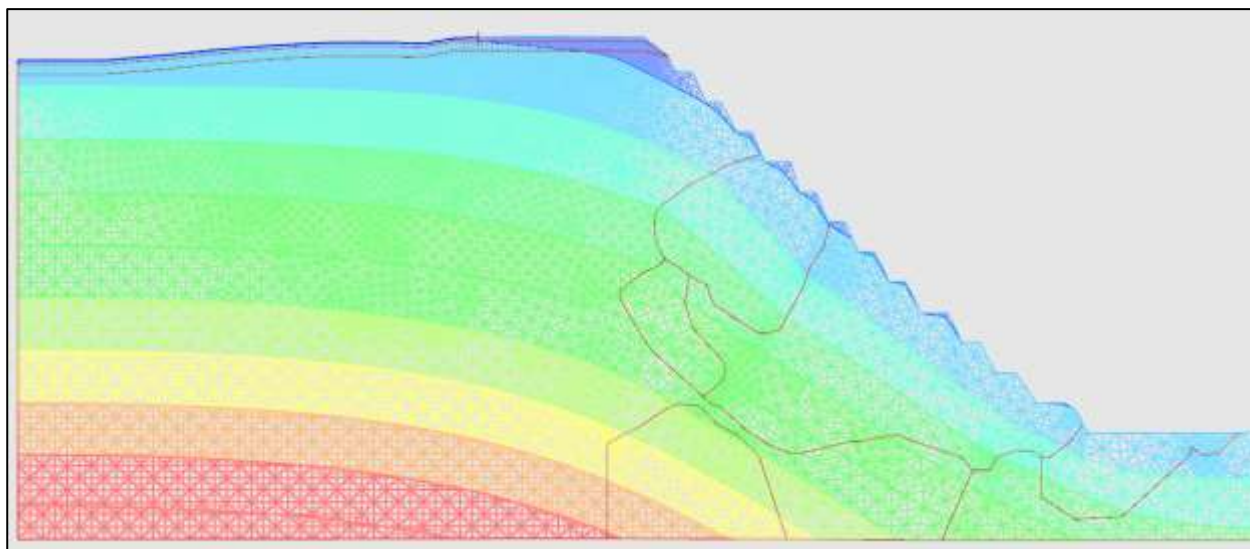


Figure 2-4: Pore water pressure distribution for base case no mitigation or drainage installed (KCB July 2014)

Analysis C:

For this analysis, the pore water pressure calculated for sensitivity 9 (Table 2-2) was modified to assume water table located 100 m below Jacko Lake. Figure 2-5 shows the pore water pressure distribution and the location of the assumed water table.

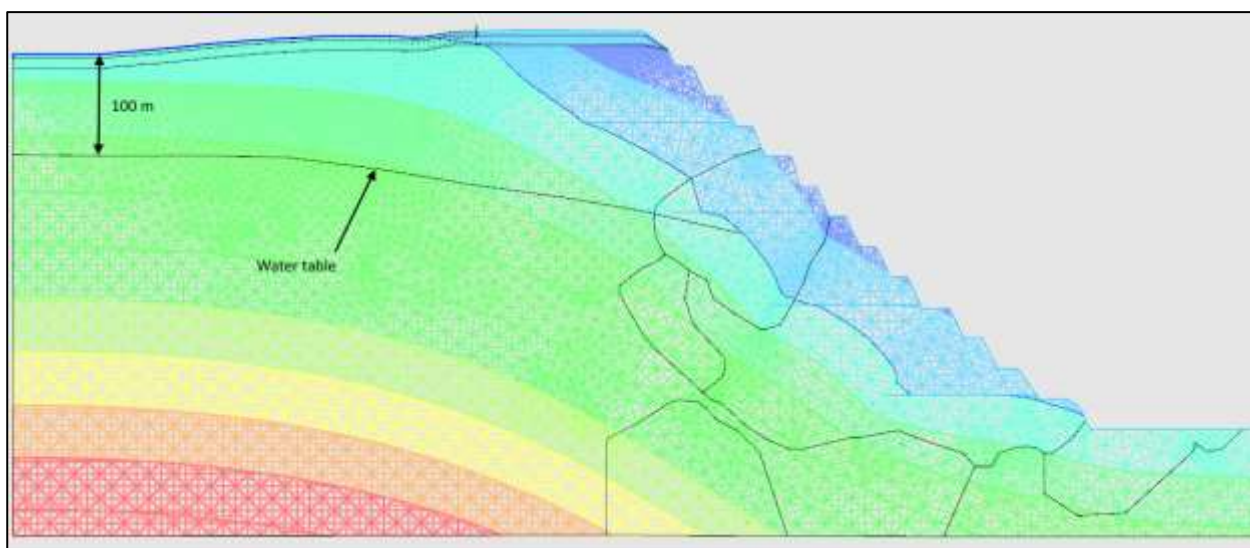


Figure 2-5: Pore water pressure distribution for sensitivity 9 (KCB July 2014)

Analysis D:

The analysis was carried out using the pore water pressure calculated in the base case with drainage (Figure 2-2).

3 Analyses Results

FLAC3D (version 4.0) was used to undertake the analyses. The assessment of the stability of each sector analysed was done using the strength reduction factor (SRF) method. In this method, after the model has reach equilibrium, the strength parameters of the rock mass and faults are reduced gradually according the following equations:

$$\phi^* = \text{atan}\left(\frac{\tan(\phi)}{SRF}\right)$$

$$c^* = \frac{c}{SRF}$$

$$\sigma_t^* = \frac{\sigma_t}{SRF}$$

Where ϕ^* , c^* and σ_t^* are the friction, cohesion and tensile strength at failure.

Figure 3-1 shows a typical displacements history point; after each reduction, the displacement increases; however, if the slope is in equilibrium, the displacements do not continue increasing. When an unstable condition is reached, the displacements continue increasing without reaching a plateau.

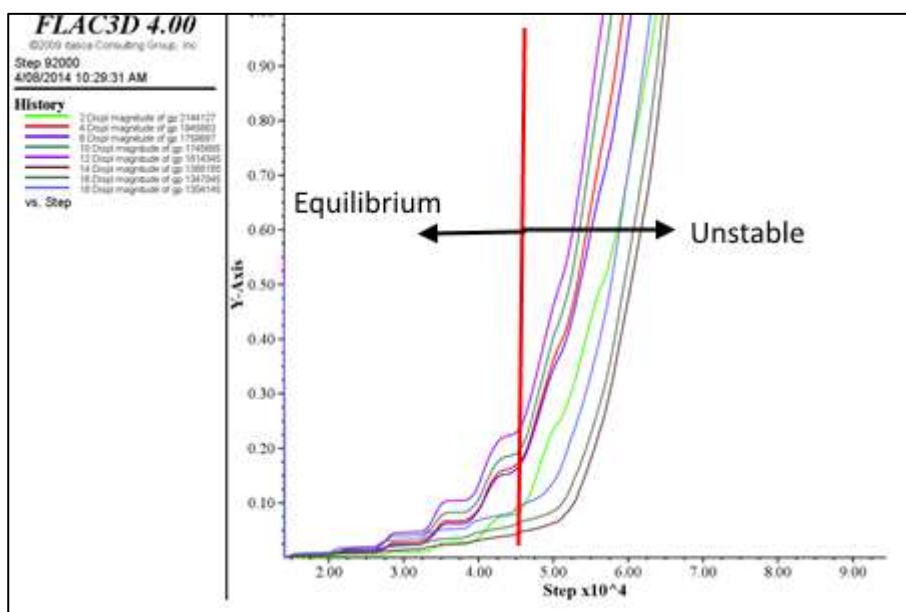


Figure 3-1: Example of typical displacement history points during an SRF calculation

3.1 Analysis A Sector 1

The analysis of Sector 1 using two different levels of drainage (125 m and 150m) was replaced with the analysis considering two water tables provided by KCB, shown in Figure 2-2 and Figure 2-3. The results of the analyses are discussed in detail in Section 3.6.

3.2 Analysis A Sector 2

Prior to the pore water pressure distributions being available from KCB (SRK June 2014) , two scenarios were considered for this sector – 125 m of drainage and an optimistic scenario with 150 m of drainage. By incorporating the 2D analysis carried out by KCB, it is possible to model a more realistic pore water pressure distribution considering both a probable case and an optimistic case (Figure 2-2 and Figure 2-3).

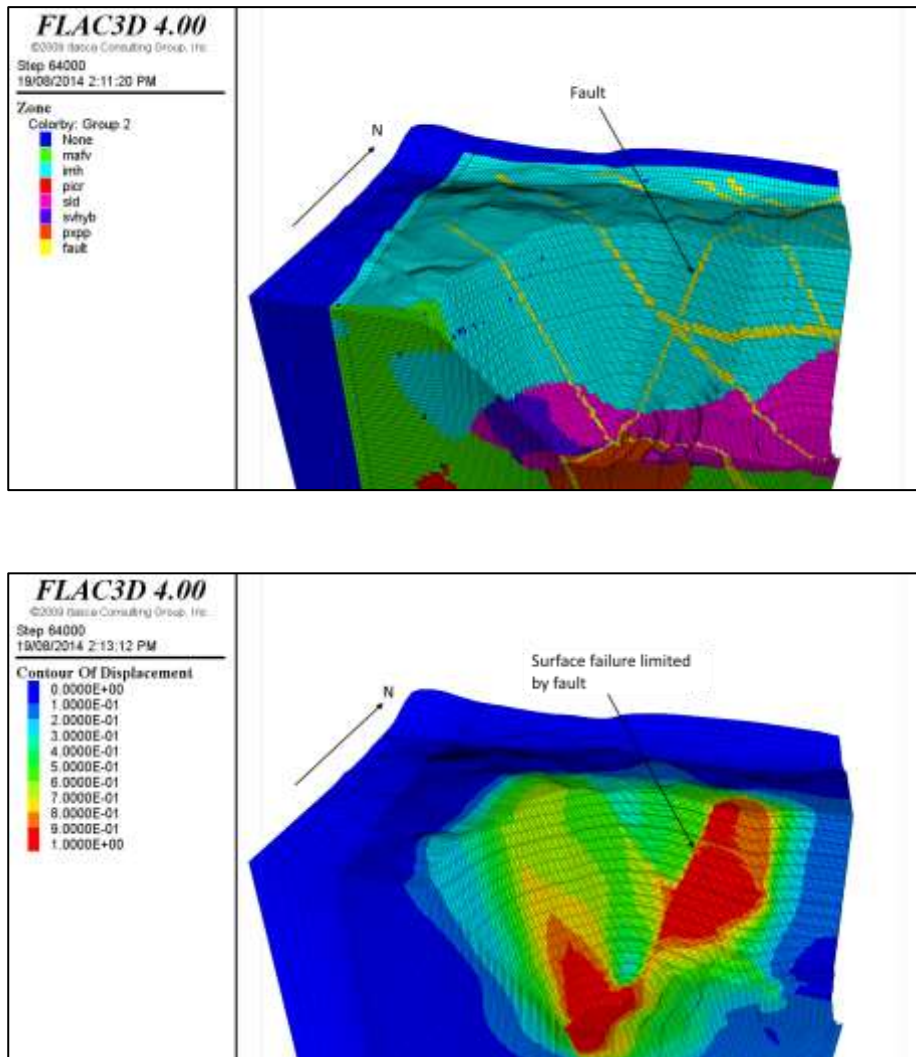


Figure 3-2: Lithology and displacements at failure - Sector 2

The stability analyses were carried out using an increased OSA of 48° (the OSA was previously 46° based on the initial wireframe supplied in June 2014); Figure 3-2 shows the lithology in Sector 2 and the displacements at failure after the SRF method was applied. It shows that one of the faults located in the area limits the extent of the failure and the fault becomes part of the surface failure. The FoS calculated for this case is 1.34, when an OSA = 48° is adopted.

3.3 Analysis A Sector 6

There is no new information about the water table in Sector 6 as this area was not covered in KCB's analysis.

The latest design received from KGHM has some differences when compared with the pit design used in the previous work of June 2014 – the pit is between 40 m and 60 m shallower, and the Picrite (PICR) (weak rock) has less exposure in the new design, as shown in Figure 3-3 and Figure 3-4.

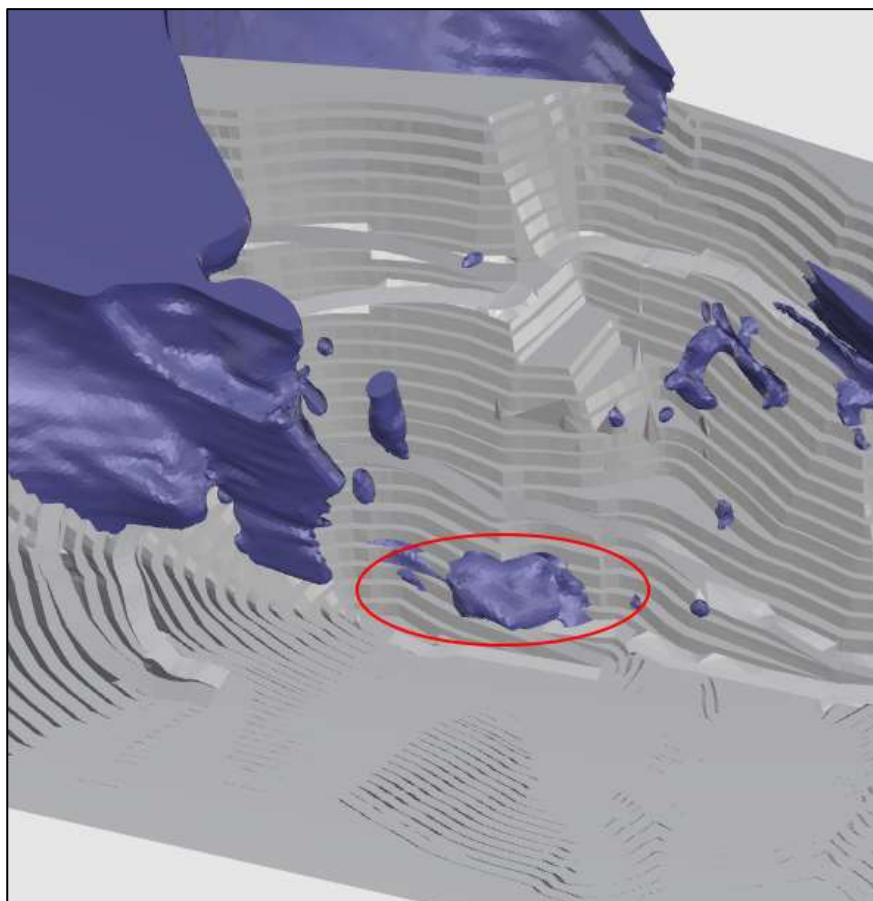


Figure 3-3: Sector 6 - Previous design showing exposure of PICR at the toe of the slope

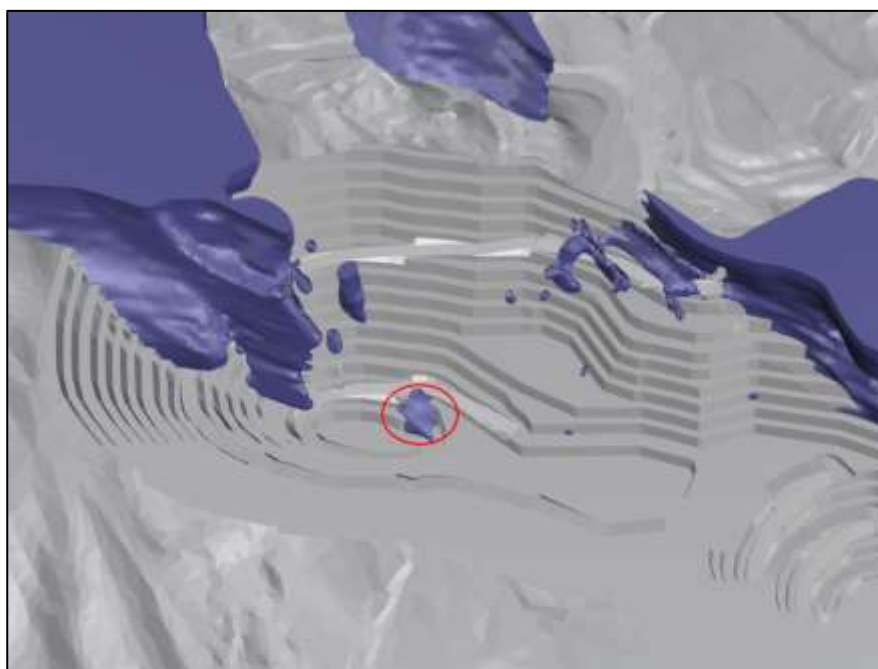


Figure 3-4: Sector 6 - Current design showing exposure of PICR at the toe of the slope

These two changes make the wall less sensitivity to the influences of the Picrite on pit wall stability and therefore the wall has been steepened. Nevertheless, it is important to recognise the sensitivity of this particular wall to changes in design based on rock mass conditions associated with the Picrite.

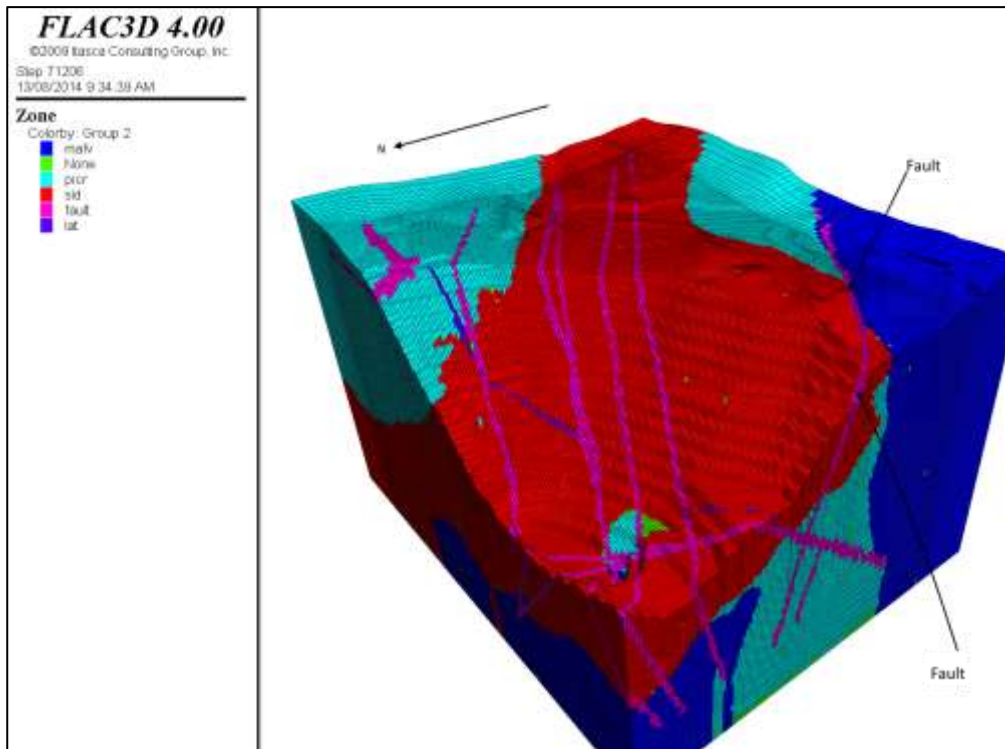


Figure 3-5: Sector 6 - Rock type

Sector 6 is unique to the other design sectors in that there is a strong SLD rock (in relative terms) on top of a weak PICR rock (Figure 3-5). The previous analysis showed that the weak rock controls the overall slope stability, with one fault being part of the surface instability.

A similar same situation occurs again based on the revised pit slope design; the fault indicated in the Figure does not trigger the mode of instability, but becomes part of it when the FoS is calculated (Figure 3-6).

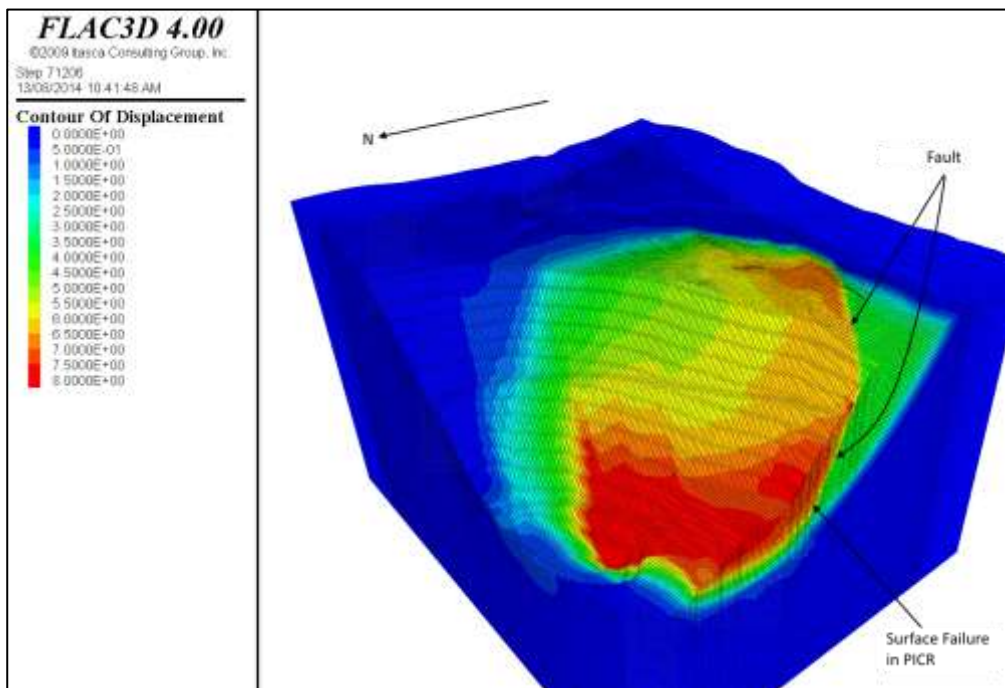


Figure 3-6: Sector 6 - Displacements at failure for Sector 6

The stability analysis using the current design (OSA = 40° in the location of Sector 6) and 125 m and 150 m of drainage indicate that the FoS for each case is 1.64 and 1.74, respectively. These values indicate that the overall slope angle for the new configuration (less exposure of PICR at the toe and pit depth reduced by 40 - 60) can be increased.

The overall angle was increased 5° (increase of 3° from the 42° recommended by SRK, 2014) to an OSA=45° for Sector 6 and the analysis was repeated for the new geometry. The FoS obtained were 1.47 and 1.61 for 125 m and 150 m of drainage. Figure 3-6 shows the displacements at failure, and indicates that PICR behind the wall and a fault controls the surface instability.

3.4 Analysis B Sector 1

The analysis considers no drainage on the pit wall on Sector 1. KCB results indicated that minimum drainage occurs if no mitigation system is put in place (Figure 2-4) and the water table remains relatively close to the pit wall surface.

During the SRF calculation, the displacements increase on every reduction of strength and a new equilibrium is reached. This process is repeated until the slope is no longer in equilibrium and the displacements continue increasing.

Under this situation, it is possible to identify two zones of instability with different FoS. Figure 3-7 shows that in Sector 1, the north-west corner has a FoS=1.12, while FoS=1.06 in the south-west corner; both are below the minimum acceptable FoS=1.30 for OSA and therefore are only marginally stable.

The *FLAC3D* analyses carried out for Sector 1 demonstrates the importance of depressurisation in maintaining stable slopes, using the design slope angles provided.

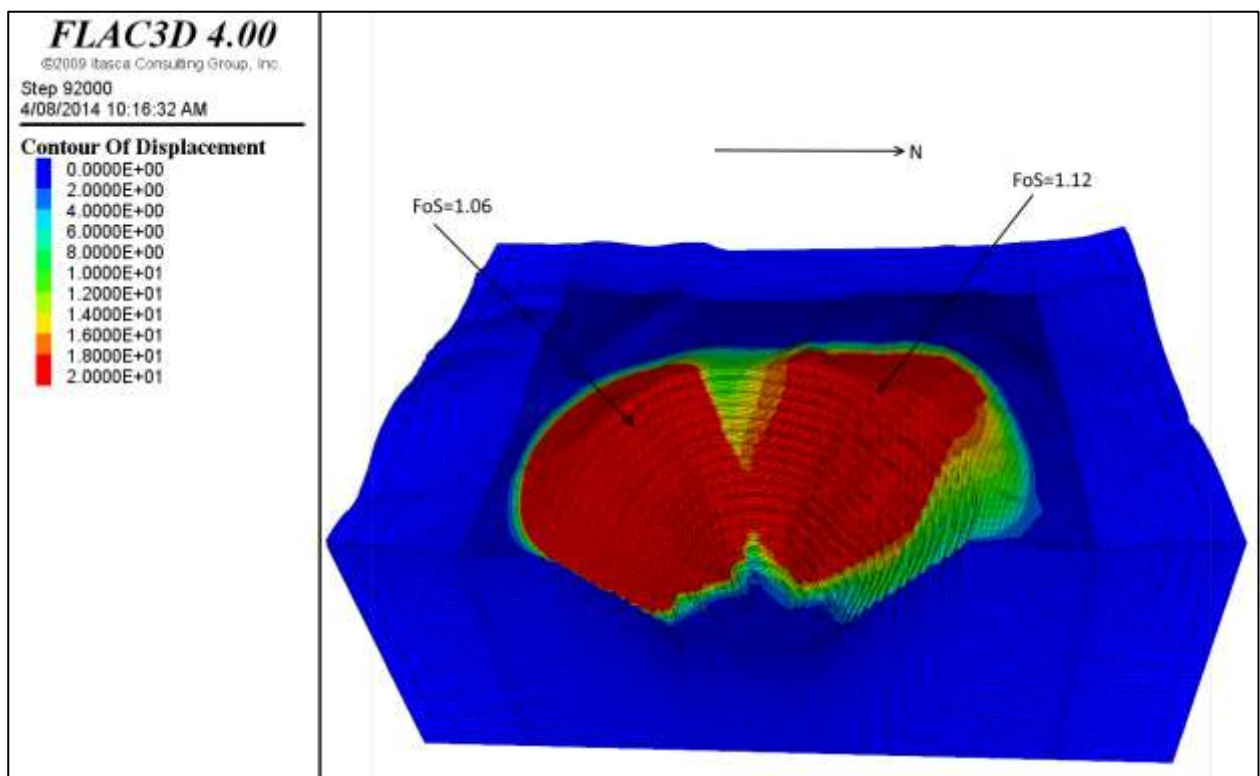


Figure 3-7: Contour of displacements after failure for Sector 1

3.5 Analysis C Sector 1

In this analysis, an optimistic water table was assumed located 100 m below Jacko Lake (Figure 2-5). The pit geometry used in the analysis corresponds to the pit design provided by KGHM which includes increasing the OSA to 48°, to make this analysis comparable to the analysis D described in the next paragraph.

The results indicate that the instability surface is located above the water table as shown in Figure 3-8 with a FoS = 1.28. The surface instability is developed mainly in PICR, the weakest rock in that area close to the surface.

The results of analysis indicate that further drainage will not improve the stability of the slope.

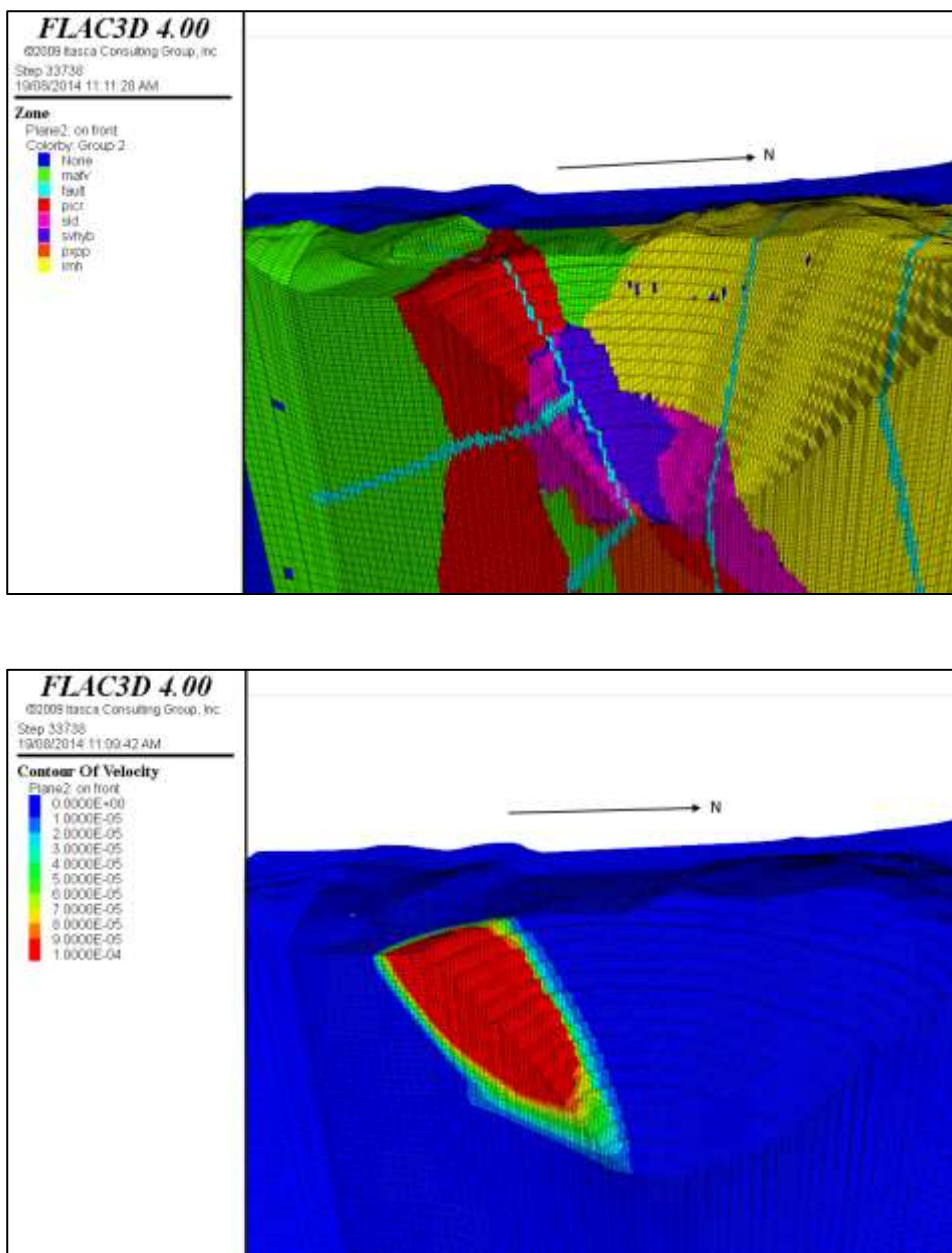


Figure 3-8: View of cross section surface failure

3.6 Analysis D Sector 1

The analysis was carried out using the pore water pressure provided by KCB and the pit geometry provided by KGHM. Two pore water pressures were considered – a base case and an improved drainage case (Figure 2-2 and Figure 2-3).

The FoS calculated using the pit design provided by KGHM and base case water table is 1.42. Figure 3-9 show the history of displacements and contour of displacements.

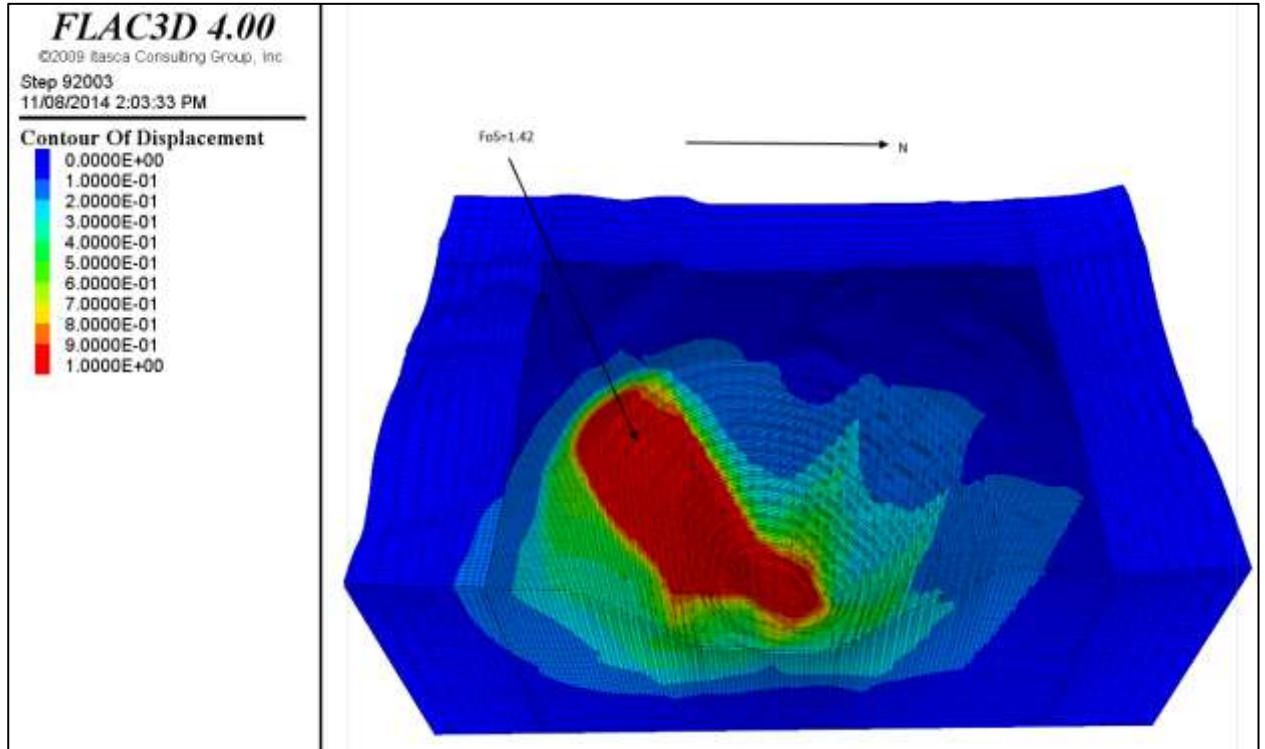


Figure 3-9: Deformation at failure - Current design

An improved design was considered – increasing the OSA from 46° to 48° in Sector 1, the pore water pressure corresponds to the base case scenario. The FoS calculated in this case is 1.30, which is the minimum acceptable FoS. Figure 3-10 show the contour of displacements at failure.

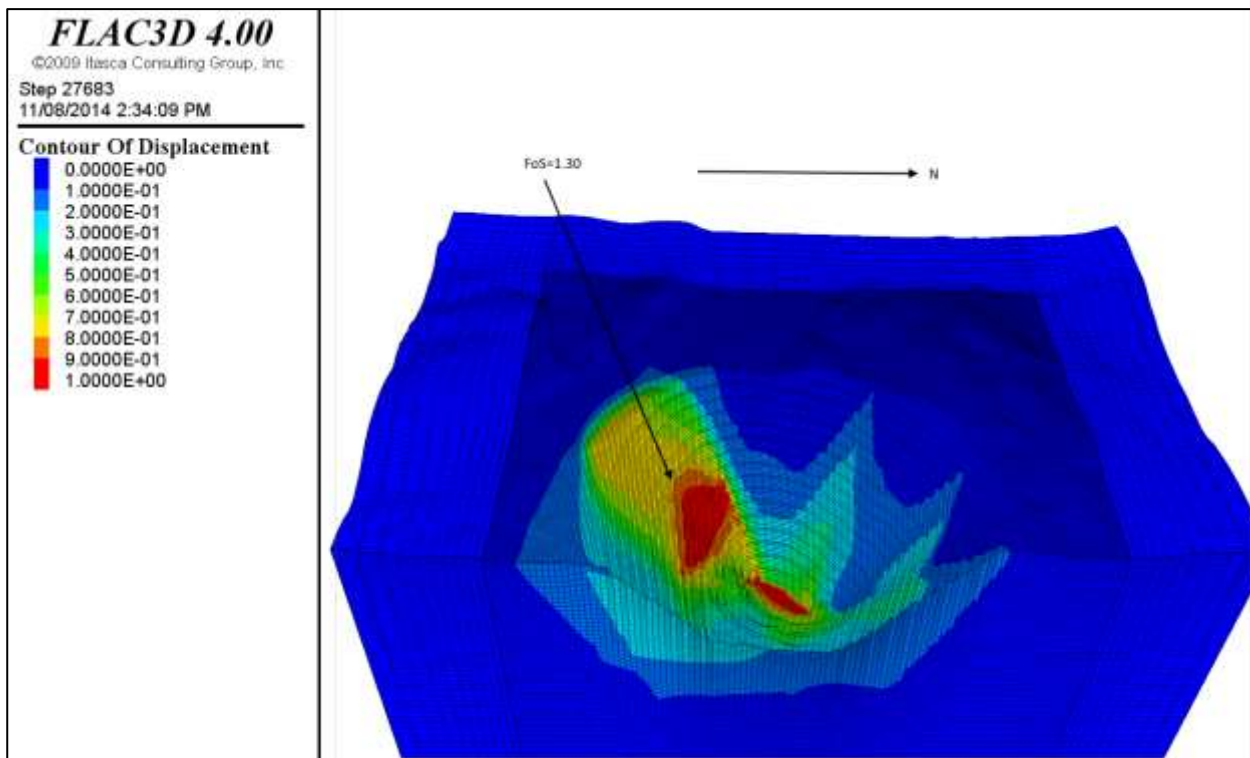


Figure 3-10: Deformation at failure - Optimised design

The stability of the optimised case was tested using the improved drainage; the results are shown in Figure 3-10.

The results of analysis indicate that the OSA at Sector 1 can be increased from 46° to 48°.

4 Conclusions and Recommendations

The analyses carried out indicate that it is possible to increase the OSA in sectors 1, 2 and 6, provided that it is possible to achieve the drainage indicated in KCB report.

For Sector 6, there was no new information about pore water distribution, although the new pit design is shallower than the pit design used previously (SRK, 2014). The combination of reduced depth and less exposure of the weak PICR rock makes it possible to increase the OSA.

It is important to recognise the sensitivity of the pit wall stability in Sector 6 to changes in design relative to the spatial distribution of weak rock.

Table 4-1 and Table 4-2 summarise the results of the analysis and recommendations.

Table 4-1: Summary of results

Sector	Design	OSA	FoS
1	Recommended (*)	46°	1.60
	Current Design(**)	43° – 45.3°	1.42
	New Recommendation	48°	1.28 - 1.30
2	Recommended (*)	46°	1.39
	Current Design	46.8°	1.54
	New Recommendation	48°	1.34
6	Recommended (*)	42°	1.33 – 1.42
	Current Design	40°	1.64
	New Recommendation	45°	1.47

(*) Corresponds to the recommended OSA based on previous SRK analyses (SRK, 2014).

(**) Current design corresponds to the design provided by KGHM, file: interim mw final min waste clipped_july 2014.dxf.

Table 4-2: Changes in OSA

Sector	Original Design (*)	Current Design (**)	Recommended
1	46°	43° – 45.3°	48°
2	46°	46.8°	48°
6	42°	40°	45°

(*) SRK June 2014

(**) June 2014 KGHM Mine Model

For completeness, the locations of the sectors are shown in Figure 4-1 and the recommended slope parameters are given in Table 4-3. This table includes the same information shown in the SRK Report of June 2014; however the OSAs for sectors 1, 2 and 6 have been updated.

It is recommended that if further new information about pore water distribution is obtained, either due to re-analysis of the current 2D models or from new 3D models, the slope parameters recommended herein should be further re-assessed to verify their validity.

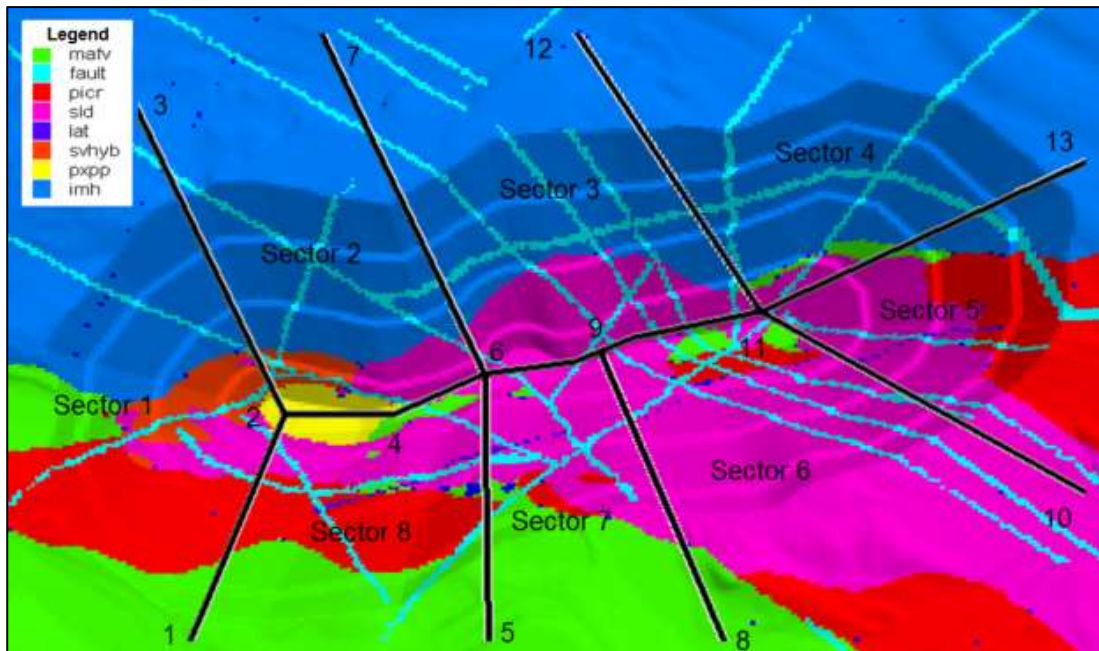


Figure 4-1: Location of design sectors

Table 4-3: Summary of recommended slope parameters (SRK, 2014) and revised recommendations for sectors 1, 2 and 6

Sector	Unit	Bench height, h (m)	BFA (°)	Berm B (m)	BSA (°)	IRA (°)	Geotech berm (m)(**)	Maximum OSA (°)
1	IMH/PXPP – LAT	30	75	17	54.2	50.2	25	48
	SLD	30	75	18	53.2	49.0	25	
	PICR (NVP)	30	65	16	48.2	45.0	25	
	MAFV (NVV)	30	65	16	48.2	45.0	25	
2	IMH/PXPP – LAT	30	75	17	54.2	50.2	25	48
	SLD	30	75	18	53.2	49.0	25	
3	IMH	30	75	17	54.2	50.2	25	50
	SLD	30	75	18	53.2	49.0	25	
4	IMH	30	75	17	54.2	50.2	25	53
	SLD	30	75	18	53.2	49.0	25	
5	IMH	30	75	17	54.2	50.2	25	53
	SLD	30	75	17	54.2	50.2	25	
	PICR (NVP)	30	65	16	48.2	45.0	25	
6	SLD (*)	30	70 (75)	20 (17)	48.1 (54.2)	44.1 (50.2)	40 (30)	45
	PICR (NVP) (*)	30	65	16.5	47.8	44.5	40 (30)	
7-8	SLD	30	75	17	54.2	50.2	25	52
	PICR (NVP)	30	65	16	48.2	45.0	25	
	MAFV (NVV)	30	65	16	48.2	45.0	25	
	SLD/PXPP – LAT	30	75	17	54.2	50.2	25	

(*) The slope design recommended has been adjusted to produce the OSA, which cannot be exceeded as explained in the text below; this applies only for the final pit wall. The numbers in brackets are the recommendations for any the interim pit walls.

(**) The geotechnical berm can be reduced to 20m in places were the combination of ramp and geotechnical berms push the OSA away from the maximum OSA indicated in the table.

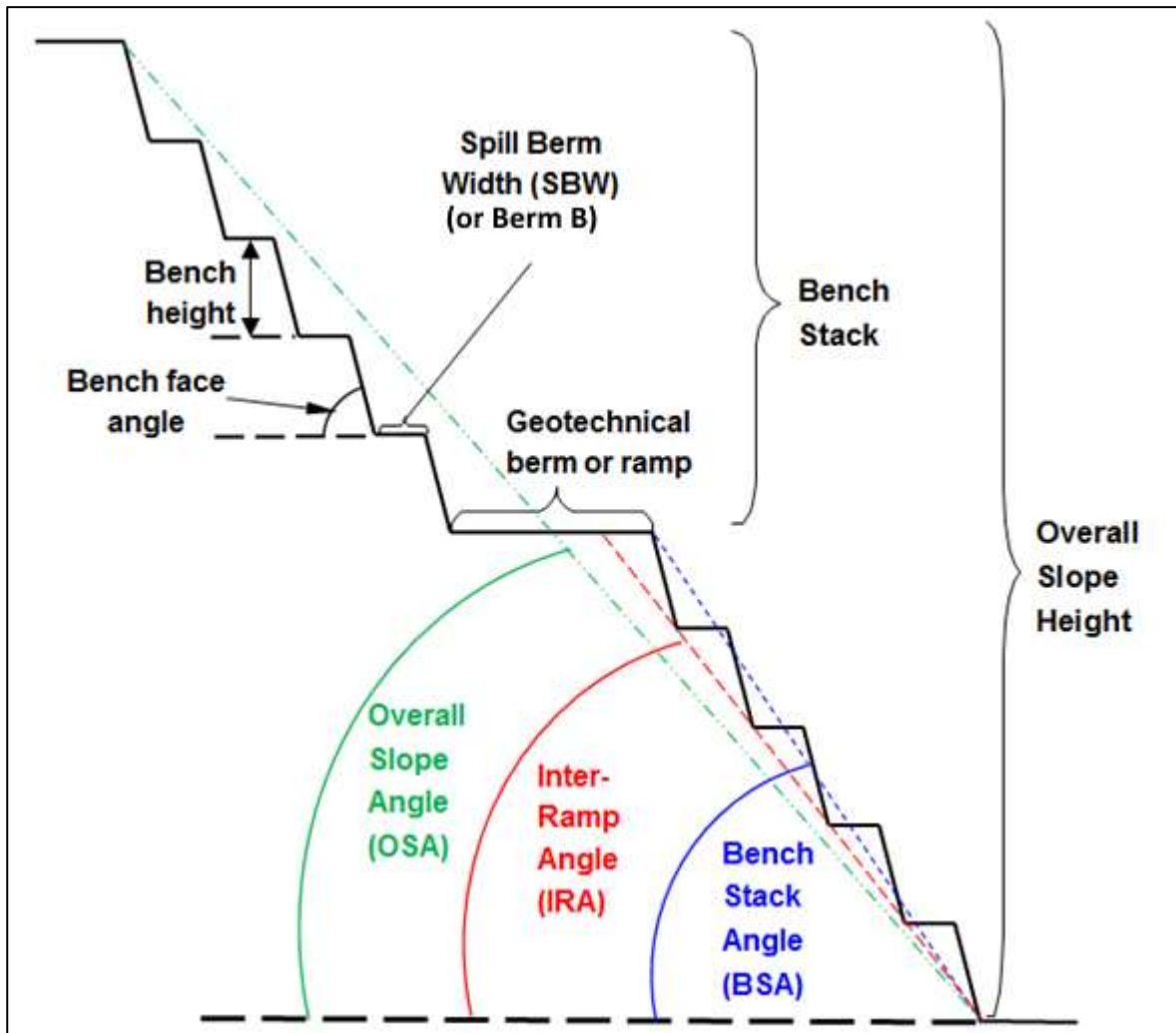


Figure 4-2: Naming convention for slope geometrical elements

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The document titled *KGH001_Review of OP parameters_Hydrogeology updated_Rev1.docx* has been reviewed by:

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SRK Report Client Distribution Record

Project Number: KGH001

Report Title: Ajax Project Open Pit - Review of Open Pit Design Parameters for Updated Hydrogeological Conditions

Date Issued: 6 November 2014

Name/Title	Company
Julian Watson	KGHM Ajax Mining Inc.

Rev No.	Date	Revised By	Revision Details
0	26/08/2014	W Gibson	Draft Report
1	6/11/2014	W Gibson	Final Report

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