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SCT Operations Pty Ltd
ABN 23 078 328 953
www.sct.gs

HEAD OFFICE
Cnr Kembla & Beach Streets Wollongong NSW 2500 Australia
PO Box 824 Wollongong NSW 2520 Australia
Telephone +61 2 4222 2777 Fax: +61 2 4226 4884
Email: sctnsw@sct.gs

MACKAY OFFICE
Telephone/Fax: +61 7 4952 5717
Email: p.cartwright@sct.gs

BENDIGO OFFICE
Telephone: +61 3 5443 5941
Email: s.macgregor@sct.gs

Chloe Piggford
Environment and Community Manager
Integra Underground Mine
640 Middle Falbrook Road
SINGLETON NSW 2330

INT4738_Rev2

Dear Chloe

HIGH LEVEL GEOTECHNICAL ASSESSMENT OF MOUNT OWEN HIGHWALL FOR PROPOSED MINING OF INTEGRA UNDERGROUND MINE LONGWALL PANELS

This report provides our high level geotechnical assessment of the likely impacts of proposed mining of longwall panels at Integra Underground Mine (IUG) on the Mount Owen North Pit (MONP) highwall.

Our assessment is based on currently available information derived from, amongst other sources, a site visit undertaken to inspect the MONP site on 23 August 2017, the shortened geometry for the Integra Underground longwall panels as received on 28 August 2017, estimates of future MONP highwall geometries based on Mount Owen Mine Operating Plans and Life of Mine End of Year Plans provided to SCT on 7 February 2017 and geological sections provided on 24 October 2017 showing the current interpretation of the Hebden Thrust.

Our assessment indicates that the top 60m of the highwall between the haul road and the first bench has potential to be impacted by subsidence from all the proposed longwall panels at IUG.

For all panels except Longwall 15, these impacts are likely to be relatively minor and mainly associated with the formation of tensile cracks. The cracks may lead to potential for increased water ingress into the slope at times of high rainfall that would contribute to an increased potential for slope instability. Minor earthworks to control inflow of surface water are likely to be effective controls.

Longwall 15 is estimated as likely to mine directly below a 45m high section of highwall in 2019. There is considered to be potential for rock falls to occur along this section of highwall soon after the longwall starts (estimated to commence in March 2019).

We recommend:

- Further detailed geotechnical assessments are conducted as part of the Extraction Plan for each longwall at a time when the mine plans for both the surface and underground operations are more fully developed.

- Further investigation of the Hebden Thrust and overburden stratigraphy is undertaken to confirm the geometries and material properties of these features.

- Appropriate stand-off distances are developed as part of a risk assessment process conducted in consultation with Mount Owen Mine.

- A Management and Monitoring Plan is developed in consultation with Mount Owen Mine as part of the Extraction Plan for each longwall.

1. INTRODUCTION

HV Coking Coal Pty Ltd (HVCC) is undertaking an Environmental Assessment (EA) for additional longwall mining in the Middle Liddell Seam at Integra Underground in the Hunter Valley. The proposed longwalls are planned to be retreated toward the southwest (i.e. in a direction away from the MONP highwall) starting as close as possible to the Hebden Thrust. HVCC commissioned SCT Operations Pty Ltd (SCT) to provide a high level geotechnical assessment of the subsidence impacts on the MONP highwall for an initial setback of about 0.2-0.3 times overburden depth recognising that opencut highwall instability is likely to present risks to the Mount Open opencut mining operations. This report presents our assessment based on currently available data.

This report is structured to provide a site description, an outline the proposed mining sequence as currently planned, a summary of experience of mining below natural cliff formations and a review of the likely impacts to the MONP highwall from the proposed longwall panels at IUG.

2. SITE DESCRIPTION

Figure 1 shows a plan of the site with the positions and estimated start dates of the proposed longwall panels relative to the open cut mining at MONP at the end of 2019 (Mount Owen 2017). Two options for longwall width are considered in this assessment:

1. Longwalls 15-19 are each nominally 320m wide and creates an extracted panel void that is 330.4m wide measured outside rib to outside rib.

2. Longwalls 15-20 are each nominally 246.2m wide and creates an extracted panel void that is nominally 256.6m wide measured outside rib to outside rib.

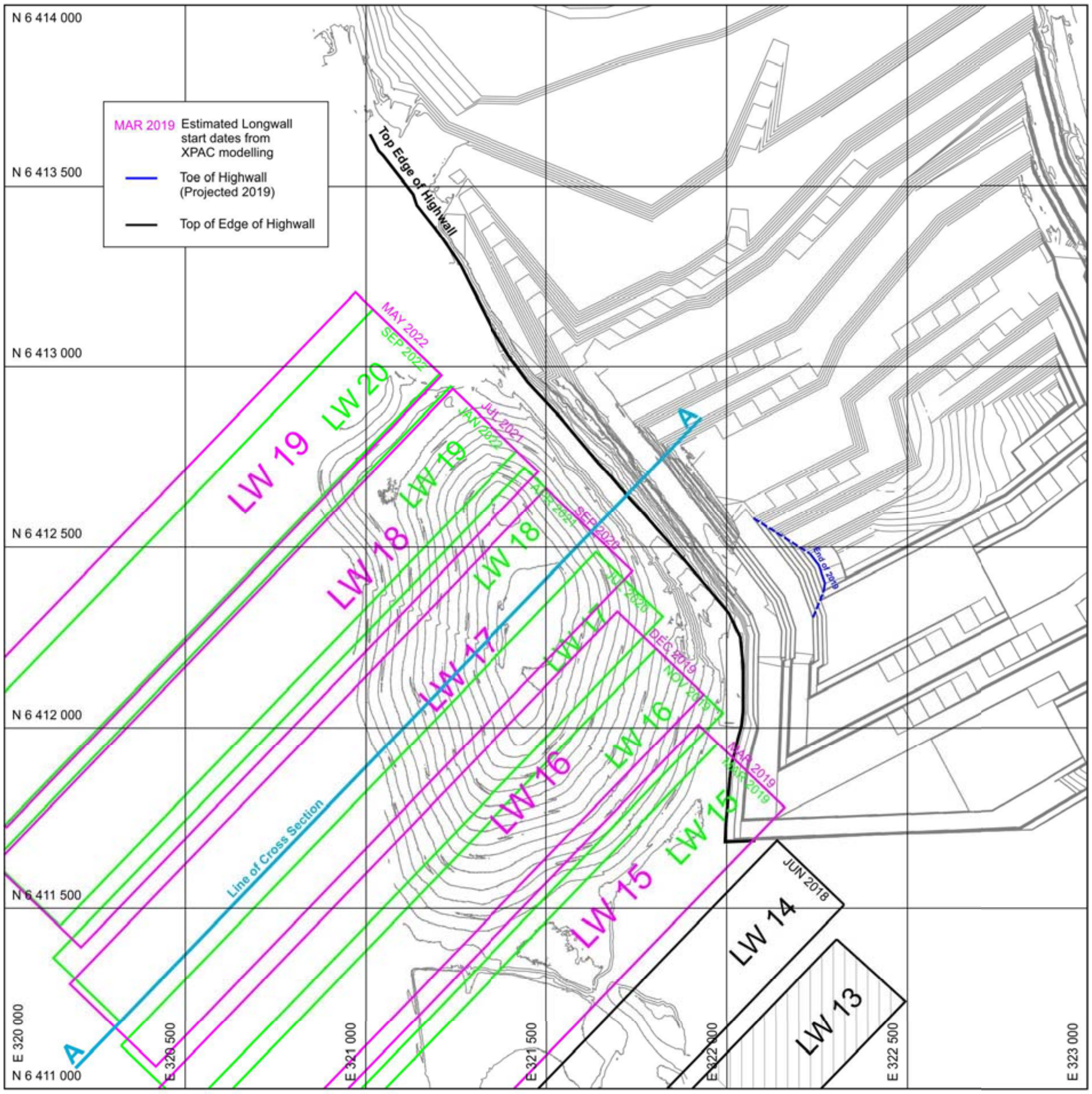

Figure 1: Site plan showing open cut mining at Mt Owen North Pit and the relative positions and start dates of existing and IUG proposed longwall panels. The Mt Owen open cut is projected to the end of 2019. The longwall start dates are estimated for the revised geometry.

These options are referred to as 320m and 246m options to remain consistent with references in other reports. The longwall numbering used in this report is based on the 320m longwall option unless otherwise stated.

Mining at MONP involves a high level of in-pit waste rock backfilling. Waste rock from different levels in the opencut excavation is placed on selected benches on the north-western side of the void. The backfill front is understood to advance to the south east at a rate of about 200m per year. At present, there is a ramp alongside the highwall down to the first bench at 60m below the rim of the opencut.

Figure 2 shows a generalised cross-section at natural scale along the centre of Longwall 17 based on available information. There is currently limited information available about the geometry of the Middle Liddell Seam in the vicinity of the Hebden Thrust. SCT understands that the latest interpretations suggest that in the area of interest this feature is predominantly a seam roll rather than an offset fault. The exact position at which the seam starts to trend upward at a rate that is too steep for longwall mining is not known.

Figure 3 shows a photo of the MONP void taken from the south-western edge looking northeast. Note that the haul road in the foreground is actually straight. The apparent curvature is an artefact of camera lens distortion. It can be seen that the north-eastern side of the haul road, at the toe of the West Dump slope, effectively defines the rim of the open cut void.

Figure 4 shows a photo of the highwall taken from the north-eastern side of the void looking back to the southwest. Backfilling operations are evident on the right hand side of the photograph. The highwall is currently approximately 230m high. The effective slope angle is about 38° from horizontal with some sections up to 60° separated by 50m wide benches at 60m to 80m vertical separation.

For the proposed geometries, the top of the 60m highwall between the haul road and the first bench is protected by offset distances that vary as shown in Table 1. The negative offset for Longwall 15 indicates that this longwall is planned to mine directly below the MONP highwall. The angle of draw equivalent is the offset distance between the start of the panel and the haul road expressed as an angle of draw i.e. tangent of offset distance divided by overburden depth. An overburden depth of 500m has been used in the calculations but this may vary depending on the geometry of the Hebden Thrust.

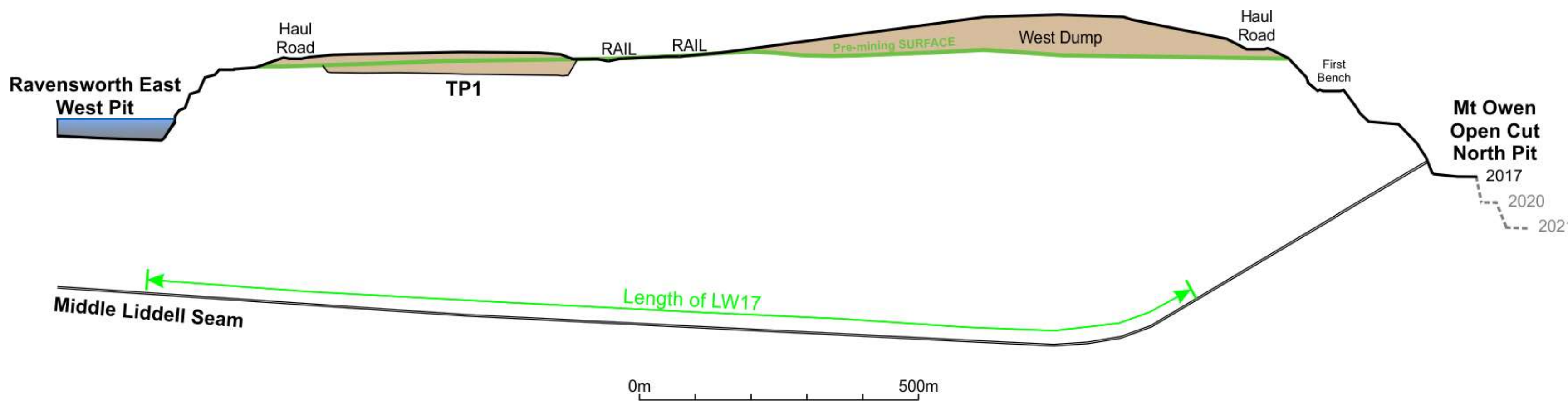

Figure 2: Generalised cross section 'A'-'A' along the centre of Longwall 17 at natural scale

Figure 3: Panorama of Mt Owen Opencut showing edge of highwall defined by haul road.

Figure 4: Photo of highwall taken from the north-eastern side of the void looking back to the southwest.

Table 1: Offset Distances from Start of Longwall Panels to Top of MONP Highwall for IUG longwall panel geometries.

Longwall	Offset Distance (m)	Proportion of Depth	Angle of Draw Equivalent (°)
320m wide longwall panels			
15	-158	-0.32	-18
16	109	0.22	12
17	128	0.26	14
18	143	0.29	16
19	187	0.37	21
246m wide longwall panels			
15	-158	-0.32	-18
16	54	0.11	6
17	146	0.29	16
18	142	0.28	16
19	151	0.30	17
20	188	0.38	21

3. EXPERIENCE OF MINING BELOW CLIFF FORMATIONS

The experience of underground mining directly below highwalls of active opencut operations is relatively limited. However, mining under highwalls is analogous to mining under natural cliff formations. Mining under natural cliff formations has been studied at numerous locations, particularly in the Western and Southern Coalfields.

These studies provide insight into the mechanics of the processes that cause mining subsidence impacts to cliff formations. This section presents a summary of this experience.

Subsidence movements associated with longwall mining can be characterised as being predominantly stretching (referred to as tensile) in nature outside the footprint of the mining void and around the fringes of the void and compressive in nature within the central part of the subsidence trough. The longwall void is created incrementally so most areas are subject to stretching at some stage. Areas within the central part of the subsidence trough, which may extend across multiple panels, are more likely to experience horizontal movements that are compressive in nature.

Two types of mining induced subsidence impacts are commonly observed on cliff formations: rock falls and perceptible cracking.

Mining-induced rock falls typically occur in areas where there is potential for horizontal compression movements in a direction parallel to the cliff face. Such movements are usually only possible directly over the longwall panels or the chain pillars between panels. Large, continuous cliff formations located directly above longwall panels are most susceptible to rock falls because these are sites where opposing horizontal compression movements can more easily develop.

The magnitude of horizontal compressive movements tends to decrease with increasing overburden depth. Rock falls in the Western Coalfield are commonly observed to occur along up to about 20% of the length of cliff that is mined under. In the Western Coalfield, the depth of mining is typically in the range from 130m to 250m below surface. Rock falls in the Southern Coalfield where the depth of mining ranges from 200m to 500m are typically less frequent and occur only along about 5% of the length of cliff directly mined under.

Movements outside the boundary of the panel tend to be tensile or stretching in nature and occur in a direction toward the longwall panel. These movements are typically evident on the surface as mining-induced cracks. The cracks usually decrease in magnitude and frequency with distance from the goaf edge.

Cracks are usually not evident beyond a distance of about 0.4 times overburden depth from a goaf edge (i.e. about 200m at Integra Underground). Cracks tend to cut across the corners of longwall panels and are usually not evident much beyond the panel corner. Cracking may occur as opening of existing joints, creation of new fractures and as shear displacements, typically on bedding planes. Cracking does not itself typically lead to cliff instability, but may allow water ingress into the slope during high intensity rainfall events. If the rate of water ingress during a high intensity rainfall event exceeds the rate water can flow out of the slope, water levels rise leading to locally increased pore water pressure. This increase in pore pressure has potential to cause slope instability by generating additional destabilising forces in a direction toward the free surface.

Experience of mining under natural cliff formations indicates that cliffs are completely protected from the effects of mining subsidence when they are located beyond a horizontal distance equal to half overburden depth from the nearest longwall panel goaf edge. Some major escarpments in the Western Coalfield have been protected by horizontal offsets of half depth plus 50m (equivalent to a horizontal distance of 0.7 times depth or 35° angle of draw). No mining induced rock falls have been observed on natural cliff formations beyond half depth (equivalent to 26.5° angle of draw) from the nearest goaf edge. Only a small number of rock falls have been observed outside of the longwall panel footprint and the few that have occurred were usually as an extension of a rock fall that was initiated over the panel.

Subsidence experience in general indicates that horizontal movements tend to develop initially in the direction toward the mining void and then soon after the longwall face has passed in the direction of longwall retreat. At the start of a panel, these two effects are in the same direction so, in flat terrain, horizontal movements tend to be greatest at the start of a panel.

In sloping terrain, another component of horizontal movement is present. This movement occurs as a result of dilation caused by fracturing within the subsiding strata and is influenced by topography rather than mining geometry. This topographic component usually occurs in a direction toward the topographic low point i.e. in a downslope direction.

When a longwall panel starts under terrain that is sloping in a direction opposite to the direction of mining, there is a tendency for horizontal movements in the direction of mining to be reduced by the effects of down slope movement. The net result is that ground movements tend to be reduced in magnitude because of this counteracting effect with the direction of movement dependent on which component is greater.

Highwalls are long and continuous structures so they are likely to be susceptible to the effects of opposing horizontal compression movements caused by mining directly below them. Highwalls typically have slopes of 40-60° so they are likely to be more stable than natural cliff formations which are often vertical.

4. IMPLICATIONS FOR MNOP HIGHWALL INSTABILITY

In this section, the implications for MONP highwall instability of the subsidence mechanics identified from observations of ground movement around natural cliff formations are discussed. The subsidence implications for the two longwall options are effectively similar.

If Longwall 15 starts under the MONP highwall around March 2019, as currently estimated, there is potential for compression movements to develop above the longwall panel and potential for highwall instability. Based on the experience of mining under natural cliff formations, rock falls would be expected along the section of highwall that is mined under by Longwall 15.

Perceptible cracking would also be likely with open cracks increasing the potential for ingress of surface run-off into the cracks to contribute to slope instability during periods of high rainfall intensity.

The section of highwall above Longwall 15 is scheduled to be excavated before the end of 2018. This section of highwall is estimated to be approximately 45m high. Longwall 15 is estimated to commence in March 2019 so there is potential for the subsidence associated with longwall mining to interact with the highwall. The detail of exactly when and how much interaction occurs will depend on the relative timings of the two operations and the eventual starting position of Longwall 15.

Longwalls 16-19 are not proposed to be mined directly under the MONP highwall. There is therefore limited potential for compression movements parallel to the highwall to generate rock falls. There is some potential for perceptible cracking to develop along the top of the highwall slope in the vicinity of the haul road that runs along the rim of the opencut. Some minor regrading and crack filling is expected to be necessary to prevent overland flow from entering any cracks that may form and potentially leading to slope instability during high intensity rainfall events.

In the event that waste rock backfill is placed against the highwall, there would be reduced potential for slope instability to develop. However, even with backfilling advancing at 200m per year to the south in the MONP, there does not appear to be any potential for backfill placed against the top 60m of the highwall to have any significant influence on highwall stability until after about 2022 (i.e. after Longwall 19 has started).

There may be flexibility in terms of the backfilling operations to provide backfill against the slope earlier in the mining cycle so as to be useful for Longwall 17. The current mining schedules for Integra Underground and MONP appear to preclude backfill being in place for Longwalls 15 and 16.

If you have any queries or require further clarification of any of these issues, please don't hesitate to contact me directly.

Yours sincerely

Ken Mills
Principal Geotechnical Engineer

5. REFERENCES

Mount Owen 2017 Drawing 2017lom_stageplan_2019eoy.dwg provided to SCT by FTP link by Mark Robinson on 7 February 2017.