Strata Control Technology

ULAN COAL MINES PTY LTD

Ulan Underground Mine: Longwall W5 End of Panel Subsidence Report

ULA5114

Mining Research and Consulting Group

SCT Operations Pty Ltd PO Box 824 Wollongong NSW 2520 Australia
Phone: +61 2 4222 2777 Email: sctnsw@sct.gs Website: www.sct.gs
ABN 23 078 328 953

REPORT TO Lucy Stuart
Environment and Community Coordinator
Ulan Coal Mines Pty Ltd
Private Mail Bag 3006
MUDGEE NSW 2850

TITLE Ulan Underground Mine: Longwall W5
End of Panel Subsidence Report:

REPORT NO ULA5114_Rev 1

PREPARED BY Ken Mills
Stephen Wilson

DATE 19 April 2020

Stephen Wilson
Mine Planner

Report No	Version	Date
ULA5114	1	31 March 2020
ULA5114	2	14 April 2020
ULA5114	Revision 1	19 April 2020

Ken Mills
Principal Geotechnical Engineer

SUMMARY

Ulan Coal Mines Pty Ltd (UCMPL) owns and operates Ulan Underground (UUG) mine approximately 25km northeast of Gulgong in the Central West of NSW. UCMPL recently finished mining Longwall W5 at UUG. UCMPL commissioned SCT Operations Pty Ltd (SCT) to review the subsidence monitoring and surface impacts from mining Longwall W5 and prepare an end of panel report to meet the requirement of the integrated Subsidence Management Plan (SMP) and Extraction Plan (EP). This report presents our review of the subsidence monitoring and mining impacts for Longwall W5 and comparisons against relevant impact assessment criteria.

Our review indicates that the subsidence effects from the mining of Longwall W5 are consistent with expectation. The magnitudes of the primary subsidence parameters are consistent with those forecast for this panel and similar to those measured over previous panels in the western domain of UUG. Subsidence impacts observed during a site visit to the area are consistent with expectation and less than forecast.

Maximum vertical subsidence measured above Longwall W5 is 1.27m and less than the maximum 1.6m forecast. Maximum tilt is 20mm/m and at the upper end of the 10-20mm/m range forecast. Maximum strain is 4mm/m in compression and 8mm/m in tension and towards the lower end of the 5-15mm/m range forecast.

The impacts are likely to be compliant with the impact criteria in the SMP Approval conditions for watercourses, groundwater, habitats, conservation areas, buildings, structures, roads and heritage sites. Subsidence impacts and environmental consequences to features are also expected to be less than the criteria specified in the subsidence performance measures of Project Approval 08_0184 for water, biodiversity, land, heritage, built features and public safety. Specific compliance for water and biodiversity needs to be confirmed by other specialists.

Subsidence impacts to natural and built features on land owned by UCMPL are generally minor in nature and less than forecast. Cracking of the surface is evident in some places, generally near the panel edges but impacts from mining are imperceptible over large areas of the panel footprint. Impacts to Aboriginal heritage rock shelters and sandstone formations are less than forecast.

Subsidence impacts on privately owned land at the start of the panel are consistent with expectation. A coincidence of mining induced cracking, a drainage line and recent heavy rainfall events, approximately 14 months after the area was mined, has led to flow into subsidence cracks and localised erosion of surface soils. The details of these impacts are being assessed separately together with a suitable remediation strategy.

Continuation of the subsidence monitoring in the western domain of UUG is recommended. This report represents the final end of panel report required by the SMP/EP for Longwalls 27-29 and W4-W5.

TABLE OF CONTENTS

PAGE NO

1. INTRODUCTION

Ulan Coal Mines Pty Ltd (UCMPL), formerly Ulan Coal Mines Ltd, operates the Ulan Underground (UUG) and Ulan West (UW) mines within the Ulan Complex, approximately 25km northeast of Gulgong in the Central West of NSW. UCMPL recently completed mining Longwall W5, the fifth longwall panel in the western domain at UUG. UCMPL commissioned SCT Operations Pty Ltd (SCT) to review and analyse the subsidence monitoring data for Longwall W5 and prepare a subsidence report suitable to meet the end of panel reporting requirements of the SMP/EP for this panel. This report presents our review and assessment of the subsidence monitoring conducted for Longwall W5 and our review of subsidence impacts based on site visit and reports by UCMPL personnel.

The report is structured to provide:

- conclusions and recommendations
- a general site description
- analysis of the subsidence measurements and monitoring
- observations of subsidence impacts
- comparisons of measured subsidence effects and observed impacts against forecasts with comparisons against:
    - relevant impact assessment criteria
    - monitoring over previous panels
    - subsidence predictions in the SMP/EP for Longwall W5
    - subsidence performance measures of Project Approval (PA08_0184).

2. CONCLUSIONS AND RECOMMENDATIONS

The measured subsidence effects from mining Longwall W5 are of the expected form and magnitude, similar to those measured over previous panels in the western domain of UUG and consistent with those forecast in SCT (2009) for the subsidence assessment for the Ulan Coal Continued Operations Environmental Assessment and used as the basis for the SMP/EP for this panel.

Table 1 summaries the primary subsidence parameters for Longwall W5 compared to the maxima forecast in the SMP/EP for the overburden range in this panel of 170-270m.

Table 1: Comparison of primary subsidence parameters for Longwall W5 with forecast parameters.

LWW5	Measured	Forecast
Vertical subsidence (m)	1.27	1.6
Tilt (mm/m)	20	10-20
Compressive Strain (mm/m)	4	5-15
Tensile Strain (mm/m)	8	5-15

Table 2 summaries the secondary primary subsidence parameters for Longwall W5 compared to the forecast values of these parameters.

Table 2: Comparison of secondary subsidence parameters for Longwall W5 with forecast parameters.

LWW5	Measured	Forecast
Chain Pillar Subsidence (mm)	**250**	800
Goaf Edge Subsidence (mm)	**160**	200-300
Angle of Draw (°)	**46**	30-50
Horizontal movement (mm)	**500**	400-500

Subsidence impacts to natural and built features observed during a site visit to the area above Longwall W5 were generally minor in nature and less than the impacts forecast in the SMP/EP.

Impacts from mining are most perceptible near the start of the panel, including on the Woodbury property, as surface cracks and potholes and along the panel edges on hard surfaces such as roads and compacted areas around farm sheds. Recent unusually heavy rainfall events have contributed to erosion of surface material across the area above Longwall W5 including into subsidence cracks at the start of the panel.

Pre and post mining surveys of surface features undertaken by UCMPL indicates impacts to Bobadeen Homestead, Aboriginal heritage rock shelter sites and sandstone formations, flow (drainage) lines, farm dams and mining and farm related infrastructure are either very minor or imperceptible.

Impacts to Aboriginal heritage rock shelter sites and sandstone formations are generally minor and less than forecast.

The effects of erosion from recent heavy rainfall events are evident as potholes along flow lines.

Measurements of subsidence effects and observations of subsidence impacts indicate that the effects from the mining of Longwall W5 are less than forecast and the impacts are likely to be compliant with the impact criteria in the SMP Approval conditions for watercourses, groundwater, habitats, conservation areas, buildings, structures, roads and heritage sites. Conservation areas for Aboriginal heritage sites at Mona Creek, Brokenback and Cockabutta Creeks and the Talbragar Fish Fossil Reserve are still remote from the mining area and were not perceptibly impacted.

Subsidence impacts and environmental consequences to other features or items are expected to be less than the criteria in the subsidence performance measures of PA08_0184 for water, biodiversity, land, heritage, built features and public safety, notwithstanding assessment for water and biodiversity impacts by other specialists. Table 3 summarises the subsidence performance measures outlined in Table 14 of Ulan Coal Continued Operations Project Approval 08_0184, and the likely status of compliance.

Table 3: Subsidence performance measures and likely compliance status.

Subsidence Performance Measure		***Assessment of status of compliance***
Water		
Ulan, Mona & Cockabutta Creeks	No greater environmental consequences than predicted in EAs	Compliance expected as main channels of these creeks too remote to be impacted.
Biodiversity		
Threatened species, populations, habitat or ecological communities	Negligible impact	Compliance expected because no greater subsidence effects compared to EAs and SMP/EPs (assessed by other specialists)
Land		
Cliffs in the Brokenback Conservation Area	Nil environmental consequences	No impacts observed indicating compliance. Current mining remote from this area
Other Cliffs	Minor environmental consequences	Compliance expected - no cliff lines in Longwall W5 footprint
Heritage		
Aboriginal Sites	Nil impact in the Brokenback Conservation Area, Grinding Groove Conservation Areas and Mona Creek Rock Shelters	Compliance expected. No impacts observed at Brokenback cliffs. Current mining remote so mining impacts not credible
Talbragar Fish Fossil Reserve	Negligible impact	Compliance expected. No impacts observed. Current mining remote so mining impacts not credible
Other Heritage Sites	No greater impact than predicted in EAs	Compliance expected (other specialists to assess) Subsidence effects are less than forecast in EP (updated since EAs).
Built Features		
All built features	Safe, serviceable and repairable unless the owner agrees otherwise in writing	Compliance expected (impacts managed via provisions of BFMP)
Public Safety		
Public Safety	No additional risk due to mining	Compliance expected (risk managed via controls in PSMP)

The continuation of subsidence monitoring along H Line for at least 2km ahead of the active longwall panel is recommended. Ideally, a high-resolution survey of the full length of the line would be undertaken at the completion of each longwall panel. Surveying the section from 2km to the north of the current panel to more than half-way across the previous panel is recommended as a minimum.

3. SITE DESCRIPTION

Figure 1 shows a plan of the surface area above Longwall W5. The mine plan and the location of the main subsidence line, H Line, are superimposed onto a 1:25,000 series topographic map of the area.

Figure 2 shows similar details as Figure 1 with Aboriginal heritage rock shelter sites superimposed on a Google Earth image dated September 2018.

3.1 Surface Features and Aboriginal heritage sites

The surface above Longwall W5 straddles the Great Dividing Range with the western portion draining to the west into tributaries of Mona Creek while the eastern section drains to the Ulan Creek upstream of the Bobadeen Water Treatment Facility (BWTF). Three drainage lines of the Mona Creek catchment are located over the western section of Longwall W5. These drainage lines are first and second order streams. They are all ephemeral in nature. Two small farm dams are located on the drainage lines of Mona Creek tributaries.

The majority of the land above Longwall W5 is owned by UCMPL. Approximately 2.8ha in the north-western corner of the panel is located on private property referred to as Woodbury. This area is approximately 2% of the total area of the panel. Approximately 55% of the surface above Longwall W5 is cleared land used for grazing purposes with the remainder semi-cleared or undeveloped bushland. The section of private property is mainly cleared land.

The landform over the eastern part of Longwall W5 is dominated by the outcrop of Jurassic strata leading to gently undulating terrain. The landform in the western part of the panel is dominated by the outcrop of Triassic sandstone strata leading to steeper terrain, drainage line gullies and sandstone formations.

Aboriginal heritage sites above Longwall W5 are located over the western half of the panel and include artefact scatter sites, isolated find sites and rock shelters. There are 25 rock shelter sites associated with sandstone formations including artefact finds and potential archaeological deposits.

Mining related or farm infrastructure and built features owned by UCMPL above Longwall W5 includes:

- The Bobadeen Homestead and associated outbuildings in the east.
- Sections of Irrigation Pivot 3 and Pivot 4 in the east.

- Water pipelines and power transmission lines.
- Two shallow farm dams in the central section.
- Other farm infrastructure including agricultural land, access tracks or roads, fences, gates and sheds.
- A section of the recently constructed unsealed access road in the northwest with access controlled by UCMPL.
- A services corridor alongside the road including overhead powerlines and underground pipelines.

3.2 Mining Geometry and Timing

Longwall W5 created an extracted void that is nominally 410m wide (coal rib to rib) and 3697m long (including the 9m wide installation roadway). The longwall started in the west at CH3688m on 18 December 2018 and mined to the east finishing production at CH0m on 22 January 2020.

The Ulan Seam dips gently to the northeast, so variation in overburden depth is mainly a result of topographic changes. The overburden depth over Longwall W5 ranges from approximately 170m in the west to 230m in the middle and up to 260m at the eastern end of the panel.

UUG mines the D working section (DWS) in the Ulan Seam. In Longwall W5, the DWS typically ranges 2.9-3.1m in thickness.

3.3 Regulatory Context and Subsidence Forecasting

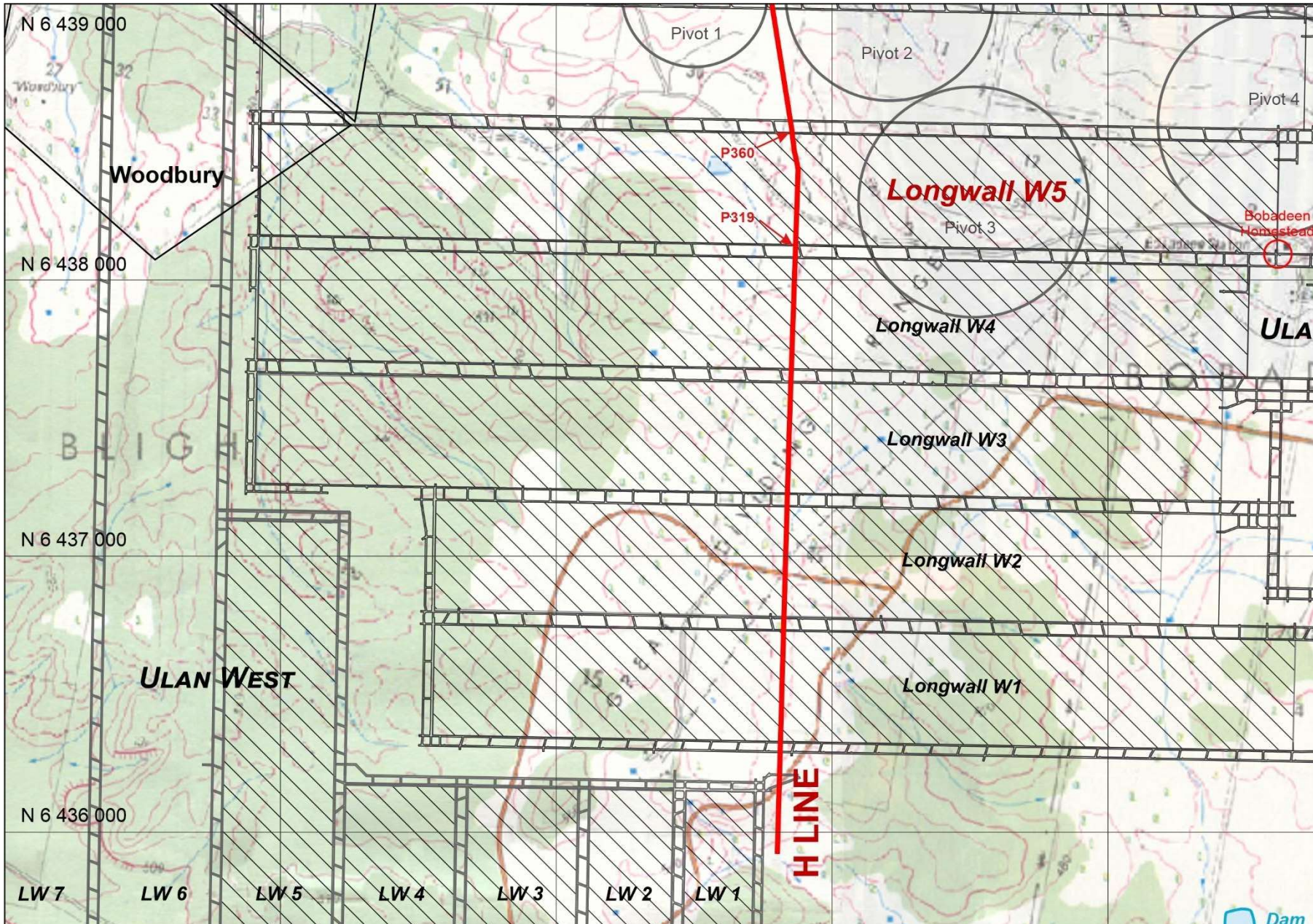
UUG and UW mines both operate under modified approval for the Ulan Coal Continued Operations (UCCO) Project 08_0184 (MOD4), originally determined in 2010.

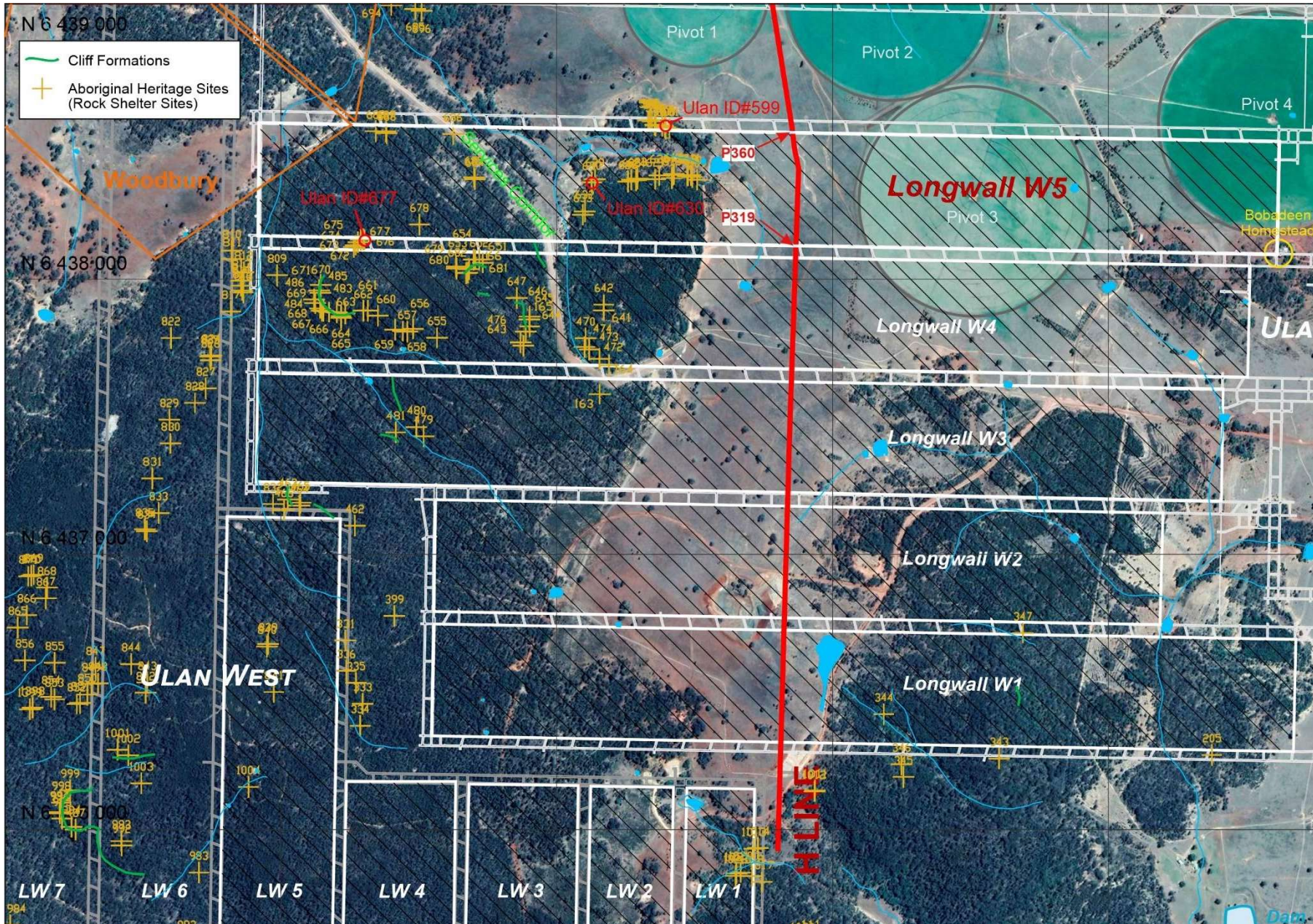
SCT (2009) presented subsidence predictions to inform the UCCO Project Environmental Assessment (EA). SCT (2009) was prepared after the mining of Longwall W1 and Longwall 23 at UUG.

An integrated Subsidence Management Plan (SMP) / Extraction Plan (EP) for the secondary extraction of Longwalls 27-29 and W4-W5 was approved in 2013 using SCT (2009) as the basis for the subsidence forecasts. This subsidence report represents the final end of panel report required by the SMP/EP for Longwalls 27-29 and W4-W5.

4. SUBSIDENCE EFFECTS MONITORING

This section presents the subsidence effects measured and subsidence impacts observed from mining Longwall W5. These effects and impacts are discussed and compared with the forecasts made in the SMP/EP for Longwalls 27-29 and W4 and W5.


N 6 439 000
N 6 438 000
N 6 437 000
N 6 436 000
Pivot 1
Pivot 2
Pivot 3
Pivot 4
P360
P319
Longwall W5
Woodbury
Longwall W4
Longwall W3
Longwall W2
Longwall W1
ULAN WEST
H LINE
LW 7
LW 6
LW 5
LW 4
LW 3
LW 2
LW 1
Bobadeen Homestead


N 6 439 000
N 6 438 000
N 6 437 000
Cliff Formations
Aboriginal Heritage Sites (Rock Shelter Sites)
Pivot 1
Pivot 2
Pivot 3
Pivot 4
Ulan ID#599
Ulan ID#677
Ulan ID#630
P360
P319
Woodbury
Longwall W5
Longwall W4
Longwall W3
Longwall W2
Longwall W1
Bobadeen Homestead
ULAN WEST
H LINE
LW 7
LW 6
LW 5
LW 4
LW 3
LW 2
LW 1

4.1 H Line

H Line is the main subsidence monitoring line for the western domain longwalls at UUG. The line traverses the longwall panels from south to north almost perpendicular to the panel direction. Figure 3 shows the grazing land along H Line above Longwall W5.

H Line crosses Longwall W5 between CH1763m and CH1740m. Longwall W5 mined directly below H Line between 5 July and 8 July 2019. The overburden depth along H Line over Longwall W5 varies from 220m to 225m. The mining height at this location is reported as 2.9m.

H Line was initially installed in 2008 prior to the mining of Longwall W1 and was subsequently extended to the north to allow far-field horizontal subsidence movements to continue to be measured. The line was recently extended to the lease boundary, 1.7km to the north of Longwall W8, with the baseline survey of the new marks undertaken in conjunction with the Longwall W5 end of panel survey.

The depth varies along H Line from approximately 200m at the start of the line to the south of Longwall W1, increasing to 240m over Longwall W3 and then remaining in the range 210-230m up to Longwall W8.

4.2 Primary Subsidence Parameters

Figure 4 shows a summary of subsidence effects for each of the longwall panels mined in the western domain including Longwall W5.

Table 4 details the monitoring results for the primary subsidence parameters along H Line for each of these panels at the time of each end of panel survey.

Table 4: Maximum subsidence over Longwall W5 and previous panels.

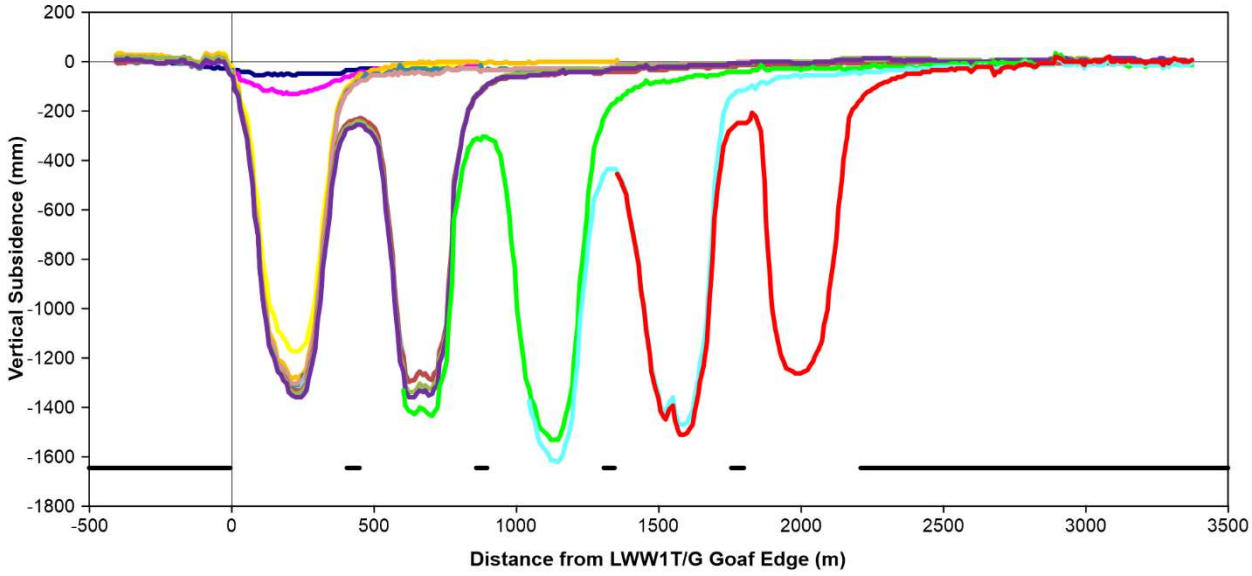
Subsidence Parameter	LWW1	LWW2	LWW3	LWW4	LWW5
Vertical subsidence (m)	1.3	1.35	1.54	1.47	1.27
Tilt (mm/m)	14	27	15	20	20
Compressive Strain (mm/m)	5	7	6	7	4
Tensile Strain (mm/m)	3	4	4	6	8

A single survey was conducted on H Line on 6 February 2020 after mining in Longwall W5 had finished. This survey extended from near the southern edge of Longwall W4, over Longwall W5 and to the northern end of the established line more than 1.1km beyond the goaf edge of Longwall W5.

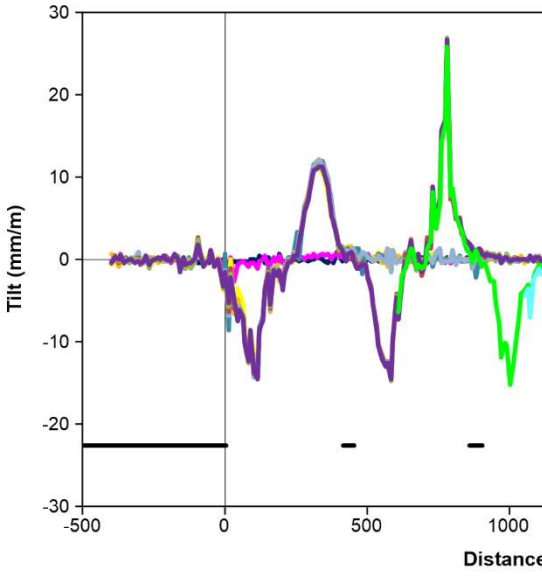
The 2.9m mining height in the vicinity of H Line is consistent with the mining height assumed for the subsidence assessment presented in SCT (2009).

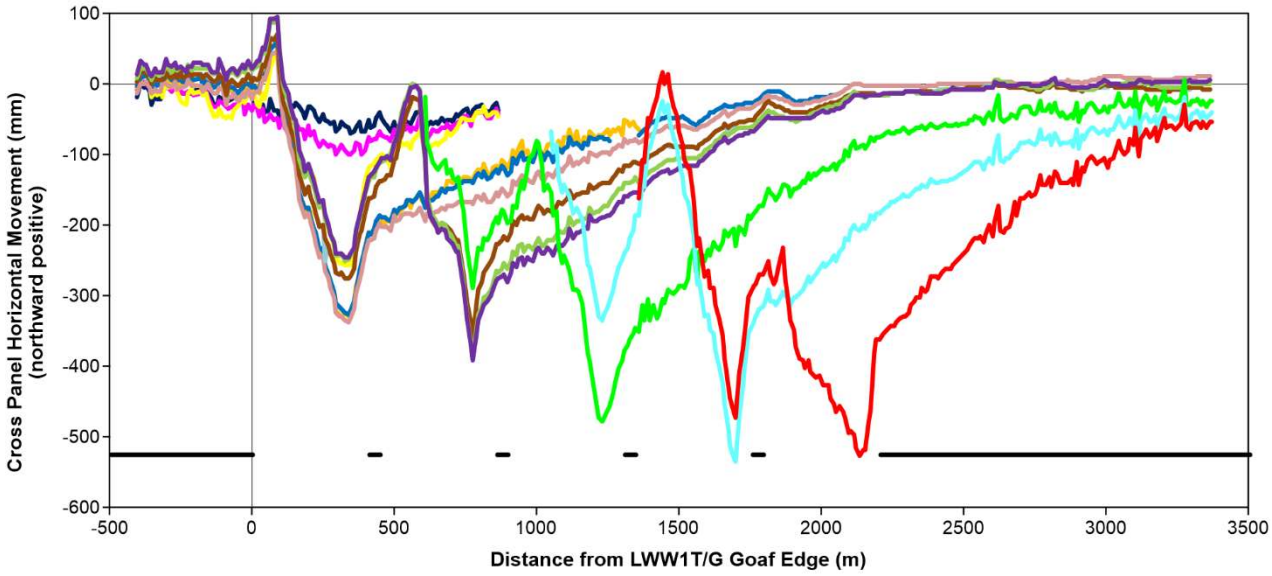
Maximum vertical subsidence measured above Longwall W5 is 1.27m. This value is less than the maximum 1.6m forecast in the SMP/EP for Longwalls 27-29 and W4 and W5.

Figure 3: Surface along H Line.

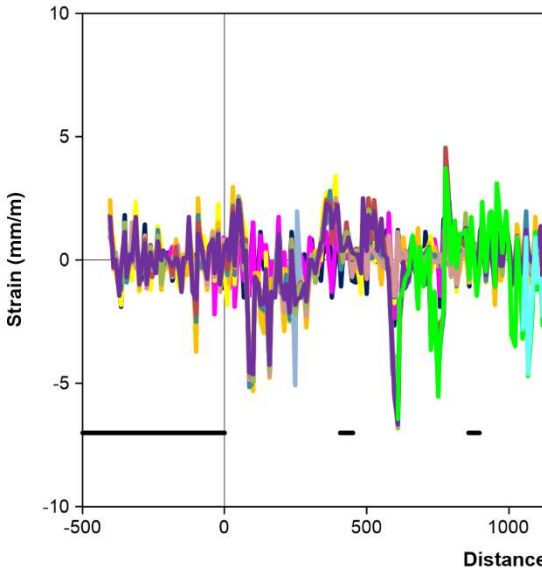


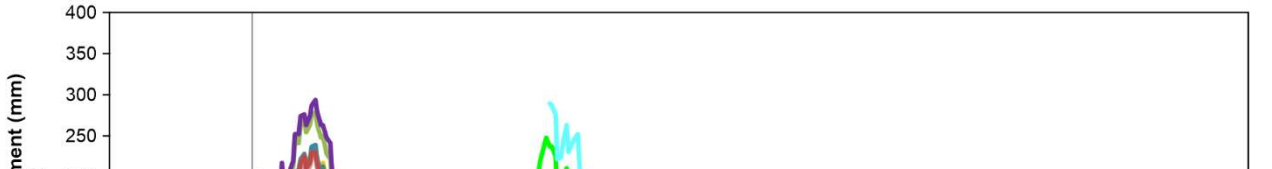
Line H - Subsidence

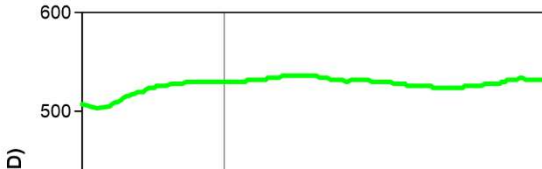




Line H - Cross Panel Horizontal Movement







Maximum vertical subsidence measured above the first three panels in the western domain has increased across each successive panel. Vertical subsidence over the inter-panel chain pillars also increased. Maximum subsidence over Longwalls W4 and W5 has reduced so that maximum subsidence over Longwall W5 is similar to the maximum subsidence measured over Longwall W1.

The variations in maximum subsidence correlate with variation in overburden depth but may also be due to cyclicity of maximum subsidence with distance along each panel. This cyclicity is apparent in the caving behaviour of the Triassic Sandstones. The maximum subsidence observed over any given panel depends on where the subsidence line happens to be in relation to the subsidence cycle.

The vertical subsidence profile over Longwall W5 does not display any significant bias associated with horizontal stress concentrations, indicating that the major horizontal stress is approximately perpendicular to the panel axis where H Line crosses Longwall W5.

Maximum tilt measured over Longwall W5 is 20mm/m. This value is at the upper end of the 10-20mm/m range forecast in SCT (2009), the SMP/EP for overburden depths of 150m to 300m.

Maximum strain measured over Longwall W5 was 4mm/m in compression and 8mm/m in tension. These values are toward the lower end of the 5-15mm/m range of maximum strains forecast in the SMP/EP.

4.3 Secondary Subsidence Parameters

A widely distributed survey control network located well outside the active mining area has allowed small, far field horizontal subsidence movements to be measured on H Line with a high degree of confidence. These small far-field horizontal movements have allowed broad scale ground displacements to be studied to provide insight into the mechanics of overburden behaviour around longwall panels.

The improved survey technique has allowed the magnitude of measured ground movements, particularly outside the panel footprint, to be measured more accurately. The magnitudes of secondary subsidence parameters such as goaf edge subsidence, angle of draw to 20mm and horizontal movements have increased as a result of the improved survey technique. These movements were occurring prior to the improvements in survey technique but were previously not able to be detected. The increases are not considered to represent a change in ground behaviour.

Vertical subsidence over the Longwall W4 to W5 inter-panel chain pillar is approximately 250mm at the completion of Longwall W5. This value is consistent with expectations for a depth of 220m but less than the maximum 800mm forecast in SCT (2009) for depths up to 300m. Subsidence above the Longwall W4 to W5 inter-panel chain pillar is similar to the subsidence above the Longwall W1 to W2 chain pillar but less than the maximum 430mm measured on H Line over the Longwall W3 to W4 chain pillar.

Goaf edge subsidence of approximately 160mm was measured above the northern edge of Longwall W5. This value of goaf edge subsidence is similar to the goaf edge subsidence measured at the Longwall W2 and W4 goaf edges but less than the 230mm measured at the Longwall W3 goaf edge. All these values are consistent with the 200-300mm goaf edge subsidence forecast in SCT (2009).

Angles of draw are sensitive to survey tolerance and are therefore somewhat interpretative. The angle of draw for Longwall W5 is estimated to be approximately 46° after consideration of survey tolerance. This value is within the range of 30-50° forecast in the SMP/EP but less than the 65° angles of draw observed after Longwall W3 and W4 were mined.

Horizontal movements above Longwall W5 panel reached a maximum of approximately 500mm. This value is similar to the maximum horizontal movements observed over Longwalls W3 and W4, and consistent with the 500mm forecast in the SMP/EP. The horizontal movements are of similar magnitude and character to the horizontal movements observed over recent longwall panels.

Since PA08_0184 was granted, ongoing subsidence monitoring has improved the understanding of subsidence behaviour at the Ulan Complex. This understanding also includes unconventional subsidence phenomena. As opportunities arise through Project Approval modification or extraction plan processes updated forecasts of subsidence effects are being incorporated in impact assessments.

The forecast magnitude of goaf edge subsidence, angle of draw and maximum horizontal movements were increased in the SMP/EP from those presented in SCT (2009) to reflect the improvements in survey technique. These greater subsidence effects are not considered to be of any significance in terms of subsidence impact. They are imperceptible for all practical purposes and occur so gradually that they do not typically impact surface features. Similar movements are likely to have been occurring for most of the time mining has occurred at the Ulan Complex, but the surveying methods used prior to Longwall W1 and Longwall 23 were not able to detect them.

4.4 Far-field Horizontal Movements and Horizontal Stress Relief

Figure 5 shows the cross panel horizontal movements measured on H Line at the completion of Longwalls W1-W5 plotted as a function of distance relative to the northern goaf edge of Longwall W5. The overburden depths at the goaf edge of these five panels range from 220m to 240m. Horizontal movements measured relative to the goaf edges of Longwalls 26, 27, 28 and 29 in the eastern domain at UUG are also plotted for reference. The overburden depth above these eastern domain panels ranges from 240m to 300m.

The horizontal movements measured over the goaf and panel edge of Longwall W5 are almost the same as those measured for Longwalls W4 and W3 and less than the those measured over Longwalls 26-29 where the overburden depth is greater.

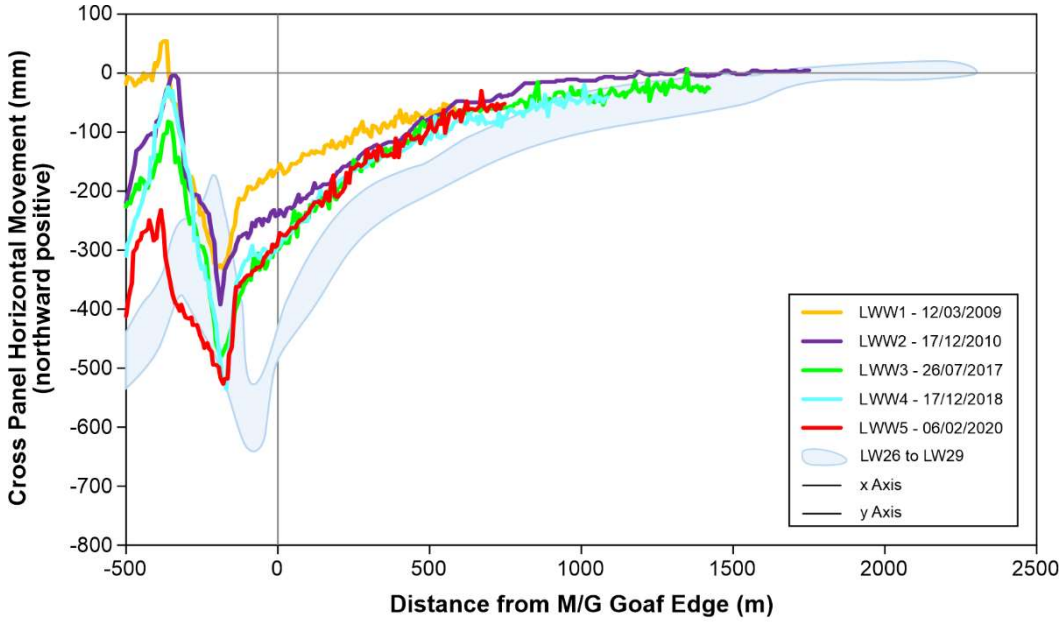


Figure 5: Cross panel horizontal movements measured on H Line at the end of Longwall W1, W2, W3, W4 and W5.

These measurements indicate a consistent pattern of horizontal displacement that increases in magnitude with overburden depth. The horizontal displacement profile implies that the far-field horizontal movements are a consequence of horizontal stress relief toward the extracted panels. As the overburden depth increases, the magnitude of horizontal stress increases so the magnitude of stress relief is greater. The greater stresses cause the larger magnitude displacements to extend for a greater distance outside the mining area.

The process that slows and eventually stops the far-field movement involves shear resistance developed on a basal shear plane. Gradually the stress relief that occurs at the goaf edge is balanced by frictional shear resistance on this basal shear plane. Frictional shear resistance appears to be low at Ulan, so far-field movements are evident to distances of the order of 1.5km to 1.8km from the goaf edge in areas where the overburden depth is 250m to 300m.

4.5 Unconventional Subsidence Behaviour

No unconventional subsidence effects were observed from the mining of Longwall W5. A compression override or ripple caused by horizontal shearing on a bedding plane was previously observed above Longwall W4. This feature has since been remediated and no extension to the previously disturbed ground or similar feature was observed above Longwall W5.

5. OBSERVATIONS OF SUBSIDENCE IMPACTS

This section discusses the subsidence impacts observed from the mining of Longwall W5. The impacts observed are compared with forecasts of impacts made in SCT (2009) and used as the basis for the UUCO Project EA and the SMP/EP forecasts. SCT understands that other specialists have undertaken monitoring of surface and sub-surface features and will independently prepare reports addressing the relevant impact assessment criteria and subsidence performance measures of PA08_0184.

SCT made a site visit to inspect the surface area above Longwall W5 on 16 and 17 January 2020 when the panel was near the finish line and in 'bolt-up'. The site visit included an inspection along H Line and other areas above Longwall W5 including roads and powerlines, Pivot 3 Irrigator, the section of private property (Woodbury) above the start line, and the Bobadeen Homestead precinct near the finish line of the panel.

Subsidence impacts to natural and built features observed during a site visit are generally minor in nature and less than the impacts forecast in SCT (2009) and in the SMP/EP.

Impacts from mining are most perceptible near the start of the panel, including on the Woodbury property. Surface cracks occur parallel to the panel edges. Most of these cracks are within the footprint of the panel. Cracking evident outside the panel footprint at the start of Longwall W5 is expected because of the topography in this area. Larger horizontal movements expected at the start of all panels are coincident with terrain sloping in the direction of mining at the start of Longwall W5. This combination of effects leads to larger cracks at the start of the panel and cracks apparent outside the panel footprint.

Surface cracks are also evident along the panel edges on hard surfaces such as roads and compacted areas around farm sheds.

Impacts to Aboriginal heritage rock shelter sites and sandstone formations more generally are minor with no rock falls recorded and only minor perceptible cracking evident at three of 18 locations (UCMPL 2020).

Subsidence impacts or environmental consequences to other features or items are expected to be less than the criteria for water, biodiversity, land, heritage, built features and public safety in the subsidence performance measures of PA08_0184, based on observations, monitoring and the primary subsidence effects being less than forecast in the UCCO EA, notwithstanding assessment of water and biodiversity impacts by other specialists.

Additional impacts associated with unusually heavy rainfall events in February and April 2020 following an extended drought are considered in this report even though these events occurred well after mining in the area was completed. Overland flow in a drainage line that has interacted with subsidence cracks above the start of the panel has led to localised surface erosion on the Woodbury property. Work to develop a remediation strategy is planned after consultation with the landowner, but an overview of the impacts is presented.

5.1 Impacts on UCMPL Property

Surface cracks observed during site visits were generally less than 50-100mm wide and most are located near panel edges. The low frequency of cracks observed is consistent with expectation based on experience in the adjacent panels.

Figure 6 shows a crack, parallel to and inside the northern panel edge of Longwall W5 where it crosses H Line.

Figure 6: Surface crack that crosses H Line.

Figure 7 shows similar cracking, near the northern side of Longwall W5 further to the east, that crosses Irrigation Road below the single pole overhead powerline at this location. No significant impacts or consequences to these built features were reported.

Minor cracking was also observed above the southern side of Longwall 5 at the hay shed 500m to the west of the Bobadeen Homestead site. Figure 8 shows the cracking parallel to and approximately 40m in from the southern panel edge at the hay shed location. There were no perceptible impacts to the hay shed structure.

Figure 7: Cracking adjacent to Irrigation Road.

a) Cracking near foundation.

b) Overview of hay shed structure.

Figure 8: Impacts to Bobadeen Hay Shed.

UCMPL (2020) reports on pre and post mining monitoring of surface features above the panel footprint as required by the SMP approval conditions for Longwalls 27-29 and W4-W5. This monitoring includes the pre and post mining condition of buildings in the Bobadeen Homestead precinct, Aboriginal heritage rock shelter sites and sandstone formations, flow (drainage) lines, farm dams and mining related or farm infrastructure. The post mining inspections for Longwall W5 were completed on 19 March 2020 after a significant (140mm) rainfall event on 17 February 2020.

No perceptible impacts from longwall mining were recorded to the Bobadeen Homestead and associated outbuildings.

The SMP/EP specifies the following three Aboriginal heritage sites are to be monitored during mining of Longwall W5:

- Ulan ID#599 (MC111), is located approximately 15m outside the northern panel edge.
- Ulan ID#630 (MC142), is located over the centre of Longwall W5.
- Ulan ID#677 (MC189), is located approximately 10m outside the southern panel edge above the Longwall W4-W5 chain pillar.

These three sites are rock shelters with artefacts. Their locations are shown in Figure 2.

No rock falls were observed, and only very minor cracking was perceptible at Site 599. No rock falls or perceptible cracking were observed at Sites 630 and 677.

Another 15 sandstone formations were also monitored. These also host rock shelter sites. Three of these are near Site 599 on the northern edge of the panel and twelve are immediately to the east of Site 630 above the centre of Longwall W5. No rock falls were recorded at any of the 15 locations monitored, and only very minor perceptible cracking or a slight change to the previous cracking was noted at two locations.

These impacts are less than the forecast in SCT (2009). Rock falls were forecast on up to 20% of the length of cliff formations located directly over mined areas and perceptible impacts were forecast along 70% of the length of cliff formations mined under or located within 0.4 times depth of the panel edge.

No perceptible impacts to the drainage line (tributary of Mona Creek) and associated farm dams were observed. However, increased erosion, most likely from the heavy rainfall event was noted in several locations. The two dams that have been mined under by Longwall W5 were reported as at near capacity following the rainfall event. Some significant erosion was recorded on some drainage lines, but this erosion is unlikely to be directly related to subsidence impacts.

The appearance of the surface cracking was noted to have changed after the rainfall event. The width of cracks was noticeably wider especially in sandy soil areas where erosion or slumping of the near surface material had fallen into the cracks.

Mining related infrastructure or built features and farm infrastructure owned by UCMPL appeared to be unaffected by mining subsidence. This infrastructure includes powerlines, pipelines and buried cables, agricultural land, irrigation equipment, fences and water troughs. Minor cracking near the panel edge was reported on the access road within the new services corridor to the northwest. No other impacts were observed along this corridor.

Minor impacts were also reported to the Pivot 3 irrigator during the active subsidence period as forecast in SCT (2018a). The horizontal movements resulted in temporary changes to the alignment and tracking of transit wheels during the transient period of subsidence movements. Tracking has since rectified itself once the longwall moved past the pivot.

Conservation areas for Aboriginal heritage sites at Mona Creek, Brokenback and Cockabutta Creek and the Talbragar Fish Fossil Reserve are all remote from the mining of Longwall W5. These areas are not expected to have experienced any perceptible impacts. No impacts were observed in the Brokenback Conservation Area or at the Talbragar Fish Fossil Reserve during surface inspections on 16 and 17 January 2020.

Subsidence impacts and environmental consequences to other features or items are expected to be less than the criteria for water, biodiversity, land, heritage, built features and public safety in the subsidence performance measures of PA08_0184, based on observations, monitoring and the primary subsidence effects being less than forecast in the UCCO EA, notwithstanding assessment of water and biodiversity impacts by other specialists.

5.2 Impacts to Private Property

The section of the Woodbury property above Longwall W5 was inspected on 17 January 2020 in company with the landholder. The impacts observed were consistent with expectation and less than the maximum forecast in SCT (2009) and in the SMP/EP.

Figure 9 shows a general view of the surface above Longwall W5. The farm dam embankment just east of the start line of the panel is in the middle ground on the left in the photograph. Cracking was observed near the panel edges both inside and outside the panel edge. The sandy soil was observed to slump into cracks in some places giving the appearance of “potholes”. Figure 10 shows an example of this type of impact.

The width of cracks parallel to the start line of Longwall W5 are expected to be larger than elsewhere along the panel because of the subsidence mechanics that generate horizontal movement. Crack width at the start of Longwall W5 is further magnified by the surface terrain sloping in the direction of mining. The largest horizontal movements occur at the start of longwall panels with the direction of movement in the direction of mining.

Figure 9: General view of section of 'Woodbury' property above Longwall W5.

Figure 10: Cracking near northern edge of Longwall W5.

Cracks that form above the start line of longwall panels are permanent and usually larger than elsewhere. The interaction of subsidence and sloping terrain causes horizontal movements to develop in a downslope direction. This effect is greatest when mining from high ground towards lower ground. The combination of sloping terrain in the direction of mining at the start of a longwall panel leads to the type of cracking shown in Figure 11.

a) Looking South.

b) Looking North.

Figure 11: Cracking in sloping terrain near start line of Longwall W5.

The two farm dams above or adjacent to the area mined by Longwall W5 had very low levels of standing water. The low water levels observed are likely to have been a combination of mining impacts and the drought conditions at the time of inspections. It is understood that UCMPL will remediate these impacts to the satisfaction of the landholder as detailed in the Private Property Subsidence Management Plan (PPSMP).

The start of Longwall W5 is located below an ephemeral drainage line that eventually flows into Mona Creek. Potholes were observed along this drainage line during the site visit on 17 January 2020. Sandy soil had eroded into a subsidence crack during a period of overland flow along the drainage line. Two heavy rainfall events in February and April 2020 have caused further erosion and an increase in the size of the potholes observed. Figure 12 shows overland flow entering subsidence cracks and the resulting erosion. A strategy of regrading the eroded areas and moving the drainage line to avoid a recurrence is expected to be effective in controlling further erosion.

6. REFERENCES

SCT 2009 "Part 3A Subsidence Assessment Ulan Coal – Continued Operations" – SCT Report ULA3367 - 14 August 2009.

SCT 2016 "Subsidence Assessment for Extraction Plan LW30 and LWW6 – LWW8 at Ulan Underground Mine" SCT Report ULA4560 - 28 September 2016.

SCT 2018a "Ulan Underground Mine: Subsidence Assessment for Irrigation Pivot 3" - SCT Letter Report ULA4917 – 31 August 2018.

SCT 2018b "Ulan Underground Mine: Subsidence Assessment for Bobadeen Homestead" - SCT Letter Report ULA4916_Rev1 – 14 December 2018.

SMP/EP 2016 "Ulan Coal Subsidence Management and Extraction Plan" - ULN SD PLN 0024 - Version: 5 - Effective 24/09/2012 – Dated May 2016.

UCMPL 2020 "Pre & Post Mining Inspection LWW5 Ulan Underground Mine".

a) Example of flow into a subsidence crack during an overland flow event.

b) Example of erosion along a drainage line following an overland flow event.

Figure 12: Erosion associated with interaction of overland flow and subsidence cracks.