Longwalls 205 to 208

Ausgrid Asset Management Plan

April 2021

DOCUMENT CONTROL

DOCUMENT DETAILS	**Title**	Longwalls 205-208 Ausgrid Asset Management Plan		
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Originator	Jeff Peck	Position Registered Surveyor Ashton Coal Operations Pty Ltd	Signed	Date 04/05/2021
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REVISIONS

Version	Date	Description	By	Approved
1	July 2020	Draft for Consultation	ACOL	-
2	October 2020	Final for Submission	ACOL	
3	April 2021	Review of 132kV monitoring frequency	ACOL	

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1 INTRODUCTION

Ashton Coal Operations Pty Ltd (ACOL), a subsidiary of Yancoal Australia Limited (Yancoal), owns the Ashton Coal Project (ACP), an underground coal mine located approximately 14 kilometres north-west of Singleton in the Hunter Valley in New South Wales (NSW) (**Figure 1**).

The ACP was granted consent on 11 October 2002 by the Minister of Planning pursuant to the provisions of the Environmental Planning and Assessment Act 1979 (DA 309-11-2001-i). The Mine is approved to produce up to 5.45 million tonnes per annum (Mtpa) of run of mine (ROM) coal and operate until 2024. The consolidated Development Consent has been modified on ten occasions, with the most recent amendment approved on 20 June 2016.

The underground mine is approved for multi-seam longwall extraction, targeting four coal seams in descending order (Pikes Gully (PG), Upper Liddell (ULD), Upper Lower Liddell (ULLD) and Lower Barrett (LB) (**Figure 2**). Development of the underground mine commenced in December 2005 and is accessed through the southern wall of the Arties Pit under the New England Highway.

ACOL has subsequently prepared an Extraction Plan for mining of Longwalls 205 to 208 in the ULLD Seam of the Ashton Underground Coal Mine, varying between 185 metres and 255 metres below the surface. Proposed mining of Longwalls 205 to 208 (the **Extraction Plan Area** – refer **Figure 3**) is due to commence March 2021 and is planned to take place over a three-year period.

INSERT FIGURE 1

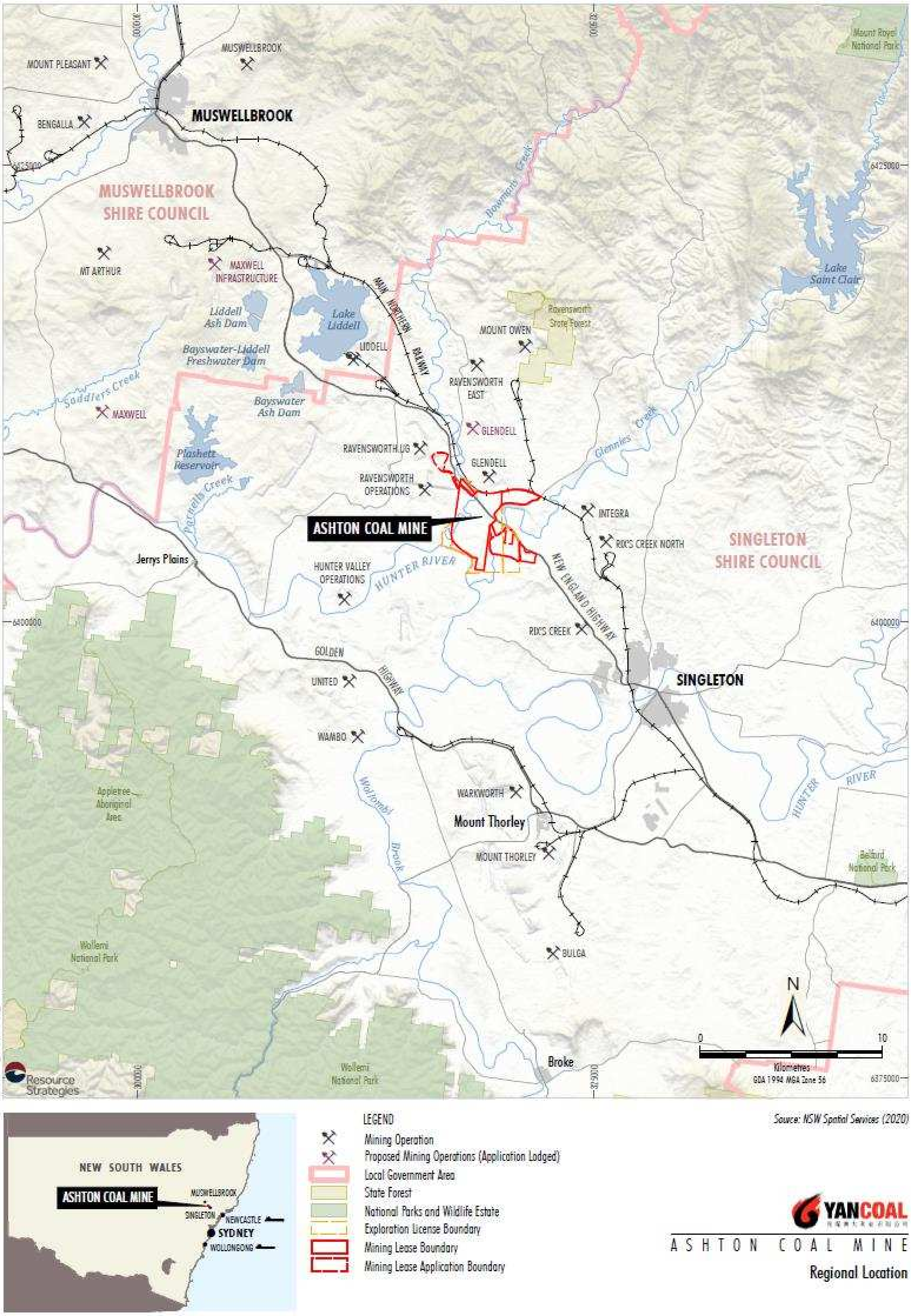

Figure 1

INSERT FIGURE 2

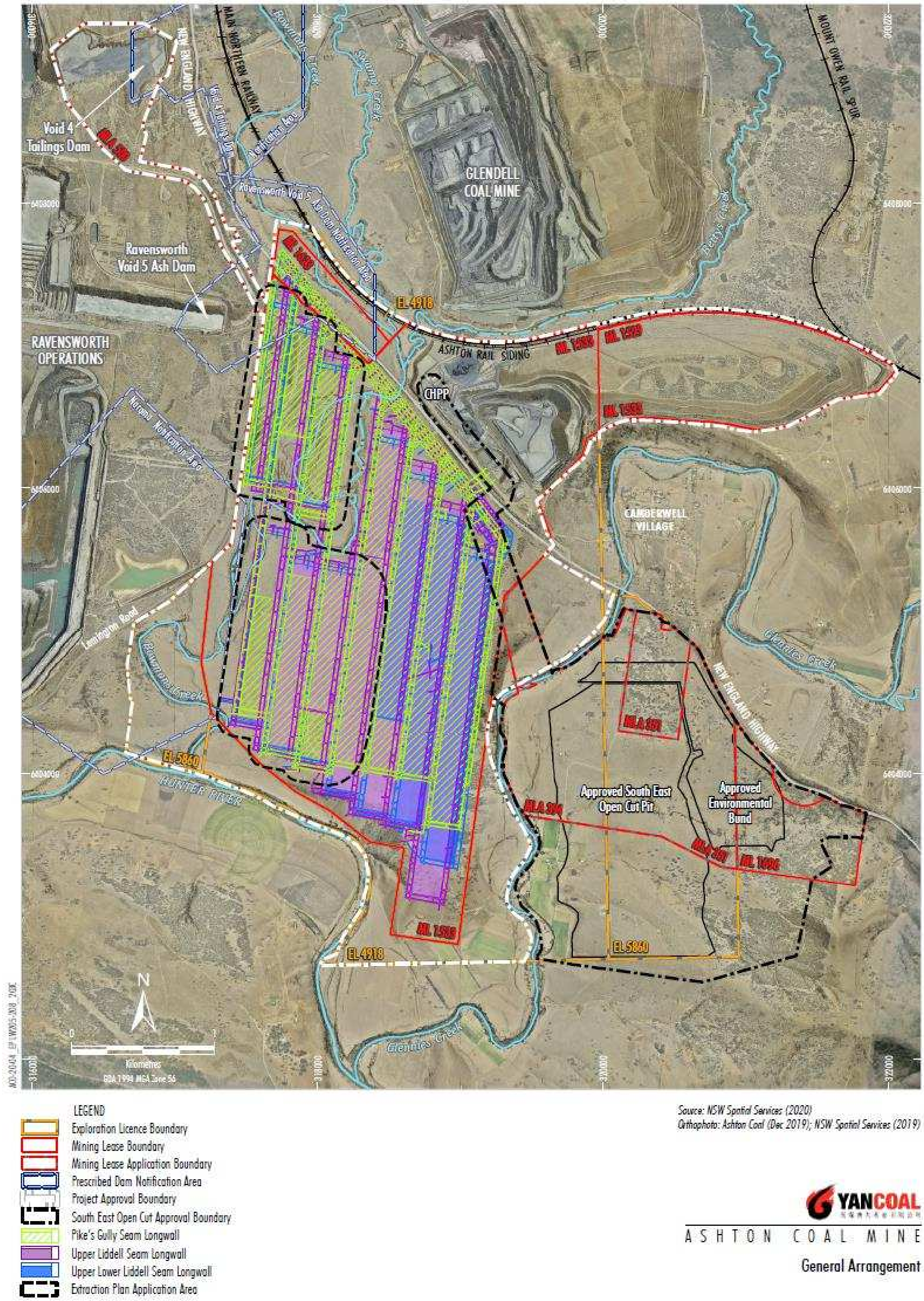

Figure 2

INSERT FIGURE 3

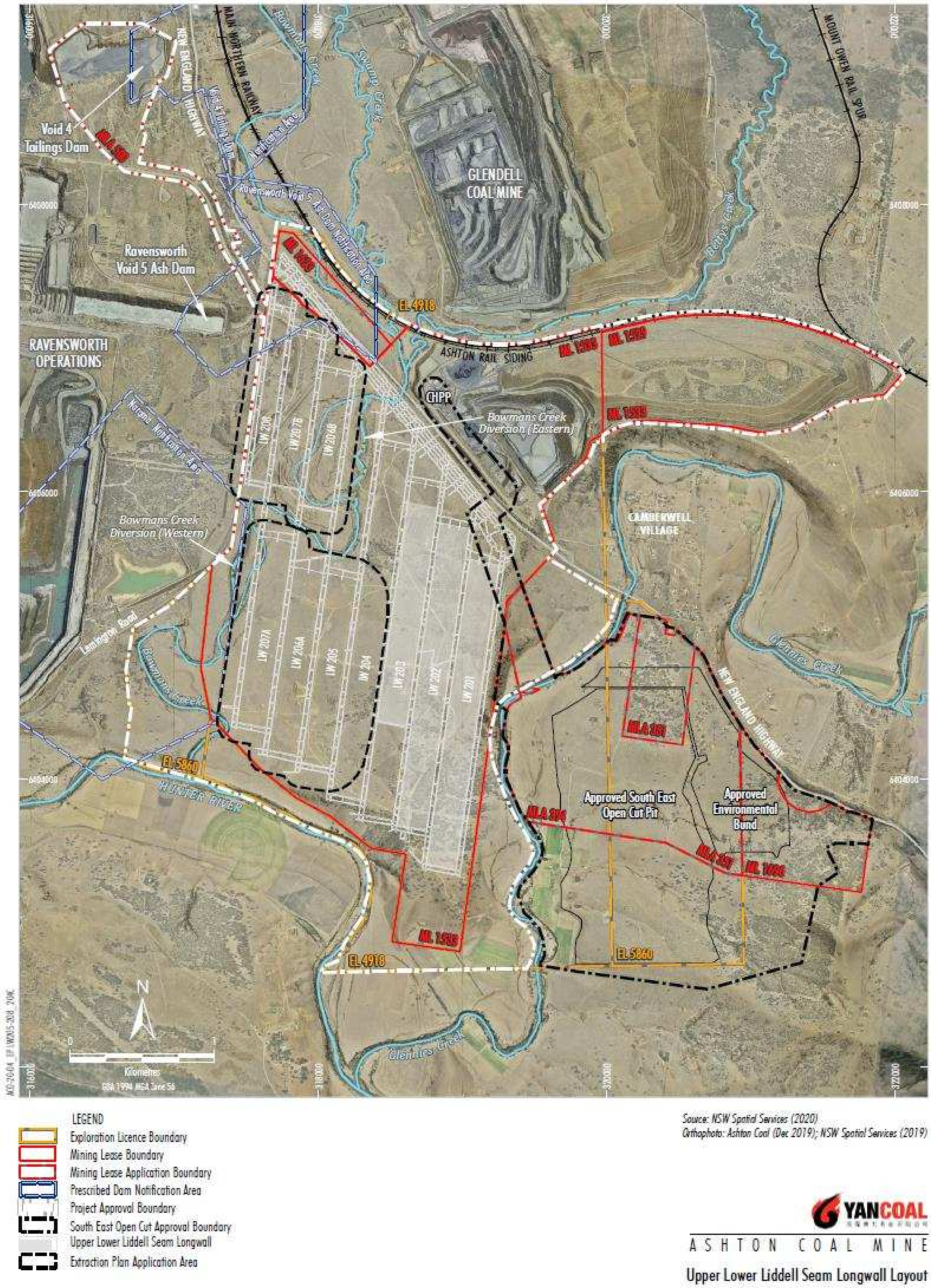

Figure 3

2 SCOPE & OBJECTIVE

This Asset Management Plan has been developed to manage risks associated with the potential subsidence impacts on Ausgrid infrastructure in the vicinity of the Longwalls 205-208 Extraction Plan area as a result of the secondary extraction of Longwalls 205-208 within the ULLD Seam.

This management plan provides a mechanism through which the potential subsidence impacts from longwall mining can be managed to maintain the safety and serviceability of the Ausgrid power supply network whilst mining is in progress.

Ausgrid infrastructure of relevance to Longwalls 205-208 has been identified as (**Figure 4**):

- a 132 kilovolt (kV) transmission line travelling roughly east-west over the southern ends of Longwalls 205, 206A and 207A;
- an 11kV transmission line travelling roughly east-west at the northern ends of Longwalls 205-208 (adjacent to the New England Highway), but largely outside the Extraction Plan area (three poles are within the Extraction Plan area); and
- an 11kV transmission line travelling roughly north-south overlying Longwalls 205, 206A and 207A.

This Asset Management Plan forms part of the Longwalls 205 to 208 Extraction Plan and should not be read in isolation.

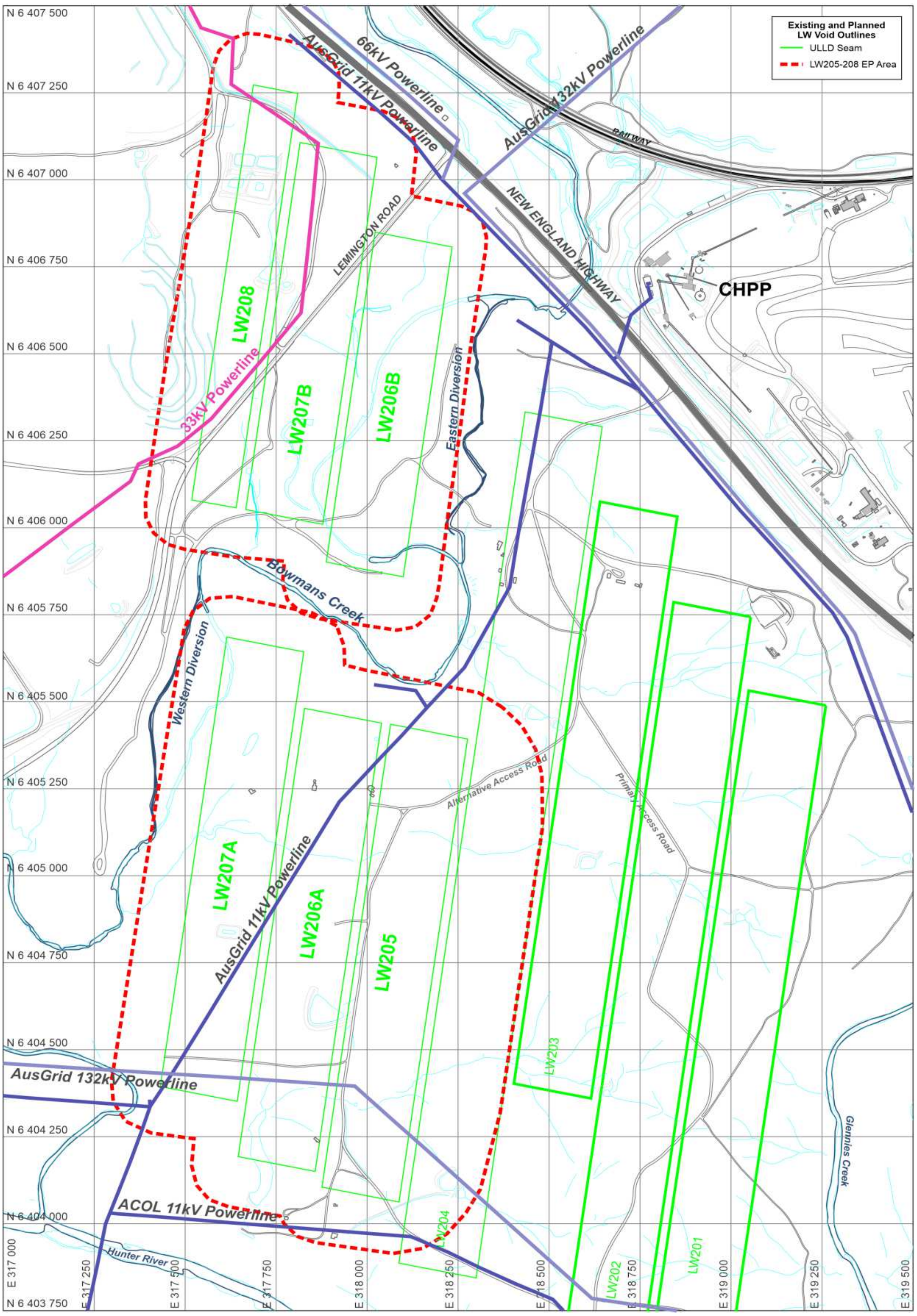

Figure 4: Plan Showing Location of Ausgrid Infrastructure in the Vicinity of Longwalls 205 to 208

3 ASSETS AND IMPACTS

3.1 PREVIOUS SUBSIDENCE MOVEMENTS

ACOL has previously mined an overlying series of longwall panels in the PG Seam and ULD Seam. The mining of Longwalls 205 – 208 in the ULLD Seam will be the third episode of mining in this area (see **Figure 2**).

The panels in each seam are arranged in a regular, parallel, offset geometry. In this arrangement, the first (PG) and third (ULLD) seams are superimposed. The second (ULD) and fourth (LB) seams are also superimposed but with a 60-metre offset to the west relative to the other two seams.

3.1.1 132kV Transmission Line

A program of pole upgrade and replacement for the 132kV transmission line was started during the period of mining the PG Seam. The aim of the program was to minimise the impacts to this infrastructure from the planned mining in the ULD Seam and underlying ULLD and LB Seams.

The 132kV transmission line was originally supported on two pole timber structures along straight sections of the line and three pole structures at the two changes in direction. Previous timber two pole structures have been progressively upgraded by ACOL to single concrete pole structures during the mining of the PG and the ULD Seam longwalls. The installation of replacement pole structures has allowed the transmission line to be more tolerant of the subsidence movements. Only one original two pole timber frame remains above the planned mining footprint above Longwall 207A. This frame will be replaced prior to the mining of Longwall 207A.

The 132kV transmission line has now been undermined by seven longwall panels in the PG Seam and five longwall panels in the ULD Seam, with no adverse impacts having been reported or measured. **Plate 1** shows a photograph of the 132kV transmission line that crosses the southern ends of PG Longwalls 5 to 7, ULD Longwalls 105 and 106A and ULLD Longwalls 205, 206A and 207A at the Ashton Underground Mine. The photograph is looking east from the last remaining two pole timber set, that is to be replaced prior to the mining of Longwall 207A, as mentioned above.

Table 1 and **Table 2** summarise the incremental and cumulative subsidence movements the 132kV transmission line will experience as result of mining the ULLD Seam based on the latest multi-seam subsidence monitoring. The latest subsidence monitoring data available for the previously extracted seams has also been included as a baseline. The subsidence predictions and impact assessment have been undertaken by Strata Control Technology (SCT) (SCT, 2020a).

Table 1. Measured and Forecast Incremental Subsidence on 132kV Transmission Line

Ausgrid Pole Numbers	Maximum Subsidence (m)			ULLD Incremental Tilt (mm/m)				ULLD Incremental Horizontal Movement (m)			
	PG & ULD Only	ULLD Only	Total	Max Tilt	Direction Toward	Permanent Tilt	Direction Toward	Initial Movement	Direction Toward	Horizontal Offset	Direction Toward
CN90463 & CN90464	**<0.02**	0.03	0.05	1	W	1	NW	0.01	W	0.02	NW
CN90079	**0.14**	**1.47**	**1.61**	**18**	**W**	**8**	**NW**	**0.1**	**S**	**0.3**	**N**
CN90080	**2.11**	**2.11**	**4.22**	**17**	**SE**	**9**	**E**	**0.2**	**SE**	**0.8**	**NE**
CN90081	**0.09**	**1.39**	**1.48**	**10**	**NE**	**5**	**NE**	**0.2**	**E**	**0.4**	**NE**
CN90469, CN90470 & CN90471	**1.21**	**2.26**	**3.47**	**17**	**E**	**12**	**NE**	**0.3**	**SE**	**0.9**	**NE**
CN90472	**0.15**	0.2	0.35	**3**	**E**	**3**	**NE**	**0.1**	**NE**	**0.2**	**NE**
CN90088	**1.57**	0.1	1.7	10	W	10	W	0.1	W	0.2	NW
CN90089	**0.84**	1.9	2.8	50	W	50	W	0.2	S	0.5	NW
CN80016	**2.15**	1.0	3.2	25	E	25	E	0.3	SE	0.9	E
CN80017	**0.67**	1.5	2.2	40	W	40	W	0.2	SW	0.5	N
CN80480, CN80481 & CN80482	**1.31**	2.1	3.4	50	E	50	E	0.2	SE	0.7	NE
CN80018	**0.19**	2.2	2.4	50	W	50	W	0.2	S	0.7	N
CN80019	**1.59**	0.7	2.3	20	E	20	E	0.1	SE	0.3	E
CN80485 & CN80486	0.1	1.4	1.5	30	NE	30	NE	0.1	N	0.4	NE
CN80487 & CN80488	-	0.1	0.2	5		5					

Source: SCT (2020a).

Note: Values in **bold** are measured values, other values are forecast.

Table 2. Measured and Forecast Cumulative Subsidence on 132kV Transmission Line

Ausgrid Pole Numbers	PG and ULD Seams			PG, ULD and ULLD Seams			PG, ULD, ULLD and LB Seams		
	Subsidence (m)	Maximum Tilt (mm/m)	Horizontal Movement (m)	Subsidence (m)	Maximum Tilt (mm/m)	Horizontal Movement (m)	Subsidence (m)	Maximum Tilt (mm/m)	Horizontal Movement (m)
CN90463 & CN90464	**<0.02**	**1.5**	**0.03**	0.05	<5	0.1	0.1	<5	0.1
CN90079	**0.14**	**5**	**0.1**	**1.61**	**14**	**0.4**	2.0	10	0.6
CN90080	**2.11**	**20**	**0.4**	**4.22**	**20**	**1.2**	6.7	50	1.7
CN90081	**0.09**	**4**	**0.15**	**1.48**	**7**	**0.5**	2.8	25	0.8
CN90469, CN90470 & CN90471	**1.21**	**7**	**0.3**	**3.47**	**13**	**1.2**	5.9	40	1.6
CN90472	**0.15**	**4**	**0.2**	0.35	3	0.3	1.3	15	0.6
CN90088	**1.57**	**8**	**0.4**	1.7	10	0.6	4.6	40	1.4
CN90089	**0.84**	**22**	**0.4**	2.8	50	0.9	4.0	20	1.1
CN80016	**2.15**	**20**	**0.3**	3.2	25	1.2	6.1	45	1.8
CN80017	**0.67**	**17**	**0.4**	2.2	40	0.9	3.9	30	1.1
CN80480, CN80481 & CN80482	**1.31**	**20**	**0.5**	3.4	50	1.2	6.2	45	1.8
CN80018	**0.19**	**2**	**0.1**	2.4	50	0.8	4.0	25	1.0
CN80019	**1.59**	**25**	**0.6**	2.3	20	0.9	4.5	30	1.6
CN80485 & CN80486	0.1	<5	0.2	1.5	30	0.6	3.1	20	1.0
CN80487 & CN80488	-	<5	0.2	0.2	5	0.4	0.3	5	0.5

Source: SCT (2020a).

Note: Values in **bold** are measured values, other values are forecast.

Plate 1: Southern 132kV Ausgrid Transmission Line Looking East from Last Two Pole Timber Set

3.1.2 11kV Transmission Line (North-South Alignment)

The single pole structures of the 11kV transmission lines have to date been found to be generally tolerant of subsidence movements experienced and the poles are closely enough spaced that ground clearances are not compromised if poles tilt towards each other. **Plate 2** shows a photograph of a section of the 11kV transmission line that traverses the Extraction Plan area generally in a north-south direction above Longwalls 205, 206A and 207A.

Plate 2: 11kV Ausgrid Transmission Line above Longwalls 5 and 6

3.2 SUBSIDENCE PARAMETER DEFINITIONS

Subsidence, tilt and strain are the subsidence parameters commonly used to define the extent of surface movements that will occur as mining proceeds.

Subsidence is the vertical distance (usually measured in millimetres) that the ground surface lowers as a result of mining, and depends on the depth of the coal seam, the thickness of the seam, the width of the extraction area and the characteristics of the overburden.

Tilt is calculated as the change in subsidence between two points divided by the distance between those points (i.e. change in slope of the surface landform as a result of mining). The maximum tilt, or the steepest portion of the subsidence profile, occurs approximately 50 metres from the edge of the longwall panel. Tilt is usually expressed in millimetres per metre.

Strain results from horizontal movements in the strata. Strain is determined from monitoring survey data by calculating the change in the horizontal length of a section of a subsidence profile and dividing this by the initial horizontal length of that section. If the section has been extended, the ground is in tension and the change in length and resulting strain are both positive. If the section has been shortened, the ground is in compression and the change in length and strain are both negative. Strain is usually expressed in millimetres per metre.

3.3 MAXIMUM PREDICTED SUBSIDENCE AND IMPACTS

Table 3 below describes the maximum predicted subsidence estimates detailed in the subsidence assessment for Longwalls 205-208 (SCT Operations, 2020b). Subsidence impacts have been categorised as:

- incremental subsidence: subsidence as a direct result of mining in the ULLD Seam; and
- cumulative subsidence: combined subsidence as a result of mining the ULLD Seam and previously mined seams (i.e. PG Seam and ULD Seam).

The incremental subsidence movements for Longwalls 205-208 in the ULLD Seam are additional to the movements that have already occurred as a result of previous mining in the PG and ULD Seams. These incremental values are added to the permanent tilts at the completion of mining in the ULD Seam to give estimates of the maximum tilts during mining in the ULLD Seam.

3.3.1 11kV Transmission Line (North-South Alignment)

This 11kV transmission line traverses the Extraction Plan area generally in a north-south alignment above Longwalls 205, 206A and 207A. Subsidence impacts are expected to have the potential to affect the serviceability of this infrastructure without mitigation and/or remediation works.

Table 3. Maximum Predicted Subsidence Parameters for ULLD Seam Longwall Panels

ULLD Seam Longwall Panels (depth range in brackets [m])	Longwalls 205-208 Forecast						
	ULLD Subs (m)	ULLD Strain (mm/m)			ULLD Tilt (mm/m)		
		General	Stacked Edges	Undercut Edges	General	Stacked Edges	Undercut Edges
Incremental Subsidence Parameters							
LW205 (185-225)	2.8	30	53	N/A	53	106	N/A
LW206A (205-240)	2.8	27	48	N/A	48	96	N/A
LW206B (175-210)	2.5	29	50	N/A	56	100	N/A
LW207A (220-260)	2.6	24	41	47	45	83	95
LW207B (190-225)	2.5	26	46	53	52	92	105
LW208 (210-240)	2.2	21	37	N/A	33	73	N/A
Cumulative Subsidence Parameters							
LW205 (185-225)	5.8	47	110	N/A	94	219	N/A
LW206A (205-240)	5.8	42	99	N/A	85	198	N/A
LW206B (175-210)	3.9	33	78	N/A	67	156	N/A
LW207A (220-260)	4.4	30	70	80	60	140	160
LW207B (190-225)	4.2	33	77	88	66	155	177
LW208 (210-240)	3.1	22	52	N/A	44	103	N/A

3.3.2 11kV Transmission Line (East-West Alignment)

This 11kV transmission line is adjacent to the New England Highway and is beyond the extent of the northern ends of Longwalls 206B, 207B and 208. No significant impacts are expected to this 11kV transmission line from the planned mining of Longwalls 205-208.

A total of three single pole structures are located within the Extraction Plan area. The poles are located above solid coal, typically around 100m from the edge of the longwalls. Vertical subsidence of less than 30mm with corresponding low levels of ground tilt and strain are expected at the closest pole to Longwall 208.

3.3.3 132kV Transmission Line (Traversing Southern Longwalls)

Impacts to this transmission line are expected to be minor and manageable under existing management plans. The original timber two pole structures have been progressively upgraded by ACOL to concrete poles structures during the mining of the PG and ULD Seam longwalls. The installation of these replacement poles and other engineering features to accommodate subsidence have made this transmission line more tolerant of the subsidence movements. Only one of the original two pole timber frames remains above the planned mining footprint. This frame above Longwall 207A is shown in **Plate 1** and will be replaced before Longwall 207A is mined.

3.4 CONSULTATION WITH AUSGRID AND FURTHER ASSESSMENT

Consultation undertaken with Ausgrid to date indicates that the work required on the 132kV transmission line falls under the definition that it 'could impact safety or security of the Ausgrid network' and therefore will be performed by Ausgrid as 'recoverable works'.

To maintain safety and serviceability of their system, Ausgrid have requested that further assessment be undertaken prior to mining of Longwall 206A (anticipated in Late October 2021). ACOL will provide Ausgrid with ground profiles including current and future (based on expected subsidence during each stage) such that Ausgrid can ensure overhead line design (e.g. ground clearances) can be maintained throughout all mining stages.

3.5 PROPOSED MONITORING/MANAGEMENT MEASURES

Monitoring of the full three-dimensional subsidence movements at the poles will take place to ensure subsidence movements are as expected in the subsidence assessment by SCT (2020).

3.5.1 11kV Transmission Line (North-South Alignment)

Prior to subsidence effects from Longwalls 205-208, most poles on this section of the line are to be relocated, in consultation with Ausgrid, into an area where subsidence movements will be small enough not to require any further mitigation or remediation works. One pole near the finishing end of Longwall 205 will need monitoring and management of subsidence effects and impacts.

3.5.2 11kV Transmission Line (East-West Alignment)

The predicted low-level subsidence effects are not expected to result in significant impacts to the poles or conductors associated with this transmission line. Nevertheless, regular visual inspections during the periods of mining the last 100m of each longwall will be undertaken.

3.5.3 132kV Transmission Line (Traversing Southern Longwalls)

As described in Section 3.4, ACOL will work in consultation with Ausgrid to ensure that overhead line design (e.g. ground clearances) can be maintained throughout all mining stages.

4 PERFORMANCE MEASURES

ACOL will aim to ensure that all built features owned by Ausgrid within the Extraction Plan area are always maintained as safe and serviceable. Any subsidence damage from ACOL's mining activities will be repaired as necessary, or else replaced and/or fully compensated or dealt with under the terms of an access or compensation agreement.

The subsidence impact performance measures relevant to Ausgrid assets under Schedule 3, Condition 29 of DA 309-11-2001-i are summarised in **Table 4**, while more specific objectives and performance measures developed by ACOL are listed in **Table 5** below.

Table 4. Subsidence Impact Performance Measures

Built Features	
Other built features, including other public infrastructure.	• Always safe. • Serviceability should be maintained wherever practicable. Loss of serviceability must be fully compensated. • Damage must be fully repaired or replaced, or else fully compensated.
Public Safety	
Public safety.	No additional risk due to mining.

Table 5. Ausgrid Electricity Transmission and Distribution Line Management Objectives

Objective	Performance Measure
• To ensure unplanned disruption to power supply does not occur as a result of subsidence related damage to transmission lines. • To prevent public safety hazards from damaged transmission lines.	• All infrastructure is assessed in consultation with Ausgrid and any required mitigation / relocation works carried out prior to undermining. • No power shortages occur due to subsidence induced damage to transmission lines. • Where subsidence related impacts are realised, transmission lines and poles within the site to remain structurally sound and serviceable at all times. • Safety – Line clearances appropriately managed and maintained.

5 MONITORING AND MANAGEMENT

The management actions that ACOL undertakes to satisfy the performance measures outlined in Section 4 are outlined in Table 6. These actions include monitoring, management and incident reporting.

Table 6. Ausgrid Asset Monitoring and Management

Item	Feature	Action/Response	Trigger/Timing
1.0	**Monitoring**		
1.01	132kV Transmission Line and North/South 11kV Transmission Line	Pre-subsidence survey of 132kV poles (top and base) to obtain xyz coordinates. The survey is to be undertaken in accordance with the approved *Subsidence Effects Monitoring Program* and the proposed methods therein.	Prior to mining the associated Longwall.
1.02		• Assets to be monitored in accordance with the *Subsidence Effects Monitoring Program.* • Visual inspections conducted during subsidence (see Section 5.1). • Undertake final inspections and survey following completion of mining.	• During active subsidence; and • Final inspection and survey following completion of mining effects.
1.03	East/West 11kV Transmission Line	No predicted subsidence impacts therefore no monitoring proposed.	No action.
2.0	**Management**		
2.01	132kV Transmission Line and North/South 11kV Transmission Line	• Structural assessment of transmission lines and implement remedial works to transmission line, as required. • For the 11kV transmission line, sheaving of the conductors on poles located in areas of high tilt such as stacked goaf edge at the northern end of Longwall 205 and at changes in direction will be undertaken to ensure that insulators and supporting cross members do not become overloaded by changes in conductor tension. • The remaining original structure (i.e. two timber poles) for the 132kV transmission line over Longwall 207A will be upgraded prior to undermining.	• Assessment to be completed prior to subsidence. • Mitigation measures (sheaving/upgrade) to be completed prior to impacts occurring.
2.02	East/West 11kV Transmission Line	No predicted subsidence impacts therefore no management actions proposed.	No action.

Item	Feature	Action/Response	Trigger/Timing
3.0	**Incident Response**		
3.01	132kV Transmission Line and North/South 11kV Transmission Line	Notify Ausgrid of any fallen/damaged electrical assets and take appropriate measures to prevent potential injury (e.g. signage, fencing).	As soon as practicable after identifying potential subsidence impacts (i.e. through inspections or service disruptions).
4.0	**Reporting**		
4.01	Item 1.01	Subsidence surveys to be provided to Ausgrid.	When completed – generally within 48 hours after completion of survey.
4.02	Item 1.02	Notify Ausgrid and provide copies of monitoring results.	If subsidence monitoring results are greater than predicted or if potential impacts are identified.
4.03	Item 2.01	Notify stakeholders. Provide copy of structural assessment.	When completed.
4.04	Item 3.01	Notify stakeholders.	Reporting as per Extraction Plan requirements.

5.1 SUBSIDENCE INSPECTIONS

Subsidence inspections will be carried out by mine staff pre-mining (prior to any subsidence effects) and, from then on, once every time mining is within 50m on the approach side of a 132kV concrete pole structure (+/- 20m) to 200m past the structure (+/- 20m) and after subsidence is deemed completed for that structure (>500m past). Visual monitoring to be done, at a minimum of once every 3 days, when structure is being undermined (i.e. ~50m before to ~200m past structure)

The inspections will be carried out to assess impact on the ground adjacent to the poles, footings, wires and conductors. Observed impacts on the ground surface may indicate an impact on the transmission line. The inspection checklist used for this task is shown in **Appendix B**.

5.1.1 Scope of Inspections

Regular surface inspections will cover a zone defined as being 200 metres behind and 100 metres in front of the current face position. The inspections will cover the full subsidence bowl out to the 45-degree angle of draw. Inspections will be carried out by mine staff and will follow the inspection checklist. Inspections will identify the following subsidence impacts:

- surface cracking – edges of extraction void and start and travelling abutments particularly in rock outcrop areas.
- surface humps (compression) – near centre of extracted panels and travelling abutment.
- step change in land surface – associated with cracking.
- damage to poles, conductors, transmission lines.

- reduced ground clearances of conductors.
- tilting of poles, increased/decreased tension in conductors; and
- bent crossarms or insulators.

5.1.2 Public and/or Transmission Line Safety Issues Identified During Inspections

If any safety issue is identified during inspections the person conducting the inspection shall:

- immediately notify the Technical Services Manager and/or Environment & Community Superintendent, who will then notify the affected parties (i.e. infrastructure owner, landholder).
- erect "NO ROAD" or barrier tape and warning signs if immediate remediation is not possible; and
- the Operations Manager shall immediately notify the NSW Resources Regulator, Landholder and the infrastructure owner if deemed a Public Safety issue (contact details in Appendix A).

5.1.3 Remediation of Transmission Line Safety Issues

If any public safety issue is identified during inspections or other safety issue is identified during assessment of monitoring or inspection results the Technical Services Manager and/or Environment & Community Superintendent shall:

- immediately contact Ausgrid and advise the identified impact.
- arrange for Ausgrid to implement immediate repairs if necessary; and
- liaise with Mine Management and Subsidence Advisory NSW to arrange long term repairs.

5.2 CONTINGENCY PLANS

Should interruption of power supply to a user occur as a result of, or suspected to be related to, subsidence impacts to the network, ACOL will attempt to provide auxiliary power supply to affected users where the interruption cannot be immediately repaired or if there is a medical or safety reason the user needs continued power supply.

5.3 REPORTING

The results of inspections will be recorded and filed. Surveys will be reported to relevant interested parties and data uploaded to the Resources Regulator's Standardised Subsidence Information Management System (SSIMS) online portal. Monitoring results will be reported annually in the Annual Review (AR) where relevant and as per Section 4.0 of Table 6. Other communications will be as detailed in the Public Safety Management Plan.

6 RESPONSIBILITIES

6.1 ASHTON OPERATIONS MANAGER

The Operations Manager must:

- promptly notify the Resources Regulator of any identified public safety issue via telephone to the central reporting number 1300 814 609; and
- complete a written notification using the online incident notification form via the Regulator Portal at https://www.resourcesregulator.nsw.gov.au/safety-and-health/notifications/incident-or-injury.

6.2 TECHNICAL SERVICES MANAGER

The Technical Services Manager must:

- authorise the Plan and any amendments.
- ensure that the required personnel and equipment are provided to enable this Plan to be implemented effectively.
- inform the Operations Manager of impacts requiring notification to the NSW Resources Regulator and/or Ausgrid; and
- liaise with officers of Ausgrid and remediation consultants and contractors as required.

6.3 ASHTON ENVIRONMENT & COMMUNITY SUPERINTENDENT

The Environment & Community Superintendent must:

- inform the landholders of impacts requiring remediation; and
- report monitoring results in the AR.

6.4 ASHTON REGISTERED MINING SURVEYOR

The Registered Mining Surveyor must:

- ensure that subsidence inspections are conducted to the required schedule and that the persons conducting the inspection are trained in the requirements of this plan and understand their obligations.
- review, assess and report subsidence monitoring results and inspection checklists; and
- promptly notify Technical Services Manager and/or the Environment and Community Superintendent of any identified public safety issue.

6.5 ASHTON TECHNICAL SERVICES TEAM

The Ashton Technical Services Team members must:

- conduct the subsidence inspection within the applicable subsidence zone to the standard required and using the subsidence inspection checklist.
- take actions to remediate any public safety issue identified during inspections; and
- where actions are beyond their capabilities immediately attempt to notify the landowner or infrastructure owner and Technical Services Manager.

6.6 AUSGRID

Ausgrid must arrange repairs as necessary through consultation between Ausgrid and ACOL.

6.7 PAYMENT OF COSTS IN RELATION TO REPAIRS

ACOL will liaise with Subsidence Advisory NSW in relation to payment for any necessary repairs such that no cost will be borne by Ausgrid.

7 TRAINING

All personnel who conduct inspections will be trained in the requirements of the Ashton Longwalls 205-208 Built Features Management Plan, Longwalls 205-208 Subsidence Monitoring Program and the Longwalls 205-208 Ausgrid Asset Management Plan.

Training will be conducted on the identification of the various subsidence impacts detailed in the Public Safety Management Plan and will include any safety aspects of those inspections.

8 AUDIT AND REVIEW

8.1 AUDIT

The requirements of the Longwalls 205-208 Ausgrid Asset Management Plan are to be audited as required.

8.2 REVIEW

A review of this plan will be undertaken:

- if the mine design criteria are changed.
- if subsidence impacts are greater than predicted.
- if required by Ausgrid; and
- following each audit.

9 REFERENCES

Strata Control Technology (2020a) *Southern 132kV Powerline: Update of Subsidence Assessment for ULLD Seam Longwalls*, Report Number ASH5188.

Strata Control Technology (2020b) S*ubsidence Assessment for the Extraction Plan for Longwalls 205 – 208 in the Upper Lower Liddell Seam*, Report Number ASH4927.

Appendices

Appendix A

Stakeholder Contact Details

Longwalls 205 - 208 Extraction Plan Stakeholder List

Position	Name	Phone
ASHTON		
Operations Manager	Aaron McGuigan	6570 9104
Technical Services Manager	Tony Sutherland	6570 9110
Environment and Community Superintendent	Phillip Brown	6570 9219
Mine Surveyor	Jeff Peck	6570 9125
Senior Mining Engineer	Ben Tockuss	6570 9124
After Hours	Ashton U/G Control Room	6570 9166
GOVERNMENT		
Subsidence Advisory NSW	Newcastle Office	4908 4300
Resources Regulator		1300 814 609
AUSGRID		
Portfolio Manager, Muswellbrook	John O'Brien	6542 9068 / 0428 234 028
Emergency	NA	13 13 88
LANDHOLDERS		
Refer to Ashton internal contact register.		

Appendix B

Subsidence Inspection Checklist

SUBSIDENCE INSPECTION CHECKLIST		
Longwall Panel		
Date		
Face Position		
Subsided Inspection Zone		
Pre-Subsidence Inspection Zone		
Area Inspected by (Print Name and sign)		
INSPECTION ITEM	**CHECKED**	**COMMENTS**
Surface cracking		
Surface humps (compression)		
Hunter River, Mine Water and Gas drainage pipelines		
Access roads and tracks		
Fences, gates, cattle grids		
Damage to Power-poles, Cross-arms, Insulators and Conductors e.g. leaning poles, increased sag in conductors, reduced ground clearance		
Dams		
Structures (houses, outbuildings)		
Other (den and/or nest trees)		

SUBSIDENCE INSPECTION CHECKLIST

Where to Inspect:

200 metres behind and 100 metres in front of the current face position.

Cover the full subsidence bowl out to the 45-degree angle of draw.

What to look for:

- surface cracking - edges of extraction void and start and travelling abutments particularly in rock outcrop areas and topographic high.
- surface humps (compression) - near centre of extracted panels, the travelling abutment and topographic lows if adjacent to steep terrain.
- step change in land surface - associated with cracking.
- slope, boulder and tree instability.
- surface slumping, erosion.
- serviceability of access tracks.
- changes to creeks, ponding, sediment load.
- general vegetation condition (in particular dieback of vegetation).
- change in conditions of 'right-of-way' access track or surrounding verges including drainage culverts and water flows as well as road cutting stability; and
- power poles and wires – adverse tilts on poles and ground clearances for wires, especially when crossing access tracks.

Actions if there is damage to non-ACOL infrastructure:

Immediately notify the:

- Operations Manager.
- Technical Services Manager and/or Environment & Community Superintendent; and
- relevant infrastructure owner/operator.

If repairs or remediation work is required these will be undertaken by Ausgrid.

Appendix C

Southern 132kV Powerline: Update of Subsidence Assessment for ULLD Seam Longwalls

Strata Control Technology

ASHTON UNDERGROUND MINE

Southern 132kV Powerline: Update of
Subsidence Assessment for ULLD Seam Longwalls

ASH5188

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 Tony Sutherland
Technical Services Manager
Ashton Underground Mine
Ashton Coal Operations Pty Ltd
PO Box 699
SINGLETON NSW 2330

Title Southern 132kV Powerline: Update of Subsidence Assessment for ULLD Seam Longwalls

Report No ASH5188

Prepared By Ken Mills

Date 24 June 2020

Stephen Wilson
Mine Planner

Ken Mills
Principal Geotechnical Engineer

Report No	Version	Date
ASH5188	1	24 June 2020

SUMMARY

Ashton Coal Operations Pty Ltd (ACOL) operates Ashton Underground Mine (AUM) near Camberwell in the Hunter Valley of NSW. ACOL is planning to mine Longwalls 205-207A in the Upper Lower Liddell (ULLD) Seam below a 132kV power transmission line owned by AusGrid. ACOL commissioned SCT Operations Pty Ltd (SCT) to provide updated estimates of the subsidence effects above Longwalls 205-207A to allow design of suitable mitigation measures for the remaining poles. This report presents updated subsidence estimates for all the 132kV power poles above longwall panels at AUM considering the revised mining geometries in the Upper Liddell (ULD) and ULLD Seams based on the latest multi-seam subsidence monitoring results.

Our assessment indicates that the impacts to the 132kV power line are manageable. Mitigation measures including locating poles remote from areas where very high tilts and strains are expected to continue to be effective. All poles above Longwalls 204-207A, except Set 11 above Longwall 207A, have now been upgraded to be more tolerant of subsidence movements. We understand the poles on Set 11 is planned to be upgraded before it is impacted by further mining subsidence.

The updated estimates of subsidence effects in this assessment are based on the latest subsidence monitoring results. These estimates are generally consistent with the previous assessment, but the maximum values are less than those forecast in earlier assessments. Subsidence monitoring on individual poles during previous mining indicates that maximum ground tilts do not fully transfer to the pole structures. Nevertheless, the revised estimates of subsidence parameters in this report are considered conservative and appropriate for impact assessment.

We recommend:

- an assessment of the structural stability of the poles and an assessment of conductor ground clearances based on the revised subsidence estimates
- appropriate mitigation strategies are implemented based on the assessments of structural stability and ground clearances
- predictions for ground movements at power pole locations are updated once the ULLD Seam has been mined prior to mining in the Lower Barrett (LB) Seam
- the current program of subsidence monitoring on each of the poles is continued.

It should be recognised that any changes to the mining plan for the remainder of the ULLD Seam and to the LB Seam layout from that used in this assessment may change the surface profiles shown.

TABLE OF CONTENTS

1. INTRODUCTION

Ashton Coal Operations Pty Ltd (ACOL) operates Ashton Underground Mine (AUM) near Camberwell in the Hunter Valley of NSW. ACOL is planning to mine Longwalls 205-207A in the Upper Lower Liddell (ULLD) Seam below a 132kV power transmission line owned by AusGrid. ACOL commissioned SCT Operations Pty Ltd (SCT) to provide updated estimates of the subsidence effects above Longwalls 205-207A to allow design of suitable mitigation measures for the remaining poles. This report presents updated subsidence estimates for all the 132kV power poles above longwall panels at AUM considering the revised mining geometries in the Upper Liddell (ULD) and ULLD Seams based on the latest multi-seam subsidence monitoring results.

This report presents subsidence estimates for the 132kV power poles within the mining footprint. The report presents updated subsidence assessments for the section of line above:

- Longwalls 201-207A in the ULLD Seam
- Longwalls 301-307A in the Lower Barrett (LB) Seam.

Potential changes to the ground surface profile along the power line alignment are presented as a basis for assessing conductor ground clearances.

Estimates in this report are an update of and supersede estimates in previous SCT reports including SCT (2014), SCT (2015), SCT (2016a) and SCT (2016b).

The report is structured to provide:

- conclusions and recommendations
- a site description and background
- a review of subsidence monitoring from the PG, ULD and ULLD Seam longwalls
- an update of the measured subsidence effects from Longwalls 201-203 and updated subsidence estimates for the planned mining of Longwalls 204-207A in the ULLD Seam
- an update of subsidence estimates for the planned longwall panels in the LB Seam.

Figure 1 shows a plan of the location of the 132kV power line that traverses the surface from east to west above the southern ends of the longwall panels at AUM.

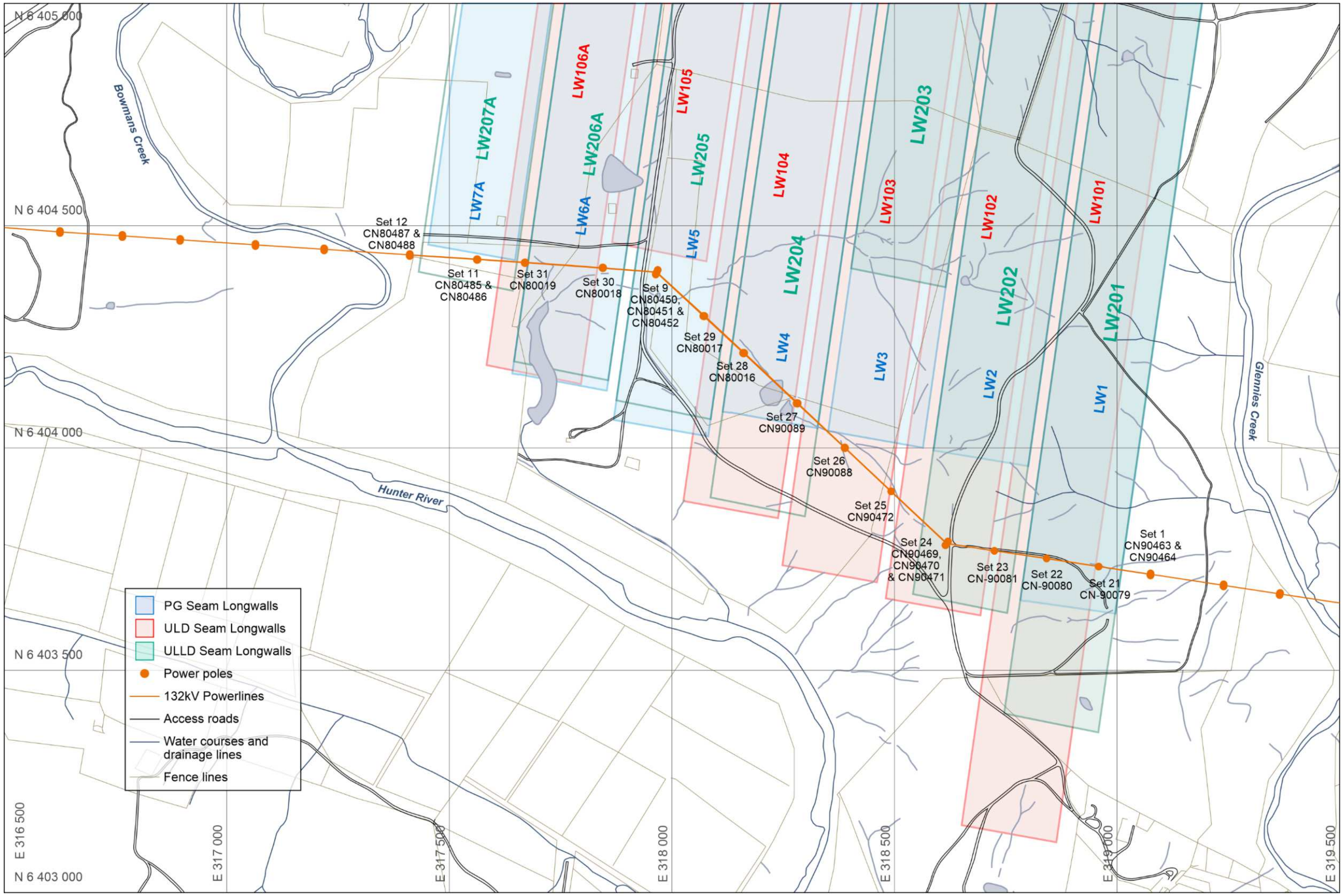

Figure 1: Locations of 132kV power transmission line relative to longwall panels at Ashton Underground Mine.

2. CONCLUSIONS AND RECOMMENDATIONS

Impacts to the southern 132kV power line from proposed mining of Longwalls 205-207A are expected to be manageable. Strategies that have been effective to date, including locating poles in areas not subject to very high tilts and strains, are expected to continue to be effective above Longwalls 205-207A. All poles above Longwalls 204-207A, except Set 11 above Longwall 207A, have now been upgraded to be more tolerant of subsidence movements. We understand ACOL are planning to replace Set 11 before the mining of Longwall 207A.

Subsidence monitoring from Longwalls 101-106A in the ULD Seam and Longwalls 201-203 in the ULLD Seam has improved our understanding of the mechanics of multi-seam subsidence behaviour. This understanding has allowed subsidence estimates along the 132kV power line to be improved. Changes to mining geometries in the ULD and ULLD Seams since earlier assessments were completed have also changed the nature and magnitude of subsidence movements at some locations. The updated estimates of subsidence parameters in this assessment are generally consistent with the previous assessment but the maximum values are less than those forecast in earlier assessments.

Table 1 presents the measured and estimated incremental subsidence associated with mining in the ULLD Seam. Measured incremental subsidence movements are available for Longwalls 201-203. Incremental subsidence movements above Longwalls 204-207A are estimated.

Table 2 presents the measured and estimated cumulative subsidence movements associated with mining in all seams, including the Lower Barrett (LB) Seam. Most of the poles were replaced during mining in the PG Seam so the measured cumulative subsidence movements mainly relate to the other seams. Cumulative subsidence above Longwalls 204-207A and the LB Seam are estimated.

Subsidence monitoring of individual poles during previous mining indicates that maximum ground tilts do not fully transfer to the pole structures. The maximum tilts recorded at poles are less than those measured nearby on ground monitoring lines in similar locations relative to the panel edges. These revised estimates in this report are considered conservative and appropriate for impact assessment.

The updated forecasts of maximum incremental and maximum cumulative subsidence for Longwalls 204-207A are 2.2m and 3.5m respectively. These maximum values are similar to those measured over Longwalls 201-203 and forecast in the previous assessment SCT (2016b) but much less than the maximum values predicted in earlier assessments.

Table 1: Measured and Forecast Incremental Subsidence on 132kV Power Line for Mining in the ULLD Seam

Pole Numbered as Survey Sets	Ausgrid Pole Numbers	Maximum Subsidence (m)				ULLD Incremental Tilt (mm/m)				ULLD Incremental Horizontal Movement (m)			
		PG only (m)	ULD only (m)	Additional for ULLD only (m)	Total (m)	Max Incremental Tilt (mm/m)	Direction Toward	Permanent Tilt	Direction Toward	Initial Movement (m)	Direction Toward	Horizontal Offset (m)	Direction Toward
1	CN90463 & CN90464	**<0.02**	-	0.03	0.05	1	W	1	NW	0.01	W	0.02	NW
21	CN-90079	Replaced	**0.14**	**1.47**	**1.61**	**18**	**W**	**8**	**NW**	**0.1**	**S**	**0.3**	**N**
22	CN-90080	Replaced	**2.11**	**2.11**	**4.22**	**17**	**SE**	**9**	**E**	**0.2**	**SE**	**0.8**	**NE**
23	CN-90081	Replaced	**0.09**	**1.39**	**1.48**	**10**	**NE**	**5**	**NE**	**0.2**	**E**	**0.4**	**NE**
24	CN90469, CN90470 & CN90471	Replaced	**1.21**	**2.26**	**3.47**	**17**	**E**	**12**	**NE**	**0.3**	**SE**	**0.9**	**NE**
25	CN90472	Replaced	**0.15**	**0.2**	**0.35**	**3**	**E**	**3**	**NE**	**0.1**	**NE**	**0.2**	**NE**
26	CN90088	Replaced	**1.57**	0.1	1.7	10	W	10	W	0.1	W	0.2	NW
27	CN90089	Replaced	**0.84**	1.9	2.8	50	W	50	W	0.2	S	0.5	NW
28	CN80016	Replaced	**2.15**	1.0	3.2	25	E	25	E	0.3	SE	0.9	E
29	CN80017	Replaced	**0.67**	1.5	2.2	40	W	40	W	0.2	SW	0.5	N
9	CN80480, CN80481 & CN80482	Replaced	**1.31**	2.1	3.4	50	E	50	E	0.2	SE	0.7	NE
30	CN80018	Replaced	**0.19**	2.2	2.4	50	W	50	W	0.2	S	0.7	N
31	CN80019	Replaced	**1.59**	0.7	2.3	20	E	20	E	0.1	SE	0.3	E
11	CN80485 & CN80486	To be replaced	0.1	1.4	1.5	30	NE	30	NE	0.1	N	0.4	NE
12	CN80487 & CN80488	0.1	**-**	0.1	0.2	5		5					

Note: Values in bold typeface are measured - values in normal typeface are forecast

Table 2: Measured and Estimated Cumulative Subsidence on 132kV Power Line for Mining in the ULD, ULLD and LB Seams

Pole Numbered as Survey Sets	Pole Numbers	(PG) & ULD			PG, ULD & ULLD			PG, ULD, ULLD, and LB		
		Cumulative Subsidence (m)	Max Tilt (mm/m)	Cumulative Horizontal Movement (m)	Cumulative Subsidence (m)	Cumulative or Forecast Incremental Max Tilt (mm/m)	Cumulative Horizontal Movement (m)	Total Subsidence (m)	Incremental Max Tilt (mm/m)	Cumulative Horizontal Movement (m)
1	CN90463 & CN90464	**<0.02**	**1.5**	**0.03**	0.1	<5	0.1	0.1	<5	0.1
21	CN-90079	**0.14**	**5**	**0.1**	**1.61**	**14**	**0.4**	2.0	10	0.6
22	CN-90080	**2.11**	**20**	**0.4**	**4.22**	**20**	**1.2**	6.7	50	1.7
23	CN-90081	**0.09**	**4**	**0.15**	**1.48**	**7**	**0.5**	2.8	25	0.8
24	CN90469, CN90470 & CN90471	**1.21**	**7**	**0.3**	**3.47**	**13**	**1.2**	5.9	40	1.6
25	CN90472	**0.15**	**4**	**0.2**	**0.35**	**3**	**0.3**	1.3	15	0.6
26	CN90088	**1.57**	**8**	**0.4**	1.7	10	0.6	4.3	40	1.4
27	CN90089	**0.84**	**22**	**0.4**	2.8	50	0.9	4.0	20	1.1
28	CN80016	**2.15**	**20**	**0.3**	3.2	25	1.2	6.1	45	1.8
29	CN80017	**0.67**	**17**	**0.4**	2.2	40	0.9	3.9	30	1.1
9	CN80480, CN80481 & CN80482	**1.31**	**20**	**0.5**	3.4	50	1.2	6.2	45	1.8
30	CN80018	**0.19**	**2**	**0.1**	2.4	50	0.8	4.0	25	1.0
31	CN80019	**1.59**	**25**	**0.6**	2.3	20	0.9	4.5	30	1.6
11	CN80485 & CN80486	0.1	<5	0.2	1.5	30	0.6	3.1	20	1.0
12	CN80487 & CN80488	0.1	<5	0.2	0.2	5	0.4	0.3	5	0.5

Notes: Values in bold typeface are measured – values in normal typeface are forecast

Maximum incremental tilt is forecast to reach 50mm/m at some of the poles. This value is similar to the level of ground tilt measured elsewhere over Longwalls 201-203 and forecast in the previous assessment but much less than the maximum values predicted in earlier assessments.

There is potential for surface ponding to develop around the base of Set 9, Set 30 and Set 31 after Longwalls 205-207A are complete. Surface drainage works are expected to be effective in managing this ponding once these works are complete.

Based on our review of the revised mining geometry and improvements in understanding of the subsidence behaviour from recent subsidence monitoring, we recommend:

- an assessment of the structural stability of the poles and an assessment of conductor ground clearances based on the revised subsidence estimates presented in this report to confirm existing and proposed mitigation measures are still appropriate and sufficient
- appropriate mitigation strategies are implemented based on the assessments of structural stability and ground clearances
- forecasts of ground movements at power pole locations are updated after mining in the ULLD Seam is complete and before the commencement of mining in the LB Seam
- the current program of subsidence monitoring on each of the poles is continued.

3. SITE DESCRIPTION AND BACKGROUND

Figure 1 shows a plan of the location of the 132kV power line that traverses the surface from east to west above the southern ends of the longwall panels at AUM.

The panels in each seam are arranged in a regular, parallel, offset geometry. In this arrangement the 1st (PG) and 3rd (ULLD) seams are superimposed. The 2nd (ULD) and 4th (LB) seams are also superimposed but with a 60m offset to the west relative to the other two seams. The naming convention for overlying panels is: Longwall 1 in the PG Seam, Longwall 101 in the ULD Seam, Longwall 201 in the ULLD Seam and Longwall 301 in the LB Seam.

ACOL mined Longwalls 1-8 in the PG Seam. Longwalls 101-106A in the ULD Seam were mined approximately 35m below and 60m offset from the PG Seam panels. No further mining in the ULD Seam is planned at this stage. ACOL recently completed mining the third panel (Longwall 203) in the ULLD Seam, approximately 30m below the ULD Seam.

The section of the 132kV located above the longwall panels and for a distance of 0.5 times depth outside the mining footprint was originally supported on two pole timber frame structures along straight sections of the line and three pole structures at changes in direction. A program of pole upgrade and replacement was started when the PG Seam was mined to minimise impacts to the power line from planned mining in the ULD Seam and the underlying ULLD and LB Seams. Two pole timber structures above the panels were progressively replaced with single pole concrete structures. Three pole timber structures at changes in direction were replaced with three free standing single poles as shown in Figures 2 and 3. Ground movements and three-dimensional movements of the poles were then surveyed during mining to monitor the response of the poles to subsidence.

Since the pole upgrade and replacement program commenced, the start lines for Longwall 105 in the ULD Seam and Longwall 203 in the ULLD Seam moved to the north to improve mining conditions underground so that neither panel mined below the 132 kV powerline. Longwall 107A in the ULD Seam was not mined and is not planned to be mined in the foreseeable future. These changes in mine plan affect the nature and magnitude of subsidence movements causing by mining the other panels.

Table 3 shows the upgrade status of the 132kV power poles above and near the southern longwall panels at AUM. Set 1, Set 11 and Set 12 remain as timber frame structures. Set 1 and Set 12 are located outside the mining area and will not be directly mined under. Set11 is planned to be replaced before Longwall 207A in the ULLD Seam is mined.

Table 3: Current Details of 132kV Power Poles

Set	AusGrid Reference	Description
1	CN90463 & CN90464	Original Timber H Frame still in position
21	CN90079	Single pole replacement in new location
22	CN90080	Single pole replacement in new location
23	CN90081	Single pole replacement in new location
24	CN90469, CN90470, CN90471	Poles replaced with same numbers
25	CN90472	Single pole replacement in new location
26	CN90088	Single pole replacement in new location
27	CN90089	Single pole replacement in new location
28	CN80016	Single pole replacement in new location
29	CN80017	Single pole replacement in new location
9	CN80450, CN80451, CN80452	Poles replaced
30	CN80018	Single pole replacement in new location
31	CN80019	Single pole replacement in new location
11	CN80485 & CN80486	Original Timber H Frame still in position
12	CN80487 & CN80488	Original Timber H Frame still in position

Figure 2: Set 24 (with conductor sheaves) at change of direction.

Figure 3: Set 9 at change of direction with concrete pad footings in position (Set 29 in background).

Figure 4 shows a photograph of Set 11, the last remaining timber frame structure, looking east. Set 11 is located over Longwall 207A. The single pole structures of Sets 30 and 31 located over Longwall 206A can be seen in the background.

Figure 4: Set 11 at right with Set 30 and Set 31 in background.

There are now replacement poles in areas where subsidence has occurred from mining in one, two and three seams. None of the poles have so far experienced subsidence from mining in three seams, but some have experienced the effects of subsidence in two seams combined with strata softening that occurred prior to the poles being upgraded in a third seam. Even after mining in the LB Seam, no poles will have directly experienced subsidence from four seams.

None of the poles are located directly over stacked goaf edges or near the start lines of panels in different seams. However, some poles are located close to areas where increased tilts and strains are expected when surface cracks at the PG and ULD Seam panel edges are remobilised by further mining in deeper seams. The effect of not mining Longwall 105 in the ULD Seam below the 132kV line results in a stacked goaf edge being formed along the edges of Longwalls 205 and 206A in the ULLD Seam with Longwalls 5 and 6A in the PG Seam. The new poles in Set 9 and Set 30 are located just beyond the zone of elevated effects expected near these stacked goaf edges. The poles of Set 9 and Set 30 have concrete pad footings to make these structures more tolerant of subsidence movements. These poles are expected to be able to accommodate the anticipated ground movements.

4. PREVIOUS SUBSIDENCE MONITORING

Monitoring of subsidence movements at AUM includes surveying on the main crossline (XL5), on end of panel longitudinal lines and on individual poles on the 132kV powerline. This expanded monitoring database provides a basis to better understand the influence of multi-seam subsidence on the 132kV power line infrastructure. The estimated subsidence effects to the 132kV power line are presented in earlier SCT reports. These reports are periodically updated in response to changes to the mining plan layout and as more multi-seam subsidence monitoring data becomes available. The magnitude of subsidence movements forecast typically reduces with each update once the uncertainty of forecasting is replaced by actual survey data.

Subsidence monitoring began with the commencement of PG Seam longwall operations in early 2007 and has continued above all the panels mined since then. Subsidence monitoring above the ULD Seam Longwalls 101-106A commenced in 2012. Subsidence monitoring above the ULLD Seam Longwalls 201-203 commenced in 2017.

The survey monitoring data and field observations of subsidence impacts provide insight into the mechanics that drive the magnitude and the distribution of subsidence movements in a multi-seam environment. Effects such as:

- differences in behaviour between strata that is undisturbed by previous mining and strata that has already been subsided
- recovery of latent subsidence adjacent to pillars in the overlying seam
- difference in ground behaviour between general background behaviour and the behaviour that occurs near stacked or undercut goaf edges
- the effect of mining direction on subsidence effects near stacked goaf edges.

These improved understandings are discussed in this section as the basis for updating the ULLD and LB Seams subsidence forecast for the 132kV power poles.

4.1 General Subsidence Behaviour

The subsidence monitoring from mining Longwalls 101-106A and the preliminary results from Longwalls 201-203 indicates that for an offset mining geometry, the maximum subsidence can be estimated with reasonable confidence in the multi-seam environment at the AUM. The subsidence profile is also relatively predictable once the specific mechanics of the interactions between the mining geometry in each are recognised.

Where supercritical width panels in two seams overlap in an offset geometry, maximum cumulative vertical subsidence from mining both seams is approximately 70% of the combined mining thickness of both seams (compared to 50-60% for the first seam mined) and incremental subsidence is in the order of 80% of the height of the second seam mined.

At some locations, the incremental subsidence is a higher proportion of the seam thickness in the second seam mined due to latent subsidence being recovered. Latent subsidence occurs during mining of a second seam when a pillar (or panel edge) in the upper seam that was previously limiting subsidence is mined under. Subsidence that was prevented from occurring during mining of the first seam by the presence of the pillar is recovered during mining below the pillar in the second seam.

The maximum values of subsidence parameters such as tilt and strain are observed to be of a similar or lower magnitude to the subsidence parameters measured in the first seam mined even though the combined vertical subsidence is greater. The maximum values of tilt and strain are typically less than the maximum calculated assuming single seam mining conditions. This behaviour is thought to be due to a general softening effect (loss of shear stiffness) of the multi-seam mining and the difference in behaviour between strata that is undisturbed by previous mining and strata that has already been subsided.

In a stacked goaf geometry where the goaf edges in the first and second seam are directly above one another, a different behaviour is observed. At these stacked goaf edges transient tilts and strains are much higher than elsewhere. At a stacked goaf edge where the lower seam is mined into solid from below an existing goaf in the upper seam, a double goaf edge is formed. Maximum tilts in these areas are observed to be about double the maximum general background levels. Horizontal strains are observed to peak at about four times background levels observed more generally along the panel.

The presence of the transition from goaf to solid at a goaf edge created by mining in the overlying seam appears to focus additional subsidence movements associated with mining the deeper seam onto fractures in the overburden strata that were created during mining in the first seam.

Where the lower seam is mined from solid to below an overlying goaf, a variation of stacked goaf edge is formed. The subsidence parameters in this case are of similar magnitude to single seam mining but the nature of the subsidence profile is significantly different. A large intact block of the overburden strata above the start of the overlying panel gradually subsides en masse as the existing goaf edge is mined under in the lower seam.

The direction of mining under an existing goaf edge changes the surface effects that develop. Mining from under a goaf to under solid produces tilts and strains at the stacked edge much higher than the general background. Mining from under solid to under a goaf produces an en masse subsidence effect with tilts and strains that are comparable to general background levels.

The magnitude, direction, and form of the total horizontal movements measured above the longwalls in the ULD Seam are consistent with the panel horizontal movement observed during mining of the PG Seam. The similarities indicate a consistent mechanism driving the horizontal movements and a strong influence of strata dilation in this process.

Single seam parameters such as angle of draw and subcritical/supercritical width are less meaningful in a multi-seam mining environment.

4.2 Power Pole Monitoring

This section presents the subsidence monitoring on the 132kV power line and a comparison of these measurements with subsidence estimates made previously. This review provides a basis to refine the forecast of subsidence effects for future mining from the improved understanding of multi-seam subsidence behaviour and observed impacts to the 132kv power line.

4.2.1 Peak Values

The monitoring results indicate maximum measured subsidence parameters at the poles are generally less than the maxima predicted in previous assessments and less than measured elsewhere over the longwall area. This outcome is at least partly because peak values from transient movements presented in forecasts are not necessarily captured by infrequent monitoring surveys.

4.2.2 Vertical Subsidence

The largest vertical subsidence measured to date along a straight section of the 132kV line is approximately 4.2m measured at Set 22 over Longwall 201. The largest vertical subsidence to date at a bend is approximately 3.5m at the new poles at Set 24 over Longwall 202. In both cases, the cumulative observed is a result of mining in the ULD and ULLD Seams in areas where the PG Seam was previously mined prior to the poles being replaced.

4.2.3 Tilt

Tilt measured on the poles is consistently less than tilt measured on ground monitoring lines in similar locations relative to the panel edges. The maximum incremental tilt from multi-seam mining measured at a pole is in the range of 20-30mm/m. The maximum incremental tilt measured on the ground in a similar location is in the range 60-70mm/m. However, as noted above, the measured values of tilt and horizontal movements are not necessarily the maximum values experienced by the poles because the ground movements affecting pole structures are relatively dynamic during the period when the longwall face passes below the pole. Surveys at individual poles are only made intermittently at intervals of about 50m of longwall face retreat and so the peak values may be missed.

Ground based subsidence monitoring lines are more suited to measuring the maximum values of tilt and horizontal movement because the maximum changes caused by mining are captured in the surface profile changes. Although tilt of the ground surface does not necessarily translate to the same level of tilt on the poles, ground surface tilt is nevertheless a good indication of the upper limit of pole tilt.

Tilt peaks as the longwall face mines below the pole and subsequently reduces with further retreat of the longwall face reaching a state of permanent tilt. The permanent tilt for one seam becomes the starting point for tilt in the next seam. It is recommended that estimates of maximum tilt for the LB Seam are updated once the permanent tilt from mining in the ULLD Seam has been measured. This approach limits the accumulation of errors associated with predictions for mining in each seam.

Roller sheaves are observed to influence the magnitude and direction of pole tilt. By balancing conductor tension with sheaves, poles are free to tilt along the power line but are constrained by the conductor tension across the line. Measured pole tilts tend to be biased in a direction along the power line.

4.2.4 Horizontal Movements

Total horizontal movements at the poles are consistent with other locations over the longwall panels. The magnitude of total horizontal movements is observed to be sensitive to location relative to the longwall panel edge. Horizontal movement is greatest at poles located over the centre of the longwall panels. Vertical subsidence is also greatest here.

In general, long-panel horizontal movements occur initially in a direction toward the approaching longwall goaf and subsequently in a direction toward the centre of the retreating longwall face. There is also a significant cross-panel eastward component of horizontal movement associated with topography and the outcrop of strata dipping moderately to the west.

5. UPDATE OF FORECAST FOR MINING IN THE ULLD SEAM

Updated subsidence estimates for the poles located above or in the vicinity of Longwalls 204-207A are presented in this section together with an update of measured values for Longwalls 201-203.

Table 1 presents the measured and estimated incremental subsidence associated with mining in the ULLD Seam. Measured incremental subsidence movements are available for Longwalls 201-203. Incremental subsidence movements above Longwalls 204-207A are estimated.

All poles above Longwalls 204-207A (except Set 11) have already been upgraded. Poles in the vicinity of Longwalls 204–207A are positioned away from stacked goaf edges in any of the seams. Maximum incremental vertical subsidence of approximately 2.2m and cumulative subsidence of approximately 3.5m is expected at the pole locations. Incremental tilt at individual poles of up to 50mm/m is forecast for impact assessment purposes.

Incremental subsidence movements for Longwalls 204-207A in the ULLD Seam are additional to the movements that have already occurred during previous mining. In most cases these additional movements are likely to increase the tilt, but in others the additional movements may reduce tilt magnitude and cause horizontal movements that move the poles back toward their original positions.

Above Longwalls 201-203, incremental vertical subsidence of 2.1-2.3m and cumulative subsidence of 3.5-4.2m were measured from the mining in the PG, ULD and ULLD Seams. Maximum tilt of 20mm/m was measured, but higher transient tilts may have occurred. Permanent tilt is generally less than 5mm/m but up to 12mm/m at Set 24. These values are similar to those forecast in the previous assessment for the ULLD Seam but much less than the maximum values predicted in earlier assessments made prior to multi-seam subsidence monitoring data becoming available. Forecast tilt direction have been somewhat different to the actual directions of movement observed due to topographic effects, cross-line restraint provided by the conductors, and other effects that are difficult to estimate with confidence.

There is potential for the base of Sets 9, 30 and 31 to be become periodically submerged following heavy rain. Surface ponding is expected at these locations after the mining of Longwalls 205-207A. Surface drainage works are expected to be effective in managing any impacts from ponding. More detail of the ponding potential is presented in SCT (2020).

6. UPDATE OF FORECAST FOR FUTURE MINING

Subsidence estimates for all poles likely to be affected by the remaining ULLD Seam mining and the deeper LB Seam longwalls are presented in this section.

Table 2 presents the measured and estimated cumulative subsidence movements associated with mining in all seams, including the Lower Barrett (LB) Seam. Most of the poles were replaced during mining in the PG Seam so the measured cumulative subsidence movements mainly relate to the other three seams.

Cumulative subsidence above Longwalls 204-207A and the LB Seam are estimated. The estimates reflect the revised mining geometries and are based on the improved understanding from the expanded multi-seam monitoring database currently available. Vertical displacement profiles, horizontal movements, tilts and strain magnitudes near stacked goaf edges as well as the general background behaviour remote from pillar edges increase confidence in the forecast estimates.

The subsidence estimates shown in Table 2 assume:

- the LB Seam longwall layout is superimposed on the ULD Seam layout
- the ULLD to LB Seam interburden is approximately 30-35m
- the LB Seam mining height is in the range 2.5-2.8m.

The estimates of subsidence parameters in Table 2 are generally less than those previously predicted consistent with actual subsidence movements from previous seams being lower than estimated and improved confidence. These estimates are however, still considered conservative and therefore appropriate for impact assessment.

Observations from multi-seam monitoring indicate the peak incremental tilts are transient in nature and generally greater than the cumulative tilts measured at the end of mining in each seam. Maximum tilt is required for the purpose of structural engineering assessments. Maximum tilt for each seam is estimated from the addition of the incremental tilt prediction and the permanent tilts remaining from the mining of the previous seam. Estimates for future mining should therefore only be made at the completion of mining in each seam once the permanent tilt for that seam is known.

We recommend subsidence forecasts for the LB Seam presented in this report are updated at the completion of mining in the ULLD Seam and the program of monitoring subsidence movements on each of the poles and comparing with forecast value is continued.

7. CONDUCTOR CLEARANCES

Subsidence movements cause a change in the surface profile and changes in the levels of individual poles. Ground clearances to the conductors can therefore change. Revised subsidence profiles for the updated mining geometry in the ULD and ULLD Seams and improved understanding of multi-seam subsidence behaviour are presented in this section. These profiles are intended to allow others to confirm adequate ground clearances at various stages of mining.

Figure 5 shows the estimated cumulative subsidence along the alignment of the 132kV powerline for each of the four seams planned to be mined. This data has been updated to reflect changes to the mining geometry and the latest monitoring, up to and including the preliminary results from Longwall 203. The estimates of vertical subsidence are generally less than the maxima previously predicted.

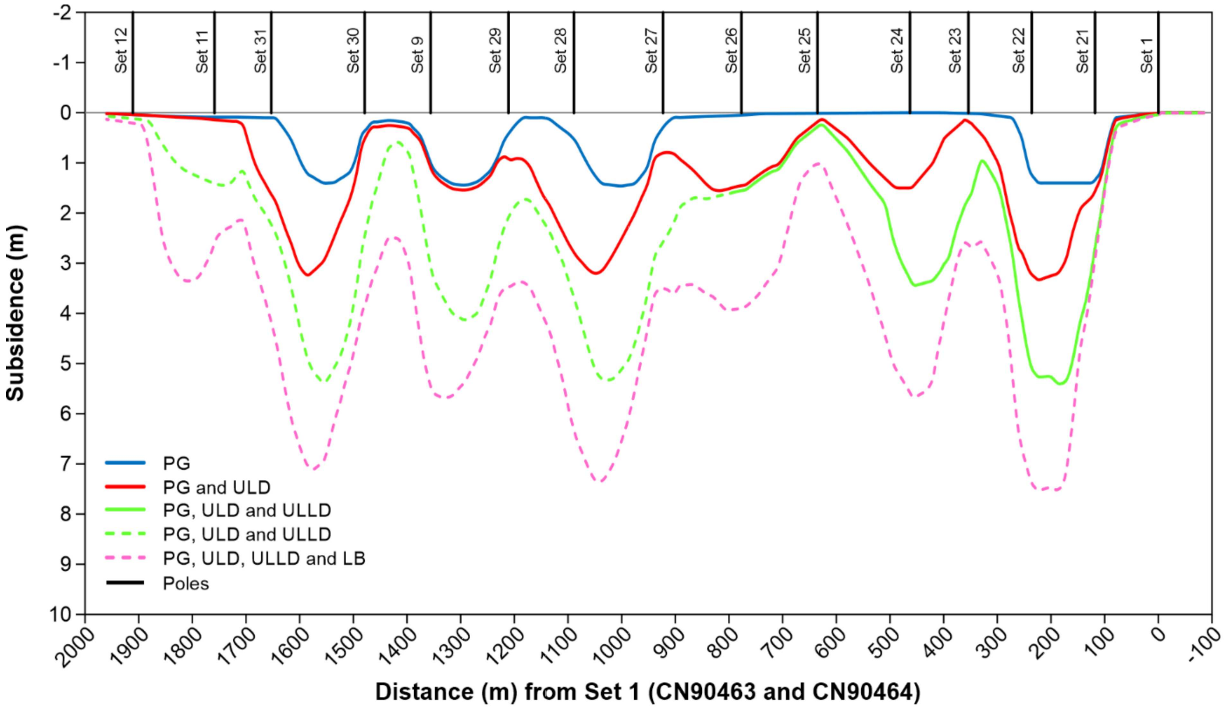

Figure 5: Estimated cumulative subsidence for each of the four seams to be mined.

Figure 6 shows the same cumulative subsidence estimates plotted relative to and at the same scale as the surface topography with the poles in their current positions (i.e. after Longwall 203). Pole heights are shown nominally 15m high.

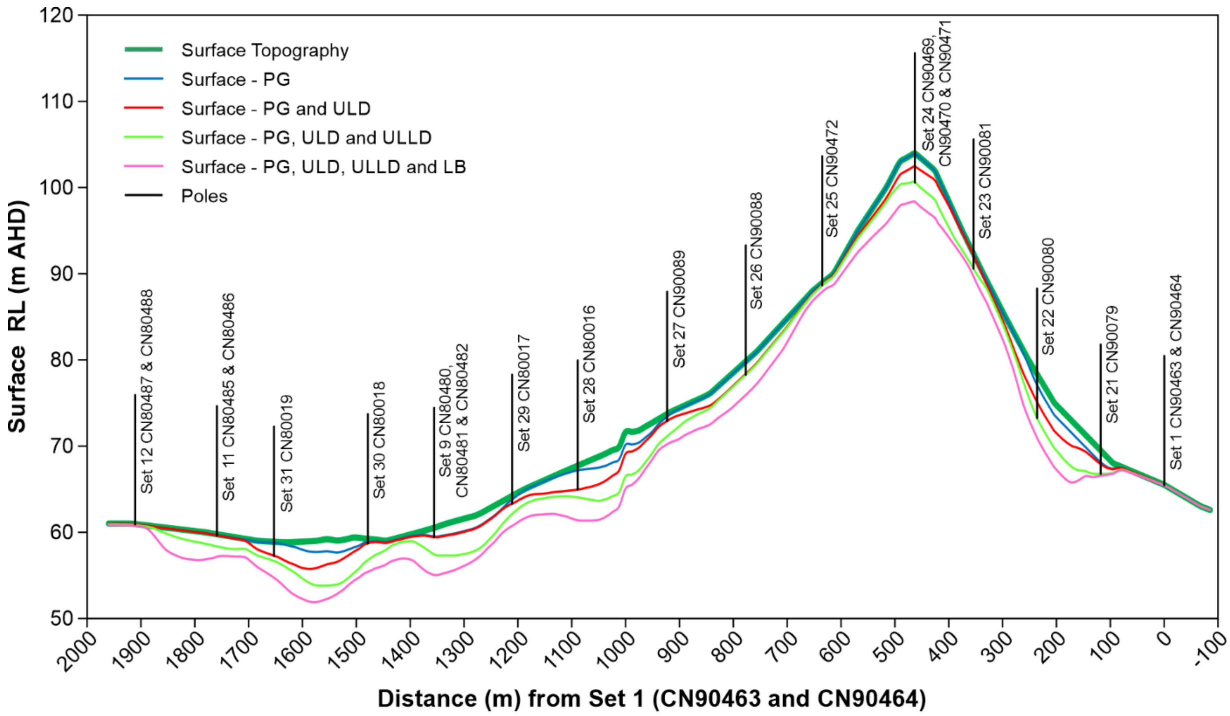

Figure 6: Estimated surface profiles after subsidence.

The locations of the poles are shown in both figures recognising that the conductor height at each pole is not known. An assessment to confirm there is sufficient ground clearance to the conductors is recommended. It should be recognised that any changes to the assumed mining plan for the remainder of the ULLD Seam and to the LB Seam layout from that used in this assessment may change the surface profiles shown.

8. REFERENCES

SCT 2014 "Subsidence Assessment for Upper Liddell Seam Mining below Southern 132kV Line at Ashton Coal Project" – SCT Report ASH4205 – 17 February 2014

SCT 2015 "Subsidence Assessment for Upper Liddell Seam Mining Below Southern 132kV Line at Ashton Coal Project for Revised Longwall 5 Geometry" – SCT Report ASH4392 – 15 July 2015

SCT 2016a "Subsidence Assessment for Upper Liddell Seam Mining Below Southern 132kV Line at Ashton Coal Project for Revised Longwall 5 Geometry and New Pole Locations" – SCT Report ASH4524 – 1 March 2016

SCT 2016b "Southern 132kV Power Line at Ashton Coal Mine: Update of Subsidence Assessment for Longwalls 201-204 in the Upper Lower Liddell Seam" SCT Report ASH4586 – 23 September 2016

SCT 2020 "Subsidence Assessment for the Extraction Plan for Longwalls 205-208 in the Upper Lower Liddell Seam" - SCT Report ASH4927_Rev2 – 27 April 2020