

Extraction Plan

Longwalls 25-31

Six-Monthly Report

Mandalong Mine

July 2020

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1 Introduction

This Extraction Plan Six-Monthly Report fulfils the reporting requirements of the Extraction Plan for Longwalls 25 to 31. The report covers the six-month period from the 1 October 2019 to 31 March 2020.

The report provides the Secretary of the NSW Department of Planning, Industry and Environment (DPIE) with a summary of subsidence and environmental monitoring results, subsidence impacts as well as any management actions undertaken during the report period.

2 Purpose and Scope

The Extraction Plan for Longwalls 25 to 31 (LW25-31) received approval from the DPE on 15 January 2019. A variation to the Extraction Plan was approved by DPIE on 28 March 2019 to modify Longwall 25 to relocate around a complex fault zone within the longwall block to ensure the safe operation of the longwall panel. A second variation to the Extraction Plan was sought and approved by DPIE in October 2019 to also relocate both Longwalls 26 and 27 around the same fault zone, leaving coal within the longwall blocks and around fault zone.

The purpose of this document is to comply with six-monthly reporting requirements of the Extraction Plan for LW25-31, consistent with the *draft Guidelines for the Preparation of Extraction Plans* (NSW Department of Planning & Environment, 2015) which states:

The reporting framework is a critical section of the Extraction Plan. DPE and DRE both consider that there is value in developing and applying a standard reporting framework for all mines which are operating under an Extraction Plan approved after 30 September 2014. The required elements of this framework are:

- *incident reporting, following any occasion of incident, in accordance with the conditions of consent and/or environment protection licence and/or any requirements in the TARP(s);*
- *bi-monthly subsidence impact reporting, following regular monthly inspections, but only if any new impact is identified. Impacts should be clearly distinguished between those which are within predictions, those which exceed predictions but remain within performance measures and/or performance indicators, and those which exceed performance measures and/or performance indicators. Impact reporting must include a full description, location identification using aerial photos with longwall layout superimposed, good photos of the impact, and preliminary characterisation of the impact in accordance with the relevant TARP(s);*
- *six-monthly reporting of all impacts and environmental monitoring results, including:*
 - *a comprehensive summary of all impacts, including a revised characterisation according to the relevant TARP(s);*
 - *any proposed actions resulting from Triggers being met in the TARP, or other actions;*
 - *assessment of compliance with all relevant performance measures and indicators;*
 - *a comprehensive summary of all quantitative and qualitative environmental monitoring results, including landscape monitoring, water quality data, water flow and pool level data, piezometer readings, etc.; and*
- *Annual Review (or Annual Environmental Management Report) reporting, to be based on each two successive six-monthly reports of impacts and environmental monitoring results. A summary of subsidence effects monitoring results should also be included.*

3 Mining Status

During the six-month reporting period, Longwalls 26A, 26B were extracted and Longwall 27A had commenced. As at the date of this report, Longwall 27A has also been completed. **Table 1** details the commencement and completion dates of longwall extraction since the commencement of longwall mining in 2005.

The Main Heading roadways have been developed past the new ventilation shaft site and included the completion of the development roadways for the commencement Longwall 29. Development was completed in Maingate 27 for Longwall 27, with additional installation roadways developed for the relocation around the fault zone for Longwall 27B. Maingate 28 has developing through the fault zone and Maingate 29 had commenced. The roadways developed and the longwall extraction undertaken during the six-month report period is shown in **Figure 1**.

Table 1 – Longwall Extraction Time Table

Longwall	Commencement	Completion
Longwall 1	25/01/05	16/08/05
Longwall 2	24/09/05	19/03/06
Longwall 3	13/04/06	16/09/06
Longwall 4	19/10/06	1/05/07
Longwall 5	8/06/07	8/01/08
Longwall 6	15/02/08	3/09/08
Longwall 7	11/10/08	24/04/09
Longwall 8	24/05/09	13/12/09
Longwall 9	14/01/10	8/08/10
Longwall 10	3/09/10	26/03/11
Longwall 11	16/04/11	12/10/11
Longwall 12	3/11/11	4/05/12
Longwall 13	18/06/12	26/11/12
Longwall 14	16/02/13	5/08/13
Longwall 15	24/09/13	22/04/14
Longwall 16	12/05/14	13/10/14
Longwall 17	6/11/14	30/04/15
Longwall 18	22/05/15	11/12/15
Longwall 19	30/12/15	24/05/16
Longwall 20	8/06/16	24/10/16
Longwall 21	8/11/16	27/03/17
Longwall 22	15/04/17	22/09/17
Longwall 23	13/10/17	24/03/18
Longwall 24	16/04/18	11/09/18
Longwall 24A	2/10/18	20/01/19
Longwall 25A	10/03/19	24/05/19
Longwall 25B	13/06/19	20/09/19
Longwall 26A	11/10/19	27/11/19
Longwall 26B	19/12/20	6/03/20
Longwall 27A	25/03/20	21/05/20
Longwall 27B	11/06/20	

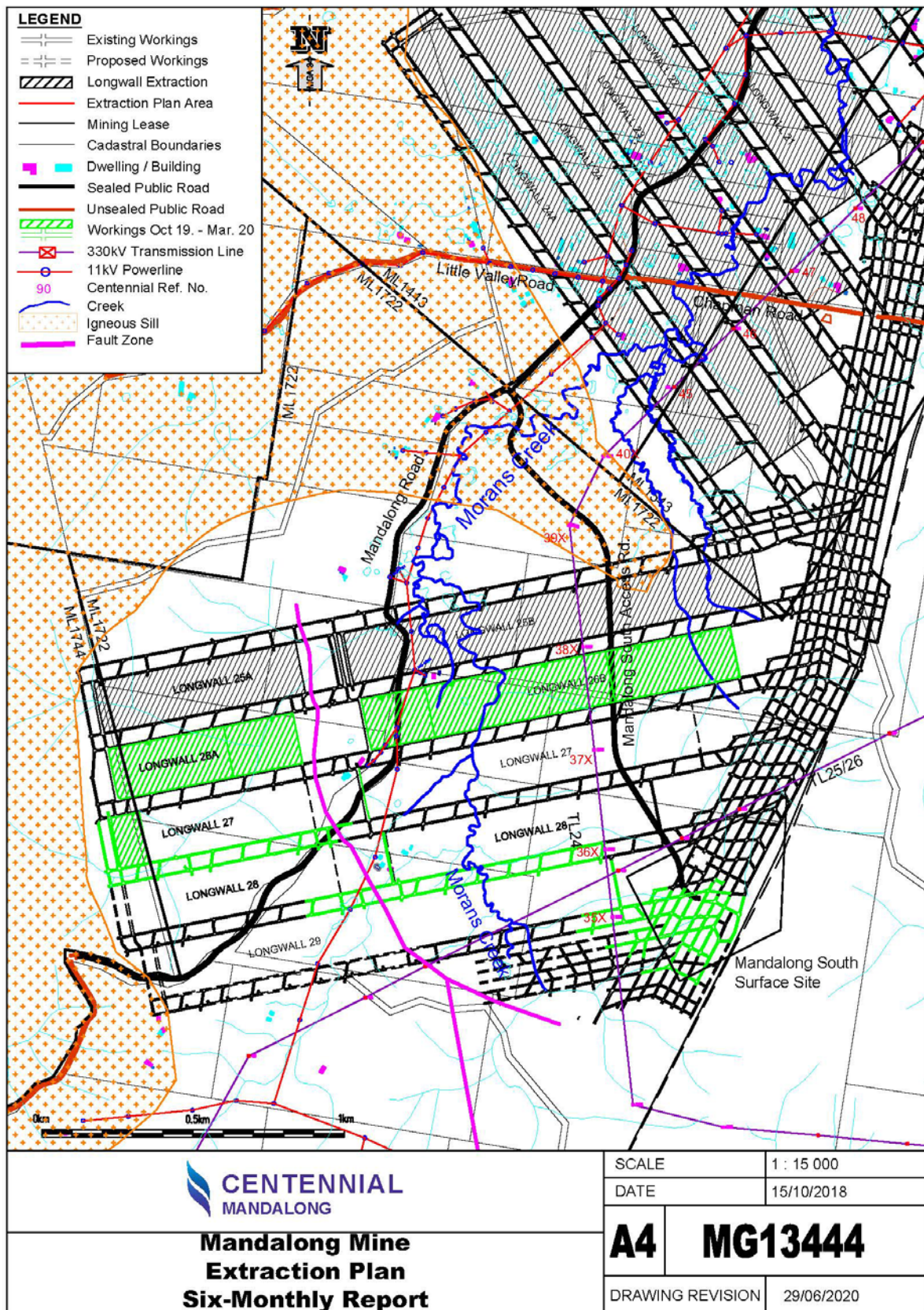


Figure 1 – Mine plan and working area from 1 October 2019 to 30 March 2020

4 Subsidence Impact Performance Measures

The Extraction Plan for LW25-31 operates within mining leases ML1722 and ML1744 and approved under Development Consent SSD-5144 MOD 8. Subsidence Performance Measures are detailed in Schedule 4, Condition 1 Table 6 and Condition 4 Table 7 as shown below in **Table 2** and **Table 3** respectively.

Table 2 – Subsidence Impact Performance Measures – Natural and Heritage Features

Watercourses	
3 rd Order and above streams Groundwater-dependent Ecosystems	- No connective cracking between the surface, or the base of the alluvium, and the underground workings. - No subsidence impact or environmental consequence greater than minor.
1 st and 2 nd Order streams	- No subsidence impact or environmental consequences greater than predicted in the documents listed in condition 2(b) of Schedule 2. - No connective cracking between the surface and the underground workings.
Aquatic and riparian ecosystems, including affected sections of Morans Creek, Wyee Creek, Tobins Creek and Mannering Creek	- Maintain or improve baseline channel stability. - Develop site-specific in-stream water quality objectives in accordance with ANZECC 2000 and <i>Using the ANZECC Guidelines and Water Quality Objectives in NSW</i> procedures (DECC 2006), or their latest versions.
Land	
Steep slopes and rock outcrops	No subsidence impact or environmental consequence greater than predicted in the documents listed in condition 2(b) of Schedule 2.
Agriculture	No loss of agricultural productivity greater than minor.
Biodiversity	
Threatened species, threatened populations and endangered ecological communities	Negligible environmental consequences.
Heritage sites	
Stone Arrangement RPS TBM 32	Negligible subsidence impacts or environmental consequences
All other Aboriginal Cultural Heritage sites/items at the site	No subsidence impact or environmental consequence greater than predicted in the documents listed in condition 2(b) of Schedule 2.
Mine workings	
First workings under an approved Extraction Plan beneath any feature where performance measures in this table require negligible subsidence impacts or negligible environmental consequences	To remain long-term stable and non-subsiding.
Second workings	To be carried out only within the approved mine plan, in accordance only with an approved Extraction Plan.

Table 3 – Subsidence Impact Performance Measures – Built Features

Key Public Infrastructure	
M1 Motorway	Always safe and serviceable.
Main Northern Railway	Damage that does not affect safety or serviceability must be fully repairable, and must be fully repaired.
330 kV power supply infrastructure	
Other Built Infrastructure	
Power lines and power poles	Always safe.
Telecommunications infrastructure	Serviceability should be maintained wherever practicable.
Privately-owned residences	
Local Roads	Loss of serviceability must be fully compensated. Damage must be fully repairable, and must be fully repaired or else replaced or fully compensated.
Other built features and improvements, (including access roads, farm dams, swimming pools, tracks and fences)	
Public Safety	
Public Safety	Negligible additional risk.

Mandalong Mine has continued to use the Safe, Serviceable and Repairable (SSR) criteria for dwellings that were defined in the original development consent DA97/800. SSR criteria is detailed in DA97/800 Schedule 2 - Conditions of the Development Consent as:

Category 3 to 5 for strain and Category D for tilt in accordance with Australian Standard AS2870 – 2011

Mandalong Mine has adopted the more conservative Category of B for Tilt (<7mm/m tilt) and assessed the Strain Category as <5mm/m tensile strain and <-5mm/ compressive strain. A summary table of AS2870 – 2011 is shown in **Table 4**.

Table 4- Classification of damage with reference to strain and tilt

	Damage Category	Classification of Strain Damage with Reference to Walls		
		Strain Category	Approximate Crack Width Limit (mm)	Description of Typical Damage
Within SSR	Low	0	<0.1	Hairline cracks.
		1	0.1 to 1.0	Fine cracks, which do not need repair.
		2	1 to 5	Cracks noticeable but easily filled. Doors and windows stick slightly.
Beyond SSR	Medium	3	5 to 15mm, or a number of cracks 3 to 5mm in one group	Cracks can be repaired and possibly a small amount of wall will need to be replaced. Doors and Windows stick. Service pipes can fracture. Weather-tightness often impaired.
	High	4	15 to 25mm but also depends on number of cracks	Extensive repair work involving breaking-out and replacing sections of walls, especially over doors and windows. Window or doorframes distort. Walls lean or bulge noticeably. Some loss of bearing in beams. Service pipes disrupted.
		5	>25	As above, but worse, and requiring partial or complete rebuilding. Roof and floor beams lose bearing and need shoring up. Windows broken with distortion. If compressive damage, severe buckling and bulging of the roof and walls.
	Damage Category	Classification of Damage with Reference to Tilt		
		Tilt Category	Tilt (mm/m)	Description of Typical Damage
Within SSR	Low	A	<5	Unlikely that remedial work will be required.
		B	5 to 7	Adjustment to roof drainage and wet area floors might be required.
Beyond SSR	Medium	C	7 to 10	Minor structural work might be required to rectify tilt. Adjustments to roof drainage and wet area floors will probably be required and remedial work to surface drainage and sewerage systems might be necessary.
	High	D	>10	Considerable structural work might be required to rectify tilt. Jacking to level or rebuilding could be necessary in the worst cases. Remedial work to surface water drainage and sewerage systems might be necessary.

5 Surface Features

The key surface features located over the three longwall panels are summarised below and shown in Figure 1.

5.1 Longwall 25A and Longwall 25B

- Four private properties;
- One private dwelling;
- Public Road – Mandalong Rd.;
- Olney State Forest;
- Centennial property and sealed access road to Mandalong South Surface Site;
- TransGrid 330 kV Transmission Line No.24 Tower 38X (relocated section of line with towers constructed on concrete cruciform footings);
- Ausgrid 11kV powerlines (subsidence mitigation measures installed by Ausgrid);
- Telstra communication lines (copper cables);
- Morans Creek and two tributaries;
- Floodplain; and
- Aboriginal Heritage sites – four grinding grooves located with angle of draw of LW25A.

5.2 Longwall 26A and Longwall 26B

- Four private properties;
- One private dwelling;
- Public Road – Mandalong Rd.;
- Olney State Forest;
- Centennial property and sealed access road to Mandalong South Surface Site;
- TransGrid 330 kV Transmission Line No.24 Tower 38X (relocated section of line with towers constructed on concrete cruciform footings);
- Ausgrid 11kV powerlines (subsidence mitigation measures installed by Ausgrid);
- Telstra communication lines (copper cables);
- Morans Creek and two tributaries; and
- Floodplain

5.3 Longwall 27A and Longwall 27B

- Four private properties;
- One private dwelling;
- Public Road – Mandalong Rd.;
- Olney State Forest;
- Centennial property and sealed access road to Mandalong South Surface Site;
- TransGrid 330 kV Transmission Line No.24 Tower 37X (relocated section of line with towers constructed on concrete cruciform footings);
- Ausgrid 11kV powerlines (subsidence mitigation measures installed by Ausgrid);
- Telstra communication lines (copper cables);
- Morans Creek and two tributaries; and
- Floodplain

6 Subsidence Management Actions

During the six month report period, 1 October 2019 to 31 March 2020, a number of subsidence impacts requiring rehabilitation works were identified from the previously extracted Longwalls 22 to 24A and recently extracted Longwall 26B. The subsidence management actions are outlined below for each longwall panel and a summary of the remnant ponding status for all longwall panels is also detailed in **Table 14** in **Section 11.3**.

6.1 Longwall 23

Repair erosion on previously rehabilitated access road and large stormwater pipe under road following the large storm event in February 2020. The size of the storm event between 6 to 9 February was estimated by Umwelt to be between a 1 in 15 and 1 in 20 year storm event.

6.2 Longwall 23

Rehabilitation works completed at sites P23 and P23B. Detail surveys and drainage design has been completed on sites P23C and P23D. The property has recently been sold and negotiations to recommence with new landholder. Refer to ponding sites in **Table 14** for further detail.

6.3 Longwall 24

Three dwellings were affected by subsidence from Longwall 24 and settlement of Longwall 23. All dwellings have remained SSR. Two of the dwellings require repair works and SA NSW and Centennial are currently managing the claims. Centennial has provided a compensation offer for one property.

6.4 Longwall 24A

Two dwellings were affected by Longwall 24A and both remained SSR. One dwelling requires repairs and both Centennial and SA NSW are currently consulting with the landowner to remediate the subsidence damage to the property. A compensation offer to repair the dwelling has been provided to the landowner. Centennial is currently consulting with the landowner to rectify drainage on the property (site P24AD).

6.5 Longwall 25A and Longwall 25B

There has been no further damage to the section of Mandalong Road pavement previously affected by subsidence during the extraction of Longwall 25B.

There has been no evidence of ponding at 'Observation Point A and Observation Point B during scheduled flood path inspections and large storm event in February 2020. One large private farm dam located over Longwall 25B that was affected by tilting from Longwall 25B has now been returned low levels of tilt following the extraction of Longwall 26B.

6.6 Longwall 26A and Longwall 26B

Two farm dams on property MS0012 were subjected to cracking from Longwall 26B subsidence. Both dams are currently being repaired by Centennial.

TransGrid Towers 38X and 39X were monitored during the extraction of Longwall 26B. Strain measure measurements on tension Tower 39X were recorded at Level 2 – Advisory for a period of time before reducing to Level 1 – Normal. Monitoring and actions were undertaken in accordance with Transmission Line Management Plan LW25-31.

7 Complaints

There were no subsidence related community complaints recorded during the six-month report period.

8 Subsidence Monitoring

Subsidence surveys are being conducted in accordance with the approved Subsidence Monitoring Programs for LW25-31 Extraction Plan. Monitoring results have been sent to the NSW Resources Regulator, Subsidence Advisory NSW (SA NSW) and infrastructure owners within 48 hours of each survey. Private landowners whose dwelling and property have been affected by subsidence have also been provided with their subsidence monitoring results and detailed explanation provided.

8.1 Monitoring

A total of 16 subsidence surveys were conducted during the six-month reporting period. This included four monitoring lines, one private dwelling and property, and heritages sites. A total of eight surveys on TransGrid 330kV Transmission Line Towers 38X and 39X were completed. **Table 5** shows a summary of the monitoring undertaken during the reporting period and plan MG10435 in **Appendix 1** shows the location of the monitoring lines.

8.2 Subsidence Monitoring Installations

No new installations.

8.3 Subsidence Monitoring Removal

No subsidence monitoring lines were removed during the report period.

An application to remove or partially remove 11 monitoring lines over the now completed Longwalls 10 to 22 was provided to the Resources Regulator in January 2020.

Table 5 – Subsidence monitoring completed 1 October 2019 to 31 March 2020

Subsidence Line	Longwall	Surveyed Dates	No. Surveys	Comment
Crossline 1	1 to 2			Removed in 2013
Crossline 2	1 to 21			
Crossline 3	1 to 2			
Crossline 3 Extension	3 to 14			
Crossline 4	4 to 7			Partially removed in 2013, LW2-7
Crossline 5	1 to 13	28/11/19	1	Partially removed in 2013, 2017 & 2018 LW1-10
Crossline 6	1 to 2			Partially removed in 2013
Crossline 7	1			
Crossline 8	3 to 21	30/03/20	1	Mandalong Rd Telstra Network Partially removed in 2013 and 2017 LW3-7
Crossline 9	5 to 12			Sauls Rd Telstra Network Partially removed in 2013 & 2018 LW5-8
Crossline 10	4 to 7			Removed in 2014

Subsidence Line	Longwall	Surveyed Dates	No. Surveys	Comment
Crossline 11	6 to 7			Removed in 2014
Crossline 12	6 to 8			
Crossline 13	6 to 7			
Crossline 14	6 to 8			
Crossline 15	11 to 12			
Crossline 16	11 to 13			
Crossline 17	12 to 14			Browns Rd
Crossline 18	16 to 21			
Crossline 19	17 to 21			Tobins Rd
Crossline 20	17 to 21			Steep Slopes
Crossline 21	25 to 29	27/2/20,	1	Mandalong Rd
Crossline 22	25 to 27			TL24 Easement (330 kV)
Crossline 23	29 to 31			
3H Creek	2 to 10			Stockton Creek
Morans Creek	15-24			Morans Creek
Wetland (42)	8-9			Removed in 2018
Wetland (58)	16-18			Wetland (4 & 5)
Wetland (68)	16-17			Wetland
LW1 Centreline 1	1			Removed in 2012
LW1 Centreline 2	2			Partially removed in 2012
LW2 Centreline 3	2			Removed in 2012
LW3 Centreline 4	3			Removed in 2012
LW4 Centreline 5	4			Removed in 2012
LW5 Centreline 6	5			Partially removed in 2018
LW5 Centreline 7	5			Partially removed in 2017
LW6 Centreline 8	6			Partially removed in 2014
LW7 Centreline 9	7			Partially removed in 2014
LW7 Centreline 10	7			Partially removed in 2017
LW8 Centreline 11	8			Removed in 2017
LW9 Centreline 12	9			Partially removed in 2017
LW10 Centreline 13	10			Partially removed in 2018
LW17 Centreline 14	17			Longwall and wetland (4 & 5)
LW25 Centreline	25	25/10/19	1	

Subsidence Line	Longwall	Surveyed Dates	No. Surveys	Comment
LW11 Maingate 1	11			Pillar monitoring
LW11 Maingate 2	11			Pillar monitoring
TL24 Tower 47 and 48 Simulation	17			Simulation sites for 330kV transmission towers
TL24 Tower 48	21			330kV Transmission Tower
TL24 Tower 47	22			330kV Transmission Tower Cruciform footing
TL24 Tower 46	24			330kV Transmission Tower Cruciform footing
TL24 Tower 45	24A			330kV Transmission Tower Cruciform footing
TL24 Tower 39X	25	25/10/19, 28/2/20, 9/3/20, 16/3/20, 23/3/20	5	At 20mm subsidence limit
TL24 Tower 38X	25-26	25/10/19, 10/2/20, 28/2/20	3	330kV Transmission Tower Cruciform footing
TL24 Tower 37X	27			330kV Transmission Tower Cruciform footing
TL24 Tower 36X	28-29			330kV Transmission Tower Cruciform footing
TL24 Tower 35X	29			330kV Transmission Tower Cruciform footing
TL24 Tower 34X	Main Headings			330kV Transmission Tower Cruciform footing
TL 24 Tower 33X	Future mining			330kV Transmission Tower Cruciform footing
Private Property (28)	9			Private dwelling
Private Property (43)	10			Private dwelling
Private Property (115)	11			Private dwelling
Private Property (116)	13			Private dwelling
Private Property (46)	13			Private dwelling
Private Property (22)	14			Private dwelling
Private Property (39)	15			Private dwelling
Private Property (67)	15			Private dwelling
Private Property (38)	16			Private dwelling
Private Property (33)	16			Private dwelling
Private Property (35)	16			Private dwelling
Private Property (20)	17			Private dwelling
State Forest (71)	17			State Forest dwelling
Private Property (82)	18			Private dwelling
Private Property (83)	19			Cricket oval

Subsidence Line	Longwall	Surveyed Dates	No. Surveys	Comment
Private Property (77)	19			Private dwelling
Fire shed (78)	19			RFS shed
Private Property (79)	19			Private dwelling
Private Property (74)	20-21			Private dwelling
Private Property (73)	22-23			Private dwelling
Private Property (89)	22			Private dwelling
Private Property (90)	23-23			Private dwelling
Private Property (88)	22-23			Private dwelling
Private Property (207)	23-24			Private dwelling
Private Property (212)	23			Private dwelling
Private Property (213)	23-24A			Trotting track
Private Property (220)	22-23			Private dwelling
Private Property (221)	22-23			Private dwelling
Private Property (219)	24	1/04/20	1	Private dwelling
Private Property MS0050	25			Private dwelling
Private Property MS0012	25-26	25/2/20	1	Private dwelling
Telstra Fibre Optic Cable	5-24A			OTDR testing on inactive cable
Aboriginal Heritage Sites	25	9/9/19	1	Heritage sites
		Total Surveys	16	

9 Subsidence Monitoring Results

9.1 Longwall 25A and Longwall 25B

Following the completion of Longwalls 26A and 26B a review of the subsidence monitoring results was conducted by Ditton Geotechnical Services (Ditton Geotechnical Services, 2020).

A significant NW-striking fault zone was identified during development of the gate roads for Longwalls 25 and 26. The faulted area comprised several normal faults with throws ranging between 0.05 m to 0.5 m with poor roof and rib conditions encountered. The mine opted to relocate the longwall around the geologically disturbed area, leaving two panels with void lengths of 632 m (LW26A) and 1254 m (LW26B). The panels were separated by a 222 m wide barrier pillar between that contained the fault.

The subsidence predictions previously presented for Extraction Plan LW25-31 approval were adjusted to reflect the possible weakening effects of the faulted area on the overburden as detailed in the Extraction Plan variation for Longwalls 26 and 27 (Ditton Geotechnical Services, 2019).

Mining in Longwall 26A commenced on 11 October and completed extraction on 27 November 2019. Subsequently, Longwall 26B commenced on 19 December and completed extraction on 6 March 2020.

During the retreat and completion of Longwall 26B, subsidence monitoring was conducted along Crossline 21 (Mandalong Rd), Crossline 22 (TL24 transmission line easement), LW25 Centreline, TransGrid Transmission Line No. 24 Towers 38X and 39X and private dwelling. **Figure 2** shows the depth of cover and subsidence monitoring lines surveyed during and after the extraction of Longwall 25B.

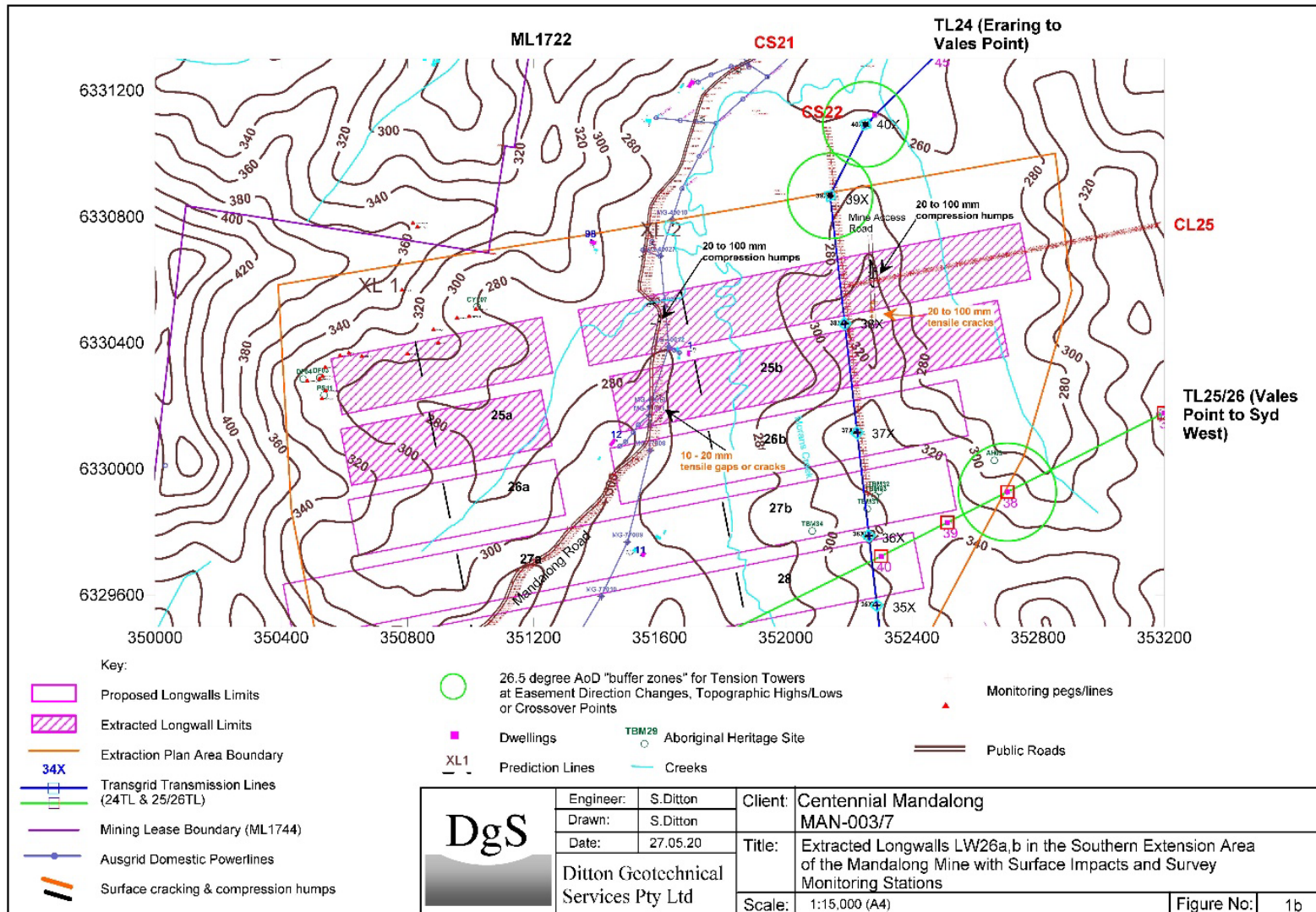


Figure 2 – Extracted Longwall 26 with Subsidence Lines and Depth of Cover

10 Comparison of Results against Predicted Subsidence Impacts

10.1 Subsidence Effect Predictions v Measured Values for LW26A and LW26B

The subsidence effect contour predictions for LW26 (mean & Upper 95% Confidence Level) were presented in Ditton Geotechnical Service (2019) report for the LW26 and LW27 variation. The predicted v. measured subsidence effects for the proposed modifications to LW26 are presented in **Table 6** and **Table 7**.

The predictions for the proposed panels considered the effects of geological structure by reducing previously assessed Subsidence Reduction Potential (SRP) of the overburden conglomerate units from 'High' to 'Moderate' along XL2. Based on a review of measured subsidence data above LW1 to 24A (Ditton Geotechnical Services, 2018) it was determined that it 'unlikely' that any faulting encountered in the proposed Extraction Plan area will reduce the (SRP) to below a 'Moderate' SRP (i.e. the previously assessed SRP for XL1 above LW26A remains unchanged).

The predicted first and final subsidence v. measured subsidence effect profiles are prepared for each survey line (CS21, CS22 and CL25B). The outcomes are summarised below:

- The measured first panel subsidence values were within the predicted mean to U95%CL along crossline CS21 (Mandalong Road).
- The measured first panel subsidence along the Transgrid easement (CS22) was 8% higher than the predicted U95%CL value, but still only 83% of the final subsidence prediction.
- The final subsidence along the LW25B centreline after LW26B was completed is now within the U95%CL value.
- The measured chain pillar subsidence between LW25A and 26B were less than predicted values.
- The measured maximum tilts exceeded the predicted U95%CL values by < 10%.
- The measured tensile and compressive strains were 'bracketed' by the predicted ranges.
- Predicted curvatures (+0.5 to -0.6 km⁻¹) were generally equal to or higher than measured values (+0.5 to -0.7 km⁻¹). There appears to be several curvature and strain reversals that exceed the predicted values, and it would also appear that the curvature contours presented do not fit the predicted values very well (probably due to the predicted chain pillar subsidence being higher than the measured values). This issue will be resolved in the next end of panel review when final chain pillar subsidence data becomes available.

Overall, it is concluded the assumed SRP (i.e. Moderate) is still performing reasonably well. It is therefore not considered necessary to adjust the prediction model for subsequent longwalls at this stage. **Figure 3**, **Figure 4** and **Figure 5** show the subsidence profiles for Crossline 21 (Mandalong Road).

Table 6 – Summary of Measured and Predicted Subsidence above LW26B

LW#	Survey Line	Panel Width W (m)	Cover Depth H (m)	W/H	Extraction Height T (m) Actual [Assumed]	First Maximum Subsidence First S _{max} (m) (Final)		TG Chain Pillar Subsidence (m)		Goaf Edge Subsidence S _{goe} (m)		AoD to 20 mm Subsidence Contour (o)	
						Predicted*	Meas. ^	Pred.	Meas.	Pred.	Meas.	Pred.	Meas.
25b	Finishing End Centreline (CL25b)	180	280	0.64	4.24 - 4.33 [4.5]	0.62 - 0.79 (0.89 - 1.05)	0.85 (1.01)	N/A	N/A	0.14 - 0.23	0.024 (0.027)	25 - 41	1 (5)
	Mandalong Rd Crossline (XL21)		273	0.66			0.75 (0.91)				0.043 - 0.080		14 - 36
	Easement Crossline (XL22)		288	0.63			0.63 (0.84)				0.112 - 0.120		12 - 41
26b	Mandalong Rd Crossline (XL21)	180	290	0.62	4.24 - 4.33 [4.3]	0.7 - 0.86 (0.97 - 1.13)	0.64	0.51 - 0.61	0.20 - 0.28	0.15 - 0.23	0.125	26.5 - 41.5	45
	Easement Crossline (XL22)		320	0.56			0.93				0.150		47

Predicted values are mean to U95%CL; Meas. = Measured; *Italics* - measured effect exceeds the predicted value by <15%; **Bold** - measured effect value exceeds prediction by more than >15%.

Table 7 – Summary of Measured and Predicted Tilts and Strains above LW26B

LW#	Survey Line	Maximum Tilt T_{max} (mm/m)		Maximum Compressive Strain $-E_{max}$ (mm/m) [Discontinuous values] *		Maximum Tensile Strain $+E_{max}$ (mm/m) [Discontinuous values] *	
		Predicted	Meas.	Predicted	Meas.	Predicted	Meas.
25b	Finishing End Centreline (CL25b)	11 - 17	7.7 (9.1)	5 - 8 [10 - 16]	3.0 (3.4)	4 - 6 [8 - 12]	9.8 {cracking} (11.1)
	Mandalong Rd Crossline (XL21)		10.6 (12.8)		3.5 (4.3)		2.7 (2.7)
	Easement Crossline (XL22)		8.9 (12.0)		4.5 (5.6)		2.6 (1.6)
26b	Mandalong Rd Crossline (XL21)	8 - 12	12.8	4 - 6 [8 - 12]	2.5	3 - 5 [6 - 10]	2.6
	Easement Crossline (XL22)		13.3		4.7		3.5

Predicted values are mean to U95%CL; Meas. = Measured; *Italics* - measured effect exceeds the predicted value by <15%;

* - Predicted strains are for a surface with deep soil cover and a 'smooth' profile. Near surface rock may cause strain concentrations which are 2 x 'smooth' profile strains.

Source: (Ditton Geotechnical Services, 2020)

10.1.1 Steep Slopes

There are moderately steep slopes above LW25A and 25B ranging between 10° and 20°. Based on the subsidence effect predictions, surface cracks ranging from 20 mm to 100 mm width may occur on the slopes. Areas with slopes < 18° are also expected to have only low erosion rate increases.

Slope gradients were predicted to increase or decrease by +0.5° and - 0.6°. No surface cracking or erosion was detected above the steep slopes on the ridge above LW26A and LW26B. No slope instability has been detected on the subsided slopes to-date.

10.1.2 Mandalong Road

The subsidence effects for Mandalong Road above Longwall 26B are summarised in **Table 8**.

Table 8 – Summary of Subsidence Predictions v Measured for Mandalong Road

LW	Final Maximum Subsidence S_{max} (m)		Final Maximum Tilt T_{max} (mm/m)		Final Maximum Tensile Strain* (mm/m)		Final Maximum Compressive Strain* (mm/m)	
	Predicted	Measured	Predicted	Measured	Predicted	Measured	Predicted	Measured
26b	0.7 - 0.86	0.64	8 - 12	12.8	3 - 5	2.6	4 - 6	2.5

Predicted values are mean - U95%CL. *italics* - measured value exceeds prediction by < 10%. * - Measured tensile and compressive strains may increase up to 2 times the predicted smooth profile strain occasionally due to crack development.

Source: (Ditton Geotechnical Services, 2020)

The subsidence effect predictions were marginally higher or lower than the maximum values observed. The impacts assessed for Mandalong Road pavement, based on the predicted subsidence effects for the entire road, are therefore still considered reasonable:

- Predicted tensile crack widths of between 20 mm and 50 mm (tensile cracks and formation gaps of 20 mm observed above LW26B).
- Compressive shearing between 20 mm and 60 mm (none observed above LW26B)
- Increase of super-elevation in the road of 0.2% to 1.5% (measured 1.3% above W26B)
- Cracking of culverts and fill embankments (none observed above LW26B)

10.1.3 TransGrid Towers

Predictions v. Measured subsidence, tilt, horizontal displacement and strain at each of the TransGrid Towers along TL25/26 Line due to LW25B and LW26B are summarised in **Table 9**. The measured values were all within the predicted ranges with no visible impacts occurring.

The measured tower values were generally within the predicted ranges (Level 1 - Low) with one relative displacement of 5 mm measured for Tower 39X (Level 2 Advisory), that subsequently returned to Level 1 -Low over a period of several weeks. There were no visible impacts to tower structures observed.

Table 9 – Predicted v Measured Subsidence Effects at TransGrid Towers 38X and 39X

Tower No	Final Subsidence [#] S _{max} (m)		Maximum Tilt T _{max} (mm/m)		Maximum Strain [^] E _{max} (mm/m)		Relative Displacements between Tower Legs	
	Predicted	Measured	Predicted	Measured	Predicted	Measured	Predicted	Measured
38X (suspension + cruciform footing)	0.59	0.280 - 0.289	2.8	0.4 - 1.1	2.9	-0.3 to 0.1	0 to 4	1
39X (tension)	0.01	0.001	0.4	<0.1	0.3	+/- 0.3	0 to 4	0 - 5

- negative subsidence indicates uplift; ^ - Tensile strain is positive

Source: (Ditton Geotechnical Services, 2020)

10.1.4 Ausgrid Power Poles

The subsidence effect predictions v. measured values at the Ausgrid timber power poles above Longwalls 25B and 26B are shown in **Table 10**. The measured values were generally less than the predicted values. There has been no observed impact to the power line network.

Table 10 – Predicted v Measured Subsidence Effects for Ausgrid Power Poles

Pole No.	LW No.	Final Subsidence S _{max} (m)		Final Tilt T _{max} (mm/m)	
		Predicted	Measured	Predicted	Measured
MG-40013	26	1.02	0.22	6.1	0.3
MG-40012	25b	0.82	0.30	10.6	1.5 - 2.5
MG-40011	25b	0.43	0.20 - 0.15	14.8	2.7 - 0.5
MG-40027	>25	0.09	0.053 - 0.051	1.0	4.3 - 3.2
MG-40028	25b	0.58	0.45 - 0.453	17	13.5 - 1.0
MG-40010	>25	<0.02	0.013 - 0.019	<1	0.1 - 0.6
GX77001	26b	0.91	0.40	9.6	2 - 5
62374	27	0.77	0.02 - 0.002	10.5	1.2 - 1.3

+ - Tensile strains are positive.

Source: (Ditton Geotechnical Services, 2020)

10.1.5 Private Dwelling

Two dwellings were affected by subsidence from Longwall 26B. One private dwelling is located over the chain pillar between LW25B and LW26B and the other over a chain pillar at the commencement end of LW26B. Subsidence monitoring was established on the dwelling at property MS0012, while the landowner on property MS0029 decline monitoring. The measured values were within the predicted ranges and no impacts were reported to at either of the two single storey dwellings.

Table 11 – Predicted v Measured Subsidence Effects for Private Dwelling

House No [#]	LW#	Subsidence S_{max}		Maximum Tilt T_{max} (mm/m)		Maximum Curvature C_{max} (km^{-1})		Maximum Strain E_{max} (mm/m)	
		Predicted	Measured	Predicted	Measured	Predicted	Measured	Predicted	Measured
1	LW25b -26b	0.45 - 0.54	0.226	1.0 - 2.0	1.1	0.36 - 0.65	N.M.	3.6 - 6.5	0.1 - 0.2

N.M. - not measured (pre and post-mining visual inspection only)

Source: (Ditton Geotechnical Services, 2020)

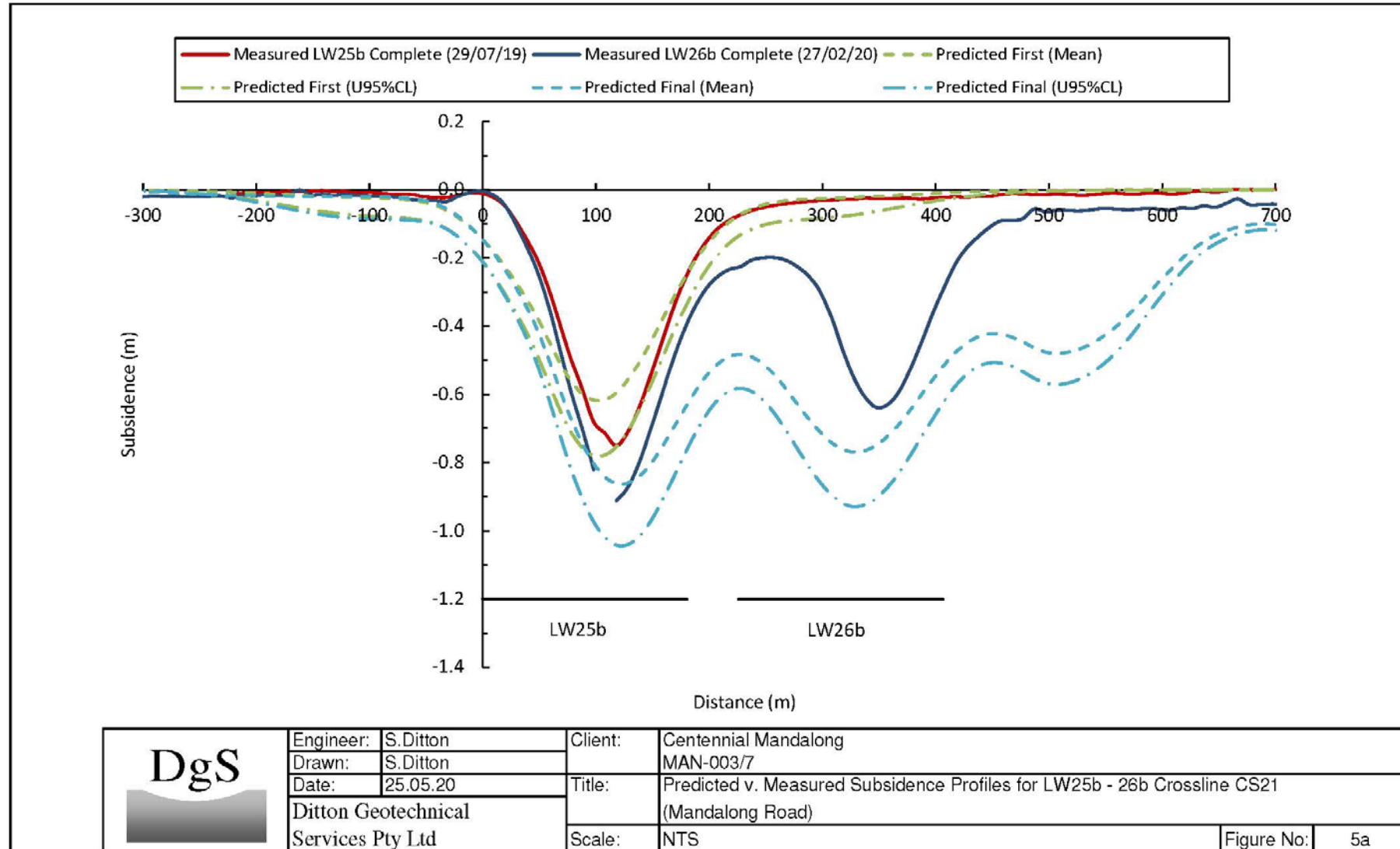


Figure 3 – Predicted v. Measured Vertical Subsidence Crossline 21

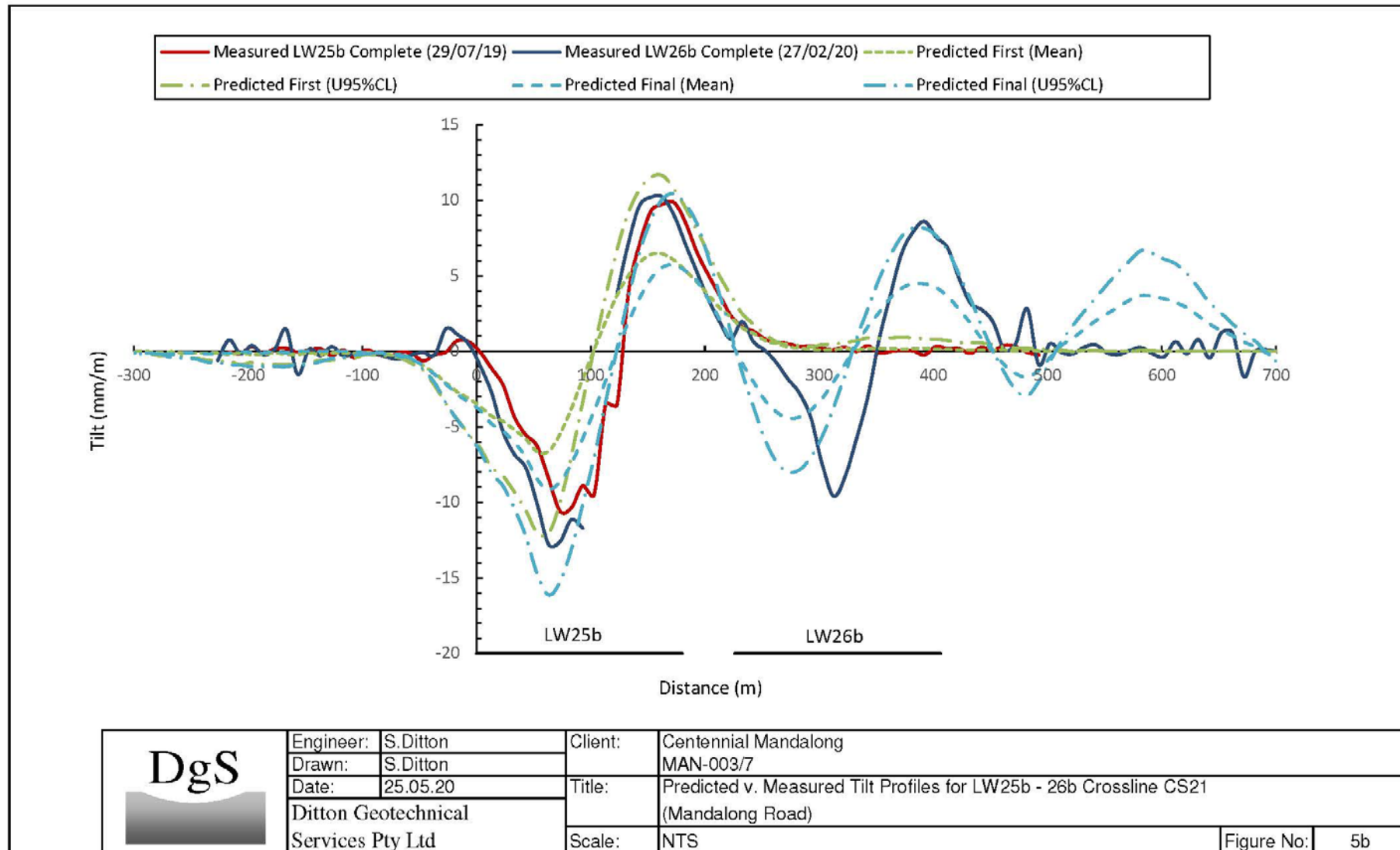


Figure 4 – Predicted v. Measured Tilts Crossline 21

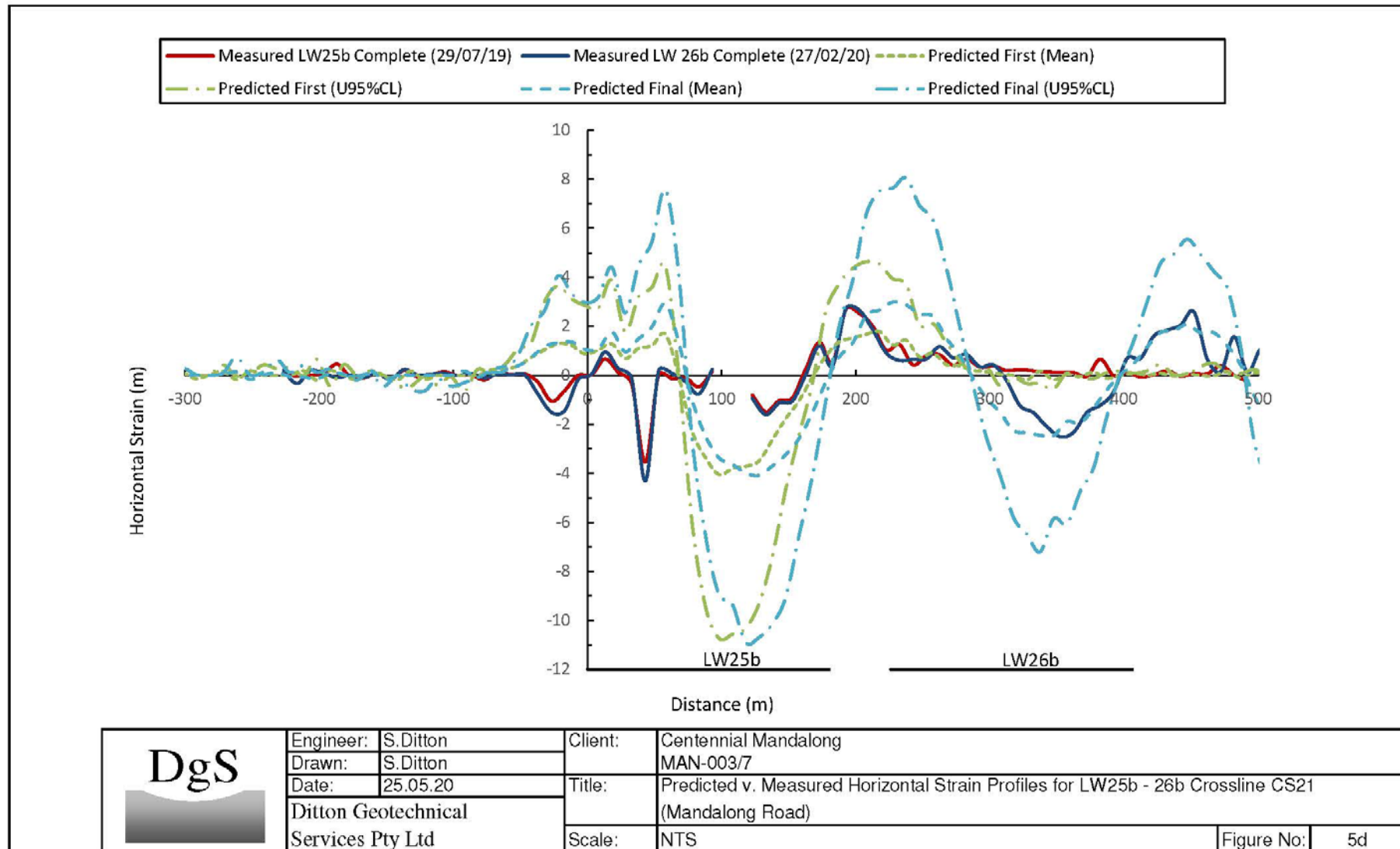


Figure 5 – Predicted v. Measured Strains Crossline 21

10.2 Assessment of Performance against Performance Measures and Predicted Impacts

Table 12 provides a summary of the assessment of subsidence performance against the specified subsidence performance measures and predicted impacts in Extraction Plan LW25-31. As shown in the summary table, subsidence impacts were within the predicted levels for private property, surface infrastructure, natural features and heritage items.

Table 12 - Assessment of Subsidence Performance against Performance Measures and Predicted Impacts

Feature	Subsidence Performance Measures	Predicted Subsidence Impact EP LW25-31	Assessment of Performance against Predicted Impact
Private Property			
Dwellings	<i>Always safe. Serviceability should be maintained wherever practicable. Loss of serviceability must be fully compensated. Damage must be fully repairable, and must be fully repaired or else replaced or fully compensated.</i>	Subsidence predictions below SSR criteria, with all dwellings remaining SSR.	Impact as predicted Two private dwellings were affected by subsidence from LW25B and LW26B and both remained SSR. Subsidence repairs to the dwellings are being managed by Centennial and SA NSW.
Flood – dwelling and access	<i>Dwelling floor level to remain 0.5m above post mining 100 year ARI flood level - acquisition and compensation procedure if subsided floor level is below flood level.</i>	All dwellings freeboard remains above 100 year flood level at the maximum predicted subsidence and two times maximum predicted subsidence.	Impact as predicted Maximum subsidence was consistent with prediction and flood modelling at the dwelling locations.
Agriculture	<i>No loss of agricultural productivity greater than minor.</i>	No loss of landuse to State Forest or agricultural productivity to private property (hobby farms) and Centennial properties.	Impact as predicted No reported or observed impact to landuse. Temporary remnant ponding repaired in consultation with landowner.
Infrastructure			
Local Roads and Access	<i>Always safe. Serviceability should be maintained wherever practicable. Loss of serviceability must be fully compensated. Damage must be fully repairable, and must be fully repaired or else replaced or fully compensated.</i>	Low level of damage predicted Mandalong Rd. To remain safe, serviceable and repairable. No change to flood hazard.	Impact as predicted Subsidence impacts consistent with prediction.
	Public Roads		

Feature	Subsidence Performance Measures	Predicted Subsidence Impact EP LW25-31	Assessment of Performance against Predicted Impact
	Management Plan LW25-31		
Electricity Transmission Lines (330kV)	<i>Always safe and serviceable.</i> <i>Damage that does not affect safety or serviceability must be fully repairable, and must be fully repaired.</i> Transmission Line Management Plan LW25-31 for TL24 Towers 33X to 38X.	No impact to serviceability of transmission lines. A section of TL24 was relocated and new towers constructed from 33X to 40X. Concrete cruciform footings constructed on towers 33X to 38X.	Impact as predicted No observed or reported damage to transmission line TL24 towers 38X and 39X. Vertical subsidence, tilts and strains were with prediction on both towers.
Powerlines (11kV)	<i>Always safe and serviceable.</i> <i>Damage that does not affect safety or serviceability must be fully repairable, and must be fully repaired</i> Powerline Management Plan LW25-31	No impact to serviceability of powerlines. Mitigation measures were installed by Ausgrid on powerlines prior to development of subsidence.	Impact as predicted No observed impact to powerlines affected by LW25B and LW26B. No interruption to service detected or reported.
Communications	Telstra Management Plan	Low impact. No disruption to copper cable network.	Impact as predicted Subsidence monitoring confirmed subsidence consistent with predicted maximum values (strains). No interruption to service detected or reported.
Natural Features			
Biodiversity	<i>Negligible environmental consequences to threatened species, threatened populations and endangered ecological communities</i>	Negligible environmental consequences.	Impact as predicted There has been no measured or reported impact to threatened flora and fauna affected by LW25 and LW26 subsidence.
Floodplain	Floodplain inspection and monitoring	Minimal changes to creek channel flows or alignment. Predicted no surface cracking on floodplain.	Impact as predicted Minimal changes to creek channel grades resulting in a negligible change to stream flows. No mining induced erosion or deterioration in stream bank condition. No subsidence related soil cracking was observed in report period in areas with higher depth of cover or

Feature	Subsidence Performance Measures	Predicted Subsidence Impact EP LW25-31	Assessment of Performance against Predicted Impact
			alluvial flood plain area above LW1 to LW26.
Remnant Ponding	Flood Modelling	Minor increase to existing ponding predicted over LW25 to LW31.	Impact as predicted No remnant ponding observed over LW25 and LW26 to date or at Observations Points 'A' , 'B' and 'C'. Remediation of remnant ponding on private properties located over LW23 to LW24A is currently in negotiations. Refer Table 14 for full details.
Groundwater	Groundwater Monitoring and Management Plan	Predicted no adverse subsidence related impacts on alluvium groundwater levels and water quality.	Impact as predicted The monitoring data indicates that there is no adverse impact on groundwater levels in the alluvial aquifers.
Steep Slopes and rock outcrops	<i>No subsidence impact or environmental consequence greater than predicted in the documents listed in SSD-5144 Condition 2(b) of Schedule 2.</i> Public Safety Management Plan LW25-31 Public Safety Management Plan LW25-31	No additional risk to public safety. No cliffs or potential for rock fall hazards exist. Possible opening of rock joints.	Impact as predicted No observed impact to steep slopes or evidence of rock falls or rollout. Minor opening of rock joints and surface cracking was observed over LW25B.
Heritage			
Heritage and Archaeology	<i>No subsidence impact or environmental consequence greater than predicted in the documents listed in SSD-5144 Condition 2(b) of Schedule 2.</i>	No impact to the three Aboriginal cultural heritage sites identified within EP LW25-31. Four grinding groves located within LW25A angle of draw.	Impact as predicted Subsidence within prediction at sites and no impact to heritage items observed during post-mining inspections. A final post mining inspection will be completed in mid 2020.

11 Environmental Monitoring and Results

11.1 Groundwater

At Mandalong, the alluvium forms an unconfined shallow aquifer with a water table typically ranging in depth from less than 1 m and up to about 3 m below ground level and aquifer thickness less than 20m. Monitoring within the alluvium has indicated that there is regular seasonal fluctuation in water level around 0.5m in the lower catchment and fluctuations between 1.5m to 2.0m in the middle to upper catchment areas. The alluvial groundwater is moderately acidic to slightly alkaline, brackish to saline, extremely hard and of sodium chloride type. Reported groundwater electrical conductivity (EC) throughout the Mandalong Mine approval area exceeds 10,000 $\mu\text{S}/\text{cm}$ at some locations.

Due to the relatively high silt and clay content of the alluvium, the groundwater yields are relatively low (typically less than 1 L/s). As a result of the low yield and relatively poor water quality, there are very few registered private alluvial groundwater bores. The environmental value of the alluvial groundwater is considered to be 'primary industry' (specifically stock watering), with the saline groundwater only suitable for stock watering.

An extensive groundwater monitoring network has been developed at Mandalong Mine with monitoring undertaken on many of the bores since August 1997. This program has been established to provide timely warnings of deviations from natural or background levels, so that if necessary, remedial measures and/or management strategies can be put in place.

The current monitoring network consists of 57 bores (refer **Figure 6**); 26 alluvial monitoring bores, 29 overburden monitoring bores and 2 coal seam monitoring bores. The bores consist of 16 nests of 2 or 3 bores monitoring strata at increasing depth at the same site. The bores are monitored every month with the water level, EC and pH being measured.

There are essentially three groundwater systems in the Mandalong Valley (mine lease area) – alluvial groundwater, bedrock groundwater and overburden/interburden.

The alluvial groundwater is the most important as a usable resource, however there are not many licensed extraction bores within the Valley. The alluvial groundwater is typically recharged from surface infiltration through the sands and upstream recharge.

The bedrock groundwater is less important as a usable resource. The permeability of the Narrabeen Group rocks is generally very low, with little groundwater yield. Any water that is localised in joints or fractures is typically of poor quality.

In the coal seam itself, the bulk permeability is low with some occasional high permeability zones associated with joints, fracture zones or faults, which results in the seam being a confined aquifer relative to the surrounding strata.

An annual review of the groundwater monitoring results for 2019 was undertaken by GHD (Mandalong Annual Groundwater Monitoring Review - 2019, 2020) .

11.1.1 Groundwater Levels

11.1.1.1 Alluvial Groundwater Sources

Groundwater levels fell after undermining at BH24A from approximately 16.8 m AHD in January 2014 to 14.8 m AHD in August 2014. Recovery was observed from June 2015, with groundwater levels recorded at 15.7 m AHD in November 2019. HARTT analysis of post-August 2014 groundwater levels at BH24A indicate the increasing trend in groundwater levels is independent of rainfall.

The overall decreasing trend in groundwater level at BH25A reflects decreasing rainfall trend and is therefore not predominately attributed to mining. The variation in groundwater levels at BH25A may be a result of the development of shallow tensile and compressive cracks resulting in localised increases in hydraulic conductivity and porosity. It is expected that such voids will fill over time and the hydraulic conductivity and porosity should return to pre-mining values. Supporting evidence has been observed at BH22A, and now also in the rising levels at BH24A.

HARTT analysis was not undertaken for the data set at BH27A due to limited observed water level records (four within 2012 only). BH27A has been dry post 2012, likely due to no alluvial aquifer being intercepted at this location atop a ridge.

Trigger values for alluvial groundwater levels have been defined in the WMP. Observed levels for 2019 have been compared to trigger values in Table 4-2. Exceedances of trigger values occurred at three locations being BH12, BH13 and BH25A (shown in bold). Exceedances were considered minor (<0.5 m) and temporary (occurring without an ongoing decreasing trend over a period of 6 months). As discussed in Section 4.1.2, the variation in groundwater levels at BH25A may be a result of the development of shallow tensile and compressive cracks resulting in localised increases in hydraulic conductivity and porosity. BH12 and BH13 are located within 1 km of BH25A, and therefore the decreasing trends are considered likely to result from the same. The low groundwater levels are also attributable to drying climatic conditions. As the site has experienced below average rainfall over the period of decreasing trend, and as there was a generally increasing trend during 2019 (although still below the trigger level in some cases), the exceedance of the trigger values are not considered attributable to mining related activities at this stage.

11.1.2 Groundwater Quality

11.1.2.1 Alluvial Groundwater Sources

Alluvial groundwater is generally characterised by pH within the range of 5 to 8 (predominantly 6 to 7) and electrical conductivity (EC) ranging from less than 1,000 $\mu\text{S}/\text{cm}$ to over 10,000 $\mu\text{S}/\text{cm}$. Alluvial groundwater quality data is plotted in Appendix B and tabulated in Appendix C.

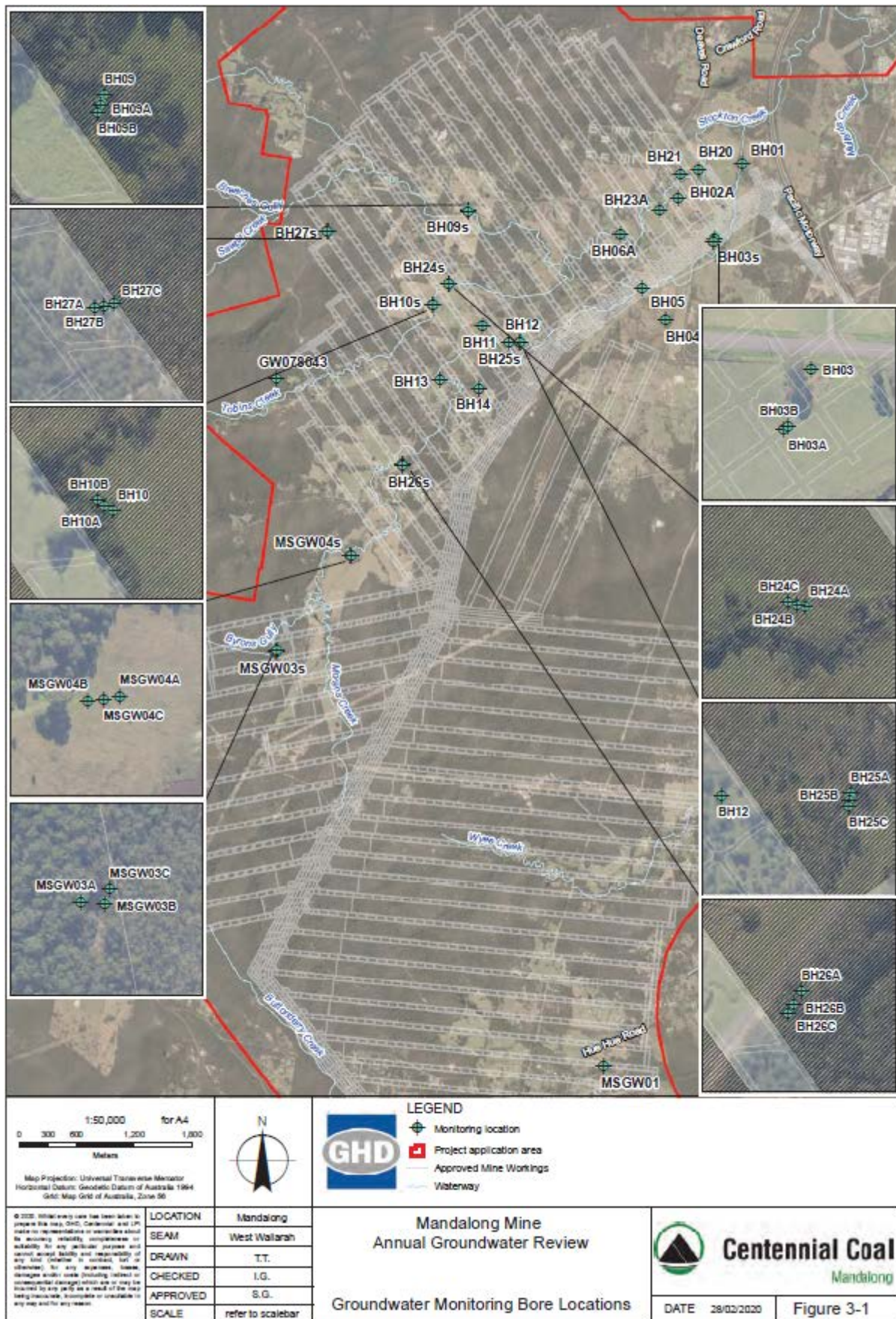
Prior to 2015, bailing sampling methods were used, resulting in variability in alluvial groundwater salinity that was considered unrelated to mining activity (AGE 2014). However, since January 2015, alluvial bores have been sampled by low flow techniques (i.e. peristaltic pump) with purging continuing until pH and EC parameters show stabilisation. Accordingly, variability within individual location datasets has generally reduced, however different locations continue to range from fresh to saline conditions.

Review of 2019 results and historical trends indicates:

- Gradually decreasing EC at BH01, which continued during 2019
- Generally stable EC and pH trend at BH09, BH10, BH11, BH12, BH13, BH14, BH24A, BH25A, BH26A, MSGW03A and MSGW04B since low flow sampling was implemented in 2015.
- Stable EC and pH trend at BH03, BH03A, BH03B, BH04 after 2017
- Continued wide variance in EC and pH at BH05, without discernible trend.

Site specific trigger values for groundwater quality are presented in the LW24-24A Extraction Plan WMP (GHD, 2018b) (refer to Table 5-1) and the performance criteria are described in the WMP (GHD, 2018a).

No exceedances occurred in alluvial bores during 2019. Further, no complaints from adjacent landholders regarding groundwater quality were received in 2019.



Source: (GHD, 2020)

Figure 6 - Groundwater Monitoring Bores and Mine Plan

11.2 Stream Channel and Floodpaths

The condition of floodpaths and stream channels are discussed in the Mandalong Mine “Floodpath Condition Report 2019” (Centennial Mandalong, 2020). Development Consent DA97/800 and Water Management Plans for both Extraction Plans LW24-24A and LW25-31 require the condition of major floodpaths be inspected every six months or following a flood event.

11.2.1 Impact Assessment Criteria

11.2.1.1 Channel Stability

Longwall 25 to 31 are located in the upper reaches of the Mandalong Valley floodplain and have the potential to impact two drainage channels, Morans Creek and Morans Creek tributary. The average predicted grade changes are likely to be minimal (less than 0.1%). The maximum predicted grade changes occur downstream of the chain pillars that separate each longwall and in the order of 0.5 to 1% which may result in localised channel instabilities, requiring ongoing monitoring and potentially requiring mitigation works.

11.2.1.2 Channel Ponding

The levels of predicted subsidence and associated grade changes along each channel section over Longwalls 25 to 31 are of a similar order of magnitude to the existing channel slopes. As such there is potential that the predicted subsidence could create new areas of in channel ponding.

11.2.1.3 Channel Erosion

The levels of predicted subsidence over proposed Longwalls 25 to 31 are not expected to significantly alter the flow conveyance capacity of the existing channels. The associated impacts on the maximum modelled flood depths and flood hazard categories are not considered to be significant. It is considered that there is minimal potential for channel realignment due to the proposed underground mining of Longwalls 25 to 31. The potential to increase erosion of the landform is expected to be minimal because of the limited amount of exposed soils, high level of groundcover and the relatively low modelled velocities, with overland flows typically between approximately 0.1 m/s and 0.7 m/s for the modelled 100 year ARI design storm event. The modelling indicates that within the main channel of the watercourses in the application area, flow velocities of up to approximately 1.8 m/s may occur during the 100 year ARI design storm event, with no significant difference in the maximum flow velocities between the pre-mining and subsided landforms at these locations.

11.3 Flooding

Development Consent SSD-5144 Schedule 4 Condition 6 (h) requires a PSMP to include:

- *a detailed subsidence impact assessment for the property, including (where relevant): a flood impact assessment, including a prediction of the minimum freeboard of the residence in a 1 in 100 year ARI flood event, and, where this prediction shows the minimum freeboard at the residence to be less than 0.5 m in a 1 in 100 year ARI flood event;*
- *recommends such works to raise, remediate or relocate the residence and/or provide suitable access to the property, prior to undermining the residence; or*
- *where these works are unable to be undertaken, offers to acquire the whole of the property, or such part of the property requested by the landowner where subdivision is approved, in accordance with conditions 3 and 4 of Schedule 5;*

11.3.1 Flooding Impact Assessment Criteria

The Mandalong South Flood Assessment LW25-31 (Umwelt, 2018) was prepared for Extraction Plan LW25-31. The assessment concluded that the freeboard on all dwellings will remain more than 0.5m above the 100 year ARI flood event. All property access routes are located well above the floodplain.

Seven potential remnant ponding locations were identified as detailed in **Table 13**:

Table 13 - Potential Remnant Ponding Locations LW25-31

Property	Observation Point	Longwall
MS0019	Location 'A'	LW25
MS0050	Location 'B'	LW25
MS0012	Location 'C'	LW26
MS0012	Location 'D'	LW27
MS0127	Location 'E'	LW30
MS0025	Location 'F'	LW30
MS0025	location 'G'	LW31

11.3.2 Monitoring Results and Comparison against Predicted Impacts.

11.3.2.1 Stream Channels and Flood paths

Flood path inspections on Morans and Tobins Creek were conducted in June and December 2019. There was no evidence of surface cracking, ponding or erosion within the creek line. Monitoring is ongoing to assess any subsidence impacts to the creek line and the predicted increase in ponding with further reporting to be provided in the Mandalong Mine, Floodpath Condition Report for 2020.

11.3.2.2 Flooding

Subsidence monitoring has indicated that maximum vertical subsidence over Longwalls 25A and LW25B has been within the maximum predicted subsidence within the floodplain. There was one major flood event during the report period. A rainfall gauge at the MSSS recorded a total of 335 mm of rainfall between Thursday 6th February to Monday 10th February 2020. The MSSS was inaccessible on Sunday 9th February due to flooding.

There has been no evidence of ponding at the two potential remnant ponding locations over Longwall 25 during both routine and floodpath inspections during the report period.

Table 14 - Summary of Remnant Ponding and Remediation for LW1-26

Remnant Ponding Remediation							
Location	Description	Remediation	Remediation Comments	Ponding Predicted	Subsidence Completed	Status	Property Ref. Lot & DP
Longwall 1 (P1)	Open grassland	No remediation required.	Negotiations with landowner finalised.	No	Yes	Completed	Ref. 6 2/557230
Longwall 2 (P2)	Open grassland	Drained	Constructed open drain and connected to nearby water course. 	Yes	Yes	Completed	Ref. 7, 8 1/557230 3/557230
Longwall 3 (P3)	Open grassland	Drained	Constructed open drain and connected to nearby water course. 	Yes	Yes	Completed	Ref. 7 1/557230
Longwall 4 (P4)	Open grassland	Allowed to remain as a source of water for stock.		Yes	Yes	Completed	Ref. 7, 59 1//557230 580/73322 7

Remnant Ponding Remediation							
Location	Description	Remediation	Remediation Comments	Ponding Predicted	Subsidence Completed	Status	Property Ref. Lot & DP
Longwall 5 (P5)	Open grassland	Drained	Constructed open drain and connected to nearby water course. Fenced to restrict stock access causing erosion. 	No	Yes	Completed	Ref. 59 580/73322 7
Longwall 6 (P6)	Open grassland	Drained	Installed sub-surface drainage and drainage to Stockton Creek. 	Yes	Yes	Completed	Ref. 56 12/582283
Longwall 6 (P6A)	Open grassland	Drained	Improved existing open drainage to ponded area. 	No	Yes	Completed	Ref. 61 903/54230 6
Longwall 7 (P7)	Open grassland fringed with Cabbage Gums and <i>Melaleuca biconvexa</i> .	Drained	Open drain constructed and connected to nearby water course. Drainage designed to allow access across by farm machinery and stock. 	Yes	Yes	Completed	Ref. 56 12//58228 3

Remnant Ponding Remediation							
Location	Description	Remediation	Remediation Comments	Ponding Predicted	Subsidence Completed	Status	Property Ref. Lot & DP
Longwall 7 (P7A)	Open grassland	Allowed to remain as extension of existing dam.	Extension of existing dam	Yes	Yes	Completed	Ref. 55 11/582283
Longwall 7 (P7B)	Open grassland		Regrade natural drainage line and open drain. 	No	Yes	Completed	Ref. 52 93/9632
Longwall 8 (P8)	Expansion of an already wet area having scattered Swamp Mahogany and <i>Melaleuca biconvexa</i> .	Remain as expansion of existing freshwater wetland and fenced. Included in Wetland Monitoring Program as Wetland 9.	Following a period of monitoring and limited options for drainage, a decision was made to fence the wetland to protect from stock and allow to develop as a freshwater wetland. 	Yes	Yes	Completed	Ref. 55 11/582283
Longwall 8 (P8A)	Open grassland and <i>Melaleuca biconvexa</i> Existing wetland	Expansion of existing Wetland 8.	To remain as a wetland.	No	Yes	Completed	Ref.42 25/755238
Longwall 9 (P9)	Mixed Cabbage Gum and paperbark forest.	Remain as extension of existing freshwater wetland.	Several threatened <i>Melaleuca biconvexa</i> paperbarks are present and remediation would involve losses of these through gaining access by machinery. Consequently remediation was not undertaken.	Yes	Yes	Completed	Ref. 57 180/85943 4

Remnant Ponding Remediation							
Location	Description	Remediation	Remediation Comments	Ponding Predicted	Subsidence Completed	Status	Property Ref. Lot & DP
Longwall 10 (P10)	Mixed Cabbage Gum and paperbark forest.	Remain as freshwater wetland.	Several threatened paperbarks <i>Melaleuca biconvexa</i> are present and remediation would involve losses of these through gaining access by machinery. Consequently remediation was not undertaken.	No	Yes	Completed	Ref. 57 180/85943 4
Longwall 11 (P11)	Mixed paperbark woodland in an already periodically inundated area. Contains threatened <i>Melaleuca biconvexa</i> paperbarks. Ponding has extended an existing wetland.	Remain as freshwater wetland	To remain as a freshwater wetland.	Yes	Yes	Completed	Ref. 44 9/800491
Longwall 13 (P13)	Open grassland and Redgum Rough-barked Apple Forest	Minor increase in low lying area. No permanent ponding.	Existing ponding has been moved towards centre of longwall panel. 	No	Yes	Completed	Ref. 44 , 50 9/800491 10/800491
Longwall 13 (P13A)	Open grassland	Minor increase in low lying area. No permanent ponding.	No impact on grazing area.	Yes	Yes	Completed	Ref. 26 10/650914
Longwall 15 (P15)	Alluvial Tall Moist Forest and Redgum Rough-barked Apple Forest.	No remediation required.	No increase to existing ponding evident.	Yes	Yes	Completed	Ref. 67, 69 16//81338 5 61/755238

Remnant Ponding Remediation							
Location	Description	Remediation	Remediation Comments	Ponding Predicted	Subsidence Completed	Status	Property Ref. Lot & DP
Longwall 16 (P16)	Redgum Rough-barked Apple Forest and Coastal Foothill Spotted Gum-Ironbark Forest.	Increase in existing ponded area remediated to pre-mining condition. Minimal impact on flora	Constructed open drain and connected to nearby water course to return existing ponding to pre-mining levels. Quarterly ecology monitoring program completed. 	Yes	Yes	Completed	Ref. 69 61/755238
Longwall 16 (P16A)	Open grassland	Filled and drain installed to restore drainage due to increase in depth and extent of ponding.		Yes	Yes	Completed	Ref.33 861/83516 0
Longwall 17 (P17)	Freshwater Wetland Complex EEC and Redgum Rough-barked Apple Forest EEC	No remediation required.	Marginal increase in extent and depth of wetland as predicted. No predicted long-term impact on wetland. Wetland 4 & 5 in Wetland Management Plan – property sole and monitoring finished 	Yes	Yes	Completed	Ref. 68 22/812406
Longwall 17 (P17A)	Open grassland and Redgum Rough-barked Apple Forest EEC	Installed open drain and pipes to reduce slight increase in area and depth of existing ponding.		Yes	Yes	Completed	Ref. 70 54/755238

Remnant Ponding Remediation							
Location	Description	Remediation	Remediation Comments	Ponding Predicted	Subsidence Completed	Status	Property Ref. Lot & DP
Longwall 18 (P18)	Freshwater Wetland Complex EEC and Redgum Rough-barked Apple Forest EEC	No remediation required.	Marginal increase in extent and depth of wetland predicted. No predicted long-term impact on wetland. Wetland 4 & 5 in Wetland Management Plan. Property sold and monitoring finished	Yes	Yes	Completed	Ref. 68 22/812406
Longwall 18 (P18A)	Open grassland	Filled ponded area to restore pasture.		No	Yes	Completed	Ref. 70 54/755238
Longwall 18 (P18B)	Prickly Ridge Forest Road Hunter Valley Moist Forest Open grassland	Upgraded road and installed additional drainage lines.	Increase in length and depth of ponding along Prickly Ridge Forest Road was remediated and road upgraded as agreed by Forest Corporation NSW. 	Yes	Yes	Completed	Ref. 71, 37 45/115922 9 46/755238
Longwall 18 (P18C)	Access road and open grassland	Raise access road, install pipes and regrade existing drain.		Yes	Yes	Completed	Ref. 70 54/755238
Longwall 18 (P18D)	Open grassland	Construct drain from dam overflow to the existing drain and regrade.		Yes	Yes	Completed	Ref. 70 54/755238
Longwall 18 (P18E)	Open grassland	Constructed dam at location of existing ponding site. Overflow constructed with open drain and pipes to creek.		Yes	Yes	Completed	Ref. 70 54/755238

Remnant Ponding Remediation							
Location	Description	Remediation	Remediation Comments	Ponding Predicted	Subsidence Completed	Status	Property Ref. Lot & DP
Longwall 18 (P18F)	Open grassland	Filled minor ponding with top soil.		No	Yes	Completed	Ref. 77 1/1063659
Longwall 19 (P19)	Farm dam and open grassland	No ponding occurred.	No ponding occurred due to LW18 and LW19 being shortened to protect property improvements.	Yes	No	Completed	Ref. 82 1/957458
Longwall 19 (P19A)	Open grassland and access road	Installed drainage to creek and upgraded access road.	Ponding against and along access road was remediated with sub-surface drainage. Upgraded access road. 	No	Yes	Completed	Ref. 82 1/957458
Longwall 19 (P19B)	Open grassland and dam	No remediation required to minor increase in existing ponding near dam.		No	Yes	Completed	Ref. 82 1/957458
Longwall 19 (P19C)	Open grassland	Regraded existing drain to remove remnant ponding in paddock.		No	Yes	Completed	Ref. 70 54/755238
Longwall 20 (P20)	Open grassland	Installed four pipes at existing ponding site and minor regrading of existing drainage line. Replace open drain with 350mm diameter pipes.		Yes	Yes	Completed	Ref. 82 1/957458

Remnant Ponding Remediation							
Location	Description	Remediation	Remediation Comments	Ponding Predicted	Subsidence Completed	Status	Property Ref. Lot & DP
Longwall 21 (P21)	Open grassland and dam	Ponding did not occur. Constructed swale drain to restore dam catchment. Modify dam inlet and cleaned out sediment from dam.	Topography of dam catchment near centre of longwall affected. Constructed open drain to restore catchment 	Yes	Yes	Completed	Ref. 74 76/755238
Longwall 22 (P22)	Observation Point F Open grassland near creek	No evidence of ponding.	Photographic monitoring points established on chain pillars and centre of Longwall 22 and 23.	Yes	Yes	Completed	Ref. 73 93/755238
Longwall 22 (P22A)	Observation Point 'G' and 'N' Open grassland		Predicted increase in existing ponding.	Yes	Yes	Monitoring	Ref. 85 4/957458
Longwall 22 (P22B)	Observation Point 'O' Channel and floodplain		Predicted increase in existing ponding.	Yes	Yes	Monitoring	Ref. 89 41/755238
Longwall 22 (P22C)	Open grassland and dam	Fill and construct drainage line to restore paddocks.	Construct table drain and fill low lying areas to provide access. Fill and construct access along boundary fence. 	Yes	Yes	Completed	Ref. 86 28/829792
Longwall 23 (P23)	Observation Point E Dam	Construct new drainage system, fill areas, adjust dam overflow and upgrade pipe under access road	Increase in ponding between dam and raised access road. 	Yes	Yes	Completed.	Ref. 90 11/869483
Longwall 23 (P23A)	Paddock	Filled ponded area with topsoil		No	No	Completed	Ref. 220 3/168774

Remnant Ponding Remediation							
Location	Description	Remediation	Remediation Comments	Ponding Predicted	Subsidence Completed	Status	Property Ref. Lot & DP
Longwall 23 (P23B)	Road reserve and driveway	Constructed new drainage lines, upgrade property access and filled ponded areas with topsoil.	Ponding along road reserve and property access road. 	No	Yes	Completed	Ref. 212 3/3039
Longwall 23 (P23C)	Open grassland and dam		Ponding and dam tilted. Remediation survey and design completed. Property sold, negotiation with new landowners.	No	Yes	In progress	Ref. 221 11/869483
Longwall 23 (P23D)	Open grassland and dam		Ponding and dam tilted. Remediation survey and design completed. Property sold, negotiation with new landowners.	No	Yes	In progress	Ref. 221 11/869483
Longwall 24 (P24)	Observation Point 'K' Trotting track	Constructed new drainage system around track and resurface affected sections. Upgrade dams and catchment.	Affected existing drainage around entire trotting track. Affected dams and catchment 	Yes	Yes	Completed	Ref. 213 2/755238
Longwall 24 (P24A)	Observation Point L Open grassland and dam	Reinstate dam overflow, fill areas, install new drainage lines and upgrade access road.	Increase in ponding on floodplain and dam. 	Yes	Yes	Completed	Ref. 219 4/168774
Longwall 24 (P24B)	Observation Point 'M' Morans Creek		Potential increase in ponding along drainage line near Chapman Rd.	Yes	No	Monitoring	Ref. 218 17/755238

Remnant Ponding Remediation							
Location	Description	Remediation	Remediation Comments	Ponding Predicted	Subsidence Completed	Status	Property Ref. Lot & DP
Longwall 24 (P24C)	Paddock and drainage line.	Partially filled ponded area and minor adjustment to existing drain grades.	Increased ponding in paddock adjacent Mandalong Rd. 	Yes	Yes	Monitoring	Ref. 220 3/168774
Longwall 24A P24AA	Dam	Raised dam overflow point to restore capacity. Constructed new dam and upgrade access track.	Tilted dam and reduced capacity.	Yes	Yes	Completed	Ref. 212 3/3039
Longwall 24A P24AB	Trotting Track	Constructed new drainage system and restored dams and catchment.	Alteration of drainage system around track. Loss of catchment to horse swimming dam.	Yes	Yes	Completed	Ref. 213 7/755238
Longwall 24A (P24AC)	Dam	Dam resealed.	Opening of sandstone joints in the base of the dam.	No	Yes	Completed	Ref. 214 198/72771 4
Longwall 24A (P24AD)	Open grassland and access road.		Ponding and poor drainage at property access road, parking area and garage. Detail survey and design completed. Negotiating with landowner.	No	Yes	In progress	Ref. 223 17/755238
Longwall 25A	Drainage line Observation Point A		Potential remnant ponding identified in flood model.	Yes	No	Monitoring	Ref. MS0050 79/755238
Longwall 25B	Drainage line Observation Point B		Potential remnant ponding identified in flood model.	Yes	No	Monitoring	Ref. MS0019 179/75523 8
Longwall 26B	Dam		Repair two leaking dams.	No	Yes	In progress	Ref. MS0012 131/75523 8
Longwall 26B	Creek crossing		Water backing-up due to small existing pipe in creek crossing. Replace pipe with appropriate size.	Yes	No	In progress	Ref. MS0029 29/755238

11.4 Cultural Heritage and Archaeology

11.4.1 Aboriginal Archaeology – LW22-23 & LW23-24A Extraction Plan Areas

In 2016, RPS prepared a Heritage Management Plan (RPS, 2016) to support an Extraction Plan for the extraction of coal from Mandalong Mine Longwall panels 22 and 23. The Study Area for the Heritage Management Plan encompassed the 26.5 degree angle of draw around the secondary extraction areas of Longwalls 22 and 23.

In 2018, RPS also prepared a Heritage Management Plan (RPS, 2018a) to support an Extraction Plan for the extraction of coal from Mandalong Mine Longwall panels 24 and 24A. The Study Area for the Heritage Management Plan encompassed the 26.5 degree angle of draw around the secondary extraction areas of Longwalls 24 and 24A.

Based on the areas surveyed and ground truthing of existing sites, a total of four Aboriginal sites were located inside the Longwall 22-23 Study Area: three that were previously identified in 2011 and one newly recorded scarred tree site named #45-3-3678 (RPS Mand 2016_1).

Two of the sites inside the Study Area were artefact scatters (#45-3-3446/45-3-3537 and #45-3-3538), one was a grinding groove site (#45-3-3454) located in the angle of draw for Longwall 21 which would not be directly undermined as a result of the extraction of Longwalls 22 or 23, and the fourth was a scarred tree site (#45-3-3678 - RPS Mand 2016_1).

Table 15 – Cultural Heritage Item Location and Subsidence Monitoring LW22-24A

AHIMS Number	Artefact No.	Aboriginal Cultural Heritage Site	Mining Location	Predicted Subsidence	Actual Subsidence	Comment
45-3-3454	RPS MAND Nth 5	Grinding Groove	Angle of Draw Longwall 21	<-20mm		Not undermined
45-3-3453	RPS MAND Nth 6	Artefact Scatter	Outside influence of mining.	-100mm		Not mined – LW20 shortened due to seam intruded by igneous sill.
45-3-3446 45-3-3537		Artefact Scatter	Longwall 22 abutment pillar	-40mm	<-20mm	Based on nearest monitoring point. Phase 3 post mining inspection 14/11/18 – no impact observed.
45-3-3538		Isolated Find	Longwall 23	-60mm		Phase 3 post mining inspection 14/11/18 - no impact observed.

AHIMS Number	Artefact No.	Aboriginal Cultural Heritage Site	Mining Location	Predicted Subsidence	Actual Subsidence	Comment
45-3-3678	RPS Mand 2016_1	Scarred Tree	Longwall 24	-700mm	-600mm	Based on nearest monitoring point (TL24 Tower 45). Phase 2 – Initial post mining inspection completed on 14/11/18. Phase 3 post mining inspection 5/9/19 - no impact observed.

A pre-mining baseline recording of Aboriginal grinding groove site AHIMS #45-3-3454-RPS (Mand North 5) was undertaken on 1 November 2016. The baseline recording located the grinding grooves to survey control standard, included a detailed archaeological recording and archival photography, as well as a 3D scan.

The baseline pre-mining recording was undertaken in accordance with Phase 1 of the ACHMP (RPS 2016). A Phase 2 recording was undertaken post mining on 1 March 2017, which did not identify any harm to the site. A Phase 3 recording was undertaken 8 months post mining on 23 October 2017, which also did not identify any harm to the site.

A pre-mining baseline recording of artefact scatters (#45-3-3446/45-3-3537 and #45-3-3538) was undertaken on 1 March 2017. The baseline recording included a detailed archaeological recording and archival photography of the artefact scatters.

A Phase 2 recording of artefact scatter (#45-3-3446/45-3-3537) was undertaken post mining of Longwall 22 on 23 October 2017, which did not identify any harm to the site.

A Phase 2 recording of artefact scatter (#45-3-3538) was undertaken post mining of Longwall 23 on 8 March 2018, which did not identify any harm to the site.

A pre-mining baseline recording of the LW24 scarred tree (#45-3-3678) was undertaken on 23 October 2017. An initial post mining inspection of the LW24 scarred tree (#45-3-3678) was undertaken on 11 November 2018. A final post mining inspection of the LW24 scarred tree was undertaken on 5 September 2019, with no impacts observed.

11.4.2 Aboriginal Archaeology – LW25-31 Extraction Plan Area

In 2018, RPS prepared a Heritage Management Plan (RPS, 2018b) to support an Extraction Plan for the extraction of coal from Mandalong Mine Longwalls 25 to 31. The Study Area for the Heritage Management Plan encompassed the 26.5 degree angle of draw around the secondary extraction areas of Longwalls 25 to 31. Eleven (11) Aboriginal heritage sites/items are located inside the Longwall 25-31 Extraction Plan Area. As shown in **Table 16** these 11 Aboriginal heritage sites/items are located within the mine workings area and thus may be impacted by subsidence.

Table 16 – Cultural Heritage Item Location and Subsidence Monitoring LW25-31

AHIMS Number	Artefact No.	Aboriginal Cultural Heritage Site	Mining Location	Predicted Subsidence	Actual Subsidence	Comment
45-3-1223	Moran's Creek	Artefact Scatter	Longwall 31	-620mm		
45-3-3469	RPS MAND STH AH03	Grinding Groove	Longwall 27	<-20mm		
45-3-3490	RPS MAND STH CYL07	Grinding Groove	Longwall 25	-80mm	-59mm	Phase 2 post-mining inspection was conducted on 5 September 2019. No visible or measured impact.
45-3-3501	RPS DF03	Grinding Groove	Longwall 25	-70mm	+13mm	Phase 2 post-mining inspection was conducted on 5 September 2019. No visible or measured impact.
45-3-3502	RPS DF04	Grinding Groove	Longwall 25	<-20mm	+17mm	Phase 2 post-mining inspection was conducted on 5 September 2019. Grinding Groove Trial Mitigation
45-3-3506	RPS MAND STH PS11	Grinding Groove	Longwall 25	-90mm	+17mm	Phase 2 post-mining inspection was conducted on 5 September 2019. No visible or measured impact. Grinding Groove Trial Mitigation
45-3-3536	RPS MAND STH TBM29	Artefact Scatter	Longwall 30	-640mm		
45-3-3539	RPS MAND STH TBM31	Grinding Groove	Longwall 28	-870mm		
45-3-3540	RPS MAND STH TBM32	Stone Arrangement	Longwall 28	-880mm		
45-3-3541	RPS MAND STH TBM33	Modified Tree (carved or scarred)	Longwall 28	-910mm		

AHIMS Number	Artefact No.	Aboriginal Cultural Heritage Site	Mining Location	Predicted Subsidence	Actual Subsidence	Comment
45-3-3542	RPS MAND STH TBM34	Grinding Groove	Longwall 28	-720mm		

A pre-mining baseline recording of Aboriginal grinding groove sites AHIMS 45-3-3501, AHIMS 45-3-3490, AHIMS 45-3-3502 and AHIMS 45-3-3506 (RPS names DF03, CYL07, DF04 and PS11) was undertaken on 8 March 2018. The baseline recording located the grinding grooves to survey control standard, included a detailed archaeological recording and archival photography, as well as a 3D scan.

Monitoring of the sites RPS DF04 and RPS PS11 (**Table 16**) (and sites DF03 and CYL07) was undertaken on 5 September 2019 in accordance with the requirements of Condition 10 of Schedule 4 of SSD-5144 (Grinding Groove Trial Mitigation) with monitoring results presented in the 2019 Annual Review. There were no impacts identified to the grinding groove sites, with a final post mining inspection scheduled to be completed in mid to late 2020 in accordance with the requirements of Condition 10 of Schedule 4 of SSD-5144 (Grinding Groove Trial Mitigation) with monitoring results to be presented in the 2020 Annual Review.

12 Bibliography

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Appendix 1 - Plan MG10435 - Subsidence Survey Lines

