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Mr Phil Enright
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Centennial Mandalong
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Report No. MAN-003/10

Dear Phil,

Subject: Subsidence Assessment for the Proposed Modifications to LW31

1.0 Introduction

This letter provides a mine subsidence assessment of the surface features above the proposed variation to the approved Longwall (LW) 31 in the Extraction Plan Approval for LW30 to 31 (dated April 2021) at the Centennial Mandalong Mine, Mandalong.

A significant igneous sill has been identified during development of the gate roads for LW30 to 31. LW31 will be approximately 726 m shorter than originally proposed in the extraction plan approval (currently 1886 m long).

The assessments of the currently approved mining layout under SSD-5144 Mod 9 for LW30 and 31 are presented in **DgS, 2021a,b** and have been referred to in this study.

2.0 Surface Features above the Proposed Mining Layout

The effects of the proposed variation to LW31 on the following surface features have been assessed against the Approved LW30 to 31 Extraction Plan:

- Steep slope No.s 2a & 2b (18º - 28º) and Rock Face Features (RF27 & 28)
- Private lots with dwellings and ancillary buildings, fences and driveways
- Power infrastructure (Transgrid and Ausgrid)
- Kiar Ridge, Toepfers and private access roads
- Aboriginal Heritage Sites

The location of the above surface features relative to the proposed variation to LW31 and approved LW30 are shown in **Figures 1a** to **1c**.

3.0 Geological Structure

The updated geological stratigraphy and structure plan showing the extent of the igneous sill and plug at seam level is presented in **Figure 1d**.

4.0 Subsidence Effect Predictions for the proposed LW30 and 31 v. Approved Extraction Plan Predictions

For comparative purposes, the subsidence effect contour predictions for the approved LW30 to 31 are re-presented in this study with upper 95% Confidence limit or Credible Worst-Case contours of subsidence, tilt and horizontal strain given in **Figures 2a-c**. The mean contours are shown in **Figures 2d-f**.

The subsidence effects for the proposed variation to LW30 to 31 are presented in **Table 1**.

Based on a review of measured subsidence data above LW25 to 29 and Mandalong Beam thickness contours it was determined that the proposed Extraction Plan area will have a Low (SRP) and remains unchanged. However, the subsidence data indicated that the model was over predicting the chain pillar subsidence and underpredicting the sag subsidence (between the pillars) by ~ 200 mm. Full review details are presented in the LW34 Approval Modification report (Mod 10); see **DgS, 2021c**.

The outcome of the review was to modify the Mandalong Beam thickness model, estimated chain pillar subsidence prediction model and the proportion of the chain pillar, goaf edge and sag subsidence used to predict the multi-panel subsidence. The adjustments have affected the previous subsidence values presented by +/- 200 mm (or +/- 15%).

The previously approved longwall predictions for LW30 to 31 are also presented in **Table 1** and taken from **DgS, 2021b**. It should be noted that the subsidence prediction XL4 had to be shifted towards the north to capture the maximum panel subsidence and resulted in a change in cover depth (and subsequently subsidence prediction for the same panel width).

Both sets of predictions indicate the final panel and chain pillar subsidence based on the assumption that approved LW32 will be extracted. It was apparent from the review of LW25 to 29 subsidence data that a super-panel subsidence profile was ‘unlikely’ to develop. It has therefore been necessary to include the final tilt predictions for LW31. First panel predictions for LW31 are presented as underlined values with final panel predictions thereafter. The final tilt predictions for LW31 and 32 were not provided in the previous assessment as it was considered the first panel predictions were adequate for an assumed ‘super-panel’ subsidence profile.

The predicted U95%CL subsidence effect contours for LW30 to LW31 are presented in **Figures 3a-c**. The mean contours are presented in **Figures 3d-f**.

Table 1 - Predicted Maximum Subsidence Effects for LW 30 to 31 (Panel Void Width W = 200 m)

LW Panel #	Panel Width W (m)	Cover Depth H (m)	W/H Ratio	Mining Height^ (T)	Chain Pillar Width w (m)	Massive Strata Unit Thickness t (m)	Unit y (m)	SRP	First S_{max} (m)		Final S_{max} (m)		Final Chain Pillar Stress (MPa) & FoS		Final Chain Pillar S_p (m)		Maximum Tilt T_{max} (mm/m)		Maximum Horizontal Tensile Strain* (mm/m)		Maximum Horizontal Compressive Strain* (mm/m)	
									m	*U95*	*m*	*U95*	*Stress*	*FoS*	*m*	*U95*	*m*	*U95*	*m*	*U95*	*m*	*U95*
LW31 Variation Predictions along Crossline XL 4 (see Figure 1a)																						
30	200	450	0.44	3.60	51	22	100	Low	0.44	0.63	1.04	1.24	47.5	1.21	0.77	0.85	**12**	19	**2**	3	2	**3**
31	200	490	0.41	3.60	53	19	100	Low	0.66	0.77	1.26	1.45	48.1	1.28	0.77	0.85	**4** **16**	6 25	**2** **3**	3 4	2 3	**3** **5**
LW31 Variation Predictions along Crossline XL 4a (see Figure 1a)																						
30	200	310	0.65	3.80	51	22	99	Low	1.03	1.26	1.30	1.53	28.7	2.00	0.43	0.53	**17**	26	**5**	8	6	**10**
31	200	335	0.60	3.60	53	30	97	Low	0.99	1.18	1.26	1.46	29.6	2.07	0.44	0.53	**11** **16**	17 25	**4** **4**	6 6	5 6	**8** **9**
Approved LW30 to 31 EP Predictions along Crossline XL 4 (see Figure 1a)																						
30	200	380	0.53	3.60	51	22	98	Low	0.57	0.77	1.01	1.21	40.0	1.44	0.90	1.05	**12**	18	**4**	6	5	**8**
31	200	450	0.44	3.60	53	19	97	Low	0.64	0.84	1.07	1.27	46.2	1.33	0.96	1.12	**6**	9	**3**	4	3	**5**
Approved LW30 to 31 EP Predictions along Crossline XL 4a (see Figure 1a)																						
30	200	310	0.65	3.80	51	11	98	Low	0.89	1.04	1.19	1.33	27.9	2.06	0.59	0.69	**15**	22	**5**	7	6	**9**
31	200	335	0.60	3.60	53	19	97	Low	0.78	0.91	1.08	1.22	29.6	2.08	0.62	0.72	**8**	12	**3**	5	5	**8**

^ - Roadway height = 3.5 m & pillar length (solid) l = 99 m. Unit y = distance to base of massive strata unit above the mine workings; SRP = refers to Subsidence Reduction Potential of the assumed strata unit for the purposes of subsidence prediction (Low, Moderate, High). * - 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; mean = average or mean prediction; U*95* = Upper 95% Confidence Limit or Credible-Worst Case prediction for smooth profiles. Tensile strains may also concentrate on the crests of steep slopes with compressive strains along the toe; underlined - first panel subsidence effects only; **Bold** - It is noted that the measured maximum tilt and tensile strains above LW 1-29 have been generally closer to the predicted mean values, whilst the compressive strains have generally matched the U95%CL predictions.

It is assessed that the predicted subsidence effects for the LW30 to 31 Variation are within 15% of the approved mining layout. The extent of subsidence effect has also been significantly reduced by the proposed shortening of LW31.

Specific predictions for the existing features within the project area are provided in the impact assessment section presented in **Section 5**.

5.0 Review of Predicted Subsidence Impacts on Surface Features within the Varied Extraction Plan Area for LW30 and 31

5.1 General

The proposed variation will reduce the extent of the previous subsidence effect predictions for the steep slopes 2a and 2b, as well as several rock-face features and the crown roads; see **Figures 2a** to **2c** (approved) and **Figures 3a** to **3c** (this variation).

Surface cracking and non-conventional subsidence impacts due to the approved LW30 to 31 Extraction Plan have been previously assessed in **DgS, 2021a** and have been reviewed in **Section 5.2** and **5.3**.

The impacts to the following features have also been re-assessed in **Sections 5.4 to 5.8** and compared to the approved predictions presented in the Extraction Plan Approval:

- House No.s 14, 34, 35 and 109
- Transgrid Towers
- Ausgrid Domestic Powerlines
- Kiar Ridge and Toepffers Road (Crown Roads)
- Aboriginal Heritage Sites

The sites assessed are those included within the 26.5^{o} angle of draw limits from the shortened LW30 and 31. The Transgrid Towers on TL24 and TL25/26 have been checked for far-field horizontal displacements and strains based on up-dated prediction models.

5.2 Surface Cracking Impacts

Based on the predicted tensile strains of 2 to 8 mm/m and compressive strains 2 to 10 mm/m, it is assessed that the likelihood and magnitude of surface cracking above LW30 to 31 is likely to range between 20 and 100 mm and within the previous ranges assessed and observed.

Cracks of up to 100 mm wide have been detected on the steep slopes and ridges above the longwall 25 and 26 to-date after subsidence of up to 1.2 m. Wider cracking may increase above the assessment area due to interaction of near surface topography and exposed Terrigal Sandstone Rock Features.

The predicted impacts to the steep slopes include:

- crack widths of 100 mm to 320 mm on steep slopes and ridges
- uplift and closure of between 20 mm and 100 mm in the central limits of the proposed longwalls or along creek beds with shallow bedrock exposures
- crack depths of between 5 m and 10 m in relatively flat terrain and up to 20 m on ridge crests in steep terrain.
- compressive strain peaks and resultant heaving / shearing is also likely to occur on the down-slope side of panels beneath steep slopes.

Impact management strategies will include visual inspections of subsided areas before and after the majority of active subsidence with remediation strategies assessed in accordance with the Land Management Plan (e.g backfilling with crushed rock or gravel).

5.3 Valley Closure Impacts (Non-conventional Subsidence)

Valley closure movements along water courses or along the crests of steep slopes that have been undermined may also see cracking due to ‘uplift’ or buckling of creek beds from compressive strain concentration. Minor valley closure impacts have only been detected once to-date above LW28b on a first order creek bed. Measured tensile and compressive strains ranged between +2 mm/m and -3.5 mm/m.

5.4 Residences

The final subsidence effect predictions at the houses due to the proposed mining layout for LW30 to 31 are summarised in **Table 3**.

The results presented in **Table 3** indicate that the maximum subsidence at the residences are predicted to range from 0.0 m to 0.40 m, with tilts ranging from 0 to 8.0 mm/m, hogging and sagging curvatures from 0.05 to 0.07 km^{-1} (radii of 20 km to 14 km), and tensile and compressive strains of 0.5 to 0.7 mm/m (including transient strains that may develop when a longwall passes below a given point on the surface).

Table 3 - Predicted Subsidence Effects* at Existing Residences above the Proposed Mine Plan for 30 to 31 (Variation)

House No.	LW #	Easting (m)	Northing (m)	Surface RL (AHD)	Final Subsidence S_{max}	Final Max Tilt T_{max} (mm/m)	Final Max Curvature C_{max} (km^{-1})	Final Max Strain E_{max} (mm/m)
Proposed LW30 to 31 Variation								
14	-	352155	6328537	60.80	0.0	0.0	0.0	0.0
34	>30	351853	6328268	69.30	0.03 - 0.070	0.0	0.0	0.0
35	31	351270	6328426	221.00	0.31 - 0.40	5.4 - 8.0	0.05 - 0.07	0.5 - 0.7 (1.5)
55	>30	351588	6327536	127.43	0.0	0.0	0.0	0.0
109	>31	351324	6329066	54.35	0.0	0.0	0.0	0.0
Approved LW 30 to 32 Extraction Plan								
14	-	352155	6328537	60.80	0.0	0.0	0.0	0.0
34	>30	351853	6328268	69.30	0.03 - 0.065	0.0	0.0	0.0
35	31	351270	6328426	221.00	0.31 - 0.39	5.4 - 7.6	0.1 - 0.14	1 - 1.4 (1.5)
55	>30	351588	6327536	127.43	0.01 - 0.04	0.0	0.0	0.0
109	>31	351324	6329066	54.35	0.0 - 0.04	0.0	0.0	0.0

* - Mean - U95%CL Values at Building Centre for Extraction Plan Longwalls. (brackets) - transitional subsidence effects for LW30 to 31; >30 = outside LW30 limits but within angle of draw.

The predicted subsidence effects have remained unchanged or increased slightly by < 5%. The management strategies presented in **DgS2021a** are still valid for the existing structures.

5.5 TransGrid Towers

The two 330kV transmission lines (TL) 25/26 and TL24 have four tension towers with high conductor angle changes that are potentially within the far-field zone of influence from the proposed longwalls 30 to 31. The new Towers 33X and 34X (TL24) and existing towers TL39 to 42 (TL25/26) have cruciform footings installed.

It is understood that TransGrid have nominated a tolerable leg spread of 10 mm for the towers (without cruciform footings). The tension tower legs are between 11.0 m and 12.86 m apart while the suspension tower legs are between 8.7 m and 10 m apart (side dimensions).

A summary of the credible worst-case (U95%CL) subsidence effect predictions for each tower due to the proposed Variation to LW30 and 31 are presented in **Tables 4A (TL25/26)** and **4B (TL24)**. The measured results for Tower 43 due to LW29 have been included in the predictions for LW30 and 31.

The results are derived from the subsidence contour predictions presented in **Figures 3a** to **3c**.

Table 4A - Final Subsidence Effects at the TransGrid Towers on Line 25/26 (Vales Point to Sydney West)

Tower #	Closest LW# (nearest distance relative to LW goaf limits)	Cover H (m) [x/H]	Final Tower Subs-idence S_{max} (m)	Max. Tilt T_{max} (mm/m)	Maximum Total Horizontal Displacement HD_{max} (mm)		Tower Horiz. Disp. MGA Grid Bearing (000°)	Maximum Horizontal Strain^ E_{max} (mm/m)		Tower Leg Spread* (mm)	
					Model 2	Model 3		Model 2	Model 3	Model 2	Model 3
Proposed Variations to LW30 and 31 Extraction Plan (Current Study)											
43	***LW29 (239 m N)***	***311 [0.77]***	***0.028***	***0.1***	***95***	***95***	***359 (NNW)***	***0.16***	**-**	***1.6 - 1.1***	***1.6 - 1.1***
43	**LW31 (465m SE)**	**311 [1.50]**	**0.035**	**0.4**	**86**	**115**	**020 (NNE)**	**0.45**	**0.36**	**2.6 - 5.1**	**1.9 - 3.8**
44	LW31 (486m SE)	432 [1.13]	0.000	0.0	58	**198**	153 (SE)	0.54	0.48	2.2 - 5.4	2.2 - 4.3
45	LW31 (555m SE)	471 [1.17]	0.000	0.0	59	**213**	079 (ENE)	0.68	0.49	3.4 - 6.7	2.4 - 4.8
46	**LW31 (804m ESE)**	412 [1.95]	**0.000**	**0.0**	**17**	**140**	**064 (NE)**	**0.19**	**0.15**	**0.9 - 1.8**	**0.8 - 1.5**
47	LW31 (1167 m NE)	403 [2.9]	0.000	0.0	5	**97**	054 (NE)	0.1	**0.04**	0.5 - 0.9	0.2 - 0.3
Approved LW30 to LW31 Extraction Plan Variation (DgS, 2021a)											
43	**LW29 (239 m N)**	**311 [0.77]**	**0.020**	**0.3**	**69**	**N/A**	**359 (NNW)**	**0.67**	**N/A**	**4.6 - 7.9**	**N/A**
43	**LW31 (468m SE)**	**311 [1.50]**	**0.035**	**0.4**	**61**	N/A	**020 (NNE)**	**0.68**	N/A	**4.7 - 8.0**	N/A
44	LW31 (486m SE)	432 [1.13]	0.000	0.0	58	N/A	120 (SE)	0.54	N/A	2.2 - 5.4	N/A
45	LW31 (491m SE)	471 [1.04]	0.000	0.0	71	N/A	120 (SE)	0.64	N/A	2.5 - 6.4	N/A
46	**LW31 (492m ESE)**	412 [1.19]	**0.000**	**0.0**	**50**	N/A	**100 (SSE)**	**0.57**	N/A	**2.7 - 6.8**	N/A
47	LW31 (647m NE)	403 [1.58]	0.000	0.0	23	N/A	060 (NE)	0.32	N/A	1.0 - 3.2	N/A

Bold - Tension Tower; *italics* - measured values at Tower 43 due to LW29; x = normal distance to LW rib side or end centre point; ^ - Maximum strain refers to major principal strain (U95%CL contours) and is aligned with tower sides. Maximum tensile strain is positive and includes far-field affects. Minor principle strain = -0.25 x major principle strain; * - Leg spread based on strain x distance between legs. Tower distances between legs vary between 12.86 m and 11.0 m for the tension towers and between 8.7 m and 10.0 m for the suspension towers; <u>Underlined</u> – Towers constructed on cruciform footings; Model 2 - Mandalong subsidence monitoring lines; Model 3 - Tower monitoring data; Predictions shown for multiple longwalls are the cumulative values for each tower.

Table 4B - Final Subsidence Effects at the TransGrid Towers on TL24 (Eraring to Vales Point)

Tower #	Closest LW #	Cover H (m) [x/H]	Final Tower Subs (m)	Maximum Tilt T_{max} (mm/m)		Maximum Horizontal Displacement HD_{max} (mm)		Tower Horiz. Disp. MGA Grid Bearing (000°)	Maximum Horizontal Strain^ E_{max} (mm/m)		Tower Leg Spread* (mm)	
				Tran-sient	Final	Model 2	Model 3		Model 2	Model 3	Model 2	Model 3
Proposed LW30 to LW31 Extraction Plan Variation												
<u>34X</u>	**30 (307m W)**	**330 [0.93]**	**0.00**	**0**	**1.0**	**58**	**164**	**270 (W)**	**0.62**	**0.47**	**3.5 - 7.4**	**2.3 - 5.5**
<u>33X</u>	**30 (560 W)**	**369 [1.52]**	**0.00**	**0**	**0**	**29**	**147**	**262 (WSW)**	**0.37**	**0.24**	**2.2 - 4.4**	**0.7 - 2.9**
Approved LW30 to LW31 Extraction Plan												
<u>34X</u>	**30 (307m W)**	**330 [0.93]**	**0.00**	**0**	**1.0**	**58**	**N/A**	**270 (W)**	**0.62**	**N/A**	**3.5 - 7.4**	**N/A**
<u>33X</u>	**30 (560 W)**	**369 [1.52]**	**0.00**	**0**	**0**	**29**	**N/A**	**262 (WSW)**	**0.37**	**N/A**	**2.2 - 4.4**	**N/A**

Bold - Tension Tower; *italics* - measured values at Tower 43 due to LW29; x = normal distance to LW rib side or end centre point; ^ - Maximum strain refers to major principal strain (U95%CL contours) and is aligned with tower sides. Maximum tensile strain is positive and includes far-field affects. Minor principle strain = -0.25 x major principle strain; * - Leg spread based on strain x distance between legs. Tower distances between legs vary between 12.86 m and 11.0 m for the tension towers and between 9.5 m and 10.0 m for the suspension towers; <u>Underlined</u> – Towers constructed on cruciform footings; Model 2 - Mandalong subsidence monitoring lines; Model 3 - Tower monitoring data; Predictions shown for multiple longwalls are the cumulative values for each tower.

The assessment of subsidence effect predictions for the TransGrid towers within the assessment area is summarised below:

<u>TL25.26 (Towers 38 to 47)</u>

- One tension tower (Tower 43) along TL25.26 has a 33° conductor angle deviation and is located outside of the 26.5° angle of draw from LW29 and LW31. Tower 43 is assessed to have cumulative tensile strains after LW31 ranging from 0.36 to 0.45 mm/m with a maximum leg spread of 4.3 mm to 5.4 mm, based on Models 3 and 2 respectively. Final Subsidence is predicted to be 35 mm with tilt of 0.4 mm/m (ENE) and horizontal displacement between 86 mm and 115 mm.

- One tension tower (Tower 46) along TL25.26 has a 0° conductor angle deviation and is also located outside of the 26.5° angle of draw from LW31. Tower 46 is assessed to have cumulative tensile strains after LW31 ranging from 0.15 to 0.19 mm/m with a maximum leg spread of 1.5 mm to 1.8 mm, based on Models 3 and 2 respectively. Final Subsidence is predicted to be 0 mm with tilt of 0.0 mm/m and horizontal displacement towards the NE between 17 mm and 140 mm.

- There are three (3) suspension towers (44, 45 and 47) located outside the 26.5° angle of draw or 1.1 to 2.9 x cover depth (H) to the west and south west of LW31. The towers are unlikely to be subsided or tilted but could move horizontally between 5 mm and 213 mm towards the goaf. Horizontal strains are predicted to range between 0.04 mm/m and 0.68 mm/m with a maximum leg spread of 0.3 mm to 6.7 mm.

TL24 (Towers 34X & 33X)

- There are two (2) tension towers located outside the 26.5^{o} angle of draw or 0.9 to 1.5 x cover depth (H) to the east of LW30. Maximum far-field displacements of 29 mm to 164 mm to the west are predicted with strains between 0.24 mm/m and 0.62 mm/m. Maximum tower leg 'spread' estimated to range between 2.9 mm and 7.4 mm (without cruciforms).

The results indicate lower tower strain predictions for Towers 43 to 47 (TL25/26) than the previous extraction plan due to their greater set-back distances from LW31. Model 3 strain predictions are also lower than Model 2 due to the higher accuracy of strain measurement technique at the Towers (i.e. calibrated steel band v. GPS).

The overall conclusion of the analysis is that cruciform footings are unlikely to be required before LW30 and 31 are extracted. Monitoring of the towers and review of the measured leg spreads should continue for LW30 and 31 as defined in the Built Features Management Plan.

5.6 Ausgrid Domestic Power Lines

The U95%CL subsidence effect predictions at fourteen (14) Ausgrid timber power poles near or above the proposed longwalls 30 to 31 are shown in **Table 5A**. The approved subsidence effects for the LW30 to 31 Extraction Plan are shown in Table 5B. The predictions are based on the U95%CL contours presented in **Figures 3a-c**.

Table 5A - Worst-Case Final Subsidence Effect Predictions for Ausgrid Power Poles above Proposed LW30 to 31

Pole No.	Easting (m)	Northing (m)	Final Subsidence (m)	Final Tilt (mm/m)	Final Ground Strain^{+} (mm/m)	Pole Base Displacement* (mm)	Pole Movement Direction (o)
Proposed LW30 to 31 Effects							
1	352108	6328379	0.00	0.0	0.1	4	296
2	352112	6328558	0.02	0.5	0.1	10	297
3	351463	6328840	0.22	6.8	2.8	136	280
4	351737	6328714	1.33	17.0	-5.5 (1.5)	340	118
5	351935	6328407	0.07	0.9	0.2	18	295
6	352021	6328395	0.02	0.8	0.1	16	298
7	351873	6328319	0.07	0.7	0.0	14	324
8	351406	6328616	0.67	12.0	-0.5 (1.5)	240	122
9	351328	6328484	0.49	9.0	-0.1 (1.5)	180	172
10	351162	6328954	0.00	0.0	*0.5*	*20*	120
11	351037	6328964	0.00	0.0	*0.5*	*20*	120
12	350892	6328932	0.00	0.0	*0.5*	*20*	120
13	350680	6328911	0.00	0.0	0.0	0	-
14	350531	6328896	0.00	0.0	0.0	0	-

Table 5B - Worst-Case Final Subsidence Effect Predictions for Ausgrid Power Poles above Approved LW30 to 31

Pole No.	Easting (m)	Northing (m)	Final Subsidence (m)	Final Tilt (mm/m)	Final Ground Strain+ (mm/m)	Pole Base Displacement* (mm)	Pole Movement Direction (o)
Approved LW30 to 31 Effects in Extraction Plan							
1	352108	6328379	0.00	0.2	0.1	4	296
2	352112	6328558	0.03	0.9	0.1	17	297
3	351463	6328840	0.20	6.8	3.2	136	280
4	351737	6328714	1.20	11.3	-5.5	226	118
5	351935	6328407	0.06	0.7	-0.2	13	295
6	352021	6328395	0.03	0.9	0.1	18	298
7	351873	6328319	0.06	0.3	0.0	5	324
8	351406	6328616	0.55	10.6	-0.5	212	122
9	351328	6328484	0.47	9.0	0.5	180	172
10	351162	6328954	0.02	0.0	*0.5*	*20*	120
11	351037	6328964	0.00	0.0	*0.5*	*20*	120
12	350892	6328932	0.00	0.0	*0.5*	*20*	120
13	350680	6328911	0.00	0.0	0.0	0	-
14	350531	6328896	0.00	0.0	0.0	0	-

+ - Tensile and compressive phases may occur during subsidence development. *italics* - far-field displacements & strains; (brackets) - transient strain; * - pole base displacement = 20 x tilt.

The predicted Final U95%CL subsidence for the poles above LW30 and 31 in **Table 5A** range between 0.0 m and 1.33 m with tilts ranging from 0 mm/m to 17 mm/m and strains from -5.5 mm/m (compressive) and 2.8 mm/m (tensile). Horizontal displacement of the pole bases is estimated to range from 0 mm to 340 mm after mining is complete.

Higher subsidence effects were assessed at some pole locations for the proposed mine plan change and is due to the modifications recently made to the prediction model and observed subsidence development over LW25 to 29.

The conductors between the poles may experience lengthening and/or shortening due to the pole tilts, which may result in conductor clearance losses. It is considered ‘very unlikely’ that the poles will be impacted by surface strains due to the low level of cracking observed to-date.

Monitoring of the poles and review of the surface impacts should continue for LW30 and 31 as defined in the Built Features Management Plan.

5.7 Public Roads (Crown and Private Access Driveways)

There are two public unsealed Crown roads (Toepfers Road and Kiar Ridge Road) present within the study area (see **Figure 1a**). The roads are unsealed with reinforced concrete pipe culverts at watercourse crossings. There are also several unsealed, gravel fire trails and private access roads.

The current condition of the roads and culverts has been assessed as good by mine site representatives.

A summary of the predicted subsidence effects acting on the roads due to the proposed longwalls are presented in **Table 6**.

Table 6 - Summary of Worst-Case Subsidence Predictions for Roads above the Proposed LW30 to 31 (U95%CL)

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)
Proposed LW30 to 31 Variations					
Kiar Ridge	30 - 31	0.02 to 0.05	0 to 2	0 to 1	**0**
Toepfers	30 - 31	0.23 to 1.02	10 to 13	2	**3**
Approved LW30 to 31 Extraction Plan					
Kiar Ridge	30 - 31	1.16	13	3	4
Toepfers	30 - 31	1.08	13	3	4

* - Tensile and compressive strains may be increased by 2 times occasionally due to crack development.

The predicted maximum subsidence effects for the roads have decreased slightly compared to the Approved Extraction Plan.

The impacts due to the predicted subsidence effects for proposed LW30 to 31 may include:

- Tensile crack widths of between 1 mm & 20 mm.
- Compressive shearing or heaving between 10 mm & 30 mm.
- Increase of super-elevation in the road of 0% to 1.3%.
- Minor cracking of culverts and fill embankments due to curvatures of +/- 0.05 to 0.3 km^{-1} (radius of curvature from 3.3 km to 20 km)

The subsidence impacts predicted for the proposed mining layout for LW30 to 31 are consistent with the approved mining layout predictions given in the Approved Extraction Plan.

Current impact management strategies for the roads will remain unchanged.

5.7 Aboriginal Heritage Site Impacts

5.7.1 Potential Impact Assessment Criteria

The likelihood of damage occurring at the heritage sites has been assessed based on the following impact parameter criteria (see **Table 7A**). The criteria consider the theoretical cracking limits of rock of 0.3 to 0.5 mm/m and the 'system' slackness or strain 'absorbing' properties of a jointed, thinly bedded and highly weathered rock mass during subsidence deformation. The lack of measured observed impact (surface cracking) due to measured strains of up to 3 mm/m above the Mandalong Mine is an example of the difference between theoretical and in-situ rock mass cracking behaviour.

The condition of the rock mass (strength/jointing and bedding) and the dimensions / orientation of the grinding groove sites and rock shelters have now been factored into the potential impact assessment for individual sites, based on the methodology presented in **Shepherd and Sefton, 2001**.

Table 7A – Impact Potential Criteria for Aboriginal Heritage Sites

Cracking Damage Potential - Indicative Probabilities of Occurrence	**Predicted 'smooth profile' Horizontal Strain (mm/m)**	
	Tensile^	**Compressive^**
Very Unlikely (<5%)	< 0.5	< 2
Unlikely (5 - 10%)	0.5 - 1.5	2 - 3
Possible (10 - 50%)	1.5 - 2.5	3 - 5
Likely (>50%)	> 2.5	> 5
Erosion Damage Potential - Indicative Probabilities of Occurrence	**Predicted Surface Gradient Change or Tilt Increase**	
Very Unlikely (<5%)	<0.3% (< 3 mm/m)	
Unlikely (5 - 10%)	0.3-1% (3 - 10 mm/m)	
Possible (10 - 50%)	1-3% (10 - 30 mm/m)	
Likely (>50%)	>3% (>30 mm/m)	

^ - transient strains originally not included in the assessment of cracking likelihood due to the apparent lack of cracking impact to natural features above LW 1-24a for tensile strains up to 3 mm/m and compressive strains of up to 6 mm/m. However, cracking has developed on ridges during subsidence development above LW25b that suggests cracking may have developed where strains exceeded 1.5 mm/m.

The 'Cracking Damage Potential' is considered the primary damage potential indicator and the 'Erosion Damage Potential' is an additional, secondary criterion that is relevant to features exposed to concentrated water flows along creeks or sites that have been damaged by cracking. Therefore, for the cases where cracking is deemed 'likely' at a site, the potential for erosion damage will also be considered 'likely'. The same logic also applies to 'possible' cracking impact sites.

5.2.2 Predicted Impacts

The predicted subsidence impacts at each feature are based on U95%CL tilts and strains and summarised in **Table 7B** and taken from contours shown in **Figures 4a** to **4c**.

Several strain mitigating (reducing) effects have also been identified during the site inspections and noted where relevant below the potential impact assessment. Where these conditions are present the predicted impact potential has been decreased by one category (i.e. a ‘likely’ strain impact is decreased to a ‘possible’ impact).

The mitigating features for grinding groove sites in order of strain isolating effectiveness are:

- the grooves are located on a loose boulder.
- the grooves are located on an elevated sandstone ledge within the creek bed and ‘open’ on one side sub-parallel to the creek centreline.
- the grooves are located between persistent orientated joints that are likely to open or shear before buckling or fresh cracking occurs.

Where jointing or open-ledge ends are not present the groove sites are considered to be “locked” into the rock mass and vulnerable to ground strains.

Based on thirteen subsided rock shelter cases presented in **Shepherd and Sefton, 2001**, it is assessed that the mitigating features for rock shelter sites at Mandalong of strain isolating effectiveness (in descending order) are:

- the shelters have been formed in large boulders and have soil foundations.
- the shelter overhangs are supported on three sides (i.e. cavernous) and less likely to collapse than single-sided shelters (i.e. blocky overhangs).
- the shelters are not directly located above longwall ribs.
- the longwall retreat directions are face-on or end-on with the long-axis of the shelter, so the shear strains are minimised relative to half-on longwall directions.
- rock shelters are typically ‘dry’.

Shepherd and Sefton, 2000 indicate that ‘rock shelters with art’ on the back walls are vulnerable to damage where compressive strains may concentrate and cause spalling damage. Shearing may develop in the weaker sandstone beds at the back of a shelter where stress notches are likely to occur from both natural weathering processes as well as mine subsidence deformation.

Table 7B - Predicted Subsidence Impacts due to the Proposed Variation to LW30 - 31 at Aboriginal Heritage Sites

Site Name	AHIMS No.	Site Type	Groove Site Plan Dimensions or Shelter Span (m)	Final Subsidence (m)	Final Horizontal Strain (mm/m)^	Cracking Damage Potential	Final Tilt (mm/m)	Erosion Damage Potential
RPS PS25	45-3-3511	Artefact Scatter	<0.05	0.93	-3.4 (1.5)	Unlikely [isolated objects]	0.6	V. Unlikely
RPS TBM29	45-3-3536		<0.05	0.01	0.2	V. Unlikely	0.4	V.Unlikely
Morans Ck	45-3-1223		N/A	0.00	0.6	Unlikely	0.5	V. Unlikely
Buttonderry Creek	45-3-1226	Grinding Groove	N/A	0.0	0.6	V. Unlikely	0.0	V. Unlikely
MS10-GG-1	*45-3-4548*		*3 x 7*	*0.0*	*0.0*	*V. Unlikely*	*0.0*	*V. Unlikely*
MS10-GG-2	*45-3-4549*		*1 x 1*	*0.0*	*0.0*	*V. Unlikely [open sided]*	*0.0*	*V. Unlikely*
MS10-GG-3	*45-3-4550*		*0.4 x 0.4*	*0.0*	*0.0*	*V. Unlikely [loose boulder]*	*0.0*	*V. Unlikely*
MS9-GG-1	*45-3-4551*		*1 x 1*	*0.0*	*0.0*	*V. Unlikely [open sided]*	*0.0*	*V. Unlikely*
MS9-GG-2	45-3-4552		3 x 5	0.70	-0.7 (1.5)	Possible	5.6	Unlikely
MS9-GG-3	45-3-4545		1 x 3	0.35	3.6	Possible [open sided]	13.9	Possible
RPS CYL05	45-3-3492		3 x 5	0.04	0.9	Unlikely	2.1	V. Unlikely
RPS PS26	45-3-3512		2 x 3	0.03	0.7	Unlikely [between joints]	1.0	V. Unlikely
MS9-OH-1	*Not a site*	Rock Shelter	*3*	*0.0*	*0.0*	*V. Unlikely*	*0.0*	*V.Unlikely*
RPS PS01	45-3-3586		2	0.68	-0.4 (1.5)	V.Unlikely [loose boulder]	12.9	Possible [l. boulder]
RPS PS02	45-3-3639		3	0.24	1.7	Unlikely [between joints]	7.8	Unlikely
RPS PS03	45-3-3640		5	0.07	0.5	V. Unlikely	1.1	V. Unlikely
RPS PS04	45-3-3641		2.5	0.07	0.3	V. Unlikely	0.9	V. Unlikely
RPS PS05	45-3-3642		two caves 1.5 & 2	0.20	1.6	Unlikely [between joints]	6.2	Unlikely
RPS PS27	45-3-3594		5	0.0	0.0	V. Unlikely	0.0	V. Unlikely
RPS PS29	45-3-3595		5	0.0	0.3	V.Unlikely	0.3	V.Unlikely
Morans Creek	45-3-1228	Rock Shelter with Art	5	0.03	0.1	V. Unlikely [loose boulder]	0.8	V. Unlikely
RPS PS28	45-3-3513	Rock Shelter with PAD	7	0.0	0.0	V.Unlikely	0.0	V. Unlikely
RPS PS32	45-3-3514		25	0.0	0.1	V. Unlikely	0.2	V. Unlikely
MS9-RS-1	*45-3-4547*		*4*	*0.0*	*0.0*	*V. Unlikely*	*0.0*	*V. Unlikely*
MS9-RS-2	45-3-4546		5	0.04	0.0	V. Unlikely [loose boulder]	0.9	V. Unlikely
MS9-RS-3	45-3-4544		5	0.02	0.1	V. Unlikely [loose boulder]	0.6	V. Unlikely

^ - Tensile strain is positive; (brackets) - transient or dynamic strains; V. Unlikely - Very Unlikely; [square brackets] - mitigating circumstances that are likely to isolate the feature from ground strains. **bold** - cracking and/or erosion impact assessed as 'likely'. Shaded - risk of impact has increased since the Mod 9 assessment; Underlined - the risk of impact has decreased since the Mod 9 Assessment; *italics* - site now not inside angle of draw from the proposed LW30 and 31.

The results for the proposed variation to LW30 and 31 in **Table 7B** have also been compared to the Approved Extraction Plan predictions presented in **Table 7C** and **Figures 5a** to **5c**.

Table 7C - Predicted Subsidence Impacts due to the Approved LW30 - 31 Extraction Plan at Aboriginal Heritage Sites

Site Name	AHIMS No.	Site Type	Groove Site Plan Dimensions or Shelter Span (m)	Final Subsidence (m)	Final Horizontal Strain (mm/m)^	Cracking Damage Potential	Final Tilt (mm/m)	Erosion Damage Potential
RPS PS25	45-3-3511	Artefact Scatter	<0.05	0.93	-3.4 (1.5)	Unlikely [isolated objects]	0.6	V. Unlikely
RPS TBM29	45-3-3536		<0.05	0.01	0.2	V. Unlikely	0.4	V.Unlikely
Morans Ck	45-3-1223		N/A	0.01	0.7	Unlikely	0.4	V. Unlikely
Buttonderry Creek	45-3-1226	Grinding Groove	Not found	0.58 (?)	1.2 (?)	Unlikely	10.0 (?)	Unlikely
MS10-GG-1	45-3-4548		3 x 7	0.03	0.0	V. Unlikely	0.3	V. Unlikely
MS10-GG-2	45-3-4549		1 x 1	0.03	0.0	V. Unlikely [open sided]	0.3	V. Unlikely
MS10-GG-3	45-3-4550		0.4 x 0.4	0.02	0.0	V. Unlikely [loose boulder]	0.3	V. Unlikely
MS9-GG-1	45-3-4551		1 x 1	0.24	1.1	Unlikely [open sided]	13.0	Possible
MS9-GG-2	45-3-4552		3 x 5	0.82	-1.0 (1.5)	Possible	6.7	Unlikely
MS9-GG-3	45-3-4545		1 x 3	0.38	4.6	Possible [open sided]	14.5	Possible
RPS CYL05	45-3-3492		3 x 5	0.05	1.3	Unlikely	2.4	V. Unlikely
RPS PS26	45-3-3512		2 x 3	0.03	0.7	Unlikely [between joints]	1.0	V. Unlikely
MS9-OH-1	**Not a site**	Rock Shelter	3	0.67	-2.0 (1.5)	Possible	4.5	*Unlikely*
RPS PS01	45-3-3586		2	0.53	0.1 (1.5)	V.Unlikely [loose boulder]	11.6	Possible [l. boulder]
RPS PS02	45-3-3639		3	0.20	2.3	Unlikely [between joints]	9.0	Unlikely
RPS PS03	45-3-3640		5	0.08	0.6	V. Unlikely	2.0	V. Unlikely
RPS PS04	45-3-3641		2.5	0.07	0.4	V. Unlikely	1.5	V. Unlikely
RPS PS05	45-3-3642		two caves 1.5 & 2	0.17	2.4	Unlikely [between joints]	8.5	Unlikely
RPS PS27	45-3-3594		5	0.01	0.05	V. Unlikely	0.1	V. Unlikely
RPS PS29	45-3-3595		5	0.61	-0.9 (1.0)	Unlikely	10.5	Possible
Morans Creek	45-3-1228	Rock Shelter with Art	5	0.04	0.0	V. Unlikely [loose boulder]	0.5	V. Unlikely
RPS PS28	45-3-3513	Rock Shelter with PAD	7	0.00	0.05	V.Unlikely	0.1	V. Unlikely
RPS PS32	45-3-3514		25	0.03	0.1	V. Unlikely	0.4	V. Unlikely
MS9-RS-1	45-3-4547		4	0.60	-1.5 (1.5)	Possible	5.6	*Unlikely*
MS9-RS-2	45-3-4546		5	0.04	0.0	V. Unlikely [loose boulder]	0.4	V. Unlikely
MS9-RS-3	45-3-4544		5	0.03	0.0	V. Unlikely [loose boulder]	0.4	V. Unlikely

^ - Tensile strain is positive; (brackets) - transient or dynamic strains; V. Unlikely - Very Unlikely;
* - see **Table 2A** for Impact Potential definitions. **bold** - cracking and/or erosion impact assessed as 'likely'. *italics* - erosion potential based on tilt may be increased to match cracking potential likelihood of 'likely' or 'possible'. Mitigating circumstances due to natural jointing and bedding due to recent inspections of the sites are not included in this table.

The proposed variation to LW31 has reduced the number of AHIMS registered sites from 25 to 20. The sites now precluded from the Extraction Plan include four grinding grooves and one Rock Shelter with PAD.

The assessed risk of cracking impact to the twenty registered sites within the 20 mm angle of draw due to the proposed LW30 to 31 are summarised below (in highest to lowest risk ranking order):

- Two Grinding Groove Sites (45-3-4552 & 45-3-4545) may 'Possibly' be impacted (10% - 50% probability).

- Two Grinding Groove Sites (45-3-3492 & 45-3-3512) are 'Unlikely' to be impacted (5% to 10% probability).

- Two Rock Shelters (45-3-3639 & 45-3-3642) are 'Unlikely' to be impacted (5% - 10% probability) due to favourable geometry/geology.

- Two Artefact Scatter sites (45-3-3511 & 45-3-1223) are 'Unlikely' to be impacted (5% - 10% probability).

- One Rock Shelter with Art (45-3-1228) and four with PAD (45-3-4546, 45-3-4544, 45-3-3513 & 45-3-3514) are 'Very unlikely' to be impacted (<5 % probability).

- One Grinding Groove Site (45-3-1226) is 'Very Unlikely' to be impacted (<5% probability).

- Five Rock Shelters (45-3-3586, 45-3-3594, 45-3-3640, 45-3-3641, 45-3-3595) are 'Very Unlikely' to be impacted (< 5% probability).

- One Artefact Scatter (45-3-3536) is 'Very Unlikely' to be impacted (<5% probability).

In terms or erosion damage potential due to high tilts (> 10 mm/m), there is one grinding groove site (45-3-4545) that may 'possibly' be damaged. There is also one rock shelter site (45-3-3586) that may 'possibly' be impacted by erosion due to high tilt (> 10 mm/m).

Compared to the previous impact assessment for the Extraction Plan (**Table 2C**), the results for the Proposed LW30 to 31 in **Table 2B** indicate the risk of potential cracking impact will not increase for any sites, decrease for one site and remain unchanged for nineteen sites as follows:

- One Grinding Groove sites (45-3-1226) will have the risk of cracking **decreased** from 'unlikely' or 'very unlikely' (from between 5% and 10% to < 10% probability).

The erosion potential is assessed to decrease from 'Unlikely' to 'Very unlikely' at one grinding groove site (45-3-1226) and from 'Possible' to 'Very Unlikely' for one rock shelter (45-3-3595).

Overall, it is assessed that the proposed Variation to LW30 to 31 Extraction Plan will have a **lower** risk of impact than the approved mining layout for LW30 to 31.

Impact management strategies for the above AHIMS sites have been developed as part of the Heritage Management Plan completed as part of the LW30-31 Extraction Plan. Based on the outcomes of this variation, no changes are required to these impact management strategies

5.2.3 Observed v. Predicted Impacts of Heritage Sites

Shepherd and Sefton, 2000 indicates that none of the shelters with spans up to 7 m or 8 m have collapsed after subsidence of 1.0 ~ 1.24 m, tilts of 2 to 8 mm/m and strains of +/- 1.6 to 1.75 mm/m (tensile & compressive).

It is assessed that the majority of the rock shelters at Mandalong have spans of < 8 m and could be subject to subsidence effects that are likely to be similar to the above cases. The likelihood that these rock shelters will collapse is assessed as ‘unlikely’. There is only one shelter (with PAD) that has a span of 25 m (45-3-3514) and is just inside the angle of draw to LW31. The magnitudes of predicted tilt (0.2 mm/m) and strain (0.1 mm/m) are very low and unlikely to impact the site.

Only two grinding groove sites and one rock shelter site have been directly undermined by LW28b at Mandalong Mine to-date. There have also been three grinding grooves outside of the extraction limits of LW25a but within the angle of draw; see **Figure 1b**.

A summary of the predicted v. measured strains and impacts at each site is summarised in **Table 8**.

Table 8 - Predicted v. Measured Subsidence Impacts at Heritage Sites To-date

Site	Type	LW#	Predicted Strain (mm/m)	Predicted Cracking Impact	Measured Strain (mm/m)	Observed Impacts	Comment
RPS DF03	GG	25a	1.0	Unlikely	<1	Nil	Observed outcome consistent with predictions
RPS PS11	GG	25a	1.0	Unlikely	<1	Nil	
RPS CYL07	GG	25a	1.0	Unlikely	<1	Nil	
RPS TBM31	GG	28b	-3.5 (1.5)	Possible	-3.5 to 1.5	Nil	
RPS TBM32	RS	28b	2.2	Possible	-3.5 to 1.5	Nil	
RPS TBM34	GG	28b	-3.0 (1.5)	Possible	-3.5 to 1.5	1 mm vertical crack sub-parallel to creek bed alignment (NE/SW) at existing NE/SW joint (pre-mining).	As above. Crack width tapers indicates buckling of rock ledge due to compressive valley closure strains. Grooves not damaged directly by crack.

GG = grinding groove site; RS = Rock Shelter

The results of the impact review after mining indicates the assessment methodology for the heritage sites is reliable and does not require adjustment of cracking threshold strains at this stage.

6.0 Conclusions

It is assessed that the predicted subsidence effects and potential impacts to natural and built features due to the proposed mining layout variation to LW31 are likely to be similar to the previously assessment presented for the Approved Extraction Plan (refer to **DgS, 2021a**).

The overall extent of subsidence and impact will be decreased.

No changes to proposed management strategies for the surface features assessed are therefore considered necessary due to the proposed mining layout or subsidence prediction model changes.

For and on behalf of
Ditton Geotechnical Services Pty Ltd

Steven Ditton
Principal Engineer and Director
BE(Civil/Hons) C.P.Eng(Civil), M.I.E.(Aust); MAusIMM
NPER 342140; MN318977

Attachments:

Figures 1a to 5c

References:

DgS, 2013. **Subsidence Predictions and General Impact Assessment for the Mandalong Southern Extension Project** DGS Report No. MAN-001/1 (12/08/13)

DgS, 2018. **Subsidence Predictions and General Impact Assessment for LW25 to 31 at the Mandalong Mine**. DGS Report No. MAN-003/1 (31/07/18).

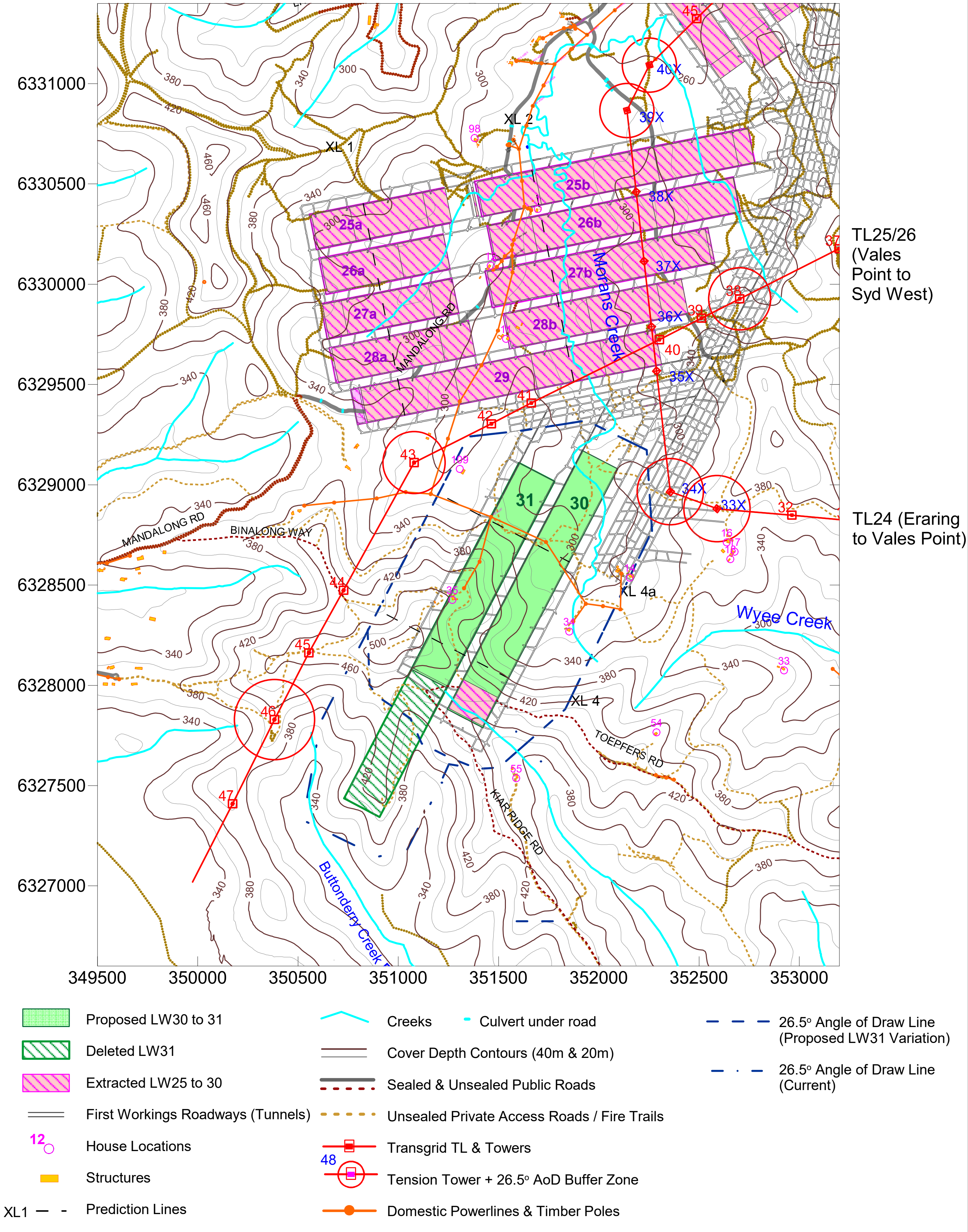
DgS, 2019. **Far-Field Movement Assessment for Proposed Upcast Ventilation Shaft to the East of LW28 and 29, Mandalong Mine** DGS Report No. MAN-004/1 (31/07/19).

DgS, 2021a. **Subsidence Predictions and General Impact Assessment for LW30 to 31 Extraction Plan at the Mandalong Mine**. DGS Report No. MAN-005/2 (15 April)

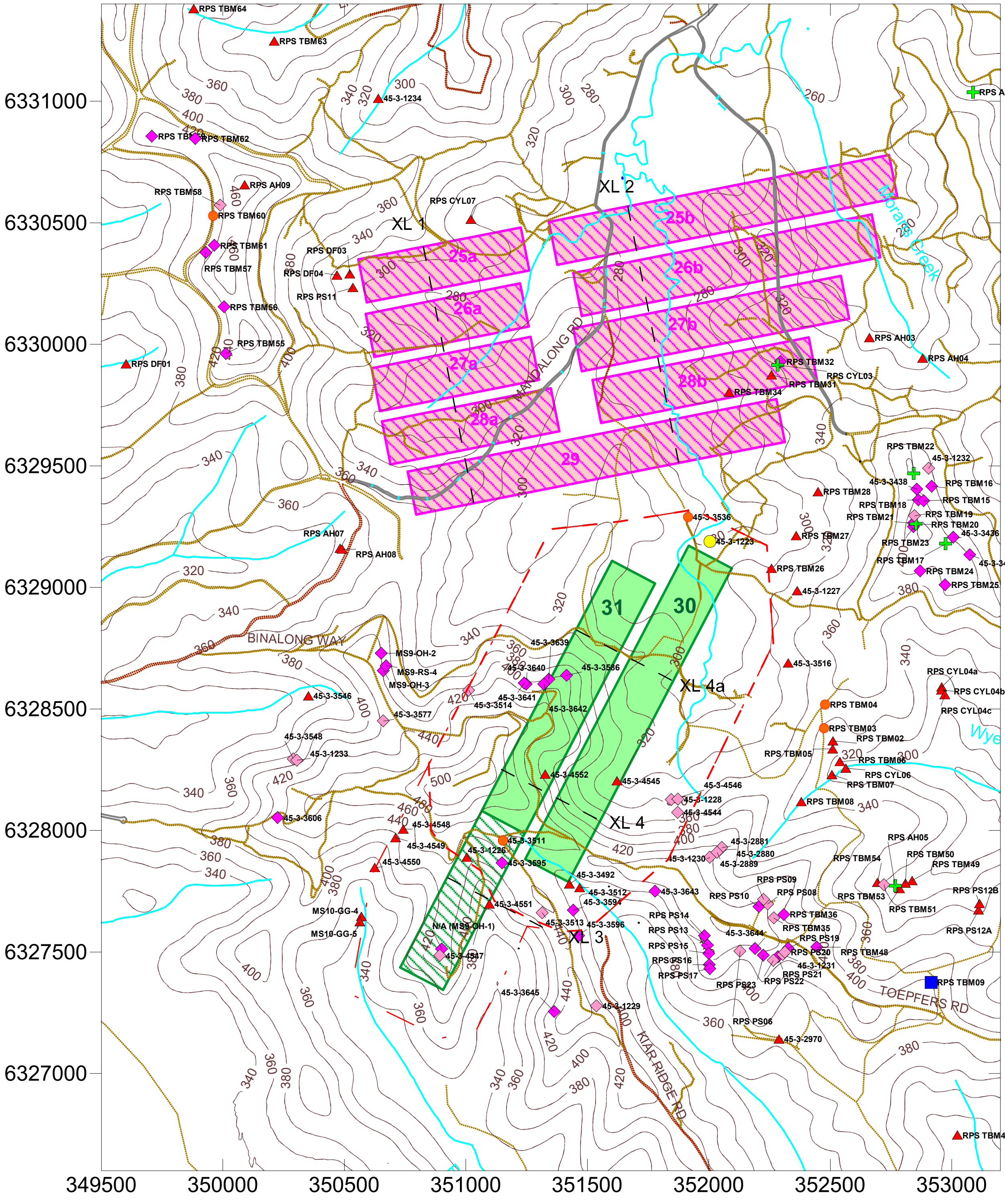
DgS, 2021b. **Subsidence Assessment for the Proposed Shortening of LW30 as a Variation to the LW30 & 31 Extraction Plan**. DgS Report No. MAN-005/8 (24 June).

DgS, 2021c. **Subsidence Assessment for the Proposed LW34 (Mod 10)**. DgS Report No. MAN-001/14 (15 July)

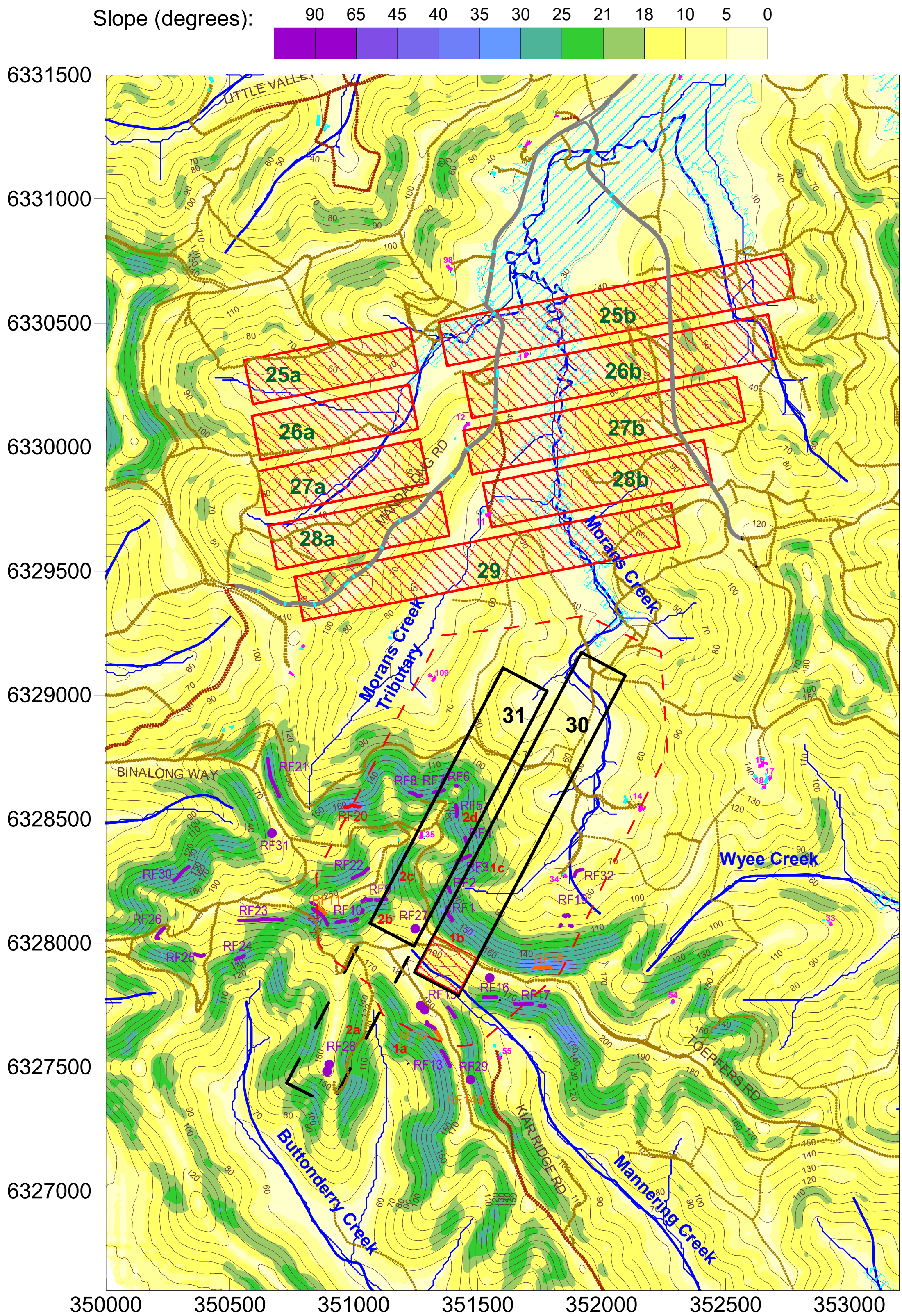
Shepherd and Sefton, 2001. **Subsidence Impact on Sandstone Cliff Rock Shelters in the Southern Coalfield, New South**. Proceedings of 5th Triennial Conference of Mine Subsidence Technological Society.



DgS	Engineer:	S.Ditton	Client:	Centennial Mandalong MAN-005/10
	Drawn:	S.Ditton	Title:	Cover Depth Contours & Built Features above the Proposed Variation to LW31 at the Mandalong Mine
	Date:	12.09.21		
Ditton Geotechnical Services Pty Ltd			Scale:	1:25,000 (A4)
			Figure No:	1a



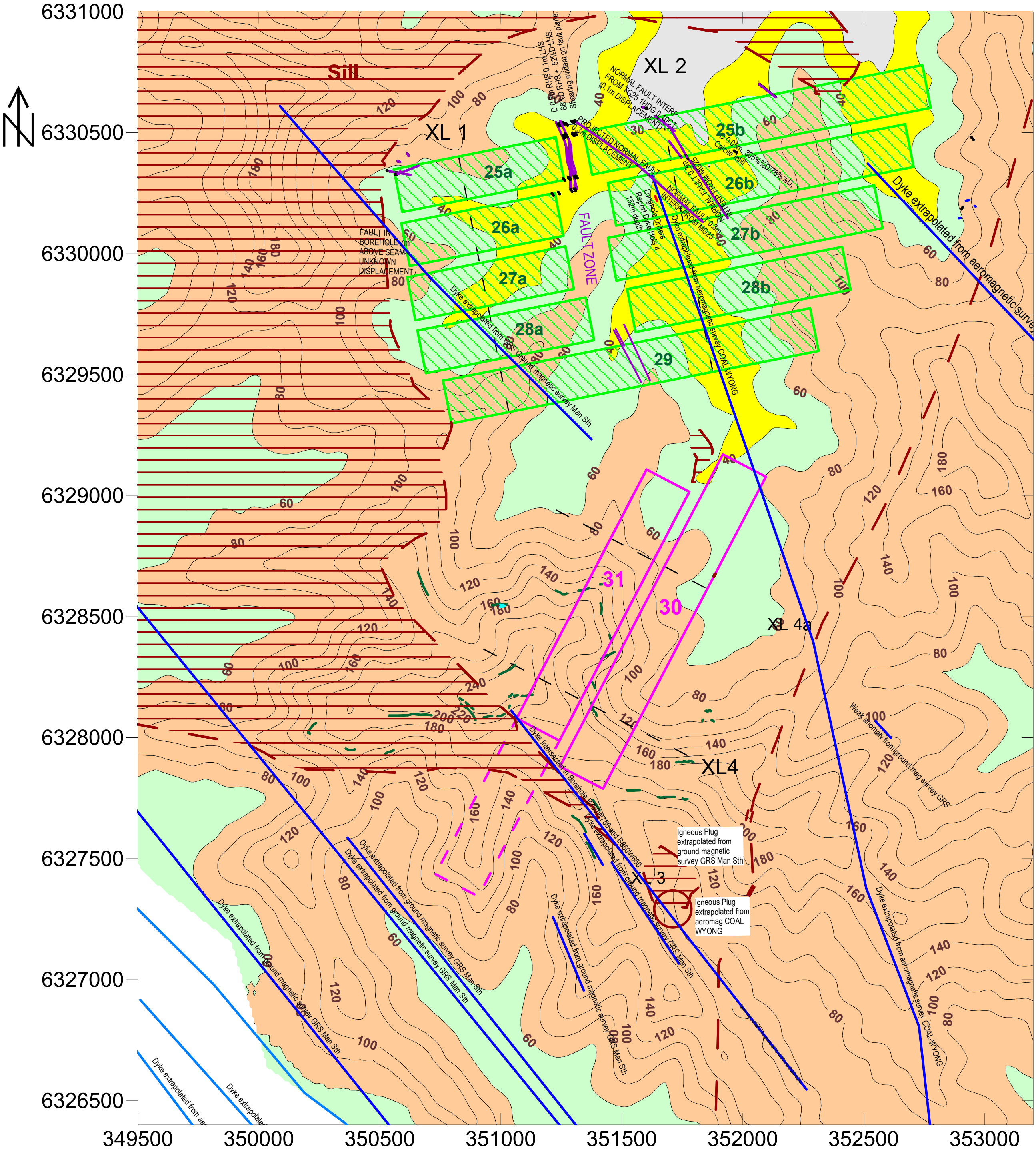
DgS Ditton Geotechnical Services Pty Ltd				
Engineer:	S.Ditton	Client:	Centennial Mandalong MAN-005/10	
Drawn:	S.Ditton			
Date:	10.09.21	Title:	Cover Depth and Aboriginal Artefact Sites above Proposed Variation to Longwall 31 at the Mandalong Mine	
		Scale:	1:25,000 (A4)	Figure No: 1b



Deleted Section for LW31	Pre-mining Levels (AHD)
Proposed LW30 - 31	Creeks & Tributaries
Extracted Longwalls	1 in 100 Year Flood Limit
Sealed Roads	Unsealed Roads/Tracks
Culverts	35 House No.

RF20	Rock Faces 10 m to 20 m high
RF11	Rock Faces 5 m to 10 m high
RF1	Rock Faces < 5m high
	Boulders < 5 m high
1a - 2c	Steep Slope No.
	26.5° Angle of Draw

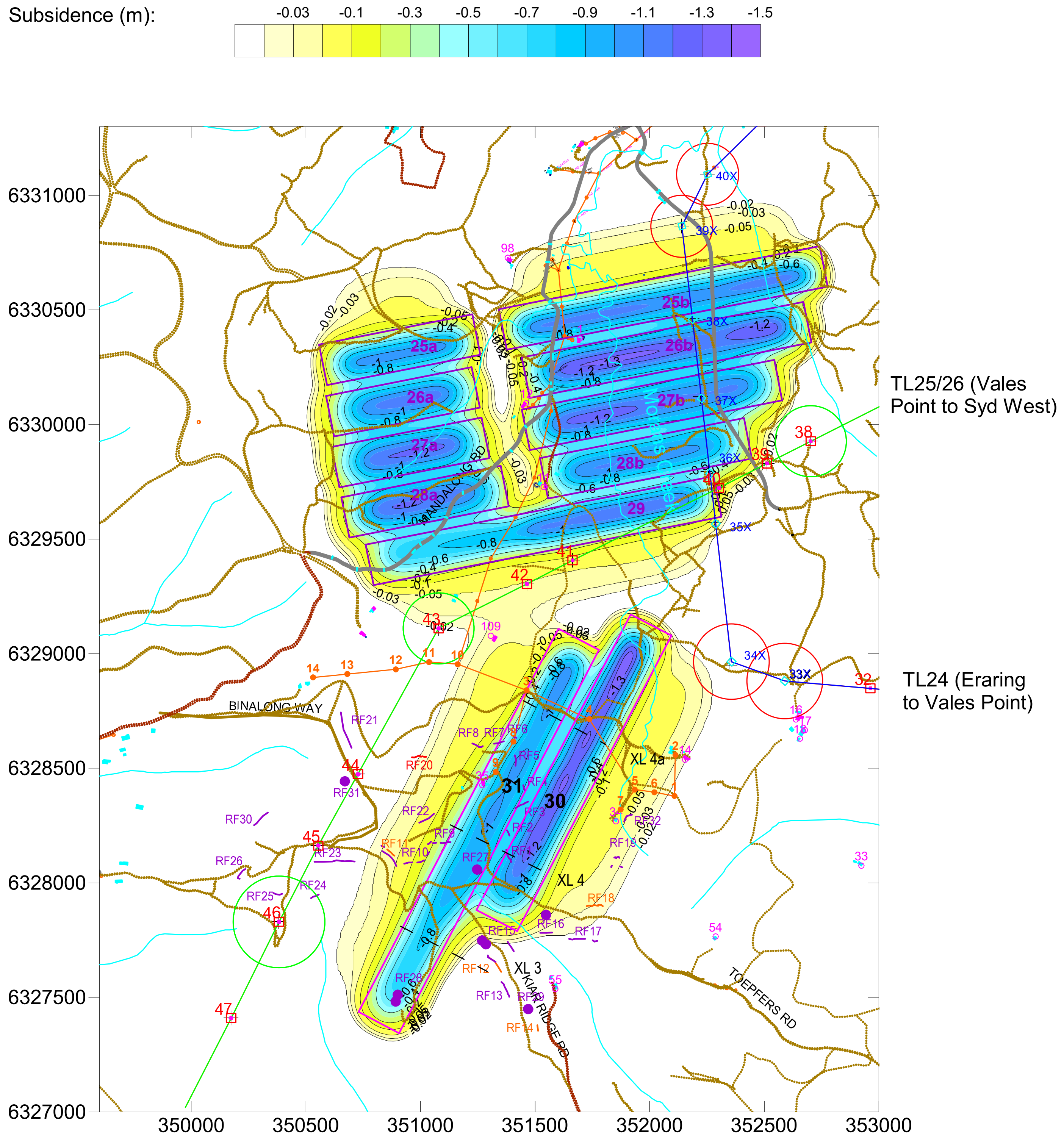
DgS				
	Engineer:	S.Ditton	Client:	Centennial Mandalong MAN-005/10
	Drawn:	S.Ditton		
	Date:	12.09.21	Title:	Pre-mining Surface Levels & Natural Features above the Proposed Variation to Longwall 31 at the Mandalong Mine
	Ditton Geotechnical Services Pty Ltd		Scale:	1:25,000 (A4)
			Figure No:	1c



Key:

Terrigal Formation - Sandstone,Conglomerate,Mudstone (60:30:10)	Seam Split Line
Patonga Claystone Formation - Sandstone:Mudstone (50:50)	Rock Faces (3 m to 15 m high)
Tuggerah Formation - Sandstone: Mudstone (70:30)	Surface Levels (m, AHD)
Quarternary Alluvium	XL1 Prediction Cross Lines
Dykes / Diatremes (known & Aeromagnetic survey interpretation)	Deleted LW31
Normal Faults (known or extrapolated)	Extracted Longwalls
Igneous Sill Intrusion Limits	Proposed LW30 to 31

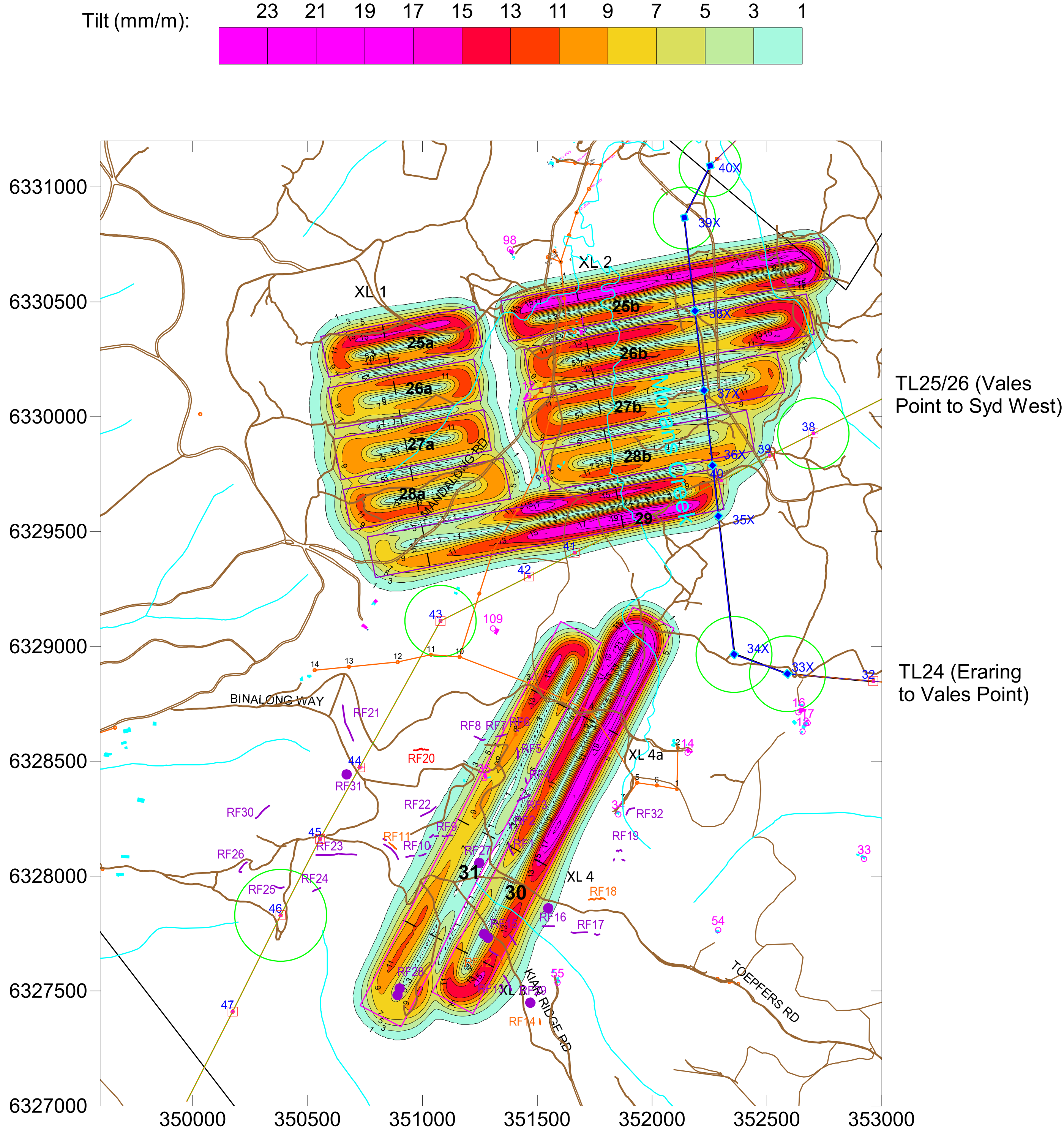
DgS Ditton Geotechnical Services Pty Ltd	Engineer: S.Ditton Drawn: S.Ditton Date: 12.09.21	Client:	Centennial Mandalong MAN-005/10
		Title:	Known/indicative Surface Lithology and In-Seam Geological Structure influencing the Proposed Longwalls 30 to 31 Variation at the Mandalong Mine
		Scale:	1:20,000 (A4) — Figure No: 1d



Key:

Proposed Longwall Panel Limits	
Approved Longwalls in Extraction Plan	
Creeks	
Roads	
10	Houses
32	TransGrid Transmission Lines & Towers
	26.5 degree AoD "buffer zones" for Tension Towers
12	Domestic Powerlines & Poles
XL4	Prediction Lines
RF20	Rock Faces 10 m to 20 m high
RF11	Rock Faces 5 m to 10 m high
RF1	Rock Faces < 5m high
	Boulders < 5 m high

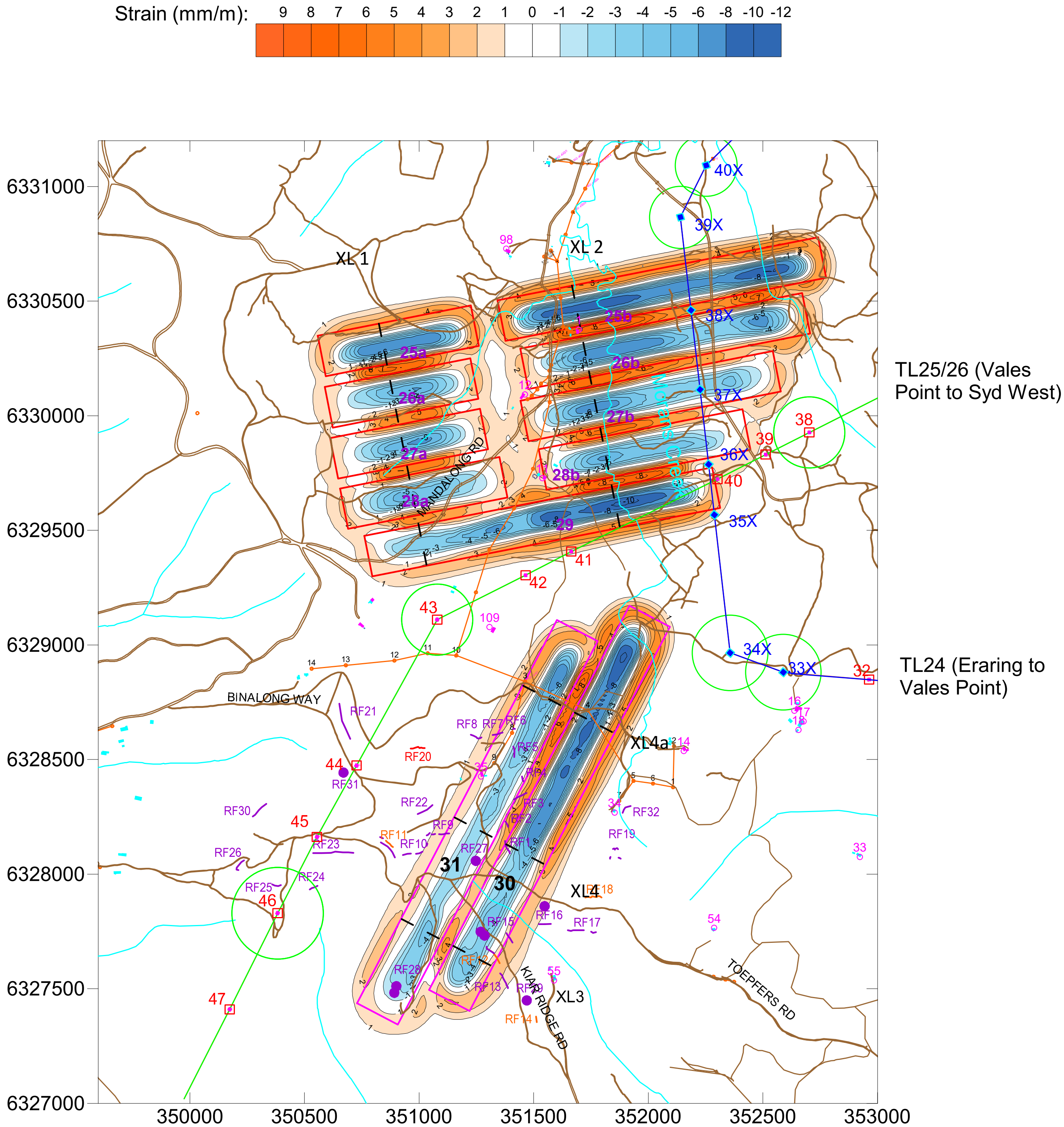
DgS Ditton Geotechnical Services Pty Ltd	Engineer: S.Ditton	Client:	Centennial Mandalong MAN-005/10
	Drawn: S.Ditton	Title:	Predicted Final Subsidence Contours (U95%CL) for the Proposed Longwalls 30 to 31 in the Extraction Plan
	Date: 11.12.20	Scale:	1:25,000 (A4)
		Figure No:	2a



Key:

- Proposed Longwall Panel Limits
- Approved Longwalls in Extraction Plan
- Creeks
- Roads
- 10 ○ Houses
- 32 TransGrid Transmission Lines & Towers
- 26.5 degree AoD "buffer zones" for Tension Towers
- Domestic Powerlines & Poles
- XL4 — — Prediction Lines
- RF20 Rock Faces 10 m to 20 m high
- RF11 Rock Faces 5 m to 10 m high
- RF1 Rock Faces < 5m high
- Boulders < 5 m high

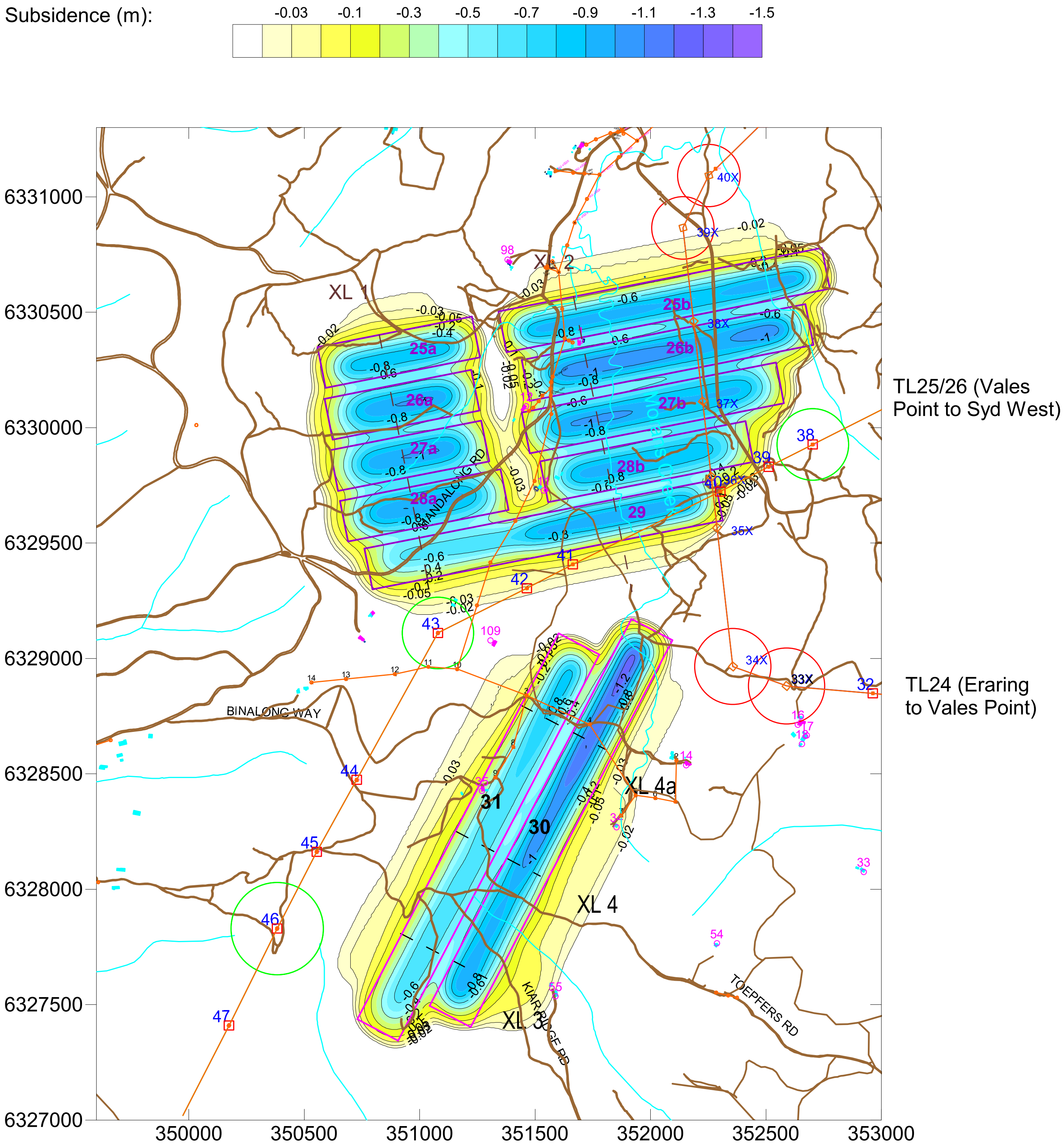
DgS Ditton Geotechnical Services Pty Ltd	Engineer:	S.Ditton	Client:	Centennial Mandalong MAN-005/10		
	Drawn:	S.Ditton				
	Date:	10.11.20	Title:	Predicted Final Tilt Contours (U95%CL) for the Proposed Longwalls 30 to 31 in the Extraction Plan		
			Scale:	1:25,000 (A4)	Figure No:	2b



Key:

Proposed Longwall Panel Limits	
Approved Longwalls in Extraction Plan	
Creeks	
Roads	
10 ○ Houses	
32 TransGrid Transmission Lines & Towers	
26.5 degree AoD "buffer zones" for Tension Towers	
Domestic Powerlines & Poles	
XL4 Prediction Lines	
RF20 Rock Faces 10 m to 20 m high	
RF11 Rock Faces 5 m to 10 m high	
RF1 Rock Faces < 5m high	
Boulders < 5 m high	

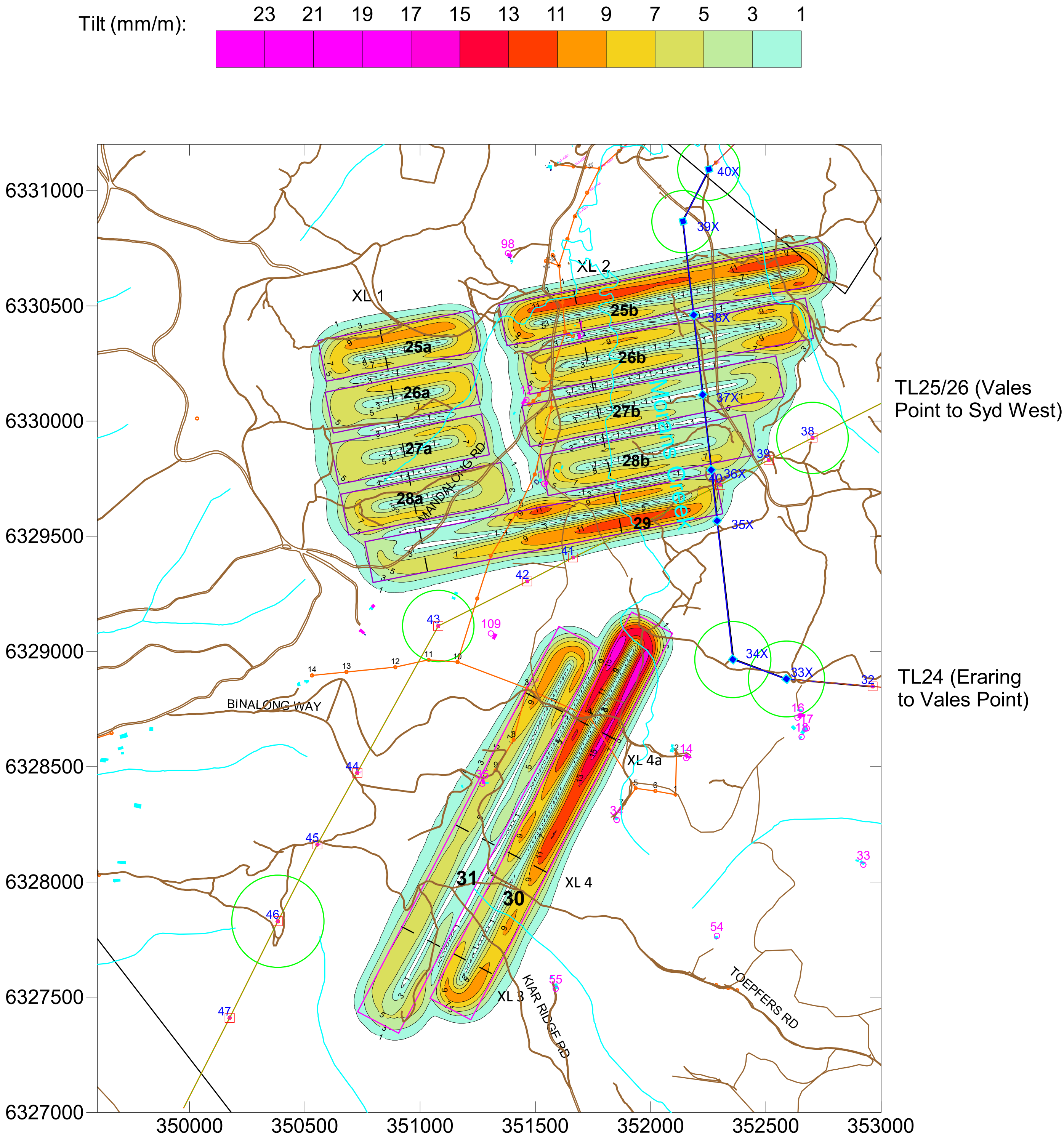
DgS	Engineer:	S.Ditton	Client:	Centennial Mandalong MAN-005/10
	Drawn:	S.Ditton		
	Date:	20.06.21	Title:	Predicted Final Horizontal Strain Contours (U95%CL) for the Proposed Longwalls 30 to 31 in the Extraction Plan
	Ditton Geotechnical Services Pty Ltd		Scale:	1:25,000 (A4) — Figure No: 2c



Key:

	Proposed Longwall Panel Limits	32	TransGrid Transmission Lines and Towers
	Approved Longwalls in Extraction Plan		26.5 degree AoD "buffer zones" for Tension Towers at Easement Direction Changes, Topographic Highs/Lows or Crossover Points
	Creeks		
	Roads		Domestic Powerlines & Poles
10	Houses		Prediction Lines

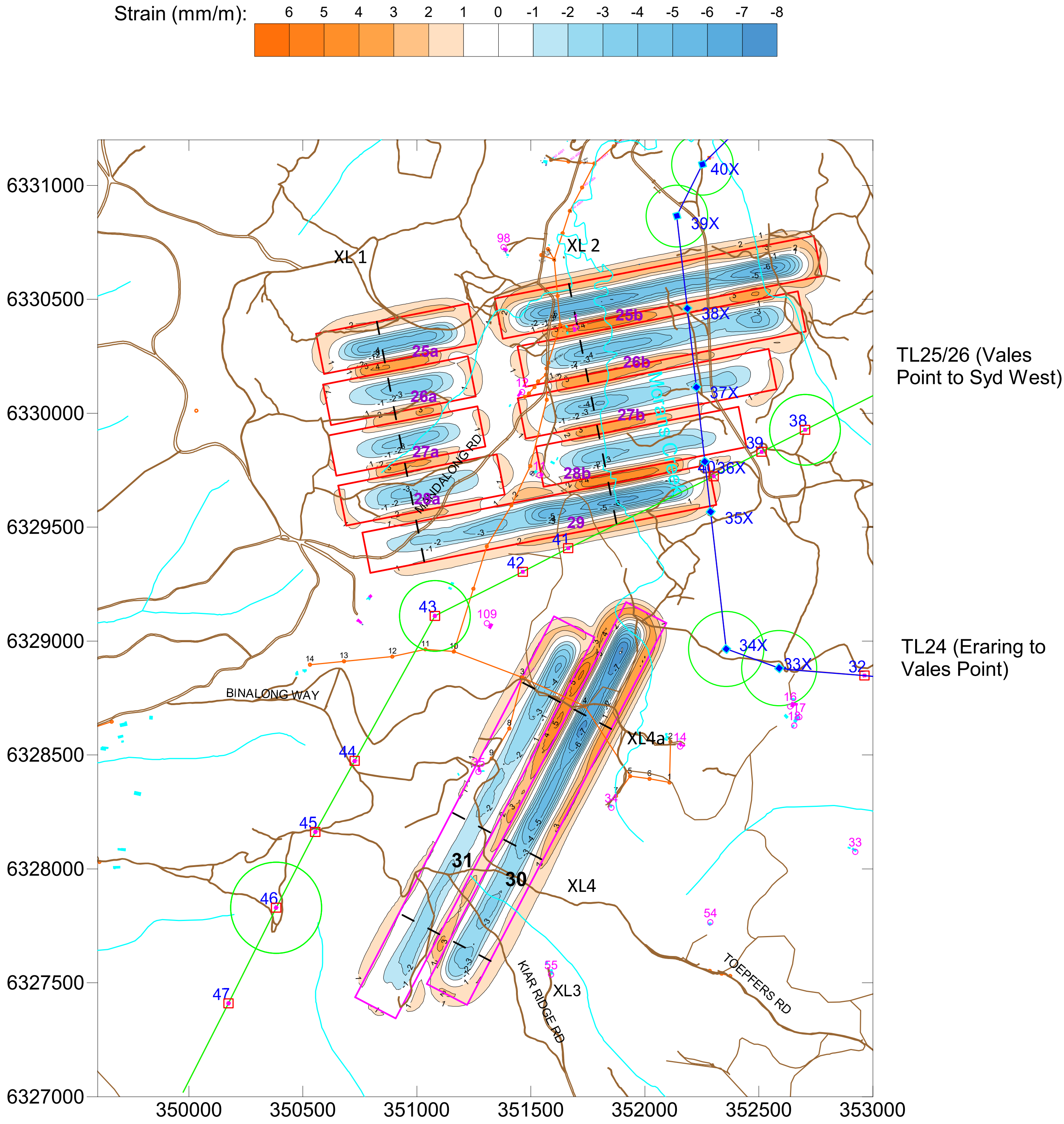
DgS	Engineer:	S.Ditton	Client:	Centennial Mandalong MAN-005/10
	Drawn:	S.Ditton		
	Date:	10.11.20	Title:	Predicted Final Subsidence Contours (mean) for the Proposed Longwalls 30 to 31 in the Extraction Plan
	Ditton Geotechnical Services Pty Ltd		Scale:	1:25,000 (A4) Figure No: 2d



Key:

- Proposed LW30 to 31
- Approved LW25 to 29
- Creeks
- Roads
- 10 Houses
- 32 TransGrid Transmission Lines and Towers
- 26.5 degree AoD "buffer zones" for Tension Towers at Easement Direction Changes, Topographic Highs/Lows or Crossover Points
- Domestic Powerlines & Poles
- Prediction Lines

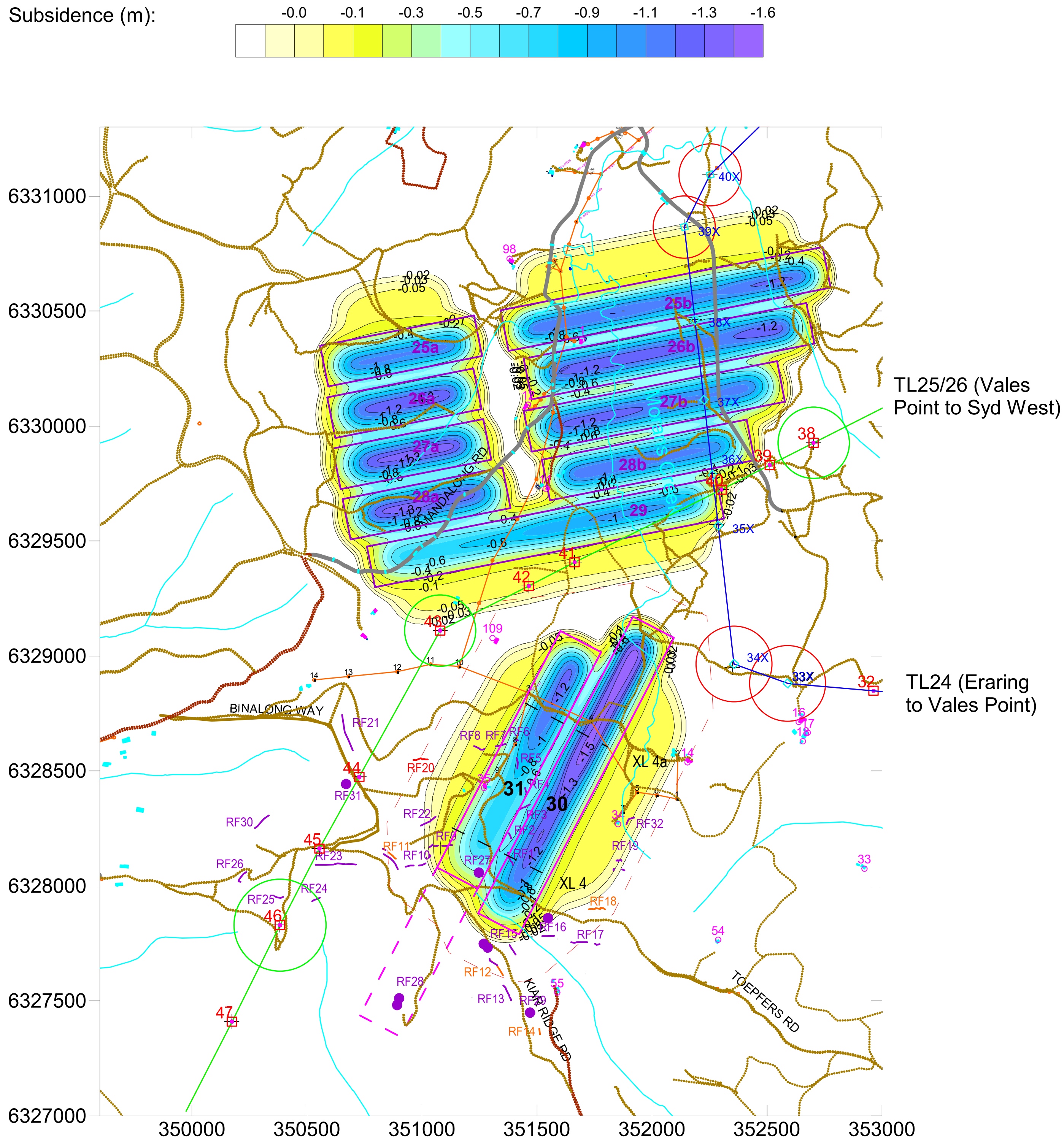
DgS	Engineer:	S.Ditton	Client:	Centennial Mandalong MAN-005/2
	Drawn:	S.Ditton		
	Date:	10.11.20	Title:	Predicted Final Tilt Contours (mean) for the Proposed Longwalls 30 to 31 in the Extraction Plan
	Ditton Geotechnical Services Pty Ltd		Scale:	1:25,000 (A4) Figure No: 2e



Key:

Proposed LW30 to 31	TransGrid Transmission Lines and Towers
Approved LW25 to 29	26.5 degree AoD "buffer zones" for Tension Towers at Easement Direction Changes, Topographic Highs/Lows or Crossover Points
Creeks	
Roads	Domestic Powerlines & Poles
Houses	Prediction Lines

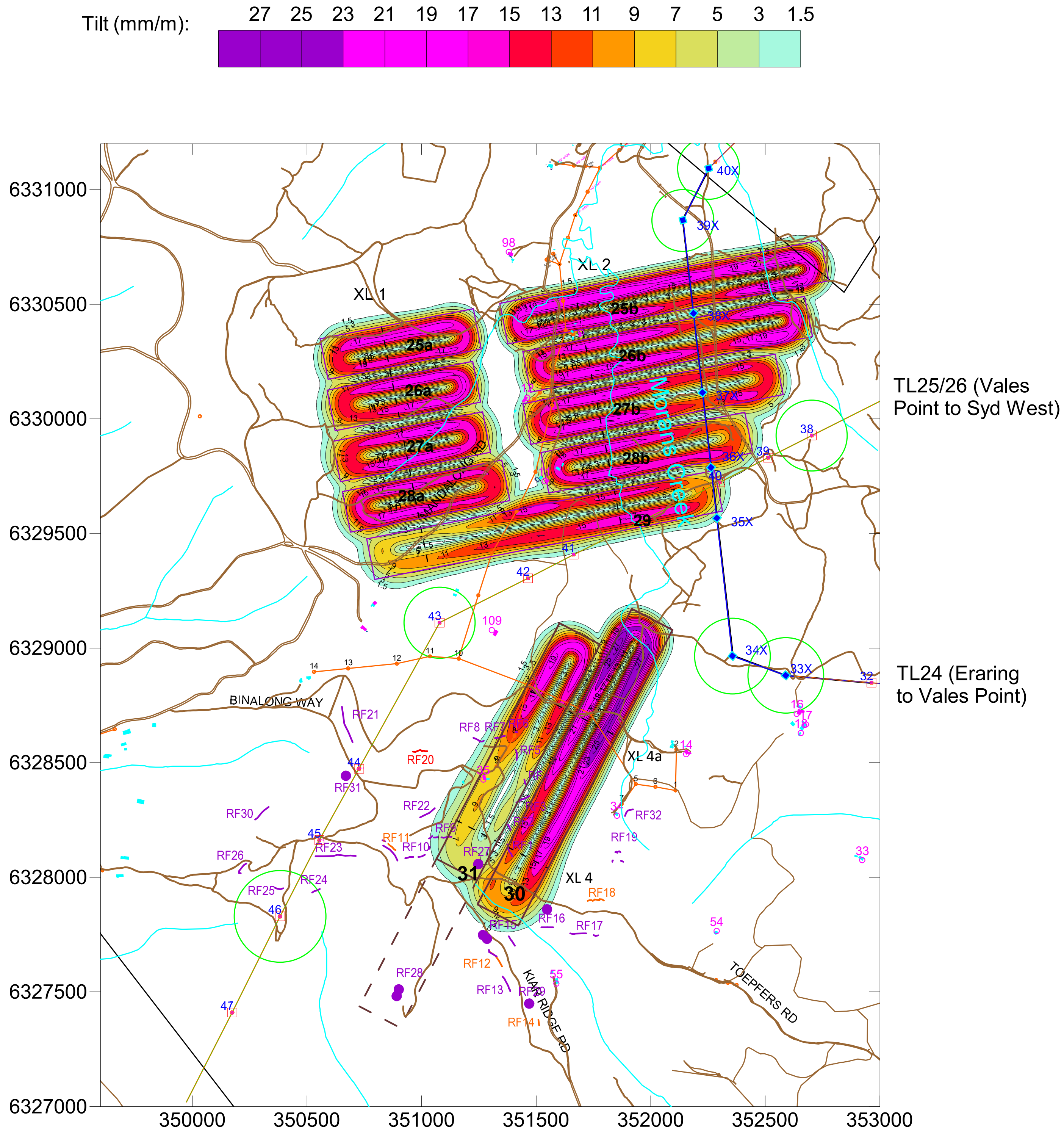
DgS	Engineer:	S.Ditton	Client:	Centennial Mandalong MAN-005/10
	Drawn:	S.Ditton		
	Date:	10.11.20	Title:	Predicted Final Horizontal Strain Contours (mean) for the Proposed Longwalls 30 to 31 in the Extraction Plan
Ditton Geotechnical Services Pty Ltd			Scale:	1:25,000 (A4) — Figure No: 2f



Key:

Deleted section for LW31	TransGrid Transmission Lines & Towers (32)
Proposed Longwall 30 & 31	26.5 degree AoD "buffer zones" for Tension Towers
Extracted Longwalls	Domestic Powerlines & Poles
Creeks	XL4 Prediction Lines
Roads	RF20 Rock Faces 10 m to 20 m high
10 Houses	RF11 Rock Faces 5 m to 10 m high
	RF1 Rock Faces < 5m high
	Boulders < 5 m high

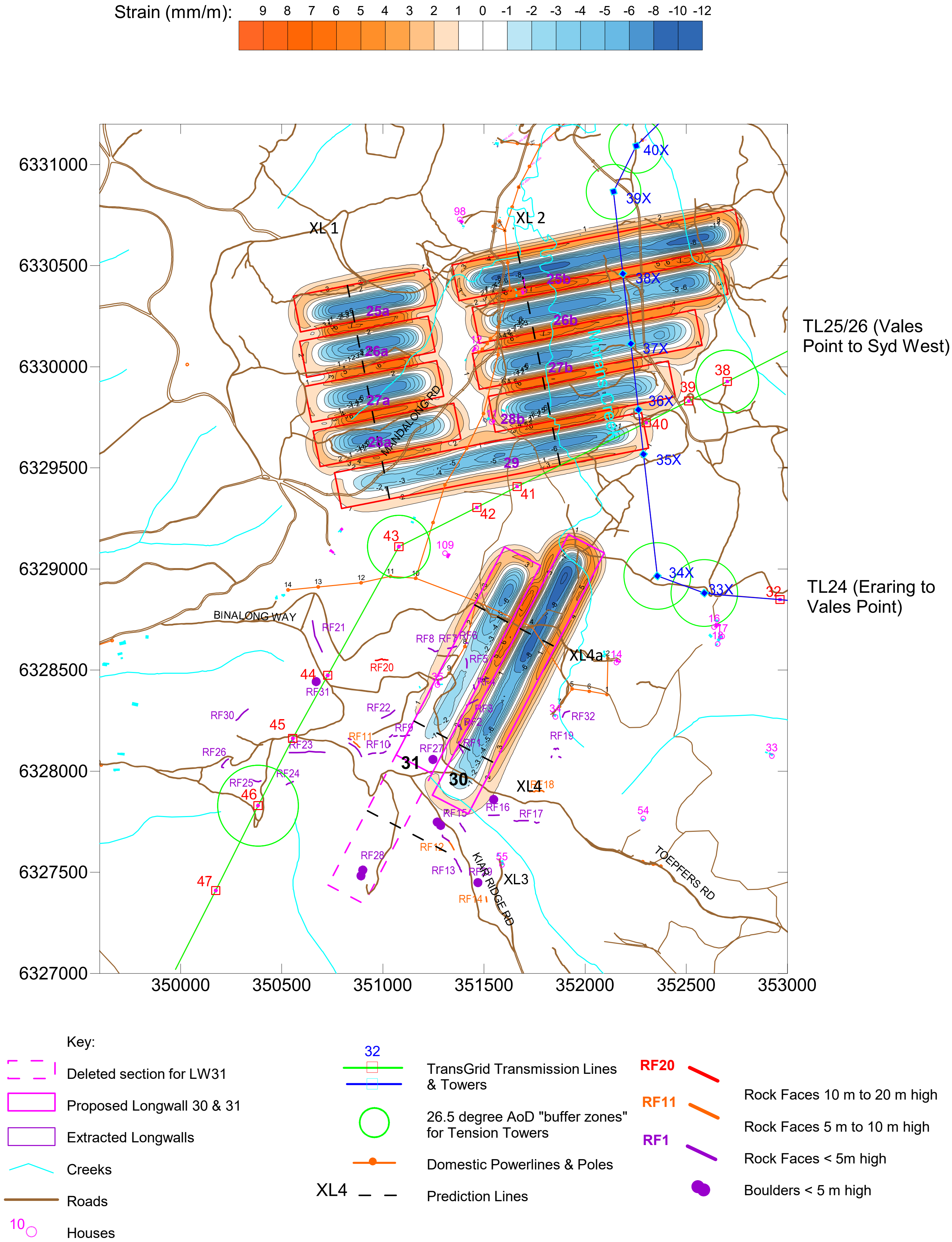
DgS	Engineer: S.Ditton	Client:	Centennial Mandalong MAN-005/10
	Drawn: S.Ditton	Title:	Predicted Final Subsidence Contours (U95%CL) for the Proposed Variation to Longwalls 30 to 31 at the Mandalong Mine
	Date: 20.06.21		
	Ditton Geotechnical Services Pty Ltd	Scale:	1:25,000 (A4)
		Figure No:	3a



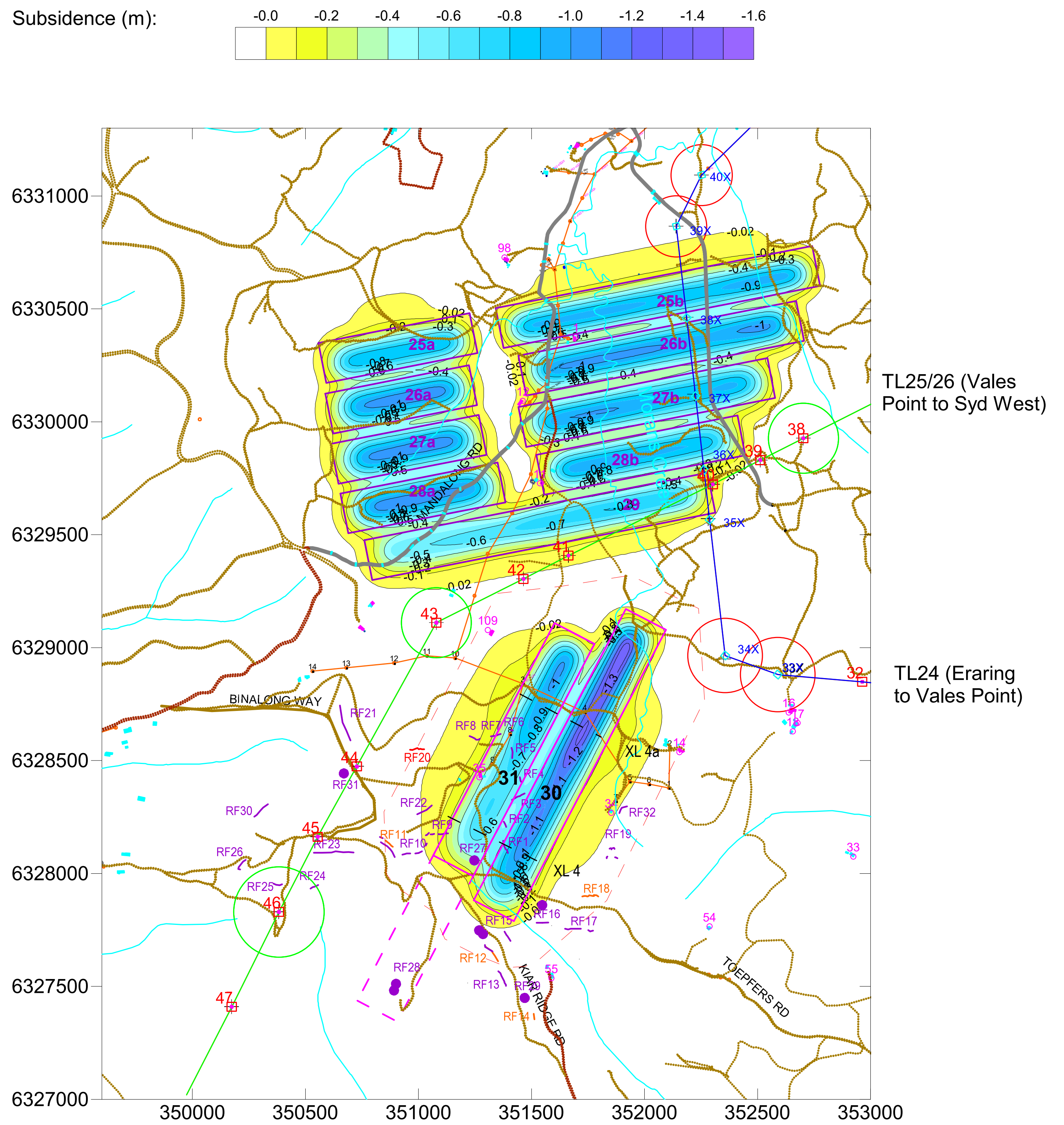
Key:

- Deleted section for LW31
- Proposed LW30 & 31
- Extracted Longwalls
- Creeks
- Roads
- 10 Houses
- 32 TransGrid Transmission Lines & Towers
- 26.5 degree AoD "buffer zones" for Tension Towers
- Domestic Powerlines & Poles
- XL4 Prediction Lines
- RF20 Rock Faces 10 m to 20 m high
- RF11 Rock Faces 5 m to 10 m high
- RF1 Rock Faces < 5m high
- Boulders < 5 m high

DgS	Engineer:	S.Ditton	Client:	Centennial Mandalong MAN-005/8
	Drawn:	S.Ditton		
	Date:	12.09.21	Title:	Predicted Final Tilt Contours (U95%CL) for the Proposed Variation to Longwall 31 at the Mandalong Mine
	Ditton Geotechnical Services Pty Ltd			
			Scale:	1:25,000 (A4)
			Figure No:	3b



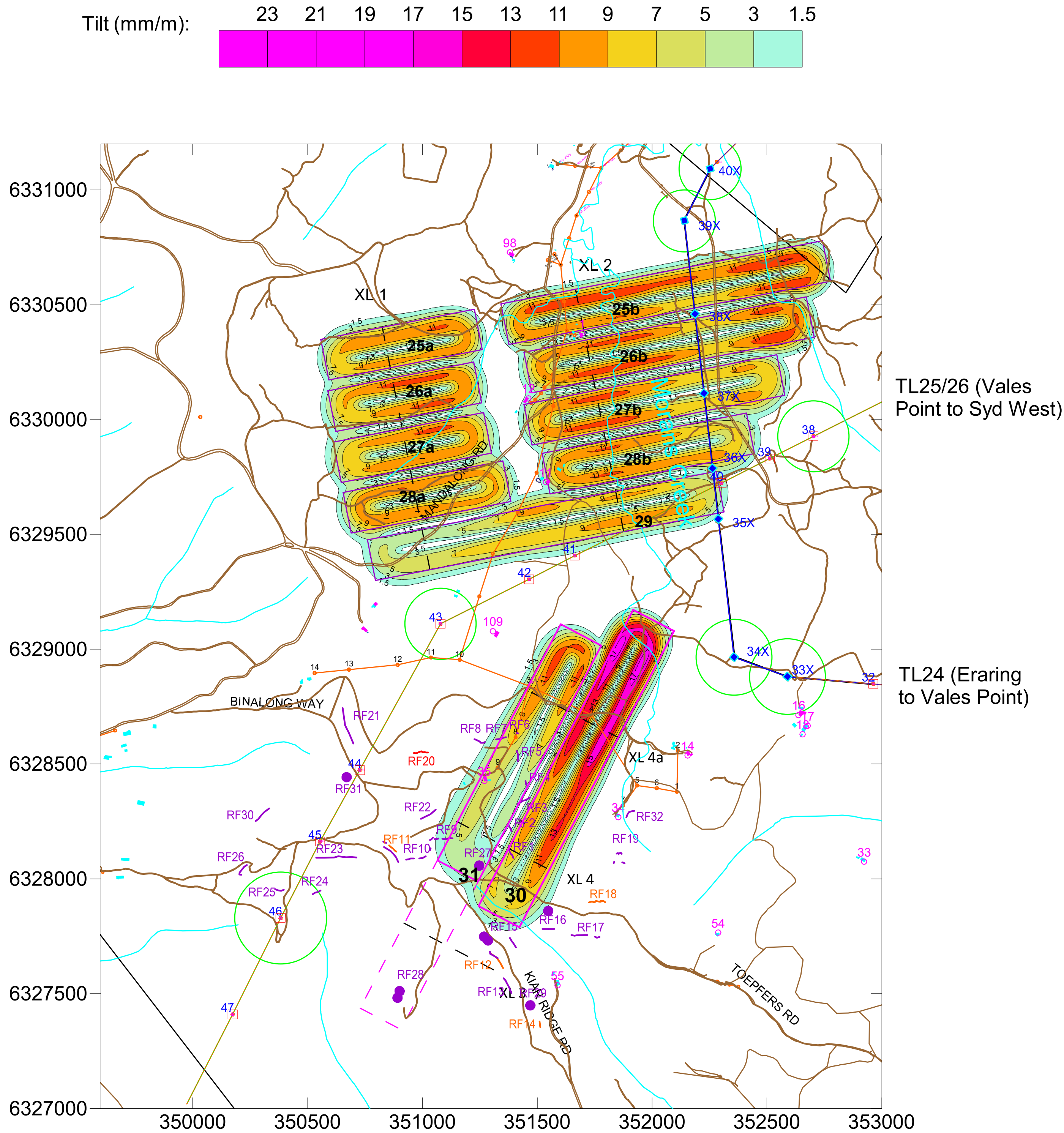
DgS	Engineer:	S.Ditton	Client:	Centennial Mandalong MAN-005/10
	Drawn:	S.Ditton		
	Date:	12.09.21	Title:	Predicted Final Horizontal Strain Contours (U95%CL) for the Proposed Variation to Longwall 31 at the Mandalong Mine
	Ditton Geotechnical Services Pty Ltd		Scale:	1:25,000 (A4)
			Figure No:	3c



Key:

Deleted section for LW31	
Proposed Longwall 30 & 31	
Extracted Longwalls	
Creeks	
Roads	
10	Houses
32	TransGrid Transmission Lines & Towers
	26.5 degree AoD "buffer zones" for Tension Towers
	Domestic Powerlines & Poles
XL4	Prediction Lines
RF20	Rock Faces 10 m to 20 m high
RF11	Rock Faces 5 m to 10 m high
RF1	Rock Faces < 5m high
	Boulders < 5 m high

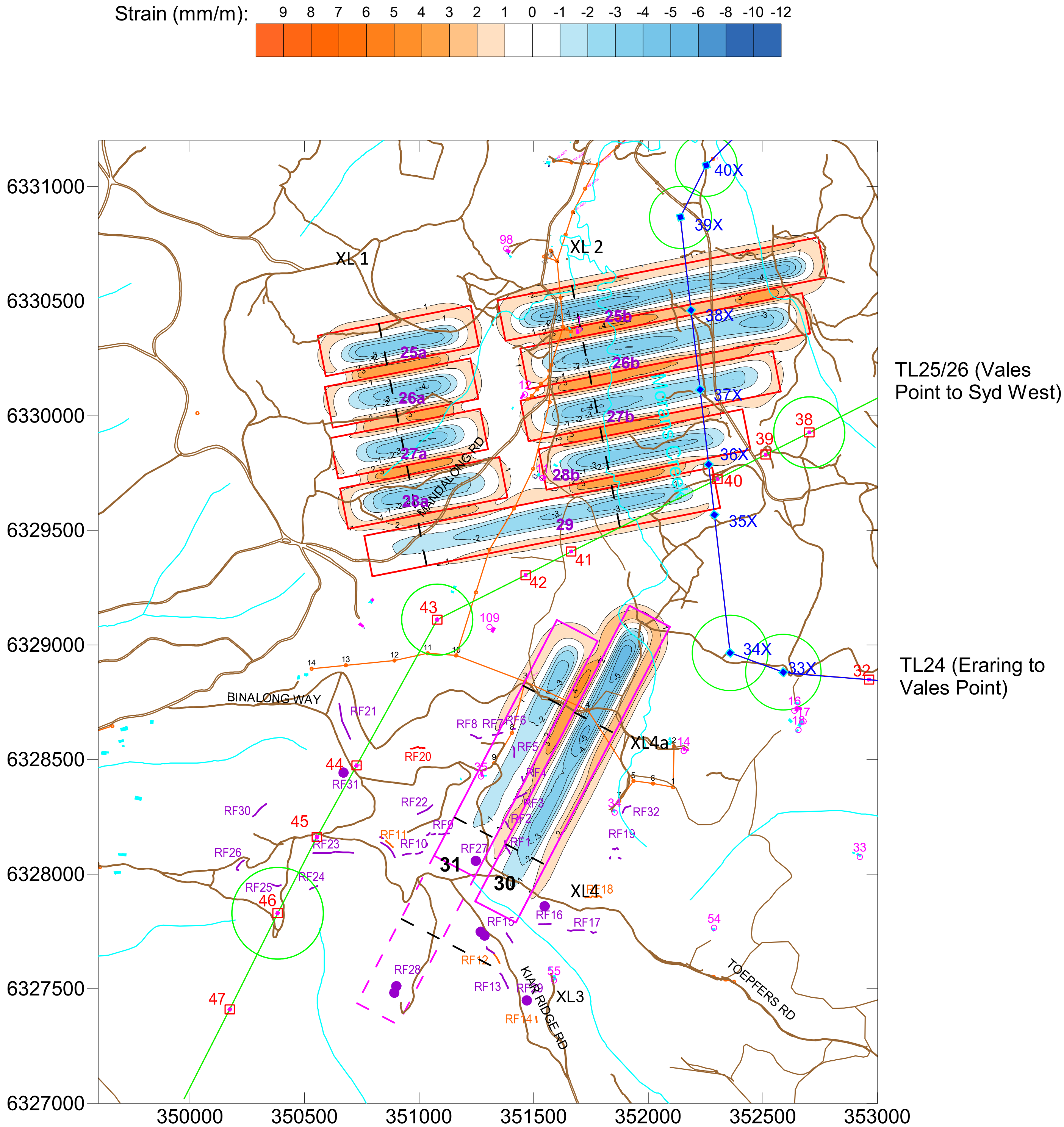
DgS Ditton Geotechnical Services Pty Ltd	Engineer: S.Ditton	Client:	Centennial Mandalong MAN-005/10	
	Drawn: S.Ditton	Title:	Predicted Final Subsidence Contours (mean) for the Proposed Variation to Longwalls 30 to 31 at the Mandalong Mine	
	Date: 20.06.21	Scale:	1:25,000 (A4)	Figure No: 3d



Key:

- Deleted section for LW31
- Proposed LW30 & 31
- Extracted Longwalls
- Creeks
- Roads
- 10 Houses
- 32 TransGrid Transmission Lines & Towers
- 26.5 degree AoD "buffer zones" for Tension Towers
- Domestic Powerlines & Poles
- XL4 Prediction Lines
- RF20 Rock Faces 10 m to 20 m high
- RF11 Rock Faces 5 m to 10 m high
- RF1 Rock Faces < 5m high
- Boulders < 5 m high

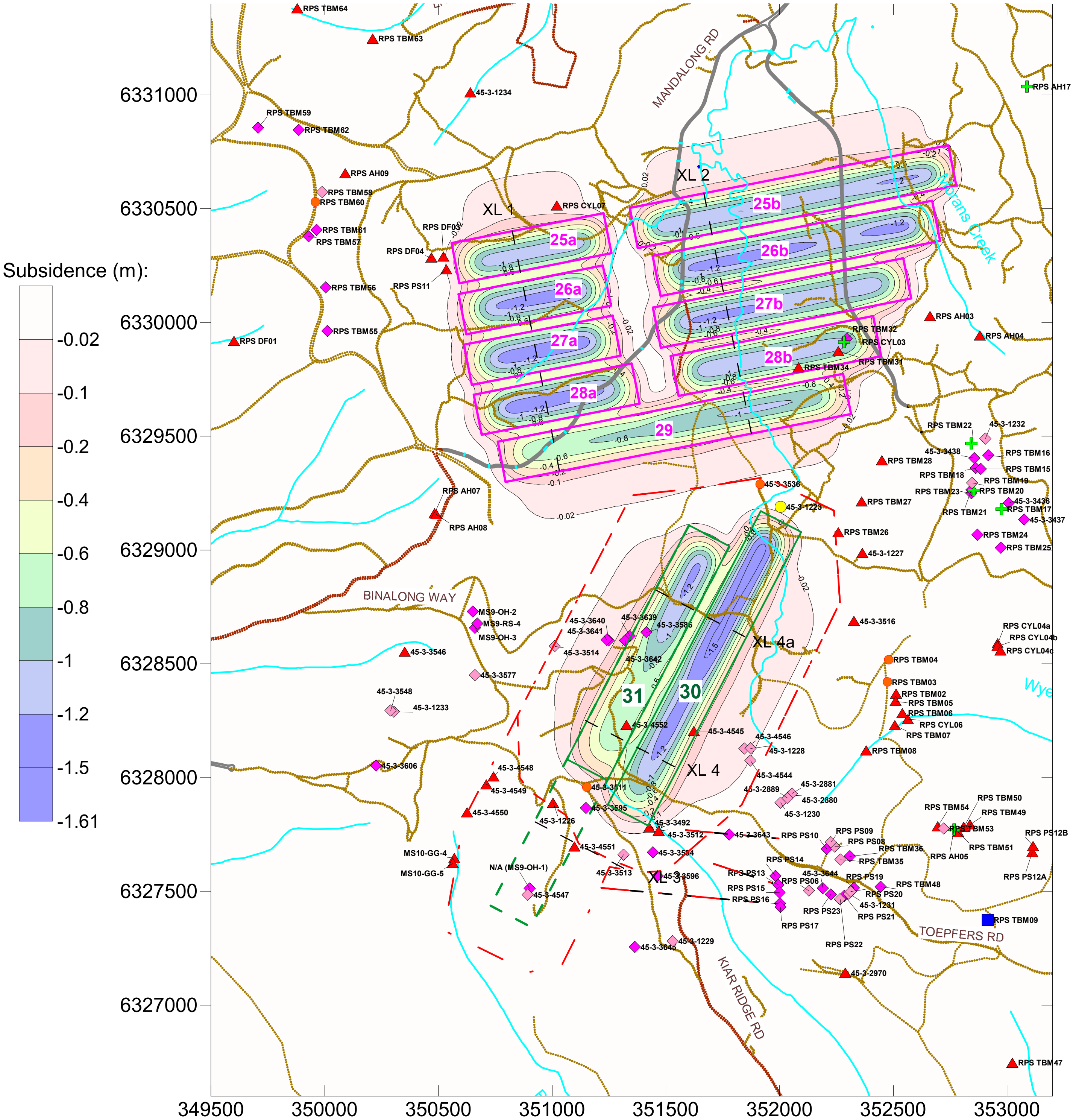
DgS	Engineer:	S.Ditton	Client: Centennial Mandalong MAN-005/8
	Drawn:	S.Ditton	
	Date:	12.09.21	Title: Predicted Final Tilt Contours (mean) for the Proposed Variation to Longwall 31 at the Mandalong Mine
	Ditton Geotechnical Services Pty Ltd		Scale: 1:25,000 (A4)
			Figure No: 3e



Key:

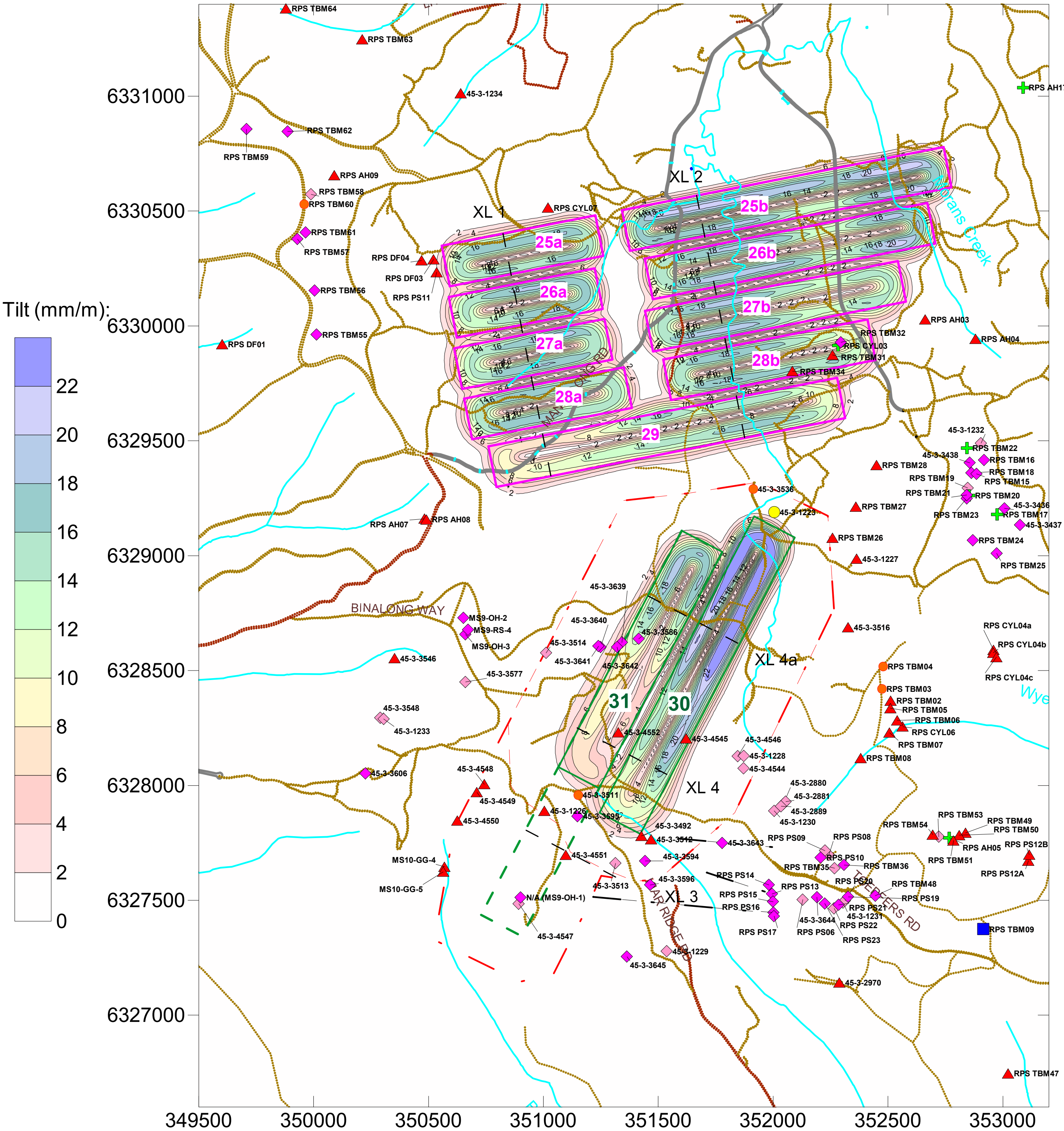
Deleted section for LW31	TransGrid Transmission Lines & Towers	RF20	Rock Faces 10 m to 20 m high
Proposed Longwall 30 & 31	26.5 degree AoD "buffer zones" for Tension Towers	RF11	Rock Faces 5 m to 10 m high
Extracted Longwalls	Domestic Powerlines & Poles	RF1	Rock Faces < 5m high
Creeks	XL4 Prediction Lines		Boulders < 5 m high
Roads			
10 Houses			

Engineer: S.Ditton		Client:	Centennial Mandalong MAN-005/10
Drawn: S.Ditton		Title:	Predicted Final Horizontal Strain Contours (mean) for the Proposed Variation to Longwall 31 at the Mandalong Mine
Date: 12.09.21			
DgS	Ditton Geotechnical Services Pty Ltd	Scale:	1:25,000 (A4) — Figure No: 3f



Deleted Section from LW31	Grinding grooves	Creeks
Proposed Variation to LW30 - 31	Rock Shelters	Roads & Tracks
Approved LW25 - 29	Rock Shelters with Art and/or PADs	
Artefact Scatter or Individual Find	26.5° Angle of Draw (Approved)	
Open Camp Site	26.5° Angle of Draw (Proposed)	
Scarred Tree		

DgS Ditton Geotechnical Services Pty Ltd	Engineer:	S.Ditton	Client:	Centennial Mandalong MAN-005/10
	Drawn:	S.Ditton		
	Date:	10.12.20	Title:	Predicted U95%CL Subsidence Contours & the Aboriginal Heritage Sites above Proposed Longwalls 30 to 31 in the Mandalong Southern Extension Area
			Scale:	1:25,000 (A4) — Figure No: 4a



Deleted Section from LW31

Proposed Variation to LW30 - 31

Approved LW25 - 29

Artefact Scatter or Individual Find

Open Camp Site

Scarred Tree

Grinding grooves

Rock Shelters

Rock Shelters with Art and/or PADs

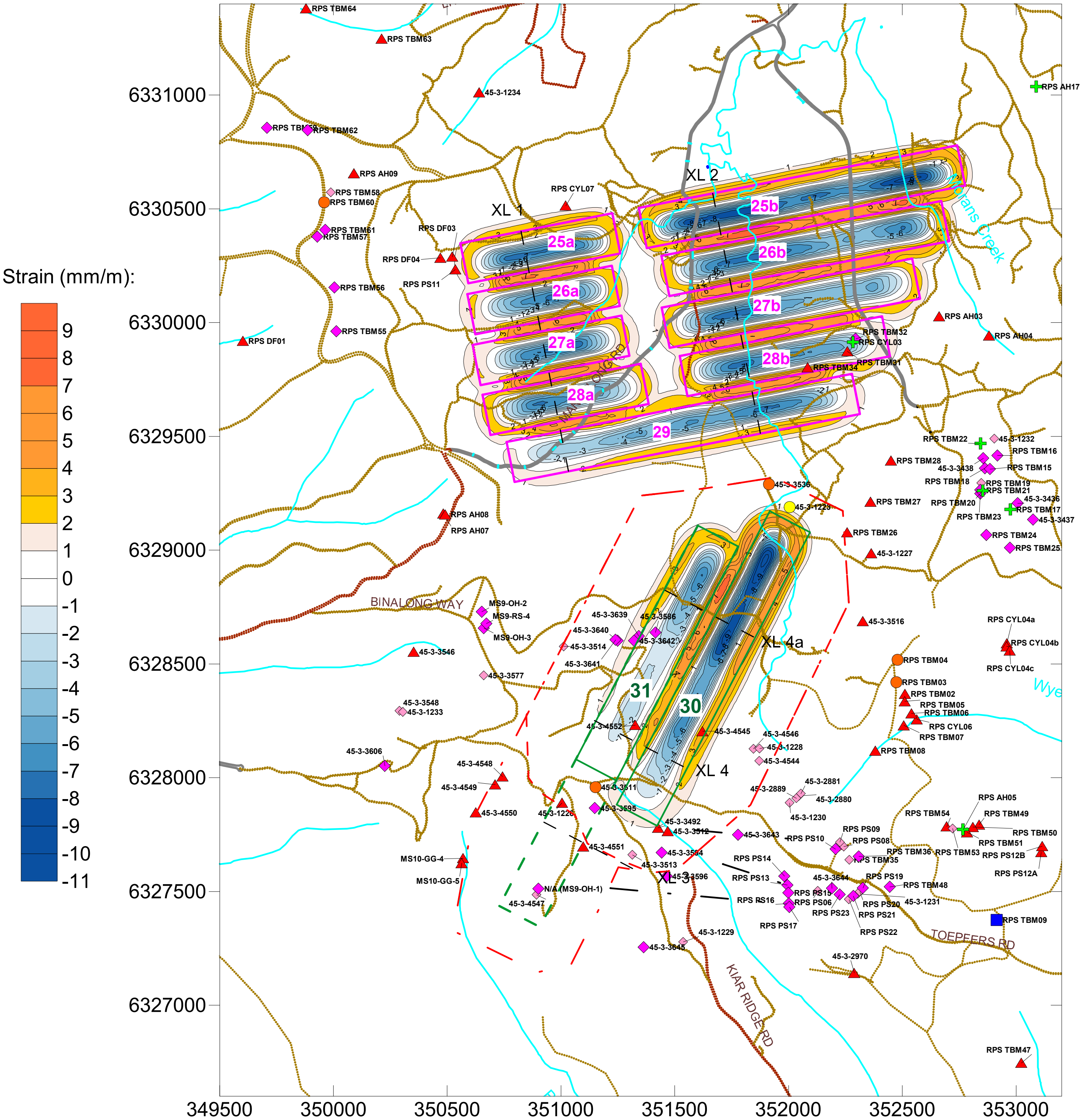
26.5° Angle of Draw (Approved)

26.5° Angle of Draw (Proposed)

Creeks

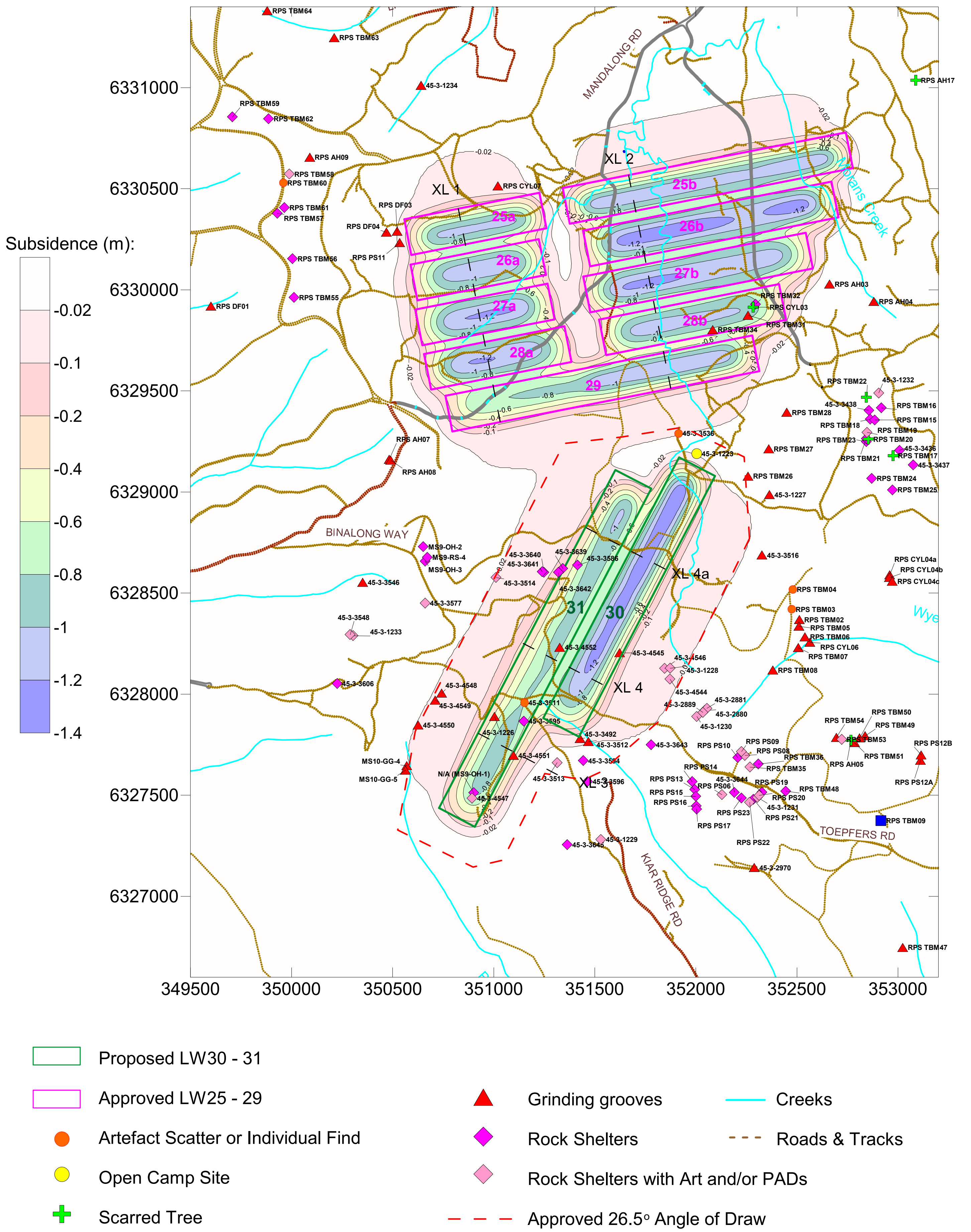
Roads & Tracks

DgS				
Ditton Geotechnical Services Pty Ltd	Engineer:	S.Ditton	Client:	Centennial Mandalong MAN-005/10
	Drawn:	S.Ditton		
	Date:	20.06.21	Title:	Predicted U95%CL Tilt Contours & the Aboriginal Heritage Sites above the Proposed Variation to Longwall 30 in the Mandalong Mine
			Scale:	1:25,000 (A4)
			Figure No:	4b

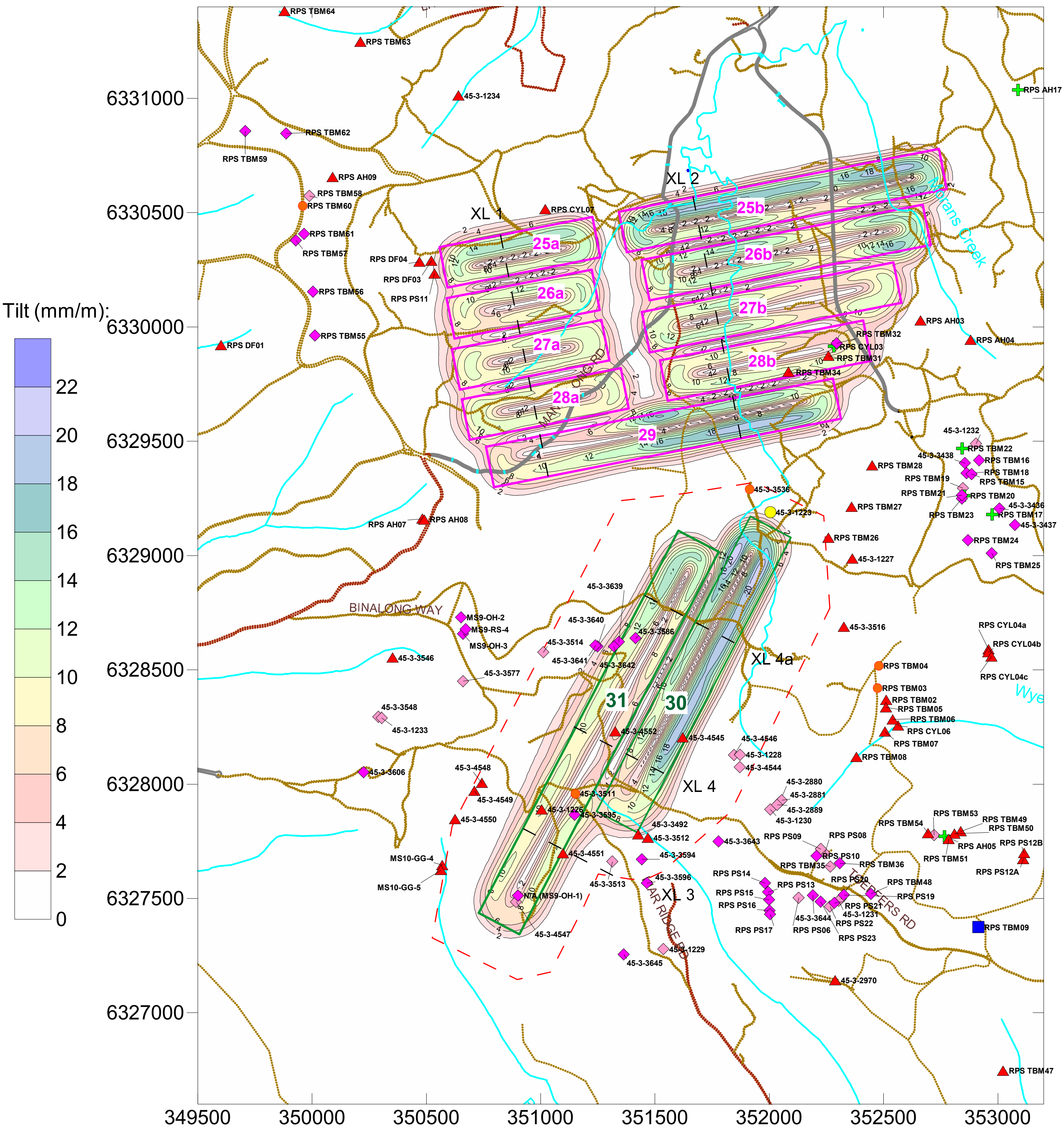


- - Deleted Section from LW31
- Proposed Variation to LW30 - 31
- Approved LW25 - 29
- Artefact Scatter or Individual Find
- Open Camp Site
- Scarred Tree
- Grinding grooves
- Rock Shelters
- Rock Shelters with Art and/or PADs
- Creeks
- Roads & Tracks
- 26.5° Angle of Draw (Approved)
- 26.5° Angle of Draw (Proposed)

DgS	Engineer:	S.Ditton	Client:	Centennial Mandalong MAN-005/10
	Drawn:	S.Ditton		
	Date:	20.06.21	Title:	Predicted U95%CL Horizontal Strain Contours & the Aboriginal Heritage Sites above Proposed Variation to Longwall 30 in the Extraction Plan
	Ditton Geotechnical Services Pty Ltd		Scale:	1:25,000 (A4)
			Figure No:	4c



DgS	Engineer:	S.Ditton	Client:	Centennial Mandalong MAN-005/10
	Drawn:	S.Ditton		
	Date:	10.12.20	Title:	Predicted U95%CL Subsidence Contours & the Aboriginal Heritage Sites above Approved Longwalls 30 to 31 in the Extraction Plan
Ditton Geotechnical Services Pty Ltd			Scale:	1:25,000 (A4) — Figure No: 5a



Proposed LW30 - 31

Approved LW25 - 29

Artefact Scatter or Individual Find

Open Camp Site

Scarred Tree

Grinding grooves

Rock Shelters

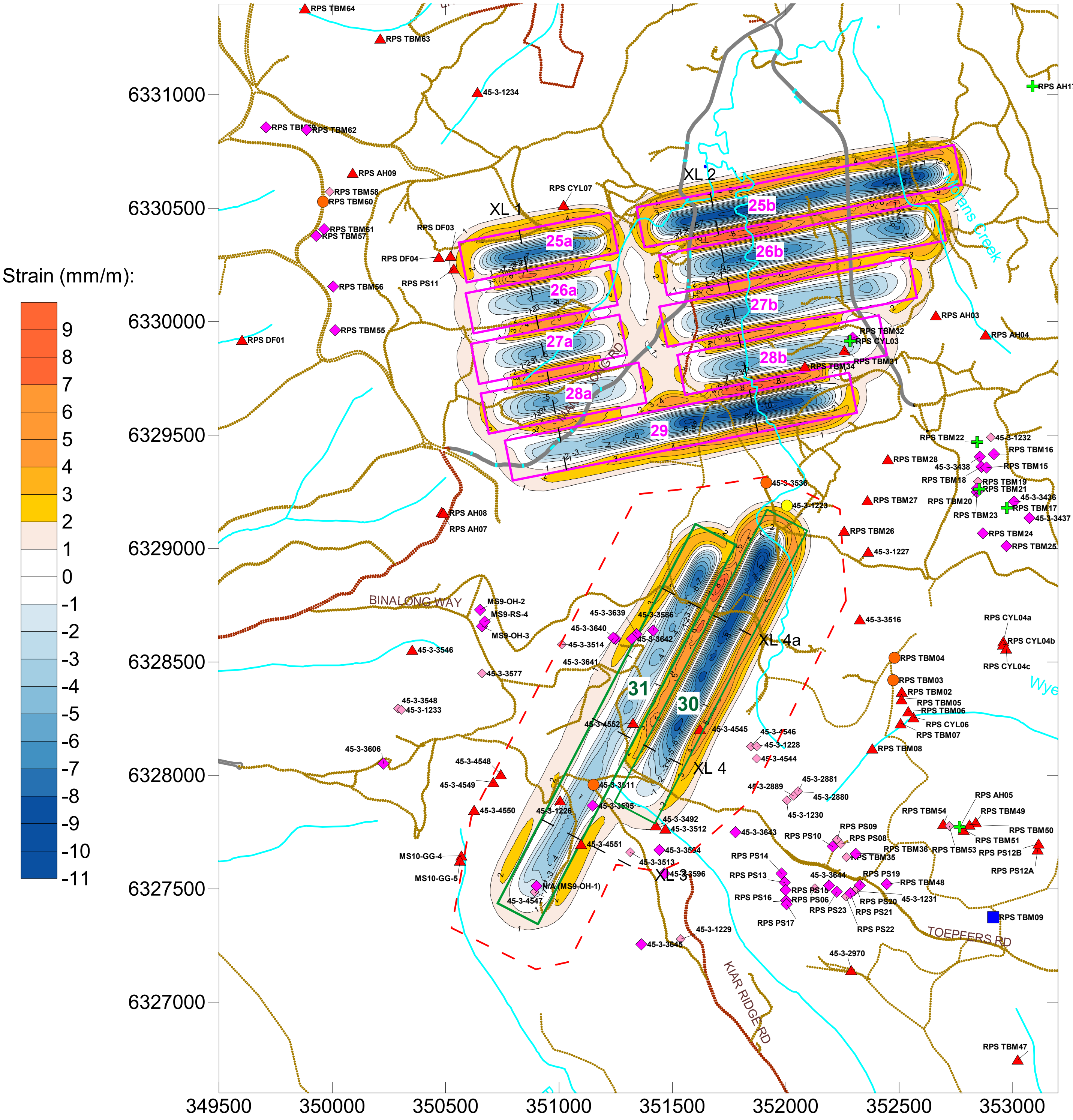
Rock Shelters with Art and/or PADs

Approved 26.5° Angle of Draw

Creeks

Roads & Tracks

DgS	Engineer: S.Ditton	Client:	Centennial Mandalong MAN-005/10
	Drawn: S.Ditton		
	Date: 20.06.21	Title:	Predicted U95%CL Tilt Contours & the Aboriginal Heritage Sites above the Approved LW30 to 31 in the Extraction Plan
Ditton Geotechnical Services Pty Ltd		Scale:	1:25,000 (A4)
		Figure No:	5b



Deleted Section from LW30

Proposed Variation to LW30 - 31

Approved LW25 - 29

Artefact Scatter or Individual Find

Open Camp Site

Scarred Tree

Grinding grooves

Rock Shelters

Rock Shelters with Art and/or PADs

26.5° Angle of Draw

Creeks

Roads & Tracks

DgS	Engineer: S.Ditton	Client:	Centennial Mandalong MAN-005/10
	Drawn: S.Ditton		
	Date: 20.06.21	Title:	Predicted U95%CL Horizontal Strain Contours & the Aboriginal Heritage Sites above Approved LW30 to 31 in the Extraction Plan
	Ditton Geotechnical Services Pty Ltd	Scale:	1:25,000 (A4)
		Figure No:	5c