SNL Building Constructions Pty Ltd

Mine Subsidence Desktop Study

For Proposed Development, Dudley Road and Kopa Street

Whitebridge

Report No. RGS00603.1-AD 9 October 2013

REGIONAL
GEOTECHNICAL SOLUTIONS

9 October 2013

SNL Building Constructions Pty Ltd
22 Pendlebury Road
CARDIFF NSW 2285

Attention: Mr Wade Morris

Dear Wade

RE: Proposed Development, Dudley Road and Kopa Street Whitebridge

Mine Subsidence Desktop Study

Regional Geotechnical Solutions are pleased to provide this report providing a desktop study on potential mine subsidence for the proposed development at Whitebridge.

If you require any further information regarding the report please do not hesitate to contact the undersigned.

For and on behalf of

Regional Geotechnical Solutions Pty Ltd

Steven Morton

Principal

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1 INTRODUCTION

At the request of SNL Building Constructions Pty Ltd (SNL), Regional Geotechnical Solutions (RGS) has undertaken a desktop study on mine subsidence for the proposed development between Dudley Road and Kopa Street, Whitebridge.

The desktop assessment was triggered due to Lake Macquarie City Council requesting a change to the building designs for the development to be undertaken between Dudley Road and an unformed section of Kopa Street, Whitebridge. The original design was to provide a number of separate townhouses fronting Dudley Road, however following review by council the council require several of the buildings to be joined to increase useable open space elsewhere on site, resulting in building structures being longer than previously proposed. The Mine Subsidence Board has some concerns about the length of the proposed buildings and their ability to tolerate movements due to mine subsidence, and has therefore requested a desktop assessment of the potential for the site to be affected by Mine Subsidence.

The proposed development will predominantly comprise two storey medium density residential buildings with basement car parking as well as associated access roads and parking, with some possible three storey sections. The buildings will be of lightweight construction.

The aim of the desktop study was to provide an assessment of the extent and nature of workings beneath the site, including assessment of the stability of typical coal pillars remaining. The assessment involved calculation of pillar stability and the associated Factors of Safety (FoS) using the tributary stress method to assess the likelihood of pillar collapse resulting in trough subsidence beneath the site. The assessment was based on record tracings based on the as surveyed plans of the workings undertaken in three seams underlying the site.

2 DESKTOP STUDY

The desktop study involved:

- Discussions and meeting with the Mine Subsidence Board to determine which seams were mined beneath the subject site;
- Procurement of the surveyed mine record tracings from the Department of Mineral Resources in Maitland;
- Assessment of the depth and thickness of each of the seams worked;
- Overlaying the surveyed mine workings from each of the coal seams over the site and surrounding area to assess the extent of mining and dimensions of coal pillars remaining in the vicinity of the site;
- Assessing the zone of influence in which mine subsidence has the potential to affect the site, based on an angle of draw of 26.5° measured from vertical.
- Assessment of the critical pillar strength, FoS and likelihood of failure in selected pillars within the zone of influence. The assessment was undertaken for the smallest, narrowest and average pillar sizes and any other pillars which were considered of interest.

3 DETAILS OF MINED COAL SEAMS BENEATH THE PROPOSED DEVELOPMENT

3.1 Extent of Workings

There are three mined seams beneath the site, all of which were initially worked using the bord and pillar method. All three seams appear to have had secondary workings to some degree. The details of the mining at each of the seams are presented in Table 1.

Table 1: Summary of Coal Seam Details

Coal Seam Mined	Assessed Maximum Depth Beneath Ground Level (m)	Thickness of Coal Seam (m)
Victoria Tunnel Seam	125	2.3
Dudley Seam	160	3.0
Borehole Seam	200	3.6

Figures 1 to 3 show the record tracings of the mine workings overlaid above the aerial photographs of the site. The figures also show each of the critical pillars assessed (in red), show the boundary line of the site (in blue) and indicate the projected zone of influence for subsidence from each seam.

3.2 Victoria Tunnel Seam

The workings of the Victoria Tunnel seam are the shallowest workings beneath the site and generally comprise regular parallelogram shaped pillars. The record tracings provided for the seam do not indicate any secondary working of the pillars near the area of influence beneath the site. The tracings do indicate a large area of secondary pillar extraction to the southwest of the site, however, adopting an angle of draw of 26.5˚ any subsidence from this extraction would not extend to the site of the proposed development.

3.3 Dudley Seam

The record tracings of the Dudley seam comprise rectangular shaped and large irregular shaped 4 and 5 sided pillars, approximately 50m wide by 95m long. The tracings also indicate a significant amount of secondary working of the large pillars beneath the site during the mid 1970's. The secondary extraction has occurred to the northeast, the southeast and the southwest of the site which is also located adjacent and to the east of a barrier pillar zone which forms the western edge of the mine workings.

3.4 Borehole Seam

The workings of the Borehole seam are at the greatest depth and generally comprise regular rectangular and parallelogram shaped pillars. The record tracings provided for the seam do not indicate any secondary working of the pillars within or near the zone of influence beneath the site.

3.4.1 Assumptions, Assessment of Pillar Strength, FoS and Likelihood of Failure

For the calculation of pillar strength the following assumptions were made:

- The pillar heights used in the assessment of factor of safety assume full depth extraction of the coal including any thin claystone, siltstone and shale lenses separating the coal seams. This is a conservative assumption in the absence of more detailed information;
- The bulk unit weight of the rock above the coal mine workings is $2.4t/m^3$;
- The assessed stress imposed by the overlying soil and rock materials has been calculated using total stress theory (no consideration has been taken for groundwater reducing the effective stress on the remaining pillars);
- The assessed FoS has been calculated using the method proposed by *Galvin et al "UNSW Pillar Strength Determinations for Australian and South African Conditions"*.

Table 2: Results of Coal Pillar FoS Assessment

Coal Seam	Assumed Bulk Unit Weight (t/m³)	Calculated Stress at Roof of Workings (MPa)	Critical Pillar Assessed	Pillar Reference	Pillar Details							Assessed Factor of Safety (FoS)
					Shape	Minimum Pillar Width W_1 (m)	Maximum Pillar Width W_2 (m)	Angle Between Adjacent Pillars f	Centre to Centre Width C_1 (m)	Centre to Centre Width C_2 (m)		
Victoria Tunnel	2.4	3.0	Smallest Pillar	VTSP1	Triangle	0.5	6.0	60˚	4.8	14.5		0.04
			Pillar Adjacent to Smallest Pillar	VTPASP4	Parallelogram	15.3	16.0	60˚	21.5	28.0		2.25
			Thinnest Pillar	VTNP2	Parallelogram	14.0	7.0	60˚	20.5	20.0		3.36
			Average Pillar	VTAP3	Parallelogram	17.5	43.5	60˚	23.0	49.0		4.95
Dudley	2.4	3.84	Smallest Pillar	DSP1	Irregular Shape	8.0	17.5	60˚	14.0	23.0		1.04
			Thinnest Pillar	DNP2	Rectangle	13.0	27.5	90˚	18.8	34.0		1.97

			Average Pillar (located away from secondary workings)	DAP3	Rectangle	19.4	38.5	90˚	25.5	39.0	3.09
			Pillars between Second Workings	DSWP4	Rectangle	19.5	24.5	90˚	79.0	31.0	0.87
Borehole	2.4	4.8	Smallest Pillar	BHSP1	Parallelogram	13.3	16.5	45˚	22.5	24.5	0.76
			Thinnest Pillar	BHNP2	Rectangle	10.5	31.3	90˚	18.7	35.0	1.02
			Average Pillar	BHAP3	Parallelogram	16.0	32.5	45˚	27.0	42.0	0.97

4 LIKELIHOOD OF PILLAR FAILURE

Table 3 below provides a correlation of FoS and probability of failure. The data from Table 3 has been adopted from the values provided by *Galvin et al (Ref 1)*.

Table 3: Relationship Between Likelihood of Failure and Factor of Safety

Factor of Safety	Probability of Failure
0.87	8 in 10
1.00	5 in 10
1.22	1 in 10
1.30	5 in 100
1.38	2 in 100
1.44	1 in 100
1.63	1 in 1,000
1.79	1 in 10,0000
1.95	1 in 100,000
2.11	1 in 1,000,000

5 SURFACE SUBSIDENCE PREDICTION

Presented in Table 4 are the estimates of surface subsidence. The estimates have been assessed based on empirical methods of predicting ground movement from underground coal mining in the Newcastle Coalfields and are based on the work undertaken by Holla in 1987 “Surface Subsidence Prediction in the Newcastle Coal Field”.

Table 4: Summary of Surface Subsidence Prediction

Coal Seam	Condition Assessed	W/H	Smax/T	Maximum Subsidence (Smax) mm	Cumulative Subsidence from Coal Seam Workings (mm)	Tensile Strain +Emax (mm/m)	Compressive Strain -Emax (mm/m)	Maximum Tilt Gmax (mm/m)	Radius of Curvature (km)	Comments
Victoria Tunnel (2.3m thick coal seam)	Trough Subsidence caused from crushing of pillars. Trough subsidence equal to the effective zone of influence in the long direction of the site of 350m (estimated effective extracted seam thickness of 30% or 0.7m)	2.8 (W = 350m) (H = 125m)	0.55	390 (effective mined seam thickness of 0.6m)	390	1.25	1.87	5.62	6.0	Trough subsidence not likely to occur as pillars generally have FoS > 2.0
Dudley (3.0m thick coal seam)	Trough subsidence caused from crushing of all large pillars. Crushing assumed to occur from 4 Chain Barrier to northwest and north east of site to pillars to unmined large pillars to east of site. Trough width of 330m (estimated effective extracted seam thickness of 55% or 1.65m)	2.06 (W = 330m) (H = 160m)	0.55	910	1300	2.27	3.41	10.23	3.5	Subsidence likely to have already occurred (FoS 0.87)
Borehole (3.6m thick coal seam)	Trough subsidence caused from crushing of pillars beneath site. Crushing assumed to occur edge of workings approximately 440m west of centre line of the site to large pillars 210m east of the centre line of the site, total trough width of 650m.	3.25 (W = 650m) (H = 200m)	0.60	1200	2500	2.40	3.60	10.8	3.0	Subsidence may have already occurred (FoS <1.0)

Coal Seam	Condition Assessed	W/H	Smax/T	Maximum Subsidence (Smax) mm	Cumulative Subsidence from Coal Seam Workings (mm)	Tensile Strain +Emax (mm/m)	Compressive Strain -Emax (mm/m)	Maximum Tilt Gmax (mm/m)	Radius of Curvature (km)	Comments
	(estimated effective extracted seam thickness of 55% or1.98m)									

Note:

- Tensile Strain +Emax = 400 x Smax/H (mm/m)
- Compressive Strain –Emax = 600 x Smax/H (mm/m)
- Tilt Gmax = 1800 x Smax/H (mm/m)

6 SUMMARY OF DESKTOP INVESTIGATION STUDY

The findings of the desktop study investigation are as follows:

Victoria Tunnel Seam

Apart from the smallest pillar assessed, the majority of the pillars of the Victoria Tunnel Seam have FoS greater than 2.0 (indicating a likelihood of failure less than 1 in 1,000,000). If trough subsidence occurred then it is calculated that the crushing would likely result in surface subsidence up to 390mm.

A probability of failure of less than 1 in 1,000,000 would normally be considered acceptable for lightweight residential development.

Dudley Seam

The Dudley seam has had significant extraction of coal from large pillars beneath the site during the mid 1970's. Although the FoS of some of the individual pillars are greater than 2, the extraction of coal from the secondary workings of the larger pillars results in FoS of less than 0.9 (likelihood of failure 8 in 10). Therefore it is highly likely that the predicted subsidence of 910mm in this area has already occurred.

Borehole Seam

The factors of safety to pillars in the Borehole Seam range from between 0.87 and 1.02 (for the individual pillars assessed) which indicates likelihood of failure between 8 in 10 and 5 in 10. Widespread crushing of the pillars in the Borehole Seam could result in surface subsidence magnitudes of up to 1200mm assuming the workings have not already collapsed.

7 RECOMMENDATIONS IN DESIGNING FOR MINE SUBSIDENCE

Based on the FoS and pillar strength results, the following is assessed:

- It is unlikely that the Victoria Tunnel seam workings will subside with FoS greater than 2.0 for remaining pillars;
- It is highly likely that the Dudley Seam workings have already crushed with FoS less than 0.9 for remaining pillars;
- The Borehole Seam workings have FoS of approximately 1.0. As the assessment of pillar strengths adopts a total stress model (i.e. neglecting effective stress conditions) some doubt remains on whether the workings have or have not crushed. Therefore designing for potential subsidence in the borehole seam is considered reasonable.

In designing for subsidence at the site an allowance should be made for potential crushing and collapse of the borehole seam workings. The following structural design recommendations should be adopted:

- Maximum subsidence: 1200mm
- Tensile Strains: 2.4mm/m

- Compressive Strains: 3.6mm/m
- Maximum Tilt: 10.8mm/m
- Radius of Curvature: 3km

8 LIMITATIONS

The findings presented in the report and used as the basis for recommendations presented herein were obtained using normal, industry accepted geotechnical design practises and standards. To our knowledge, they represent a reasonable interpretation of the general condition of the site. Under no circumstances, however, can it be considered that these findings represent the actual state of the site at all points.

If you have any questions regarding this project, or require any additional consultations, please contact Matt Rowbotham or the undersigned.

For and on behalf of

Regional Geotechnical Solutions Pty Ltd

Steven Morton

Principal

References

Galvin J.M, Hebblewhite B.K and Salamon M.D.G "UNSW Pillar Strength Determinations for Australian and South African Conditions".

Holla L "Mining Subsidence in New South Wales: 2. Surface Subsurface Prediction in the Newcastle Coal Field" Department of Mineral Resources 1987.

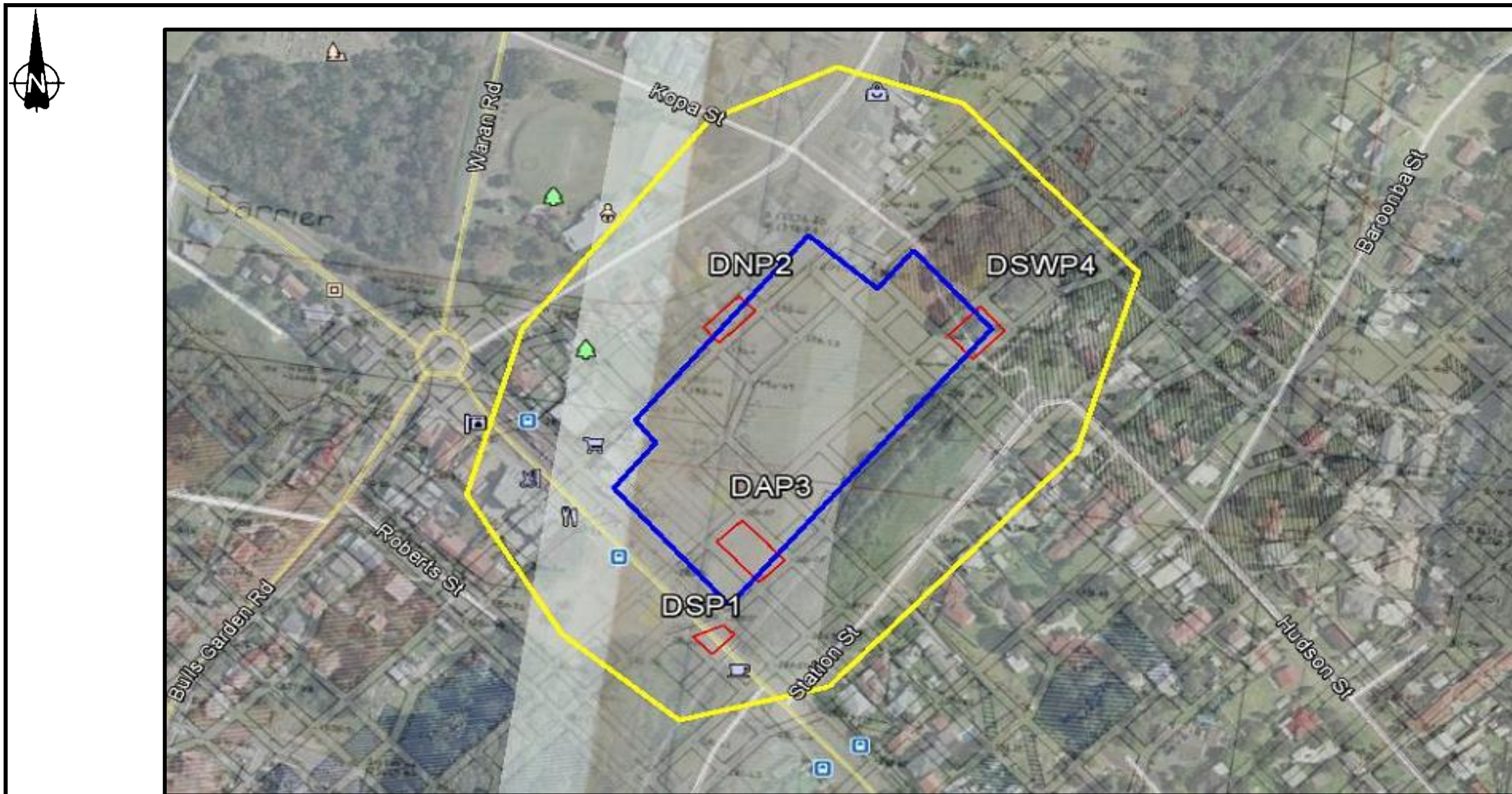
Figures

Legend

- Site Boundary
- Pillars Assessed
- Inferred Zone of Potential Subsidence Affecting Site

REGIONAL GEOTECHNICAL SOLUTIONS

Client	SNL Building Constructions Pty Ltd	Job No.	RGS00603.1 - AD
Project:	Proposed Development Dudley Road and Kopa Street, Whitebridge	Drawn By:	MR
	Mine Subsidence Desktop Study	Date:	11-Oct-13
Title:	Mine Workings Interpretation Plan - Victoria Tunnel Seam	Drawing No.	Figure 1



Legend

Site Boundary	Pillars Assessed
Inferred Zone of Potential Subsidence Affecting Site	

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	Mine Subsidence Desktop Study	Date:	11-Oct-13
Title:	Mine Workings Interpretation Plan - Dudley Seam	Drawing No.	Figure 2

Legend

Site Boundary

Pillars Assessed

Inferred Zone of Potential Subsidence Affecting Site

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Client	SNL Building Constructions Pty Ltd	Job No.	RGS00603.1 - AD
Project:	Proposed Development Dudley Road and Kopa Street, Whitebridge	Drawn By:	MR
	Mine Subsidence Desktop Study	Date:	11-Oct-13
Title:	Mine Workings Interpretation Plan - Borehole Seam	Drawing No.	Figure 3