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Proposed Development 11-17 Mosbri Crescent, The Hill

MINE SUBSIDENCE REPORT

6 May 2021

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1.0 INTRODUCTION

Mine Subsidence and Mining Engineering (MS&ME) is advised Crescent Newcastle Pty Ltd (Crescent) is preparing to lodge an amended Development Application for the development of the NBN site at 11 to 17 Mosbri Crescent, Newcastle with Newcastle City Council. This report was prepared by MS&ME following an assessment of mine subsidence matters in response to a request by Mr. Mark Purdy, Development Manager of Stronach Property (Stronach) on behalf of Crescent Newcastle Pty Ltd.

The site is located within the Newcastle Mine Subsidence District and Subsidence Advisory NSW's (SA NSW) approval is required for subdivision and surface development. The site is also located within the Newcastle Local Government Area and is identified as:

PROPERTY DETAILS	
ADDRESS	11-17 Mosbri Crescent, The Hill
ALLOTMENT	Lot 1
DEPOSITED PLAN	DP 204077
COUNCIL	NEWCASTLE

The site is undermined by old and abandoned mine workings in two coal seams, namely the Yard Seam and the Borehole Seam.

The advice provided in this report applies only to the Proposed Development for and is not to be used for other purposes.

I understand that Crescent Newcastle seeks development consent for the following proposed form of development (Proposed Development) at 11 – 17 Mosbri Crescent, The Hill (Site) as generally described in the *'Addendum Statement of Environmental Effects'* prepared by SLR Consulting Pty Ltd dated 24 August 2020:

(a) demolition of existing structures on the Subject Site;

(b) earthworks, including mine grouting works;

(c) construction of residential accommodation comprising 172 dwellings, being:

  (i) 11 x 2-storey townhouse style dwellings fronting Mosbri Crescent, located above a basement car park containing 32 visitor spaces and 13 resident spaces;

  (ii) 3 x residential flat buildings (Building A, B and C) containing 161 dwellings, being:

    (A) Building A including a 9 storey east wing and 6 storey west wing;

(B) Building B comprising 7 storeys and a roof top communal open space, with 9 town house style dwellings facing the internal courtyard; and

(C) Building C comprising 5 levels;

(d) interconnected car parking for Building A, B and C located on the ground floor and first floor, containing 3 visitor spaces and 194 resident spaces;

(e) pedestrian path providing connection from Mosbri Crescent to Kitchener Parade;

(f) associated landscaping, communal open space, services and site infrastructure; and

(g) strata subdivision (172 lots).

FIG 1: Existing surface development and Lot 1 DP204007

2.0 SUBSIDENCE ADVISORY NSW AND SURFACE DEVELOPMENT

The Coal Mine Subsidence Compensation Act 2017 No 37 (the CMSC Act) has the objective to provide for a fair, efficient and sustainable compensation framework for dealing with the impacts of coal mine subsidence.

Part 3 Section 20 of the CMSC Act provides for the declaration of mine subsidence districts. Within a mine subsidence district, a person must not carry out work, or cause work to be done, in connection with the erection or alteration of an improvement or subdivide land, or cause such land to be subdivided, except in accordance with the approval of the Chief Executive.

Under Part 3 Section 22 of the CMSC Act, the Chief Executive may grant an approval to alter or erect improvements, or to subdivide land either subject to conditions or unconditionally or may refuse to grant the approval. Such conditions may include conditions relating to the class or nature of improvements, the height, weight, type of material, number of storeys and method of construction of any improvements within the district. Such conditions may vary according to the location, class or nature of such improvements. Approvals are valid for 5 years.

Development approved and constructed in accordance with Subsidence Advisory NSW's (SA NSW) conditions is covered for compensation under the CMSC Act in the event of mine subsidence damage occurs. Property owners can liaise with SA NSW should they need clarification regarding damage to their property and their rights under the Act

As the Proposed Development Lot 1 in DP 204077 is located within a mine subsidence district, approval of SA NSW is required to "alter or erect improvements, or to subdivide land" pursuant to s22 of the CMSC Act.

On 16 October 2019 General Terms of Approval (Original GTAs) were issued by SA NSW under s22 of the CMSC Act. Those Original GTAs were issued in respect of an earlier form of the Proposed Development, being the development the subject of the Development Application as originally lodged with Council and before the Proposed Development was amended in August 2020.

The Original GTAs stated that:

> "Prior to commencement of construction
>
> …
>
> SA NSW requires any subsidence risk due to a potential collapse in the Yard Seam workings to be effectively eliminated.
>
> Submit a proposal acceptable to SA NSW to remove the risk of subsidence that could cause damage that would exceed the threshold of safety, serviceability and very slight damage (in accordance with AS2870 – Damage Classification). The proposal shall include, but not necessarily be limited to grouting of the mine voids. Any other measures that SA NSW deem necessary may also be included in the proposal.
>
> …
>
> SA NSW requires that the risk of subsidence in the Borehole Seam be limited to the extent that the proposed development will remain safe,

serviceable and any damage will be limited to "very slight" (in accordance with AS2870 – Damage Classification). Submit a proposal acceptable to SA NSW that satisfies this requirement. The proposal shall include, but not necessarily be limited to grouting of the mine voids and structural engineered design. Another other measures that SA NSW deem necessary may also be included in the proposal."

The Current Mine Grouting Strategy has been comprehensively assessed in the various reports that were submitted to, and discussed with, SA NSW for them to issue General Terms of Approval dated 16 October 2019. This included independent expert advice.

On 7 May 2020, SA NSW's advised Condition 4 had been met.

On 9 December 2020 that Conditions 4, 6a and 6b have been met subject to grouting being able to be completed.

3.0 MINE WORKINGS AND CURRENT MINE GROUTING STRATEGY

Details regarding the mine workings, site investigation and analysis completed are included in the Current Mine Grouting Strategy provided in documents as part of Crescent's submission to Newcastle City Council and can be referenced in those documents. They are therefore not repeated here.

3.1 MINE WORKINGS

The Record Tracing RT566 sourced from NSW Planning and Environment – Resources and Energy; Division of Resources and Geoscience indicates that the Subject Site is undermined by old mine workings in the Yard Seam and Borehole Seam.

YARD SEAM - Records indicate the Yard Seam is mined in the eastern part of Newcastle, and the possible extent of the Yard Seam is shown by a line on Record Tracings. Less information is known about the status of the Yard Seam, other than from site investigation at various locations in Newcastle. The depth of the Yard Seam beneath the site is around 41m – 45m.

BOREHOLE SEAM. In Newcastle, the Borehole Seam was mined by the Australian Agricultural Company (AACo). The Record Tracing shows detailed mine workings in the Borehole Seam that are well laid out and based on site investigation of numerous sites in Newcastle, it is considered there is a good correlation with the location of the mine workings. I would consider the Record Tracings for the Borehole Seam in this area to be good quality with the only issue being a possible variation in the seam height extracted. The depth to the Borehole seam is around 90m – 100m

The mine workings in both the Yard Seam and the Borehole Seam have stood in the vicinity of the Subject Site for over 100 years.

There were 3 recorded subsidence events as shown on Record Tracing RT566. These are noted as "Creep 1 (Southern)" dated 15 May 1906, "Creep 2 (Middle)" dated 17 January 1907, and "Creep 3 (Northern)" dated 17 January 1908. These creeps were thoroughly investigated and were the subject of the 1908 Royal Commission. The creeps did not progress further to the east, although it was at a time when stresses on the coal pillars would have been readjusting.

In Australia, it is accepted industry practice to use the University of NSW Pillar Design Method (Galvin, J.M., Hebblewhite, B.K., Salamon, M.D.G., & Lin, B.B. (1998) *Establishing the Strength of Rectangular and Irregular Pillars,* ACARP Research Project No. C5024. UMRC Research Report RR3/98, School of Mining Engineering, The University of New South Wales) and classify mine subsidence risk and refer to Factor of Safety and Probability of Failure. An analysis is included in Coffey Report *Mine Subsidence Investigation* dated 14 January 2019.

Whilst the mine workings have stood for over 100 years and there have been no further subsidence events, this does not mean there is not a risk of mine subsidence. That is the reason why SA NSW is requiring the old mine workings to be grouted prior to construction of the Proposed Development.

3.2 MINE SEAM GROUTING

To achieve SA NSW's requirements, it is necessary to grout the mine workings. A *'Mine Grouting Remediation Strategy Summary Report'* dated 20 October 2020 has been prepared by Coffey (Current Mine Grouting Strategy) which details the works that are proposed to be undertaken to comply with the Original GTAs.

I consider it may be useful to those reading this report to clarify a common misconception that old mine workings have to be grouted to support the weight of the building. With the weight of 100 metres of strata overlying the mine workings, the weight of the buildings proposed as part of the Proposed Development is relatively small and is often offset by demolition of existing structures or removal of material as part of construction work. Details can be provided by a Structural Engineer.

SA NSW's requirement to for remediation works, such as grouting, is initiated by the potential for the building to be damaged in the event mine subsidence occurs and the requirement for SA NSW to provide compensation to meet the reasonable and necessary expense incurred or to be incurred as a result of such damage, as is their responsibility under the CMSC Act.

Mine grouting by filling, or partially filling, of old mine workings with a cementitious grout, as is proposed in the Current Mine Grouting Strategy, is a recognised method of

stabilising mine workings and/or increasing the factor of safety of coal pillars. Grouting of the mine workings improves stability of the mine workings and therefore reduces the risk of subsidence. This enables mine subsidence to be controlled such that the mine subsidence risk and potential damage to structures can be managed within engineering design parameters. The grout is of a consistency that allows it to penetrate fallen material or fill cracks in the mine or overlying strata. I believe grouting was first used in Newcastle when the Yard Seam beneath the proposed Tax Office site was grouted around 1988 and has been undertaken at many locations since that time, including the Honeysuckle Development area.

The Current Mine Grouting Strategy indicates that a grouting project involving two coal seams will be required to achieve SA NSW's conditions. The Current Mine Grouting Strategy indicates that boreholes required for the purpose of grouting will be drilled only from within the boundaries of the Site. Full grouting will be undertaken in the Yard Seam and strategic grouting in the Borehole Seam. The Current Grout Strategy estimates around 2000 cubic metres of grout will be required to preclude future subsidence from the Yard Seam. Given that boreholes for filling the Yard Seam are proposed to be closely spaced, I am satisfied that such filling can be done effectively.

From its origin within the Site, the grouting will be distributed to the mine voids below:

(i) the Subject Site;

(ii) parts of Pitt and Brown Streets;

(iii) Arcadia Park (Lot 7003 in DP1077043; Lot 7004 in DP1077043); and

(iv) Mosbri Crescent Park (Lot 20 in DP216346).

The proposed location of boreholes is shown in FIG 2.

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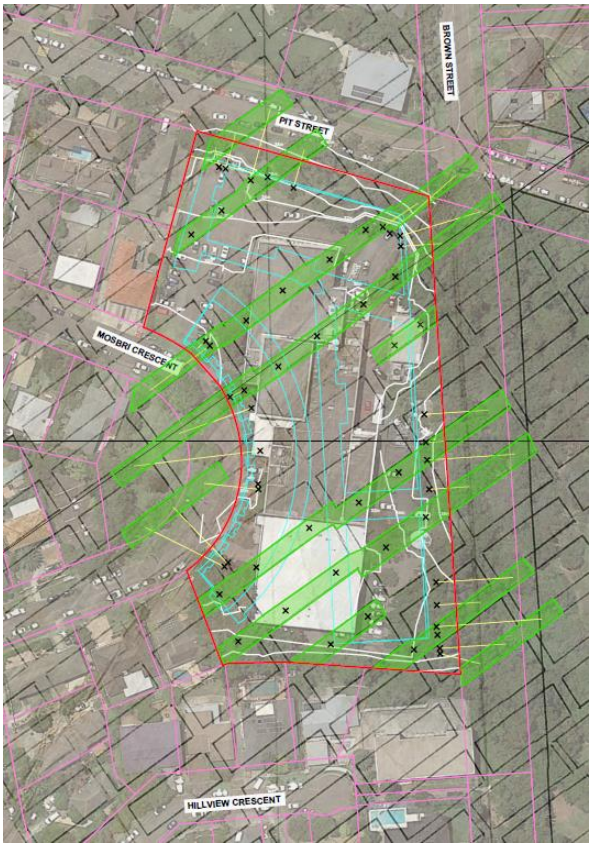
FIG 2: Borehole location for grouting the Borehole Seam.



The Current Mine Grouting Strategy proposes grouting along rows of coal pillars. The report prepared by Ditton Geotechnical Services Pty Ltd (DgS) at Appendix B to the Current Mine Grouting Strategy provides the results of modelling of the predicted subsidence effects in respect of the Current Mine Grouting Strategy and advised (page 3):

> *"The results indicate that the Proposed Modification will still be within the Safe, Serviceable and Practically Repairable (SSR) limits assumed for the proposed structures. The increase in horizontal displacement is due to a minor increase in tilt, which is now estimated to be up to 2 mm/m at the high rise buildings (previously 1.2 mm/m) and up to 2.6 mm/m at the townhouses (previously 1.2 mm/m).*
>
> *The amended grouting strategy has resulted in minor increases to the subsidence effect predictions with no change to the predicted 'negligible' impacts to the structures."*

Northrop Consulting Engineers Pty Ltd have advised they can achieve SA NSW's Original GTAs for these design parameters.

Section 3.4 of the Current Mine Grouting Strategy deals with post remediation validation and advises *'As noted by GAPL, it will be critical that the grout as injected meets the parameters as adopted by DgS in their models.'* Rubble where present on the floor of the mine workings will need to be encapsulated to meet the requirements modelled by

DgS and this is essential as indicated in Section 3.10 and will need to be verified. Verification boreholes (proof drilling) can be drilled from within the Site to confirm the grouting has been achieved to the extent required by the modelling. Grout product is tested to laboratory standards to confirm the required strengths have been achieved.

In the lead up to SA NSW issuing the Original GTAs, the original mine grouting strategy was reviewed by Galvin & Associates Pty Ltd (GAPL). It is not necessary for me to repeat those details of the Expert Reviews of GAPL dated August 2019 and March 2020 here but I do highlight the following comments included by GAPL in the Expert Review dated March 2020, which state:

> *"The assumptions, approximations and limitations of analysis techniques and input parameters are generally well identified. These are unavoidable irrespective of the methodology adopted, other than backfilling, and are addressed for the most part in a conservative (safer) manner".*
>
> *"One of, if not the most critical parameters in the analysis and also the most difficult to quantify ahead of field work is the physical and mechanical properties of the cemented backfill (comprising in-situ rubble and voids injected with cemented flyash). It is essential that these properties are validated in the field, especially in respect to the effective bulk modulus of the cemented backfill and the extent to which voids may still be present in the backfill, and the design modified to be more conservative if required."*

GAPL was engaged by SA NSW to review the Current Mine Grouting Strategy, and provided his comments by letter dated 1 November 2020 to SA NSW confirmed that:

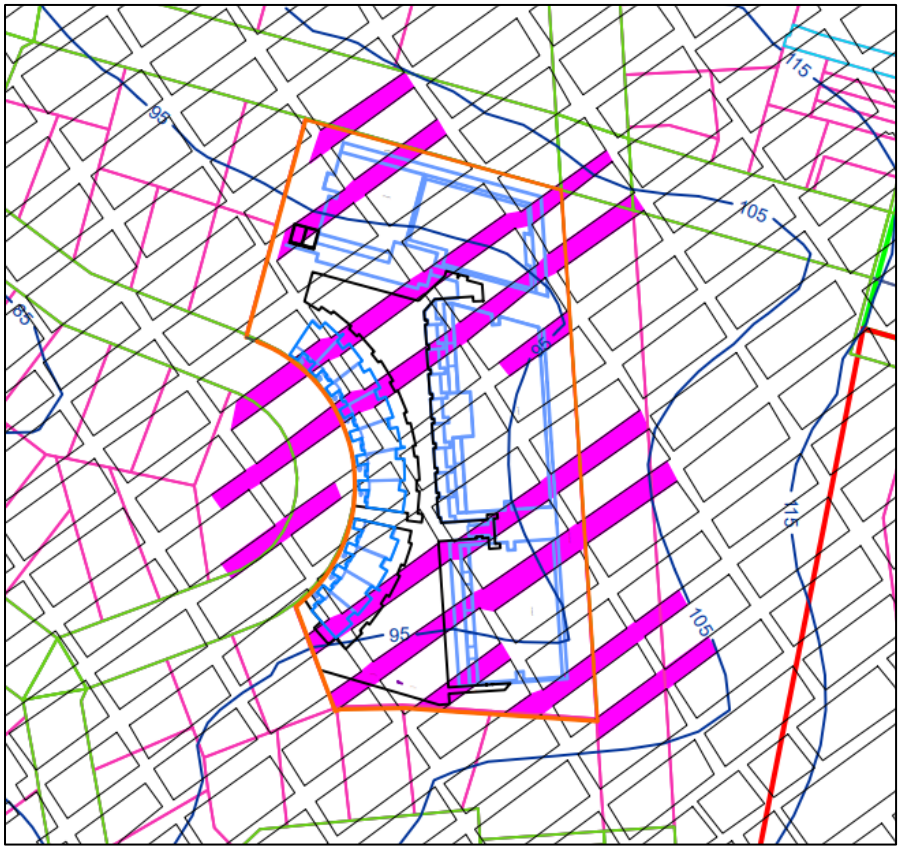
> "…*My judgment is that from a theoretical perspective, the revised pattern could lead to more irregular load sharing between the pillars if surrounding workings were to become unstable. Nevertheless, that is unlikely to influence coal pillar performance under the site to any significant degree, and, in fact, the revised grouting pattern could potentially increase the overall stability of the pillar system. However, one could expect a slight increase in subsidence effects around the perimeter of the development site due to less protection being provided within the angle of draw.*
> *In this case, the changes can be assessed quantitatively utilising the numerical model developed by Ditton Geotechnical Services and applied to the original design. My previously (sic) review of that model stands. I note that the model has been used to predict subsidence parameters for the revised layout should mine instability develop and I see no reason why the level of confidence associated with the new predictions should be any different to that associated with the original predictions."*

It is my opinion that it will be essential to establish a comprehensive procedure for implementing the grouting strategy that includes analysis and review of mining information obtained from drilling, method and sequence of grout placement, verification and a process to address the situation should any part of the actual outcome require a

design modification to achieve what has been modelled for the Current Mine Grouting Strategy. This process usually occurs at the time final arrangements and engagements of contractors is proposed.

Figure 3 illustrates the grouting proposed as part of the Current Mine Grouting Strategy.

FIG 3: – 'Lot Boundaries and Proposed Grout in the Borehole Seam: Preferred Option 2, DgS Report No. COF-009/2 prepared by Ditton Geotechnical Services dated 22 August 2020



The modelling completed by DgS, and reviewed by GAPL, does not require the grout in the Boreholes Seam to be "*hard up against the roof*" in all mine headings, as the requirement is to strengthen the sides of the coal pillars, and not hold up the roof. For the Borehole Seam in the Current Mine Grouting Strategy, modelling utilises a conservative grout angle of repose of 1V:6H along the bords and 1V:10H across the bord assuming the more conservative 6m seam height with grout at the borehole taken to the roof.

In GAPL's Expert Review dated March 2020, GAPL advises:

> *"GAPL agrees with DGS (2020b) that because the mined height in the cut-throughs is likely to be significantly lower than down the long sides of the pillars, the impact of rib spall on pillar strength is reduced. However, GAPL remains of the view that it would be judicious to also grout the cut-throughs."*

A similar situation exists with the Current Mine Grouting Strategy and I also agree with DgS and the modelling does not require the cut-throughs to be grouted. I am also of a similar view to GAPL that it would be judicious to grout the cut-throughs. Whilst the Current Mine Grouting Strategy does not require cut-throughs to be targeted it is possible with the proposed grouting extending along pillars (rather than an isolated pillar in the original grouting strategy) that grout will flow into at least some cut-throughs. The DgS modelling also does not require grout to extend to the intersection on two coal pillars beneath the site as there are full rows of grouting in the adjacent roadway. I am of the view that it would be judicious to do this. This can be achieved by drilling from within the Subject Site.

In undertaking modelling DGS considered the possibility for a mine subsidence event to be initiated from a particular direction were considered. DgS had to model a credible worst-case scenario that this could occur from any direction and include that in the contour plans – see Figure 4. In reality, a mine subsidence event is expected to be initiated from a particular area.

DRILLING OF GROUT BOREHOLES

The mine workings in the Borehole Seam beneath Newcastle are systematically laid out, as can be observed from Record Tracing RT566.

In the past 20 years, many boreholes have been drilled down to these mine workings and it is considered there is a good level of accuracy in encountering mine workings (headings as opposed to coal pillars). The mine headings are in the range of 4m – 6m wide and continuous in length in the area, so this is a reasonable target when drilling old mine workings.

Coffey has already drilled four boreholes and undertaken sonar inspections on two of these which has assisted in confirming the layout of the mine workings.

The Grout Plan included in the Current Mine Grouting Strategy shows the planned layout of boreholes for grouting the Yard Seam and the Borehole Seam.

The boreholes, to be drilled by conventional means, for the Borehole Seam have been located to inject grout to achieve the coverage as modelled. However, it is a routine part of carrying out mine grouting works to review information as it becomes available, and I cannot rule out the possibility of additional boreholes being necessary to ensure grouting achieves at least that required by the modelling. Should additional boreholes be required, they can be drilled from within the Subject Site. Boreholes will also need to be drilled from the Subject Site for the purpose of verification.

There has been some speculation that Directional drilling will be required to drill the grout boreholes. Directional Drilling is a highly technical and sophisticated method of drilling used primarily in the oil and gas industry where drilling is undertaken with

steered drilling heads to achieve a very high level of accuracy. The boreholes are often deep and in instances multiple boreholes are drilled off the main borehole.

It is not necessary to utilise this technology to drill angled boreholes to intersect mine workings at a maximum depth of 100 metres with a maximum angle of around 25° to the vertical. The Current Mine Grouting Strategy proposes angle drilling as opposed to directional drilling.

Coffey has provided examples where angled drilling has occurred for the purpose of grouting including:

- University of Newcastle NewSpace (9 storeys), with a site area of 3,800m2 (note this project was completed six years ago). Inclination from vertical up to 30°.
- Sky Residences (180 units over 19 storeys) with a site area of 3,400m2. Inclination from vertical up to 20°.
- The Verve, two towers up to 19 storeys with a site area of 4700m2. Inclination from vertical up to 24°.
- University of Newcastle Honeysuckle City Campus Development, Site 1 only, with a site as of 7,700m2. Inclination from vertical up to 14°.

4.0 ADDITIONAL MATTERS RAISED BY OTHERS

During the lead up to Cresent's submission to Newcastle City Council there were a few matters raised as a concern by others. They are dealt with briefly in the following sections.

4.1 EARTHQUAKE RISK

In December 1989, an earthquake measuring 5.6 on the Richter shook Newcastle and claimed 13 lives and caused extensive damage to buildings and other structures. It was suggested little is known about the effects of the earthquake on mine workings and parts of the Yard Seam had collapsed and damaged buildings. Given the Yard Seam workings will be grouted this is not an issue for the site.

In 2002, Geoscience Australia (Dhu T, Jones T, *Earthquake Risk in Newcastle and Lake Macquarie*, Minerals and Geohazards Division, Geoscience Australia 2002) undertook an assessment of the earthquake risk in Newcastle and Lake Macquarie. This comprehensive document can be referenced if more information regarding the 1989 Earthquake is required.

It is incorrect to indicate that nothing is known of the effect of an earthquake on mine workings. There were many underground coal mines in operation when the 1989 earthquake occurred. I was an Underground Coal Mine Manager of an operating mine and experienced firsthand the outcomes of the earthquake. I can advise that the underground mine workers I spoke to immediately after the earthquake did not know the event occurred, other than experiencing disruption to underground power. Before

resumption of operations, I arranged for a thorough inspection to be carried out of the mine workings (as I know other Mine Managers in the area did) and do not recall any damage to the mine workings having resulted from the earthquake

4.2 GROUTING AND SUBSIDENCE PARAMETERS

The matter has been raised that the stabilisation of workings beneath the development site may result in differential surface settling surrounding the site resulting in nearby properties experiencing ‘substantial’ damage than the development site.

The risk of mine subsidence and surface impacts to existing structures currently on the site, and surrounding properties, is already present. If mine subsidence were to occur now, there is the potential for existing structures to be subject to the full suite of mine subsidence effects. These are defined as:

(v) Subsidence Smax (m)

(vi) Strain +/- Emax (mm/m)

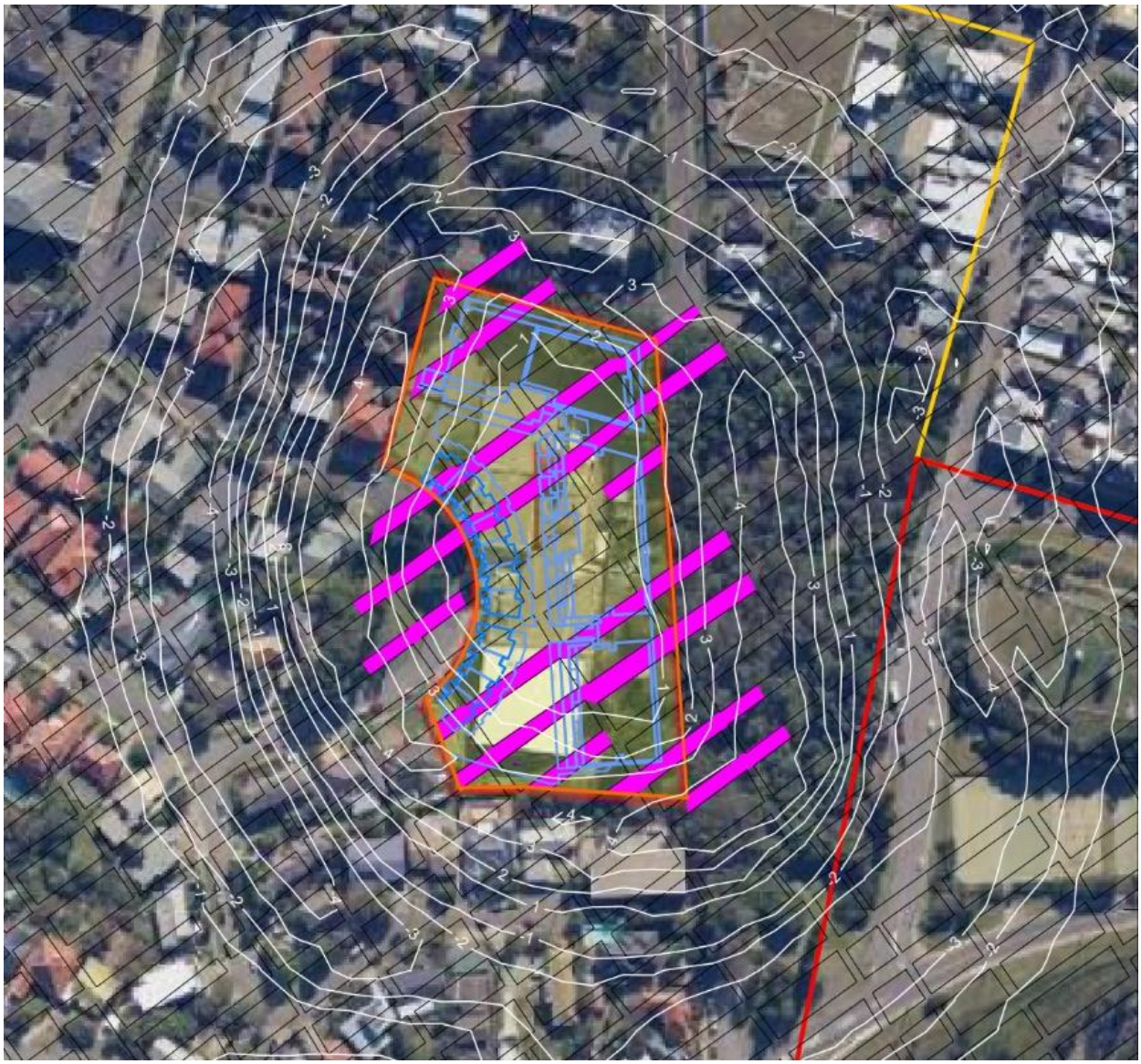
(vii) Tilt (mm/m)

(viii) Curvature (km)

Depending upon the behaviour of the subsidence event, existing structures could be subject to the same maximum predicted subsidence parameters calculated by DGS as illustrated in the subsidence contour plans as the subsidence 'wave' passed beneath the area. It is my observation after inspecting buildings damaged by subsidence over a period exceeding 20 years that not all residential structures are damaged following mine subsidence after undermining and that mine subsidence strains are not uniform in nature. There is a low risk the maximum predicted subsidence parameters would be exceeded. If a subsidence event were to occur today there can be no assurance where the subsidence effects will stop (as occurred with the original creeps to the east) and some structures will be subject to similar residual subsidence parameters as detailed in the DGS subsidence contour plan (Figure 4 below) attached as Appendix B to the Current Mine Grouting Strategy.

Grouting of old mine workings not only limits mine subsidence impacts under a site but also has the potential to reduce the likelihood of a subsidence event to occur in the first instance by increasing the stability of that area. It also has the potential to prevent a subsidence event progressing further and damaging more property.

Fig 4: Predicted Final Horizontal Strain Contours with Aerial Photo and Proposed Grout in the Borehole Seam: Preferred Option 2 prepared by Ditton Geotechnical Services



It can be seen from Figure 3 that in the area covered by the strain contours, the 4mm/m zone only makes up a portion of the area and in some cases is located where there are no surface structures. The majority of the area has strains of less than 4mm/m. It is also clear that strains will affect the Subject Site and grouting therefore was not intended to prevent any subsidence related ground movement.

Reference has been made to damage classifications in the 1975 National Coal Board Engineer Handbook. This document was a useful starting point for the management of mine subsidence at a time when more detailed assessment of the impacts of mining in Australia were being developed. The document included the assessment of damage to what I would describe as UK style structures that were inflexible in structure. There are references to 14m long semi-detached houses and a 60m long terrace of houses.

The following diagram from the 1975 National Coal Board Engineer Handbook [1] was for.2 storey brick structures and therefore doesn't provide for different types of construction. Modern structures are more flexible and therefore have a greater level of tolerance to ground movement. Based on available aerial information it appears many structures would be less than 30m in length. For the purpose of conservatism, I have used 35m.

FIG 5: Impact Classification with Deflection Ratios for Two Storey Brick Structures [1]

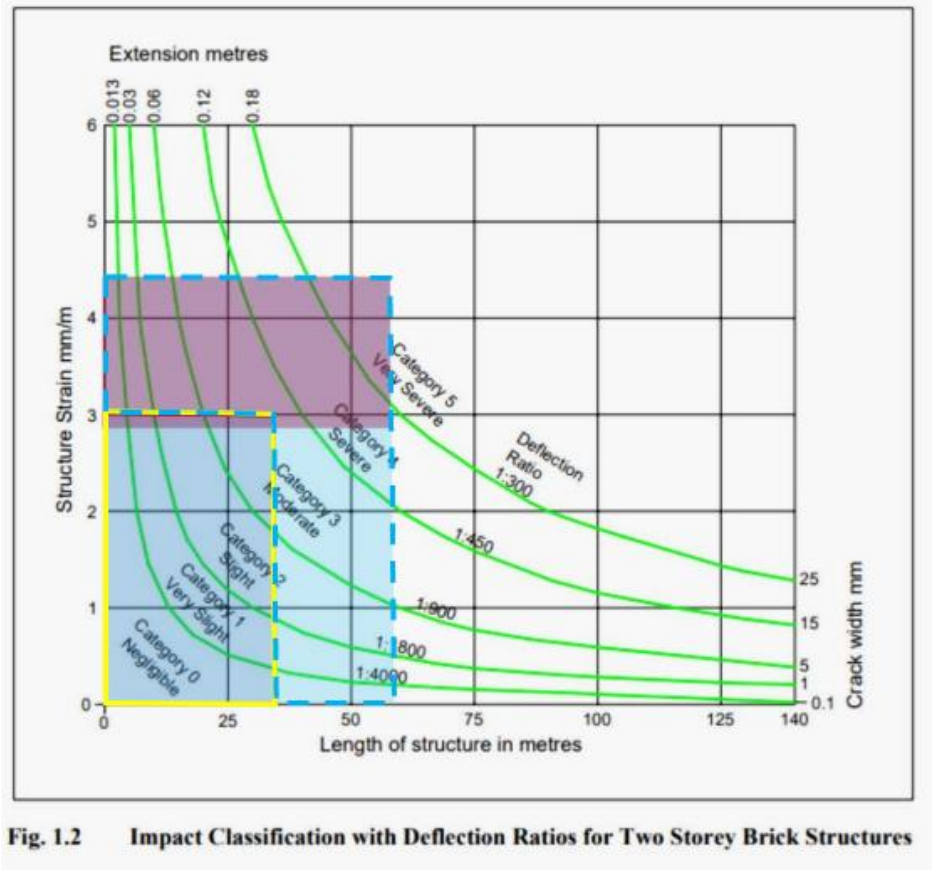


Fig. 1.2 Impact Classification with Deflection Ratios for Two Storey Brick Structures

The zone enclosed by the yellow dashed line added by the author shows the possible damage category for 2-storey brick structures if the strains were <3mm/m and the building length <35m.

The zone enclosed by the yellow dashed line combined with the zone enclosed by the blue dashed line shows the possible damage category for 2-storey brick structures in the maximum strains were around 4.5mm/m and the building length up to 58m.

Based on Figure 5, it is expected most 2-storey brick structures would be in the "very slight to moderate" category.

If the strains were 2mm/m or 3mm/m and the building was 30m long and constructed of flexible design in accordance with relevant codes and standards, then the risk and magnitude of damage is reduced.

Structures approved by SA NSW are covered under the provisions of the CMSC Act.

5.0 CONCLUSION

In my opinion the *'Mine Grouting Remediation Strategy Summary Report'* dated 24 August 2020 prepared by Coffey (Current Mine Grouting Strategy) which details the works that are proposed to be undertaken to comply with the Subsidence Advisory NSW's Original GTAs, is able to achieve the outcomes required.

The Current Grout Strategy has been modelled by DGS and reviewed by GAPL. Northrop has advised they can design for the mine subsidence parameters.

The Current Mine Grouting Strategy requires grouting of the Yard Seam and partial grouting of the Borehole Seam. All drilling will be undertaken from within the site.

On 9 December 2020, SA NSW has issued advice to indicate Conditions 4, 6a and 6b have been met subject to grouting being able to be completed.

It is important the Current Mine Grouting strategy by reviewed as additional information becomes available to ensure the strategy is fully implemented and verified and achieves the requirements of the modelling completed by DGS.

Structures approved by SA NSW are covered under the provisions of the CMSC Act.

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