

21 October 2015

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MELBOURNE VIC 3000

## **LATROBE CITY COUNCIL**

### **GEOTECHNICAL PEER REVIEW – LABTROBE PLANNING SCHEME AMENDMENT C87**

Dear Terry

#### **1.0 INTRODUCTION**

Golder Associates Pty Ltd [**Golder**] has undertaken a geotechnical peer review of a PSM Consult Pty Ltd [**PSM**] report entitled “Latrobe Planning Scheme Amendment C87: Traralgon Growth Area Review, Submission Number 22, Loy Yang Mine” dated 14 April 2015 Ref PSM2690-001R [**PSM report**]. The PSM Report is presented as a Witness Statement prepared by Mr Tim Sullivan, of PSM, and sets out his views regarding a number of matters relating to the impact and potential future impact of nearby mining activities on development and potential future development within the township of Traralgon, and provides its view with respect to the sufficiency or otherwise of the current 1 km buffer distance around the mine provided under Clause 21.07 of the Latrobe Planning Scheme.

Our geotechnical peer review of the PSM Report was undertaken in accordance with our proposal dated 1 September 2015 (Ref P1539765-001-L-Rev0), responding to a brief from Maddocks dated 27 August 2015. Documents provided with the brief and which have been referred to as considered necessary in undertaking this Peer Review are listed as an attachment to this report. This is the first stage of a two stage process to assess the geotechnical risks to the township of Traralgon arising generally from mining activities in the Latrobe Valley, and in particular from the Loy Yang open cut mine, but in particular if the recommendation presented by Mr Sullivan that the Buffer Zone should be extended beyond the present 1 km setback from the crest, or top of mine batter. Approval to proceed with this work was provided by telephone and subsequently by an email from Maddocks dated 11 September 2015.

Our review was undertaken by Dr Chris Haberfield, Principal, in conjunction with Mr Max Ervin, Senior Consultant. Both have significant experience and knowledge of the geotechnical issues arising from mining in the Latrobe Valley.

This report summarises the results of our review and provides recommendations in relation to the conclusions reached in the PSM Report. Our recommendations include a qualitative assessment of whether the identified issues are significant or are likely to only be speculative and tolerable to Council’s risk profile, and whether we have identified any potential gaps in PSM’s analysis of the issues. Our report also provides general comments on risk to the town from geotechnical hazards associated with the mining operations and identifies possible areas within the PSM proposed extended buffer zone which may have higher risk than others.

As a result of this initial study we expect to be able to identify what additional work is required to provide the risk assessment requested, and provide as part of this report. Refining the scope of the further work in conjunction with Maddocks and Council will be desirable as this may depend upon whether a semi qualitative risk assessment is sufficient to inform Council’s ongoing dialogue in relation to the matter, or whether a full quantitative risk assessment is required.



## 2.0 REVIEW OF THE PSM REPORT

### 2.1 General Comments

We have undertaken a high level review of the PSM report. We have restricted our review comments to the main issues, recommendations and conclusions raised in the PSM Report. There are a number of specific statements in the PSM Report that are made without sufficient justification or appear to be based on experience, interpretation and conjecture. For a number of these we have an alternate interpretation, whilst others we disagree with. We have not provided specific comment on these in this report, however we can provide such comment if required.

The PSM Report provides information relating to historical settlement (vertical movement or subsidence), horizontal movements and stability incidents that have occurred within the Latrobe Valley generally as a result of mining. Although much of this information relates to areas other than Loy Yang Mine and Traralgon, it is still relevant, in a general sense, to the assessment of mining impact on the township of Traralgon.

At paragraph 33 of the PSM Report, PSM indicate they have recently developed a Draft Guideline (not further defined) on behalf of the Victorian Government, as a result of "a renewed focus to further understand the stability of the coal mines, the Latrobe Valley wide impacts and to provide a framework for better managing the risks". We have not sighted the Draft Guideline, but PSM rely upon its content in the conclusions reached in the PSM Report. In particular, an "Area of Influence" is described by PSM (Para 17) as being incorporated into the Guideline. This Area of Influence is described by PSM as "*the zone outside the mine crest that has undergone significant movement in the past and or is subject to significant ongoing movement in the future as a result of mining activities*"

Based on their assessment of monitoring data for the area adjacent to Loy Yang mine, PSM adopt a boundary to this Area of Influence which extends between 1300 m and 1600 m to the north of the Loy Yang mine crest in areas of past mining, but do not define this further to the east in the area where mining is continuing (See Figure 19 from PSM Report, attached). The basis for selecting the boundary of the Area of Influence is stated as (paragraphs 73 and 74) being the point at which "*the stresses are interpreted as being partly relieved*", and on Fig.5 (attached) this is shown as "*inflection point 2*" the selection of this "*inflection point*" appears to be somewhat arbitrary, and no basis for it is presented.

The purpose of defining this Area of Influence appears to be to identify the area north of the mine and in the township of Traralgon which has been or could be potentially affected by mining activity. Historical settlements appear to have been ignored in the PSM assessment of Area of Influence. Instead, the Area of Influence proposed by PSM appears to only consider historical horizontal movements that have occurred around Loy Yang Mine and historical "catastrophic" stability incidents (or instability) that have occurred at mines throughout the Latrobe Valley.

In reality, settlement, horizontal movements and instability all have the potential to impact on development, and need to be considered in a risk assessment for future development. In general the impact of horizontal movements and instability reduces significantly with distance from the mine, whereas settlement is more widespread (due to widespread dewatering of the underlying aquifers). The Area of Influence proposed by PSM extends beyond the current 1 km buffer zone and encroaches into the Traralgon township.

Whilst the identification of an Area of Influence delineates an area which has the potential to experience ground movement from mining activities (i.e. defines the area where there is a potential hazard from mining), it does not necessarily mean that development within this area has an unacceptable level of risk from mining activities. The risk needs to be assessed, and mitigation measures, if required, implemented. This is no different than what is usually undertaken for developments in areas that fall within wildfire or erosion management planning overlays. The PSM report does not present an assessment of risk level within the Area of Influence.

The PSM Report includes a number of photographs showing the impact of instability that has occurred at various mines in the Latrobe Valley and elsewhere. Many of these photographs are without doubt alarming, but they are unlikely to be relevant to the Traralgon township. With respect to the Area of Influence as defined by PSM, the impact of the various Latrobe Valley instability incidents considered in the PSM report is restricted to within about 730 m from the toe of the relevant mine batter where the instability occurred (see PSM Figure 15, attached), or within about 300 m to 400 m of the crest of the mine batters. This is well within the current 1 km buffer zone and generally within PSM's designated Zone 1 of the Area of Influence. The

existing buffer zone around the mine is to ensure that development does not occur in areas that can be impacted by incidents of instability at the mine. Based on the information presented in the PSM Report, the existing 1 km buffer zone would therefore appear to be prudent and satisfactory.

The remaining area inside an (as yet to be reasonably defined) Area of Influence but outside of the existing buffer zone is of primary interest to the Council. This is the area in which development has occurred, or may continue to occur and which has and may continue to experience stable ground movements (as distinct from instability) as a result of mining activities. The risk to development will depend not so much on the total magnitude of movement, but on the differential movement from one point to another. Provided the differential movements are small enough (magnitude not yet defined), the assessed risk will be within tolerable limits. The purpose of a risk assessment is to estimate the severity of differential horizontal and vertical ground movement (the hazard) throughout this area and assess the risk to development, services and infrastructure associated with these ground movements.

## 2.2 Stability Incidents

The PSM Report (at Section 7 page 7) identifies a number of mining related stability incidents that have occurred in the Latrobe Valley since 2003. Of the incidents listed in the PSM report, we have independent knowledge of the incidents listed below. These incidents all occurred within or close to the mines in question and their immediate impact (with respect to stability) was restricted to well within a distance of 1 km from the mine (i.e. from the crest of the nearest relevant mine batter)<sup>1</sup>:

1. 2003 – Yallourn Mine – block movement during construction of the Morwell River Diversion during reasonably intense rainfall. The construction works blocked a drainage path which resulted in a groundwater rise within the underlying coal joints and about 0.5 m movement of a batter within the mine;
2. 2007 – Yallourn Mine – Latrobe River batter failure – block movement due to infiltration of water from the river which failed into the mine. The PSM Report states the northeast batter of the mine had been moving for many years as a result of stress relief from mining and indicates a maximum horizontal movement of the crest of the mine batter prior to the incident of about 1.8 m. The horizontal movements resulted in cracks opening up in the coal under the river which allowed water infiltration into the coal which led to the failure. PSM assess, but cannot confirm and don't provide any evidence that significant movements (not defined) "*were probably occurring at least one km from the mine crest.*" The failure that occurred is described in the PSM Report as being "*500 m in length and extended back 150 m from the mine crest*". This failure only occurred because of a continuous supply of water from the river;
3. 2009 – Hazelwood Mine – sinkholes in the Morwell Main Drain – had no immediate impact outside of the drain, but could potentially have led to batter movement as occurred in 2011 (see item 4 below);
4. 2011 – Hazelwood Mine – northern batter movement due to water infiltration through a large sinkhole that formed in the Morwell Main Drain during a reasonably intense rainfall event resulting in cracking and closure of the Princes Freeway. Figure 15 in the PSM report indicates cracking resulting from the incident was restricted to within 640 m of the toe of the northern batter (or within about 200 m to 300 m from the crest of the batter). The movement of the northern batter resulted from the large volume of water in the drain which was able to infiltrate into the coal seams through the sinkhole in the drain. Movement ceased once there was no more water to infiltrate. Significant remediation works on the drain (including lining of the drain) have since been completed;
5. 2012 – Yallourn Mine – failure of the Morwell River Diversion. This event is unrelated to mining activities and had no immediate (stability related) impact outside of the mine;
6. 2014 – Hazelwood Mine – movement of the northern batter of the mine caused by water introduced onto the batter to fight the Hazelwood Mine Fire. Figure 15 in the PSM report indicates cracking resulting from the incident was restricted to within 200 m to 300 m of the toe of the northern batter (or in other words within the mine batter itself) ;

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<sup>1</sup> Many of the figures in the PSM report do not contain a distance scale which makes it difficult to assess accurately the distance from the crest of the batters where cracking and movement have been observed/measured. We have used other sources of information as well as scaling from the PSM figures to estimate distances from the crest of the batters.

We have little independent knowledge of the following incidents listed in the PSM Report.

1. 2007 – Loy Yang Mine - southern batter movement. The PSM report provides no further details of this incident;
2. 2007 – Yallourn Mine - failure of fire service main in the “Yallourn Township Field”. The PSM report provides no further details of this incident;
3. 2010 and 2011 – Yallourn Mine, “*re-initiation of movements on the western batters of old Township Mining Field, extending outside the mine and across public roads*”. We have knowledge of ongoing movement of this batter which correspond with increases in groundwater levels within the coal. However, we have no knowledge of a particular “incident” as described by PSM. We infer that some of the data points in Figure 15 of the PSM report (e.g. “*Yallourn YTF Haunted Hills Rd*”) relate to this movement and indicate cracking was limited to an area within 500 m of the toe of the batter or within about 200 m of the crest of the batter. The PSM report provides no further details of this “incident”;
4. 2014 – Yallourn Mine – “*Latrobe Road cracking and sinkholes*”. The PSM Report states this incident occurred on 29 June 2014 and was “*caused by a buildup of a stress concentration due to mining, which was released suddenly by a large scale block slide of the coal seam....The sliding of the coal seam took weeks to months to spread over a very large area more than a kilometre long*”. PSM conclude “*This event is considered to be a significant stability incident. It resulted in effects some way outside the Mining Licence.*” However, PSM do not explicitly state how far these effects extended outside of the mine. Figure 15 in the PSM Report indicates cracking from this event was limited to within 600 m of the mine batter toe, or within about 200 m to 300 m from the crest of the batter; that is well within 1 km of the mine crest.

The PSM Report also refers to the Lewis anomaly (see PSM Report section 10.3.4), which is associated with the Morwell Mine and which manifested as a sudden movement in 1966/67. PSM consider this to have been a similar incident to the Latrobe Road incident, both of which were “*large scale block movements of the coal caused by sudden release of a horizontal stress concentration*”. Figure 15 of the PSM Report indicates cracking associated with the Lewis anomaly was limited to within about 670 m from the toe of the Morwell Mine batter, which we estimate to be within about 300 m to 400 m of the crest of the mine, and accordingly we do not consider this incident has any greater bearing on the risks associated with development outside a 1 km buffer zone than the other stability incidents cited by PSM.

In fact, all of the maximum crack distances shown in Figure 15 of the PSM Report, indicate that cracking was limited to within 730 m from the toe of the mine batter. This approximates to cracking being limited to within about 300 m to 450 m of the crest of the mines in question, and well within a 1 km buffer distance.

Based on our assessment of the stability incidents identified in the PSM Report, we are of the opinion that:

- i) Stability incidents have been caused by an increase in ground water levels (usually from infiltration of water from the surface into the coal joints) or due to sudden release of stress concentration as a result of mining. The instability is short lived, with movements effectively ceasing once ground water levels drop or stresses are relieved;
- ii) Their immediate impact (with respect to stability) has been restricted to well within a distance of 1 km from the mine. That is, there is no evidence that we are aware of that identifies significant stability issues at a distance of more than 1 km from the mine batter crests at any of the mines in the Latrobe Valley.
- iii) The stability incidents have generally occurred independent of when mining was undertaken, in some instances many years after mining was completed in the area (e.g. Northern batters of Hazelwood mine). This is in contrast to general horizontal movement and settlement (due to mining, not groundwater lowering), the rate of which generally diminishes with time after completion of mining activity.

Whilst some of the photographs shown in Attachment D of the PSM Report may be alarming, they are only indicative of the effects of such incidents in the immediate area of the incident. They are not representative of what may occur at distances in excess of 1 km from the crest of the mine batters. The effect of these stability incidents at distances of greater than 1 km from the mine appears to be insignificant.

Thus, if there were to be any expansion of the authorised mine boundary, the area which could be affected by possible stability incidents would extend accordingly, but would be expected to still be contained within, say, 500 m of the new mine crest location. Settlement and horizontal (stable) movements could extend beyond this zone of potential instability, and expansion of the buffer zone to remain 1 km from the mine crest would be prudent.

### 2.3 Fundamental Issues for Stability in the Latrobe Valley

The PSM report identifies a number of geotechnical factors which impact on the behaviour of the ground, and hence on the interaction between the mines and townships and mining related risks in the Latrobe Valley. We agree with the factors PSM identify and also agree that:

- *“the batter and mine stability is very sensitive to water and the high in-situ stress” and that “large movements are the normal operating situation”;*
- *“In a general engineering context this situation means potential for significant risks”;*
- *“The history [of mining in the Latrobe Valley] is punctuated by significant stability incidents that have occurred over short time intervals compared to the period of their development”;* and
- *“..even though some of the past and ongoing movements may not by themselves constitute a hazard, these movements may make the area sensitive to external water loading events, for example rainfall runoff and earthquakes’.*

However, the stability incidents identified by PSM, ground movements and risks need to be considered in context.

As set out in Section 2.2 above the impact (and hence risks) associated with the stability incidents identified in the PSM report reduce significantly with distance from the mine, with no evidence (to our knowledge) of significant impact being identified beyond 500 m from the mine batter crest (refer PSM Figure 15 attached). This means that these incidents are unlikely to represent a hazard to the area outside the current buffer zone, and therefore do not need to be considered in a risk assessment for future development of the Traralgon township.

However, there are other ongoing mining related stable<sup>2</sup> movements that extend more than 1 km from the mine that could potentially impact on the Traralgon township and hence may need to be considered.

### 2.4 Measured Ground Movements

There is a long history of ground movement and monitoring of ground movement in the Latrobe Valley. For example, monitoring of ground movement around the Morwell Mine has been ongoing for in excess of 60 years. Over this period, the Morwell township has experienced settlements of up to about 2 m. Council would be aware of the impacts that such settlement has had on the township. Settlements of this magnitude due to groundwater drawdown are not unusual and there are many very large cities that have experienced in excess of 2 m settlement due to drawdown of groundwater; e.g. Shanghai, Mexico City and Venice.

Figure 4 of the PSM report shows that settlement of between 150 mm and about 1 m has occurred over the last 50 or 60 years at various locations throughout the Latrobe Valley (including in the townships). The monitoring results indicate that these settlements are on-going, and continue for many years after mining activity has ceased in the adjacent areas. However, about 10 to 15 years after mining ceases, it appears these settlements and horizontal movements reduce to rates of between about 5 mm per year and 25 mm per year. In the case of settlement, the monitoring data does not differentiate between settlement induced directly from mining activity and the effect of groundwater lowering. However, for comparison, (developed) areas of South Melbourne are settling at not dissimilar rates of between 5 mm and 10 mm per year.

Appendix E of the PSM Report contains graphs of measured total vertical and horizontal movements with time along three “stability lines” north of the Loy Yang Mine.

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<sup>2</sup> As distinct from unstable movements resulting from instability

The measured data indicate the greatest vertical and horizontal movements generally occur within the (north) batter of the mine and generally decrease with distance from the mine batter.

For example, based on the data provided in Appendix E of the PSM report, maximum settlements of between 1.5 m and 1.8 m have been measured since about 1988 at up to about 300 m from the crest of the mine batter. However at a distance of about 1 km from the crest of the mine batter, the total measured vertical settlement has reduced to between about 0.3 m and 0.8 m. Most of the measured settlements occurred prior to 2003. The current measured rate of settlement at 1 km from the crest of the mine is about 15 mm per year.

Similarly, maximum horizontal ground movements of between about 1.8 m and 3.5 m have been measured at the north mine batter since 1988. However at a distance of about 1 km from the crest of the mine batter, the total measured horizontal ground movement has reduced to between about 0.3 m and 0.5 m. Most of the measured horizontal movements occurred prior to 2003. The rate of measured horizontal ground movement at 1 km from the crest of the mine is currently (since 2006) a maximum of about 4 mm per year. It is expected that these relatively insignificant vertical and horizontal movements will continue for many years.

The PSM Report identifies the following sources of on-going (rather than related to a specific stability incident) mine related ground movements in the Latrobe Valley:

- i) movements caused by excavation of the pit and subsequent relief of in situ stresses. These ground movements are relatively localised around the mines, but can continue to occur as creep after mining has been completed;
- ii) movements due to local and regional dewatering and depressurisation of the aquifers underlying the mines and the Latrobe Valley in general. These ground movements are relatively wide spread; and
- iii) movements related to instability (which we have already considered in Section 2.3 above).

The ground movements that have been measured are a combination of all of the above, and it is difficult to separate the measured movements into the various components identified.

However, as acknowledged in the PSM report (paragraph 56), *“uniform settlement may not be an issue. However, if it impacts on the hydrological design of man-made structures or natural drainage features then risks will probably arise.”* With respect to existing and future development the risk lies in differential movements and the gradients of horizontal movement (or horizontal strain) and settlement (or vertical strain) with length (e.g. over the width of a house or street for example).

Again using the data provided in Appendix E of the PSM Report, we have made a preliminary estimate of the total (average) differential movements that have occurred since about 1988 at 1 km from the crest of the mine batter. Our analyses indicate total horizontal and vertical differential movements of 0.2 mm/m to 0.4 mm/m and 0.4 mm/m to 0.7 mm/m respectively. These correspond to maximum total (average) horizontal and vertical strains of about 0.04% and 0.07 % respectively since 1988. These strains are relatively low and would not typically be expected to cause any significant damage to structures, services or infrastructure, and can be satisfactorily accommodated in good design practice. By way of comparison, if designing a house foundation for a moderately reactive site (a common situation)<sup>3</sup>, it would be assumed that differential vertical movements of up to 40 mm over a horizontal distance of perhaps 10 metres would need to be accommodated (that is 5 to 10 times more severe than the differential strains above), and these would be addressed by standard design practice. Similarly, drainage design would often provide falls of 1% and so without significant modification to common practice could be reasonably expected to accommodate the differential movements described.

## 2.5 Area of Influence at Loy Yang Mine

The PSM Report adopts the concept of an “Area of Influence” around the Loy Yang Mine, as described earlier. In arriving at the Area of Influence, PSM assesses that three movement zones can be identified (paragraph 73), and appear to base the boundary between these zones on assessed “inflection points” in measured horizontal movement (see PSM Figure 5, attached) as follows (for Stability Line N5):

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<sup>3</sup> Australian Standard AS 2870-2011 Residential slabs and footings

Zone 1: *“0 m to 1200 m from the batter toe, (or about 0 m to 800 m from the batter crest) where the majority of movement has occurred and where it is interpreted that the in-situ horizontal stress has been completely relieved”;*

Zone 2: *“1200 m to 1800 m (we note that on Figure 5 this is shown as 1700 m) from the batter toe, (or about 800 m to 1400 m from the batter crest) where the stresses are interpreted to be partially relieved”;* and

Zone 3: *“Greater than 1800 m from the batter toe, (or greater than about 1400 m from the batter crest) where high in-situ stresses remain and limited movement has occurred”.*

Paragraph 77 of the PSM Report identifies the *“edge of the Area of Influence”* as between 1300 m (Stability Line N5) and 1600 m (Stability Line N3) from the mine crest.

We agree that there is an *“Area of Influence”* around the Loy Yang Mine (and indeed any mine) which relates to horizontal ground movement, and that this area could extend a significant distance from the crest of the mine. However, of significance are the horizontal and vertical strains that have occurred or could reasonably be expected to occur in the future within the Area of Influence.

Notwithstanding the above discussion, we note that the brief provided to PSM by Ashurst Australia (as appended to the PSM Report) introduces at Section 5.1, page 5 the concept of the depth of mining being increased from the current depth of approximately 160 m to 250 m. The brief then provides estimates of predicted subsidence under this scenario. The discussion and recommendations in the PSM report appear to rely on the monitoring data available from the present mining operations. In the event the mine were deepened to 250 m we would expect the potential impact of the mine would be more widespread, and a careful review of whether the 1 km buffer would still be adequate would need to be undertaken, and for that matter the PSM Area of Influence might also need to be reassessed by PSM. If this is a likely scenario, it should be more fully addressed in any risk assessment undertaken.

### **3.0 RISKS TO TRARALGON TOWNSHIP FROM MINING**

Risks from geotechnical related hazards are usually assessed on the basis of either being *“tolerable”* or *“unacceptable”* risk in respect to both risk to life and risk to property. The Landslip Risk Management guidelines published by the Australian Geomechanics Society (2007)<sup>4</sup> define tolerable risks as *“risks within a range that society can live with so as to secure certain benefits. It is a range of risk regarded as non-negligible and needing to be kept under review and reduced further if practicable.”*

The risk to the Traralgon township from mining related activities is directly dependent on the severity of the hazards that occur due to mining (and the type of development etc.). On the basis of our comments presented above, we consider the primary hazards to the township arise from (stable) horizontal movements and settlement. We consider that impact from catastrophic instability incidents at the mine are not credible outside the existing 1 km buffer zone and are therefore unlikely to be critical to the outcomes of a risk assessment.

At Loy Yang Mine the magnitude of horizontal movement and settlement decrease with distance from the mine. As a result, the severity of this hazard will also likely decrease with distance from the mine. As these movements occur slowly over years, they present no credible hazard to life, but may present a hazard to permanent development, services or infrastructure.

For the reasons set out above, we consider it likely that a risk assessment would conclude that risk to life from mining related activities in areas outside of the existing 1 km buffer zone was *“tolerable”* and within normal societal norms. Risk to property outside the 1 km buffer zone boundary may or may not be tolerable (depending on the outcomes of a risk assessment and Council’s view of what constitutes a tolerable risk), but is likely to reduce with distance beyond the existing 1 km buffer zone. As set out above, the differential movements (strains) outside the buffer zone are relatively low and would not typically be expected to cause any significant damage to structures, services or infrastructure, and can be satisfactorily accommodated in

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<sup>4</sup> Practice note guidelines for landslide risk management 2007”. Australian Geomechanics, Vol 42, No 1, March 2007. These guidelines are incorporated into the erosion management overlay for a number of Councils around Australia (including, Colac Otway, Yarra Ranges, Frankston, Mornington and Pittwater) for development of areas with susceptibility to landslip.

good design practice. For this reason we anticipate that a risk assessment would likely show that risks associated with such movements are tolerable.

#### 4.0 NEXT STEPS

The next step in the process is to undertake a risk assessment for areas outside the 1 km wide buffer zone. The risk assessment would concentrate on risk to property (buildings, services, infrastructure etc). We recommend that this risk assessment be qualitative, rather than quantitative. This is because to undertake a quantitative risk assessment we would need to know the value of each and every property or asset and then assess the potential damage to each should the hazard occur. This is not practical.

Critical steps for a qualitative risk assessment would include:

- i) define the areas of existing and proposed development as well as the types of development etc. in the area outside of the buffer zone that are of interest to the Council;
- ii) obtain and review historical information (which may be in Council archives or reports for Council) relating to documented or observed damage in Morwell and Traralgon resulting from ground movements;
- iii) review historical ground movement data in the Morwell and Traralgon areas, in particular if there has been any observed cracking or obvious distress to infrastructure or development beyond 1 km from the relevant mine crest. – we have access to a significant volume of data, but there may be data that we don't have access to;
- iv) analyse the historical data to assess existing strain levels which will be used to define hazard zones within the Traralgon township;
- v) estimate potential impacts on generic forms of building, services and infrastructure identified by Council and assess risk levels in each hazard zone, suggest potential mitigation measures if required.

#### 5.0 KEY FINDINGS

We have reviewed the PSM Report, and associated documentation provided, and have concluded:-

- The PSM Report describes a number of serious stability incidents associated with the Latrobe Valley mines. However, none of these has impacted beyond about 400 m from the crest of the relevant mine. The 1 km buffer zone presently applied to the Loy Yang mine therefore satisfactorily addresses any reasonable expectation of the extent of such instability should it occur.
- Whilst horizontal and vertical movements associated with mining activity will almost certainly occur beyond the present 1 km buffer zone, discrete or sudden differential movement (e.g. obvious cracking) is not expected. The PSM Report makes no mention of such observations beyond about 400 m from the crest of any of the Latrobe Valley mines. The recommended risk assessment should investigate this further.
- The PSM Report suggests the 1 km buffer zone is inadequate to protect communities from any adverse effects from further coal winning. PSM do not elaborate on what constitutes an "adverse effect". However, based upon the monitoring data presented by PSM, it appears that movements associated with mining activity, specifically differential or relative movements (strain), beyond the present 1 km buffer zone whilst real are likely to be able to be accommodated with appropriate planning and engineering design, for both infrastructure and structures.
- In the event the mined depth of the Loy Yang mines is extended beyond the present approximately 160 m, to a suggested 250 m, these conclusions would need to be reviewed.



## 6.0 LIMITATIONS

This Document has been prepared for the particular purpose outlined in Golder's proposal and no responsibility is accepted for the use of this Document, in whole or in part, in other contexts or for any other purpose.

Conditions may exist which were undetectable given the limited nature of the enquiry Golder was retained to undertake with respect to the site. Variations in conditions may occur between investigatory locations, and there may be special conditions pertaining to the site which have not been revealed by the investigation and which have not therefore been taken into account in the Document. Accordingly, additional studies and actions may be required.

Where data supplied by the client or other external sources, including previous site investigation data, have been used, it has been assumed that the information is correct unless otherwise stated. No responsibility is accepted by Golder for incomplete or inaccurate data supplied by others.

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## 7.0 CLOSURE

If you have any questions, please do not hesitate to contact the undersigned.

Yours sincerely

**GOLDER ASSOCIATES PTY LTD**



Chris Haberfield  
Principal

CMH/ASR/cmh



Max Ervin  
Senior Consultant

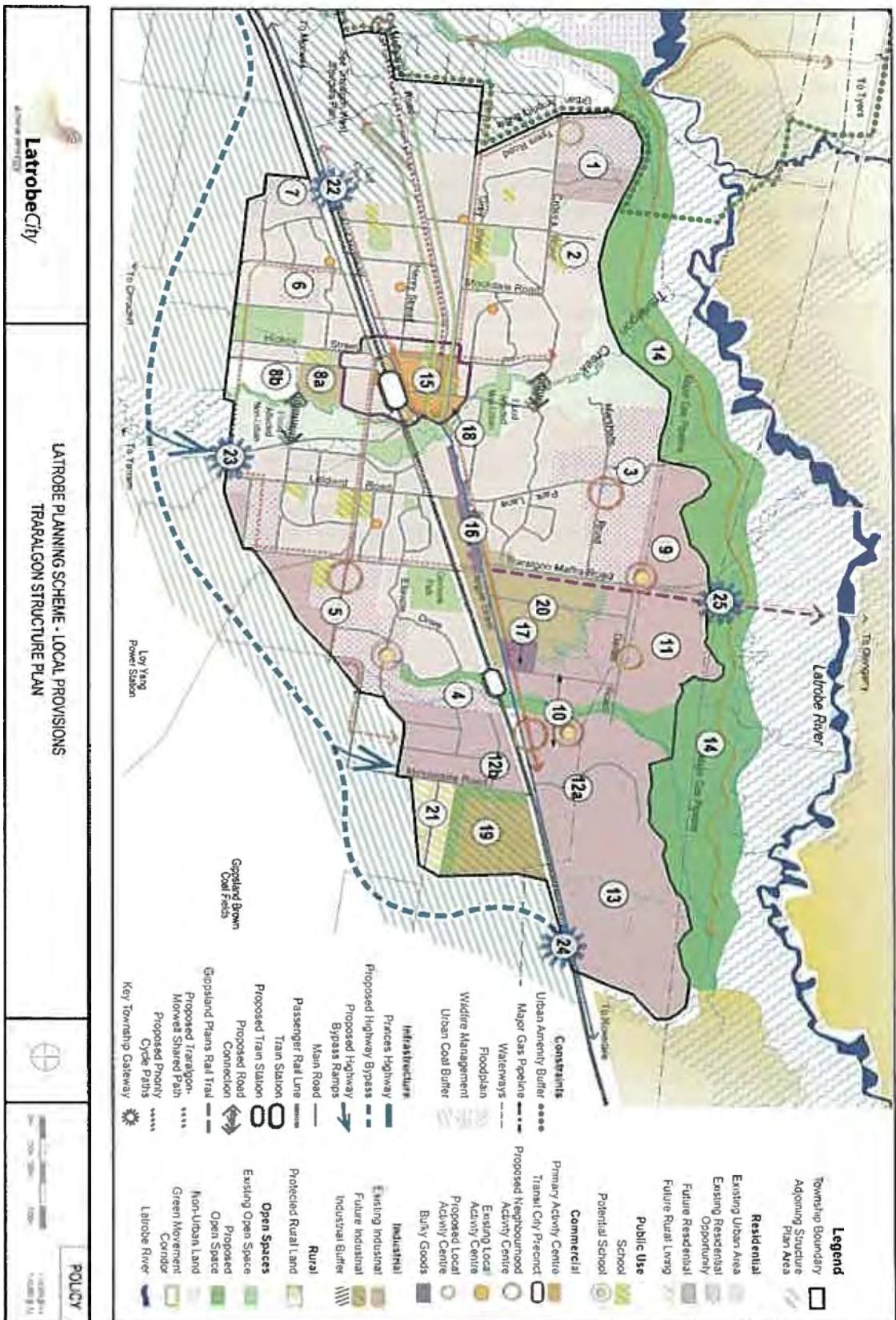
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## Attachments

Maddocks' Brief and List of documents provided  
PSM Report Figure 5  
PSM Report Figure 15  
PSM Report Figure 19

Part of the attachment has been removed from the Report as these matters are considered to be confidential in accordance with section 89 (2) (h) of the *Local Government Act 1989* as it deals with a matter that the Council or Special Committee considers would prejudice the Council or any person.

Appendix A



Latrobe City

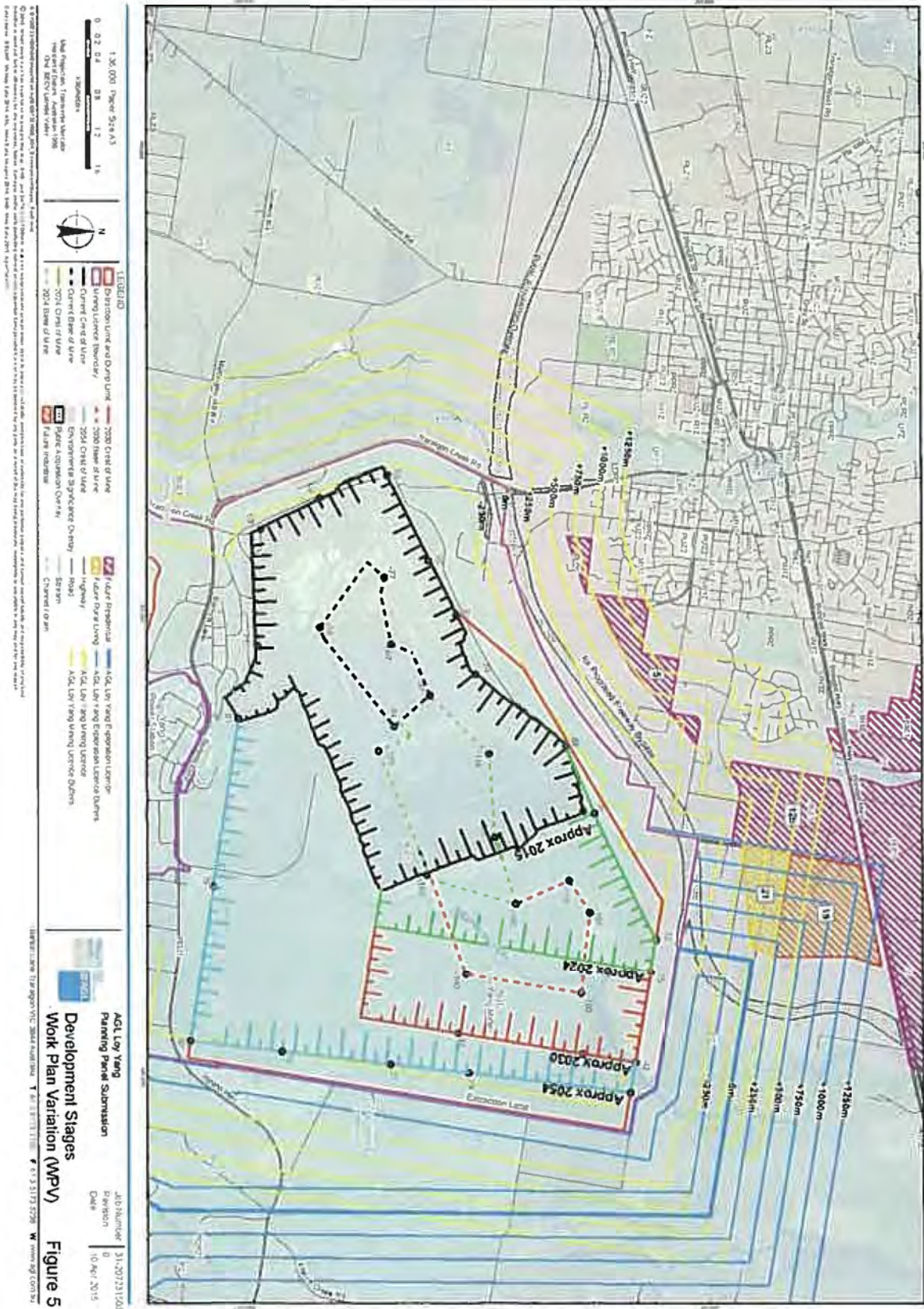
LATROBE PLANNING SCHEME - LOCAL PROVISIONS  
TRARALGON STRUCTURE PLAN



POLICY



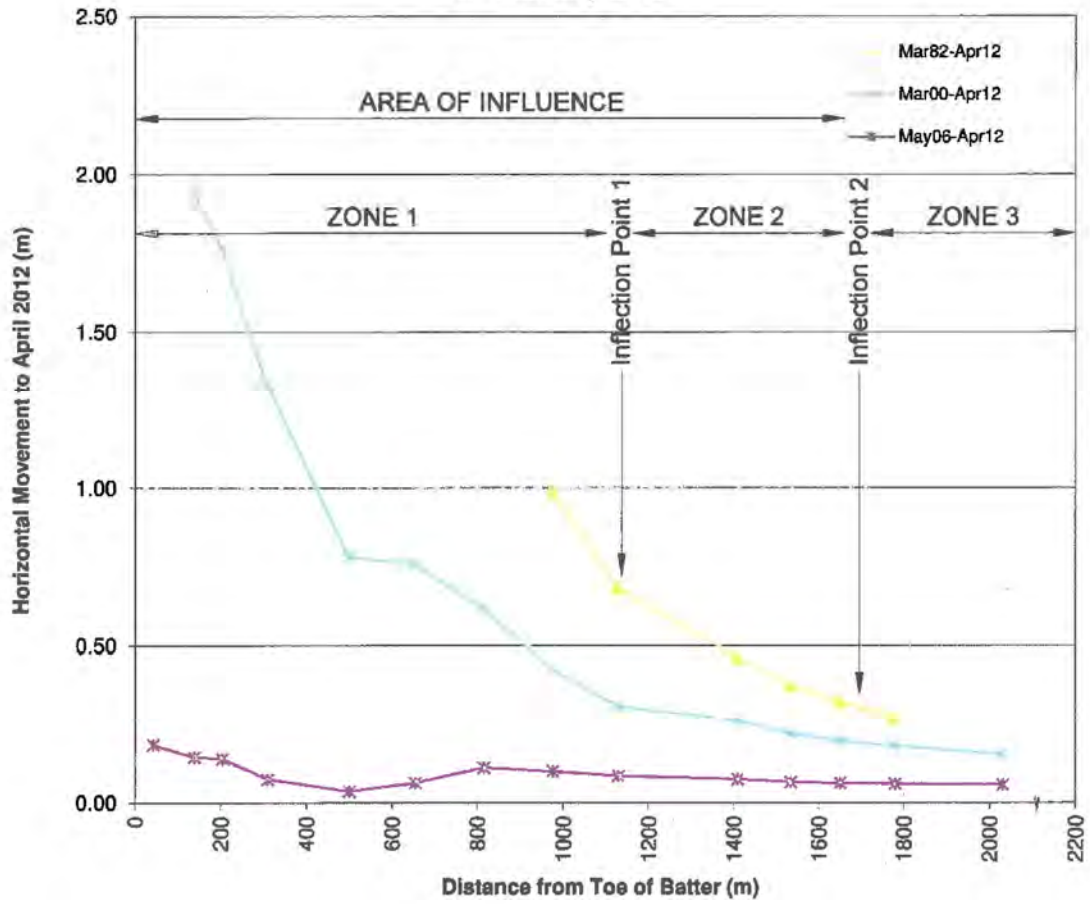
Appendix B



## Attachments

	Document	Date
<b>Amendment C87 Documents</b>		
1.	C87 Panel Report	22 June 2015
2.	Latrobe City Council C87 Submission, Part A and B	April 2015
3.	Latrobe City Council C87 Expert Witness Report prepared by Hansen	10 April 2015
4.	<b>Scheme Provisions – Latrobe City Council C87</b> Post-Exhibition Changes Instruction Sheet A3 set of all Plans Clause 21.02 Clause 21.04 Clause 21.05 Clause 21.06 Clause 21.07 Clause 21.08	
5.	Explanatory Report – C87	August 2014
6.	<b>Reference Documents</b> Traralgon Growth Area Review Background Report Traralgon Growth Area Review Framework Traralgon West Structure Plan Australian paper: Maryvale Pulp Mill Buffer Requirements	August 2013    July 2011
<b>AGL Loy Yang Expert Reports</b>		
7.	Expert Evidence of Tim Sullivan, Pells Sullivan Meynink	14 April 2015
8.	Expert Evidence of Stuart McGurn, ERM	April 2015
9.	Location Plan Maps	10 April 2015
<b>Other reports</b>		
10.	<i>Overview of Managing Groundwater and Impacts and Loy Yang Open Cut – Foley, Nicol and Missen</i> Geotechnical Advice – Response to Submissions 24 and P89A Traralgon Bypass Bypass	2012  September 2014

### Loy Yang Mine N5 Stability Line



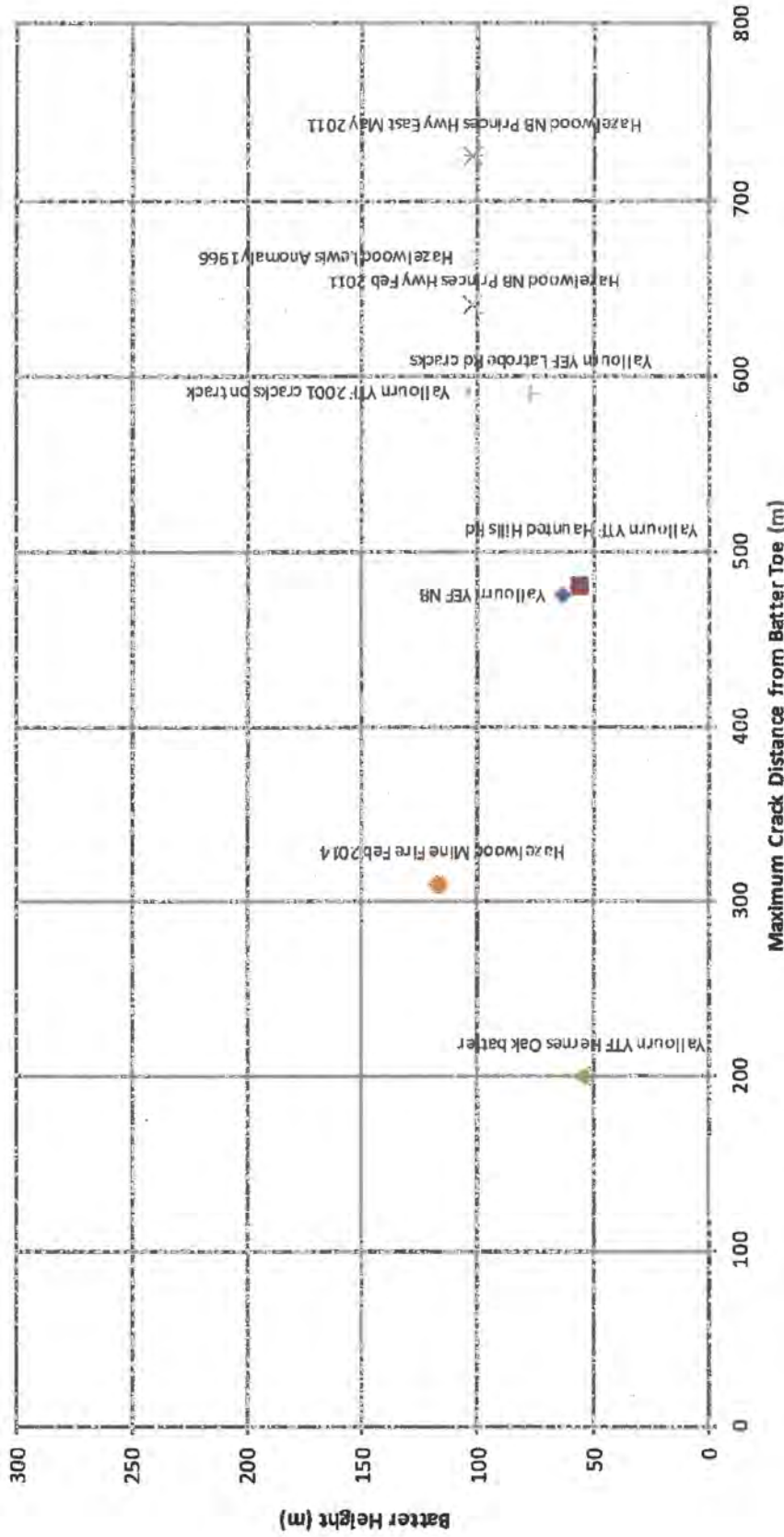
Pells Sullivan Meynink

Ashurst Australia  
Traralgon Planning Board  
Loy Yang  
Horizontal Movement Vs Distance from  
Toe of Pit Wall - N5 Stability Line 2012

PSM2690-001R

Figure 5

# Maximum Crack Distances in Latrobe Valley Mines

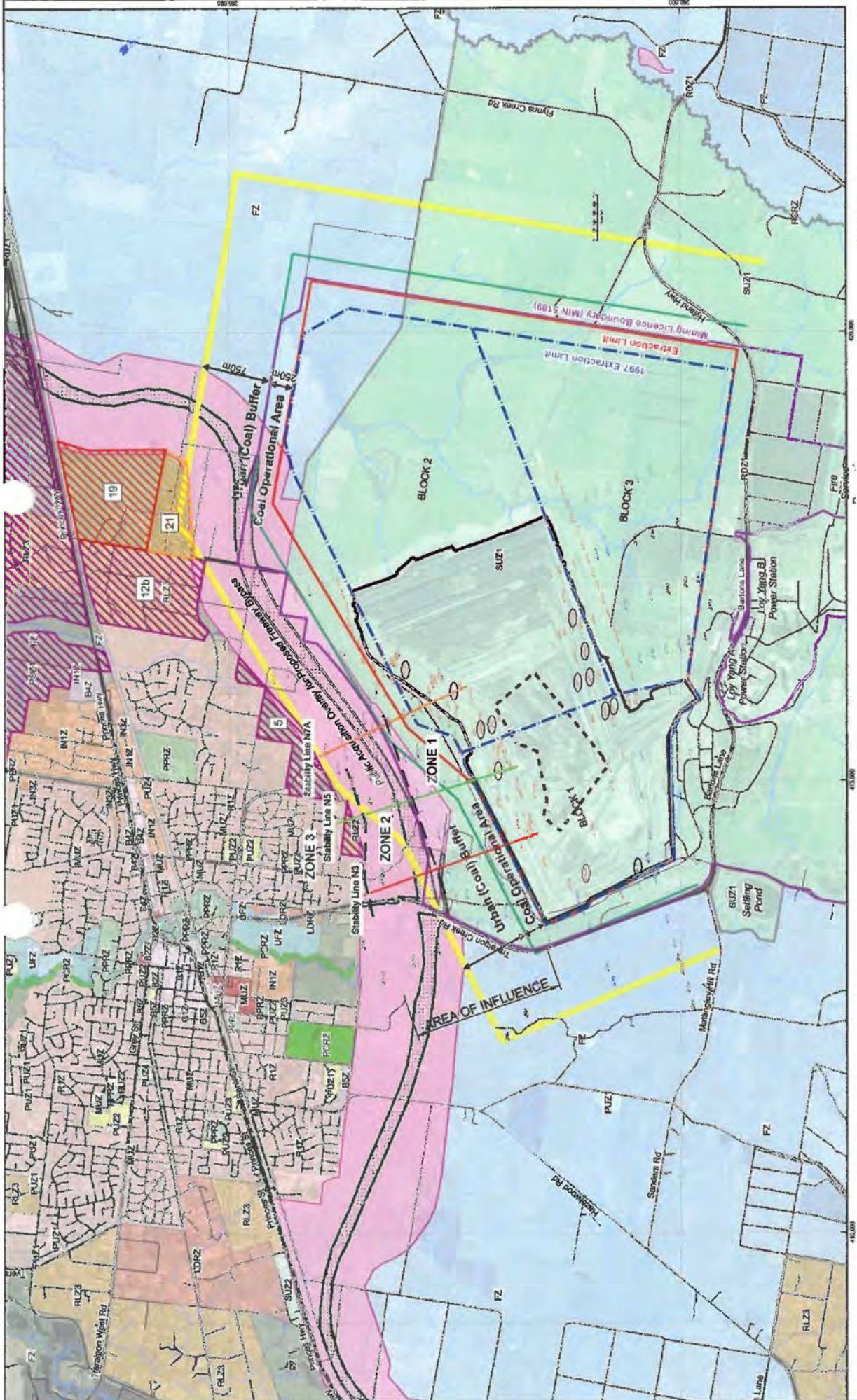


- Yallourn YEF NB
- ✕ Hazelwood NB Princes Hwy Feb 2011
- ▲ Yallourn YEF Latrobe Rd cracks
- Yallourn YTF Haunted Hills Rd
- ✕ Hazelwood NB Princes Hwy East May 2011
- Yallourn YTF 2001 cracks on track
- Yallourn YTF Haunted Hills Rd
- Hazelwood Mine Fire Feb 2014
- Hazelwood Lewis Anomaly 1966



Ashurst Australia  
 Traralgon Planning Board  
 Loy Yang

Comparison of Cracking from Significant Incidents  
 with Batter Groudwater Control Measures



Ashurst Australia  
 Traragon Planning Board  
 Loy Yang

Comparison of Area of Influence  
 with Planning Zones

PSM  
 Pells Sullivan Meynink

Figure 19

Scale (m)  
 0 500 1000 1500 2000

**LEGEND**  
 -SUZ1 Monitored Every 6 Months  
 -SUZ1 Monitored Yearly  
 -SUZ1 Monitored Every 3 Years  
 -SUZ1 Other  
 -SUZ1 Recommended in 2009 and 2012 to be monitored 3-monthly