E02/00326

HLA-Envirosciences Pty Limited
ABN 34 060 204 702

Our Ref: U909
Your Ref: S01/00200 DA-309-11-2001-I

RECEIVED
- 2 2002
S. HADDAD

28 March 2002

PlanningNSW
Executive Director
Sustainable Development
GPO 3927
Sydney NSW 2001

Attention: Mr Sam Haddad

Dear Sir

RE: Ashton Coal Mine Project – Camberwell

I refer to your correspondence dated 15 March 2002 regarding the Ashton Coal Mine Project at Camberwell. Please note that additional information was provided to PlanningNSW and the Department of Land and Water Conservation (DLWC) by correspondence dated 14 March 2002.

Appended to this correspondence are our responses to the seven (7) issues you requested additional information upon. We welcome and greatly appreciate your assistance in convening a meeting of senior New South Wales government managers to discuss progressing the assessment of the Ashton Coal Mine Development Application and environmental impact statement.

The Ashton Coal Mine Project gives rise to a number of environmental impacts which "straddle" various government agencies. For example, the partial relocation of Bowmans Creek has been commented upon by DLWC, EPA, Fisheries, Agriculture and NPWS each of whom appear to be seeking mutually exclusive outcomes. We support the whole of the government merits based approach to the assessment of the project.

Yours faithfully

HLA-Envirosciences Pty Limited

Alan Wells
Regional Manager

U909 PLNSW Let_28.03.02

Matt,
For advice
& attention
Chris 3/4

Chris Ritchie
For attention/advise pls.
SHaddad
2/4.

Newcastle Office: 18 Warabrook Boulevarde Warabrook NSW 2304
All Mail Should Be Addressed To: PO Box 73 HRMC NSW 2310 **Ph: (+61 2) 4968 0044** Fax: (+61 2) 4968 0005
Email: mail@hla-enviro.com.au

1. Subsidence Impacts

Please refer to Holt and Associates reply which is supplied as an appendices to this response.

2. Groundwater Impacts

"Clarification of apparent differences in modeling results and stated conclusions regarding groundwater recharge".

Bores WML010 and WML014 are both screened in the deeper coal measures not in the alluvium, despite the fact that WML010 is located on the Bowmans Creek alluvium. The modeling referred to in Section 7.2, Appendix H relates to recovery of water levels in the coal measures, not in the alluvium. The water levels in the shallow alluvium are expected to rise faster due to increased access to recharge from rainfall and ponding in the chain of ponds either naturally or by design.

The long term impacts of dewatering and recharge of the Bowmans Creek alluvium and the resulting water levels and quality, given the likely connection between the alluvium and the underground mine, have been addressed in the EIS and the supplementary responses of 28 February 2002 and 14 March 2002. These include:

- Sections 8.1.2 – 8.1.3 of Appendix H of the EIS deal specifically with expected worst case conditions of vertical fracture connection between the mine and the base of the alluvium. It is predicted that the average groundwater quality in the alluvium may rise from about 1200 µs/cm to about 1700 µs/cm. The resultant impacts on salinity during low flows in Bowmans Creek and Hunter River were assessed to be small and negligible respectively (Section 8.1.3). Mitigation measures to reduce the impacts of diffuse saline leakage were proposed (Section 8.1.3). These included planting salt tolerant, deep rooting trees to lower the water table. It is further noted that the natural salinity of base flows in Bowmans Creek and groundwater under much of the Bowmans Creek alluvial flats is about 2000 µs/cm. Therefore it is expected that most of the deeper rooting groundwater dependant vegetation is adapted to this level of salinity, particularly as the subsoil's over much of the project area have medium to high salinity (Appendix I Sections 4.3.4 and 5.1).

- Section 2.0 of letter of 14 March 2002 to DLWC discusses the risk of vertical fracture connection and concludes that the risk is moderate to high in only a few areas at the northern end of longwalls 4 and 5. The risk reduces to the south as the thickness of coal measures cover increases. Therefore, the actual long term impacts are likely to be less than that predicted by the worst case scenario considered in Section 8.1.2 in Appendix H of the EIS.

"Assess the long-term impacts of changes in groundwater quality due to connection with mine waters on existing native vegetations and agricultural land on the proposed site".

- Subsidence will cause surface tensional cracking down to a depth of about 15 m from the ground surface. A wave of surface tensional cracking advances along the panel over the longwall face, but experience shows these cracks close as the longwall faces pass, the ground subsides and horizontal compressional conditions occur. Open surface tensional fractures may occur along the length of the panel and at each end of the panel where horizontal tensional conditions occur.

The passage of the longwall face and the accompanying wave of tensional cracking causes a temporary increase in fracture porosity and the water table in the near surface strata may temporarily decline. Under compression conditions after the longwall face has passed (i.e. over the goaf), the water table recovers again. Rainfall or river recharge expedites this recovery. Recovery of water levels may be slower over the tensional zones associated with the ribs and ends of each longwall panel where surface cracking may remain open longer.

The mining of subsequent underlying panels will repeat the process with the passage of the longwall face and the accompanying wave of surface tensional cracking, but the depths of cracking is not expected to increase. The presence of expansive clayey fine grained sediment, clayey weathered rock or expansive mudstone strata may seal the surface cracking due to the clays swelling on exposure to the water and air. Thus a decline in the shallow water table can be expected as each longwall passes, which may affect deeper rooting vegetation (note: the water table was already 5 to 8 m below the ground surface under most of the Bowmans Creek alluvium) but is not expected to significantly impact shallow rooting vegetation (i.e. agricultural crops, grasses) that rely on soil moisture.

Longer term lowering of the shallow water table will only occur where the surface tensional cracks connect with open vertical fractures above the mine goaf. There is a moderate to high risk of this occurring under a small area at the northern end of longwall panels 4 and 5, and possibly part of longwall 6, where the thickness of coal measures cover ranges from 85 m to 110 m under the alluvium.

This risk is explained in more detail in Section 2.0 or responses to DLWC on 14 March 2002.

In conclusion it is doubtful that there will be sufficient long-term change in the groundwater quality in the Bowmans Creek alluvium, even in the event of some local interconnection between the mine and the surface to adversely affect existing native vegetation and agricultural land.

3. Agricultural Impacts

"Quantification of various classes of Agricultural Land"

Provided in Table 1 is the approximate areas for the various classes for land capability and agricultural suitability, which are present on the Ashton area. The approximate area of impact in relation to each classification is provided in the adjacent column. The area of impact has included areas of open cut mining, emplacements, pit top facilities and subsidence.

TABLE 1
QUANTIFICATION OF LAND IMPACTS

Agricultural Class	Total (ha) Area In The DA	% of Potential Impact	Land Capability Class	Total (ha) Area In The DA	% of Potential Impact
Class 1	210	37%	Class II	190	22.5 %
Class 3	380	91%	Class IV	290	81%
Class 4	215	69%	Class V	370	80%
Class 5	50	0%	Class VI	30	10%
Total	880	65%		880	65%

As is demonstrated in Table 1, areas of Class 1 agricultural land or Class II Capability are significantly less impacted from the development, than other areas of poorer class lands. These soils are impacted through subsidence, with the degree of subsidence highly variable. These areas will not be lost for future agricultural purposes.

"Detailed assessment of long-term impacts of subsidence on groundwater quality and quantity, surface topography and surface water, soil stability and ultimately agricultural suitability."

The long term impacts of subsidence on groundwater quality and quantity have been extensively discussed in the previous sections in relation to groundwater. There were also addressed in the responses provided to DLWC on the 28th February 2002 and 14th March 2002. It was predicted that there would be little impact on shallow rooting vegetation despite the predicted fall in the water table as mining proceeds. This is due to the current water table being approximately 5 - 8 metres below the surface.

The issue of surface water on site as a result of subsidence was discussed in our response to DLWC on the 28th February 2002. Submitted with this response was a series of plans which demonstrate the proposed methods for managing surface runoff, during the operation at Year 8, 11 and 15 (Refer Figures PB 8, 9 &10). During the operation of the underground mine, swales are to be constructed to divert surface runoff from ponding areas and also to minimize the impact of erosion. Pumping can dewater potential ponding areas.

132 ha

A large portion (approx. 63%) of the agricultural land (Class 1) will not be impacted by the proposal. It is located closer to the river flat areas and is outside the zone of subsidence. It is intended that these areas be preserved and agriculture practices be promoted in these areas.

It was predicted there may be a propensity for soil erosion in areas of subsidence due to the incidence of dispersive soils. The areas of particular susceptibility are along the drainage lines. It has therefore been proposed in the Conceptual Landform and Vegetative Pattern (refer Figure A), that salt tolerant, deep rooting species be planted. These will include species of River Oak and Swamp Oak.

"A Detailed discussion by a suitably qualified professional of the local and regional significance of the loss of agricultural land , with particular reference to the Class 1 land and any other agricultural impacts."

The majority of the impacts from the proposal will be on agricultural lands, which are classified as 3-5. Mining will not impact a large portion of Class 1 land, with most of the land available for agricultural purposes post-mining. There is a small portion in the vicinity of the existing Bowmans Creek ox bow, which will be planted with riparian and salt tolerant vegetation, which are for habitat compensation. There will also be approximately 15 hectares associated with the creek diversion.

how much

The proposed planting on the southern portion of lease area is concentrated in riparian areas, existing remnant woodland and existing screen planting. Vegetation corridors for fauna migration will link with existing vegetation in these areas. These corridors have been proposed for the steeper slopes of Class 3 land.

White Mining has engaged specialist consultants, Sanders and Associates, to assess the options for agricultural production of the Ashton site. It was concluded that the property has good potential as a dairy farm, horse stud or irrigation farm. Essentially a number of land practices will be implemented to enhance the agricultural production whilst allowing for the potential impacts from underground mining. These include:

- Upgrading of the irrigation system. Pipelines will be installed up through the center line of the longwall panels;
- Fencing on the site will be altered to exclude cattle from the subsided areas. Fences will be erected in alignment with the mines gate roads. This will provide corridors for cattle movement, whilst excluding them from subsided areas.
- Fodder crops will be re-cultivated on the flat areas, which comprise of the Class 1 agricultural soils. Crops have not been grown in these areas for some time.

The proposed management practices for the site and the re-activation of fodder crops on the good quality agricultural soils are a benefit to regional agricultural practices. As has been demonstrated there is a very small loss of Class 1 agricultural land on the Ashton area, which is insignificant when assessed in a regional context. The majority of this land has been preserved for improved agricultural practices.

"Conceptual post-mining vegetative cover plan"

A Conceptual Landform and Vegetation Patterns has been developed for the Ashton site. This plan aims to satisfy the seemingly competing requirements of sustaining agricultural land and embellishing existing native habitat. Refer Figure A.

A breeding population of the protected Grey-crowned Babbler currently resides in the southern woodland. This is located on Class 3 and 4 agricultural lands. The plan aims to increase the area of the woodland to approximately 200 hectares, which is required for a viable population. The corridors, which are depicted, will link this woodland with the proposed planting in the northern area of the lease area.

A riparian strip of River Oak has been limited to 50m either side of the existing creek bed and creek diversion. This has minimized the impact on Class 1 land, but addresses the need to satisfy the need for aquatic habitat replacement.

Planting of Swamp Oak along the drainage lines and within the Bowmans Creek oxbow area will be undertaken to mitigate the potential impact from soil erosion and potential soil salinity problems.

4. Project Justification and Alternatives

"A detailed analysis of alternative mine plans that would reduce the impacts on Bowmans Creek and eliminate the need to divert the creek. It may be useful to present and discuss mine plans considered by the Technical Working Group of WML, DMR and DLWC in 2000/2001"

Numerous mining scenarios were investigated during the development of the conceptual mine plan and the feasibility study. These included:

- Open cut mine methods, including truck and shovel operations and dragline options;
- An underground mine utilising continuous miner technology, including bord and pillar as well as place changing methodologies; and
- An underground mine utilising longwall technology, with a variety of panel orientations, mining limits and seam choices.

The selected mine plan was adopted following a detailed evaluation of the safety, environmental and financial aspects of each option. The nominated mine plan is considered to be the only option that can deliver a viable financial outcome, whilst maintaining acceptable standards of safety and environmental impact. However, the following overview is provided in response to your specific question.

Open cut mining methods were considered. The conceptual mine plan commenced on the crop line of the Pikes Gully seam at the eastern side of the mine lease south of the New England Highway and followed the dip of the seam towards the west until the economic limit of the mine was reached. The mine was quite small and highly visible from the Village of Camberwell. It was considered that the high visibility would not be acceptable to the residents of the village or the nearby farming community.

An underground mine that utilised continuous miner technology was considered, but the high rate of coal sterilisation, the relatively poor economics associated with this type of operation and the safety issues associated with the need for personnel to work under an unsupported roof during routine production mitigated against its viability. At the end of the day, the amount of coal that could be recovered via this option was insufficient to amortise the fixed costs associated with the development of the mine.

An underground longwall mine was considered the best option. The geological assessment identified four seams of suitable thickness for extraction by longwall methods and there was no evidence of significant faults, dykes or intrusions within the area. The extent of the mine was limited by the relatively small area of the mine lease and by the physical features which included the New England Highway in the north; Glennies Creek in the east, the Hunter River in the south and Bowmans Creek in the west.

Three different positions were considered for the mine portal (or entry), with the selected option being highwall access off the Arties Pit. This option allowed the main gate roads to be aligned under the New England Highway, thereby maximising the amount of coal that could be recovered by the longwall whilst minimising the subsidence impact on the highway. This design conformed with the "Guidelines for Coal Mining and Roads with respect to Subsidence", which was issued by the Mine Subsidence Board in association with RTA, DMR and DUAP.

Two different options were considered for the orientation of the longwall panels, an east-west option and a north-south option. The most critical factor in this determination was the direction of the principal horizontal stress in this region. This stress is particularly important for the deeper seams as the development of underground roadways interrupts this stress and forces it to realign itself. If the orientation is not correct, it can lead to floor heave in a soft floor and roof falls in a soft roof. It is therefore important that the longwall panels be aligned within 30 degrees of the principal horizontal stress. In the Ashton area, this stress is directed slightly east of north, so the north-south orientation was selected as the preferred option. Other factors which mitigated against the east-west orientation of the longwall panels include:

- The dip of the coal is about 5 degrees to the west-south-west. Orienting the longwall panels in an east-west direction maximises the apparent dip of the development headings and results in the working face being the lowest drainage point at all times during the development phase. This is not advisable for reasons of safety and productivity.

- An east-west orientation of the longwall panels reduces the maximum panel length from 2900 metres to 1600 metres. Apart from sterilising about 10% of the recoverable coal, the development ratio associated with this option is significantly larger than the north-south option.

- An east-west orientation of the longwall panels also requires that all transport be conducted on a grade of 5 degrees. This has obvious implications for the safe movement of men and machinery.

Once the decision was made to align the longwall panels in a north-south direction, it was necessary to consider the extent of mining in that orientation. The Joint DMR / DLWC / WML Technical Working Party concluded that the limit of subsidence from mining should not encroach onto Glennies Creek or the alluvials associated with the Hunter River. The impact of the mine on Bowmans Creek alluvium was therefore the only issue that remained to be addressed. With the diversion considered to be an acceptable option, the impact on alluvium was further subdivided into issues associated with subsidence, issues associated with potential connection to ground and surface waters and issues associated with a combination of the both. The assessment included safety, environmental and financial considerations and examined the following options:

1. Constructing a diversion of Bowmans Creek (as per the EIS), and

2. No diversion to Bowmans Creek

The longwall panels were shortened in option 2 to ensure that the watercourse was outside of the line of zero subsidence. The outcome compared to the base case (ie option 1 as presented in the EIS) were as follows:

TABLE 2
NO DIVERSION OF BOWMANS CREEK

Outcome	Unit	Option 2
ROM Coal sterilised	Mt	11.72
Mine life shortened	Years	4
Lost work opportunity	Man years	292
Foregone royalty	$M	16.8

Consideration was given to the width of the longwall panels. Smaller panels require an increased amount of development headings and would create more subsidence troughs. Six panels of 250m width were preferred over the original seven panels of approximately 210m width.

Consideration was also given to the length of the longwall panels in the development of the EIS. The southern extent of the panels was shortened to leave a barrier to the Hunter River alluvials. The northern extent of longwall panel 6 was reduced to accommodate a meander in the diverted alignment of Bowmans Creek.

A mine plan that offset the gate (or access) roads on each side of the longwall panel by half the panel width was also considered. The current mine plan has the workings for each seam superimposed on the lower seams. This provides structural stability within the gate roads, but maximises the cumulative effect of subsidence. Offsetting the gate roads would minimise the cumulative subsidence, but could reduce the safety of the gate road when a lower seam is extracted below it. Superimposed gate roads remains the preferred option for both structural integrity and safety.

As reported in Appendix P of the EIS, the extraction of coal by longwall methods will cause subsidence of the surface. The amount of vertical movement caused by the subsidence will be related to the amount of coal extraction below the surface and its position comparative to the gate roads at the end of each panel as these are fully supported for safety reasons. Surface cracking will be associated with mining extraction, but the depth of this cracking will be limited to about 15m.

There will also be cracking associated with the longwall itself, as the "caving" effect behind the supports will instigate cracking that will propagate some 30m towards the surface. However, the drainage of surface or alluvial groundwater will only occur if there is direct connectivity between the surface cracks and the cracks associated with the goaf.

The potential for this connection obviously decreases with the depth of mining, particularly in the absence of significant geological faults (there have been none identified in the area of the underground mine), so an extensive review was undertaken by Holt & Associates to identify the depth at which mining could occur under the alluvials.

This review covered numerous mines in the local area, including Hazeldene, Cumnock, Homestead and Liddell Mines and applied those learnings to the Ashton case. It was particularly noted that:

- The Cumnock Mine had undermined Davis creek with two seam workings without any recorded loss of water from the creek. The upper seam was 70 – 80 metres below the surface at that point and the geology was very similar to Ashton.

- In the Foybrook leases both the Pikes Gully and Liddell seams were mined in two collieries. The Liddell seam was fully extracted at a depth of 130 metres below Bowmans Creek. Some faulting and dyke development was encountered in the workings. Water from Bowmans Creek entered the workings and some surface flow was lost.

- In the Liddell Mine, longwall panels were extracted from beneath Bowmans Creek in the two Liddell Seams at a depth of 165 metres. Geological discontinuities were present, but there is no record of water entering the workings.

In the absence of any evidence of faults or dykes in the area of the Ashton underground mine, it was concluded that mining in a single seam should be able to occur at a depth of 80 metres without surface connectivity. However, in order to address the "worst case" possibility, we assumed that a geological discontinuity may be present.

The options addressed concerns about the potential for connective cracking from the surface to the mine (and therefore the drainage of alluvials) in the northern end of longwall panels 4, 5 & 6.

In summary, numerous mining options were investigated during the development of the conceptual mine plan and in the preparation of the feasibility study. The safety, environmental and financial aspects of each scenario were assessed in detail. The selected option was considered to provide the best achievable balance between the competing objectives and subsequent reviews have only reinforced this opinion. The proposal to divert Bowmans Creek has been the subject of intense scrutiny, but we have clearly demonstrated that the riverine ecology can be protected and enhanced by duplication of the "pool and riffle" effect contained within the current creek alignment.

"Alternative project layout drawings and a comparison of likely environment impacts with the preferred proposal."

Two options have been considered.

Option 1 was the diversion of Bowmans Creek along the western boundary of the mining lease. This was presented in the EIS.

Option 2 was the "no diversion" case.

The environmental issues associated with Option 1 versus Option 2 were discussed at length in the EIS and subsequent letters of clarification. Suffice to say that the flow path of Bowmans Creek is bedrock controlled, resulting in a "pool and riffle" effect that the proposed diversion would mimic. The current creek alignment is also highly modified, with an extensive diversion above the New England Highway and numerous examples of bank stabilisation works such armouring, tree planting, etc, in the lower reaches of the creek. Fish migration is inhibited by the DLWC stream gauging station, which provides an effective barrier at all times except flood conditions.

A considerable amount of information was also presented in the EIS about the potential impact of the proposal on groundwater. As noted above, it is considered unlikely that the groundwater contained in the alluvials will be drained post mining by the underground mine. The groundwater will be pumped out under DLWC licence during mining to longwall 4. However, as the EIS is based on "worst case" principles, consideration was given to how that issue would be managed should it occur. It was noted that the groundwater associated with Bowmans Creek amounted to only 750ML; that it had limited economic and ecological value; that the water management system in the underground mine could accommodate such an inflow and that it would regain its status quo following the cessation of mining.

"Justification for the proposal to mine under Bowmans Creek, compared to the potential alternatives. This analysis must consider the long-term combined impacts of the proposal, the potential for irreversible damage, and the accuracy of impact predictions, and discuss the application of the precautionary principle in the context of ecologically sustainable development. "

The proposal presented in the EIS involves the diversion of Bowmans Creek. No mining will occur under the diverted waterway.

The justification for the proposal was presented in the EIS. A summary of this justification compared to the identified alternatives is presented above.

Worst case scenarios were identified and evaluated in the EIS, so the actual impact should be less than that presented in the EIS.

Only limited cases of irreversible damage were noted. Some artefact scatters will be affected by open cut mining or overburden dumping.

The precautionary principle was addressed in Section 8.3.2 of the EIS.

5. Air Quality Impacts

We note that planningNSW has engaged a consultant to review information supplied.

6. Flora and Fauna Impacts

We note that a site visitation was arranged for Monday 25 March 2002. Our understanding is that no further information needs to be supplied.

7. Blasting Impacts

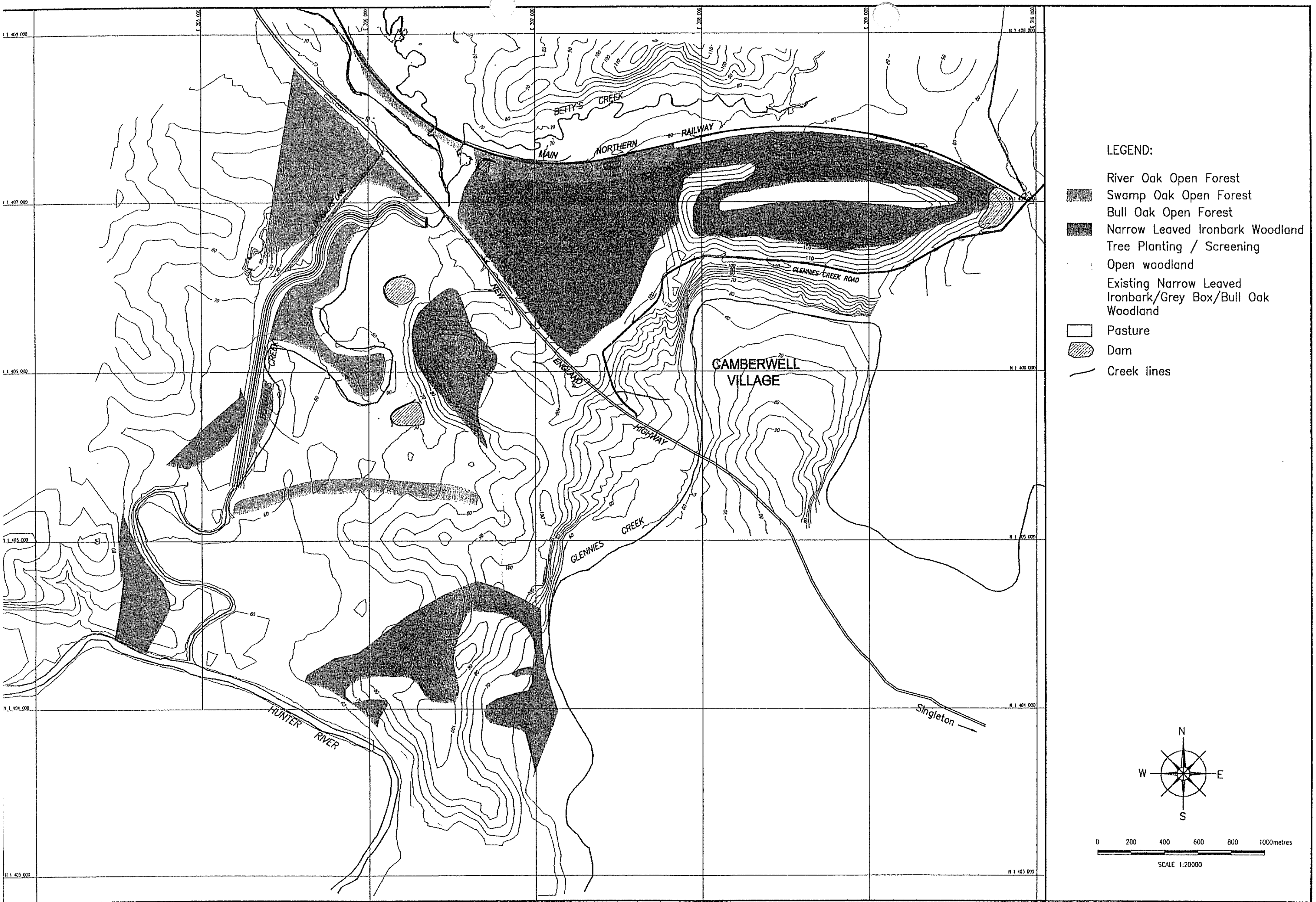
St Clement Anglican Church is listed within the Singleton Local Environmental Plan 1996 as being an item of environmental heritage of local significance. Aston Coal Mine project considered the potential impact of blasting upon St Clements Anglican Church and residences located within Camberwell Village and surrounding infrastructure.

Blasts were designed by White Mining Limited so that maximum ground vibration velocity levels at St Clements Anglican Church do not exceed 2 mm/s –refer to Section 5.8.2 Non Indigenous Heritage of the EIS.

The design criteria of 2 mm/s is an established standard for items of environmental heritage located in close proximity to coal mines in the Hunter Valley. The 2 mm/s maximum ground vibration velocity criteria adopted for the Ashton Coal Mine project is significantly below the Australia and New Zealand Environment and Conservation Council (ANZECC) and Australian Standard (AS) 2187.2 – 1993 as detailed in Section 3.5.3 Blasting of the EIS.

By limiting the blast design criteria to 2 mm/s at St Clements Anglican Church ensured that the residences within Camberwell Village would not exceed adopted standards.

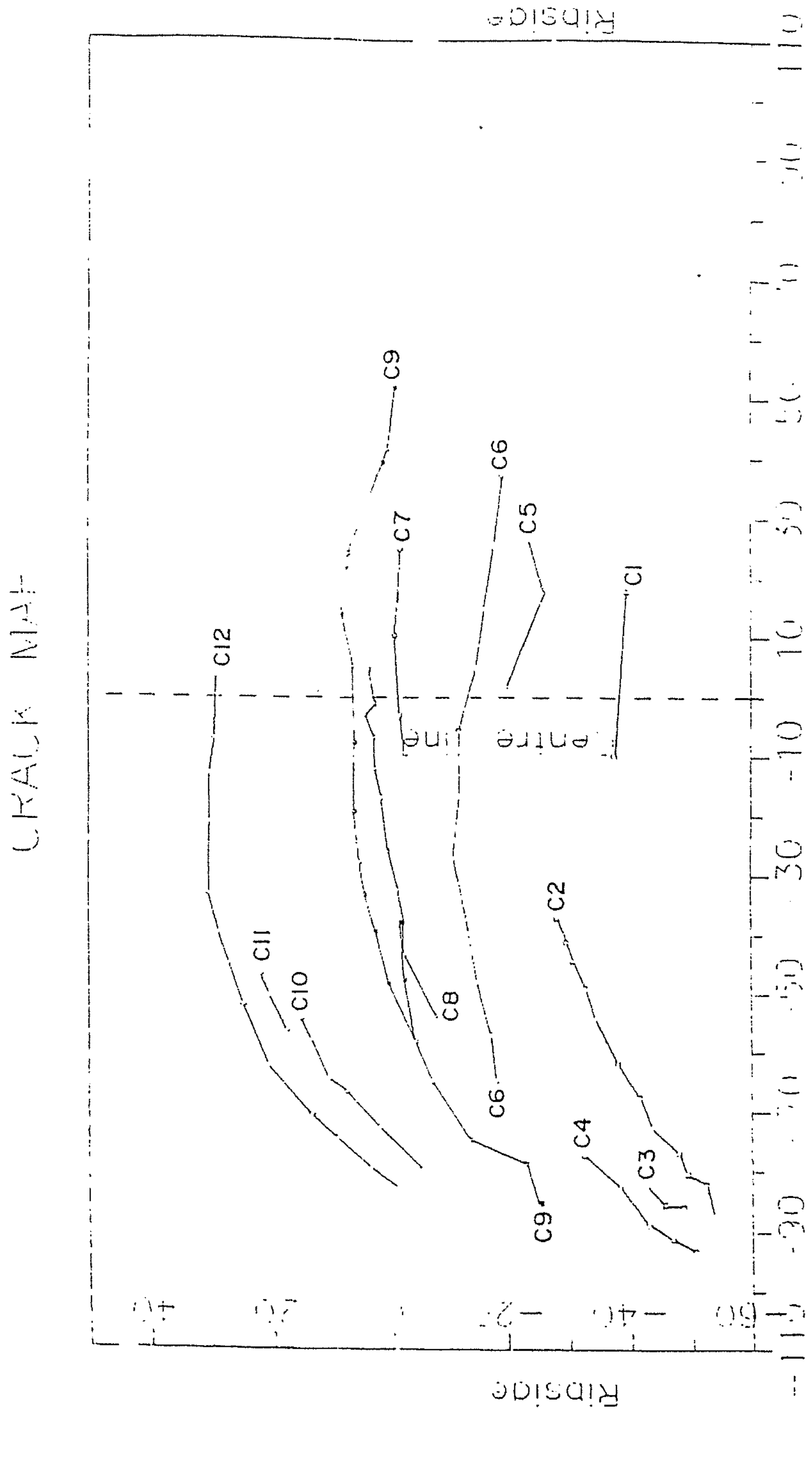
The proponent and St Clements Anglican Church trustees have agreed that a blast monitor be established in the church grounds to monitor blasts. Furthermore, the proponent will undertake a structural survey of the church to determine its structural integrity prior to commencement of operations. Should any damage be caused to the church as a consequence of blasting from the Ashton Coal Project, the proponent will undertake building repairs.



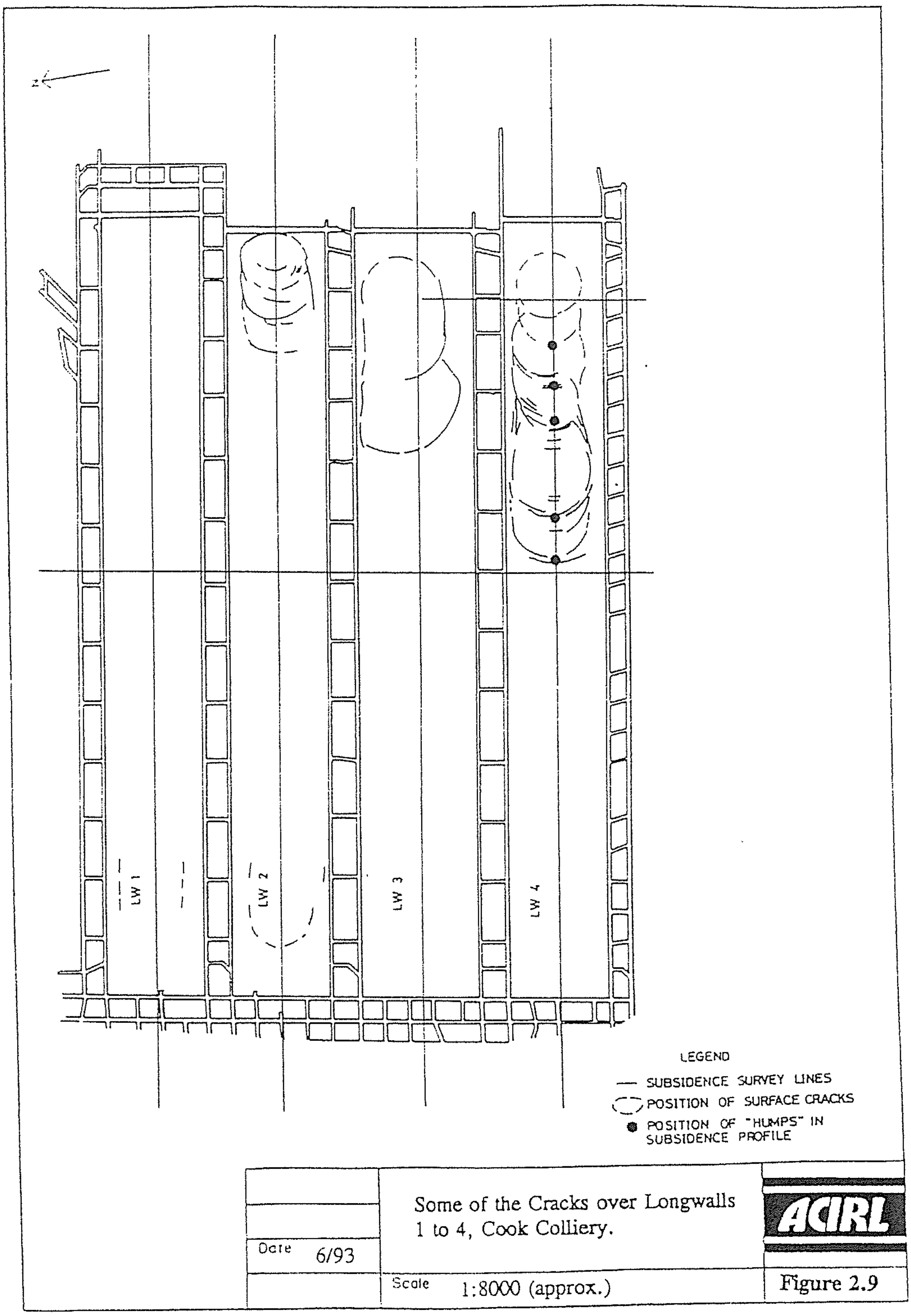
CO - RESOURCES PTY.LTD.

CONCEPTUAL FINAL LANDFORM AND VEGETATION PATTERNS

FIG. A



CRACKING MEASURED OVER PART OF LONGWALL PANEL 4, LIDDELL STATE MINE
(Unisearch Report R8292 by McNally & Li, June 1991)



(From ACARP END OF GRANT REPORT 1311, June, 1993 – Improved Methods of Subsidence Engineering)

The subsidence impact on this section of land will be ground cracking as explained in Section 5.3 of Appendix P. The management of this is explained in Section 6.2. *"In the event that surface cracks appear they may need to be dozed over...* The report also noted that small cracks anneal naturally with time.

If there is an issue of dozing of cracks affecting the vegetation then either smaller equipment or even hand methods can be employed to remove cracks if this is the desired outcome.

Section 4.1 of the EIS states that no significant impact is expected to occur to flora. The vegetation specialists have taken the comments regarding subsidence prepared by GHA, and drawn their expert conclusions.

- ***Justify the 100mm subsidence predicted on the New England Highway...***

See pages 8, 9 and 10 above. This concern appears to be due to a misunderstanding of where cracking occurs, and how the ground subsides. Strains will be approaching zero asymptotically so there will be no cracking. This is why this was not stated specifically in the Subsidence Assessment report in Section 5.4, first two paragraphs.

CLOSURE

It became evident during discussions with government officers that there were concerns also that 4 seam mining 'Had never been done before" and that this was something new with potentially unknown and understated impacts. Multi-seam mining has occurred in the Southern, Newcastle and Hunter coalfield for many, many years. Two seams have been mined in the Southern Coalfield and are reported in Holla & Barclay (2000). Three seam mining has occurred at Muswellbrook Mine, two seam at Liddell, Cumnock and Hazeldene mines near the Ashton proposal. Multi-seam mining was approved for Dartbrook after an extensive Evironmental Inquiry in the early 1990's, Powercoal has conducted multi-seam mining around Lake Macquarie for many years. Multi-seam mining has occurred at Teralba Colliery. The Glendon Brook Mine north east of Singleton was planned with 7 levels of mining and approved at least ten years ago. Multi-seam mining is more common than is generally realised. It does not matter if one, three or four seams are mined. The thickness of the seams, the depths of the seams and the nature of the cover strata determine the likely surface impacts.

It also became evident that there was a developing scenario that cracking of the ground surface would inevitably lead to significant water loss into the mine. The available facts do not support this. How can large volumes of water move down narrow cracks? There is enough knowledge of subsidence to be able to develop limits to cover depth thickness to allow mining to proceed without connectivity. Our corrected report suggests this limit should be 150m for extraction of four seams at Ashton.

Yours Faithfully

Graham Holt

Graham Holt B.Sc (Hons), M.Eng.Sci. MIEAust CPEng, FAIMM (CP)
Principal Geotechnical Engineer

- ***"Clarify the relationship between angle of draw, subsidence and surface cracking....."***

Three guidelines for Surface Subsidence Prediction have been produced by the Department of Mineral Resources; the Mine Subsidence Board has produced guidelines for mining under powerlines, roads and railway lines. The Department of Mineral Resources has had a subsidence engineering section since the late 1970's. We add for explanation an appendix (Appendix I) of the Subsidence Impact Assessment report (Appendix P, EIS) that describes subsidence terminology, and provide sufficient information in predictions for any person to duplicate the calculations.

Section 3.1 of the report also states that .... *" In general the amount of ground strain and curvature arising from subsidence determines how much surface damage might occur, not the amount of vertical subsidence."*

The Angle of Draw has been defined most recently in Holla & Barclay (2000) as the angle between the vertical and the line joining the edge of the mining void with the edge of the subsidence trough. This is shown in Appendix I of the Subsidence Impact Assessment Report (Appendix P, EIS). Holla and Barclay continue ... *" The subsidence profile in theory is asymptotic to the original surface. The definition therefore requires a judgement to be made for establishing the point of zero subsidence at the profile extremities."* The judgement in New South Wales, made by the Department of Mineral Resources is 20mm. Further details can be obtained by a reading of Section 3.3, p10 of Holla and Barclay (2000).

A study of the diagram of the characteristics of trough subsidence, given in Appendix I (in EIS, Appendix P) will show that maximum tensile strains occur theoretically between the inflection point and the goaf edge. Strain falls to zero at the zero subsidence limit. Above a panel compressive strain can also cause cracking. A study of the diagram will show that maximum compressive strain theoretically occurs between the inflection point and the centre of the panel. By extension if there is no strain at the zero subsidence limit, then there can be no cracking.

So, cracking occurs almost completely within the surface print of an extracted area according to theory. Anomalous geological conditions can alter this, as is explained in Appendix P of the EIS.

The last bend of Bowmans Creek downstream of the proposed diversion, as shown in Figure 5.5 of the EIS just touches the Zero Subsidence Limit at the scale of the map in the EIS. There will be no impact on the creek according to this prediction line. The location of the Zero Subsidence Limit is defined by the Angle of Draw, which is defined by the Department of Mineral Resources as 26.5 degrees as described in Section 3.3, Appendix P.

- ***"Fully assess the impacts of subsidence and surface cracking on native vegetation....***

At the time of preparation of the Subsidence Impact Assessment report it was understood, after touring the site that the remaining "native vegetation" at the inbye ends of proposed panels 1 to 4 had been heavily modified by cattle grazing for more than 100 years, and could not be regarded as natural native vegetation.

The procedures in that guideline were taken into account in assessing subsidence impact on the New England Highway. If there is an issue at large it could be argued that there is not sufficient detail availble about final underground roadway layouts at the EIS stage of the project. The letter to the RTA, detailed above, points out that subsidence impact assessment is based on the conceptual mine plan provided by the client at the time. Conceptual mine plans can be changed in some circumstances to suit specific needs and requirements. The concerns over the bridge over Bowmans Creek are a case in point.

Undermining of highways has been occurring for many years with the approval of the relevant authorities. Holla and Thompson (1988) in "Ground Movement in Multi-seam Mining" Vol CE30 No.5 Civil Engineering Transactions, described the effects of 2.33m of subsidence on the Pacific Highway at Wyee. The Fassifern Seam Longwall panels were at a depth of 206m with partial extraction of the Great Northern Seam above at a depth of 185m. The highway damage was not significant from a traffic safety point of view even though it settled up to 2.23m with horizontal alignment altering by up to 265mm. Various water pipes were broken by the vertical and horizontal near-surface movements. The value of recovered coal was roughly $22m. The cost of reported damage was a small fraction of this.

Five other case studies are provided in the Guideline mentioned above.

We refute the statement that predicted subsidence impacts within the New England Highway road reserve have not been justified.

Request for the following information.......

- ***Clarification of the extent and impact of predicted subsidence and surface cracking.....***

Appendix P of the EIS provides subsidence prediction methodology, subsidence predictions and impact assessment. Further information has been provided in letters to the RTA (7 January), to DLWC through HLA-Envirosciences (draft letter 7 February), in telephone calls to Mssrs Withford of the RTA and Hancock of the DLWC, in replies for the EPA and now this letter. Apart from one editorial mistake due to editing an earlier draft of the Subsidence Impact Assessment report there is no inconsistency in what GHA have presented. Documents referenced are detailed in Section 9 Appendix P as well as in this letter to the best of the writer's knowledge. Planning NSW can access any of these documents as all are in the public domain.

As to clarification by "a suitably qualified professional" Planning NSW would be aware that apart from more than 20 years experience in subsidence engineering the writer also assessed mining proposals as a Senior Scientific Officer with both the former SPCC and DOEP during 1978 – 1980, has been expert witness for the Dartbrook and Mt Airly Inquiries as well as expert witness in court actions involving subsidence issues. The writer was also Chairman of the Mine Subsidence Technological Society for the past three years and is currently Acting Chairman.

throughs provides solid coal underneath the New England Highway without affecting operational requirements underground. This is but one example that demonstrates how readily the highway environment can be protected. (Attached plan not provided in this report)

Even this layout will eliminate most of the roadways and cut-throughs that would otherwise represent a potential risk for collapse in the long term.

Clearly the main entries driven from the highwall will need to cross beneath the highway. The crossings will be between 30m and 35m depth. The risk of potholing at this depth is much lower but even so the short sections of roadways could carry additional support. The amount of support required would be determined once the final mine layout is determined. The same approach would apply to the most easterly roadway for Panel 1 that connects to main entry 1 at 24m – 25m cover depth under the highway.

If there is concern regarding conventional coal roof support then there are a number of steel alternatives that could be placed beneath the New England Highway. The same approach can apply if ever the highway is duplicated. The mine life is at least 20 years. If decisions are made to duplicate the highway in this time the access tunnels can be retrofitted with additional permanent support if needed.

It is understood that the deeper workings will not require duplication of the Pikes Gully Seam layout as ventilation requirements and conveyor locations will be different. There will not be a need to utilise the highwall entries for all ventilation requirements, and conveyors will be directing coal up inter-seam drifts in the western part of the resource area. With a different roadway layout for the deeper workings there will not be a risk of multiple collapse of coincident workings causing impacts on the highway corridor. (The longwall panels overlap for ground stability purposes and this is reflected in the subsidence predictions).

In summary adjustment of the mine layout to maintain the integrity of the New England Highway will not compromise the proposed mining operation. Such adjustments are common in order to minimise risk of damage to surface improvements and underground workings.

We would recommend that the RTA be involved in discussions when the detailed planning phase for mining operations commences, that different phases of additional support for workings less than 30m under the highway be considered as mining progresses. The application of the concepts of increasing pillar size, avoiding intersections under the roadway, and applying extra support where there are realised concerns, are able to ensure stable surface conditions for the New England Highway."

On 25 March 2002 during a site visit a representative of Planning NSW was provided with a copy of the publication "Guidelines for Coal Mining and Roads with Respect to Subsidence," jointly prepared by the Roads and Traffic Authority and the Mine Subsidence Board in association with the Department of Mineral Resources and the Department of Urban Affairs and Planning, as well as the New South Wales Mineral Council and Coal Operations Australia Limited.

"Predicted subsidence impacts within the New England Highway road reserve have not been justified"

Predicted subsidence impacts for three short sections of the New England Highway were provided in Section 5.4 of the EIS. In addition a more detailed response to specific concerns were provided to Mr Gerard Withford of the RTA on 7 January 2002 through Mr P. Barton of White Mining Limited. That response is repeated in full here:

"Re: Subsidence Impact on New England Highway

In response to the concerns expressed by the RTA regarding subsidence impact on the New England Highway as a result of mining the Ashford resource we offer the following comments.

In the subsidence environmental impact statement of July 2001 we considered that there would be no impact on the highway. (By "highway" we also include cuttings, drainage structures, embankments and the like).
We referred directly to subsidence impacts from longwall operations. Conceptual mine roadway layouts were not available at that time. Aware that conceptual mine plans commonly change once detailed planning gets underway we did not express concern regarding first workings.

The conceptual mine plan shows a regular grid of access roadways and (crosscutting) cut-throughs from the mine entries to Panel 1 in the Pikes Gully Seam. The Pikes Gully Seam workings are the shallowest workings. The depth of cover under the New England Highway is as low as 25m for some sections of roadways and cut-throughs in the Pikes Gully Seam. The grid of workings is nominal, allowing for intake air along travelling and conveyor roads, and return air along two other roads. There is in fact no need for the mine plan to require 4 parallel roads on a regular grid – it is conventional practice to set out conceptual mine plans in this manner.

There is a slight risk that over a long period of time (after cessation of mining), that roadway support systems could deteriorate such that a section of roadway or cut-through could collapse and pothole through to the surface. The possible modes of collapse are potholing at intersections or from isolated sections of (mine) roadway falling. Collapse of entire (mine) roadways cannot be considered a realistic model. The risk is low but the consequences would be very high. It is also relevant to note that modern first working layouts are designed to be permanently stable so there is a high Factor of Safety (usually 2.0 or more) on the tunnels from the commencement of mining. Additionally all mine entries developed at shallow depths off highwalls have additional support for some distance. This detail in design is developed at the detailed planning stage.

The regular grid layout of the workings can be modified so that the New England Highway is above solid coal pillars of twice the (indicated) width for cover depths between 25m and 30m. We would consider 30m of cover consisting primarily of sandstone to be sufficient to provide permanent support for first workings. Such modification could also ensure that there are no intersections of roadways beneath the New England Highway. This can be achieved by varying the route of the main travelling road and return ventilation roads, whilst keeping the conveyor roads straight. The attached plan shows that very slight variations in the layout of roadways and cut-

Appendix P that as mining moves deeper the area on the surface that undergoes maximum tensile strain moves further away from the original tensile zone developed by mining of the uppermost seam and the amount of tensile strain reduces.

The issues of connectivity between the surface and underground workings need to be understood very carefully.

Surface cracking is common over longwall extraction panels at the range of depths that will be at the Ashton site. Surface cracks only connect to workings if the workings are close enough for the cracking associated with the goafed rocks above the mined out voids to connect with any cracks that might occur at the surface. As we pointed out by way of illustrative examples in our draft letter HLA-Envirosciences P/L of 7 February cracking at the surface most commonly occurs above the sides of the extracted area, as well as across the area as curvi-linear lines. The example from Cook Colliery, Queensland was for workings at 235m depth, while the example from the old Liddell State (now Cumnock Colliery) was for workings at 80m depth. (The illustrations are appended to this letter report on pages 13 and 14).

It is perhaps worth repeating the comments made in the draft letter of 7 February: letter HLA-Envirosciences P/L. "Cumnock Mine has undermined Davis Creek with two seam workings, the upper seam being 70m – 80m below the surface. It has not recorded any loss of water from the creek, and has not recorded any water entering workings from the creek. Cumnock has also observed cracking on the dry, rocky hillslopes but rapid closure of cracking in the muddy stream banks. It is successfully managing subsidence issues.

Another incident involving water directly impacting mine operations occurred at Liddell Mine. In this case it was water from another abandoned mine that entered through the roof strata to flood the longwall operation. It was not water draining from Bowmans Creek as we were led to believe at the time of compilation of the subsidence impact report for the Ashton project.

The minimum cover depth under the channel of Bowmans Creek for the proposed mine will be 95m.

In our subsidence impact report we considered that the lower workings would re-activate cracking and that this would lead to loss of water from Bowmans Creek. The experience at Cumnock to date has proven this to be incorrect."

Experience is a better guide than theoretical discussion about what may or may not happen.

We are at a loss to understand the linkage expressed in the Additional Information request between subsidence and surface cracking on native vegetation such as woodland habitat for the Grey Crowned Babbler. We do not expect the patch of grazing affected bushland over the start ends of Panels 1 to 4 to suffer any adverse effects as a result of subsidence. Each subsidence event is relatively small and strains are low. The experience of the extensive bushland over the nearby Cumnock Colliery serves as a guide that there is minimal if any impact on bushland.

A draft letter to HLA-Envirosciences P/L dated 7 February 2002 contained the following statements regarding questions raised by DLWC:

"Potential for the water management system of the underground workings to be affected from stormwater runoff entering fractures, particularly in the abandoned channel of Bowmans Creek."

This comment has "potential" as the operative word. Clearly no mining operation is going to work in a way that permits water to inundate the operating workings. For large amounts of water to enter workings there needs to be large openings connecting directly from the surface to the mine workings. In the absence of geological discontinuities we do not anticipate there will be large openings by way of cracks. We have already suggested a minimum cover depth of 150m and the minimum depth of cover under the abandoned channel is 95m. White Mining Limited has indicated that sections of the abandoned channel would be pumped out when mining underneath. Any further remediation work would be decided depending on the nature and extent of damage to the abandoned channel

It is well known in the coal mining industry both locally and overseas that interconnection is possible at shallow cover depths. As depth of cover increases the likelihood is reduced. This issue is covered in detail by Holla and Barclay in chapter 9 of the recently published Southern Coalfields Guideline (June, 2000).

It must be emphasised that there is no direct link between connectivity and the amount of vertical subsidence. These are two separate issues. Connectivity can occur when there is insufficient depth of cover and when there is geological structure that can facilitate a linkage as discussed above.

The draft letter to HLA-Envirosciences P/L pointed out instances where water entry had occurred at lesser depths of cover than is planned for Ashton. The particular discussion was additional to the detailed predictions of subsidence supplied in Appendix P so there was little point in repeating the detailed subsidence predictions tabled in that particular appendix.

"Planning NSW is not confident that the subsidence cracking predictions as modified by the information provided to DLWC are accurate due to the apparent differences in maximum subsidence between quoted examples and the predicted 6m multi-seam subsidence at Ashton."

We are not aware that subsidence cracking predictions have ever been modified by GHA in our advice to White Mining Ltd.

Again the same confusion between vertical subsidence and cracking appears to have arisen. These are two different issues. The fact that there will be multiple episodes of subsidence, as pointed out in Appendix P of the EIS, and that each episode of subsidence will have small strains, both tensile and compressive associated with it (refer Tables 1 to 4, Appendix P) seems to have been misunderstood. This may be because it was not made clear in the

For the UK, for example, a minimum cover thickness is 105m for a maximum seam thickness of 1.7m, and a maximum tensile strain of 10mm/m. Chile sets 150m as a minimum cover depth and 5mm/m as maximum tensile strain. Japan sets 60m for 0.8m thick seams, while Canada sets a greater depth of 213m for thicker seams of 2.7m. The standards differ from country to country because the geology and experience of water entry differ

The principal control to prevent any connectivity is the thickness of cover strata. The available information pertinent to the Ashton area was detailed in the Appendix P of the EIS report dated October 2001. The examples provided in the report led to the suggestion that 150m would be a sufficient buffer – this being updated from the earlier suggested figure of 200m.

DETAILED RESPONSE TO ADDITIONAL INFORMATION REQUEST – SUBSIDENCE ISSUES

1. Subsidence Impacts

In Appendix P (not J), which is the Subsidence Impact Assessment prepared by this company there is an error on page 13. The details are as follows:

Our original subsidence impact report to White Mining Ltd dated July 2000 opinioned that *"if mining were to proceed under Bowmans Creek flow (in the creek) would be disrupted, and significant quantities of water could be expected to enter workings".*

This report developed into a Subsidence Impact Assessment report by July 2001, at which time on the available information we made the statement *"The experience of these earlier workings suggests strongly that multiple seam workings at less than 200m depth beneath Bowmans Creek would most likely result in water loss into the workings".* This was based on earlier information from the Liddell Mine.

Later in 2001 we obtained information from former Coal & Allied personnel (Pers Comm R. Davis, former Chief Geologist) regarding the flooding of the longwall in Liddell Underground Mine. Until this time most people had believed that Bowmans Creek water had flooded the longwall in the Middle Liddell Seam from the surface above. It was this belief coupled with the evidence from Hazeldene and the reporting from Wyee that led to the statement of a minimum depth of workings for multi-seam mining under the creek being 200m to avoid water entry.

Coal & Allied personnel pointed out that the flooding was not from Bowmans Creek flows but from water flowing through the barrier between the flooded Hazeldene Mine and the Liddell Mine. The impact of this knowledge is to significantly reduce the apparent cover depth required to prevent surface water ingress to workings in multi-seam operations. The minimum cover depth reduces from the earlier suggested 200m to around 150m.

Each subsidence event from each panel is relatively small compared with what would happen if all the coal was in one seam and mined out.

Geological discontinuities such as faults and dykes can concentrate strain, and this is discussed in the Subsidence Impact Assessment Report in Appendix P of the Ashton EIS. White Mining Ltd has indicated that to the best of its knowledge – based on a grid of boreholes, there are no major structures such as faults and dykes in the proposed mining area.

INTERCONNECTION OF SURFACE CRACKS AND THE MINE WORKINGS

Because there have been a number of well publicised episodes of surface stream capture by coal mining operations there is correctly concern about the potential of the proposed mining to capture water from Bowmans Creek in particular. We detailed examples in the EIS Appendix P, and provide further details below as requested by Planning NSW. Here we offer some general comments.

The issue of mining under bodies of water has received significant attention overseas and locally. It was the subject of detailed scrutiny at the Reynolds Inquiry into Mining Under Stored Waters in 1975 (Report of the Commissioner Justice Reynolds – Coal Mining under Stored Water). The NSW Dams Safety Committee has paid close attention to the issue of ground cracking and connectivity to mine workings for many years. It has an extensive bibliography of reports on this topic.

By way of general comments surface cracking as a result of coal extraction is believed to extend only a short distance from the surface downwards. For convenience the distance is usually regarded as roughly similar to the depth of weathering of near surface rock strata. In the Hunter Valley weathering limits are commonly 12m to 15m. This zone always has more jointing that can promote ground cracking as a result of normal weathering processes. The fresh rock beneath is commonly less jointed with joints often occurring in widely separated zones in response to folding of the strata on a regional scale. This can be observed in any highwall of any open cut mine around the Hunter Valley.

The cracking that occurs in the roof strata to a mined out area is usually limited in its vertical extent. The zone of active strata collapse is commonly regarded as about 30m high for a 2m thick seam. Above this strata bend (and crack) and settle but with a lot less cracking. Eventually connection between cracks propagating upwards is lost and a water tight roof remains, even though strata may have subsided. A good illustration of worldwide views on the limits of vertical cracking is the thickness of cover required by various countries to ensure no connectivity between bodies of water and mine workings. Holla and Barclay (2000) listed these in table form on P. 87 of the Southern Coalfields guideline in a discussion on mining under water bodies and natural features (Chapter 9).

These strains resulted in ground cracking, and the location of some of the cracking was recorded and reproduced in the report. A copy of Figure 2.9 ,which shows the distribution of some of the cracling is shown on page 13 of this report. It reveals that ground cracking is confined within the surface print of the extracted area beneath. The pattern of cracking is related to the way the massive roof strata caved.

Cracking and strain monitoring were also recorded over part of Longwall Panel 4 at the Liddell State Mine (now Cumnock Colliery). Here longwall extraction was at 80m depth, with extraction thickness of 3.1m. High tensile strains were recorded and this was reported due to *the shallow cover depth and large extraction height* (End of Grant report p11). A plot of some of the crack locations over the panel is also provided on page 14 at the end of this report. The figure shows a similar distribution of cracks across part of the surface print of the extracted area. Again cracking was confined within the surface print of the extracted area beneath.

As the longwall retreats along the block of coal ground cracking can occur along the sides of the surface print of the extracted area, and across the surface from side to side. The cracks that occur across the surface print generally tend to close up once the tensile ground stretching phase passes and the compressive (shortening phase of subsidence kicks in. However the cracking along the sides of the surface print usually do not close because the ground over the sides remains permanently "stretched". It is usually these cracks that may require remedial work rather than the cracks across the panel.

So the parts of the ground surface that can be affected by cracking can be identified with reasonable accuracy, even though the actual size and specific location of individual cracks cannot. Cracking, if it is going to occur will happen within the surface print of each longwall panel along the sides after extraction of coal beneath, and across the panel during actual extraction. The "across panel" cracks will usually close after the longwall extraction moves away. The side cracks tend to remain.

CRACKING FROM MULTI-SEAM MINING

There was concern initially expressed that the same cracks formed by the shallowest mining would be constantly re-activated by mining of other seams below. At first glance this appears logical, but in reality as mining proceeds deeper and deeper from the surface, the surface area affected by the highest tensile strains that cause cracking moves further away on each side. The surface cracks across a panel get closed up during the compressive phase of ground movement. The reason the zone of highest tensile strain moves further away is that the subsidence trough widens as mining proceeds to deeper levels.

Another aspect of the proposed mining at Ashton is that the mining of 4 seams totalling about 8m thickness of coal to produce up to 5.9m of subsidence would have a lesser impact on the ground surface that if a single thick seam of coal was mined at the same depth as the lowest seam. Mining of thinner seams results in lower strains than the mining of thicker seams. Reference to Tables 1 to 4 of the Subsidence Impact assessment report (Appendix P, EIS) shows that predicted tensile strains gradually reduce with ever increasing depth of cover for each seam.

based mathematical modelling.

In New South Wales the Department of Mineral Resources produced three booklets detailing empirical methods for predicting subsidence from single seam workings. These are for the Southern, Western and Newcastle Coalfields (Holla, 1985 & 1987). The method contained in each booklet is based on the results of a number of subsidence surveys carried out in each of the coalfields. The methods are completely empirical, based on real subsidence monitoring of single seam workings. In June 2000 the Department of Mineral Resources published an updated guideline for the Southern Coalfield called Mine Subsidence in the Southern Coalfield NSW, Australia (Holla & Barclay). It contains an excellent section on the general principles of subsidence in Chapter 3.

The principal alternative to empirical prediction practised in New South Wales is mathematical modelling using computer-based methods. Mathematical modelling to determine subsidence levels can give good general predictions where no data base of survey results is available (Holt, 1988), but suffer when there are no data with which to calibrate the model. Models also have difficulty in determining the accurate shape of a subsidence trough, and in determining the likely levels of subsidence without considerable manipulation of the data. This is because of the simplifying assumptions that must be built into a model to enable it to mathematically simulate the process of strata caving. Modelling is not yet a practical proposition when the impact on specific localised structures is under examination.

There are some models which use empirical data from survey information, but these cannot claim to be true mathematical models since they do not rely on mathematical simulation of material failure and movement, but rather utilise actual subsidence data then develop an approximate curve fitting "solution".

SUBSIDENCE AND GROUND CRACKING

Cracking of the ground surface occurs when there is sufficient strain developed in the ground by the collapsing and settlement of strata beneath. There are no "rules" about the level of strain required to cause cracking of the ground surface. Low strains of 2-3mm/m can cause ground cracking depending on depth of mining, height of extracted area and nature of rock strata overlying the coal workings. Strain has two forms – tensile and compressive. Tensile strain occurs when the ground is extended as settlement occurs. Compressive strain occurs when the ground shortens at the concluding stages of settlement or subsidence.

Research conducted in Australia has documented the location and nature of ground cracking at two collieries in particular. ACIRL conducted an ACARP research project (No. 1311) in the early 1990's to try to develop improved methods of subsidence engineering. This followed from earlier subsidence research conducted by the writer (at ACIRL) in the early 1980's. The End of Grant Report documents cracking over Cook Colliery in Queensland and Liddell State Colliery in the Hunter Valley.

The Cook Colliery extracted longwall panels at about 235m depth. Seam thickness was 2.9m. Maximum strains measured were 20mm/m, with most strains less than 10mm/m (p 19, End of Grant Report).

28 March 2002

Mr I. Callow
Project Manager
White Mining Limited
P O Box 699
Singleton N.S.W. 2330

Dear Mr Callow

Re: Ashton Project – Attachment 1 – Additional Information Request

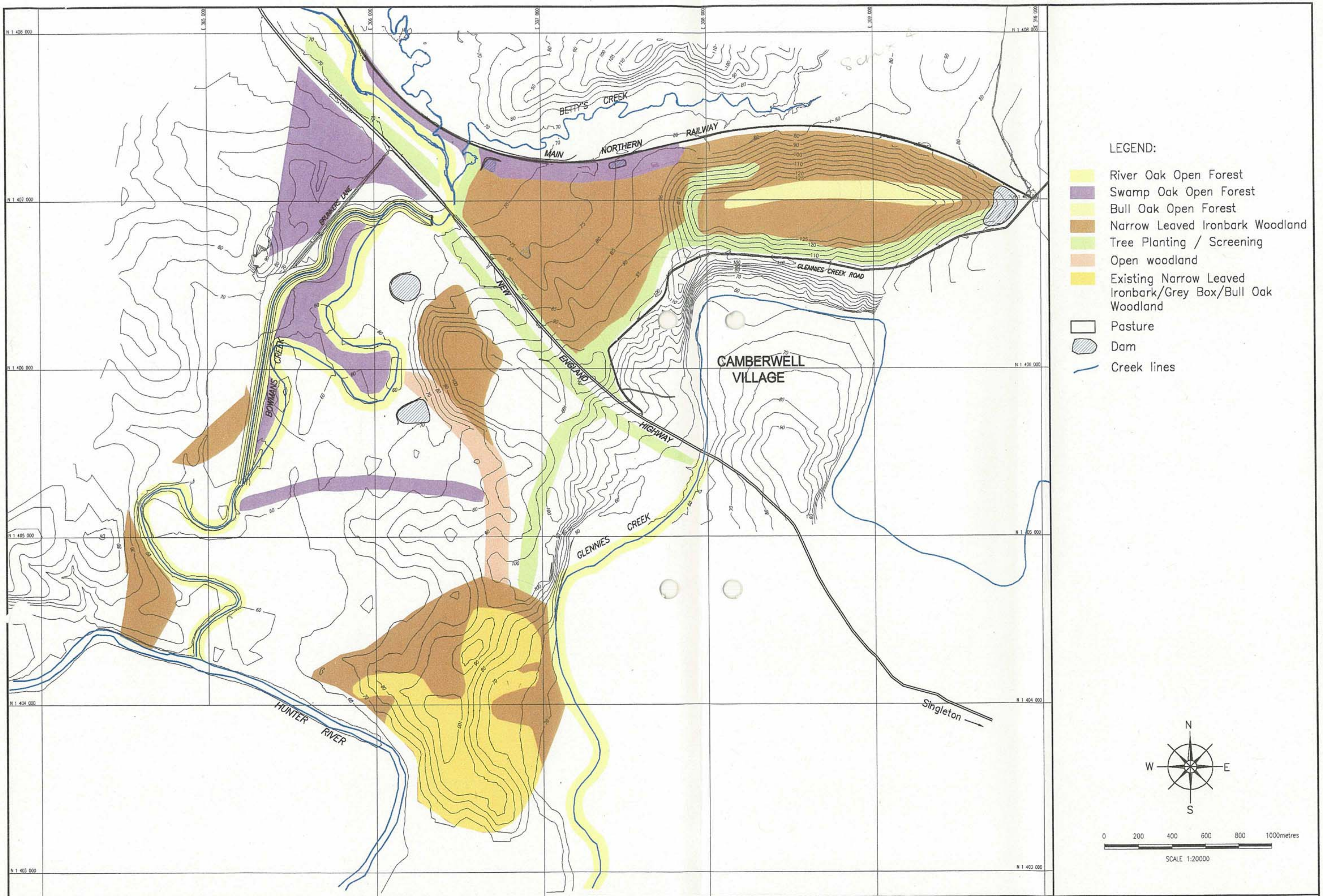
In response to your request please find our reply to the issues listed in Planning NSW Additional Information Request dated 15 March 2002. We have prefaced the formal request for additional information with an overview of subsidence and some general comments on local experience with ground cracking. The general subsidence overview is from the original text of the Ellalong Mine Extension report prepared in 1995 by GHA and published in the Environmental Impact statement. It is updated slightly to account for the publication of the Southern Coalfields Subsidence Guideline by Holla and Barclay in June, 2000. Additional comments on local experience with ground cracking incorporates the latest available information on experiences with multi-seam subsidence in the Hunter Valley.

SUBSIDENCE PREDICTION – AN OVERVIEW

When coal is mined from a coal seam by underground methods, the support provided by the coal to overlying rocks is removed. Some rocks such as siltstone and shale can span over small distances, and not collapse into an opening below. Others such as sandstone and conglomerate can span 80 m or more before collapsing, or caving.

When the distance to span over mined out areas becomes too much for the particular strata (or layers), they break and fall in to the space underneath. First workings in a coal mine do not produce spans of unsupported roof that can fail over large distances because the pillars of solid coal between the roadways (of the first workings) provide support to the overlying strata. Secondary extraction is when large areas of the coal seam are removed either by removal of pillars or by mass extraction with machinery such as longwall mining equipment. If enough roof strata are affected by the collapse then effects can be carried through to the surface. The movement of the surface is known as subsidence. Movement continues until caving rock blocks up the available space.

Unlike a steel beam, which is made of the same material throughout, and whose strength and behaviour properties can be predicted accurately, strata are extremely variable in composition, strength and behaviour. There are no physical laws that can accurately describe the way in which rocks behave, and all assessments of the behaviour of rocks and rock strata must be through approximations based on experience (empirical methods) or computer-



CO - RESOURCES PTY.LTD.

CONCEPTUAL FINAL LANDFORM AND VEGETATION PATTERNS

FIG. A