



NARAMA WEST MODIFICATION

RESPONSE TO SUBMISSIONS

for

Xstrata Coal Pty Limited

June 2013

Hansen Bailey

ENVIRONMENTAL CONSULTANTS

NARAMA WEST MODIFICATION

RESPONSE TO SUBMISSIONS

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June 2013

For:

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NARAMA WEST MODIFICATION
RESPONSE TO SUBMISSIONS

for
Xstrata Coal Pty Limited
Ravensworth Operations

1 INTRODUCTION

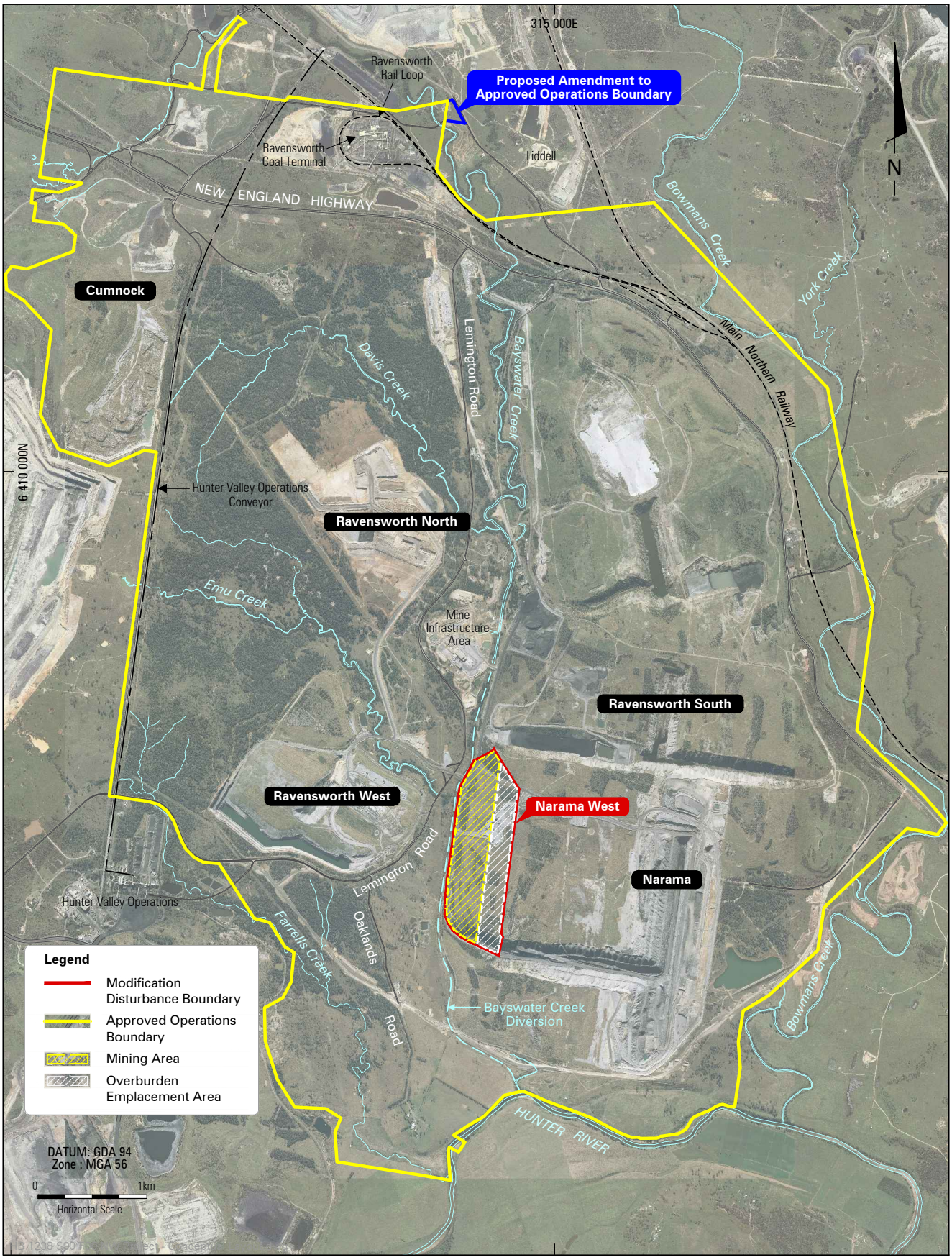
Ravensworth Operations Pty Limited (Ravensworth Operations) is a wholly owned subsidiary of Xstrata Coal Pty Limited (Xstrata Coal) and is comprised of the active Ravensworth North and Narama mining areas and the former Cumnock, Ravensworth West and Ravensworth South mining areas. Currently, open cut mining activities at Ravensworth Operations are carried out in accordance with Project Approval 09_0176, dated 11 February 2011, to provide high quality thermal and semi-soft coking coal to export and domestic markets at a maximum of 16 Million tonnes per annum of Run of Mine (ROM) coal.

On the 4 April 2013, Xstrata Coal applied to the Department of Planning and Infrastructure (DP&I) to modify Project Approval 09_0176 under Part 3A of the *Environmental Planning and Assessment Act 1979*. The Narama West Modification (the Modification) seeks to recover approximately 2.7 Million tonnes of ROM coal by open cut mining methods. The conceptual layout of the Modification is illustrated in **Figure 1**. As part of the Modification, a range of administrative amendments have also been sought to Project Approval 09_0176.

The application for the Modification is supported by the *Narama West Modification Environmental Assessment* (EA) prepared by Hansen Bailey Environmental Consultants (Hansen Bailey) (2013).

DP&I provided to Xstrata Coal a total of four submissions from regulatory agencies in relation to the EA, including the New South Wales (NSW) Office of Environment and Heritage (OEH), Division of Resources and Energy (DRE), NSW Environment Protection Authority (EPA) and NSW Office of Water (NOW). Copies of the submissions received are provided in **Appendix A**.

This Response to Submissions document (RTS) has been prepared by Hansen Bailey on behalf of Xstrata Coal to address the submissions pertaining to the EA. Responses to submission issues have been prepared and structured by stakeholder in accordance with **Appendix A**. Excerpts outlining the key issues from the submissions are reproduced in italics with a response to each following as normal text. Technical specialists involved in the preparation of the EA have provided expert advice for the RTS, where applicable.



NARAMA WEST MODIFICATION

Conceptual Modification Layout

FIGURE 1

2 RESPONSE TO STAKEHOLDER SUBMISSIONS

2.1 NSW OFFICE OF ENVIRONMENT AND HERITAGE

2.1.1 Aboriginal Cultural Heritage

Issue

Aboriginal cultural heritage values

OEH acknowledges the significance of the local environment to the local Aboriginal community. OEH notes the existence of numerous Aboriginal sites in the immediate locality and acknowledges that the proposed modified area contains landforms which have yielded a significant volume of evidence of Aboriginal occupation. These sites include artefact scatters, camp sites, grinding grooves, potential archaeological deposits (PADs) and culturally modified trees. There is also a strong possibility that currently undetected cultural material may be present within the project area in those areas where Aboriginal objects have not been previously identified and it is expected that the proponent would develop management strategies to appropriately address this matter.

Response

Xstrata Coal recognises and acknowledges the significance of the local environment to the local Aboriginal community, including the possible presence of as yet undetected cultural material within the Modification disturbance boundary. As outlined in Section 7.10 of the EA, should any unidentified Aboriginal archaeological sites be located during operations, the appropriate procedures of the approved Aboriginal Cultural Heritage Management Plan (ACHMP) will be implemented. As also outlined in Section 1.1 of the EA, the Modification is within the footprint of an approved overburden emplacement area, which has previously been disturbed by mining activities, and as such the locating of undetected Aboriginal cultural material is unlikely.

Issue

Management of Aboriginal cultural heritage

OEH acknowledges the proponent proposes to manage any previously unidentified Aboriginal objects subject to the proposed modification in accordance with the approved Aboriginal Cultural Heritage Management Plan (ACHMP). OEH encourages the proponent to take this opportunity to review the content of the current ACHMP to ensure it addresses all the implications on Aboriginal cultural heritage for this project proposal.

Response

While the Modification is expected to have nil impact on Aboriginal cultural heritage, Xstrata Coal will review the current ACHMP to ensure it addresses all possible implications on Aboriginal cultural heritage that may arise as a result of the Modification.

Issue

Proposed amendment to approved operations boundary

OEH refers to the discussions between Ravensworth Operations and OEH on 27 July and 27 August 2012 concerning the Newdell substation augmentation works program and the location of the approved project boundary. It is noted that Aboriginal cultural heritage values are located in this area and the immediate surrounds. This includes Aboriginal sites 'LID6' (site # 37-3-0448) and 'LID4' (site # 37-3-0451) and associated PADs. It was understood that there was a possibility that the substation augmentation works program had the potential to disturb Aboriginal objects and this disturbance may occur outside of the currently approved 'project disturbance area' in an area to be protected and monitored only.

OEH also understands that the proponent committed to investigating this matter further in accordance with the approved ACHMP, in consultation with the Aboriginal community following advice from the DP&I (in letter dated 21 August 2012) and prior to any augmentation works being undertaken. However, the current modification proposal has not included any additional details of the investigations undertaken or any of the results obtained in support of this proposal. It is therefore strongly recommended that the proponent provides additional details documenting the Aboriginal cultural heritage values associated with this additional area in support of the proposed development modification. These should include:

- *Details of any additional Aboriginal cultural heritage investigations undertaken within the proposed amendment to the approved operations boundary*
- *Details of any Aboriginal sites and/or PADs associated with this area*
- *In the event that any additional development activities likely to occur in this area have the potential to, or, are likely to impact or harm Aboriginal objects, detailed management strategies development in consultation with the registered Aboriginal parties for this project.*

OEH is therefore not in a position to support the proposed amendment to the approved operations boundary until the above matters are addressed by the proponent.

Response

The proposed amendment to the approved operations boundary is an administrative amendment only and does not seek approval for any works or disturbance in this area. The Newdell substation is already constructed and in operation and no changes to this, as currently approved, is proposed. The requirement to amend the approved operations boundary was requested by DP&I given that the boundary currently runs through the centre of the substation. The proposed amended operations boundary encompasses the substation entirely by following the cadastral boundary on which the substation is located.

Following consultation with the Aboriginal community and OEH in mid to late 2012, the Newdell substation augmentation works program, described in the submission above, was deemed to no longer be required and as such never progressed. This was a completely

separate process and is not in any way related to the requirement to amend the operations boundary.

To reiterate the findings in the EA, this amendment to the approved operations boundary will have no operational or environmental consequence, including no impacts to items of Aboriginal heritage. As such, no additional Aboriginal cultural heritage investigations are deemed necessary for this area. This matter was clarified with Diane Crossdale, Manager Planning and Aboriginal Heritage for OEH, in a meeting on 24 May 2013.

Issue

Blast vibration assessment for site 'REA 86'

OEH refers to Section 6.1 and Appendix G of the EA. It is noted that the proponent has discussed the proposed amendment to incrementally increase the vibration limit at Aboriginal site: 'REA 86' (site # 37-3-0982) with OEH during February 2013. Following the recent discussions on 21 February, OEH was still concerned with the details of the documentation provided by the proponent in support of the proposed increase to the vibration limit and the potential detrimental impact this proposal may have on the 'REA 86' site. OEH has raised the following issues which remain outstanding following these discussions:

- *The case studies provided by the proponent provide non-specific examples with completely differing geo-matrixes (pasterboard vs sandstone) with limiting relevance to the discussion concerning site 'REA 86'.*
- *The proponent has indicated that there is limited relevant scientific literature available concerning this topic. However, a brief search of relevant international publications by OEH revealed numerous examples of studies targeting similar scenarios. Some studies have specifically targeted the degradation of sandstone following hysteresis and overlapping wave forms. OEH would welcome contact with the proponent to assist in providing further details of these studies.*
- *OEH requires a summation of relevant scientific literature to clarify/determine what acceptable vibration limit is appropriate in these or similar circumstances, in particular to limit any potential impact on site 'REA 86'.*
- *Editorial matter. OEH refers to Figure 1 of the letter from Terrock Consulting Engineers (dated 19 February 2013). Further information is required by the proponent to clarify the source of the data presented in this figure.*

Given the above concerns, OEH is not in a position to support the current findings of the blast vibration assessment for site 'REA 86' and recommends that the above matters are appropriately addressed by the proponent prior to any consideration of the determination of the proposed modification proposal. Any additional information provided should also be appended to the approved ACHMP as required.

Response

A meeting was held with OEH on 24 May 2013 to discuss the key issues raised in their submission pertaining to the EA. From this meeting, it was requested that Xstrata Coal review and consider the additional literature that had been identified and provided by OEH. Accordingly, Terrock Consulting Engineers (Terrock) has completed a review of the additional literature articles. A list of the reference articles reviewed and the findings of this review are provided in **Appendix B**. In summary, Terrock concluded that the additional reference documents do not provide any new or relevant information that can be used for the assessment and as such does not alter the conclusions of Appendix G as provided in the EA.

Further to the literature review, Terrock has prepared a supplementary report, which outlines the scientific approach that was adopted in Appendix G of the EA. It also provides additional justification for the proposed staged approach to incrementally increase the blast vibration criteria for Aboriginal grinding groove site REA 86 (REA 86) and addresses potential cumulative effects (see **Appendix C**). This document was provided to OEH on 4 June 2013 to inform their decision making process.

The supplementary report concludes that with the assumptions and comparisons made having regard to the relevant scientific literature, proposed increases in the blast vibration criteria from 30 millimetres (mm) /second (s) to a maximum of 175 mm/s will not cause further cracking of the sandstone ledges at REA 86. As stated in the EA, Xstrata Coal has committed to adopting an incremental approach whereby an interim limit of 60 mm/s will be initially applied. If observations and analysis show no change to REA 86 and monitoring validates the predictions from the strain analysis, the blast vibration limit will be progressively increased to 120 mm/s and then potentially to 175 mm/s, if required.

Following review of the supplementary report, OEH has provided written correspondence outlining that adequate justification has been provided to demonstrate that the likelihood of damage to the sandstone of REA 86 is low to nil. Based on this prediction, OEH has confirmed to Xstrata Coal that it agrees to the incremental increase of the blast vibration criteria for REA 86 as proposed in the EA (see **Appendix D**).

Aboriginal stakeholder consultation regarding the approach to increasing the blast vibration limit at REA 86 was conducted in accordance with the *Aboriginal Cultural Heritage Consultation Requirements for Proponents 2010* (DECCW, 2010). The results of the analysis (Terrock, 2012) and the approach to increasing the blast vibration limit at REA 86 were reported to Aboriginal stakeholders (see Appendix H of the EA). As part of the ongoing consultation process, Xstrata Coal has committed to engaging Aboriginal stakeholders in monitoring REA 86 when the blast vibration criterion increases to 60, 120, and 175 mm/s.

Issue

Local Aboriginal community consultation

Effective heritage management requires knowledge of values or cultural significance. An understanding of what makes a place culturally significant and why, enables appropriate

decisions to be made about the management of that place. OEH recognises and acknowledges that Aboriginal people are the primary source of information about the value of their heritage and how this is best protected and conserved and must have an active role in any Aboriginal cultural heritage planning process.

OEH also encourages the proponent to maintain continuous consultation processes with the Aboriginal community for the entire life of the project and for all Aboriginal cultural heritage matters associated with the project area. As a general rule, gaps in the consultation process of six months or more will not constitute a continuous consultation process. Where a proponent envisages a gap of more than six months it is recommended that representatives of the local Aboriginal community are regularly informed of any progress.

Response

Xstrata Coal's engagement and consultation activities with the local community specific to the Modification are summarised in Section 6 of the EA, which outlines newsletters, Ravensworth Operations Community Consultative Committee meetings and the Xstrata Coal website as primary tools of stakeholder engagement.

Aboriginal stakeholder engagement is continuously carried out with regards to activities across Ravensworth Operations in accordance with the conditions of Project Approval 09_0176 and the ACHMP. This involves holding progress update consultation sessions with registered Aboriginal parties at least once every six months. Examples of such engagement are shown in Appendix H of the EA.

2.1.2 Threatened Biodiversity

Issue

OEH understands that the footprint of the proposed Narama West Open pit is about 89 hectares in size, of which about 72 hectares comprises rehabilitated overburden, and the remaining 17 hectares comprises disturbed vegetation beside the Bayswater Creek diversion channel (EA, s.7.8 & Appendix E). A Speckled Warbler, a declining woodland bird species as 'Vulnerable' under the Threatened Species Conservation Act 1995 was reported on the boundary of the proposed open pit area during the site inspection in October 2012.

The Speckled Warbler was observed in rehabilitated woodland on overburden in vegetation not (yet) considered to contain suitable nesting habitat (EA, Appendix E, pg 22), but details of this record were not provided, particularly date, number of animals and location. OEH requires the provision of this information in order to complete its assessment of the impact of this proposal on threatened biodiversity before recommended conditions of approval can be provided.

Response

The ecological impact assessment prepared by Cumberland Ecology for the EA (see Appendix E of the EA) identified one individual Speckled Warbler in rehabilitated woodland on an existing overburden emplacement area within the Modification disturbance boundary on 4 October 2012. The coordinates of the sighting were recorded as MGA E314165, N6406728.

Following cessation of operations in the Modification disturbance boundary, this area will then be utilised as an overburden emplacement area for future mining at Ravensworth Operations as approved under PA 09_0176 and rehabilitated in accordance with the approved Mining Operations Plan. Based upon improvements to rehabilitation techniques in recent years, woodland can now be re-established to a higher standard than current rehabilitation. This will result in a return to a similar or better habitat state for flora and fauna in the long term.

2.2 NSW DIVISION OF RESOURCES AND ENERGY

2.2.1 Mining Title

Issue

Under the Mining Act 1992, the proponent is required to hold appropriate mining titles from DRE in order to mine this mineral. DRE understand that the proposed modification is within existing mining titles held by the proponent.

Under the Mining Act 1992, mining and rehabilitation are regulated by conditions included in the mining lease, including requirements for the submission of a Mining Operations Plan (MOP) prior to the commencement of operations, and subsequent Annual Environmental Management Reports (AEMR).

DRE has no objections to this proposed Modification to recovery of approximately 2.7 million tonnes of ROM coal by open cut mining methods over a period of two years.

If approved, the proponent should submit a revised MOP to incorporate this modification.

Response

Upon project approval, Xstrata Coal will prepare and submit a revised Mining Operations Plan for Ravensworth Operations, which incorporates the Modification.

2.2.2 Rehabilitation Plan

Issue

DRE recommends that the following condition be incorporated into any planning approval:

The Proponent must prepare and implement a Rehabilitation Plan to the satisfaction of the Director General of Department of Trade & Investment, Regional Infrastructure & Services. The Rehabilitation Plan must:

a. Be prepared in accordance with DRE guidelines and in consultation with relevant agencies and stakeholders including Forests NSW;

b. Be submitted and approved by the Director General of Department of Trade & Investment, Regional Infrastructure & Services prior to the commencement of construction;

c. Address all aspects of rehabilitation and mine closure, including final landuse assessment, landscape, final void management, rehabilitation objectives, domain objectives, completion criteria and rehabilitation monitoring.

Response

As outlined in Section 7.16 of the EA and in accordance with the conditions of Project Approval 09_0176, following cessation of operations in the Narama West mining area, the resultant mine void will be backfilled with overburden and then used as an overburden emplacement area for future mining operations as currently approved. The area subject to the Modification will then be rehabilitated in accordance with the Mining Operations Plan, Rehabilitation Plan (as per DRE's new reporting requirements) and Project Approval 09_0176.

2.3 NSW ENVIRONMENT PROTECTION AUTHORITY

2.3.1 Air Quality

Issue

The proposed Project will occur concurrently with existing approved Narama activities. Given that state wide mining intensity is not proposed to increase, and mining machinery and infrastructure will be shared between the two pits, a proportional reduction in activity at the approved Narama site is expected. On this basis, it is unlikely that the air quality impacts from the Project will differ significantly from those predicted and observed from current mining activities at the Narama mine site – existing Project Approval 09-0176 (11 February, 2013).

Best practice management of fugitive particle emissions should be used to reduce the likelihood of offsite impacts from the mining complex. As a minimum, this should include proactive and reactive management strategies, continuous real time monitoring and meteorological measurement and forecasting systems. The EPA recommends the inclusion of the condition included in Attachment 1 in any conditions of approval.

(a) By <xxxx> the proponent must prepare an updated air quality management plan for the site. The plan must include the following information, as a minimum, for all dust generating activities at the site:

- *Key performance indicator(s);*
- *Monitoring method(s);*
- *Location, frequency and duration of monitoring;*
- *Record keeping;*
- *Response mechanisms; and*
- *Compliance reporting.*

(b) The air quality management plan must be submitted to the Department of Planning and Infrastructure for approval prior to the commencement of Narama West Modification activities at the site.

Response

Xstrata Coal notes EPA's recommendations. Should these recommendations be incorporated in the conditions of project approval, Xstrata Coal will revise the existing Air Quality Management Plan, as required, in consultation with EPA. However, it is considered that the existing Air Quality Management Plan as currently approved will adequately account for the continued management of air quality impacts from Ravensworth Operations, including those within the Narama West mining area.

2.3.2 Noise and Blasting

Issue

The EPA is satisfied that any noise and blasting impacts associated with the Project will be appropriately regulated through the existing Licence. The EPA recommends that the Department of Planning & Infrastructure seek a commitment from the proponent to comply with these requirements.

Response

Xstrata Coal will continue to comply with the requirements of the existing Environment Protection Licence.

2.3.3 Water

Issue

The EPA is satisfied that any potential water quality and management issues will be appropriately regulated through the existing Licence.

Response

Submission noted.

2.3.4 Administrative Amendments

Issue

The EPA notes that the proposal of additional administrative modifications to the current project approval and provides the following comment:

(a) Alteration to the approved operational boundary to include the Newdell substation.

The EPA advises that, given the relevant land is already the subject of Environmental Protection Licence 2652 ("the Licence"), the EPA has no objection to the proposed modification.

(b) Inclusion of additional commitments to the blast management plan requirements

The EPA advises that, as the proposed inclusions do not impact upon the blasting related requirements of the Licence, the EPA has no comment to the proposed modification.

(c) Changes to the Aboriginal grinding groove blast vibration criterion

The EPA advises that this proposal does not relate to matters for which the EPA performs a regulatory function.

(d) Removal of the specified Aboriginal archaeologist in the relevant PA conditions.

The EPA advises that this proposal does not relate to matters for which the EPA performs a regulatory function.

Response

Submission noted.

2.4 NSW OFFICE OF WATER

2.4.1 Groundwater Modelling

Issue

The impact on surface water is based on the numerical model for the Ravensworth Operations. The proponent has determined that simulation of the Narama mining area demonstrates that impacts to baseflow from these operations are predicted to be negligible. There is insufficient information provided to determine what is defined as a negligible impact on baseflow.

Response

The groundwater impact assessment prepared by Australian Groundwater and Environmental Consultants for the EA (see Appendix D of the EA) identified that previous mining activities within the Narama mining area removed the southern portion of the alluvium associated the original alignment of Bayswater Creek. As such, no alluvium exists within the immediate vicinity of the Narama West mining area.

The assessment also recognised that the approved extent of the Ravensworth North and Narama mining areas, situated adjacent to the Modification disturbance boundary, are significantly greater in magnitude and depth than the relatively small Narama West mining area (see Figure 4 of the EA). The cumulative impact of these approved adjacent operations are predicted to result in further depressurisation of existing local alluviums, including the northern portion of Bayswater Creek and the Hunter River, over time as mining continues to advance.

Given the absence of the southern Bayswater Creek alluvium, limited connectivity to other local alluvial sources based on location and extent, the fact that the proposed depth is relatively shallow and the cumulative impacts of adjacent operations, the Narama West mining area is largely dry. As such, the Narama West mining area is not capable of drawing upon and in turn reducing the baseflow of the northern portion of Bayswater Creek or the Hunter River.

Issue

The proponent has used a steady state 2D SEEP/W to assess the impacts of the proposed modification. It is not identified why this approach was taken rather than using the existing numerical model developed for the Ravensworth Operations... The proponent has not

classified the steady state 2D SEEP/W model to Australian groundwater modelling guidelines.

Response

The scope of the groundwater impact assessment prepared by Australian Groundwater and Environmental Consultants for the EA (see Appendix D of the EA) was established by conducting a review of available data and in consultation with NOW on 20 November 2012. This approach indicated that the proposed Narama West mining area posed a very low risk to the local groundwater regime given the area is largely dry and is not predicted to contribute to the cumulative impact of existing approved adjacent mining areas. In this regard, a more simplistic two dimensional model (SEEP/W model), a Class 1 model under the *Australian Groundwater Modelling Guidelines* (Barnett et al., 2012), was deemed suitable to quantify the limited impacts of the Modification.

2.4.2 Licensing and Water Sharing Plans

Issue

There is insufficient information to determine if the current entitlement is sufficient to account for the current inflows into the mined void. An entitlement of 150ML/yr is equivalent to an inflow of 0.41ML/yr. The proposed modification will cause additional inflows into the Narama mining area of 7.2ML/yr.

Response

Measuring the volume of groundwater intercepted by open cut mining is particularly challenging for operators given contributions are received from varying water sources, including rainfall, seepage from overburden and groundwater from Permian coal measures.

As groundwater contribution cannot be measured directly, Ravensworth Operations use a water balance model to estimate components of the overall water balance. The model estimates the groundwater seepage component at less than 0.5 megalitres (ML)/day from the Narama mining area, which equates to a maximum of 183 ML/year. This volume is marginally higher than the current entitlement to offset the mining area seepage of 150 ML/year. While it is considered improbable the groundwater intercepted exceeds 150 ML/year, future water balance modelling for the next Annual Review will assess the groundwater contribution to confirm the existing entitlement offsets the impacts from existing operations and the proposed Narama West mining area.

2.4.3 Aquifer Impact Assessment

Issue

There is no comment by the proponent on groundwater quality in less productive porous/fractured rock or highly productive Hunter River alluvium, specifically "any change in the groundwater quality should not lower the beneficial use category of the groundwater source beyond 40m from the activity" (see Table 1).

Response

Previous assessments (MER, 2009) indicated the groundwater sourced from the Permian coal measures in the vicinity of the Narama West mining area is typically brackish to saline with total dissolved solids in the order of 6,000 milligrams (mg)/litre (L). The salinity therefore limits the beneficial use of the groundwater.

Geochemical studies (MER, 2009) indicated long term water quality in the final voids at Ravensworth Operations to exhibit a pH range from 6.5 to 9 and a total dissolved solids range from 1,000 mg/L increasing to 4,000 mg/L over time. The water quality in the final voids will be of a similar quality to the surrounding Permian coal measures and therefore no change in the beneficial use of this water is likely.

It is widely accepted that groundwater in the Permian coal measures naturally discharges to the Hunter River alluvium where fresher groundwater occurs. It is the high rainfall recharge rate through the Hunter River alluvium that maintains its low salinity. Mining associated with the Modification will not affect this recharge process. In this regard, no lowering of the beneficial use category of the Hunter River alluvium will occur.

3 CONCLUSION

As demonstrated in the EA and further within this RTS, the Modification's impacts have been minimised as far as practicable. Given the scale and nature of the Modification, operations will remain relatively consistent with Project Approval 09_0176 and as described in the *Ravensworth Operations Project Environmental Assessment* (Umwelt, 2010). Furthermore, administrative amendments sought to Project Approval 09_0176 have been determined to have no operational or environmental consequence.

Ravensworth Operations, with consideration of the Modification, will be capable of conducting activities under the conditions of Project Approval 09_0176, Environment Protection Licence 2652, the management plans implemented under this approval and the statement of commitments provided in Table 3 of the EA.

4 ABBREVIATIONS

Abbreviation	Description
ACHMP	Aboriginal Cultural Heritage Management Plan
DP&I	NSW Department of Planning and Infrastructure
DRE	NSW Division of Resources and Energy
EA	*Narama West Modification Environmental Assessment*
EPA	NSW Environment Protection Authority
Hansen Bailey	Hansen Bailey Environmental Consultants
L	Litre
mg	Milligram
ML	Megalitre
mm	Millimetres
The Modification	Narama West Modification
NOW	NSW Office of Water
NSW	New South Wales
OEH	NSW Office of Environment and Heritage
Ravensworth Operations	Ravensworth Operations Pty Limited
REA 86	Aboriginal grinding groove site REA 86
ROM	Run of Mine
RTS	Response to Submissions
s	Second
Xstrata Coal	Xstrata Coal Pty Limited

5 REFERENCES

Barnett, B., Townley, L., Post, V., Evans, R., Hunt, R., Peeters, L., Richardson, S., Werner, A., Knapton, A. and Boronkay, A. (2012) *Australian Groundwater Modelling Guidelines*, Waterlines Report 82, National Water Commission, Canberra.

Hansen Bailey Environmental Consultants (Hansen Bailey) (2013) *Narama West Modification Environmental Assessment* .

Mackie Environmental Research (MER) (2009) *Ravensworth Operations Pty Ltd, Groundwater Management Studies – Ravensworth Operations Project*.

NSW Department of Environment, Climate Change and Water (DECCW) (2010) *Aboriginal Cultural Heritage Consultation Requirements for Proponents 2010*.

Terrock Engineering Consultants (Terrock) (2012) *Determining Safe (Non-Damaging) Ground Vibration Limits for the REA 86 Site*.

Umwelt Pty Ltd (Umwelt) (2010) *Ravensworth Operations Project Environmental Assessment*.

Appendix A

Stakeholder Submissions

NSW GOVERNMENT | Office of Environment & Heritage

Your reference: PA 09_0176 MOD1
Our reference: DOC13/14037; FIL13/4124
Contact: Robert Gibson, 4908 5851

Ms Elle Donnelly
Planner, Mining & Industry Projects
Department of Planning & Infrastructure
GPO Box 39
SYDNEY NSW 2001

Dear Ms Donnelly

RE: NARAMA WEST OPEN CUT MODIFICATION (PA 09_0176 MOD1), RAVENSWORTH OPERATIONS PROJECT– REVIEW AND REQUEST FOR FURTHER INFORMATION

I refer to your email dated 8 April 2013 seeking comment and recommended conditions of approval for the proposed modification to the Narama West Open Cut, which is part of the Ravensworth Operations Project.

The Office of Environment and Heritage (OEH) understands that the proposed modification involves the following:

- develop the Narama West Open Pit over an area of about 89 hectares to recover about 2.7 million tonnes of Run-Of-Mine coal from the Bayswater Seam over a two year period in an area used for overburden emplacement in the Narama mining area
- enlarge the Approved Operations Boundary of the Ravensworth Operations in the north by about two hectares in order to include the Newdell substation on Lot 10-0 DP 700429
- include additional commitments to the blast plan requirements
- change the peak vibration blast criteria from 30mm/s to 175mm/s with respect to protecting Aboriginal grinding grooves
- remove the requirement for a specific company's Aboriginal archaeologist in Condition 6.10.1 of PA 09_0176 for one from any company.

OEH has reviewed the Environmental Assessment (EA) for the proposed modification with regards to Aboriginal cultural heritage and threatened biodiversity and has found the information on Aboriginal cultural heritage provided so far to be insufficient. The main problems OEH has identified are the lack of details of Aboriginal cultural heritage investigations in the proposed expansion area for the Approved Operations Boundary, and the findings of those investigations. OEH has concerns regarding the lack of data to support statements in the EA about the predicted negligible impacts of increasing the blast peak vibration limit on the grinding groove site ('REA 86'). OEH also requires details on the Speckled Warbler record made in the Narama West project area during fieldwork on which the EA is based.

OEH's review of this proposal is provided in **Attachment 1**. OEH requires additional information from the proponent before it is able to complete its full assessment of this project before being able to provide recommended conditions of approval.

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If you require any further information regarding this matter please contact Robert Gibson, Regional Biodiversity Conservation Officer, on 4908 6851.

Yours sincerely

23 APR 2013

RICHARD BATH
Head – Hunter Planning Unit
Regional Operations

Enclosure: Attachment 1

ATTACHMENT 1

ASSESSMENT OF THE PROPOSED NARAMA WEST OPEN CUT MINE (PA 09_0176 MOD1) AND RECOMMENDED CONDITIONS OF APPROVAL

OEH has reviewed the Environmental Assessment titled 'Narama West Modification: Environmental Assessment for Xstrata Coal Pty Limited' dated April 2013 ('the EA'), including 'Appendix E: Ecological Impact Assessment', and 'Appendix H: Aboriginal Consultation Records'.

ABORIGINAL CULTURAL HERITAGE ASSESSMENT

Aboriginal cultural heritage values

OEH acknowledges the significance of the local environment to the local Aboriginal community. OEH notes the existence of numerous registered Aboriginal sites in the immediate locality and acknowledges that the proposed modified project area contains landforms which have yielded a significant volume of evidence of Aboriginal occupation. These sites include artefact scatters, camp sites, grinding grooves, potential archaeological deposits (PADs) and culturally modified trees. There is also a strong possibility that currently undetected cultural material may be present within the project area in those areas where Aboriginal objects have not been previously identified and it is expected that the proponent would develop management strategies to appropriately address this matter.

Management of Aboriginal cultural heritage

OEH acknowledges the proponent proposes to manage any previously unidentified Aboriginal objects subject to the proposed modification in accordance with the approved Aboriginal Cultural Heritage Management Plan (ACHMP). OEH encourages the proponent to take this opportunity to review the content of the current ACHMP to ensure it addresses all the implications on Aboriginal cultural heritage for this project proposal.

Proposed amendment to approved operations boundary

OEH refers to the discussions between Ravensworth Operations and OEH on 27 July and 27 August 2012 concerning the Newdell substation augmentation works program and the location of the approved project boundary. It is noted that Aboriginal cultural heritage values are located in this area and the immediate surrounds. This includes Aboriginal sites '*LID6*' (site # 37-3-0448) and '*LID4*' (site # 37-3-0451) and associated PADs. It was understood that there was a possibility that the substation augmentation works program had the potential to disturb Aboriginal objects and this disturbance may occur outside of the currently approved 'project disturbance area' in an area to be protected and monitored only.

OEH also understands that the proponent committed to investigating this matter further in accordance with the approved ACHMP, in consultation with the Aboriginal community following advice from DP&I (in letter dated 21 August 2012) and prior to any augmentation works being undertaken. However, the current modification proposal has not included any additional details of the investigations undertaken or any of the results obtained in support of this proposal. It is therefore strongly recommended that the proponent provides additional details documenting the Aboriginal cultural heritage values associated with this additional area in support of the proposed development modification. This should include:

- details of any additional Aboriginal cultural heritage investigations undertaken within the proposed amendment to the approved operations boundary
- details of any Aboriginal sites and/or PADs associated with this area
- in the event that any additional development activities likely to occur in this area have the potential to, or, are likely to impact or harm Aboriginal objects, detailed management strategies developed in consultation with the registered Aboriginal parties for this project.

OEH therefore is not in a position to support the proposed amendment to the approved operations boundary until the above matters are addressed by the proponent.

Blast vibration assessment for site 'REA 86'

OEH refers to Section 6.1 and Appendix G of the EA. It is noted that the proponent has discussed the proposed amendment to incrementally increase the vibration limit at Aboriginal site: '*REA 86*' (site #37-3-0982) with OEH during February 2013. Following the recent discussions on 21 February, OEH was still concerned with the details of the documentation provided by the proponent in support of the proposed increase to the vibration limit and the potential detrimental impact this proposal may have on the '*REA 86*' site. OEH has raised the following issues which remain outstanding following these discussions:

- The case studies provided by the proponent provide non-specific examples with completely differing geo-matrixes (plasterboard vs sandstone) with limiting relevance to the discussion concerning site '*REA 86*'.
- The proponent has indicated that there is limited relevant scientific literate available concerning this topic. However, a brief search of relevant international publications by OEH revealed numerous examples of studies targeting similar scenarios. Some studies have specifically targeted the degradation of sandstone following hysteresis and overlapping wave forms. OEH would welcome contact with the proponent to assist in providing further details of these studies.
- OEH requires a summation of relevant scientific literature to clarify/determine what acceptable vibration limit is appropriate in these or similar circumstances, in particular to limit any potential impact on site '*REA 86*'.
- OEH understands that repeated blasting of a sandstone outcrop weakens the integrity of the sandstone matrix over time. Repeated blasts may cause damage to the surface of the stone, particular as a result of hysteresis in the sandstone structure. OEH therefore requires additional details and clarification from the proponent regarding the cumulative impact on the sandstone matrix by repeated blasting cycles.
- Editorial matter. OEH refers to Figure 1 of the letter from Terrock Consulting Engineers (dated 19 February 2013). Further information is required by the proponent to clarify the source of the data presented in this figure.

Given the above concerns, OEH is not in a position to support the current findings of the blast vibration assessment for site *'REA 86*' and recommends that the above matters are appropriately addressed by the proponent prior to any consideration of the determination of the proposed modification proposal. Any additional information provided should also be appended to the approved ACHMP as required.

Local Aboriginal community consultation

Effective heritage management requires knowledge of values or cultural significance. An understanding of what makes a place culturally significant and why, enables appropriate decisions to be made about the management of that place. OEH recognises and acknowledges that Aboriginal people are the primary source of information about the value of their heritage and how this is best protected and conserved and must have an active role in any Aboriginal cultural heritage planning process.

OEH also encourages the proponent to maintain continuous consultation processes with the Aboriginal community for the entire life of the project and for all Aboriginal cultural heritage matters associated with the project area. As a general rule, gaps in the consultation process of six months or more will not constitute a continuous consultation process. Where a proponent envisages a gap of more than six months it is recommended that representatives of the local Aboriginal community are regularly informed of any progress.

THREATENED BIODIVERSITY

OEH understands that the footprint of the proposed Narama West Open Pit is about 89 hectares in size, of which about 72 hectares comprises rehabilitated overburden, and the remaining 17 hectares comprises disturbed vegetation beside the Bayswater Creek diversion channel (EA, s.7.8 & Appendix E). A Speckled Warbler, a declining woodland bird species listed as 'Vulnerable' under the *Threatened Species Conservation Act 1995* was reported on the boundary of the proposed open pit area during the site inspection in October 2012.

The Speckled Warbler was observed in rehabilitated woodland on overburden in vegetation not (yet) considered to contain suitable nesting habitat (EA, Appendix E, pg 22), but details of this record were not provided, particularly date, number of animals and location. OEH requires the provision of this information in order to complete its assessment of the impact of this proposal on threatened biodiversity before recommended conditions of approval can be provided.

NSW GOVERNMENT | Resources & Energy

OUT13/10067

Ms Elle Donnelley
Planner
Mining & Industry Projects
Department of Planning and Infrastructure
GPO Box 39
SYDNEY NSW 2001

Dear Ms Donnelley

Ravensworth Operations Project
Narama West (PA 09_0176 Mod 1)
Environmental Assessment Review

I refer to your email of 26 March 2013 regarding the Xstrata Coal Pty Limited application to modify its consent for the Ravensworth Operations Project, Narama West under the Environmental Planning and Assessment Act 1979.

NSW Trade & Investment, Regional Infrastructure & Services, Division of Resources & Energy (DRE) has reviewed the *Narama West Modification Environmental Assessment* (EA) dated April 2013 and provides the following comments which are directed at specific areas of DRE responsibility for this proposal.

MINING TITLE

Under the *Mining Act 1992*, the proponent is required to hold appropriate mining titles from DRE in order to mine this mineral. DRE understand that the proposed modification is within existing mining titles held by the Proponent.

Under the *Mining Act 1992*, mining and rehabilitation are regulated by conditions included in the mining lease, including requirements for the submission of a Mining Operations Plan (MOP) prior to the commencement of operations, and subsequent Annual Environmental Management Reports (AEMR).

DRE has no objections to this proposed Modification to recovery of approximately 2.7 million tonnes of ROM coal by open cut mining methods over a period of two years.

If approved, the proponent should submit a revised MOP to incorporate this modification.

Department of Trade & Investment, Regional Infrastructure & Services
Division of Resources and Energy
PO Box 344 Hunter Region Mail Centre NSW 2310
516 High St Maitland NSW 2323
Tel: 02 4931 6666 Fax: 02 4931 6776 www.industry.nsw.gov.au
ABN 72 189 919 072

REHABILITATION PLAN
DRE recommends that the following condition be incorporated into any planning approval:

The Proponent must prepare and implement a Rehabilitation Plan to the satisfaction of the Director General of Department of Trade & Investment, Regional Infrastructure & Services. The Rehabilitation Plan must:

a. be prepared in accordance with DRE guidelines and in consultation with relevant agencies and stakeholders including Forests NSW;

b. be submitted and approved by the Director General of Department of Trade & Investment, Regional Infrastructure & Services prior to the commencement of construction;

c. address all aspects of rehabilitation and mine closure, including final landuse assessment, landscape, final void management, rehabilitation objectives, domain objectives, completion criteria and rehabilitation monitoring.

DRE is available to meet with the Proponent to assist in developing the above documents for their operation.

Should you have any enquires regarding this matter please contact Julie Moloney, Principal Adviser, Industry Coordination on (02) 4931 6549.

Yours sincerely

Adrian Delany
Acting Director, Industry Coordination

2. 5. 13

NSW EPA

Our reference: DOC13/13833; LIC08/952-05
Contact: Emma Paull (02) 4908 6828

24 APR 2013

Elle Donnelley
Planner
Mining & Industry Projects
NSW Department of Planning & Infrastructure
GPO Box 39
SYDNEY NSW 2001

Dear Ms Donnelley

XSTRATA COAL PTY LIMITED – NARAMA WEST MODIFICATION (PA 09_0176)

Reference is made to your email dated 8 April 2013 to the Environment Protection Authority (EPA) seeking comments and any recommended conditions of approval for the Narama West Project Modification ("the Project").

The EPA understands the modification application is pursuant to Section 75W of the *Environmental Planning & Assessment Act 1979* and seeks approval for the recovery of approximately 2.7 Mt of ROM coal by open cut mining methods over a period of two years within the Narama West mining area. The Project includes an area of approximately 89 hectares within the footprint of an approved overburden emplacement area.

Mining will be undertaken by truck and shovel and/or dragline extraction with overburden being transferred to an existing overburden emplacement area.

All activities associated with the Project will be consistent with the currently approved operations and will not result in an increase in the life of the approved mine. It will increase the programmed production rate for approximately two years but production will remain within the approved maximum limit of 16Mtpa ROM coal.

The EPA has reviewed the information provided with the modification application and provides the following comment.

Air Quality
The proposed Project will occur concurrently with existing approved Narama activities. Given that site wide mining intensity is not proposed to increase, and mining machinery and infrastructure will be shared between the two pits, a proportional reduction in activity at the approved Narama site is expected. On this basis, it is unlikely that the air quality impacts from the Project will differ significantly from those predicted and observed from current mining activities at the Narama mine site - existing Project Approval 09-0176 (11 February, 2013).

Best practice management of fugitive particle emissions should be used to reduce the likelihood of off site impacts from the mining complex. As a minimum, this should include proactive and reactive management strategies, continuous real time monitoring and meteorological measurement and forecasting systems.
The EPA recommends the inclusion of the condition included in Attachment 1 in any conditions of approval.

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Tel: (02) 4908 6800 Fax: (02) 4908 6810
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Noise and Blasting
The EPA is satisfied that any noise and blasting impacts associated with the Project will be appropriately regulated through the existing Licence. The EPA recommends that the Department of Planning & Infrastructure seek a commitment from the proponent to comply with these requirements.

Water Quality and Management
The EPA is satisfied that any potential water quality and management issues will be appropriately regulated through the existing Licence.

Additional Administrative Modifications
The EPA notes the proposal of additional administrative modifications to the current project approval and provides the following comment:

a) Alteration to the approved operational boundary to include the Newdell substation.
The EPA advises that, given the relevant land is already the subject of Environment Protection Licence 2652 ("the Licence"), the EPA has no objection to the proposed modification.

b) Inclusion of additional commitments to the blast management plan requirements.
The EPA advises that, as the proposed inclusions do not impact upon the blasting related requirements of the Licence, the EPA has no comment to the proposed modification.

c) Changes to the Aboriginal grinding groove blast vibration criterion.
The EPA advises that this proposal does not relate to matters for which the EPA performs a regulatory function.

d) Removal of the specified approved Aboriginal archaeologist in the relevant PA conditions.
The EPA advises that this proposal does not relate to matters for which the EPA performs a regulatory function.

Please contact Emma Paull on (02) 4908 6828 if you require any further information.

Yours sincerely

24.4.13

BILL GEORGE
A/Head Regional Operations Unit – Hunter
Environment Protection Authority

Encl: Attachment 1 – Recommended Conditions of Approval

Attachment 1 – Recommended Conditions of Approval

(a) By <xxxxx> the proponent must prepare an updated air quality management plan for the site. The plan must include the following information, as a minimum, for all dust generating activities at the site:

- Key performance indicator(s);
- Monitoring method(s);
- Location, frequency and duration of monitoring;
- Record keeping;
- Response mechanisms; and
- Compliance reporting.

(b) The air quality management plan must be submitted to the Department of Planning and Infrastructure for approval prior to the commencement of Narama West Modification activities at the site.

NSW GOVERNMENT | Department of Primary Industries

OUT13/12644

29 MAY 2013

Ms Elle Donnelley
Mining and Industry Projects
NSW Department of Planning and Infrastructure
GPO Box 39
SYDNEY NSW 2001

Elle.Donnelley@planning.nsw.gov.au

Dear Ms Donnelley,

Ravensworth Operations Project (PA 09_0176 Mod 1)
Response to exhibition of Environmental Assessment

I refer to your email dated 8 April 2013 requesting advice from the Department of Primary Industries (DPI) in respect to the above matter.

Comment by NSW Office of water
The NSW Office of Water (Office of Water) appreciates the opportunity to review the Environmental Assessment (EA) for the Narama West Modification submitted by Xstrata Coal Pty Ltd. The key issues that should be addressed by the applicant are listed below and detailed comments are provided in Attachment A. Recommended approval conditions are also included in Attachment A.

1. The applicant classifies the model based on the Australian Groundwater Modelling Guidelines.
2. The applicant supplies sufficient information to confirm that the existing Part 5 *Water Act 1912* licence is adequate for the total take of water from the proposed modification and the existing groundwater inflows into the Narama mine void.
3. The applicant addresses the minimal impact considerations of the Aquifer Interference Policy with respect to groundwater quality for the highly productive Hunter River Alluvium and the less productive porous rock.
4. The applicant defines negligible impact in relation to baseflow.

For further information please contact Christie Jackson, Water Regulation Officer, Tamworth, on ph (02) 6701 9652 or Christie.Jackson@water.nsw.gov.au.

Agriculture, Fisheries, Crown Lands and Forestry divisions do not have any comments on the EA.

Yours sincerely

Phil Anquetil
Executive Director Business Services

Attachment A

Ravensworth Operations Project (PA 09_176 Mod 1)
Response to exhibition of Environmental Assessment
Additional comments by the NSW Office of Water

Groundwater Management:

The Ravensworth Operations has a network of 26 piezometers and 12 vibrating wire piezometers, no sites are within the proposed mining area and no new sites were installed as part of this assessment.
The proposed modification is within the area where a numerical model was prepared by Mackie Environmental Research (2009) to provide model predictions of groundwater impact for the Ravensworth Operations Project.

Pre-mining groundwater levels in the Ravensworth Operations Project area were predicted to be approximately RL 55 m to RL 60 m. The model showed that the 2009 piezometric level in the shallow Permian coal measures in the proposed Narama West mining area are between RL 0 m and RL 40 m, which the proponent considered was consistent with the groundwater level data. These predicted model elevations are a drawdown of between 20 m to 60 m from pre-mining groundwater levels.

The proponent identifies that drawdown for the Ravensworth Operations Project in 2040 is predicted to between 80 m to 170 m below pre-mining levels. They have predicted drawdown in the Bayswater Seam within the proposed Narama West mining area to be fully dewatered and depressurised from the approved mining activities at the Ravensworth Operations.

Geology/Hydrogeology
The proponent presents the conceptual hydrogeology of the site based on a summary of data presented in previous more detailed investigations (MER 2009; MER 2012 & Umwelt, 2011). The three main aquifer systems identified within the vicinity of the Narama West mining area, these are:

- Quaternary alluvium primarily associated with the Hunter River and major drainages;
- parts of the overlying weathered zone or regolith; and
- Permian coal seams.

The main channel of the Hunter River is approximately 1.4 km to the south of the proposed Narama West mining area. The alluvium associated with the Hunter River is generally comprised of 10 m to 20 m of unconsolidated gravels, sands, silts and clays.

The Permian formations occur as a regular layered south-easterly dipping sedimentary sequence, which can be categorised into the following hydrogeological units:

- hydrogeologically "tight" and hence very low yielding to essentially dry sandstone, siltstone and conglomerate that comprise the majority of the Permian interburden/overburden;
- low to moderately permeable coal seams, which are the prime water bearing strata within the Permian sequence.

The coal seam aquifers are typically confined above and below by Permian interburden or overburden. Groundwater within the coal seams is transmitted through the cleats of the coal. As the depth of the coal seam below ground level increases, so to do the confining pressure on the coal cleats. This increased depth of burial typically results in a decrease in the hydraulic conductivity of the coal seam.

Surface water bodies and Groundwater Dependent Ecosystems

The main surface water bodies in the vicinity of the proposed modification are Bowmans Creek to the east, Bayswater Creek on the western margin and the Hunter River to the south.

Previous mining activities within the Narama mining area have removed the southern portion of the alluvium associated the original alignment of Bayswater Creek. The proponent notes that there is no notable baseflow in Bayswater Creek due to the removal of the alluvium.

The proponent has identified no known Groundwater Dependant Ecosystems (GDEs) within Ravensworth Operations, which includes the Narama West mining area.

Existing Groundwater Users

The proponent has identified that there are no identified private boreholes within or near the Narama West mining area.

Groundwater Modelling

The proponent has conceptualised that the eastern margin of the proposed West Narama modification is the Narama void. The Narama mined void has been backfilled with overburden, which the proponent has identified would be more permeable than the Bayswater Seam and the Permian overburden. They have anticipated that this will enhance seepage and drawdown in the coal seam.

The proponent has identified that the interpreted groundwater level contours for the Bayswater Seam show that on the western margin of the Narama West mining area, the groundwater levels are likely to be approximately RL 40 m. These levels reduce to the east and south following the dip of the Permian strata. At the south-eastern corner of the Narama West mining area, the groundwater levels are assessed to be RL 20 m. Based upon the Bayswater Seam floor structure contours, it is assessed that the coal seam is unsaturated over the eastern and southern part of the Narama West mining area and potentially partially saturated to the north and west.

To assess the volume of groundwater presently seeping into the proposed mine void and the above conceptualisation, a steady state 2D SEEP/W cross sectional numerical model was developed by Australasian Groundwater and Environmental Consultants Pty Ltd.

The model is non-calibrated and based on a number of assumed parameters, including recharge rates, constant head boundaries and seepage.

The assessment of the broader groundwater impacts of the proposed modification are addressed by reference to the numerical model previously developed for the broader Ravensworth Operations Project.

The proponent has justified that the model is fit for purpose by replicating the groundwater level outcomes of the Ravensworth Operations Project numerical model.

The proponent identifies that the model predicts 0.0115 m^3/day per metre of model section and is assumed to be representative of the 1700m length of the mine area, being equivalent to a flux of 19.6 m^3/day through the Narama West mining area.

The proponent considers that this volume would be removed by evaporation and as bound moisture in the local and overburden.

The impact on surface water is based on the numerical model for the Ravensworth Operations. The proponent has determined that simulation of the Narama mining area demonstrates that impacts to baseflow from these operations are predicted to be negligible. There is insufficient information provided to determine what is defined as a negligible impact on baseflow.

The proponent has used a steady state 2D SEEP/W to assess the impacts of the proposed modification. It is not identified why this approach was taken rather than using the existing numerical model developed for the Ravensworth Operations. It can only be assumed that there were limitations and the steady state 2D SEEP/W model would provide the most accurate prediction of the impacts of the modification.

The long term impacts of the groundwater level drawdown in the Narama West mining area is determined by the proponent to be overshadowed by the depressurisation from existing approved mining activities at the Ravensworth Operations and that there would be no cumulative impact to groundwater associated with the modification.

The proponent has not classified the steady state 2D SEEP/W model to the Australian groundwater modelling guidelines. It is considered that this is a class 1 model.

Groundwater Monitoring

The proponent has identified that that existing Water Management Plan for the Ravensworth Operations includes groundwater monitoring, which includes existing monitoring in the vicinity of the Narama West mining area is adequate to monitor the impact of the modification.

It is considered that this is justified due to the proposed modification being overshadowed in the long term by the existing approved mining activities.

Licensing and Water Sharing Plans

The proponent has identified that Part 5 *Water Act 1912* licence (20BL170749) entitlement of 150 ML/year is held for the Narama mining area. The current estimated inflow to the mined void is less than 0.5 ML/day.

There is insufficient information to determine if the current entitlement is sufficient to account for the current inflows into the mined void. An entitlement of 150 ML/yr is equivalent to an inflow of 0.41 ML/day. The proposed modification will cause additional inflows in the Narama mining area of 7.2 ML/year.

The proponent has identified that the groundwater inflows into the proposed Narama West mining area will have a negligible impact on the alluvial water source in the area. Any losses from the alluvium will be consistent with those predicted for the existing approved operations. They have determined that no additional licensing for groundwater interception under the *Water Management Act 2000* and relevant water sharing plan is required.

Aquifer Impact Assessment

A summary of the consistency of the proposed modification to the Aquifer Interference Policy minimal impact considerations is shown in Table 1.

Table 1: Level 1 Aquifer Interference Policy minimal impact considerations

Aquifer	Category	Level 1 Minimal Impact Consideration	Assessment
Porous/ Fractured Rock	Less Productive	Less than or equal to 10% cumulative variation in the water table, allowing for typical climatic "post-water sharing plan" variations, 40m from any: (a) high priority groundwater dependent ecosystem; or (b) high priority culturally significant site; listed in the schedule of the relevant water sharing plan. A maximum of a 2m decline cumulatively at any water supply work.	There is no predicted cumulative impact associated with the proposed modification. The area of the modification is overshadowed by existing approved mining groundwater level drawdowns.
		Any change in the groundwater quality should not lower the beneficial use category of the groundwater source beyond 40m from the activity.	There is no comment by the proponent on groundwater quality.
Alluvium – Hunter River alluvium	Highly productive	Less than or equal to a 10% cumulative variation in the water table, allowing for typical climatic "post-water sharing plan"(2) variations, 40m from any: (a) high priority groundwater dependent ecosystem; or (b) high priority culturally significant site; listed in the schedule of the relevant water sharing plan; or A maximum of a 2m decline cumulatively at any water supply work.	There is no predicted cumulative impact associated with the proposed modification. The area of the modification is overshadowed by existing approved mining groundwater level drawdowns

		(a) Any change in the groundwater quality should not lower the beneficial use category of the groundwater source beyond 40m from the activity; and (b) No increase of more than 1% per activity in long-term average salinity in a highly connected surface water source at the nearest point to the activity. Redesign of a highly connected(3) surface water source that is defined as a "reliable water supply"(4) is not an appropriate mitigation measure to meet considerations 1.(a) and 1.(b) above.	There is no comment by the proponent on groundwater quality.

Surface Water Management:

The main surface water bodies in the vicinity of the proposed modification are Bowmans Creek to the east, Bayswater Creek on the western margin and the Hunter River to the south. The EA outlines there will be little difference in total catchment area captured by storages on the site for the modification in comparison with that captured by the approved existing operation.

Recommended Conditions of Approval

The Office of Water suggests the following to be included as conditions of any project approval for the application.

1. The applicant must ensure that it has sufficient water licences to account for the change in mining operations as a result of the modification.

2. The applicant must ensure it has sufficient licensed entitlement in each water source from which water is extracted or intercepted, to account for the take of water under all circumstances for the life of the project, and for any post-mining interception of water.

3. The applicant must hold a water access licence for any surface water runoff that is harvested, diverted or captured in excess of the site's Harvestable Right for each relevant surface water source.

4. The proponent must maintain records of water taken from all water sources and provide to the Office of Water when requested. Records of water taken must be include in an annual environmental monitoring report.

5. The current Water Management Plan must be updated for the project in consultation with the Office of Water, to reflect any changes as a result of the modification.

End Attachment A

Appendix B

Ravensworth North – Grinding Grooves (REA 86)
Review of OEH Recommended References

TERROCK
CONSULTING ENGINEERS

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Alan B. Richards
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Adrian J. Moore
Dip.C.E.,B.E.(Min.), M.Eng.Sc., M.I.E.Aust.

RAVENSWORTH NORTH – GRINDING GROOVES (REA 86)

REVIEW OF SOME OEH RECOMMENDED REFERENCES

Dowding, C.H, Blast Vibration Monitoring and Control (1984)
Construction Vibrations; Prentice-Hall (1996)

These are general well regarded textbooks with no specific reference to material deterioration of sandstone. Gives examples of fatigue failure and repetitive loading of plasterboard cited in Terrock's response to demonstrate that if a ductile material is loaded to 50% of the failure strain then the number of loading cycles increases to 10^5. Sandstone is considered to be a ductile material with a similar cycle load expected at loadings well below the failure strain. This hypothesis was reinforced by Haimson, B.C. for Berea Sandstone.

Bollinger, G.A. Blast Vibration Analysis (1980)

This is a good basic primer on blast vibration analysis, however it is outdated having been first published in 1971. There is nothing about the deterioration of sandstone in its contents.

Haimson, B.C. "Effects of Cyclic Loading on Rock", Dynamic Geotechnical Testing, ASTM STP 654, pp. 228 – 245, 1978

Extremely useful reference for describing and quantifying the hysteresis effect on the cyclical loading of sandstone and granite in uniaxial tension. Is used to demonstrate that the PPV_g limits proposed combined with the incremental/observational approach will produce strains well below those at which hysteresis occurs.

> "*All four rock types exhibited clear fatigue characteristics in uniaxial tension. The S-N curves for all rocks were linear and were represented approximately by the equations S = 100 – 7 logN. They all showed a fatigue strength of approximately 65 percent of the monotonic strength at 10^5 cycles [9, 12]"* (p. 237)

Tutuncu, A.N. **An Experimental Investigation on the Role of Pore Fluids on the Non-Linear Hysteretic Behavior of Beretic Sandstone; unknown date University of Texas – Article**

Non-linear viscoelastic behaviour of sedimentary rocks, Parts 1 & 2 Hysteresis effects and influence of type of fluid on elastic moduli

A Discussion on Possible Mechanisms of Nonlinear Hysteretic Behavior in Sedimentary Granular Rocks : Grain Contact Adhesion vs Stick Slip Sliding; Unknown Date University of Texas

A series of descriptions of investigations into the dynamic properties of Berea sandstone in both dry and brine saturated states. Demonstrated that the dynamic Young's Modulus and Poisson's ratios vary with frequency of the loading and a variety of sandstones exhibit frequency dependant elastic behaviour over a range of frequencies from 10 to 10,000,000 hz.

However, in the frequency range expected at the Grinding Grooves (10 – 20 hz) there is little change in Young's Modulus.

Similar effects were observed for P wave and Shear wave velocities of 2750 and 2450 m/s respectively for the frequency range 10 – 15 hz. The range of compressional axial stresses applied to show the hysteresis effects was from 1 Mpa to 28 Mpa compared to a maximum proposed of 0.8 mPa for 120 mm/s at the Grinding Groove site.

From these papers it can be reasonably concluded that the dynamic tensile loadings applied to the Grinding Groove sandstone (0.4 – 0.8 Mpa) are well below loadings at which hysteresis and time dependant stress/strain ratios are significant, whether sandstone is dry or saturated.

Badge, M.N. et al, The Effect of Machine Behaviour and Mechanical Properties of Intact Sandstone Under Static and Dynamic Uniaxial Cyclic Loading; February 2005, Volume 38, Issue 1, pp 59-67

Not considered relevant as it deals with the behaviour "of a sandstone subject to rock burst in the roof of a Czech underground coal mine".

Burdine, N.T. **Rock Failure Under Dynamic Loading Conditions; SPE Journal Volume Volume 3, Number 1 Pages 1 – 8, March 1963**

Not considered relevant as it deals with improvements in the design of rock drills.

Heming, X.U. et al **Hysteresis and two-dimensional nonlinear wave propagation in Berea Sandstone; Journal of Geophysical Research: Solid Earth (1978-2012) V105, Iss B3, Pp6163-6175, 10 March 2000**

Describes laboratory testing of Berea Sandstone in the strain regime 10 to 1000 με. Considered to replicate the work of Haimson B.C. and Tutuncu et al at higher strain levels which are not particularly relevant.

Gusella, V. **Safety Estimation Method for Structures with Cumulative Damage.; J. Eng. Mech., 124(11), 1200–1209**

Not considered relevant as it deals with the response of masonry buildings to cyclical loadings and cumulative damage.

Fan, X. Jian, W. **Experimental research on fatigue characteristics of sandstone using ultrasonic wave velocity method; College of Environment and Resources, Fuzhou University, Fuzhou, Fujian 350108, China**

Compares the behaviour of long term dynamic loading of rock and concrete from ultrasonic wave velocity. Paper was not accessible from a Chinese website.

Xia, X. et.al. **A case study on rock damage prediction and control method for underground tunnels subjected to adjacent excavation blasting, Tunnelling and Underground Space Technology**
Volume 35, April 2013, Pages 1–7

Not relevant. Paper is about rock damage from tunnelling.

Zhang, P. et.al. **Fatigue properties analysis of cracked rock based on fracture evolution process, Journal of Central South University of Technology, Volume 15, Issue 1, pp 95-99, February 2008.**

Not relevant. Reports on loading a laboratory specimen at 81.6% of the uniaxial compressive strength at 1 hz frequency which is well above the loadings at the Grinding Grooves site.

Adrian J. Moore
4th June 2013

Appendix C

Ravensworth North – Grinding Grooves (REA 86)
Outline of the Science

TERROCK
CONSULTING ENGINEERS

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Adrian J. Moore
Dip.C.E.,B.E.(Min.), M.Eng.Sc., M.I.E.Aust.

RAVENSWORTH NORTH – GRINDING GROOVES (REA 86)

Outline of the science

1. Introduction

An outline of the available scientific literature is hereby presented to ascertain the possible cumulative effects of the ground vibration from repeated Mine blasting on the Grinding Groove sites (REA 86). A methodology is proposed to quantify the science behind increasing the target vibration limit of 30 mm/s in incremental steps to 60 mm/s and then to 120 mm/s with a possible increase to an ultimate limit of 175 mm/s. An intermediate target of 100 mm/s could be evaluated before progressing to 125 mm/s. Before progressing to a higher limit, the effect on the rock ledges must be shown to be non-damaging by observation, PPV_g and strain measurements, and reference to baseline terrestrial photogrammetry.

2. Relationship between PPV (ground), charge mass and Distance

Site Law $$PPV_g = Kv\left(\frac{\sqrt{m}}{D}\right)^{1.6}$$

PPV_g is a function of

- Charge mass (energy source)
- Distance*
- Energy transferred to the ground*
- Vibration transmission characteristics of the ground*
- Depth of soil, degree and depth of weathering at receiver and along the transmission path*
- Initiation sequence
- Direction of firing
- Drilling pattern.

**fixed*

PPV_g increases with charge mass and reduces with distances. Vibration measurement permits a Site Law to be established between the blast and the target Site which becomes the basis of controlling vibration to target limits. This enables accurate prediction and control of PPV_g to target levels if as many of the variable contributing factors as possible are kept constant. A similar initiation sequence (to prevent wavefront reinforcement) and a constant direction of firing are most important.

The relationship between PPV_g and distance is shown in **Figure 1** on log-log array so it is represented as straight lines. The current approved limit is 30 mm/s with a proposal to incrementally increase the target limit to 120 mm/s (with a possible ultimate target of 175 mm/s). 175 mm/s is the target limit indicated to result in stress of about 35% of the ultimate tensile failure strain. The target limits apply at the Grinding Grooves irrespective of distance, with the blast design based on the Site Law to limit ground vibration. The vibration levels decrease with distance as shown in **Figure 1.**

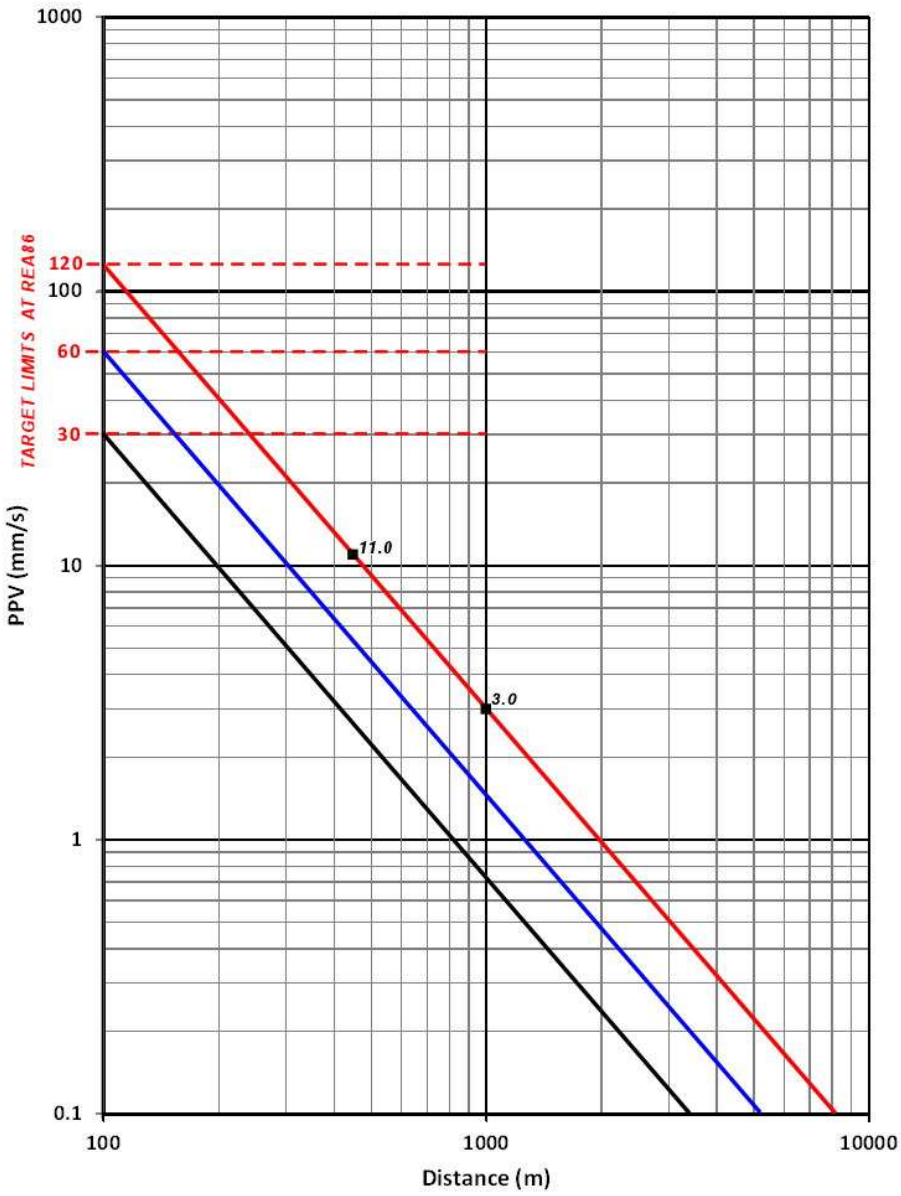

Figure 1 – PPV_g vs Distance for various target vibration limits and a 1.6 exponent

Two points can be made with reference to **Figure 1**. Firstly, in order to comply with a target limit, the scale of blasting may have to be reduced by means of smaller diameter blast holes, decked explosive charges and smaller blasts. At some distance from REA 86, standard blasting practice will comply with the target level and beyond this standard blasting practice will result in ever decreasing vibration levels.

Secondly, the outcome of this is that there will only be a limited number of blasts resulting in target limits (in the order of tens), with a larger number of blasts (perhaps hundreds) resulting in ever decreasing vibration levels. This is further compounded by the multi coal seams involved, with parting blasts below the first coal seam resulting in lower vibration levels at closer distances because of a more complex across strata transmission path.

In summary, there will be a limited number of blasts resulting in vibration at the target limit at REA 86 compared to a large number of blasts at lower vibration levels because of the increased separation distance.

3. Relationship between PPVg and Structure Response

Structure Response Amplification of PPV_g is a function of:

- Frequency spectra in the ground motion (forcing frequency)
- Natural frequency of the structure (possibility of resonance)
- Exposure time or number of cycles at the peak PPV_g.

Investigations have shown that the Amplification is highest at low PPV_g's (e.g. 1 mm/s) and reduces below 1 at high PPV_g's (e.g. 200 mm/s). For structures on or in the ground such as the grinding groove rocks, there is no amplification.

4. Relationship between PPVg and Ground Strain

Plane Wave Strain Theory is used to prove that

$$\text{Ground Strain} = \frac{PPV_g}{\text{Seismic Velocity}}.$$

Investigations including ground strain measurements at the grinding groove site have shown the Shear Wave Velocity (1200 m/s) gives the best relationship between measured strain and predicted strain using Plane Wave Strain Theory.

The shear wave velocity can be determined from comparing the wave arrivals on the wavetraces and using the Speed of Sound in air (340 m/s) as a calibrator.

5. Working Strains / Allowable Strains / Failure Strains – First Principles

From Hookes Law

Modulus of Elasticity (Young's Modulus) E

$$E = \frac{\text{Stress}}{\text{Strain}}$$

$$\therefore \text{ Strain} = \frac{\text{Stress}}{E}$$

For ductile materials such as concrete and steel, Codes and Standards are usually consulted to provide guidance on the Strength of Materials in the form of safe working stresses, which are the failure stresses with an acceptable Factor of Safety applied.

However, in the case of the natural rock structures such as the grinding groove site, a more back to basics approach is considered. Rock, as a structural unit is stronger in compression than tension and is most likely to fail under tensile loading. The flexing of the ground surface as the ground vibration waves pass produces tensile forces (as well as compressional forces). The AusIMM Field Geologists Manual lists a range of flexural tensile strains for sandstone to be 140 με to 1000 με, so there is considerable variation of sandstone properties. The strength of the sandstone in question is unknown but can be determined by laboratory testing of collected specimens. Providing the tensile strains of the sandstone are not exceeded by the flexure, no new cracks can form.

- Typical example of Strain Comparisons is as follows:

  PPV = 100 mm/s PPV = 175 mm/s

  Ground Strain = $\frac{100}{1200 \text{ x } 10^3}$ = 83.3 με = $\frac{175}{1200 \text{ x } 10^3}$ = 145 με

  Compared to Flexural Tensile Strain = 140 $\rightarrow$ > 1000 με

  This indicates that the weakest sandstone has a significant factor of safety at 100 mm/s with an ultimate target limit of 175 mm/s possibly exceeding the strength of the weakest sandstone. If the rock strength permits a considerable Factor of Safety may exist. Testing of the REA 86 sandstone is necessary to justify a possible upper limit.

- This approach is reinforced by on-site measurement of an overhang failure by the author at the Mangoola Mine in the Hunter Valley. The dimensions of the failed overhang were measured and analysed as a cantilever beam failure. The flexural tension of the upper surface of the failed overhang was determined to be about 2 MPa. Using a Minimum Elasticity Modulus of 10 Gpa, the failure strain indicated is about 200 με, which provides order of magnitude confirmation of the previous assumption;

- The science to date suggests that a PPV of 100 mm/s would not exceed the tensile flexural strength of typical sandstone and has a considerable safety factor for the weakest sandstone. New cracks would therefore not develop in the sandstone. From investigations at other sites, the articulations provided by vertical and other joints allows for considerable flexure of the rock mass to be absorbed by the articulations before new cracks are likely to form. This approach is also considered to be conservative;

- Also, the entire articulated rock mass flexes as an integral unit as the waves pass with no discordant motion likely to concentrate stress and cause damage or loose blocks to fall. This may be evidenced from video recording of open cut high wall blasts. Any damage to the rock face only occurs locally just beyond the extremities of the blast pattern.

6. Hysteresis and other Effects of Cyclical Loading of Rock

The significance of hysteresis on the possible long term degradation of sandstone due to long term vibration exposure, creep or fatigue failure is demonstrated in the writings of Haimson, B.C. (1978). The stress – strain curve for Berea Sandstone in uniaxial tension is shown in **Figure 2**. If the sandstone is loaded to a stress of 2250 kPa (2.25 Mpa), the corresponding strain is 1400 με. If the loading is removed, the residual strain is 800 με. The next loading cycle of 2250 kPa produces a strain of 1,540 με which returns to 1000 με. Each loading cycle results in a reducing rate of increase of residual strain, with ultimate failure of the sample after 11 cycles. The loading of 2250 kPa was to 95% of the failure stress of the sandstone tested (see **Figure 3**).

The failure stress of 2.25 mPa in this example is of similar magnitude to the 2 Mpa indicated at the Mangoola overhang collapse. The comparisons are therefore deemed to be valid.

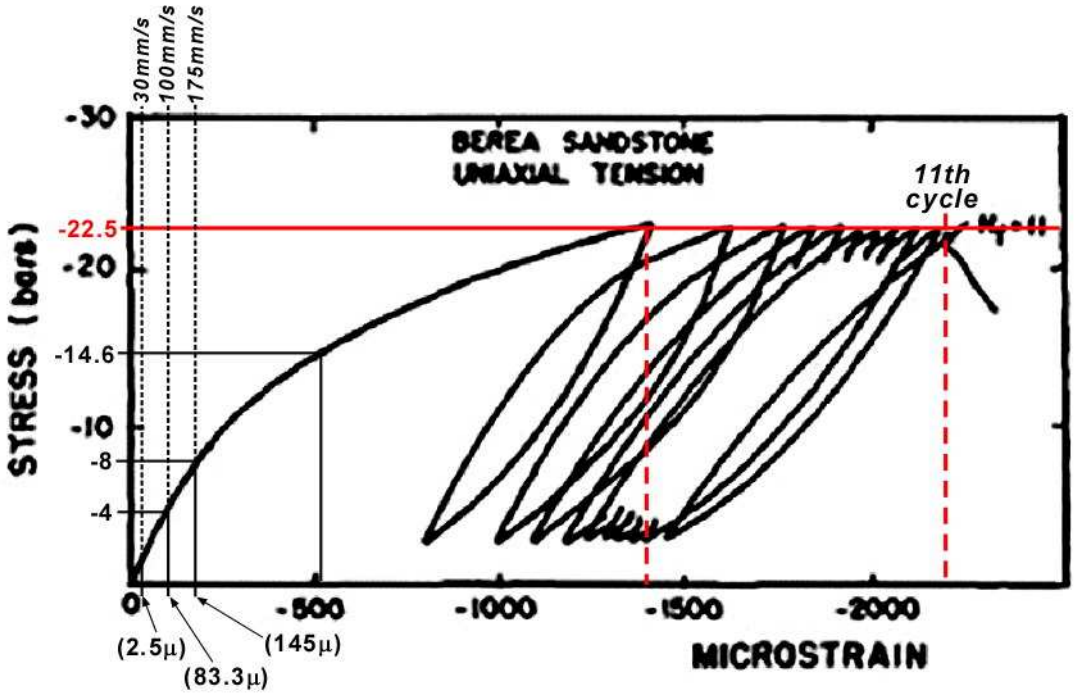

Figure 2 – Typical Stress-Strain Curve in Uniaxial Tension (Berea Sandstone) (after Haimson)

With reference to **Figure 2**, the comparable loading with the grinding groove vibration loading is described as follows:

The peak ground strain from 100 mm/s is 83.3 με and from 175 mm/s is 145 με. This represents tensile stresses of 400 and 800 kPa respectively or 17% and 34% of the maximum loadings of 2250 kPa. The maximum loadings from the maximum PPVs proposed are less than the ultimate tensile failure stresses of the sandstone by a considerable margin. The effects of hysteresis are shown to occur when the stress reaches 2250 kPa or the strain exceeds 1400 με in the first loading cycle. Therefore it can be reasonably concluded that the effects of hysteresis is of concern if the sandstone is loaded close to its ultimate failure strengths or greater than 1450 με. This supports the findings of the first principles approach and shows its inherent conservatism with the assumption of a Flexural Tensile Strain in the range 140 – 1000 με.

With the low range of strains resulting from the incremental increase in ground vibration proposed, hysteresis, using the Berea Sandstone example, is seen as not being a significant issue for the REA 86 Sandstone.

The papers by Tutuncu et al reinforce the findings of Haimson. The dynamic Young's Modulus and Poissons ratio do vary with the frequency of the loading as do the P and S wave velocities, and whether the test sample is dry or saturated with brine or a chemical solution (hexadecane). However, the range of the loading frequencies in the paper is from 10 to 10,000,000 hz and the applied compressional axial stresses from 1 Mpa to 28 Mpa are well outside the range predicted to apply at the Grinding Groove Site. At the Grinding Groove site, the frequency is predicted to range from 10 – 15 hz and axial stress to 0.8 Mpa at 170 mm/s. The expected loadings are well below the levels at which hysteresis, grain contact adhesion and stick slip sliding have been shown to occur by the testing outlined in these papers.

7. Cumulative Effects of Blasting

The problem of the cumulative effects of a long term loading leading to fatigue failure is addressed as a strength of materials issue in many codes and standards, e.g. AS 4100 – 1998 for steel structures.

An example was given in the Terrock 19th February 2013 report for plasterboard, which was the best example found for the continued effects of blasting, from the blasting references.

The constant theme of the fatigue failure determinations is that the lower the cumulative loading in terms of the ultimate failure load, the more loading cycles can occur before fatigue failure ultimately occurs. This is reflected in the writings of Haimson and Tutuncu et al, which come from a geophysical research approach.

Haimson states, "*All four rock types*" (including Berea Sandstone) "*exhibited clear fatigue characteristics in uniaxial tension. The S – N curves for all rocks were linear and were represented approximately by the equation S = 100 – 7logN. They all showed fatigue strength of approximately 65% of the monotonic strength of 10^5 cycles".* The S – N curve for the Westerly granite (typical of the 4 rocks considered including Berea Sandstone) is shown in **Figure 3**. In Figure 2, at the maximum stress of 95% of the failure stress, failure occurred after 11 cycles. This is clearly shown in **Figure 3.**

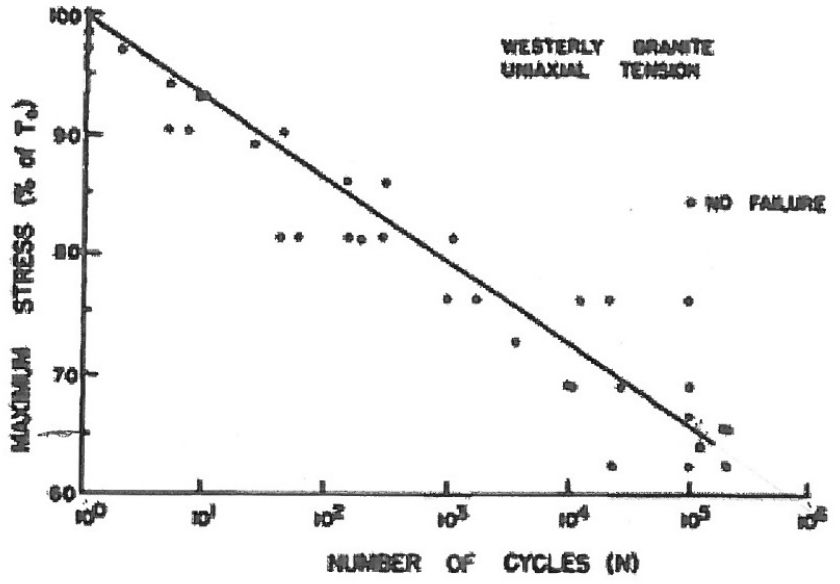

FIG. 10—*Experiment results and S-N curve for Westerly granite under cyclic uniaxial tension.*

Figure 3 – (Figure 10 from Haimson) – Experiment results and S-N curve for Westerly Granite under Cyclic Uniaxial Tension

Figure 3 shows the experimental results with maximum stress plotted against the number of loading cycles for Westerly granite. This further supports the hypothesis presented in "Cumulative Effects of Blasting Near REA 86" (19 Feb 2013) for "plasterboard" with similar results. With the maximum stress loading at 65% of the failure stress, the number of cycles before failure approaches 10^5. The maximum loading at 100 mm/s is about 17% of the failure strain of Berea sandstone. The Berea sandstone and Westerly granite have similar tensile strength properties, and the number of cycles before failure increases exponentially to an extremely large figure (many millions). If the number of cycles at the target limit of 100 mm/s for each blast is 20 (see **Figure 5**), the number of blasts is still a large number. It must also be considered that the pit configuration is such that vibration of the target limit will only occur from a relatively small number of blasts. As the extraction area moves away from the grinding grooves, vibration at reducing levels will result from an increasing number of blasts.

The references confirm the science that demonstrates that the ultimate target limit of 175 mm/s will also be conservative and have a considerable Factor of Safety regarding development of hysteresis and fatigue failure. However, this 'science' needs to be established by the monitoring program proposed.

Rock is variable elastic material that behaves in a similar manner to other elastic materials and the same principles apply. In the case of the grinding grooves, the failure strength of the rock is unknown, but can be determined by testing. A vibration limit can be sufficiently below the failure strength that fatigue will not be an issue because of the limited number of vibration cycles from a dynamic blasting situation. The stress associated with 65% of 2.25 Mpa, i.e. 1.46 Mpa corresponds to a strain of 500 με which is predicted to result from a PPV_g of 600 mm/s. There is no proposal to consider a target limit beyond 175 mm/s.

Fatigue failure or reduction of rock strength by continuous exposure to vibration is not seen to be an issue at the vibration levels proposed.

8. Ground Flexure

The actual flexure of the surface of the rock ledge can be predicted by Sine Wave theory.

For 175 mm/s at 15 Hz frequency, the surface displacement is

$$\frac{\text{PPV}}{2 \cdot \pi \cdot \text{f}} = \frac{175}{2 \cdot \pi \cdot 15} = 1.85\text{mm}.$$

The wave length is $\frac{\text{Shear Wave Velocity}(V_s)}{\text{Frequency}(f)} = \frac{1200}{15} = 80\text{m}.$

Fifteen Hz was chosen as being representative of close distance frequencies with a basis when 65 ms delays are used in the initiation sequence. The prime frequency generated by 65 ms delays is 15.4 Hz, but is subject to directional variation due to a 'Doppler' effect, i.e. frequency changes if the source moves.

The shape of the surface flexure is shown in **Figure 4**:

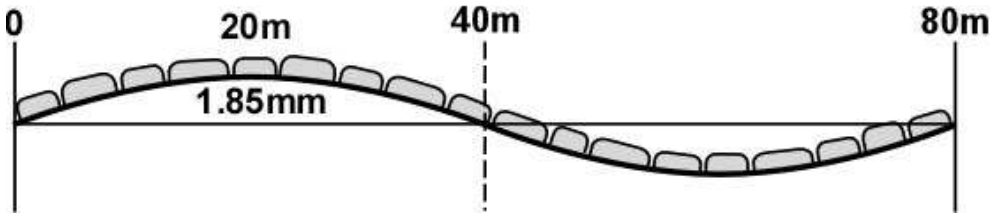

Figure 4 – Dimensions of the Surface Flexure at 175 mm/s (schematic, not to scale).

Flexure is absorbed by the joint articulations

The jointing planes of the rock ledge are spaced much less than 20m apart. The flexure can therefore be accommodated by movement on the articulations provided by the joints. It is most likely that no individual rock block will be subjected to the full surface flexure and flexural tensile failure will not develop in an individual block. This adds further conservatism to the conclusions of the methodology adopted.

The surface of the rock is not a continuous rock layer, but is articulated into discrete blocks by jointing planes. The observations by Terrock at a Wilpinjong rock shelter were that the separate rock blocks move synchronously in an integral wave. There are no discordant blocks moving counter to the main motion, thereby increasing strain and the potential for damage.

Strain analysis has shown that new cracks will not be formed in the rock ledge because the tensile strength of the rock will not be exceeded by the flexure. The discrete blocks of the surface of the rock ledge will flex as an integral unit within the constraints of the surface wave motion.

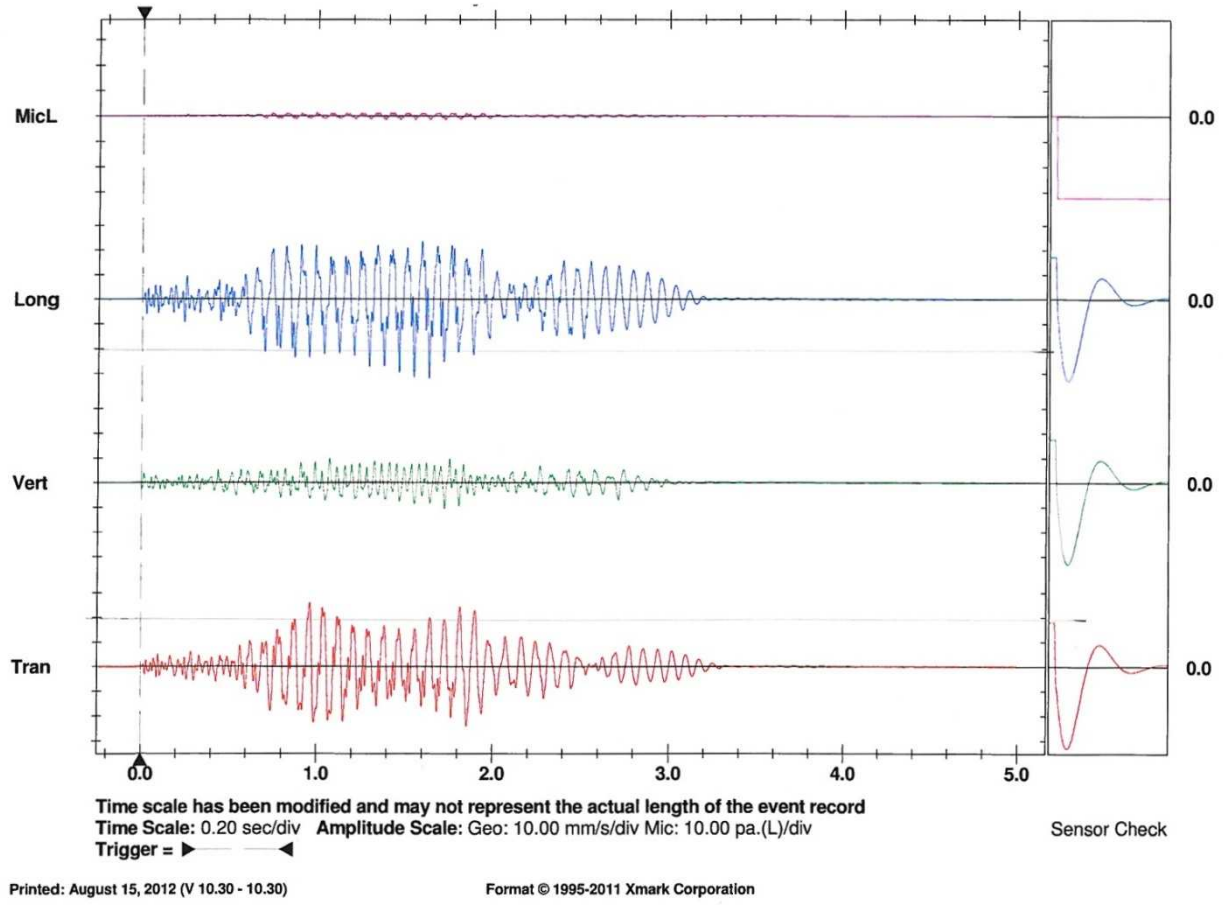

Figure 5 – typical blast wavetrace with 15 peaks at or near the maximum

9. Conclusions

Investigations into the concerns raised in the OEH letter of 23rd April 2013 (Doc 13.4.14037; FIL 13/4/124) and review of the list of references provided has not altered the conclusions of the Terrock Report "Cumulative Effects of Blasting Near REA 86" (19th February 2013), namely:

"Upon consideration of the science of the elastic behaviour of materials, in my opinion, it may be reasonably concluded that vibration from repetitive blasting will have no cumulative effect on the rocks of the grinding grooves".

The 'science' of structure response to vibration, the strains induced, and the elastic behaviour of materials is mainstream, but requires further quantification for specific rock structures.

Appropriate Site Law will be readily established by the continuing analysis of routine PPV_g measurements on the grinding groove site, especially as PPV_g levels increase, to design blasts to achieve any PPV_g target level.

To establish the relationship between PPV_g and induced strain will require direct strain measurements to be taken to confirm or quantify the science at each step of the increments proposed. The strain gauges will indicate if residual strain remains after a blast, as a possible indication of hysteresis. The width of existing cracks can be monitored across permanent targets to record any changes that may be blast related or have other causes (with the approval of the stakeholders). The strain gauges can also be used as dynamic crack width monitors.

The first principles approach, reinforced by the literature search, has indicated that vibration within the range of PPV_g's proposed will not damage the rock ledges of REA 86 and with a considerable safety margin. Weakening of the sandstone by hysteresis processes by long term exposure does not appear to be significant because the target levels of vibration are too low compared to the failure stresses of sandstone. The possibility of long term fatigue failure is low for the same reasons.

The available science shows that, with the assumptions and comparisons made, blasting vibration will not cause further cracking of the sandstone ledges at REA 86. This must be proven by a specific site investigation. What is required is the incremental/observational approach proposed to increase the target PPV_g from the currently approved 30 mm/s to 60 mm/s to 120 mm/s (with another possible step at 100 mm/s and a possible ultimate target of 175 mm/s). The observations and strain measurements must clearly establish that the interim target limits are as predicted by the science and not causing damage before the target limit is increased to the next level. The number of measurements and observations required at each level will be determined by the consistency of the results.

Adrian J. Moore
4th June 2013

References

Haimson, B.C., “Effect of Cyclic Loading on Rock”, *Dynamic Geotechnical Testing*, ASTM STP 654, American Society for Testing and Materials, 1978, pp. 228 – 245.

Tutuncu, A.N., Sharma, M.M., and Podio, A.L.,”A Discussion on Possible Mechanisms of Nonlinear Hysteretic Behavior in Sedimentary Granular Rock**:** Grain Contact Adhesion vs Stick Slip Sliding**”**, 1995, University of Texas

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Appendix D

Office of Environment and Heritage Correspondence
Review of REA 86 Blast Vibration Criteria

NSW GOVERNMENT | Office of Environment & Heritage

Your reference: REA86 Vibration Limits
Our reference: DOC13/27661; FIL13/4124
Contact: Roger Mehr, 6773 7005

Mr Andrew Kelly
Ravensworth Complex
PO Box 294
MUSWELLBROOK NSW 2333

Dear Mr Kelly

On 23 April 2013, the Office of Environment and Heritage (OEH) provided advice to the Department of Planning and Infrastructure regarding a proposed modification to the existing Narama West Open Cut Operation (PA 09_0176 MOD1). The advice provided by OEH requested further information regarding the proposal to incrementally increase the approved vibration limits. I am writing in response to further information supplied to OEH on 4 June 2013 regarding the possible cumulative effects of raised vibration limits on grinding grooves located at Aboriginal Site REA 86 (AHIMS# 37-3-0982).

On 21 February and 4 June 2013, OEH received further information to inform the decision making process regarding this request. OEH has reviewed the information provided and considers that adequate justification has been provided to show that the likelihood of damage to the sandstone in which the grinding groves occur is low to nil. OEH notes that the increased vibration levels proposed at REA 86 will occur incrementally with assessment of any impacts occurring at each increment. OEH understands that the next level of increase will only occur once such an assessment has confirmed that no damage has resulted from the vibration levels already achieved. OEH also understands that the final maximum vibration level has been demonstrated as falling significantly below the levels expected to cause physical damage to the sandstone matrix or grinding grooves.

Based on the above understanding, OEH agrees to the requested modification to authorised vibration limits to the sandstone outcrop located at REA 86. If you have any further enquiries regarding this issue please contact Roger Mehr, Archaeologist, on 6773 7005.

Yours sincerely

17 JUN 2013

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