APPENDIX

F

PROGRESS REPORT TO THE WASTE MANAGEMENT TASK FORCE 2006

Progress Report to the Waste Management Task Force:

BHP-Billiton (Illawarra Coal) Coal Wash Management.

DECEMBER 2006

Executive Summary.

In line with Illawarra Coal's commitment to sustainable development, 2006, saw Illawarra Coal (IC) re-intensify it's efforts in the area of Coal Wash management. A new strategy was implemented, building on the good work to date and already delivering promising outcomes and strong progress in many areas. Of note are the following key points:

- The review and investigation of Westcliff Stage 2 Coal Wash Emplacement area capacity expansion was completed, proposing another 5.8 million tonnes capacity be added to the current design. This amounts to a 39% capacity increase above the existing design capacity of 15Mt for the Stage 2 emplacement. This capacity expansion can only be safely realised once access to the proposed Stage 3 emplacement area is granted.

- Completion of a full project proposal for Phase 2 of the Overburden Grout Injection Project (OBGI), including system design and site investigation.

- Submission of an application for further funding for the OBGI Project to the Australian Coal Association Research Program (ACARP).

- Completion of an independent and comprehensive sampling, testing and analyses program delivering a highly detailed specification for Coal Wash. A fact sheet and indemnity / release forms package was also developed for potential users of Coal Wash (see Appendix E)

- Identification of new opportunities for CoalWash usage including small to medium civil/residential development uses with approx. 27,000 tonnes of product already delivered during 2006.

- Identification and initial engagement with current owners/operators of quarries and degraded excavation sites to facilitate beneficial rehabilitation options for future employment generating land opportunities.

- Continued the work with an strategic alliance partner for a possible Coal Wash fired power plant at West Cliff Colliery.

- Investigations into Coal Wash usage in aggregates (see Appendix G) and soil mixes. Approx.2500 tonnes of Coal Wash was used by South Coast Equipment P/L in soil mixes at Bluescope Steel's site.

- Commenced site investigations and studies required to seek approval for the Stage 3 Westcliff Coal Wash Emplacement Area. A Project Team has been formed with a view to submitting an Application to the Minister for Planning for further consent under the conditions of the Development Consent for Dendrobium Mine.

- Worked with Department of Environment and Conservation, Wollongong City Council and Department of Planning to develop a regulatory framework for

Coal Wash to facilitate its beneficial use as fill. This included; development of a draft fill specification for approval under the proposed Protection of the Environment Operations (Waste) Regulation, updating Wollongong City Councils Policy for use of Coal Wash in residential developments, and consideration of Coal Wash by Department of Planning in the Metropolitan Construction Materials Strategy. (see Appendix H)

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Background

The Dendrobium Mine Conditions of Consent requires that BHP Billiton (Illawarra Coal) submit an annual report on progress to the initial report into Coal Wash Emplacement Alternatives. The relevant extract from the Commission of Inquiry (COI) is shown in Appendix A.

These reports were required to be submitted to the then Department of Urban Affairs and Planning; then the Department of Infrastructure, Planning and Natural Resources (DIPNR) and now the Department of Primary Industries and to other Government bodies, as well as the then BHP Waste Management Task Force.

Several changes have occurred since the COI requirements were made that impact on these requirements:

- BHP Billiton and Blue Scope Steel were formed from the demerger of BHP.
- The original intent and operation of the Task Force was impacted by these and other changes.
- DIPNR discontinued Task Force meetings in late September 2004 due to resource issues. The relevant email correspondence is shown in Appendix B.

Mining and Associated operations.

Some operational changes have occurred at Illawarra Coal since the 2005 Annual report. These changes have had some limited impact on Coal Wash.

- Following the completion in late 2005 of the Contract Mining Agreement with Delta Mining Pty Limited to produce coal at Elouera Colliery, (now renamed Delta Colliery), 1 Longwall (LW14, approx.500,000 tonnes of ROM coal) has been extracted without incident and the extraction of Longwall 17 is imminent. The Mine is scheduled to cease operations in April 2007.

- Wongawilli Emplacement Area, which ceased Coal Wash emplacement operations in May 2005, has been completely capped and vegetated successfully. A draft Post-Closure Plan with accompanying Post-Closure Monitoring Plan was submitted to regulatory agencies and the community for consideration. The abovementioned plans were finalised during 2006 and the Environment Protection Licence was varied to reflect the non-operational status of the emplacement and the post-closure monitoring requirements. Minor rehabilitation and post-closure action continue to be implemented at the site. The success of this rehabilitation has demonstrated the ability of a successfully rehabilitated Coal Wash emplacement area to be prepared for future beneficial use.

- All Coal Wash produced from Dendrobium Coal Preparation Plant (DCPP) and WestCliff Coal Preparation Plant (WCPP) since May 2005 not used for alternate purposes, has been emplaced at West Cliff Mine Emplacement Area No.2. The tonnages emplaced during the financial year 2005/06 were 646,072 tonnes from WestCliff Coal Prep Plant (WCPP) and 1,481,757 tonnes from the Dendrobium Coal Prep Plant (DCPP). The Coal Wash from DCPP was hauled to Westcliff Stage 2 Emplacement Area without incident, utilising trucks which are delivering product to BlueScope Steel and PKCT, by backloading these trucks with Coal Wash to minimise truck numbers on the haulage route.

- A site survey was undertaken of the West Cliff Area No 2 Coal Wash Emplacement Area in August 2006 to measure the remaining emplacement capacity. Approximately 8.4 million tonnes of emplacement capacity was remaining in West Cliff Area No 2 at that time under the present management plan. The initial planning work on the Stage 3 area has found that this survey only considered the total volume and did not consider the benched working system used to manage the emplacement area.

- In order to progress Coal Wash emplacement using the current proven system, there is only approximately 5.7 million tonnes capacity of operational life in Stage 2 before the emplacement area adjoins the dirty water treatment area. This fact has supported the commencement of work to lodge a Submission for Further Consent for Stage 3 Emplacement Area at West Cliff Colliery as stated in the EIS submitted for Dendrobium Mine and which will comply with the relevant conditions stated in the Commission of Inquiry findings.

Coal Wash Alternatives.

Illawarra Coal have committed to the following principles and actions for Coal Wash and will continue to include them in the 5 year Business Plan for Illawarra Coal currently being re-drafted.

- Coal Wash minimisation and sustainable usage are key business drivers.
- Pursue all options for the management of Coal Wash with equal vigour.
- Develop a Life of Resource strategy for Coal Wash.
- Reliance on only surface emplacement of Coal Wash is not sustainable.

Illawarra Coal have investigated alternate technologies during 2006 with relevant staff attending the AUSIMM Symposium in Sydney "Disposal of Mining Waste – An Increasingly Significant Activity" in March 2006 and NSW Minerals Council (2006) Environment and Community Conference to ensure that developments in relevant areas were not overlooked. Contact was also made with Professor Colin Ward, Professor of Geology at the University of NSW and also the CSIRO Centre for Sustainable Coal Research with a view to assessing if any emerging technologies could be further investigated. No additional areas of investigation were identified.

Investigations into alternatives to Coal Wash Emplacement have continued and have become focussed on the most promising key areas of the COI requirements and others discovered by Illawarra Coal. The other alternatives, although still being actively pursued and developed, are proving to be impractical as long term solutions at this

time, therefore IC's strategy to seek the more promising potential alternate uses as a priority.
We will report on the progress of these less promising alternatives to emplacement first.

Coal Wash for Brick Making.

This is still continuing, albeit in very small amounts (592 tonnes to Boral in 2006 to date). The restraints for increasing usage have not yet been overcome as follows:

- There is still significant competition from cheaper alternative materials.
- The high iron content of Coal Wash restricts its use to red or brown firing clay mix.
- From a sustainability perspective, Coal Wash supplemented energy and clay needs in brick manufacture, but increased greenhouse emissions by up to 30% (extracted from the 2001 report of L.Andrews of the University of Newcastle, 2003 CSIRO report commissioned by BHP Billiton).

Use of Coal Wash for Power Generation.

During the year, Illawarra Coal has continued to investigate the use of Coal Wash at existing NSW power stations by observing the results of tenders. Unfortunately, it is still found that the cost of using Illawarra Coal Wash is clearly uncompetitive when compared with locally available coal on a cost per energy unit basis. Again, the high cost of transport to these Power Stations is the main impediment. Also, most users are tied to long term supply agreements and are concerned over the low energy value and high ash content of Coal Wash.

Last year, Illawarra Coal formed a Strategic Alliance with another Company to investigate the use of Illawarra Coal's Coal Wash, at an on site Power Plant based at WestCliff Colliery. These new systems are complex and sophisticated but offer some hope that the process can be used to produce electricity from Coal Wash. This potential use for Coal Wash will rely on the use of mine return air as well as Coal Wash for fuel feedstock.

The other Company is investigating the economic and operational feasibility of this proposed project. Due to strict Commercial Confidentiality Agreements signed by both partners, we are unable to share the initial findings of this study. It is to be noted however, that it is very early in the process and that initial information gathering and collation/investigation is still occurring. It would be fair to say though, that the early results are not encouraging based on financial, environmental (greenhouse, air pollutant, water consumption) and waste management (fly ash) considerations.

This study encountered some difficulty as key staff left employment with the alliance partner, causing significant discontinuity in the study work. This has recently been rectified and work has recommenced to complete the PreFeasability Report.

Underground emplacement of Coal Wash – Goaf Filling.

This work is being incorporated into the Overburden Grout Injection Project and further study is being done on the findings and implications of this investigation with regard to goaf-filling using Coal Wash. Information on goaf filling was provided in the 2005 Task Force Report.

Some significant obstacles to goaf-filling were identified last year that require much more detailed investigation and consideration. Slurry pumping techniques and system design for both projects have many commonalities. Safety of our employees and mine workings is an overriding concern and Illawarra Coal have decided to proceed very cautiously before this technology can be trialled in a live mine environment.

Illawarra Coal are planning to build on the use of void filling techniques for subsidence mitigation to progress the underground emplacement of Coal Wash. Illawarra Coal have committed to trial underground emplacement following the subsidence mitigation trials, subject to safety and economic criteria being satisfied.

We will now report on those areas of Coal Wash alternate usage that have made progress and are showing promising potential.

Overburden Grout Injection – Subsidence Mitigation.

Surface subsidence caused by underground mining is a recognised major issue of community concern. Whilst remedial and mitigation measures have been successful, they are very costly and difficult in some situations. Illawarra Coal , through it's commitment to sustainable development, is actively working towards preventing subsidence through the work of projects like the Overburden Grout Injection project, which shows promising potential to deliver major benefits in this area and will utilise large amounts of fine Coal Wash in doing so.

Simply, a slurry mixture containing fine Coal Wash or fly ash is pumped under pressure into the voids created by underground mining to mitigate the subsidence effects on the surface, effectively "grouting" the void space. The ACARP funded Stage 1 Project completed in 2005, concentrated on the development of Overburden Grout Injection technology to control mining subsidence. This led to the Illawarra Coal / CSIRO jointly funded project to progress the use of this technology.

During 2006, the Illawarra Coal / CSIRO Stage 2 project to research Overburden Grout Injection was finalised. A full Project Proposal including a system design and site investigation were completed and submitted. This research is confidential and unfortunately cannot be shared in this report. A number of outstanding issues were identified in this report, requiring further study and investigation before a field trial of the technology can be undertaken.

These issues include:

- Provide more detailed information on the nature and extent of bed separation zones.
- Investigate the nature of the required barrier between the injected strata and the goaf in order to prevent migration of injected water and rejects into the workings or goaf area.
- Investigate near-surface stress changes associated with Longwall extraction and the mechanism for valley closure and upsidence.
- Determine the types of sensitive surface features that this technology could be effectively used to prevent.
- Undertake a cost-benefit analysis for the technology.
- Undertake additional work on reject material flowability, injectability and chemistry.

To continue this promising work, Illawarra Coal have lodged an application for further funding from ACARP (see Appendix C). The announcement of successful projects will be in mid December and if successful, it is envisaged that the studies would be scheduled to complete in December 2008. It should be noted that this project is high cost, is not without risk of failure and will take considerable time before a proven application can be demonstrated. Despite these concerns, Illawarra Coal is committed to continuing this work.

Road Pavement and Civil Construction Usage.

Coal Wash usage for road making and civil usage is still proving to be difficult due to the continuing heavy competition from alternative materials and Coal Wash's low performance characteristics for certain applications.

However, a strategy review in this area led Illawarra Coal to pursue civil usage from a new perspective. It is based on the strengths of Coal Wash as a product, being:

- Large, consistent and reliable volumes of inert fill.
- Available free of charge at loading point and a contribution towards the freight charge.
- Illawarra Coal's knowledge and expertise in Coal Wash Emplacement

Illawarra Coal instigated discussions with Boral Pty Ltd, a major quarrying company with sites in the Illawarra and southern and western Sydney to assess opportunities for Coal Wash usage in quarry and general site rehabilitation. These discussions led to an opportunity for Coal Wash to be used immediately in the rehabilitation of the Boral Brickworks site at Moorebank in Western Sydney. Investigations of this opportunity found that materials that were able used at this site were required to be Virgin Excavated Natural Material (VENM) as described in the Protection of the Environment Operations Act.

IC began work towards satisfying the regulatory requirements for the Moorebank site and discovered that VENM materials being emplaced at this site were paying between $3-6 per tonne to deposit VENM at the site. A further review of the available literature for beneficial use of VENM in the Sydney Metropolitan Region (see the Rocla EIS for their Kurnell development proposal - http://quarry.rocla.com.au/nsw/eis.html for recent evaluation of this market) demonstrated that Illawarra Coal would not be in a position to compete with VENM in the Sydney Region based on economic factors alone.

Further to the cost of disposal of VENM in the Sydney Metropolitan area, freight quotes obtained to transport Coal Wash from IC sites on the 85km one way trip to Moorebank rendered this option financially unachievable. It was quickly apparent that IC could not compete economically within the Sydney market and that VENM status must be obtained for Coal Wash if similar opportunities were to be pursued Advice sought from the DEC confirmed that Coal Wash must not be classified as VENM, and was therefore unable to be used at the Moorebank site.

An industry consultant, Don Reed & Associates, was engaged to identify any other landfill opportunities within economic transport cost reach of IC's operations. This has led to IC entering discussions with Boral and RIC (Rail Infrastructure Corporation) with a view to Coal Wash being used to rehabilitate quarry sites, particularly at the Bombo and Dunmore quarries. A full report from Don Reed & Associates is expected to be completed shortly detailing the volumes and timing of these opportunities. It is thought that this holds great promise for Coal Wash, though the timing of these opportunities is as yet uncertain, as is the interest of the current quarry owners/operators.

Following the receipt of the Don Reed and Associates report, IC will develop a targeted strategy for this market segment and prioritise and direct work to those sites that are approaching the rehabilitation stage.

Currently, discussions are being held with a local business that has a degraded, excavated site that requires rehabilitation and is within economic transport cost reach. An opportunity exists to emplace at least 1 million tonnes of Coal Wash in 2007 and the business concerned is in discussions with Wollongong City Council and the DEC to determine if this opportunity can be pursued. This company has requested that the matter remain confidential for the time being.

Continuing the strategy of targeting appropriate fill sites, IC has a program to identify and contact professional civil engineers engaged in the local area to identify small to medium sized fill opportunities in the local area. This initiative has already led to Coal Wash being supplied to the following sites in the Illawarra:

- Lysaghts Oval Figtree, soccer ground redevelopment by the Wollongong Sport and Recreation Trust emplacing approx. 2000 tonnes of Coal Wash to raise the height of the carpark area.
- Edenvell P/L's land development at O'Briens Road, Figtree which is currently taking approx.25,000 tonnes of Coal Wash as engineered fill.
- Discussions currently underway with Dandaloo Oval, Kanahooka developers to use Coal Wash as drainage and fill material.
- Discussion currently underway with the Light & Hope Clubhouse, Unanderra to use Coal Wash as fill material.

During 2006, small loads of Coal Wash have been taken by several domestic users eg. 61 tonnes in Port Kembla home sites, 123 tonnes at Berry (farm road), 62 tonnes by Dapto Sand & Soils (trial in fill and soil mixes). To progress these opportunities, IC are in discussions with a local transport and earthmoving company to act as a distributor for small amounts of Coal Wash. Once appointed, it is envisaged that a marketing campaign to promote Coal Wash will be conducted locally to raise the profile of Coal Wash for this purpose.

Fill up existing waste emplacement areas.

Earlier reports have mentioned the additional volume achieved in Stage 2 of West Cliff Emplacement Area in 2001/02. There have been no developments in sites not owned by BHPB. There continues to be no opportunity of acquiring these other emplacement areas. No new sites for large scale Coal Wash emplacement have been identified.

Despite the earlier success of extending the capacity of Stage 2 and in order to ensure that the Stage 2 Emplacement Area at WestCliff was maximised, IC instigated a site study with GHD Longmac and Olsen Environmental Consultants to determine the possibilities (see Appendix D1). A summary of the proposed Stage 1 and 2 West Cliff emplacement expansion options at April 2006 is provided in Table 1.

MODIFICATIONS TO PLANNED EMPLACEMENT FORMATION		ESTIMATED EMPLACEMENT CAPACITY
STAGE 1		
1	Planned emplacement capacity	1.9Mt
2	Stage capacity increased following revision of the formation height limitation.	2.7Mt
Total Stage 1		4.6Mt
STAGE 2		
1	Initial planned emplacement capacity	9.25Mt
2	Planned increase in capacity following revision of the formation height limitation & installation of BC 1 drain.	5.75Mt
3	Planned increase in capacity following revision of surface table drain opposite BC 1.	0.33Mt
4	Planned increase in capacity following revision of western perimeter drain arrangement.	1.7Mt
Total Stage 2		17.0Mt (Subject to final design of Stage 2.)

Table 1: Summary of Coal Wash emplacement capacity at West Cliff.

Following the April 2006 investigation and report, concern about the structural integrity of the emplacement internal drainage system was raised by GHD Longmac. In response to these concerns, a comprehensive analysis of both the emplacement material properties and simulation of the internal drainage infrastructure of the emplacement was carried out. This work is yet to be finalised and reported to Illawarra Coal, however the analyses indicate that up to 20.8Mt of Coal Wash emplacement capacity could be available in Stage 2. This represents a 225% increase in the original design capacity of the Stage 2 emplacement, and is only possible due to the exacting manner in which the emplacements has been designed, constructed and managed.

A draft discussion of the issues associated with the Stage 2 capacity increase and accompanying maps is provided in Appendix D2. As described in the discussion accompanying Figure 4 in Appendix D2, pragmatic and practical emplacement engineering considerations determine the capability of the maximum Stage 2 emplacement capacity to be realised. In short, the analysis shows that only an additional 5.7Mt of Coal Wash can be robustly and safely emplaced in Stage 2 until further benches need to be utilised in the proposed Stage 3 emplacement area. Similarly, issues arising from emplacing Coal Wash up to and/or over dirty water dam P4 highlight the necessity of developing additional dirty water treatment systems at the site.

Due to the linkage in planning this expansion and the design for Stage 3, work is currently underway to present a comprehensive and detailed Management Plan for the entire site. The Consent authority for Stage 2 is the Department of Primary Industries DPI) and submission of an application to extend the height and volume of Stage 2 is expected to be lodged with the DPI in due course.

The planning for the Stage 3 emplacement area is underway and a Key Performance Indicator for the project is that the maximum possible capacity for the area is achieved, whilst maintaining a safe and environmentally responsible site, and minimising disturbance to vegetation and other environmental/cultural heritage values that exist on site. The above studies have provided an enhanced level of engineering design input that will enable Illawarra Coal to maximise emplacement volume for any given footprint area.

Understanding and Improving Coal Wash quality.

During the revitalisation of IC's Coal Wash strategy, it became apparent that the data for Coal Wash was outdated and sporadic. In order to correct this, IC employed a local independent testing agency, CCI Australia, to conduct a detailed and comprehensive sampling, testing and analyses program to determine all the required criteria.

Sampling was carried out on the total and split production streams of Coal Wash from both of IC's Coal Preparation Plants over some months. This has now provided the business with a complete understanding of Coal Wash quality and how Coal Wash may be better utilised and marketed. The complete set of analysis results are to be found in Appendix E. An indemnity/release form has also been developed to assist in the marketing of Coal Wash for fill projects. This is available in Appendix F.

During the early period of the sampling process, IC became aware that the Coal Wash from Dendrobium Coal Preparation Plant (DCPP) exhibited higher moisture levels than was optimum for emplacement and some possible alternate uses. A Project Team was formed, incorporating expert engineers and coal technologists to improve the Total Moisture content and handleability of Coal Wash from DCPP.

The Project Team operated under BHPB's Operating Excellence Business Improvement methodology. Key findings resulting from the initial stage of the project were:

- Improvement of the tailings press feed density and flow control were critical. Work was required to control the underflow density, attain press feed tank homogenisation and improve control of the press feed flow control and bowl level control.
- Water supply security to sprays and flocculant dilution were critical.
- Seek to automate the press feed control and manage the flocculant/solids relationship.
- Increase the residence time in contact with the press rollers.
- Have an independent expert peer review the work.

The Project Team recommended that is was essential to:

- Continue sampling to extend the base line data
- Install density control meter and density loop control thickener underflow
- Redesign agitator 10.01 tank.
- Develop automated process control on presses
- Trial new flocculants
- Secure water supply to flocculant dilution and sprays
- Install extra rollers on 1 press as a trial
- Standardise press set-up
- Continue optimisation of E-press
- Incorporate findings from independent expert process review.

This work is starting to show early promise and Illawarra Coal have also installed a Moisture Meter on the Coal Wash Bin at DCPP to alert operators when Coal Wash moisture exceeds specific limits, so that it can be diverted for temporary storage and drainage, alleviating any possibility that overly wet Coal Wash will be taken on to public roads or to customers.

To facilitate market development and penetration for recycled products, Illawarra Coal has provided a submission to the Department of Planning for the drafting of the Metropolitan Construction Materials Strategy. Our inclusions to this strategy is provided in Appendix H.

Manufactured aggregate and sand

Illawarra Coal undertook a preliminary laboratory investigation at the University of Wollongong to assess the potential of Coal Wash to manufacture aggregate and/or sand for the materials construction market. The results proved that Coal Wash is an unsuitable material for this purpose. See Appendix G for technical detail.

What will we do in 2007 ?

The program of work for 2007 will concentrate on the following areas:

- Progress the local site fill opportunity (1 million tonnes plus) identified.
- Progress discussions and negotiations with quarry operators concerning long term rehabilitation potential for Coal Wash
- Clarify the Waste Fill Regulations status of Coal Wash and develop agreed specification for use as fill
- Continue the Overburden Grout Injection Project
- Continue the strategic alliance to determine the potential for a Coal Wash fired power station at WestCliff Mine.
- Appoint a Distributor for small loads of Coal Wash and actively market this ability.
- Actively pursue opportunities for Coal Wash at small to medium sized sites as engineering fill material.
- Finalise plans for the expansion of the capacity increase for the WestCliff Stage 2 Coal Emplacement Area and seek approval from DPI.
- Complete the submission for further consent to the Minister for Planning for the WestCliff Stage 3 Coal Wash Emplacement Area.

Conclusion

Illawarra Coal has continued to demonstrate a commitment to the Dendrobium COI outcomes with regard to Coal Wash. We believe that our own business imperatives have now overtaken any regulatory imposition and we have clear and immediate business drivers to pursue alternative uses for Coal Wash.

The Company has continued to employ a professional Manager to advance work in this area and installed Coal Wash management as a key component of Illawarra Coal's Business Plan. Funding and staff resources have been directed to support the ongoing research into alternatives, some of which are now starting to show promise as possible long term, partial alternatives to emplacement.

Thank you for your time and interest in reading this report. Your feedback and ideas are most welcome and will be highly valued by us.

Please direct any enquiries regarding this report to Andrew Gray at Illawarra Coal on **0419 689 523** or **Andrew.W.Gray@BHPBilliton.com**

APPENDIX A: Dendrobium Mine development consent (extract)

5.1 Stage 3 Coal Wash Emplacement Area

Alternatives to waste emplacement at Area No 3 West Cliff and reporting

(a) The Applicant shall fully evaluate the technical and commercial aspects of using alternatives to the proposed waste emplacement area No 3 at the West Cliff site. The report with recommendations shall be submitted to the Director-General, NPWS, Waste Task Force (the existing task force which reviews BHP waste management), and WdSC no later than 31 December 2003. The report shall consider, but not be limited to:

- Filling up existing waste emplacement areas available to the applicant;
- Underground disposal;
- Coal Wash brick;
- Road pavement; and
- Power station use.

(b) From the date of submission of the report, the Applicant shall provide an annual written report to the Director-General, NPWS, Waste Task Force, and WdSC, detailing progress undertaken during that period to pursue alternatives to the use of Emplacement Area No.3. The Applicant shall provide any reasonable additional information relevant to these reports and any other reasonable requirements for the reports, if so requested by the Director-General.

(c) The Applicant shall submit a report by 31 December 2008 with recommendations to the Director-General, NPWS, Waste Task Force, and WdSC whether any alternatives to Emplacement Area No 3 are feasible. This will include consideration whether modifications will be required to this consent

(d) The Director-General may, after considering any submission made by relevant government authorities, Waste Task Force, and CCC on the report, notify the Applicant of any requirements with regard to any recommendations in the report. The Applicant shall comply with those requirements within such time as the Director-General may require

APPENDIX B: Waste Management Task Force

Gray, Andrew W

From: Renee Allen-Narker [Renee.Allen-Narker@dipnr.nsw.gov.au]
Sent: Thursday, 2 September 2004 11:09 AM
To: Grimson, Keith KG
Subject: RE: Waste Task Force meetings

That's sounds fine. When you put the update together, I will distribute it. In the meantime, we'll put the next meeting on hold. I'll let everyone know formally, and distribute the minutes from the last meeting as well. When the Strategy is updated I'll also criculate that. We're just a bit short of staff at the moment, so work may be a little delayed.

Regards
Renee

Renee Allen-Narker
Regional Planner
DIPNR
Illawarra & South Coast Office
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>>> "Grimson, Keith KG" <Keith.G.Grimson@BHPBilliton.com> 2/09/2004 9:29:45 am >>>

I am overseas at the moment and will not be returning until 4 October. I would like to distribute an update of progress but this does not require a meeting. I can send the update to you for distribution

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From: Renee Allen-Narker [mailto:Renee.Allen-Narker@dipnr.nsw.gov.au]
Sent: Wednesday, 1 September 2004 11:56 AM
To: keith.g.grimson@bhpbilliton.com
Subject: Waste Task Force meetings

Hi Keith,

Due to a lack of resources, we are considering putting the Task Force meetings on hold for a few months, unless the next meeting is likely to provide the group with some important updates, in which case we'll go ahead.

Do you have any significant changes, critical issues or progress at Billiton to report to the group on, on September 9? Or, do you require urgent feedback from the group over any issues?

I will be in contact asap once we have clarified whether the 9 September meeting will go ahead or not.

APPENDIX C: ACARP proposal

2006

ACARP PROPOSAL SUMMARY

(OFFICE USE ONLY)

PROJECT TITLE	**SUBSIDENCE CONTROL USING COAL WASHERY WASTE**
APPLICANT ORGANISATION/S	CSIRO Exploration and Mining; BHP Billiton Illawarra Coal; Mine Subsidence Engineering Consultants Pty Ltd
REFERENCE NUMBER (full proposals only)	**26202**

PROJECT LEADER

Name	Dr. Baotang Shen		
Organisation	CSIRO Exploration and Mining		
Address	PO Box 883 Kenmore, QLD 4074		
Email	Baotang.shen@csiro.au		
Phone	07 3327 4560	**Fax**	07 3327 4666

SECOND PROJECT LEADER (only if more than one applicant organisation)

Name	Mr Greg Poole and Mr Mike Armstrong		
Organisation	BHP Billiton Illawarra Coal		
Address	PO Box 514 Unanderra, NSW 2526		
Email	Greg.R.Poole@BHPBilliton.com; Mike.Armstrong@BHPBilliton.com		
Phone	02 4224 6304; 02 4224 6252	**Fax**	02 4224 6259

FUNDS REQUESTED FROM ACARP (exclusive of GST)	**$345,195**
OTHER SOURCES OF FUNDS (exclusive of GST)	
Cash	
In-Kind (e.g. salaries, equipment purchase)	$80,053 (BHPB); $75,600 (CSIRO); $50,000 (Moranbah North); $50,000 (Mandalong)
Facilities (e.g. overheads, use of existing equipment)	
TOTAL PROJECT COST (exclusive of GST)	**$600,848**
PROJECT DURATION (in months)	24 months
PARENT PROJECT (only if seeking an extension project)	

APPLICABLE CATEGORY (select applicable category/categories)

Note: Sustainability category proposals will be assessed by 1 or more of the following committees

- [X] **MINE ENVIRONMENT & SUSTAINABILITY** (UNDERGROUND)
- [ ] OPEN CUT MINING
- [ ] COAL PREPARATION
- [ ] TECHNICAL MARKET SUPPORT
- [ ] GREENHOUSE GAS MITIGATION

SUBSIDENCE CONTROL USING COAL WASHERY WASTE

1. EXECUTIVE SUMMARY

This project aims to provide Australian underground coal mines with a viable and cost-effective subsidence control method using *overburden inter-strata grout injection technology*. The outcomes of this project will progress this technology toward the first full scale trial of the overburden grout injection technology at West Cliff Colliery and possible applications to several other Australian underground coal mines, including Moranbah North and Mandalong.

Overburden grout injection of coal washery waste will have two significant benefits to a mine using the technology:

- Reduce mine subsidence by up to 60%.
- Dispose of approximately 240,000 tonnes of coal waste in an injection area of 300m×500m.

A previous ACARP project "Feasibility Study of Subsidence Control Using Overburden Grout Injection Technology - C12019" (Guo et al, 2005) was conducted by CSIRO with support from BHP Billiton Illawarra Coal and Xstrata Baal Bone Colliery, in which the injection material was flyash produced in coal-fired power stations.

Following the ACARP project, BHP Billiton Illawarra Coal together with CSIRO conducted detailed pre-trial studies for applying the technology to the BHPB's West Cliff Colliery. The trial was designed to use the coal washery waste produced in the local coal processing plants. The study identified several key issues that need to be resolved before the first full scale trial can be undertaken at the mine:

- The potential of the overburden grout injection method to reduce subsidence movements and provide protection to surface features such as rivers, pipelines, roads, railways, bridges etc. need to be assessed and quantified.
- The hydraulic barrier between the injection horizon and the underground workings needs to be optimised to minimise the risk of grout, water and gas migration to the longwall face and goaf.
- The option of using a wide range of coal washery wastes needs to be assessed.

These issues are common in most Australian underground coal mines that are looking into the application of this technology for both subsidence control and coal waste disposal.

In the proposed project, we will address the above issues by conducting detailed site monitoring and numerical modelling at West Cliff Colliery. We will also conduct detailed feasibility and economic analysis of the application of this technology to two other selected mines: Moranbah North and Mandalong and for the industry in general.

The key tasks to be conducted in this project will include:

- Address the key technical issues identified for the 1st full scale trial at West Cliff Colliery, including determination of the safe and effective grout injection horizons and quantitative assessment of the effects of the protective improvements by grout injection on the stability of surface features.
- Provide feasibility assessments for Moranbah North Mine and Mandalong Mine, based on the measurement data at these mines and knowledge/findings at West Cliff Colliery.
- Provide detailed economic analyses of grout injection operations in different site conditions to highlight the benefits and costs of the technology for each site.
- Investigate the feasibility of using a wide range of coal washery wastes as the injection material.

The outcomes of the project will be a set of technical data and knowledge that will guide a first full scale trial and future applications of the overburden grout injection technology in Australia.

The proposed project will take 2 years to complete. The total project cost is $600,848. ACARP funding of $345,195 is requested.

2. OBJECTIVES

The main objective of the proposed project is to test and utilise a cost-effective technology to control mine subsidence.

Detailed objectives include:

- Address the key technical issues identified for the 1st full scale trial at West Cliff Colliery, including determination of the safe and effective grout injection horizons and quantitative assessment of the effects of the protective improvements by grout injection on the stability of surface features.
- Provide feasibility assessments for Moranbah North Mine and Mandalong Mine, based on the existing measurement data at these mines and knowledge/findings of West Cliff Colliery.
- Provide detailed economic analyses of grout injection operations in different site conditions to highlight the benefits and costs of the technology for each site.
- Investigate the feasibility of using a wide range of coal washery wastes as the injection material.

3. STATE OF THE ART

Mining induced ground subsidence can significantly increase mining costs where major surface structures, facilities and natural environments need to be protected from ground movements. Longwall mining under river systems, gorges, cliffs, power lines, pipelines, communication cables, major roads, railways, bridges, and other significant surface facilities has occurred at a number of underground mines in Australia. Increasingly, mine subsidence is becoming a major issue of community concern, particularly in New South Wales. To date, subsidence under such sensitive surface features is mainly controlled by leaving large blocks of unmined coal behind. This method not only sterilizes the coal resource, but also increases mining costs as a result of production loss and longwall relocation. Remedial and mitigation measures to manage damage caused by subsidence can often be very costly.

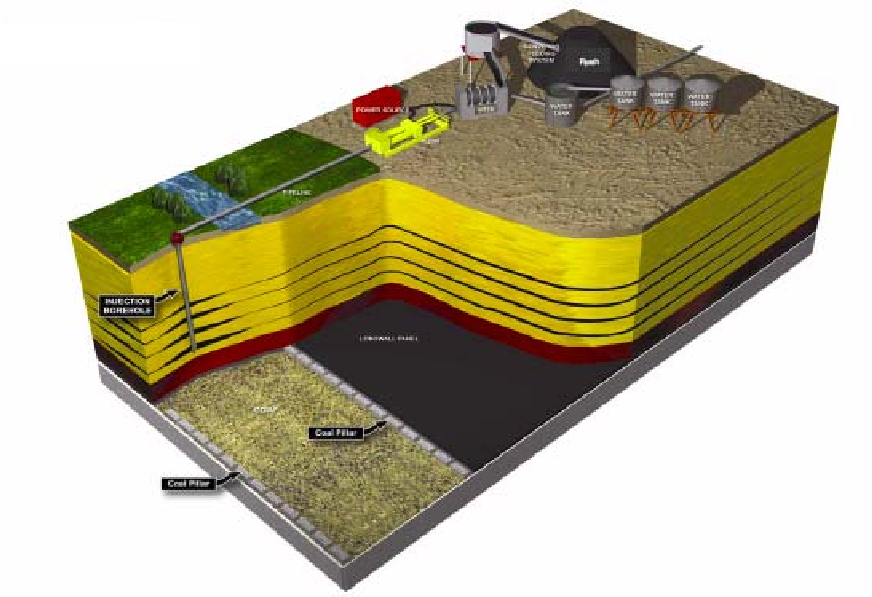

Figure 1. A schematic drawing of the overburden injection technology to control mining induced subsidence.

Overburden inter-strata grout injection is a technology used to control coal mine subsidence by injecting fine waste material (e.g. flyash) into the overburden during longwall mining. This technology was developed in the late 80's in China and it has been successfully used in many mines in China with reported subsidence reduction ratios of up to 60%. The main concept of this technology is that grout material made of typically flyash and water is injected into the overburden bed separation openings caused by longwall mining (Figure 1). The injected material fills the bed separation gaps and hence reduces the propagation of the overburden movement to the surface.

This subsidence control technology has major advantages over other subsidence control methods (e.g. backfill):

- The operations are conducted on the surface through boreholes, and hence will not interfere with underground mining operations.
- The technology uses waste material (e.g. flyash or coal washery fines) as the injection material, hence reduces the need for surface waste disposal and the associated environmental protection issues.
- The method is highly economical with minimised environmental impacts and substantial outcomes at relatively low operational costs.

In the sections below we describe a major application case in China and two major studies conducted recently in Australia.

3.1 OPERATIONS AT TANGSHAN MINE, CHINA

Tangshan Mine is one of the major mines in China currently carrying out the overburden grouting operations. The mine is extracting a 9m coal seam at a depth of about 550m using the Longwall Top Coal Caving method, in which substantial surface subsidence could have resulted if it hadn't been controlled. Within the mine lease are the densely populated Tangshan City and a major national railway line connecting Beijing to Shanhaiguan.

The overburden grout injection operation was carried out in Tangshan Mine in 1999 in Panel 3694 (Figure 2). This panel was 410m long and 90m wide. Two boreholes were used for grout injection. The grout was made of flyash from the local power plant and water at a ratio of about 1:3.

Over a period of 10 months, a total of 354,390 m^3 grout with 77,035 m^3 flyash were injected through the two boreholes.

With the overburden grout injection, the actual maximum surface subsidence monitored after mining the panel was 429 mm which, when compared with the predicted subsidence of 1336 mm for the case where no grout was used, represents a significant reduction. A short-term subsidence reduction ratio of 68% has been achieved, while the final long-term subsidence ratio - after all neighbouring panels are mined - is estimated to be more than 40%.

In another grouting operation (in Panel T2191), a total volume of 1,300,139m^3 of grout was injected, which used 288,075m^3 of compressed wet fly ash. The resultant subsidence reduction ratio is expected to be again more than 40%.

To date, overburden grout injection has been conducted in a total of eight longwall panels in Tangshan Mine. The average subsidence reduction ratio achieved was about 40%. The operation under the major national railway line was particularly successful, and achieved the expected major economic benefits. Combined with the railway real-time backfill and repair operations, the overburden inter-strata grout injections ensured that the coal pillar beneath the railway was mined safely.

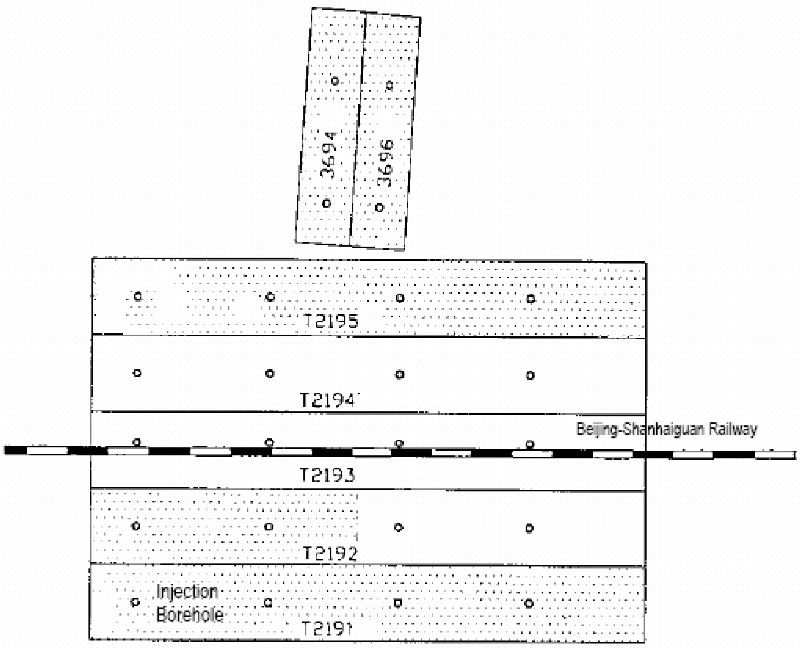

Figure 2. Plan of overburden grout injection at part of Tangshan Mine.

3.2 Feasibility study by CSIRO/ACARP for application in Australia

An ACARP project entitled "*Subsidence control using overburden grout injection technology*" (C12019) was conducted by CSIRO in 2003-2005, aimed to assess the feasibility of applying the overburden grout injection technology in the Australian mine conditions.

The project focused on using flyash, the same grout injection material as used in China. Systematic laboratory tests were carried out to investigate the injectability, sedimentation, consolidation and environmental effects of the Australian flyash grout. Key findings of this study are that flyash from Australian power plants is environmentally safe for grout injection operations, and a grout with a solid flyash concentration of 40-50% gives the optimal workability, flowability or injectability into underground fractures.

A pilot injection trial was conducted in a shallow overburden (40m) at Baal Bone Colliery, aimed at testing the injection process and grout flow in overburden fractures. The trial was conducted several months after undermining when subsidence had already developed. Over a period of 4 days, a total of 200 tonnes of flyash was injected through one borehole. The grout flow and filling effects in the overburden were monitored using a downhole camera (RaaX system) and ground penetration radar (GPR). It was found that the grout had penetrated to a far distance, at least 130m from the injection borehole. It was also evident that the injection had effectively filled the major fractures in the overburden strata (see Figure 3).

The feasibility study concluded that the overburden injection technology by flyash is feasible and applicable to some Australian site conditions, particularly those with an overburden depth of 300m or more.

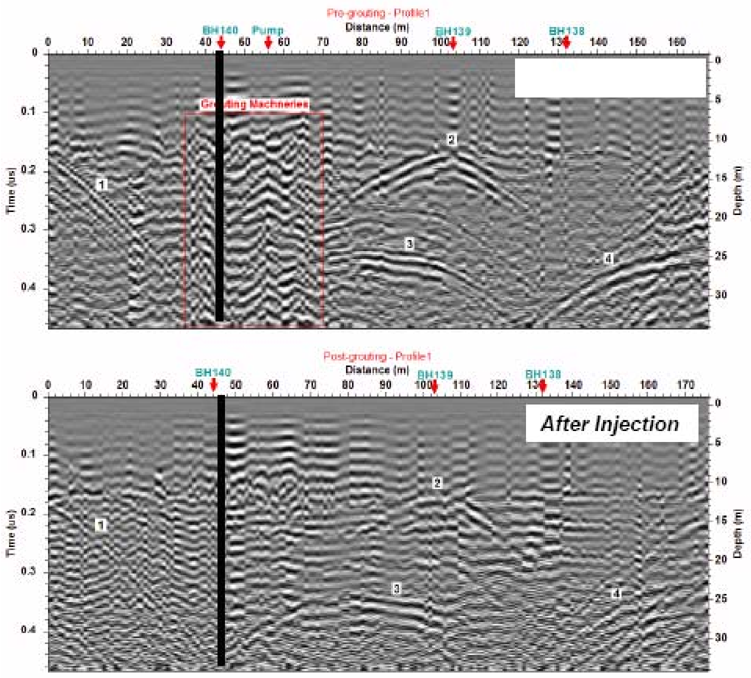

Figure 3. Filtered GPR Images for a vertical cross section along the centreline of the panel - top figure shows results before grout injection and bottom figure shows afterward. Notice, major open fractures (marked as 1,2,3,4) observed before the injection, have almost faded out (filled) after the injection.

3.3 Pre-trial investigation and design by BHPB/CSIRO at West Cliff Colliery

Following the ACARP project, BHPB Illawarra Coal and CSIRO have conducted a site specific investigation and designed an injection system for a full scale trial at West Cliff Colliery. The study identified, addressed and overcame some major safety issues, and for the first time successfully installed a deep hole surface extensometer in the Bulgo Sandstone to measure the strata movement during undermining in the injection target zone. The interpreted bed separations in the Bulgo Sandstone and rock above are shown in Figure 4.

The study considered the usage of the coal washery rejects from the local coal processing plants as the major injection material. A series of laboratory tests together with slurry pipeline loop tests were conducted on the coal washery fines. It was found that the coal washery fines from both West Cliff and Dendrobium Coal Processing Plants are suitable for injection as the grout material. Furthermore, use of the coal washery fines as the injection material in continuous overburden injection operations at West Cliff Colliery helps to dispose most of the fine waste rejects and hence reduce cost of surface disposal.

The study has also produced a detailed injection system design including pump capacity, pipeline specification, injection borehole configuration and injection horizon and timing.

However, several key technical issues remain outstanding and need to be address before BHPB Illawarra Coal can practically commit to a first full scale trial in Australia. These issues include:

1. The injection horizon needs to include the immediate zones above and below the Bulgo Sandstone to achieve a subsidence reduction ratio greater than 40%. These zones were not included in the measurement zones of the previously installed extensometer and piezometers, hence they will need to be reinvestigated and new measurement programs have to be designed.

2. The achievable level of protection to surface features including Georges River, major pipelines, road and bridges is not yet convincingly understood. Further quantitative, proving assessments need to be carried out.

Although these issues were raised for the specific field trial, they are also common concerns for other mines that may implement this technology. Addressing and solving these issues will not only facilitate the 1st full scale trial at West Cliff Colliery, but also help substantially with the implementation of the technology into other Australian coal mines.

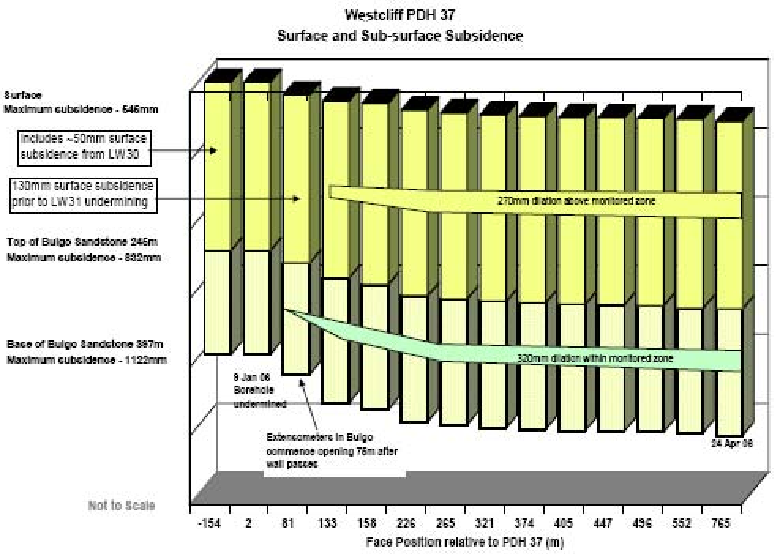

Figure 4. Progression of surface and sub-surface subsidence at West Cliff measured at the fixed borehole PDH37 with respect to the moving LW face.

4 PROGRAM AND WORK SCHEDULE

The work program will have the following components:

- Pre-trial geotechnical investigation at West Cliff Colliery.
- Feasibility assessment for application to Moranbah North and Mandalong.
- Economic analysis of applying this technology in different site conditions.
- Injectability of coal washery waste from different mines as the injection material.

They are described in details in the following sections.

4.1 Pre-trial geotechnical investigation at West Cliff Colliery (March 2007 – June 2008)

4.1.1. Measure bed separation openings and determine thickness of the hydraulic barrier

A deep-hole extensometer and three piezometers were previously installed in the Bulgo Sandstone in LW31 at West Cliff Colliery in a limited depth range. They have returned valuable data on the Bulgo Sandstone and will continue to operate when the next longwall panel (LW32) is mined. However, due to their limited depth range, the critical information that are needed for a first trial grout injection, i.e. the data on the geomechanical and hydraulic behaviour of the overburden strata immediately above and below the Bulgo Sandstone, are missing from the existing instruments.

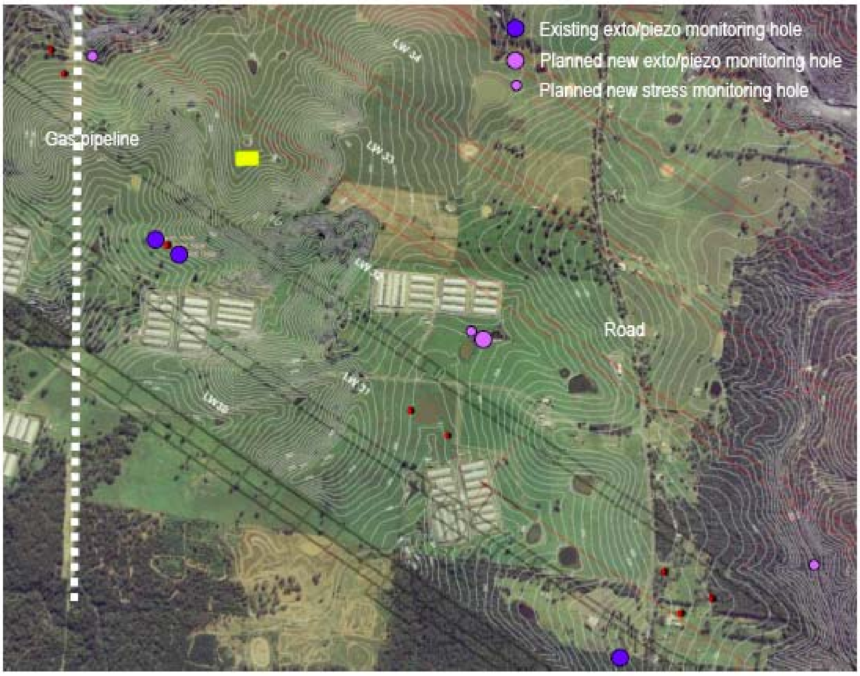

Figure 5. Mining layout and proposed geotechnical monitoring at West Cliff Colliery.

This project will install a new extensometer and a piezometer in LW32, see Figure 5. The extensometer anchors will be located several meters below the Bulgo Sandstone to cover the important interface between the Bulgo Sandstone and Stanwell Park Claystone, while still leaving a safe thickness of claystone to prevent gas and water migration into the goaf or longwall workings. Anchors will also be located in the Bald Hill Claystone to include the key interface at the top of the Bulgo Sandstone. The exact depth of these anchors will be determined based on the requirements for preventing water cross contamination between the Hawkesbury Sandstone and Bulgo Sandstone.

A piezometer will also be installed at the bottom of the extensometer hole. The piezometer will be suspended by a cable in the open hole and designed to be free moving during the bed separation process. This arrangement will ensure that the piezometer and its data cable will not be damaged during subsidence.

This task determines the injection horizons and the volume of the grout that can be injected into the overburden, making it possible to estimate the maximum subsidence reduction ratio when the overburden grout injection technology is applied.

The location of the monitoring site has been selected within a valley area in order to address the concerns and issues of valley closure and upsidence that have been observed in such regions. This will be conducted several months after the completion of the previous extensometer/piezometer monitoring in LW31, making it possible to reuse the existing equipment and significantly reduce project costs.

4.1.2. Measure sub-surface stress change and investigate mechanism of valley closure and upsidence

In Illawarra, some of the future mine reserves are overlain by the Georges River and gas/water pipelines. Fracturing and upsidence of the river bed can occur during subsidence, causing water loss from stream such as the Georges River. A previous ACARP project (*Impacts of Mine Subsidence on the Strata & Hydrology of River Valleys* - C8005/C9067 – by Arthur Waddington) has investigated this issue. An existing ACARP project (*Damage Criteria and Practical Solutions for Protecting Undermined River Channels* - C12016 – by Greg Poole and Ken Mills) is developing a range of practical strategies for assessment, mitigation and remediation of mining induced damage to river channel systems.

The response of the gas/water pipelines to subsidence is currently being investigated extensively by BHPB Illawarra Coal and pipeline owners, using a set of monitoring methods including strain gauges and 3D survey.

It is generally accepted that river damage and upsidence are caused by a significant increase in horizontal stresses in the subsurface strata after being undermined. However, there has not been substantial measured data of the stress change during mining to verify and quantify this mechanism. Such data will be very important to quantitatively evaluate whether and when damage to a surface feature can occur under a given subsidence condition.

In the proposed project, we will install nine stressmeters in shallow ground (<40m deep) in LW32 at three locations (i.e. at the pipelines location, at the extensometer location, and in river bed, see Figure 5) to monitor the change in the strata horizontal stress, before, during and after undermining. This monitoring will provide essential data to specify the required thresholds of subsidence reduction ratios that can effectively protect the river and the gas/water pipelines.

This stress monitoring will be complementary to the existing monitoring program being conducted by BHPB Illawarra Coal and other mines in the area. Prior to this monitoring, we will review existing or planned monitoring instruments to optimise the arrangement of the stress monitoring program to be consistent with other instruments.

This task will include extensive consultation with Dr Ken Mills, BHPB Illawarra Coal, and other monitoring teams, to ensure past experience and other monitoring data are considered and included in this study.

We will also review the existing surface subsidence monitoring plan in LW32, and if needed, will add additional survey lines particularly at the three locations where the sub-surface stresses are monitored, i.e. the pipelines location, the extensometer location at a valley, and around the Georges River. The subsidence data will be analysed with the help of Dr Arthur Waddington from Mine Subsidence Engineering Consultants to understand and analyse the mechanism of subsidence and valley closure.

4.1.3 Quantify the protective effect of grout injection on sensitive surface features.

Based on the monitoring and measurement results, we will determine and specify the possible degree of protection to the key surface features from the application of the overburden grout injection technology at West Cliff Colliery. The results of this task will determine and confirm the final protection target(s) and the location of the 1st full scale trial at West Cliff Colliery.

This task includes the following components:

- Estimate the subsidence reduction ratio using Chinese empirical formula and CSIRO's 3D numerical models.

- Estimate the surface strain using empirical method verified by Mine Subsidence Engineering Consultants.

- Estimate the sub-surface stresses based on the measured stress results without grouting and the estimated surface strain with grouting.

- Estimate the reduction of damage to different surface features after applying grouting, using the combined numerical and empirical methods.

- Classify the surface features that the grout injection can lead to a sufficient and acceptable damage reduction, and recommend the protection target(s) in the full scale trial at West Cliff.

Milestone 1 (June 2008) – Section of trial site and recommendation of protection target at West Cliff.

4.2 Feasibility assessment for application to Moranbah North and Mandalong (August 2007 – March 2008)

The project will investigate the feasibility of applying the overburden grouting technology to two other mines: Moranbah North and Mandalong. Compared with West Cliff, these mines have different mining and geotechnical conditions. The protective targets are also different, ranging from river and railways at Moranbah North, to residential and industry facilities at Mandalong.

For each of the two mines we will conduct studies as listed below:

- Review the available geological, geotechnical and hydrogeological information and monitoring data of the overburden movement during longwall mining. Since both mines have plans of new overburden monitoring within the project duration, we will work with the mine to design a flexible monitoring program to provide necessary data required for a potential overburden grout injection operation.

- Investigate bed separation locations and timing by using the existing and new monitoring data and 3D numerical modelling.

- Estimate the subsidence reduction ratio from using the overburden grout injection technology for the site specific conditions.

- Quantitatively assess the degree of protection to the targeted surface features.

Site specific overburden monitoring data are important for this task. Moranbah North Mine has previously monitored the overburden movement in several panels using surface extensometers, and has a plan to install new extensometers and piezometers. Mandalong Mine has a sufficient piezometer measurement database which can be used for this project, and it will install new extensometers to support the proposed project.

The existing monitoring data and the newly planned monitoring installations from these mines will be key inkind contributions to the proposed project.

Milestone 2 (May 2008) – Technical feasibility identified for application in each of the two mines.

4.3 Economic analysis of applying this technology in different site conditions (November 2007 – August 2008)

Using overburden grout injection technology to control surface subsidence has been reported to return significant economic benefits in Chinese mines. It is expected that the economic benefits will be more pronounced in Australian mines, because there are more environmental restrictions in Australia than in China.

Key economic benefits to the mine applying this technology include:

- Reduce remedial treatment costs for sensitive surface features.
- Reduce or eliminate production loss associated with longwall relocation.
- Reduce or eliminate coal sterilisation.
- Reduce costs associated with coal washery waste disposal.

Key cost items of a grouting operation include:

- Site specific geotechnical investigation and injection system design.
- Injection equipment purchase or hiring.
- Injection operation and monitoring.
- Material supply (mainly transport costs since coal washery waste is normally free of cost).

The costs vs benefits will be highly site specific. To conduct an economic analysis, we will first establish a general economic model which includes typical costs and benefits related to the subsidence damage and grout injection operations. We will then apply this economic model to each of the three mines (West Cliff, Moranbah North, Mandalong) to produce the site specific economic analysis for each mine.

The results from the economic analysis will provide essential information for mine management to process with trials of this technology.

The results will also provide preliminary benchmarks for other mines with similar conditions to apply this technology.

Milestone 3 (August 2008) – Economic feasibility identified for all 3 mines.

4.4 Injectability of coal washery waste from different mines as the injection material (July 2008 – October 2008)

Coal washery waste is available locally at most coal mines in Australia. Using coal washery waste as the grout material has major advantages over flyash due to its availability and short transportation distance. However, injecting coal washery grout into the overburden has not previously been trialled in Australia or China, and hence poses some technical risk.

To reduce and manage the risk, the proposed project includes systematic laboratory tests of coal washery waste from the three participating mines. The key testing components are:

- Flowability tests (viscosity, segregation, settlement & consolidation characteristics, particle size distribution);

- Injectability tests (laboratory model simulation of grout injection in fractures). The tests will be conducted using CSIRO's injection rig, built within a previous ACARP project (C12019) specifically for this purpose;

- Chemical tests. It is designed to investigate the possible impact of grout on ground water quality and ensure the injection does not pose unacceptable risks to the surface and sub-surface environment.

The previous tests on fine coal wash from the West Cliff and Dendrobium Coal Processing Plants conducted in a BHPB/CSIRO study (Shen et al. 2006) will be made available to this project. This project will focus on the local injection material from the other two mines.

A general assessment of coal washery waste as the injection material will be conducted based on the test results from different sites. This assessment will be useful not only for the mines investigated, but also for the industry as a whole.

Milestone 4 (October 2008) – Recommendation of grout design for all 3 mines.

4.5 Project final reporting (November 2008 – December 2008)

The research results from the project will be systematically analysed and a final report will be written and submitted.

Milestone 5 (December 2008) – Delivery of final project report.

The work schedule of the project is summarised in Figure 6.

5 SAFETY IMPLICATIONS

The project will require installing monitoring instruments into the Bulgo Sandstone and its immediate interfaces with other strata above and below this Sandstone unit at the West Cliff Colliery. There is a risk that boreholes drilled beyond the Bulgo Sandstone may lead to an increased gas/water migration into the goaf. There are also concerns that borehole casing ended above the Bulgo Sandstone could cause water cross-contamination between the Hawkesbury Sandstone and Bulgo Sandstone. A preliminary assessment has been carried out by the project team in a meeting, where they considered to be feasible to extend the drill hole open section 5-10m below and above the Bulgo Sandstone. This will enable monitoring the important interfaces and zones, while at the same time not compromising the impermeable claystone hydraulic barriers above and below the Bulgo Sandstone. A more comprehensive risk assessment will be conducted prior to the commencement of the installation of the monitoring instruments.

A key safety issue of the mine site application of the overburden grout injection technology is the possibility of grout migration to the underground workings. To eliminate this risk, a sufficiently thick hydraulic barrier needs to be left between the injection horizon and the mining seam. This project will investigate these questions through piezometer monitoring and numerical modelling analyses.

Moranbah North Mine is particularly concerned with the issue of the overburden grouting operation increasing the loading force on the longwall supporting systems. As part of our engagement responsibility with the mines, we will conduct a detailed review and assessment on this issue (and any other future concerns) within this project.

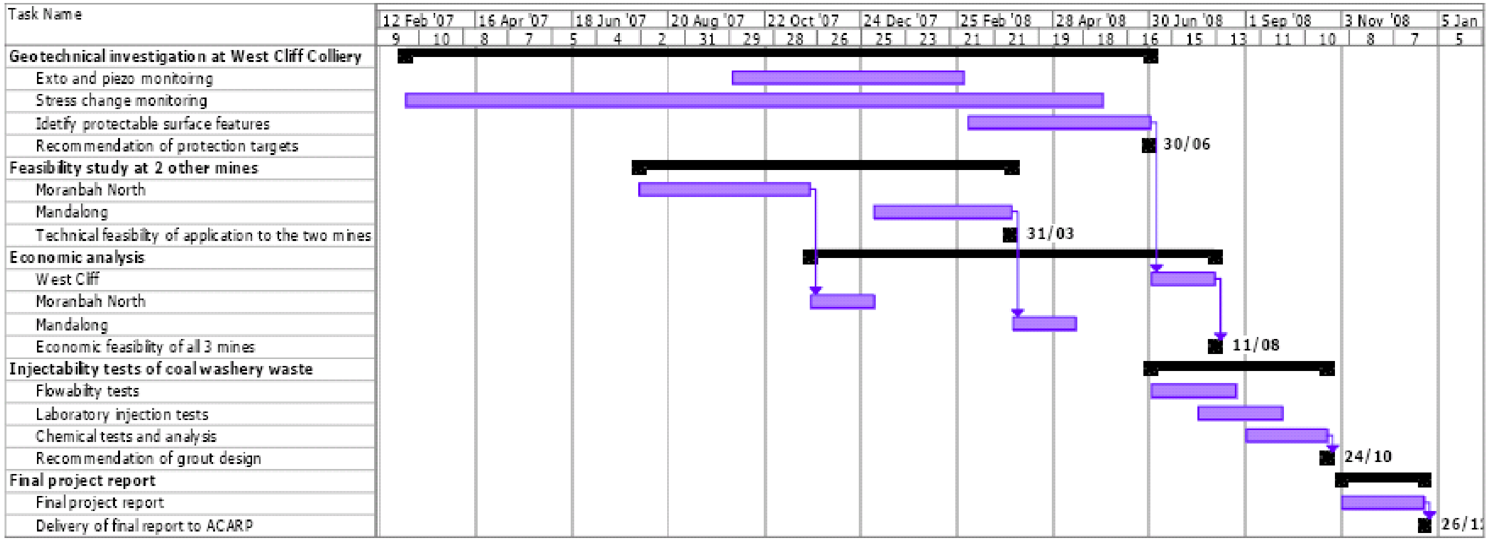

Figure 6. Project schedule.

6 EXPECTED OUTCOMES AND BENEFITS

The key outcome of this project will be a set of technical data and knowledge that will lead to the realisation of the first full scale trial and future applications of the overburden grout injection technology to control mine subsidence in Australia.

These data and knowledge will include:

- The volume and timing of the overburden bed separation and the minimum thickness of the hydraulic barrier. These data are essential for the design of the injection horizon, injection capacity and timing.
- The response mechanism of the surface features (such as rivers, pipelines, railways) to mine subsidence, and quantification of the mitigative effects of the grout injection on the protection of such features.
- Identification of the surface features requiring subsidence protection and the level of protection that can be provided by the overburden injection technique.
- Injectability of the coal washery waste from different sites with different sizes. An optimal grout that can include the coarsest possible coal washery waste will maximise waste disposal.
- Economic feasibility of applying the overburden grout injection technology to mines with different mining conditions and protection targets.

This study will identify and remove the technical hurdles that might persist in a first full-scale trial of the overburden technology being considered by BHP Billiton Illawarra Coal. This trial must be a success to result in the future wide spread applications of the technology to other Australian underground coal mines.

This study will also provide a feasibility assessment of applying this technology to Moranbah North and Mandalong Mine. The results will be useful for other Australian mines with conditions similar to these mines.

The benefits from using the overburden grout injection include:

- Reduction of mine subsidence and protection of important surface features. Hence, it assists operations to maintain license to operate and reduces costs of remedial measures.
- Underground disposal of coal washery waste. Hence it reduces environmental impacts and costs of conventional surface disposal.

The potential economic benefits are enormous. A typical grout injection operation is expected to cost about $2million. It will replace the traditional subsidence control measure using longwall relocation and save the cost of production loss and coal sterilisation (typically >$10million).

It is envisaged that this project will have a high likelihood of success due to the extensive previous studies and research work of the project team. The team believes that the potential to apply overburden grouting technology in Australia, which has been used in China successfully for more than 15 years, is high.

7 RESOURCES & BUDGET

The summary project budget is listed below. A detailed project costing is given in Appendix I.

LABOUR (ex GST)				
Person	*Man days*	*$/Man day*	*Cost to Project*	*Cost to ACARP*
CSIRO (B. Shen, H. Alehossein)	164	$1,200.00	$196,800	$131,200
BHPB (G. Poole, M. Armstrong)	16	$1,200.00	$19,200	$0
MSEC (A. Waddington, D. Kay)	32	$1,200.00	$38,400	$38,400
	212		***$254,400***	***$169,600***

EXPENSES (ex GST)		
Equipment Purchase		
Extensometer & Piezometer Monitoring System (West Cliff)	$62,663	$11,810
Stressmeters Monitoring System (West Cliff)	$45,335	$45,335
Extensometer & Piezometer Monitoring System (Moranbah North)	$50,000	$0
Extensometer & Piezometer Monitoring System (Mandalong)	$50,000	$0
Other costs		
Geotechnical measurements sub-contract (West Cliff)	$92,450	$82,450
Chemical tests	$20,000	$20,000
Access to laboratory facilities	$0	$0
Technology Transfer (CSIRO)	$10,000	$0
Travel	$16,000	$16,000
	$346,448	***$175,595***
TOTAL FUNDS REQUESTED FROM ACARP		**$345,195**

8 TECHNOLOGY TRANSFER AND COMMERCIAL ASPECTS

Technology transfer of the project outcomes will be carried out in two ways as follows:

- The results of site specific field investigation and desktop study will be directly applied to the three mines involved for the 1st field trial at West Cliff Colliery and the future applications in the Moranbah North and Mandalong.
- The study results of this project will be reported in detail to ACARP and presented in conferences and workshops to the Australian mining community to increase community awareness of this new technology and to build confidence in the effectiveness of this technology in controlling subsidence and protecting sensitive surface features.

9 RESEARCH TEAM

Dr. Baotang Shen, CSIRO Exploration and Mining - Project Leader, Principal Geotechnical Engineer.

Baotang is the key researcher in the previous ACARP subsidence control project C12019. He has led CSIRO's research in the recent BHPB/CSIRO project of site investigation and system design for a full scale trial of the overburden injection technology at West Cliff.

Mr Greg Poole (Manager Resource and Exploration) and Mr Mike Armstrong (Geological Services Manager), Project co-leaders. BHP Billiton Illawarra Coal

Greg and Mike were principal participants in the West Cliff Overburden Grout Injection study. Mr Poole also participated in a study tour of overburden grout injection in China.

Mr Arthur Waddington and Mr Donald (Don) R Kay, Mine Subsidence Engineering Consultants Pty Ltd.

Arthur and Don established Mine Subsidence Engineering Consultants Pty Ltd and are specialised in the prediction of mine subsidence ground movements and the assessment of possible damage from mine subsidence movements. Arthur has managed a major research project, funded by ACARP grants on the impacts of mine subsidence on the strata and hydrology of river valleys. Don was granted funding, by NERRDC, to undertake a two-year study into the effects of subsidence on steep topography and cliff lines.

Dr Habib Alehossein (RPEQ Civil & Mining), CSIRO Exploration and Mining, Principal Geotechnical Engineer

A senior civil engineer with more than 25 years experience in engineering construction, consulting, design, analysis, research and academia in various mining, civil, electrical and mechanical engineering projects and programs.

10 REFERENCES

Guo H., Shen B., Chen S., and Poole G. (2005) "Feasibility Study of Subsidence Control Using Overburden Grout Injection Technology – ACARP Project C12019 Final Report". CSIRO Exploration and Mining Report P2005/335.

Shen B, Alehossein H., Guo H., Pala J., Armstrong M., Poole G. and Riley P. (2006) "Overburden Grout Injection Project for Targeted Subsidence Reduction at BHPBilliton Illawarra Coal Operations, Phase 2, Site Investigation and System Design" CSIRO Exploration and Mining Report P2006/118.

Appendix I. Detailed costing of the project

BUDGET	Estimated mandays	Cost of mandays including overhead component	Software, instrument, consumables, contractors	Travel	Total cost	Other support costs -CSIRO Inkind	Facility Management Inkind	Cash from CSIRO	Cash & In-kind salary overheads (Company)	Resultant ACARP funding required
			COSTING					FUNDING		
Task 1 - Investigation West Cllif										
Drilling & Casing of 1 hole 0-410m	8	$9,600	$55,750		$65,350				$9,600	$55,750
Extensomter equipment and installation	4	$4,800	$51,663	$2,500	$58,963	$1,600			$44,853	$12,510
Piezeometer equipment and installation	4	$4,800	$11,000	$2,500	$18,300	$1,600			$6,000	$10,700
Drilling of 3 holes 0-40m (38mm)	8	$9,600	$26,700		$36,300				$9,600	$26,700
Stressmeter equipment and installation	4	$4,800	$45,335	$5,000	$55,135	$1,600			$0	$53,535
Subsidence monitoring and analysis	16	$19,200	$10,000		$29,200				$10,000	$19,200
3D numerical modelling and analysis	16	$19,200			$19,200	$6,400			$0	$12,800
Prediction of protective effect on surface features	24	$28,800			$28,800	$6,400			$0	$22,400
Sub total	**84**	**$100,800**	**$200,448**	**$10,000**	**$311,248**	**$17,600**	**$0**	**$0**	**$80,053**	**$213,595**
Task 2 - Feasibility study of 3 other mines										
Moranbah North		$0			$0	$0			$0	$0
New or exiting exto and pizeo monitoring			$50,000		$50,000				$50,000	
Review and analysis of existing data	4	$4,800		$3,000	$7,800	$1,600	$0	$0	$0	$6,200
3D numerical modelling and analysis	8	$9,600			$9,600	$3,200			$0	$6,400
Prediction of protective effect on surface features	12	$14,400			$14,400	$3,200			$0	$11,200
Mandalong					$0				$0	$0
New or exiting exto and pizeo monitoring			$50,000		$50,000				$50,000	
Review and analysis of existing data	4	$4,800		$3,000	$7,800	$1,600	$0	$0	$0	$6,200
3D numerical modelling and analysis	8	$9,600			$9,600	$3,200			$0	$6,400
Prediction of protective effect on surface features	12	$14,400			$14,400	$3,200			$0	$11,200
Sub Total	**48**	**$57,600**	**$100,000**	**$6,000**	**$163,600**	**$16,000**	**$0**	**$0**	**$100,000**	**$47,600**
Task 3 - Economic analysis										
Economic model	8	$9,600			$9,600	$3,200			$0	$6,400
Analysis - West Cliff	8	$9,600			$9,600	$3,200			$0	$6,400
Analysis - Moranbah North	8	$9,600			$9,600	$3,200			$0	$6,400
Analysis - Mandalong	8	$9,600			$9,600	$3,200			$0	$6,400
Sub Total	**32**	**$38,400**	**$0**	**$0**	**$38,400**	**$12,800**	**$0**	**$0**	**$0**	**$25,600**
Task 4 - Grout material testing										
Flowability tests	16	$19,200			$19,200	$6,400	$0		$0	$12,800
Injectability tests	16	$19,200			$19,200	$6,400			$0	$12,800
Chemical tests			$20,000		$20,000	$0			$0	$20,000
Assessment of grout material from different sites	8	$9,600			$9,600	$3,200			$0	$6,400
Sub total	**40**	**$48,000**	**$20,000**	**$0**	**$68,000**	**$16,000**	**$0**	**$0**	**$0**	**$52,000**
Report Preparation										
Reporting and project management	8	$9,600			$9,600	$3,200	$0			$6,400
Technology transfer					$10,000			$10,000		
Sub total	**8**	**$9,600**	**$0**	**$0**	**$19,600**	**$3,200**	**$0**	**$10,000**	**$0**	**$6,400**
Project Total	**212**	**$254,400**	**$320,448**	**$16,000**	**$600,848**	**$65,600**	**$0**	**$10,000**	**$180,053**	**$345,195**

Appendix II – Letters of Support

BHP Billiton:	Illawarra Coal	Mr Mike Armstrong (Geological Services Manager)
Centennial Coal:	Mandalong Mine	Mr John Turner (Mine Manager)
Anglo Coal:	Moranbah North Mine	Mr Adrian Moodie (Senior Geotechnical Engineer)
Helensburgh Coal:	Metropolitan Colliery	Mr Tony De Santis (General Manager)

Illawarra Coal - Carbon Steel Materials

Resource and Exploration
Illawarra Coal Holdings Pty Ltd
Picton Rd, Mt Keira West
New South Wales 2500 Australia
PO Box 514 Unanderra
New South Wales 2526 Australia
Tel: +61 2 4224 6298 Fax: +61 2 4224 6529
bhpbilliton.com

13th September 2006

Dr Baotang Shen
CSIRO Exploration and Mining
PO Box 833
Kenmore QLD 4069

Re: Subsidence Control Using Coal Washery Waste

Dear Dr Shen,

Your proposal to undertake further investigation into the injection of coal washery waste for subsidence control is timely and has the potential to be of great benefit to the coal mining industry.

BHP Billiton Illawarra Coal has recognised the potential difficulties associated with mining adjacent to large urban areas and in regions of environmental sensitivity. A technology such as this, which has the potential to ensure protection to sensitive man-made and natural features, will also assist the industry in increasing the reserve base and providing greater continuity of operations.

BHP Billiton Illawarra Coal, together with the CSIRO, recently completed a study on this topic with very encouraging results. This proposed ACARP investigation will be of invaluable assistance in addressing a number of additional and remaining issues that have originated from the previous investigations. This study will assist in providing the additional knowledge that is required to enable a field trial of the technique in the future.

For these reasons this project has the potential to provide another valuable environmental management tool and, as such, has our support.

Yours sincerely,

M. Armstrong

Mike Armstrong
Geological Services Manager

Centennial Mandalong

177 Mandalong Road
Mandalong NSW 2264
PO Box 487
Morisset NSW 2264 Australia

T 02 4973 0900
F 02 4973 0999

www.centennialcoal.com.au

August 31, 2006

Dr Baotang Shen
Principal Research Scientist
CSIRO Exploration and Mining,
PO Box 883 Kenmore, QLD 4069, AUSTRALIA

Dear Sir,

RE: Support for ACARP Proposal "Subsidence Control Using Coal Washery Waste"
REF NO. 26202

Mandalong Mine would like to confirm our support of the proposal for injection of coal washery fines to reduce subsidence and are happy to commit assistance as stated in the proposal REF NO. 26202.

Yours faithfully,

JOHN TURNER
MINE MANAGER

Centennial Mandalong Pty Limited ABN 74 101 508 892
W:\Cooranbong\Tech-Services\-Subsidence\General\Subsidence grout injection support letter.doc

Moranbah North Coal

Note

To	Baotang Shen	Cc	
From	Adrian Moodie		
Date	7th September 2006		
Subject	Support of ACARP Subsidence Control Project		

Baotang

Having reviewed the details of your proposed ACARP project -Subsidence Control Using Coal Washery Waste, Moranbah North Coal would like to provide support. There are the following potential benefits to MNC that this form of technology advancement could bring:

- Minimisation of impact/damage to the rail line;
- Minimisation of damage to the Isaac River and river banks;
- Improved success rate in preventing strata shearing from blocking gas release via goaf drainage holes;
- Improved understanding of the caving characteristics for the 300m face.

As such we will be happy to provide use of current data gather at site and give the opportunity to assist in gather further information.

Adrian Moodie
Senior Geotechnical Engineer
Moranbah North Coal

Anglo Coal (Moranbah North Management) Pty Ltd
Goonyella Road Moranbah 4744 Australia PO Box 172 Moranbah 4744 Australia
Tel +61 (0)7 4968 8600 Fax +61 (0)7 4968 8678 www.anglocoal.com.au
ABN 14 069 603 587 Ref
A member of the Anglo American plc group

ANGLO COAL

HELENSBURGH COAL PTY LTD
METROPOLITAN COLLIERY

PO BOX 402
HELENSBURGH 2508

28 August 2006

Dr Baotang Shen
CSIRO Exploration and Mining
PO BOX 883 Kenmore, QLD 4074

Our Ref:ACA005let

Dear Baotang,
Subsidence Control Using Coal Washery Waste

The issues of coal washery waste disposal and impacts of surface subsidence are of high relevance to HCPL. Future mining areas at Metropolitan Colliery may include undermining of surface features including river channels and surface infrastructure. The potential reduction of subsidence by up to 60% in critical areas would be expected to improve resource recovery and reduce the level of protection required.

It is noted that the proposed research would be complimentary to a previous ACARP Project C8005/C9067 which made inroads into the issue of mine subsidence impact on river valleys, and to an existing ACARP Project C12016 investigating potential methods of protecting undermined river channels. HCPL consider that the research effort in the area of subsidence impact on surface features should continue.

HCPL support the proposed project, in particular the intention to quantify aspects such as bed separation and the thickness of the hydraulic barrier between goaf and surface.

Yours Sincerely

Tony De Santis
General Manager

Helensburgh Coal Pty Ltd
Registered Office
Parkes Street
Helensburgh NSW 2508

ABN 49 086 463 452
ACN 086 463 452
All Correspondence to
PO Box 402
Helensburgh NSW 2508

Greg Tarrant
Technical Services Manager
Tel : 02 4294 7292
Fax : 02 4294 2064
Mob: 0427 947 292

APPENDIX D1: Review of options to increase Stage 1 & 2

WEST CLIFF MINE
BRENNANS CREEK
REFUSE EMPLACEMENT AREA

REVIEW OF OPTIONS TO INCREASE THE CAPACITY OF STAGES 1 & 2

BHPBilliton Illawarra Coal

Date: April 2006

oec

1.0 INTRODUCTION

The coal reject material produced from the processing of coal is disposed of on leasehold land at West Cliff Mine (WCM). The refuse emplacement facility is adjacent to the mine site in Brennans Creek and is operated as a controlled valley fill. Coal Washery Refuse (CWR) is deposited in benches across the valley and progressively down the valley. As each section of fill reaches the designed height, it is covered with topsoil and re-vegetated. The final landform created by the emplacement is planned to blend with the regional morphology and will be masked from public view by the visual screening of existing eucalypt forest.

The overall planning concept for the Coal Refuse Emplacement Area is to provide a facility, which will accept large quantities of CWR over an extended period of time. The emplacement area will develop in the valley over a number of Major Stages between WCM South Site and the Colliery Dam.

This report reviews previous steps and future options to maximise the amount of CWR that can be deposited in each stage of the emplacement without compromising the environmental protection guidelines that apply to the site or the stability of the valley fill formation.

The estimated capacity of the completed Stage 1 Brennans Creek Refuse Emplacement Area is 4.6Mt.

The current estimated capacity for Stage 2 is approximately 15Mt. The actual capacity is yet to be verified, as recent changes to the North Site coal handling infrastructure and possible development of the Endeavour Drift Project will impact on the final shape of the emplacement formation.

It is also anticipated that detail changes will be made to the emplacement shape, as the formation develops, that will increase the volume of CWR eventually emplaced.

2.0 INITIAL PLANNING OF EMPLACEMENT

In 1989 Sinclair Knight and Partners developed the initial concept for the Brennans Creek Refuse Emplacement Area. The emplacement footprint was planned to extend, in four stages, from the West Cliff Mine South Site to the headwaters of Brennans Creek Dam. The formation height was to be limited to 24m and would have a design capacity of 21Mt and a life of 45 years.

2.1 Development of Stage 1

CWR deposition commenced in Brennans Creek Valley beside the South Site mine facilities and followed the Sinclair Knight emplacement strategy. In 1998, Stage 1 of the emplacement was nearing completion and approval was being sort for Stage 2.

2.2 Planning for Stage 2

Olsen Environmental Consulting (OEC) undertook the design for Emplacement Stage 2 in 1998. The emplacement formation was planned to maximise the amount of refuse that could be disposed of in the valley fill in compliance with the Sinclair Knight guidelines.

The factors that affect the emplacement capacity include:

- Area of emplacement footprint.
- Depth of emplaced refuse fill.
- Finished surface contour of the emplacement and stormwater drainage.
- Rate of compaction of fill material.

2.3 Emplacement Footprint

To maximise refuse deposition volume the emplacement footprint was planned to cover the largest possible area of land in Brennans Creek valley within a system of perimeter drains. The perimeter drains are formed where the finished refuse fill level meets the valley flanks. The eastern extremity of the emplacement abuts the mine infrastructure area. The western extremity was initially determined by the location of an archaeological site, identified as BC1, which dictated the starting level and location of the perimeter drain (not Brennans Creek clean water by-pass drain).

2.4 Archaeological Site BC 1

Aboriginal Site BC 1 is located on the western perimeter of the proposed emplacement. The site includes 50 grinding grooves and 3 engraved groove channels on a large open rock shelf and is the most significant aboriginal site in the upper reaches of Brennans Creek. Preservation of the site was recommended in an Archaeological Survey undertaken by Caryll Sefton in 1989 and endorsed by the Tharawal Local Aboriginal Land Council (TLALC) in 1990.

In order to preserve the site the western side of the emplacement was generally limited to a valley contour level below BC 1, so the refuse fill would not bury it. This restriction limited the emplacement footprint and consequently the volume of fill that could be emplaced.

Approval was gained from the National Parks & Wildlife Service, through negotiations with the TLALC, to a scheme to preserve three less significant aboriginal sites (BC 3, 4 & 10) in the area. The scheme enabled these sites to be buried by the emplacement fill.

2.5 Emplacement Height Limitation

The initial emplacement planned by OEC generally maintained an emplacement within the 24m formation height limit specified by Sinclair Knight. The depth restriction limited the volume of fill that could be emplaced.

2.6 Finished Surface Contour and Stormwater Drainage

The emplacement side batters were planned at starting grades of 1 in 5 that flattening off towards the top of the emplacement formation. This grade was generally adopted to blend with the surrounding landscape and to minimise erosion impacts before the refuse batters could be revegetated and stabilised. Intermediate table drains across the formation side batters were employed to minimise the incidence of runoff flow concentration, which can result in severe erosion. Experience at WCM has shown that even moderately sloping coal refuse banks are highly erodable. In areas where steeper batter grades were unavoidable specific erosion protection measures would be used.

The emplacement surface contour was designed to permit the formation of stormwater table drains at non-eroding grades across the emplacement to carry runoff flows to the perimeter drainage system. The table drains were generally planned at grades between 1% and 1.25% for which a stabilised grass lining would be adequate to prevent erosion. Sections of table drains that exceed this slope would be provided with hard linings to resist erosion.

2.7 Rate of Compaction

To ensure the emplacement formation remains stable during construction and when complete and to maximise the amount of material emplaced a relative compaction rate of 95% Standard Maximum Dry Density was specified for the

CWR fill. To ensure the required rate of compaction was being reached compaction testing was to be undertaken on a systematic basis.

3.0 STEPS TAKEN TO INCREASE STAGE 1 CAPACITY

To ensure as much CWR as practical was placed on Stage 1 before Stage 2 commenced, GHD–LongMac were engaged in 1999 to review the Sinclair Knight emplacement height limit of 24m. GHD recommended that the material parameters would not impede raising the emplacement to a height in excess of 30m. As a consequence of this recommendation the design height of the northern (unfinished) end of the stage was raised an additional 8m. Surface Table drains and formation batters were revised to accommodate the additional refuse fill.

The modified formation provided space for an additional 2.7Mt of CWR to be added to emplacement.

4.0 STEPS TAKEN TO INCREASE STAGE 2 CAPACITY

Following the GHD-LongMac review of the emplacement height limitation, various options were examined to increase the amount of CWR that could be emplaced in Stage 2 by increasing the height of the formation. The study recommendations provided for additional fill height but the emplacement footprint area was still limited by the size, location and level of BC 1.

This limitation was nullified by the connection of a stormwater drain from the small valley where BC 1 is situated to the Brennans Creek by-pass channel. The pipeline provided an alternative to drainage from BC 1 flowing around the western perimeter of the emplacement formation. This allowed the emplacement footprint to be widened on the western side to the by-pass drain and the fill to be raised above the BC 1 site level. The modified formation provided space for an additional 5.75Mt (approximately) of CWR to be added to emplacement.

5.0 OPTIONS TO FURTHER INCREASE CAPACITY OF EMPLACEMENT

5.1 Options for Additional Capacity in Stage 1

The lower northern benches of Emplacement Stage 1 is in the process of being re-opened for additional deposition of CWR as part of the southern extremity of Stage 2.

The option to re-open a major part of Emplacement Stage 1 for further CWR deposition would adversely impact on a currently overtaxed surface water drainage system. Pond P4 is designed to contain overflow from the mine site retention pond system and run-off from a 17ha area disturbed by CWR emplacement operations following a design storm event. The current active emplacement area covers a considerably greater area. Any further expansion of emplacement operations, without finishing and rehabilitating equivalent areas, would increase the risk of non-compliance with pollution control guidelines.

Dirty water run-off from the re-activated emplacement operation would need to be directed into the site drainage system via Pond P1 to avoid disturbing the existing active emplacement area on Stage 2.

In addition 5 years of regenerated tree growth on the Stage area would be lost.

Mark Beale has recently agreed to a review of the mine site clean and dirty water drainage system. The review will examine the existing stormwater and process water drainage and treatment systems and the changed circumstances bought about by the continued development of surface infrastructure, increase in mine production and expansion of the CWR emplacement deposition area.

5.2 Options for Additional Capacity in Stage 2

5.2.1 Increase Width of Emplacement

A recent modification to the method used to develop the emplacement side batter slopes would, in certain circumstances, provide additional emplacement capacity. Currently a 10m wide temporary perimeter drain is established at the toe of the emplacement formation batter. This drain initially intercepts dirty water run-off from the deposition operations and directs it into the emplacement detention pond (P4). After the area is regenerated the drain is converted to clean water flow and diverted into adjacent by-pass drains.

The modified procedure involves covering the CWR side batter slope with topsoil as the formation is being developed so only clean water flows from the side of the emplacement. This arrangement allows run-off water to flow almost directly into the permanent by-pass drain thus eliminating the need for a temporary perimeter drain. The modification can only be applied on the western side of the emplacement as separate clean and dirty water perimeter drains will be permanently required on the eastern side. This emplacement procedure is currently being implemented and will permit the emplacement fill to be widened in this area by up to 10m. The modification will provide emplacement space for a further 1.7Mt of CWR.

For this emplacement method to be fully implemented it will be necessary to have stocks of soil material available to cover the emplacement batters as they are being developed. An existing source is the spoil from the Brennans Creek by-pass drain excavation. The recovery of all of this material would be necessary and will add to emplacement area costs.

The availability of sufficient quantities of suitable soil material to cover the completed emplacement formation will be an ongoing problem as it is a scarce commodity on the site. It will be important to recover as much soil as possible from the stripping operations and distribute it carefully.

5.2.2 Increase Height of Emplacement

In 2005 detail planning for the east-west table drain adjacent to BC 1 was modified to provide a higher finished surface profile for an area of the emplacement opposite the No2 Coal Stockpile. The modification will provide emplacement space for a further 0.33Mt of CWR.

As a result of the emplacement height limitation being raised and the installation of a separate stormwater drain from BC 1 aboriginal site the design height of Stage 2 was generally increased. The current layout includes areas where the fill formation will reach a height of 54m.

The GHD-LongMac study that recommended the formation could “exceed 30m in height” was undertaken with CWR being sourced from West Cliff Mine and Appin Colliery. As the planned formation height significantly exceeds the 30m figure and the majority of CWR is now sourced from Dendrobium workings it would be appropriate to review the height limits again before a decision to further raise the formation height, to obtain additional emplacement volume, was made.

Mark Beale has recently agreed to engage GHD-LongMac to again review the height limit based on the change in CWR product and the current deposition technique. The review will also assess the impact of the increased overburden on ground water pipes, pits and formation stability.

5.2.3 Increase Emplacement Batter Grades

As the planned Emplacement Stage 2 footprint extends across the full width of Brennans Creek valley from the by-pass drain to the mine infrastructure area and the formation height limit is being reviewed, the only remaining option to increase the deposition capacity is to change the finished surface contour design parameters. Previous capacity modifications have been made without changing these guidelines.

Even with the current slope guidelines erosion occurs on the emplacement if particular attention is not placed on batter protection and grade control of stormwater run-off paths across the emplacement area. A general steepening of batter slopes and table drain grades will only increase erosion, scouring and sedimentation impacts. The large surface areas of emplacement batters and the extensive lengths of run-off drain would require considerable effort and materials to effectively control erosion after significant rainfall.

Protection of the clean water drainage system from contamination is also at significant risk if large-scale erosion was to occur. It is recommended that the emplacement batter slops and drain grades used to develop the emplacement area to date be maintained.

6.0 SUMMARY OF CWR EMPLACEMENT CAPACITY

MODIFICATIONS TO PLANNED EMPLACEMENT FORMATION		**ESTIMATED EMPLACEMENT CAPACITY**
STAGE 1		
1	Planned emplacement capacity	1.9Mt
2	Stage capacity increased following revision of the formation height limitation.	2.7Mt
Total Stage 1		**4.6Mt**
STAGE 2		
1	Initial planned emplacement capacity	9.25Mt
2	Planned increase in capacity following revision of the formation height limitation & installation of BC 1 drain.	5.75Mt
3	Planned increase in capacity following revision of surface table drain opposite BC 1.	0.33Mt
4	Planned increase in capacity following revision of western perimeter drain arrangement.	1.7Mt
Total Stage 2		**17.0Mt** (Subject to final design of Stage 2.)

APPENDIX D2: Review of options to increase Stage 2

DETAILS SHOWN ON FIGURE 1
(November 2006)

Figure 1 Shows:

1. Revised Stage 2 Emplacement shape.

2. Emplacement surface contours at 0.5m intervals

3. Emplacement surface grades generally 1 in 4 and 1 in 3.

4. Table drains, “V” shaped 10m wide at variable grades, flow direction shown

5. Location of ground water drain and planned route through Pond P4

6. Brennans Creek Diversion Drain and clean water cutoff drains

P3
P4
P2
P1
NORTH SITE
WEDDERBURN
ROAD
No.1 STOCKPILE
No.2 STOCKPILE
No.3 STOCKPILE
STAGE 2
STAGE 1
BULLI\APPIN
ROAD
FIGURE-1
20 0 20 40 60 80 100
SCALE OF METRES
J.S
S.P.
10.11.06
6\25 VICTORIA ST
WOLLONGONG
NSW 2500
PH:42 283144
FAX:42 283155
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oec
CAD
OLSEN ENVIRONMENTAL CONSULTING
WEST CLIFF MINE
GENERAL LAYOUT STAGE 2 REFUSE EMPLACEMENT
FINAL CONTOURS AND GENERAL GRADES
DP-3551A

DETAILS SHOWN ON FIGURE 2
(November 2006)

<u>Figure 2 Shows:</u>

1. Section through emplacement formation

2. Natural GL generally along floor of Brennans Creek valley

3. Finished level of emplacement when surveyed in July 2006

4. Finished level of the completed emplacement as planned in 2000

5. Finished level of the completed emplacement as revised in 2006

6. Table showing the emplacement volume when surveyed in July 2006, as planned in 2000 and revised in 2006.

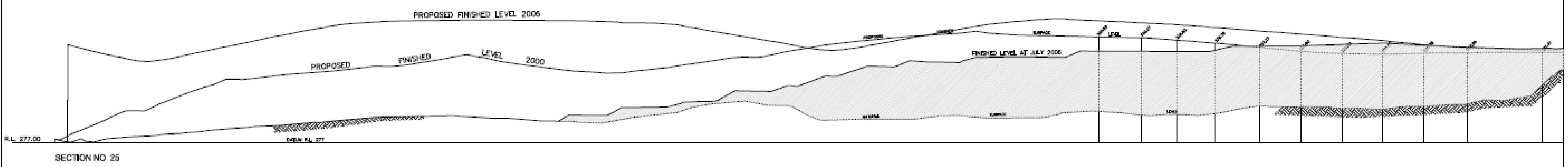
THE PROPOSED CAPACITY OF EMPLACEMENT STAGE 2 WHEN PLANNED IN 2000 WAS 15.0Mt

IF THE EMPLACEMENT FILL HEIGHT IS INCREASED OVER THE GROUND WATER DRAIN & THE FORMATION AND TABLE DRAINS ARE MADE GENERALLY STEEPER THE REVISED CAPACITY IS 20.8Mt

IF THE EMPLACEMENT IS REVISED TO 20.8Mt THE REMAINING FILL CAPACITY OF STAGE 2 IS 14.7Mt

IF DEVELOPMENT INTO STAGE 3 WERE DELAYED FOR AN EXTENDED PERIOD OF TIME STAGE 2 WOULD BE COMPLETED IN APPROXIMATELY
4.9 (plus) years

- The rate at which refuse could be emplaced during the final 3 years of this 4.9 (plus) year period would be reduced due to the gradually contracting deposition area.



SECTION NO 25

FILL CAPACITY OF EMPLACEMENT	
VOLUME OF REFUSE EMPLACED AT LAST SURVEY (4\07\06)	6.1 Mt
ORIGINAL DESIGN CAPACITY OF STAGE 2 (YEAR 2000)	15.0 Mt
REVISED DESIGN CAPACITY OF STAGE 2 (YEAR 2006)	20.8 Mt

FIGURE–2

DESIGN J.S	DATE	THIS DRAWING & ALL INFORMATION THEREIN (INCLUDING ALL COPYRIGHT RESIDING THEREIN) IS THE PROPERTY OF OLSEN ENVIRONMENTAL CONSULTING WOLLONGONG N.S.W. AND IS CONFIDENTIAL AND MUST NOT BE MADE PUBLIC OR COPIED. IT IS LOANED ON THE CONDITION THAT IT WILL BE RETURNED UPON DEMAND AND IS NOT TO BE USED DIRECTLY OR INDIRECTLY IN ANY WAY DETRIMENTAL TO OUR INTEREST.	oec
DRAWN S.P.	DATE 10.11.06		
6\25 VICTORIA ST WOLLONGONG NSW 2500 PH:42 283144 FAX:42 283155			CAD

OLSEN ENVIRONMENTAL CONSULTING

WEST CLIFF MINE
GENERAL LAYOUT STAGE 2 REFUSE EMPLACEMENT
LONGITUDINAL SECTION THROUGH EMPLACEMENT

SDR No:	SCALE:	DRAWING No: DP-3551B	REV:

20 0 20 40 60 80 100
SCALE OF METRES

DETAILS SHOWN ON FIGURE 3
(November 2006)

<u>Figure 3 Shows:</u>

Section through emplacement formation

1. Natural GL generally along floor of Brennans Creek valley

2. Finished level of emplacement when surveyed in July 2006

3. Finished level of the completed emplacement as revised in 2006

4. Fill bench development profile that represents the point at which the emplacement must advance into Stage 3 to maintain the required minimum area for deposition operations

---

IT WILL BE NECESSARY TO ADVANCE INTO STAGE 3 WHEN THE LAST AREA AVAILABLE FOR REFUSE DEPOSITION ON STAGE 2 IS APPROXIMATELY 26ha

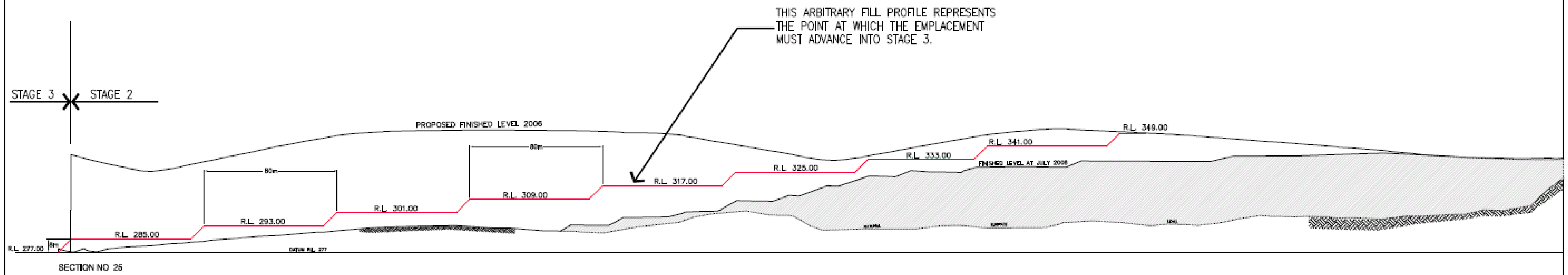
THE VOLUME OF REFUSE THAT CAN BE DEPOSITED ON THE EMPLACEMENT BEFORE IT IS NECESSARY TO ADVANCE INTO STAGE 3 IS 5.7Mt

AT CURRENT DEPOSITION RATES (0.25Mt/month**) THE 5.7Mt OF REFUSE WILL BE EMPLACED IN APPROXIMATELY** 1.9 years

- An area of approximately 26ha is required by the emplacement contractor to tip, dry, spread and compact the coal refuse being delivered to the site.

- The area available to the emplacement contractor for refuse deposition has a direct impact on the time Dendrobium refuse has to dry before access onto the area is required for further emplacement.

- Truck access onto areas of Dendrobium refuse before sufficient drying has occurred is unsafe and further deposition impractical until the material is firm enough to support truck movements.



SECTION NO 25

FIGURE–3

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S.P.	10.11.06		
6\25 VICTORIA ST WOLLONGONG NSW 2500 PH:42 283144 FAX:42 283155			CAD

OLSEN ENVIRONMENTAL CONSULTING

WEST CLIFF MINE

GENERAL LAYOUT STAGE 2 REFUSE EMPLACEMENT
LONGITUDINAL SECTION THROUGH EMPLACEMENT
SHOWING 80m x 8m BENCH DEVELOPMENT

DRAWING No: DP-3551C

DETAILS SHOWN ON FIGURE 4
(November 2006)

Figure 4 Shows:

1. Footprint of Emplacement Stage 2
2. Plan view of the emplacement area to be rehabilitated in early 2007
3. Plan view of indicative fill bench development that represents the point at which the emplacement must advance into Stage 3

THE PREPARTION OF EACH NEW DEPOSITION BENCH (eg 80m to 100m wide**) TO ADVANCE THE EMPLACEMENT FORMATION DOWN THE VALLEY TAKES APPROXIMATELY:** 2 to 3 Months

- A longer preparation period should be allowed where the emplacement advances over Pond P4 as considerably more work will be required to isolate sections of the pond and remove the sludge and unsuitable material from the storage area.

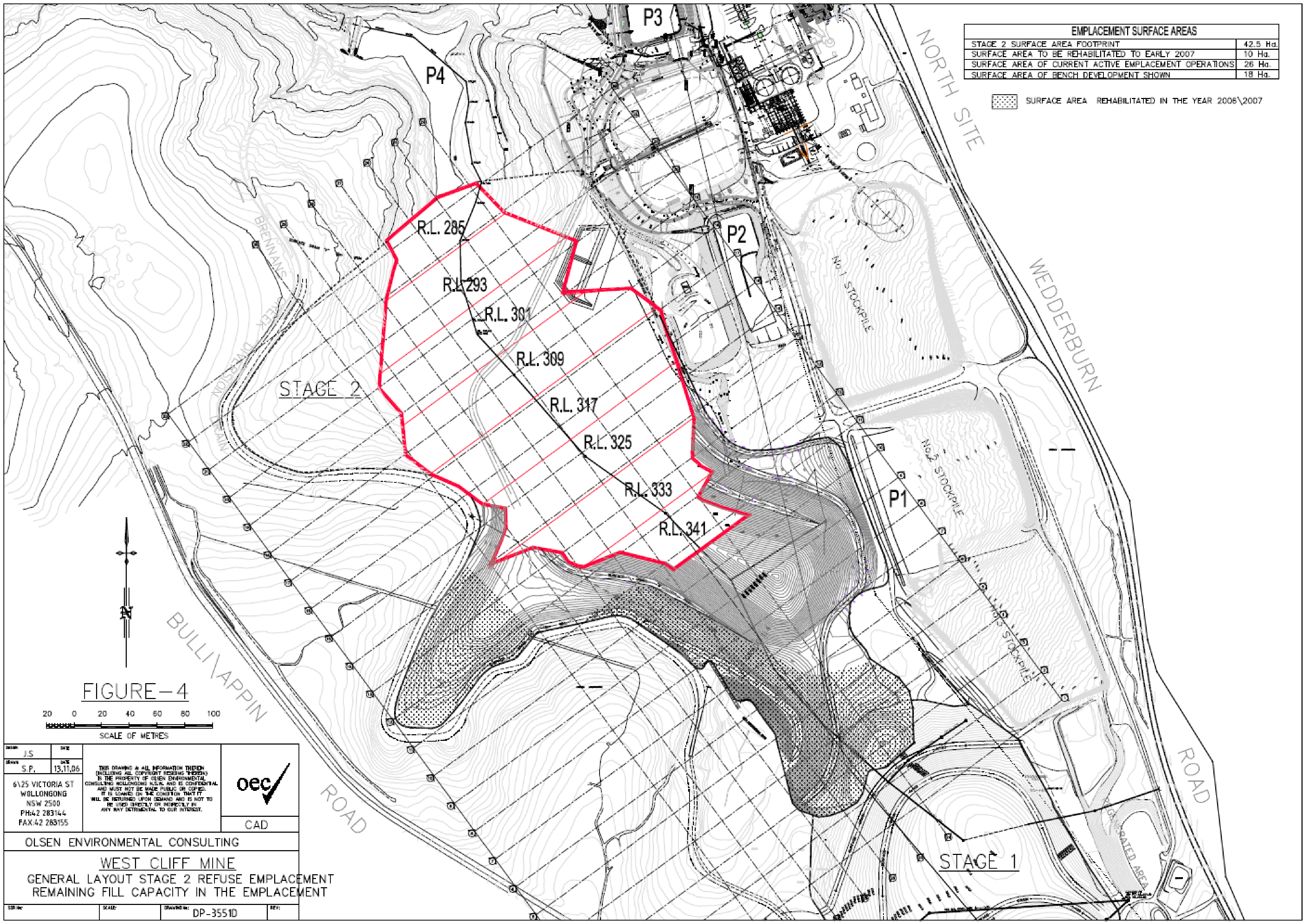
THE APPROXIMATE LEAD TIME REQUIRED BEFORE IT WILL BE NECESSARY TO ADVANCE THE EMPLACEMENT INTO STAGE 3 IS:

- Place 5.7Mt of refuse to bring the emplacement level up to the indicative bench development profile 1.9 years
- Prepare the first fill bench in Stage 3 0.2 years
- Base date for volume estimates July 2006 0.3 years
- Lead time available (approximately) 1.4 years

THE MAJOR DEVELOPMENT WORKS THAT NEED TO BE ADDRESSED WHEN DEPOSITION OF REFUSE EXTENDS INTO STAGE 3 AND BEGINS TO OVERTAKE POND P4 INCLUDES:

- Revision of emplacement haul road system
- Construction of Pond to augment and eventually replace P4
- Extension of east and west clean water cut off drains
- Extension of Brennans Creek diversion drain
- Relocation of slimes settling ponds

- Revision of mine site and emplacement drainage systems to accommodate catchment changes and comply with EPA licence requirements.


EMPLACEMENT SURFACE AREAS
STAGE 2 SURFACE AREA FOOTPRINT 42.5 Ha.
SURFACE AREA TO BE REHABILITATED TO EARLY 2007 10 Ha.
SURFACE AREA OF CURRENT ACTIVE EMPLACEMENT OPERATIONS 26 Ha.
SURFACE AREA OF BENCH DEVELOPMENT SHOWN 18 Ha.
SURFACE AREA REHABILITATED IN THE YEAR 2006\2007
P3
P4
P2
P1
NORTH SITE
WEDDERBURN ROAD
BULLI\APPIN ROAD
STAGE 2
STAGE 1
No 1 STOCKPILE
No 2 STOCKPILE
R.L. 285
R.L. 293
R.L. 301
R.L. 309
R.L. 317
R.L. 325
R.L. 333
R.L. 341
N
FIGURE-4
20 0 20 40 60 80 100
SCALE OF METRES
J.S
S.P. 13.11.06
6\25 VICTORIA ST
WOLLONGONG
NSW 2500
PH:42 283144
FAX:42 283155
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CAD
OLSEN ENVIRONMENTAL CONSULTING
WEST CLIFF MINE
GENERAL LAYOUT STAGE 2 REFUSE EMPLACEMENT
REMAINING FILL CAPACITY IN THE EMPLACEMENT
DP-3551D

APPENDIX E: Coal Wash data and product specification: fill

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Processing & Logistics

November 2006

Introduction

Coal Wash is the non-carbonaceous fraction from the processing of Run of Mine (ROM) coal to produce coking and energy coal. Depending on coal seam properties and Coal Washing technologies, Coal Wash yield may be up to 40% of the ROM coal mined. Coal Wash composition is dependant on the depositional environment in which the coal seam was laid, however it is primarily comprised of soft sedimentary rock, clay, silt, sand and a small amount of residual coal. Occasionally, some igneous rock intrusions are mined and are present in Coal Wash. Coal Wash is currently emplaced in purpose built landfills on or close to mining operations. Coal Wash has been successfully used as select fill for residential subdivisions in the Illawarra, fill for rehabilitating industrial and mine sites, and for limited commercial applications such as brick making. Illawarra Coal is pursuing a range of alternatives to Coal Wash emplacement in order to maximise the beneficial use of Coal Wash. One promising alternative is the use of Coal Wash for civil fill. To succeed in the development of using Coal Wash as fill, it is necessary that Coal Wash be considered as a fill product where it meets appropriate quality specifications. T6 facilitate its use as a general fill product, Coal Wash must not be considered as a waste.

Waste Regulatory regime

Coal Wash is in essence clay and rock that has been separated from excavated natural material (run of mine coal) using specific gravity separation techniques. The Coal Wash produced by Illawarra Coal is not contaminated with manufactured chemicals or sulfidic minerals. Coal Wash is not mixed with any other wastes. As such, Coal Wash has been assessed and classified in accordance with the Waste Guidelines as inert waste.

Waste Facilities

Coal Wash is not explicitly defined as a waste in the POEO Act waste definitions. Coal Washery reject landfill sites that receive over 20,000 tonnes per year are Scheduled as a Waste Facility by the POEO Act. However, the following premises are not classified as waste facilities:

- premises where Coal Washery reject (and no other type of waste) is disposed of on site,
- premises where only Coal Washery reject are used solely for the purpose of road or railway construction.

The POEO Act appears to support the use of Coal Wash for road and railway construction, whilst imposing a licensing requirement for off-site Coal Wash landfills. Imminent changes to the Protection of the Environment Operations (Waste) Regulation will facilitate the development of a fit for purpose specification of Coal Wash generated by Illawarra Coal, which will remove Coal Wash from consideration and regulation as a waste where it is used for a defined purpose.

What is coal and Coal Wash?

Coal is a combustible, sedimentary, organic rock formed from ancient vegetation, which has been consolidated between other rock strata and transformed by the combined effects of microbial action, pressure and heat over a considerable time period. This process is referred to as 'coalification'. Layered between other sedimentary rocks, coal is found in seams ranging from less than a millimetre in thickness to many metres.

Coal is composed mainly of carbon (50-98%), hydrogen and oxygen, and smaller amounts of nitrogen, sulphur and other elements. It also contains a little water and grains of inorganic matter that remain as a residue known as ash when coal is burnt.

Initially peat, the precursor of coal, was converted into lignite or brown coal - coal types with low organic 'maturity'. Over many more millions of years, the continuing effects of temperature and pressure produced additional changes in the lignite, progressively increasing its maturity and transforming it into the range known as sub-bituminous coals.

As this process continued, further chemical and physical changes occurred until these coals became harder and more mature, at which point they are classified as bituminous or hard coals.

Large coal deposits only started to be formed after the evolution of land plants in the Devonian period, some 400 million years ago. Significant accumulations of coal occurred during the Carboniferous/Permian period (350-225 million years ago) in Australia. The black coals found in the NSW Southern Coal Fields were formed between 225 and 180 million years ago. The black coal mined by BHP Billiton Illawarra Coal consist of the Bulli and Wongawilli seams. The stratigraphy of the Southern coal measures is shown in Figure 1.

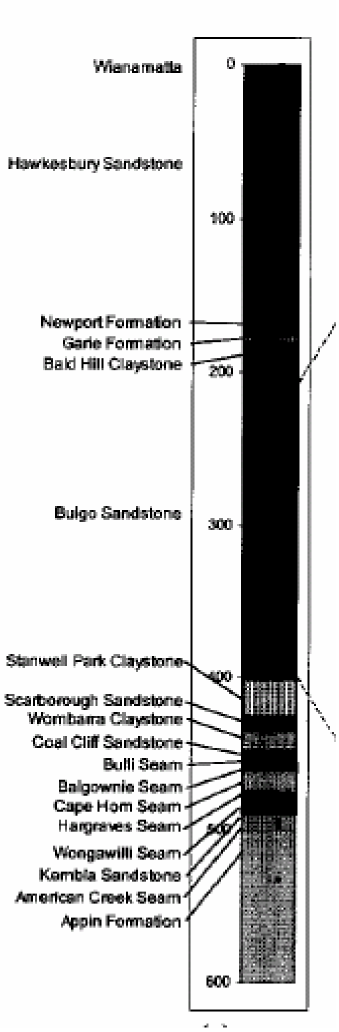


Figure 1: Stratigraphy of the Southern coal measures

Coal Mining and Coal Preparation

BHP Billiton - Illawarra Coal operates five underground coal mines. The Appin, West Cliff and Douglas Park Mines extract the Bulli coal seam, whereas the Dendrobium and Delta mines extract Wongawilli seam coal. All Illawarra Coal mines extract ROM coal using longwall mining techniques. Longwall mining involves the use of mechanised shearers to cut and remove the coal at the face, which can vary in length from 100-300 m.

Self-advancing, hydraulic-powered supports temporarily hold up the roof whilst the coal is extracted. The roof over the area behind the face, from which the coal has been removed, is then allowed to collapse. Over 75 per cent of the coal in the deposit can be extracted using this method.

Coal preparation refers to the treatment of ROM coal to enhance its suitability for particular end-uses. The extent and method of treatment depends on the properties of the coal and its intended purpose. It may require only simple crushing or it may need to go through a treatment process to reduce the inorganic mineral impurities.

Around 80 percent of all coal mined, and most of the black coal destined for export in Australia, is washed to provide a twofold advantage:

- it upgrades the quality of the coal; and
- it improves the economics of transportation by removing most of the non-combustible material

All ROM coal mined by Illawarra Coal is washed. Three main products streams result from the Coal Washing process, including: coking coal, energy coal and Coal Wash. Small amounts of jig coal are produced at the West Cliff Coal Preparation Plant.

Coal Processing

Illawarra Coal Washes and blends its coal at coal preparation plants at West Cliff and the Dendrobium Washery at Port Kembla.

The ROM coal is elevated to raw coal storage bins in preparation for processing through the Coal Preparation Plant's coal treatment modules. Within the plant, coal is sorted and cleaned according to 3 size fractions - coarse coal, small coal, and fine coal.

Coarse coal is fed to a three-product, two-stage heavy media dense medium bath containing a magnetite suspension that acts as a heavy media separation agent separating coking coal, energy coal and Coal Wash. Magnetite (Fe_3O_4) is a fine black magnetic powder that has high specific gravity. The separation in this unit occurs because of the differential densities of the three products. Small coal is processed in two parallel circuits of two stage dense medium cyclones. Here the primary cyclones separate the raw coal feed into coking coal and raw middlings. The raw middlings then becomes feed for the secondary cyclone circuits where energy coal and Coal Wash become the products.

The fine raw coal is processed by flotation cells. Here a slurry of coal and water is aerated to generate bubbles where the surface properties of the coal differentiate themselves from that of the tailings thereby enabling separation into a coking coal fraction and a Coal Wash stream. The coking coal slurry is dewatered on both horizontal and drum vacuum filters. The fine Coal Wash steam is thickened and dewatered. All streams of coking coal, energy coal and the Coal Wash are separated and dispatched to customers via product bins.

A process schematic of the Dendrobium and West Cliff Coal Preparation Plants are shown in Figures 1 and 2 respectively.

Figure 1: **Dendrobium Coal Preparation Plant**

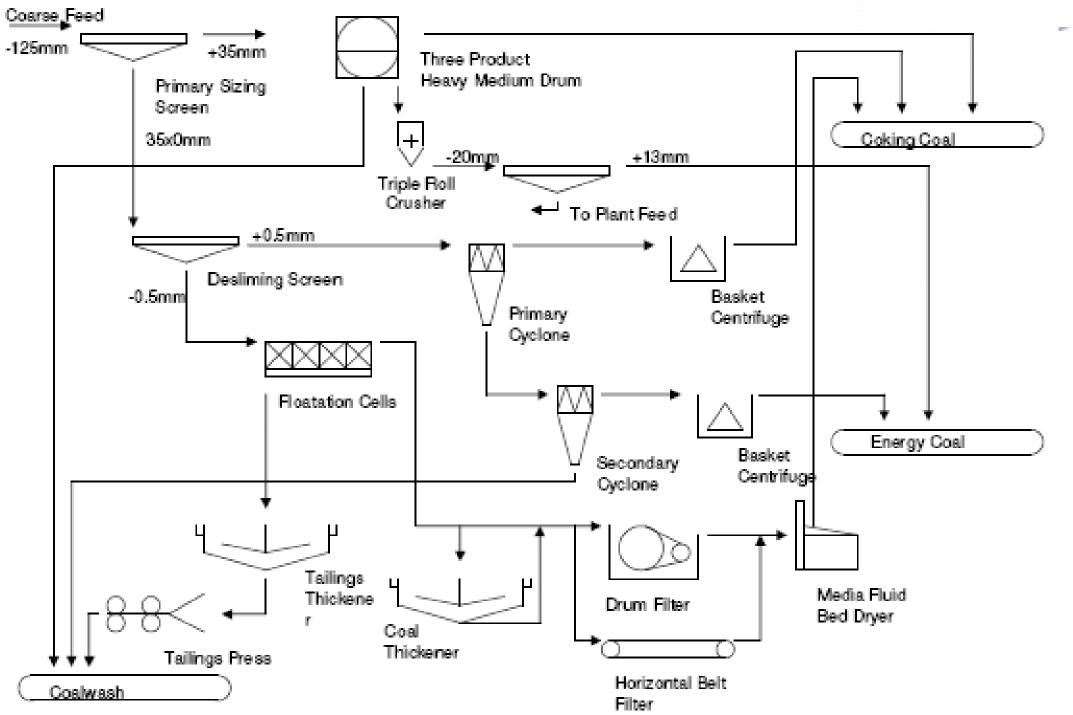
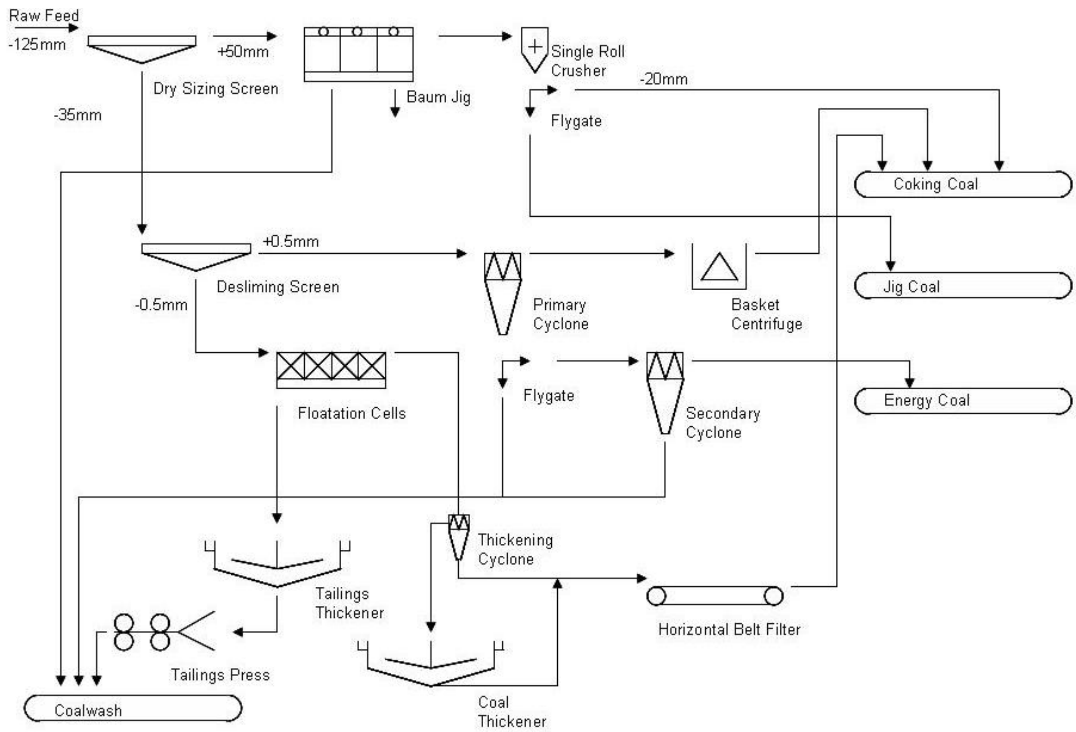


Figure 2: **West Cliff Coal Preparation Plant**



HISTORICAL USES OF COAL WASH FOR CIVIL PURPOSES

Coal Wash originating from the Bulli and Wongawilli seams has been successfully used for civil purposes in the Illawarra. Wollongong City Council have prepared the *Technical Policy 2.40 New Coal Washery Refuse in Subdivisions* to specify the manner in which Coal Wash must be managed to form a stable landform for residential purposes. This technical Policy is provided in Appendix B. Examples of these applications include; residential development (Pioneer Beach Estate – Woonona East, Haywards Bay – Yallah) and industrial rehabilitation projects (Bluecope Steel – No3 battery, noise barriers). BHP Illawarra Coal's former Coal Wash emplacement at Wongawilli has been constructed in accordance with Wollongong City Council's Technical Policy and is currently being considered for residential development purposes.

Plate 1: Haywards Bay Estate

Plate 2: Pioneer Estate

COAL WASH CHEMICAL AND PHYSICAL PROPERTIES

Sampling and testing program

A program of representative sampling from both the West Cliff and Dendrobium Coal Preparation Plants was undertaken during April-May 2006 to determine the chemical and physical properties of the Coal Wash. The sampling and analysis program for both coal preparation plants is shown in Tables 1 and 2. All Coal Wash generated at the Dendrobium Coal Preparation Plant reports to the one Coal Wash loading bin. Coal Wash generated at West Cliff is separated into two streams, "bin" which is the course fraction and "beltpress" which is the very fine fraction.

Laboratory data sheets are provided in Appendix A. A photo showing the colour and physical nature of Coal Wash is shown in Plate 3.

Plate 3: Appearance of Coal Wash

Table 1: Dendrobium Coal Preparation Plant Coal Wash Testing Regime

Chemical tests	Test method	Total	No. of samples per stream
Proximate analysis		✓	3 daily samples each week for 3 weeks
Soil moisture content	AS 1289.2.1.1	✓	3 daily samples each week for 3 weeks
Energy value	GCV	✓	3 daily samples each week for 3 weeks
Other chemistry	Phosphorus	✓	1 composite sample each week for 3 weeks
Ultimate analysis	C, H, S, N	✓	1 composite sample collected over 3 weeks
Ash analysis		✓	1 composite sample collected over 3 weeks
Trace elements	Full list – ICP-MS	✓	1 composite sample collected over 3 weeks
Radionuclides		✓	1 composite sample collected over 3 weeks
Elemental scan		✓	1 composite sample collected over 3 weeks
Crystalline silica		✓	1 composite sample collected over 3 weeks

Physical tests	Test method	Total	No. of samples per stream
Sizing	AS 1141.11/12 or AS 1289.3.6.1 +	✓	3 daily samples each week for 3 weeks
Artificial weathering		✓	1 composite sample collected over 3 weeks
Triaxial shear strength		✓	1 composite sample collected over 3 weeks
Adiabatic self heating		✓	1 composite sample collected over 3 weeks
pH		✓	1 composite sample collected over 3 weeks
Soil conductivity		✓	1 composite sample collected over 3 weeks
Dry density / moisture content relationship	AS 1289.5.1.1 and AS 1289.5.1.2	✓	1 composite sample collected over 3 weeks
Atterberg limits	AS 1289.3.1.1 and AS 1289.3.2.1	✓	1 composite sample collected over 3 weeks
Californian Bearing Ratio	AS1289.6.1.1	✓	1 composite sample collected over 3 weeks

+ sizing test to include 150mm and 200mm in addition to the range specified in AS 1141.11 and AS 1141.12

Table 2: West Cliff Coal preparation Plant Coal Wash Testing Regime

Chemical tests	Test method	Beltpress	Bin	No. of samples per stream
Proximate analysis		✓	✓	1 daily samples each week for 3 weeks
Soil moisture content	AS 1289.2.1.1	✓	✓	1 daily samples each week for 3 weeks
Energy value	GCV	✓	✓	1 daily samples each week for 3 weeks
Other chemistry	Phosphorus	✓	✓	1 composite sample each week for 3 weeks
Ultimate analysis	C, H, S, N	✓	✓	1 composite sample collected over 3 weeks
Ash analysis		✓	✓	1 composite sample collected over 3 weeks
Trace elements	Full list	✓	✓	1 composite sample collected over 3 weeks
Radionuclides		✓	✓	1 composite sample collected over 3 weeks
Elemental scan		✓	✓	1 composite sample collected over 3 weeks
Crystalline silica		✓	✓	1 composite sample collected over 3 weeks

Physical tests	Test method	Beltpress	Bin	No. of samples per stream
Sizing	AS 1141.11/12 or AS 1289.3.6.1 +	✓	✓	1 daily sample each week for 3 weeks
Artificial weathering			✓	1 composite sample collected over 3 weeks
Triaxial shear strength			✓	1 composite sample collected over 3 weeks
Adiabatic self heating			✓	1 composite sample collected over 3 weeks
pH			✓	1 composite sample collected over 3 weeks
Soil conductivity			✓	1 composite sample collected over 3 weeks
Dry density / moisture content relationship	AS 1289.5.1.1 and AS 1289.5.1.2		✓	1 composite sample collected over 3 weeks
Atterberg limits	AS 1289.3.1.1 and AS 1289.3.2.1		✓	1 composite sample collected over 3 weeks
Californian Bearing Ratio	AS1289.6.1.1		✓	1 composite sample collected over 3 weeks

+ sizing test to include 150mm and 200mm in addition to the range specified in AS 1141.11 and AS 1141.12

Chemical properties of Coal Wash

The chemical properties of Coal Wash from both Coal Preparation Plants is described in Tables 3 and 4. Where relevant, these data are compared to the inert waste contaminant threshold values for waste classification of non-liquid wastes with leachate test (see Table A4 SCC1 and TCLP1 values – EPA Environmental Guidelines: Assessment, Classification and Management of Liquid and Non-liquid Wastes).

Table 3: Contaminant Concentrations of West Cliff Coal Wash

(a) Trace element chemical contaminants

Contaminant	Bin (mg/kg)	Beltpress (mg/kg)	Inert waste SCC1 (mg/kg)	Bin reject TCLP (mg/l)	Beltpress TCLP (mg/l)	Inert TCLP1 (mg/l)
Arsenic	4.0	1.9	500	<0.05	<0.05	0.5
Beryllium	2.0	2.0	100	<0.1	<0.1	0.1
Chromium (total)	51	31	1900 Cr (VI)	<0.05	<0.05	0.5 Cr (VI)
Cadmium	0.21	0.13	100	<0.01	<0.01	0.1
Lead	21	15	1500	<0.05	<0.05	0.5
Mercury	0.14	0.17	50	<0.001	<0.001	0.02
Molybdenum	4	4	1000	<0.1	<0.1	0.5
Nickel	29	22	1050	<0.05	<0.05	0.2
Selenium	0.8	0.7	50	<0.1	<0.1	0.1
Silver	0.27	0.13	180	<0.05	<0.05	0.5
Antimony	1.3	2.1				
Barium	340	720				
Bismuth	0.48	0.39				
Boron	34	22				
Bromine	<8.7	14				
Cobalt	6	5				
Copper	96	28				
Gold	0.009	0.015				
Indium	<0.1	<0.1				
Iodine	<4.5	2.5				
Iridium	0.023	0.035				
Manganese	370	280				
Osmium	<0.002	<0.002				
Palladium	0.023	0.005				
Platinum	0.065	0.001				
Rhodium	0.015	0.010				
Rubidium	56	21				
Ruthenium	0.032	0.007				
Scandium	16	11				
Strontium	110	260				
Tellurium	<0.10	<0.1				
Thallium	0.48	0.26				
Tin	7	3				

Titanium	3900	2500			
Vanadium	57	46			
Zinc	42	36			
Crystalline silica (%)	<0.01	3.0			

(b) Major element chemical composition

Ultimate analysis	**Bin %**	**Beltpress %**
Carbon	27.02	
Hydrogen	1.89	
Sulfur	0.03	
Nitrogen	0.53	

(c) Physio-chemical composition

Property	**Bin**	**Beltpress**
Total Moisture (%)	7.2	33.8
Volatile Matter (%)	13.6	18.6
Ash (%)	66.6	42.5
Calorific value (kcal/kg)	2116	4375
Relative ignition temperature (^{o})	>200	NA
Total Sulfur (%)	0.06	0.20
Phosphorus (%)	0.043	0.112
Combustible content (%)	29.7	36.6
Electrical conductivity (µS/cm)	410	NA
pH	10.1	10.0

(d) Ash analysis

Ash analysis (%)	**Bin reject**	**Beltpress reject**
SiO_2	61.2	54.2
Al_2O_3	24.6	26.5
Fe_2O_3	5.4	7.5
CaO	2.3	4.0
MgO	1.1	1.1
Na_2O	0.34	0.48
K_2O	2.5	2.2
TiO_2	1.0	0.98
Mn_3O_4	0.11	0.11
P_2O_5	0.16	0.64
SO_3	0.44	1.0
BaO	0.08	0.22
SrO	0.03	0.10
ZnO	<0.02	<0.02
V_2O_5	0.02	0.04

(e) Radionuclides

Radionuclide	Bq/kg
Pb-210	52
Pb-212	49
Pb-214	54
Ac-228	53
K-40	450

Table 4: Contaminant Concentrations of Dendrobium Coal Wash

(a) Trace element chemical contaminants

Contaminant	Bin (mg/kg)	Inert waste SCC1 (mg/kg)		Bin TCLP (mg/l)	Inert waste TCLP1 (mg/l)
Arsenic	5.7	500		<0.05	0.5
Beryllium	2	100		<0.1	0.1
Chromium (total)	12	1900 as Cr (VI)		<0.05	0.5 Cr (VI)
Cadmium	0.21	100		<0.01	0.1
Lead	21	1500		<0.05	0.5
Mercury	0.10	50		<0.001	0.02
Molybdenum	8	1000		<0.1	0.5
Nickel	16	1050		<0.05	0.2
Selenium	0.7	50		<0.1	0.1
Silver	0.41	180		<0.05	0.5
Antimony	0.6				
Barium	180				
Bismuth	0.48				
Boron	41				
Bromine	7.4				
Cobalt	2				
Copper	160				
Gold	8				
Indium	<0.1				
Iodine	<4.5				
Iridium	0.025				
Manganese	620				
Osmium	<0.002				
Palladium	0.070				
Platinum	0.061				
Rhodium	0.039				
Rubidium	25				
Ruthenium	0.055				
Scandium	11				
Strontium	99				
Tellurium	<0.1				
Thallium	0.34				
Tin	17				

Titanium	2500			
Vanadium	22			
Zinc	46			
Crystalline silica (%)	<0.01			

(b) Major element chemical composition

Ultimate analysis	**%**
Carbon	24.33
Hydrogen	1.90
Sulfur	0.23
Nitrogen	0.55
Phosphorus	0.015

(c) Physio-chemical composition

Parameter	**Total (%)**
Total Moisture content	12.0
Volatile Matter	14.4
Ash	65.6
Calorific value (kcal/kg)	2286
Relative ignition temperature (^{o})	>200
Combustible content	26.1
Electrical conductivity (µS/cm)	163
pH	9.6

(d) Ash analysis

Chemical composition	**Dendrobium Total (%)**
SiO_2	65.0
Al_2O_3	24.1
Fe_2O_3	6.5
CaO	0.39
MgO	0.72
Na_2O	0.32
K_2O	1.2
TiO	0.68
Mn_3O	0.15
P_2O_5	0.05
SO_3	0.16
BaO	0.05
SrO	0.02
ZnO	<0.02
V_2O_5	<0.02

(f) Radionuclides

Radionuclide	Bq/kg
Pb-210	<30
Pb-212	50
Pb-214	44
Ac-228	56
K-40	200

Physical properties of Coal Wash

A summary of the physical properties of Coal Wash from both Coal Preparation Plants is described in tables 5 and 6. Where relevant, these data are compared to the engineering specifications described in the Specification for *Supply of Recycled Material for Pavements, Earthworks & Drainage* (‘*the Greenspec*’) for select fill.

Table 5: West Cliff Coal Wash Physical Properties

(a) Sampled moisture content

Average Moisture Content	Bin	Beltpress
% (gravimetric moisture content)	7.2	33.8

(b) Particle Size Distribution

Sizing (mm)	Bin (%)	Beltpress (%)
+200	0	
-200 + 150	0	
-150 + 75	1.55	
-75 + 63	1.41	
-63 + 37.5	10.85	
-37.5 + 25.0	11.82	
-25.0 + 19.0	7.59	
-19.0 + 11.2	16.71	
-11.2 + 8.0	8.42	
-8.0 + 6.3	5.80	
-6.3 + 4.0	8.59	
-4.0 + 2.8	3.27	
-2.8 + 2.0	3.99	
-2.0 + 1.18	5.13	1.28
-1.18 + 0.6	5.03	0.12
-0.6 + 0.425	2.27	0.24
-0.425 + 0.335	0.92	0.36
-0.355 + 0.212	2.36	2.11
-0.212 + 0.150	1.25	3.00

-0.150 + 0.075	1.20	8.07
-0.075	1.84	84.81

(c) Atterberg Limits and Californian Bearing Ratio

Parameter	Bin	Greenspec Select Fill
Liquid Limit (%)	Not obtainable	NA
Plastic Limit (%)	Not obtainable	NA
Plasticity Index (%)	Non-plastic material	12 (max)
CBR (%)	40	5 (min)

(d) Triaxial shear strength

Parameter	Bin
Cohesion (kPa)	199
Angle of friction (^{o})	54

(e) Maximum dry density

Parameter	Bin
Maximum dry density (t/m3)	1.62
Optimal moisture content (%)	10.5

Table 6: Dendrobium Coal Wash Physical Properties

(a) Sampled moisture content

Average Moisture Content	Total
% (gravimetric moisture content)	12.0

(b) Particle Size Distribution

Sizing (mm)	%
+200	0.00
-200 + 150	0.28
-150 + 75	2.90
-75 + 63	1.83
-63 + 37.5	10.13
-37.5 + 25.0	9.31
-25.0 + 19.0	6.71
-19.0 + 11.2	13.5
-11.2 + 8.0	8.56
-8.0 + 6.3	4.26
-6.3 + 4.0	7.76
-4.0 + 2.8	3.98
-2.8 + 2.0	5.24

-2.0 + 1.18	6.46
-1.18 + 0.6	6.47
-0.6 + 0.425	2.56
-0.425 + 0.335	1.30
-0.355 + 0.212	2.13
-0.212 + 0.150	0.94
-0.150 + 0.075	1.22
-0.075	4.46

(c) Atterberg Limits and Californian Bearing Ratio

Parameter	Dendrobium Total	Greenspec Select Fill
Liquid Limit (%)	28	NA
Plastic Limit (%)	18	NA
Plasticity Index (%)	10	12 (max)
Linear shrinkage (%)	4.0	NA
CBR (%)	15	5 (min)

(d) Triaxial shear strength

Parameter	Bin
Cohesion (kPa)	7
Angle of friction (^{o})	56

(e) Maximum dry density

Parameter	Bin
Maximum dry density (t/m3)	1.69
Optimal moisture content (%)	12.0

Interpretation of results

Coal Wash chemical properties

The trace element concentrations in the bin and beltpress streams of Coal Wash generated at West Cliff, as well as the Dendrobium Coal Wash, readily complies with the specifications for Inert Waste described in the *EPA Environmental Guidelines: Assessment, Classification and Management of Liquid and Non-liquid Wastes*. The total concentration for trace elements in Coal Wash generated by Illawarra Coal is at least two orders of magnitude less than the threshold criteria (SCC1) for Inert Waste. Similarly, the leachability trace element concentrations are less that the limits of detection for the elements that require testing in the *EPA Environmental Guidelines: Assessment, Classification and Management of Liquid and Non-liquid Wastes* and significantly lower than the threshold criteria (TCLP1) for Inert Waste. As such, the trace element composition of Coal Wash generated at West Cliff Coal Preparation Plant poses little or no contamination risk to the environment or public health.

Crystalline silica, also known as silicon dioxide (SiO_2), is the basic component of sand, quartz and granite rock. It accounts for 12 percent of the earth's crust by weight and is ubiquitous (in varying proportions), including in aggregates, sand, mortar, concrete and stone, and is also in the air and the soil. The National Occupational Health and Safety Commission (NOHSC) set standards for airborne crystalline silica. The concentration of crystalline silica is Coal Wash is substantially less than other forms of VENM (e.g. crushed sandstone) and poses a low risk to workers and the community if appropriate dust control and construction methods are used when using Coal Wash as fill.

The West Cliff and Dendrobium bin Coal Wash streams combustibles content complies with the Wollongong City Council Technical Policy 2.40 of a mean value not greater than 30% with the upper value not exceeding 40%. The relatively low combustibles content is also reflected in the low calorific value of the Coal Wash. The West Cliff beltpress Coal Wash stream has a slightly higher combustibles content (and corresponding calorific value), although this material is unsuitable for use as fill in it own right due to its physical attributes (see particle size distribution). The relative ignition temperature for both West Cliff and dendrobium Coal Wash is greater than 200^oC, meaning that internal emplacement temperatures must be very high to initiate spontaneous combustion.

Total sulphur concentration is low and indicates that the Coal Wash is not pyritic and has a low potential to produce acidity. The electrical conductivity (1:5 water extract) for Dendrobium Coal Wash is low (165 µS/cm) in comparison to the indicative electrical conductivity value of 350 µS/cm for upland rivers in NSW (ANZECC 2000). West Cliff Coal Wash has slightly higher electrical conductivity of 410 µS/cm. As expected, the pH of Coal Wash (1:5 water extract) is high (9.6-10.1) as a result of the high bicarbonate content of the material. BHP Billiton has undertaken investigations of the ecological effects of the discharge of mine water from West Cliff Colliery into Brennans Creek. This discharge includes all seepage and treated runoff from the Coal Wash emplacement. No ecological impacts were attributed to the discharge of mine water from the site into Brennans creek and into the Georges River.

Ash analysis of Coal Wash confirms that the major constituents are typical sedimentary rock clay minerals comprising high proportions of silicon, aluminium and iron.

The *EPA Environmental Guidelines: Assessment, Classification and Management of Liquid and Non-liquid Wastes* uses a threshold of 100 Bq/g to assess materials as a hazardous waste. As shown above, the radionuclide concentration of Coal Wash is several orders of magnitude below this threshold criteria, and is within the 'normal' range expected from non-concentrated earth material.

Coal Wash physical properties

Particle size distribution data for the West Cliff and Dendrobium bin Coal Wash stream demonstrate that a well graded fill material is produced.

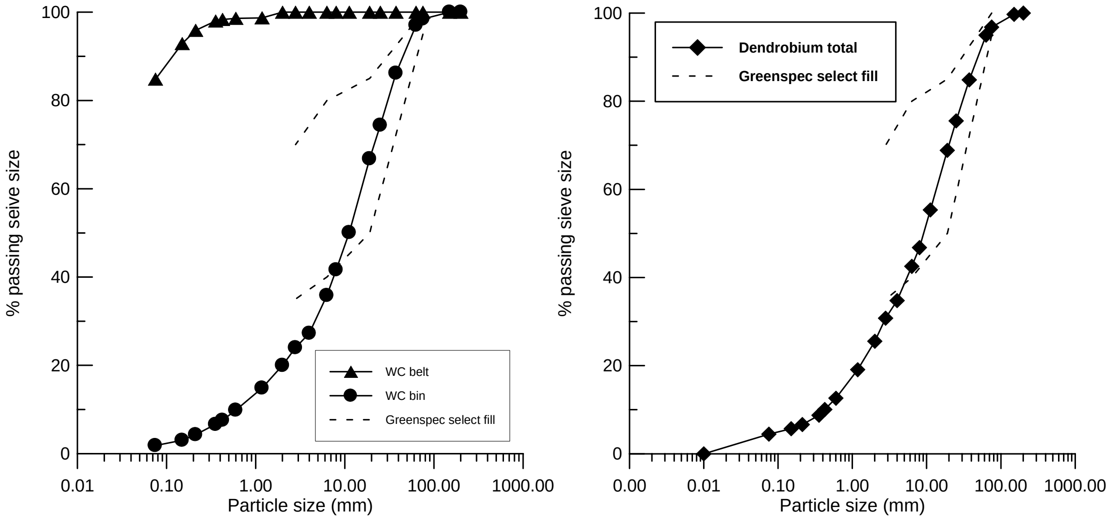


Figure 3: Particle size distribution for Coal Wash

As shown in Figure 3, the bin Coal Wash stream are consistent with the particle size distribution for Select Fill - Class C as described in the *Resource NSW Specification for Supply of Recycled Material for Pavements, Earthworks and Drainage (the Greenspec).* The proportion of fines (<2.36 mm) reporting to the Coal Wash bins is marginally outside the *Greenspec* recommendations.

The particle size distribution for the beltpress Coal Wash from West Cliff, is as expected, showing a very high proportion of fines which makes this material unacceptable as a fill when used on its own. Nethertheless, this Coal Wash stream may have other applications (such as in soil mixes) or use as fill if carefully blended with coarser Coal Wash material.

Dendrobium Coal Wash exhibits plastic behaviour and has a Plasticity Index within the range specified in the *Greenspec*. In contract, West Cliff Coal Wash exhibits elastic behaviour and the Plasticity Index cannot be determined.

The West Cliff and Dendrobium Coal Wash achieves maximum dry densities of 1.62 and 1.69 t/m^3 at 10.5 and 12.0% gravimetric moisture contents, respectively. The 'as sampled' moisture contents from the West Cliff and Dendrobium bins were 7.2% and 12% respectively, indicating that ex-bin moisture content of both materials is suitable for achieving 95% maximum dry bulk density during field compaction. The Californian Bearing Ratio (CBR) from West Cliff and Dendrobium Coal Wash was 40% and 15%, respectively, which is greater than the minimum 5% recommended by the Greenspec.

As demonstrated by this data, and historical real world applications in the Illawarra, Coal Wash from the Southern Coal Measures is capable of being successfully used for engineering fill for residential, commercial and some industrial purposes.

COAL WASH MONITORING PROGRAM

Illawarra Coal employ NATA accredited laboratories to undertake the relevant laboratory test work in accordance with relevant Australian Standards.

Contaminant concentration

The generation of Coal Wash via the coal preparation processes used by Illawarra Coal does not inherently contaminate or otherwise change the nature of the Coal Wash residual material. As such, we propose to validate the chemical composition of the Coal Wash product stream in accordance with the following frequency:

a) change in mining domain;
b) annually [if (a) has not occurred]

The contaminant concentration of the Coal Wash generated at both West Cliff and Dendrobium Coal Preparation Plants will be determined on a representative composite sample collected over a three week period. The concentration of contaminants listed in Tables 3 and 4 will be measured.

Where any non-conformance with the specification is determined, Illawarra Coal will consider retesting the Coal Wash to confirm the result. Where result(s) do not conform with the criteria, dispatch of Coal Wash to receivers will cease and the Department of Environment and Conservation will be informed as soon as practicable.

Physical Properties

Australian Standard (AS 3798) Guidelines on earthworks for commercial and residential developments recommends that if limits on the moisture content of a fill material during compaction are specified, then the reasonably required degree of compaction should be achieved. AS 3798 also recommends a minimum 95% density ratio be achieved for residential purposes. The optimum and range of moisture contents is determined from the standard or modified compactive effort tests (AS 1289.5.1.1 or AS 1289.5.1.2). Daily and/or real time monitoring of moisture levels in the Coal Wash will determine if this material is suitable for dispatch. A contingency procedure will be developed and agreed with each receiver of Coal Wash to either manage out of specification moisture contents at the receival site (by on-site drainage, blending or drying) or return the out of specification product to Illawarra Coal.

We propose to validate the optimum and range of moisture contents as determined from the standard or modified compactive effort tests (AS 1289.5.1.1 or AS 1289.5.1.2) for the Coal Wash product streams in accordance with the following frequency:

a) change in mining domain;
b) annually [if (a) has not occurred]

In addition, we will determine the particle size distribution, Atterberg Limits and Californian Bearing Ratio for the relevant Coal Wash product streams in accordance with the above frequency.

Coal Wash specification

On the basis of the aforementioned chemical and physical data and comparison with existing specifications or definitions for select fill, waste and Australian Standards, Illawarra Coal proposes the following performance standards for use of Coal Wash as fill for residential, commercial or rehabilitation fill.

Chemical specification

Contaminant	**Maximum conc. (mg/kg)**
Arsenic	100
Beryllium	20
Chromium (total)	380
Cadmium	20
Lead	300
Mercury	10
Molybdenum	200
Nickel	210
Selenium	10
Silver	36

Parameter	**Total (%)**
Combustible content (%) average	30
Combustible content (%) max	40
Electrical conductivity (µS/cm)	500
pH	10.5

Physical specification

Parameter	
Moisture content (%)	Optimal moisture content + 3% Dendrobium < 15% West Cliff < 12%
Californian Bearing Ratio	> 5%

Particle size distribution (% passing screen size)	**%**
200 mm	100
75 mm	95-100
19 mm	50-85
6.7	40-80
2.36	20-70

Appendix A: Laboratory Data Sheets for Coal Wash Testing Program

CCI AUSTRALIA

CCI AUSTRALIA PTY LTD
ABN: 64 001 285 927
24 Glastonbury Avenue UNANDERRA NSW 2526
TEL (02) 4272 4224 FAX (02) 4272 4190
E-MAIL admin.wol@cciaustralia.com.au

CERTIFICATE OF SAMPLING & ANALYSIS

Ref : W7647

THIS IS TO CERTIFY that we did carry out the sampling and analysis of the below mentioned:

CLIENT : BHP Billiton Illawarra Coal Pty Limited

STREAM : Westcliff Bin Reject

SUBJECT : Sampling, preparation and analysis of coalwash reject samples. The coal was sampled from the Westcliff Washery.

DATES SAMPLED: 11th, 18th and 25th May 2006

SAMPLING & ANALYSIS : Sampling and analysis was carried out in accordance with Australian Standards.

Total Moisture	(as received basis)	7.2	%
Moisture	(air dried basis)	1.0	%
Ash	(air dried basis)	66.6	%
Volatile Matter	(air dried basis)	13.6	%
Total Sulphur	(air dried basis)	0.06	%
Calorific Value	(air dried basis)	2116	kcal/kg
Combustible Content	(as received basis)	29.7	%

Phosphorus in coal

Sample 1 (11 May 2006)	(air dried basis)	0.028	%
Sample 2 (18 May 2006)	(air dried basis)	0.044	%
Sample 3 (25 May 2006)	(air dried basis)	0.057	%

Dated: 7 September 2006 at WOLLONGONG

Signed for and on behalf of CCI Australia Pty Ltd

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CCI AUSTRALIA

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CLIENT : BHP Billiton Illawarra Coal Pty Limited

SUBJECT : Sampling, preparation and analysis of coalwash reject samples. The coal was sampled from the Westcliff Washery.

STREAM : Westcliff Bin Reject

DATE SAMPLED : 11th, 18th and 25th May 2006

SAMPLING & ANALYSIS : Sampling and analysis was carried out in accordance with Australian Standards.

Ash Analysis (in ash)

SiO_2	61.2	%
Al_2O_3	24.6	%
Fe_2O_3	5.4	%
CaO	2.3	%
MgO	1.1	%
Na_2O	0.34	%
K_2O	2.5	%
TiO_2	1.0	%
Mn_3O_4	0.11	%
P_2O_5	0.16	%
SO_3	0.44	%
BaO	0.08	%
SrO	0.03	%
ZnO	<0.02	%
V_2O_5	0.02	%

Sizing

		+	200mm	0.00	%
-	200	+	150	0.00	%
-	150	+	75.0	1.55	%
-	75.0	+	63.0	1.41	%
-	63.0	+	37.5	10.85	%
-	37.5	+	25.0	11.82	%
-	25.0	+	19.0	7.59	%
-	19.0	+	11.2	16.71	%
-	11.2	+	8.0	8.42	%
-	8.0	+	6.3	5.80	%
-	6.3	+	4.0	8.59	%
-	4.0	+	2.8	3.27	%
-	2.8	+	2.0	3.99	%
-	2.0	+	1.18	5.13	%
-	1.18	+	0.600	5.03	%
-	0.600	+	0.425	2.27	%
-	0.425	+	0.355	0.92	%
-	0.355	+	0.212	2.36	%
-	0.212	+	0.150	1.25	%
-	0.150	+	0.075	1.20	%
-	0.075			1.84	%

Dated: 7 September 2006
At WOLLONGONG

Signed for and on behalf of
CCI Australia Pty Ltd

CCI AUSTRALIA

CCI AUSTRALIA PTY LTD
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STREAM : Westcliff Bin Reject

DATE SAMPLED : 11th, 18th and 25th May 2006

SAMPLING & ANALYSIS : Sampling and analysis was carried out in accordance with Australian Standards.

Trace Elements (in coalwash)

Antimony	1.3	(mg/kg)
Arsenic	4.0	(mg/kg)
Barium	340	(mg/kg)
Beryllium	2	(mg/kg)
Bismuth	0.48	(mg/kg)
Boron	34	(mg/kg)
Bromine	<8.7	(mg/kg)
Cadmium	0.21	(mg/kg)
Chromium	51	(mg/kg)
Cobalt	6	(mg/kg)
Copper	96	(mg/kg)
Gold	9	(ppb)
Indium	<0.1	(mg/kg)
Iodine	<4.5	(mg/kg)
Iridium	23	(ppb)
Lead	21	(mg/kg)
Manganese	370	(mg/kg)
Mercury	0.14	(mg/kg)
Molybdenum	4	(mg/kg)
Nickel	29	(mg/kg)
Osmium	<2	(ppb)
Palladium	23	(ppb)
Platinum	65	(ppb)
Rhodium	15	(ppb)
Rubidium	56	(mg/kg)
Ruthenium	32	(ppb)
Scandium	16	(mg/kg)
Selenium	0.8	(mg/kg)
Silver	0.27	(mg/kg)
Strontium	110	(mg/kg)
Tellurium	<0.1	(mg/kg)
Thallium	0.48	(mg/kg)
Tin	7	(mg/kg)
Titanium	0.39	(%)
Vanadium	57	(mg/kg)
Zinc	42	(mg/kg)
Crystalline silica	<0.01	(%)

Dated: 7 September 2006
at WOLLONGONG

Signed for and on behalf of
CCI Australia Pty Ltd

CCI AUSTRALIA

CCI AUSTRALIA PTY LTD
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STREAM : Westcliff Bin Reject

DATE SAMPLED : 11th, 18th and 25th May 2006

SAMPLING & ANALYSIS : Sampling and analysis was carried out in accordance with Australian Standards.

TCLP Leachability – Toxicity Characteristics

pH of Extraction Fluid	5.0
pH Leachate – Initial	10
pH Leachate – Final	5.0

Total Recoverable Metals in Leachate

Silver	<0.05	(mg/L)
Arsenic	<0.05	(mg/L)
Beryllium	<0.1	(mg/L)
Cadmium	<0.01	(mg/L)
Chromium	<0.05	(mg/L)
Molybdenum	<0.1	(mg/L)
Nickel	<0.05	(mg/L)
Selenium	<0.1	(mg/L)
Mercury	<0.001	(mg/L)
Lead	<0.05	(mg/L)

Dated: 7 September 2006
At WOLLONGONG

Signed for and on behalf of
CCI Australia Pty Ltd

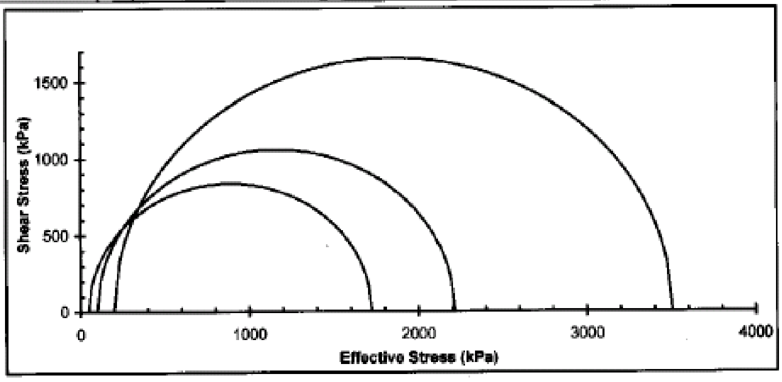
Australian Geomechanical Laboratories Pty Ltd
ABN 25 015 835 559

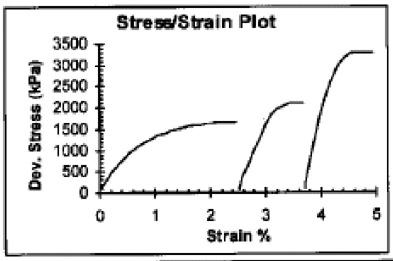
1/29 Finchley Street, Milton, Qld. 4064
P.O. Box 434, Paddington, Qld. 4064
Telephone: (07) 3217 5535
Facsimile: (07) 3217 5311
Email: aglabs@bigpond.net.au

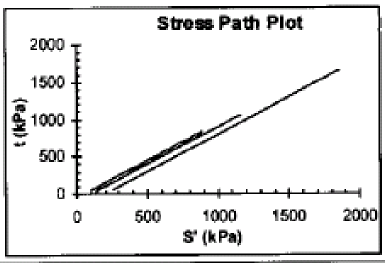
TRIAXIAL TEST REPORT

AS 1289.6.4.2

Client:	Coffey Geotechnics Pty Ltd	Report No.	608506-CU
Project:	SCL1151/1	Test Date:	31/8/06
		Report Date:	5/9/06
Client ID: WC Rejest		Depth (m):-	
Description: (GP) SANDY GRAVEL-black		Test Description: Consolidated Undrained with pwp	
Specimen Dimensions (mm): 76.0 Dia: 152.2 Length		Sample Type: Single Individual specimen remoulded*	







Failure Criteria: - Peak Principal Stress Ratio *Stages 1 & 2 **Stages 2 & 3

MOISTURE CONTENT (%)				PARAMETERS * / **
Initial:	7.0	Confining Pressure (kPa):	50, 100, 200	C' (kPa): 199 / 122
Final:	9.5	Rate of Strain (mm/min: %):	0.013 : 0.009	
		Wet Density (t/m³):	1.81	
Remarks: *to a target of 100% of Standard Maximum Dry Density.		B' Response (%):	98	φ' (deg.): 54.5 / 59
		-13.2mm material tested		

Sample and compaction data supplied by the client | Note: Graphs not to scale | Page 1 of 1

This Document is issued in accordance with NATA's accreditation requirements.
Accredited for compliance with ISO/IEC 17025
The results of the tests, calibrations, and/or measurements included in this document are traceable to Australian/National standards

Authorised Signatory

J. Russell

Manager

N ATA Accredited Laboratory Number 9926

Form Number: GT008-5

CCI AUSTRALIA PTY LTD
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E-MAIL admin.wol@cciaustralia.com.au

CERTIFICATE OF SAMPLING & ANALYSIS

Ref : W7647

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CLIENT : BHP Billiton Illawarra Coal Pty Limited

SUBJECT : Sampling, preparation and analysis of coalwash reject samples. The composite was prepared from samples from the Westcliff Washery.

STREAM : Westcliff Overall Reject

DATES SAMPLED: 11th, 18th and 25th May 2006

SAMPLING & ANALYSIS : Sampling and analysis was carried out in accordance with Australian Standards.

Ash Analysis (in ash)

SiO_2	61.1	%
Al_2O_3	24.8	%
Fe_2O_3	5.0	%
CaO	2.1	%
MgO	0.93	%
Na_2O	0.34	%
K_2O	2.6	%
TiO_2	1.0	%
Mn_3O_4	0.09	%
P_2O_5	0.22	%
SO_3	0.44	%
BaO	0.06	%
SrO	0.03	%
ZnO	<0.02	%
V_2O_5	0.02	%

Ultimate Analysis (dry basis)

Carbon	27.02%
Hydrogen	1.89 %
Sulphur	0.03 %
Nitrogen	0.53 %

Soil Conductivity (us/cm)	410
pH	10.1
Relative Ignition Temperature	>200°C

Dated: 7 September 2006
At WOLLONGONG

Signed for and on behalf of
CCI Australia Pty Ltd

CCI AUSTRALIA

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STREAM : Westcliff Overall Reject

DATE SAMPLED : 11th, 18th and 25th May 2006

SAMPLING & ANALYSIS : Sampling and analysis was carried out in accordance with Australian Standards.

Trace Elements (In coalwash)

Antimony	1.4	(mg/kg)
Arsenic	3.9	(mg/kg)
Barium	390	(mg/kg)
Beryllium	2	(mg/kg)
Bismuth	0.46	(mg/kg)
Boron	24	(mg/kg)
Bromine	<8.1	(mg/kg)
Cadmium	0.20	(mg/kg)
Chromium	53	(mg/kg)
Cobalt	6	(mg/kg)
Copper	89	(mg/kg)
Gold	12	(ppb)
Indium	<0.1	(mg/kg)
Iodine	<3.0	(mg/kg)
Iridium	30	(ppb)
Lead	20	(mg/kg)
Manganese	350	(mg/kg)
Mercury	0.14	(mg/kg)
Molybdenum	4	(mg/kg)
Nickel	30	(mg/kg)
Osmium	7	(ppb)
Palladium	21	(ppb)
Rhodium	3	(ppb)
Platinum	39	(ppb)
Rubidium	54	(mg/kg)
Ruthenium	100	(ppb)
Scandium	<2	(mg/kg)
Selenium	0.7	(mg/kg)
Silver	0.33	(mg/kg)
Strontium	130	(mg/kg)
Tellurium	<0.1	(mg/kg)
Thallium	0.46	(mg/kg)
Tin	8	(mg/kg)
Titanium	0.39	(%)
Vanadium	56	(mg/kg)
Zinc	41	(mg/kg)
Crystalline silica	<0.01	(%)

Radionucleides

Pb-210	52	(bq/kg)
Pb-212	49	(bq/kg)
Pb-214	54	(bq/kg)
Ac-228	53	(bq/kg)
K-40	450	(bq/kg)

Dated: 7 September 2006
At WOLLONGONG

Signed for and on behalf of
CCI Australia Pty Ltd

Australian Geomechanical Laboratories Pty Ltd
ABN 23 065 600 595

1/29 Finchley Street, Milton, Qld. 4064
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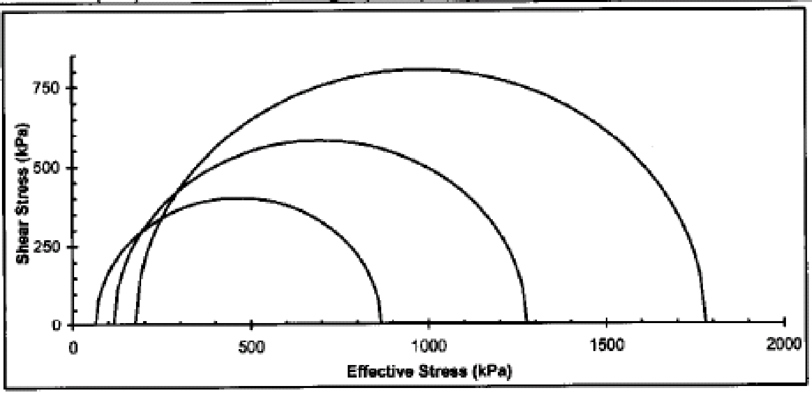
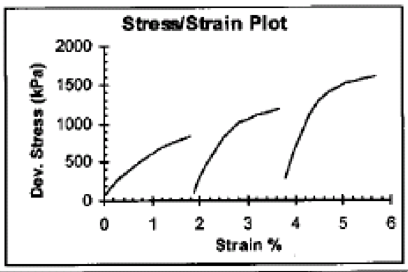
Telephone: (07) 3217 5535
Facsimile: (07) 3217 5311
Email: aglabs@bigpond.net.au

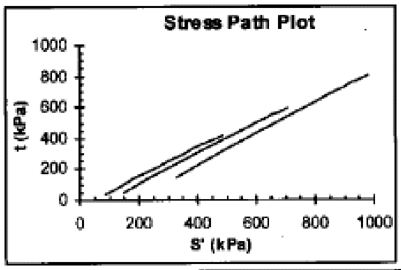
TRIAXIAL TEST REPORT

AS 1289.6.4.2

Client:	Coffey Geotechnics Pty Ltd	Report No.	608507-CU
Project:	SCL1151/1	Test Date:	29/8/06
		Report Date:	5/9/06
Client ID: WC Total Rejest		Depth (m):-	
Description: (GP) SANDY GRAVEL-black		Test Description: Consolidated Undrained with pwp	
Specimen Dimensions (mm): 76.0 Dia: 152.2 Length		Sample Type:Single Individual specimen remoulded*	







Failure Criteria: - Peak Principal Stress Ratio *Stages 1, 2 & 3

MOISTURE CONTENT (%)				PARAMETERS *
Initial:	10.0	Rate of Strain (mm/min: %):	0.013 : 0.009	C' (kPa): 59
Final:	12.5	Wet Density (t/m³):	1.80	
Remarks: *to a target of 100% of		B' Response (%):	99	
Standard Maximum Dry Density.		-13.2mm material tested		φ' (deg.): 51.5
		Confining Pressure (kPa):	50, 100, 200	

Sample and compaction data supplied by the client | Note: Graphs not to scale | Page 1 of 1

This Document is issued in accordance with NATA's accreditation requirements.
Accredited for compliance with ISO/IEC 17025
The results of the tests, calibrations, and/or measurements included in this document are traceable to Australian/National standards

Authorised Signatory

J. Russell

Manager

N ATA Accredited Laboratory Number 9926

Form Number: GT008-5

coffey geotechnics
SPECIALISTS MANAGING THE EARTH

1/222 Berkeley Road, Unanderra, NSW, 2526
Ph: (02) 4272 6071 Fax: (02) 4272 6075

california bearing ratio test results

client : CCI
principal :
project : LABORATORY TESTING
location : UNANDERRA

job no : SCL1153/1
laboratory : WOLLONGONG
report date : September 07, 2006
test report no. : SCL06/491

test procedure : AS1289 6.1.1
laboratory compaction method : AS1289 2.1.1, 5.1.1 RETEST OF CW06-0447

sample number :		CW06-0447			
depth: m					
location:					
date sampled:					
date tested:		22/8/06			
material description:		Coalwash			
maximum dry density: t/m³		1.62			
optimum moisture content: %		10.8			
field moisture content %		1.1			
retained on 19mm AS sieve: %		0			
+19mm material included:		No			
C.B.R. test – before soaking	dry density t/m³	1.61			
	density ratio %	99.5			
	moisture content %	11.9			
	moisture ratio %	110			
C.B.R. test – after soaking	dry density t/m³	1.62			
	density ratio %	100.0			
	moisture content %	12.5			
C.B.R. test	number of days soaked:	4			
	surcharge: kg	4.5			
	moisture content after test % – top 30 mm	10.8			
	moisture content after test % – remaining sample	12.3			
	swell after soaking: %	-0.30			
	penetration: mm	2.5/5.0			
	C.B.R. value: %	**18/25**			

remarks :

Form Number L2.8R1 Version 6.0

NATA WORLD RECOGNISED ACCREDITATION

The tests, calibrations or measurements covered by this document have been performed in accordance with NATA requirements which include the requirements of ISO/IEC 17025 and are traceable to national standards of measurement. This document shall not be reproduced except in full.

NATA Accredited Laboratory No. 431
Approved Signatory:
JON THOMPSON
WOLLONGONG MANAGER

Date : 7/9/06

AUSTRALIA

CCI AUSTRALIA PTY LTD
ABN: 64 001 285 927
24 Glastonbury Avenue UNANDERRA NSW 2526
TEL (02) 4272 4224 FAX (02) 4272 4190
E-MAIL admin.wol@cciaustralia.com.au

CERTIFICATE OF SAMPLING & ANALYSIS

Ref : W7647

THIS IS TO CERTIFY that we did carry out the sampling and analysis of the below mentioned:

CLIENT : BHP Billiton Illawarra Coal Pty Limited

STREAM : Dendrobium Total Reject

SUBJECT : Sampling, preparation and analysis of coalwash reject samples. The coal was sampled from the Dendrobium Coal Preparation Plant.

DATES SAMPLED: 10^{th}, 11^{th}, 12^{th}, 16^{th}, 18^{th}, 19^{th}, 23^{rd}, 25^{th} and 26^{th} May 2006

SAMPLING & ANALYSIS : Sampling and analysis was carried out in accordance with Australian Standards.

Total Moisture	(as received basis)	12.0	%
Moisture	(air dried basis)	1.0	%
Ash	(air dried basis)	65.6	%
Volatile Matter	(air dried basis)	14.4	%
Total Sulphur	(air dried basis)	0.23	%
Calorific Value	(air dried basis)	2286	kcal/kg
Combustible Content	(as received basis)	26.1	%

Phosphorus in coal

Week 1 (10-12 May 2006)	(air dried basis)	0.011	%
Week 2 (16-19 May 2006)	(air dried basis)	0.018	%
Week 3 (23-26 May 2006)	(air dried basis)	0.015	%

Soil Conductivity	(us/cm)	163
pH		9.6

Dated: 7 September 2006
at WOLLONGONG

Signed for and on behalf of
CCI Australia Pty Ltd

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SUBJECT : Sampling, preparation and analysis of coalwash reject samples. The coal was sampled from the Dendrobium Coal Preparation Plant.

STREAM : Dendrobium Total Reject

DATE SAMPLED : 10th, 11th, 12th, 16th, 18th, 19th, 23rd, 25th and 26th May 2006

SAMPLING & ANALYSIS : Sampling and analysis was carried out in accordance with Australian Standards.

Ash Analysis (in ash)

SiO_2	65.0	%
Al_2O_3	24.1	%
Fe_2O_3	6.5	%
CaO	0.39	%
MgO	0.72	%
Na_2O	0.32	%
K_2O	1.2	%
TiO_2	0.68	%
Mn_3O_4	0.15	%
P_2O_5	0.05	%
SO_3	0.16	%
BaO	0.05	%
SrO	0.02	%
ZnO	<0.02	%
V_2O_5	<0.02	%

Ultimate Analysis (dry basis)

Carbon	24.33	%
Hydrogen	1.90	%
Sulfur	0.23	%
Nitrogen	0.55	%

Sizing

		+	200mm	0.00	%
-	200	+	150	0.28	%
-	150	+	75.0	2.90	%
-	75.0	+	63.0	1.83	%
-	63.0	+	37.5	10.13	%
-	37.5	+	25.0	9.31	%
-	25.0	+	19.0	6.71	%
-	19.0	+	11.2	13.50	%
-	11.2	+	8.0	8.56	%
-	8.0	+	6.3	4.26	%
-	6.3	+	4.0	7.76	%
-	4.0	+	2.8	3.98	%
-	2.8	+	2.0	5.24	%
-	2.0	+	1.18	6.46	%
-	1.18	+	0.600	6.47	%
-	0.600	+	0.425	2.56	%
-	0.425	+	0.355	1.30	%
-	0.355	+	0.212	2.13	%
-	0.212	+	0.150	0.94	%
-	0.150	+	0.075	1.22	%
-	0.075			4.46	%

Dated: 7 September 2006
At WOLLONGONG

Signed for and on behalf of
CCI Australia Pty Ltd

CCI AUSTRALIA

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CLIENT : BHP Billiton Illawarra Coal Pty Limited

SUBJECT : Sampling, preparation and analysis of coalwash reject samples. The coal was sampled from the Dendrobium Coal Preparation Plant.

STREAM : Dendrobium Total Reject

DATE SAMPLED : 10th, 11th, 12th, 16th, 18th, 19th, 23rd, 25th and 26th May 2006

SAMPLING & ANALYSIS : Sampling and analysis was carried out in accordance with Australian Standards.

Trace Elements (in coalwash)

Antimony	0.6	(mg/kg)
Arsenic	5.7	(mg/kg)
Barium	180	(mg/kg)
Beryllium	2	(mg/kg)
Bismuth	0.48	(mg/kg)
Boron	41	(mg/kg)
Bromine	7.4	(±2.0 mg/kg)
Cadmium	0.21	(mg/kg)
Chromium	12	(mg/kg)
Cobalt	2	(mg/kg)
Copper	160	(mg/kg)
Gold	8	(ppb)
Indium	<0.1	(mg/kg)
Iodine	<4.5	(mg/kg)
Iridium	25	(ppb)
Lead	21	(mg/kg)
Manganese	620	(mg/kg)
Mercury	0.10	(mg/kg)
Molybdenum	8	(mg/kg)
Nickel	16	(mg/kg)
Osmium	<2	(ppb)
Palladium	70	(ppb)
Platinum	61	(ppb)
Rhodium	39	(ppb)
Rubidium	25	(mg/kg)
Ruthenium	55	(ppb)
Scandium	11	(mg/kg)
Selenium	0.7	(mg/kg)
Silver	0.41	(mg/kg)
Strontium	99	(mg/kg)
Tellurium	<0.1	(mg/kg)
Thallium	0.34	(mg/kg)
Tin	17	(mg/kg)
Titanium	0.25	(%)
Vanadium	22	(mg/kg)
Zinc	46	(mg/kg)
Crystalline silica	<0.01	(%)

Radionucleides

Pb-210	<30	(bq/kg)
Pb-212	50	(bq/kg)
Pb-214	44	(bq/kg)
Ac-228	56	(bq/kg)
K-40	200	(bq/kg)

Dated: 21 August 2006
at WOLLONGONG

Signed for and on behalf of
CCI Australia Pty Ltd

AUSTRALIA

CCI AUSTRALIA PTY LTD
ABN: 64 001 285 927
24 Glastonbury Avenue UNANDERRA NSW 2526
TEL (02) 4272 4224 FAX (02) 4272 4190
E-MAIL admin.wol@cciaustralia.com.au

CERTIFICATE OF SAMPLING & ANALYSIS

Ref : W7647

THIS IS TO CERTIFY that we did carry out the sampling and analysis of the below mentioned:

CLIENT : BHP Billiton Illawarra Coal Pty Limited

SUBJECT : Sampling, preparation and analysis of coalwash reject samples. The coal was sampled from the Dendrobium Coal Preparation Plant.

STREAM : Dendrobium Total Reject

DATE SAMPLED : 10th, 11th, 12th, 16th, 18th, 19th, 23rd, 25th and 26th May 2006

SAMPLING & ANALYSIS : Sampling and analysis was carried out in accordance with Australian Standards.

TCLP Leachability – Toxicity Characteristics

pH of Extraction Fluid	5.0
pH Leachate – Initial	9.8
pH Leachate – Final	5.0

Total Recoverable Metals in Leachate

Silver	<0.05	(mg/L)
Arsenic	<0.05	(mg/L)
Beryllium	<0.1	(mg/L)
Cadmium	<0.01	(mg/L)
Chromium	<0.05	(mg/L)
Molybdenum	<0.1	(mg/L)
Nickel	<0.05	(mg/L)
Selenium	<0.1	(mg/L)
Mercury	<0.001	(mg/L)
Lead	<0.05	(mg/L)

Relative Ignition Temperature >200°C

Dated: 7 September 2006
At WOLLONGONG

Signed for and on behalf of
CCI Australia Pty Ltd

Australian Geomechanical Laboratories Pty Ltd
ABN 15 010 631 091

1/29 Finchley Street, Milton, Qld. 4064
P.O. Box 434, Paddington, Qld. 4064
Telephone: (07) 3217 5535
Facsimile: (07) 3217 5311
Email: aglabs@bigpond.net.au

TRIAXIAL TEST REPORT

AS 1289.6.4.2

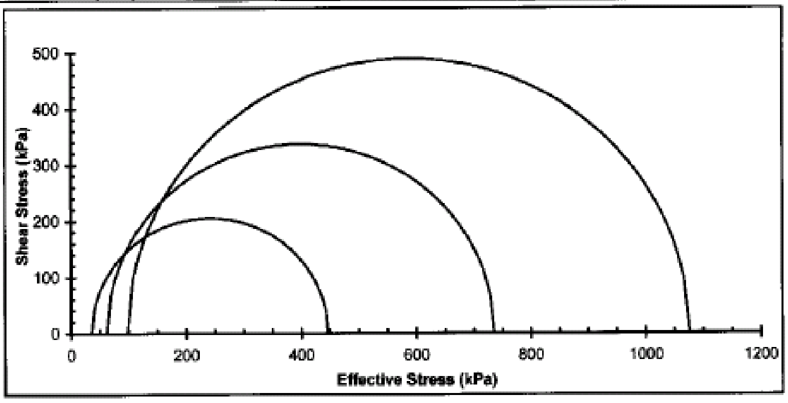
Client:	Coffey Geotechnics Pty Ltd	Report No.	608509-CU
Project:	SCL1151/1	Test Date:	29/8/06
		Report Date:	5/9/06

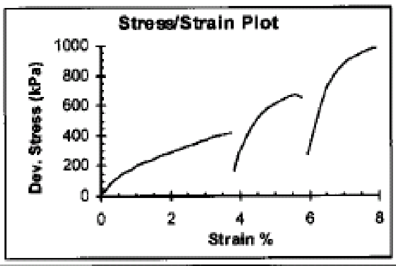
Client ID: Dend Total Refuse — Depth (m):-

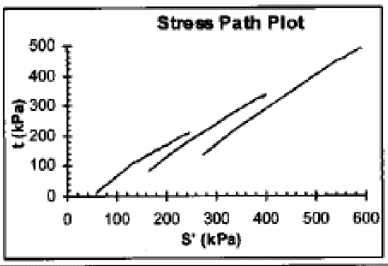
Description: (GP) SANDY GRAVEL-black — Test Description: Consolidated Undrained with pwp

Specimen Dimensions (mm): 76.0 Dia: 152.2 Length — Sample Type:Single Individual specimen remoulded*

7







Failure Criteria: - Peak Principal Stress Ratio *Stages 1 & 2 **Stages 2 & 3

MOISTURE CONTENT (%)				PARAMETERS * / **
		Confining Pressure (kPa):	50, 100, 200	
Initial:	10.2	Rate of Strain (mm/min: %):	0.013 : 0.009	C' (kPa): 7 / 24
Final:	11.0	Wet Density (t/m^3):	1.88	
Remarks: *to a target of 100% of Standard Maximum Dry Density.		B' Response (%):	99	φ' (deg.): 56.5 / 54
		-13.2mm material tested		

Sample and compaction data supplied by the client — Note: Graphs not to scale — Page 1 of 1

This Document is issued in accordance with NATA's accreditation requirements.
Accredited for compliance with ISO/IEC 17025
The results of the tests, calibrations, and/or measurements included in this document are traceable to Australian/National standards

Authorised Signatory

J. Russell

Manager

N ATA Accredited Laboratory Number 9926

Form Number: GT008-5

coffey geotechnics
SPECIALISTS MANAGING THE EARTH

1/222 Berkeley Road, Unanderra, NSW, 2526
Ph: (02) 4272 6071 Fax: (02) 4272 6075

california bearing ratio test results

client : *CCI* | job no : *SCL1153/1*

principal : | laboratory : *WOLLONGONG*

project : *LABORATORY TESTING* | report date : *August 10, 2006*

location : *UNANDERRA* | test report no. : *SCL06/441-01*

test procedure : *AS1289 6.1.1*

laboratory compaction method : *AS1289 5.1.1, 2.1.1*

sample number :			CW06-0447	CW06-0448	CW06-0449	CW06-0450
depth: m			-	-	-	-
location:			W/C Reject 90/10 Total / Belt Press	W/C Total Reject	60/40 Mix 321/816 Dend Wash	Dend Total Refuse
date sampled:			-	-	-	-
date tested:			21/7/06	21/7/06	21/7/06	21/7/06
material description:			Coalwash	Coalwash	Coalwash	Coalwash
maximum dry density: t/m³			1.62	1.62	1.50	1.69
optimum moisture content: %			10.8	10.5	10.0	12.0
field moisture content %			1.8	1.1	2.7	2.5
retained on 19mm AS sieve: %			-	-	-	-
+19mm material included:			No	No	No	No
C.B.R. test	before soaking	dry density t/m³	1.33	1.58	1.51	1.67
		density ratio %	82.0	97.5	100.5	99.0
		moisture content %	8.9	10.0	8.3	11.7
		moisture ratio %	82	95	83	98
	after soaking	dry density t/m³	1.33	1.59	1.51	1.68
		density ratio %	82.0	98.0	100.5	99.5
		moisture content %	13.6	10.7	11.9	12.8
	number of days soaked:		4	4	4	4
	surcharge: kg		4.5	4.5	4.5	4.5
	moisture content after test %	top 30 mm	17.2	21.2	10.6	12.6
		remaining sample	13.3	10.2	11.5	12.7
	swell after soaking: %		-0.03	-0.55	-0.06	-0.38
	penetration: mm		2.5/5.0	2.5/5.0	2.5/5..0	2.5/5.0
	C.B.R. value: %		**4/4**	**35/40**	**14/15**	**13/15**

remarks :
Sampled By Client
NOTE: field moisture content is not as recieved samples were dried prior to commencing testing

NATA WORLD RECOGNISED ACCREDITATION

The tests, calibrations or measurements covered by this document have been performed in accordance with NATA requirements which include the requirements of ISO/IEC 17025 and are traceable to national standards of measurement. This document shall not be reproduced except in full.

NATA Accredited Laboratory No. 431
Approved Signatory:
ANTHONY HUGHES
LABORATORY MANAGER

Date : 10/8/06

Form Number L2.8R1 Version 6.0

Appendix B

WOLLONGONG CITY COUNCIL - TECHNICAL POLICT 2.40

NAME:	NEW COAL WASHERY REFUSE IN SUBDIVISIONS
PROGRAM:	DEVELOPMENT MANAGEMENT
FUNCTION:	DEVELOPMENT ASSESSMENT & COMPLIANCE
DIVISION:	WORKS & SERVICES

File No: SU19294

OBJECTIVE

To allow the use of coalwash in residential type subdivisions.

POLICY STATEMENT

The use of Coal Washery refuse for filling in residential type subdivisions be permitted under the following conditions:

1 Very coarse materials (greater than 150 mm) or fine slurry materials (tailings) are to be rejected.

2 Structures are to be slab-on-ground design. Other footing designs by a Structural/Geotechnical Engineer may be considered.

3 Compaction to be in layers under full engineering control to at least 100% standard density.

4 Combustibles contents to be determined from site sampling at a regular frequency. Minimum testing requirements:

Quantity of Coalwash to be Emplaced (tonnes)	Minimum Frequency of Testing (tonnes per test)
< 5,000	1,000 (5 tests)
< 25,000	2,500 (10 tests)
< 125,000	6,000 (20 tests)
< 500,000	15,000 (35 tests)
< 2,000,000	30,000 (65 tests)
> 2,000,000	50,000

5 Combustibles contents to be at a mean value not greater than 30% with the upper value not exceeding 40%.

6 Inert fill should be used to backfill service trenches.

7 Coalwash is to be covered by at least 300 mm of inert cover.

8 Proper site control to prevent run-off or dust nuisance.

STATEMENT OF PROCEDURES

This section has been considered, however, the ‘Statement of Procedures’ is covered within the Policy Statement and there is nothing further which needs to be added.

APPENDIX F: Release and indemnity for WestCliff / Dendrobium Coal Wash

THIS RELEASE IS EXECUTED on [*INSERT DATE*]
PARTY: [RELEASOR'S NAME OR LEGAL IDENTITY] ([ABN/ACN/ARBN - if any]) of [Address] (Releasor)
RECITAL:

Endeavour Coal produces WestCliff/Dendrobium Coal Wash as a by-product of its coal preparation processes. The Releasor wishes to acquire WestCliff / Dendrobium for its own uses and accordingly, makes the following acknowledgments and agrees to provide the following release and indemnity.

Interpretation

Definitions

Affilliate means means a related body corporate as defined in the Corporations Act 2001 (Cth) and is deemed to also mean:

BHP Billiton Plc;

any body corporate controlled by BHP Billiton Plc;

any body corporate jointly controlled by BHP Billiton Limited and BHP Billiton Plc taking into account the aggregate percentage interests of their respective direct and indirect shareholdings in that body corporate; and

any body corporate controlled by the body corporate referred to in paragraph (c).

For the purposes of paragraphs (b) to (d) above, one body corporate controls another when at the relevant time it owns either directly or indirectly not less than 50% of the voting shares of that other body corporate.

Claim means a claim, action, proceeding or demand made against Endeavour Coal, any of its Affiliates or any its employees and agents, however it arises and whether it is present or future, fixed or unascertained, actual or contingent in relation to the WestCliff / Dendrobium Coal Wash provided to the Releasor or the consequences of the Releasor or a third party failing to comply with any Laws with respect to the WestCliff / Dendrobium Coal Wash provided to the Releasor.

Endeavour Coal means Endeavour Coal Pty Ltd ABN 38 099 830 476.

Law means a statute, ordinance, code, regulation, by-law, local law, official directive, order, instrument, undertaking, obligation or applicable judicial, administrative or regulatory decree, judgement or order and includes the conditions and standards, authorisations, licences, permits consents, assurances, bonds or similar requirement including all applicable standards and obligations under the common law and at any time means the Laws at that time.

WestCliff / Dendrobium Coal Wash means Coal Wash material produced by Endeavour Coal as a by-product from the coal preparation process].

Release

The Releasor releases Endeavour Coal and its Affiliates, its employees and agents and former employees and agents from all present or future liability in respect of any Claim.

The Releasor and Endeavour Coal wish to resolve all possible disputes between them and the release extends to any present or future liability, whether or not the facts or law giving rise to such actual or potential liability are known to either of them, or have been discussed between them.

Indemnity

The Releasor indemnifies Endeavour Coal and its Affiliates, its employees and agents and former employees and agents against all present or future liability to any person in respect of any Claim.

The indemnity extends to any present or future liability whether or not the facts or law giving rise to such actual or potential liability are known to either party or have been discussed between them.

ACKNOWLEDGMENTS

The Releasor acknowledges and agrees that in relation to WestCliff / Dendrobium Coal Wash:

whilst Endeavour Coal provides the information in Annexure A in order to assist the Releasor, Endeavour Coal must make its own enquiries and investigations as to the suitability, use, and any authorisations necessary in relation to WestCliff / Dendrobium Coal Wash;

Endeavour Coal does not warrant that WestCliff / Dendrobium Coal Wash is suitable or fit for the Releasor's use;

it will at all terms conform with such instructions, procedures, rules or directives as may be given by Endeavour Coal in connection with WestCliff / Dendrobium Coal Wash;

ensure that its staff is competent and have the necessary skills and equipment to collect WestCliff / Dendrobium Coal Wash in the manner instructed or directed by Endeavour Coal;

comply with all safety & other requirements notified in writing by Endeavour Coal; and

comply with all applicable Laws.

GENERAL

The Releasor must not disclose any information in respect of any Claim or this document other than as required by law.

Any provision of this document which is unenforceable, or partly unenforceable is, where possible, to be severed to the extent to make this document enforceable, unless this would materially change the intended effect of this document.

EXECUTED as a deed.

[Execution clause for company]

EXECUTED by **[Releasor]** in accordance with section 127(1) of the Corporations Act

Signature of Director	Signature of Company Secretary
Name of Director	Name of Company Secretary

[Execution clause for natural person]

SIGNED, SEALED and **DELIVERED** by [Releasor] in the presence of:

Signature of witness	Signature of party
Name	

Information Sheet

Relevant Certificate’s and data are included for the particular Coal Wash to be delivered.

APPENDIX G: Assessment of coalwash for aggregate production

Dr Bruce Blunden
Environment and Community Manager
Processing and Logistics – Illawarra Coal

and

Visiting Fellow
University of Wollongong
Faculty of Engineering

Introduction

Coal Wash is the non-carbonaceous fraction from the processing of Run of Mine (ROM) coal to produce coking and energy coal. Depending on coal seam properties and Coal Washing technologies, Coal Wash yield may be up to 40% of the ROM coal mined. Coal Wash composition is dependant on the depositional environment in which the coal seam was laid, however it is primarily comprised of soft sedimentary rock, clay, silt, sand and a small amount of residual coal. Occasionally, some igneous rock intrusions are mined and are present in Coal Wash. Coal Wash is currently emplaced in purpose built landfills on or close to mining operations. Coal Wash has been successfully used as select fill for residential subdivisions in the Illawarra, fill for rehabilitating industrial and mine sites, and for limited commercial applications such as brick making. Illawarra Coal is pursuing a range of alternatives to Coal Wash emplacement in order to maximise the beneficial use of Coal Wash.

The Department of Environment and Conservation (DEC) in a letter to BHP Billiton dated 14 April 2006 suggested that different streams of coalwash may need to be addressed differently for end uses such as; manufactured sand, aggregate/road base and general fill or drainage medium.

To assess the capability of course coalwash being generated from the Dendrobium Washery to make aggregate, Illawarra Coal undertook a preliminary laboratory testing program at the University of Wollongong on 25-26 July 2006. Analyses were performed in accordance with *Australian Standard 1141.0 – 1999 Methods for sampling and testing aggregate*s, and the results assessed against the performance specifications defined in *Australian Standard 2758- 1998 Aggregates and rock for engineering purposes*. These standards are applicable for concrete aggregates, railway ballast, aggregate for sprayed bituminous surfacing, and asphalt aggregates.

Methods

Approximately 40 kg of Coal Wash was collected from the Dendrobium Coal Preparation Plant on Friday 21 July 2006. The sample was allowed to air dry in an effort to remove any free water from the material then passed through a jaw crusher set at a jaw aperture of 26.5 mm. Figure 1 shows the Coal Wash aggregate product generated by the crushing process.

Figure 1: Crushed coal wash aggregate.

Representative sub-samples were collected for the following analyses:

- Particle size distribution
- Particle shape
- Weak particles
- Particle density and bulk density
- Drying shrinkage
- Loss on ignition

All analyses were undertaken in accordance with the relevant test methods specified in *AS 1141 Methods for sampling and testing aggregates*.

Particle size distribution

Coal Wash aggregate was tested for particle size distribution in accordance with AS1141.11. Figure 2 shows the particle size distribution of Coal Wash after crushing with a jaw crusher set at 26.5 mm jaw spacing. The crushed and screened Coal Wash aggregate is compared to the upper and lower bounds for particle size set for 28mm aggregate prescribed by AS2758.

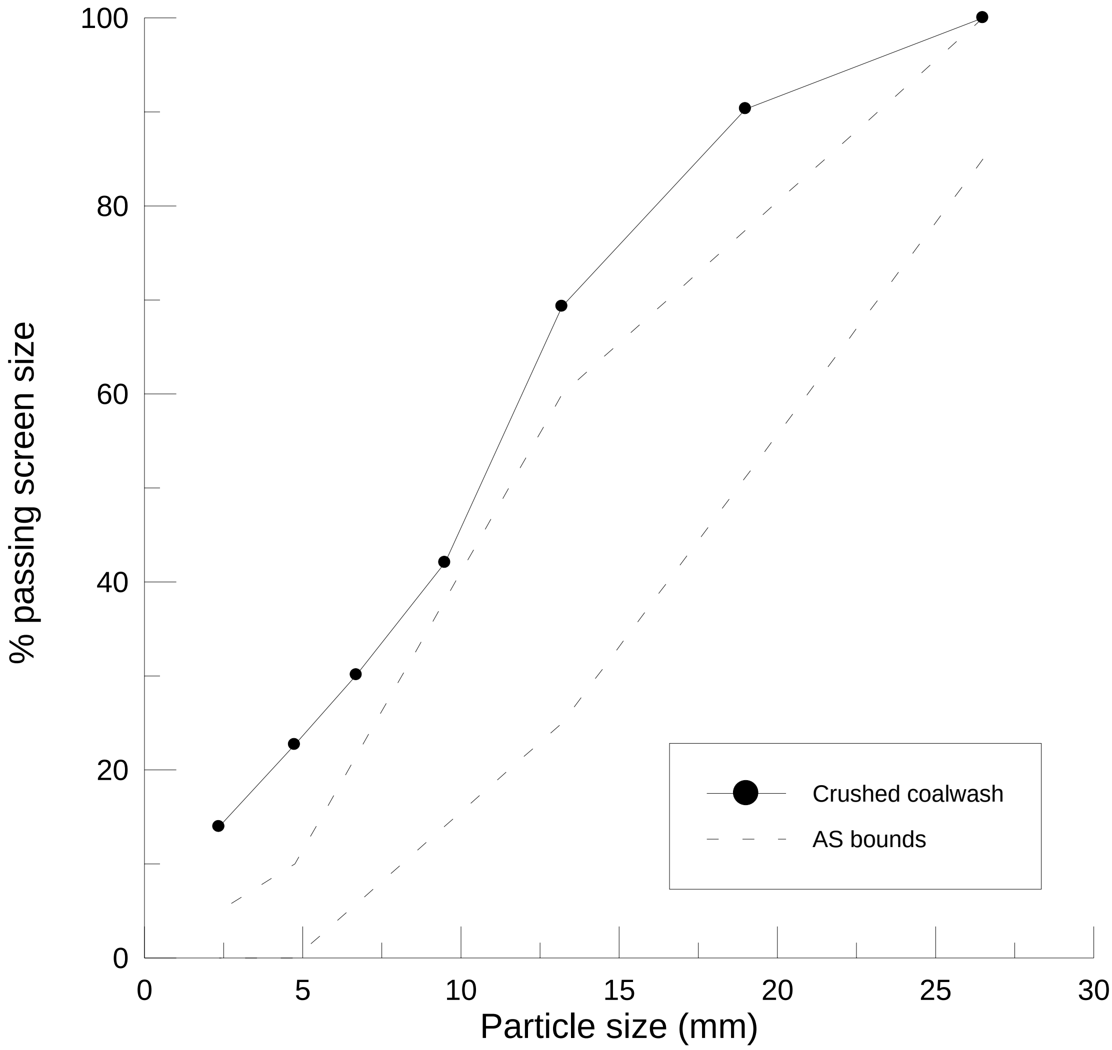


Figure 2: Particle size distribution of manufactured coalwash aggregate

The amount manufactured Coal Wash passing set screen sizes fall outside the upper particle size requirements for 28 mm nominal aggregate. Importantly, the amount of material < 2.36 mm diameter present in the Coal Wash aggregate is considerably higher than the 0-5% allowed for in the Australian Standard. Given the propensity of Coal Wash to generate fines when crushed, it is unlikely that a crushing and screening process would enable a satisfactory aggregate of appropriate particle size distribution to be manufactured.

Particle shape in course aggregate

The particle shape in course aggregate was determined on Coal Wash aggregate in accordance with AS1141.15 for material retained on a 9.5 mm sieve. AS2758 requires that the proportion of misshapen particles in course aggregate retained on the 9.50mm test sieve shall not exceed 10% using a 3:1 ratio. The results of the misshapen particles test is shown in table 1.

Table 1: Misshapen particles in Coal Wash aggregate

Particle shape	**% of total**
Flat	35
Elongated	12
Flat & elongated	42
Angular	11

Flat and elongated particles are deemed to be misshapen by AS2758. As such, 89% of the coal was aggregate produced is misshapen. The particle shape results show that crushed Coal Wash does not conform to AS2758 for particle shape.

Weak particles in course aggregate

The proportion of weak particles in course aggregate was determined on Coal Wash aggregate in accordance with AS1141.32. AS2758 requires that the proportion of weak particles in course aggregate shall not exceed 0.5%.

Test results showed that the proportion of weak particles in Coal Wash aggregate was 4.3%. This shows that Coal Wash aggregate has too much soft material to be considered as aggregate as defined by AS2758.

Loss on ignition

The combustible content of Dendrobium Coal Wash sampled during May 2006. Analysis showed that the Coal Wash had a combustible content of 26.1%. This is significantly higher than the recommended maximum allowable loss on ignition of 5%.

Drying shrinkage

When analysis samples for drying shrinkage, AS2758 requires that the following materials shall not be used as aggregates:

(a) Volcanic breccia
(b) Mudstone
(c) Sandstone
(d) Shale
(e) Highly weather or altered rocks

Visual inspection of the Coal Wash mineral fractions (excluding coal or carboniferous material) showed that the majority of the rock that comprises Coal Wash is shale, with minor fractions of mudstone or sandstone.

As such, Coal Wash shall not be considered as aggregate.

Other tests

The results of basic material property tests undertaken on crushed coalwash are provided in table 2.

Table 2: Material properties of Coal Wash.

Property	**Result**
Bulk density – uncompacted	1.27 t/m^3
Bulk density – compacted	1.69 t/m^3
Apparent particle density	2.2 g/cm^3

Manufactured sand

Allied to this investigation is the consideration of screened Coal Wash mineral fines for manufactured sand. AS1141.24 requires that sand particles of silt size be as strong as quartz. Whilst not tested directly, the mineral composition of Coal Wash is unlikely to meet this specification.

Conclusion

Analyses undertaken in accordance with AS2758 confirm that Coal Wash is an unsuitable material for crushing and screening to make aggregate. In summary, the constituent rocks that forms the mineral component of Coal Wash is too soft and well structured to form appropriately strong aggregate. In addition, Coal Wash has a considerable non-mineral composition. Crushed Coal Wash fails AS2758 on several parameters and we recommend that no further work on the assessment or development of Coal Wash for aggregate material be undertaken. Similarly, Coal Washes capability to be processed to form manufactured sand is not worthy of further investigation.

APPENDIX H: Sydney construction materials strategy

- SUBSTITUTES & RECYCLING –

Discussion Paper

22nd March 2006

With DEC comments

Introduction

Construction materials are those extractive and recycled resources that are used in the construction of buildings (domestic, industrial, commercial buildings), roads, and other structures and uses (e.g. fill, pipe bedding, drainage features). They include natural sources of sand (including glass sand and foundry sand), hard rock and clay-shale. Sydney's population is expected to grow from 4.33m in 2006 to almost 5.5m in 2035 (DIPNR 2004). Construction of housing and infrastructure to service this growth, and for urban renewal, will place further pressure on already dwindling natural sources of sand, hard rock aggregate and clay shale. The relatively low unit value of these materials means that natural sources are usually only marginally more expensive than substitutes and more readily accessible. Consequently, there is an increasing need to develop cheap, suitable substitutes to take pressure off the need to use natural sources of sand and hard rock (there are no viable substitutes for clay-shale) for construction purposes. On site recycling requirements in Development Control Plans and levies on natural materials are examples of policies which may encourage increased use of substitutes.
(Recycled construction and demolition waste is 30% more cost effective than natural products)

The focus of the recycling and substitutes section of the Sydney Construction Materials Strategy is to recommend appropriate courses of action to reduce the pressure on natural sources of sand and hard rock aggregate to supply the Sydney market, by promoting the increased use of recycled products and other substitutes.

Demand for Construction Materials

The natural construction materials covered by the Sydney Construction Materials Strategy include sand, hard rock aggregate and clay shale. Currently there is approximately 6.7mt of sand, 12mt of hard rock aggregate and 1.5mt of clay shale used each year in the Sydney construction industry (Pienmunne & Whitehouse 2001; Pienmunne 2000; MacRae 2001). In addition to this, there is approximately 3-4mt of recycled and other materials used as substitutes for construction materials derived from various sources. (There is also in excess of 5mt of Virgin Excavated Natural Material from infrastructure development that now also uses as a substitute for quarried products) While the exact amount substituting for natural sources of sand and hard rock is difficult to quantify, it represents about 10%-20% of the construction materials market, a percentage that must be increased significantly to reduce pressure on natural sources. Appendix 1 gives an indication of the range of uses of natural sources of construction materials and the quantities involved in each use. (This paper appears to confuse excavated materials flows with "demand" and generally implies that recycled material is of inferior quality to some naturally sourced materials – this was a perception some years ago but the evolution of a "GreenSpec" recycled C & D waste is a quality substitute)

Sand

Natural sand is used in a number of construction applications including readymixed concrete, concrete products, asphalt, fill, mortar, glass and other industrial uses. Sand produced in the Sydney region consists of three basic types: fine to medium grained; medium-coarse grained; and clayey sand (Whitehouse 1997). In addition to these construction purposes, natural sand is also used in landscaping, golf courses, glass making, foundry moulds and other industrial purposes.

Over the next 30 years supply of natural sources of sand are expected to become scarce as demand increases with the increased population of Sydney. The two major sources of construction sand for Sydney, Kurnell and Penrith Lakes, will become exhausted over the next 5 years and several existing operations in Port Stephens and Newnes Plateau are close to the end of their supply. Although there are potential resources in these and other areas within close proximity to Sydney (Somersby Plateau, Maroota, Southern Highlands, Shellharbour/Kiama), the reliance on development of substitutes for natural sources of sand is most critical. Table 1 shows the projected sand requirements for the Sydney construction industry over the next 30 years, based on a ratio of 1.5t per annum per head of population (that which is currently consumed). This shows a steady increase in population (and sand requirements) over this period so that by 2035 the per annum sand requirements will be approximately 8.2mt.

Table 1 – Population and Sand Requirement Predictions 2006 - 2035

	2006 - 2010	2011 - 2015	2016 - 2020	2021 - 2025	2025 - 2030	2031 - 2035
Start Pop	4,335,300	4,554,200	4,762,200	4,965,400	5,161,500	5,345,300
End Pop	4,510,420	4,720,600	4,924,760	5,122,280	5,308,540	5,479,620
5 yr Increase	175,120	166,400	162,560	156,880	147,040	134,320
Sand (mt) Req - (5yr total)	**33.17**	**34.78**	**36.33**	**37.83**	**39.26**	**40.59**

As existing developments become exhausted, and environmental constraints limit the utilisation of some resources, there will be an increased pressure on new areas to become available to supply natural sand to the Sydney market. A significant contribution from substitute sources of sand will be required, and it is clear that development of sand substitute technology and stimulation of markets for substitute sand should be a high priority.

Hard Rock

Natural coarse aggregate and related products can be broadly divided into two categories with different end uses; crushed broken stone (CBS) and prepared road base (PRB). CBS refers to high quality aggregate derived from river gravel and from quarried hard rock which is crushed and screened in various sizes and used in concrete, bituminous road sealing, and railway ballast. PRB is a product made up of crushed rock fragments that are blended with fine grained materials such as crusher dust or weathered rock with a grading which will produce maximum density on compaction (Pienmunne 2000).

The Sydney planning region consumes up to 13 million tonnes of coarse aggregate per annum, the bulk of which comes from within the region. The proportion of imports has increased from about 10% in the 1970s to present levels of about 20% of the yearly consumption, and this is expected to increase in the future as local resources are depleted (Pienmunne 2000). Penrith Lakes and Prospect will be exhausted in the next 5 years and there is likely to be a shortfall in aggregate production from natural sources unless other deposits within reasonable distance from Sydney are developed. There are large identified deposits of hard rock in the Southern Highlands, Shellharbour/Kiama, Hartley (near Lithgow), Langley Heights (near Oberon) and Port Stephens LGA.

It is estimated that approximately 10% of the coarse aggregate requirements in the Sydney construction industry are currently met by recycled materials (Pienmunne 2000). It is likely that this proportion is capable of being increased with policies encouraging sorting, reuse and recycling policies, thus prolonging the life of existing hard rock quarries.

Clay Shale

The main products made from clay shale resources around the Sydney region are bricks and pavers (93%) and roofing tiles (7%). Based on trends in clay shale production and in production of bricks and pavers, demand for clay shale in the Sydney Region is declining. The decline in demand is thought to be due to more efficient use of clay shale raw materials by using extrusion method of brick production and increased usage of clay and shales from excavations for construction sites (MacRae 2001).

Demand for clay shale over the life of the Strategy is likely to be about 2Mtpa. Resources currently held under consent are sufficient to supply the region for another 30 years, and unsecured reserves of over 250Mt are sufficient to supply the Sydney and NSW market for clay shale for over 100 years. This trend, coupled with the significant available and potential resources in the Sydney region means that there is less pressure for new areas to be developed. There are no suitable substitutes for natural sources of clay-shale in the construction industry.

Substitutes and Current Use

Secondary aggregates in the form of spoil from excavations infrastructure development, blast furnace slag, ash from coal fired power generation and waste rock from mining operations continue to augment the use of primary aggregates, particularly in metropolitan areas, but generally only for lower performance applications like roadbase and select fills. (this is not necessarily correct in that substitutes are now used in a very wide range of applications including the use of slag in high strength cement) Other substitutes, such as manufactured sand is also used in the manufacture of readymixed concrete. However, in most applications it is difficult to quantify the use of recycled products and substitutes on a regular basis and whether they are used in the

Sydney or other markets (especially Newcastle and Illawarra). Ideally substitutes should :

- meet industry quality control to standards for the particular use (e.g. AS 2758.1-1985 on aggregates and rocks for engineering purposes, Part 1 – Concrete Aggregates)
- have a security of supply (i.e. they are accessible to the Sydney construction market and have potential to offer long term supply)
- are available in sufficient quantities to be a viable replacement for natural sources (i.e. the quantity available is large enough to be commercially viable to continue production over a long period of time)

The main construction material substitutes are discussed below.

Recycled Construction and Demolition Materials
Current Practices

Construction and demolition (C&D) waste materials are estimated to constitute approximately 16% of total waste generated (Bakoss and Ravindrarajah 1999) (This reference is now well out of date and should not be used). Recycling of C&D material is increasing as more and more waste is recovered and the amount going to landfill decreases (11% reduction between 1998-2003). In 2003 there was approximately 3.5mt of C&D waste generated in the Sydney region (DEC 2004), with a recovery rate (i.e. amount recycled) of 70% (2.5mt). This recovery rate is only 6% below the target recovery rate of 76% for 2014 (Resource NSW 2003). The main producers of C&D waste are demolition companies, developers, builders, local government and the Roads and Traffic Authority (Whitehouse 1997).

Recycling of C&D material is sometimes done on-site using mobile crushers. This reduces the amount of C&D waste going to landfill (and thus transport costs involved) as the crushed material is used on-site for roadbase, pavement and drainage pipe bedding (In reality most of the on site treated materials are then taken off site for use elsewhere). Alternatively, C&D waste is transported by trucks to recycling sites where it is crushed and sorted into various products (e.g. roadbase, different grades of aggregate). The relatively high density of C&D waste makes recovery more financially attractive than disposal costs which include both the landfill gate price and the disposal levy. Generally the gate fee for recyclers accepting C&D concrete and brick waste material is from $1 - $15 per tonne depending on location, quantity and quality. This contrasts with tip fees (including waste levy) of approximately $35-$60 per tonne. As a result there is a significant financial incentive for construction companies to recycle material rather than sending it to landfill.

Some local councils have Development Control Plans (DCPs) to ensure waste reduction and reuse of materials and recycling is maximised. DCPs are one mechanism that can be used to increase the amount of recycling of C&D material by requiring on-site sorting and crushing of waste, and reuse on site. (This is rarely the case and the DCP is aimed at encouraging best practice which is much wider than simply on site reuse)

The Department of Environment and Conservation has issued a “Construction and Demolition Recycling Directory” which gives details of recycling operators, the material they receive and the products they produce from recycled C&D material. (DEC are no longer producing such a directory as we are in negotiations with the Telephone Book producer Sensis to utilise their data base and its search engine for online information. By the use of this medium up to date information will be available – suggest reference to a directory be removed) There are some 50 facilities around Sydney dedicated to recycling of waste from demolition activities and construction sites. These facilities are vitally important to resource recovery, as they help reduce the reliance on natural materials for the construction industry by processing more than 2.5 million tonnes of recycled material each year. Some local government agencies (Randwick, Warringah, Fairfield) also operate C&D recycling facilities (Whitehouse 1997). It is important that companies wanting to dispose of C&D waste are aware of the facilities available and the types of waste that can be recycled in the construction industry. It is equally important that the range of products available from recyclers is widely known in the construction industry and the standards that they meet.

Processing of recycled construction and demolition material is guided by standards and specifications such as the "Specification for Supply of Recycled Material for Pavements, Earthworks and Drainage" (see Appendix 2). Standards are an important tool in increasing confidence in recycled C&D products.

There is a Code of Best Practice for waste processing in the C&D industries (Waste Management Association of Australia) which provides guidelines for management of C&D waste in demolition, transporting and processing stages. Such Codes are likely to improve the quality of C&D material recycled, thus giving greater confidence in the standard of materials available.

Substitutes for:	sand and hard rock	
Current quantities available for reuse:	2.5 million tonnes p.a.	
Applications:	Road base (~1mt)	sand and hard rock
	Bedding	sand
	Fill	sand and hard rock
	Low strength concrete	sand
	Asphalt	sand and hard rock
	Gabions	hard rock

Factors Affecting Supply and Demand

With ongoing construction and urban renewal, there is a constant supply of construction and demolition materials available for reuse / recycling. In 2003-2003 over 2.2mt of concrete, brick, sandstone and sand was received at recycling depots and reprocesses for reuse as roadbase (46.7%), drainage medium (16.3%), select fill (11.3%), bedding material, concrete aggregate (0.9%) and other products. Crushed recycled brick is generally only used as fill. (DEC 2004) (Crushed Brick is used in a wide rage of construction and landscaping products – not just fill). The level of waste disposal in the C&D sector has increased by around 14% since 1990 (Not sure where this figure has come from but the increase is well in excess of 14%). This represents a strong sector interest in reuse and recycling. DCPs requiring on-site sorting, reuse and recycling would further increase the amount of C&D waste available for recycling.

Price, quality, variability and durability of recycled C&D products are reasons for reluctance by potential users to use such products (NSW Waste Boards 2000) (This reference is now out of date and quality is no longer a barrier due to the industries development of the "GreenSpec"). For demand to increase, a combination of regular supply, competitive pricing and products meeting acceptable standards would be required. As mentioned above, by imposing the requirement to sort, recycle and reuse on-site through DCPs, the supply of recycled C&D is likely to increase. Pricing of the recycled products could be made more attractive to potential users by imposing a levy on use of natural materials for purposes where a suitable (i.e. meets relevant Australian Standard) recycled substitute is available. (Recycled C & D material is 30% more cost effective than natural products). Product accreditation systems are also likely to increase confidence in recycled products. (This has now been largely done and is outlined in the C & D Waste Action Plan)

Recycled C&D Material – Options for Increasing Level of Use

- DCPs would ensure that on-site sorting, crushing and reuse of material is maximised.
- Development of standards, specifications and products accreditation systems would give greater confidence in recycled products.
- A current directory of services and products available is essential in increasing the use of these materials. DEC (Resource NSW) compiled one in 2002 and this should be updated with more information on standards of recycled material supplied.
- Encouraging adoption of formal purchasing policies supporting the use of recycled C&D content products is likely to increase use of recycled C&D material
- Encourage industry initiatives (e.g. Code of Practice) to provide assurances that demolition or construction waste is not contaminated with asbestos chemical contaminants.

Quarry Sand / Manufactured sand

Current Practices

Quarry sand (crusher fines/ crushed hard rock residue) is produced during the crushing of hard rock for coarse aggregate. This material is by nature very angular and, while it is available in a range of sizes, it is suitable only for those applications in which the shape of the grain has little importance or is required to be angular. In addition, the availability of crusher fines is limited by a number of factors. Firstly, they are produced in declining amounts due to improved crushing techniques. Secondly, the bulk of crusher fines are utilised in other quarry products such as road base, and thus are not available for use as fine aggregate. Thirdly, the availability of crusher fines is governed by the demand for coarse aggregate.

Material termed *'manufactured sand'* is produced by either additional processing of crusher fines, or by crushing hard rock to sand size particles. In the first case, crusher fines are reprocessed to reduce the proportion of fine particles so as to improve the overall grading of the material. In the second case, where the primary objective is to manufacture sand, hard rock is crushed and then reprocessed to improve the shape of the resulting particles and the grading of the material (Whitehouse 1997).

Significant quantities of coarse-grained sand are manufactured in the other States, and may therefore be a long term supply option for coarse-grained sand. The use of manufactured sand in concrete, however, requires approximately 25% more fine to medium-grained sand in the mix (O'Flynn and Stephens 2000) and fine- to medium-grained sand of adequate quality can not be manufactured with present technology (O'Flynn and Stephens 2000). Therefore there is a demand for fine- to medium grained sand which can only be supplied by natural sources. Furthermore, the availability of manufactured sand is constrained partly by similar factors as quarry sand above, and partly by the fact that using high quality hard rock to produce sand reduces the availability of such rocks for use as coarse aggregate (Whitehouse 1997).

Ideally the a sand resource should be located near a hard rock quarry for ease of blending of materials to avoid double handling (for example at Dunmore, Peats Ridge and Southern Highlands).

Substitutes for:	sand
Current quantities used:	100,000 – 300,000 tonnes p.a.
Applications:	Concrete mixes Road base Bedding Low strength concrete Asphalt

Factors Affecting Supply and Demand

There is likely to be a significant growth in the supply of manufactured sand from aggregate crushing as a sand substitute. This will be influenced by improved crushing techniques to produce more uniform size and shape of fines; and the demand for coarse aggregate. There is the potential to double the life of a natural sand resource by mixing 50:50 with manufactured sand. Manufactured sand when blended with natural sand for concrete manufacture must meet Australian Standard 2758.1, "Aggregates and Rock for Engineering Purposes, Part 1 Concrete Aggregates".

Manufactured Sand – Options for Increasing Level of Use

- Because of its potential to substitute for sand in ready mixed concrete (especially with new admixture technology) the optimal use of manufactured sand is blending with natural sand for use in the higher value products such as ready mixed concrete, general construction and in concrete products, rather than other lower level uses such as fill.
- Industry research into technology (e.g. crushing techniques, admixtures) to increase the volume of manufactured sand suitable for concrete mixes.

Blast Furnace Slag (Iron Rock / BF Sand / Steel Rock

Current Practices

There are three principal types of blast furnace slag produced at steelworks:

- Iron Rock (iron blast furnace rock slag)
- BF Sand (Iron blast furnace granulated slag)
- Steel Rock (Basic Oxygen Steelmaking (BOS) rock slag)

Solidified and cooled *iron rock* is excavated from blast furnace pits and transferred to stockpiles or to a crushing and screening plant. Equipment used for these processes is similar to that used in a hard rock quarry (without the need for blasting). Iron rock is crushed and screened to produce aggregates for concrete and road pavements. Fines produced as a result of the crushing and screening is used as a component of "manufactured sand" in concrete (Also used in cement manufacture). Iron rock has been a major road pavement material in the Illawarra and Sydney region for many years. Iron rock complies with the requirements of AS 2758.1 "Aggregates and Rock for Engineering Purposes, Part 1 – Concrete Aggregates (Gregory & Jones 2005).

BF Sand is formed when molten iron blast furnace slag is directed into a granulator, where high volume, high-pressure water sprays instantly quenches it to form coarse sand like material. After solidifying, cooling and draining, BF sand is trucked to stockpiles for later delivery to a slag grinding plant. BF sand is used as a cement replacement, and as a partial sand replacement (i.e. it can be blended finer sand) in concrete products and as a self stabilising media for pavement materials. Its properties also meet the specification for filter sand, if loosely packed (Gregory & Jones 2005). BF sand does not contain substances that have harmful effects on strength and durability of concrete such as chlorides, organic impurities, clay and seashell, and it can be processed to a standard where it has a compressive strength equivalent to natural sand (Takahashi and Yabuta 2002).

Steel rock is a solidified form of the molten slag that comes from Basic Oxygen Steelmaking (BOS). After separation of metals the slag is crushed and screened, and appropriate sized aggregates are used for asphaltic concrete or roadbase. Good stability and skid resistance properties of the aggregate gives it technical advantage over many quarried materials.

The technology for granulating of blast furnace slag is sufficiently advanced to produce fine concrete aggregate that can replace sand and/or hard rock. Blast furnace slag is a low value product and would otherwise be disposed of as waste. It can also be used in other reuse applications, as it is in other countries (e.g. sand-capping material, marine blocks in artificial reefs, calcium silicate fertiliser).

The steelworks at Port Kembla currently produce about 1.6-1.8 million tonnes of blast furnace slag annually, the bulk of which is used in the Illawarra. The amount of slag sand used in the Sydney Planning Region is thought to be very small.

Substitutes for:	sand / hard rock
Current quantities used:	0.6mt p.a. (mainly Illawarra – negligible amounts to Sydney)
Applications:	Concrete Asphalt Roadbase Filter material Fill

Factors Affecting Supply and Demand

Iron and steel making processes yield an "endless quarry" with output being constrained only by the quantity of iron and steel produced.

Although it is a suitable substitute for sand and other aggregates in concrete manufacture, slag sand is not available in suitable quantities to be a significant substitute for fine aggregate. Consequently, most of the product is used close to the source (i.e. Illawarra region). Current utilisation of blast furnace slag is 69% (Gregory & Jones 2005) leaving room for increased substitution of natural sources of fine aggregates as a construction material.

There may also a misunderstanding of the properties of slag that prevent its more widespread use as a substitute for aggregate. If slag products are not accepted as "construction material" then there is significant risk that large volumes will be forced to landfill as a result. Part of the reluctance to use slag products in construction applications hinges on DEC stating definitively the acceptance of steel slag as a "construction material" when not emplaced as fill.

Slag Sand – Options for Increasing Level of Use

- Further investigation and marketing the use of iron rock, BF sand and steel rock, especially in the Illawarra and southern Sydney areas..

Fly Ash

Fly ash is pulverised fuel ash and furnace bottom ash produced by coal fired power stations. The material has some potential for use as a sand alternative due to its light weight and self cementing properties. Fly ash initially consists of fine angular fragments which must be reprocessed before the material is suitable as either coarse or fine aggregate. Fly ash improves workability, speeds construction and is capable of increasing the strength of concrete because of its self cementing properties. Fly ash with lower self cementing properties can also be used as a fine aggregate in concrete manufacture. (Its also used in cement manufacture) The light weight of fly ash enables it to be used as aggregate in applications which require strength but have restrictions on the weight of the structure.

Agglomerated fly ash is produced by chemically combining particles for ease of handling and transport. However, this process requires a large fly ash availability and agglomeration technology requires major development, so this is not a viable substitute at this stage.

Substitutes for:	sand
Current quantities used:	4mt available (approx) 1.3mt currently used
Applications:	Concrete - 0.4mt (cement substitute) Embankment Fill – 0.9mt

Factors Affecting Supply and Demand

The current constraints on the use of fly ash are the processing required and transport costs (remote sources and the need for covered transport) from Lithgow or the Hunter Valley which are the nearest sources to the Sydney Region. Concrete manufacturing plants in the Central Coast, Hunter, Salamander Bay, Scone, Tamworth and Armidale may be able to increase the use of fly ash as coarse aggregate in their products, but it is unlikely to produce a significant source of fine sand.

Fly Ash – Options for Increasing Level of Use

- A solution to the processing and transport difficulties, and an identified set of regular users is needed to encourage greater use of fly ash as an aggregate substitute.

Spoil – Excavated Rock and Soil

Current Practices

Many major infrastructure projects in the Sydney Region pass through sandstone and sand material with the potential for use as sand and aggregate substitutes. It is estimated that there is between 1-5 million tonnes of spoil material generated per year in the Sydney region from excavation of foundations for projects, in earth works preparing sites for projects and in tunnelling projects. The usefulness of this spoil material for construction purposes is governed by the local geology of the project site, the type of material and the method of extraction. Much of the material could and is being crushed and used as fill and road bed.

Selective extraction and intensive processing would be required to produce good quality construction material. This adds to the costs of excavation and/or product. The major use would be for fill or roadbase on or near the site.

Substitutes for:	sand and hard rock
Current quantities used:	1mt – 5mt p.a.
Applications:	Road base Fill

Factors Affecting Supply and Demand

Under the present construction regimes, the amount of excavated materials which may be substituted for natural sand and aggregate in high quality applications is likely to be highly variable and very project specific. A number of companies have attempted to crush and wash the spoil material to generate sand for concrete use. The outcome is variable depending on geology and extraction method. The material is however, suitable for use as fill.

With changes in construction techniques and increased obligations through development of planning provisions such as Development Control Plans (requiring sorting, recycling and reuse on site of spoil material) to use spoil material, there could be a significant increase in the use of this material.

Spoil / Excavated Rock and Soil – Options for Increasing Level of Use

- DCPs to ensure that on-site sorting, crushing and reuse of material is maximised during major developments.

COAL WASH

Current Practices

Coal Wash includes non-carbonaceous and other non-specification fractions from the washing and processing of Run of Mine (ROM) coal to produce coking and energy coal. The proportion of ROM coal which ultimately is not used as product and contributes to Coal Wash depends on coal seam properties, Coal Washing technologies used and the type of coal product to meet customer requirements. Coal Wash yield may be up to 40% of the ROM coal mined, especially where strict coking properties are required for the production of steel.

Coal Wash composition is dependant on the depositional environment in which the coal seam was laid down, however it is primarily comprised of soft sedimentary rock, clay, silt, sand and other carbonaceous material. Occasionally, some igneous rock intrusions and/or sedimentary bands are mined and present in Coal Wash. Coal mining operations located in the NSW Southern Coal Field currently produce approximately 4Mt/year of Coal Wash. Coal Wash is currently emplaced in purpose built landfills on or close to mining operations. However, Coal Wash has been successfully used as select fill for residential subdivisions in the Illawarra, fill for rehabilitating industrial and mine sites, and for limited commercial applications such as brick making.

Substitutes for:	Sand, hard rock, VENM, clay-shale
Current quantities used:	4mt p.a. (available)
Applications:	Select Fill Brick making Environmental rehabilitation of mines/quarries/industrial sites

Factors Affecting Supply and Demand

Coal Wash generation is an integral part of coal mining operations. A constant supply of Coal Wash (approx 4mt/yr) is generated by coal mining operations in the Illawarra and Southern Highlands. The physical and chemical properties of the material is governed by the geology of the coal seam and Coal Washing process. Within individual coal seams and washing plants, Coal Wash is produced at relatively constant rate and with known product variability. Transport cost from the Illawarra/Southern Highlands to application sites in Sydney is the major cost associated with use of Coal Wash.

In a similar manner to Spoil, changes to planning and other regulatory instruments to substitute natural materials with recycled or manufactured products could facilitate a significant increase in the use of Coal Wash for beneficial purposes. Substantial benefits in terms of reduced emplacement areas could also flow from an increase in the use of Coal Wash for beneficial purposes.

Others

There are other potential substitutes (e.g. rubber crumb) to fine and coarse aggregates which would need substantial research and development before they could be considered as realistic options. They are currently too expensive to produce on a large scale, technology is not sufficiently advanced as yet to make them cheap and long term prospects, and they could not compete with natural sources of sand and aggregate or the substitutes described above. They include:

(There are a wide range of other substitutes that should be considered such as Coal Wash – 4mtpa use as substitute unprocessed construction material, compost – substitute for quarried loam of which approx 500ktpa is quarried each year, cement fibre board rejects – about 50krpa as a sand substitute, glass – about 50ktpa could be used as a drainage medium and natural substitute in concrete and Portland cement substitute, foundry sand- about 50 ktpa as substitute in asphalt and compost)

Role of NSW Government Agencies, Councils and Industry Organisations

DEC

The Department of Environment and Conservation administers the Waste Avoidance and Recovery Act 2001 and implements the Waste Avoidance and Recovery Strategy required under that Act. It also reports on progress of the Strategy each year. It is the primary agency in NSW for the reduction of waste and promotion of recycling and use of recycled products, and has produced a directory of recyclers for C&D material in Sydney. The Department also has responsibilities under the Protection of the Environment Administration Act 1991, Protection of the Environment Operations Act 1997, and the Protection of the Environment Operations (Waste) Regulation 2005, in relation to waste reduction, recycling and administration of waste levies. (Also has a key role in increasing the use of waste materials as substitutes for natural materials and the use of regulatory and licensing measures to influence change in this area)

DoP

The Department of Planning (DoP) is responsible for strategic planning and the assessment and approval of major projects in NSW. Part of the strategic planning undertaken by DoP is the Sydney Construction Materials Strategy of which the Substitutes and Recycling Discussion Paper is a part. One way in which DoP can influence recycling of C7D material is to develop a model DCP to guide Councils in making DCPs requiring sorting, recycling and reuse of materials on site. Development approval conditions are another way in which use of substitutes can be encouraged (e.g. requirement to reuse quarry crusher fines). (The DoP have been closely involved in developing consent conditions for the reuse of spoil /VENM on large projects – not just crusher fines. Whilst the DCP helps towards recycling most is off site.)

RTA and Other Infrastructure Agencies

The Roads and Traffic Authority are responsible for building and maintenance of many of the roads in NSW. Consequently they are a major user of recycled roadbase and other substitutes for natural sources of sand and gravel. (They have been greatly involved in the “GreenSpec” specifications for the reuse of materials). They also have implementation guidelines for the NSW WRAPP. Railcorp are a major user of aggregate as rail bedding and fill, and potentially a major user of substitute aggregates which meet the specifications for those uses.

Councils

Local councils are required to make Local Environmental Plans and Development Control Plans which set out the land use requirements in the local government area. Like RTA, local councils are a major builder and repairer of roads and thus, a potential high user of recycled roadbase and other products. Councils may also impose development consent conditions requiring maximisation of recycled construction materials and waste avoidance.

Other NSW Government Agencies

Department of Commerce is responsible for Government tendering policy and specifications. This policy may be used to favour tenderers which use recycled construction materials or which maximise reuse and recycling procedures.

Industry

A number of different industries have an interest in recycling and substitutes for natural sources of aggregate. Concrete manufacturers have an interest in substitutes for aggregates used in readymixed concrete, such as manufactured sand. Industry invests in research and development of substitute materials and admixtures which enable a broader range of aggregates to be suitable for readymixed concrete manufacture. Industry are also involved in encouraging waste avoidance and recycling through groups such as the Waste Management Association of Australia (WMAA) who develop guidelines and polices on waste treatment and maximisation of recycling. Other industry groups are quarries (maximising production of manufactured sand) and C&D recyclers.

Current legislation and policies

There are laws and policies in place to encourage use of substitute materials for construction purposes. These are listed below.

Relevant Legislation

Waste Avoidance and Resource Recovery Act 2001
Environmental Planning and Assessment Act 1979
Protection of the Environment Operations Act 1997
Protection of the Environment Operations (Waste) Regulation 2005

Policies / Strategies

Waste Avoidance and Resource Recovery Strategy 2003
NSW Government Waste Reduction and Purchasing Policy- WRAPP (1997)
RTA – Implementation of NSW Government WRAPP

Discussion

There are clear financial and environmental benefits of using recycled materials and other substitutes for construction materials. To reduce Sydney's dependence on natural sources of construction materials, the supply of viable alternatives must be increased. Processing of material into industry accepted products should be promoted, and demand for those products fostered through increased knowledge and confidence. Existing polices favouring use of recycled products and substitutes for natural construction materials need to be strengthened to expand the markets for such products and their widespread application. If support of substitute construction materials can be promoted in the supply, processing and demand areas, then pressure for use of natural materials will decrease.

The materials with most potential to provide sustained supply of products that substitute for natural sources of sand and aggregate are:

- recycled construction and demolition material – especially in road bases, bedding material, low strength concrete, fill and asphalt
- quarry sand / manufactured sand – especially when blended with natural sand for use in concrete
- blast furnace slag - especially in Illawarra and southern Sydney

- Excavated rock and soil - although occurring in large quantities in some projects, is more limited to opportunistic reuse on site and it is difficult to quantify the contribution to overall sand and aggregate use over the long term. Planning controls may assist in maximising its reuse.

Fly ash is also available in large quantities but is limited by the transport distances to places (concrete plants) where it can be optimised in its use rather than used as fill.

To maximise the contribution of these substitutes in replacing natural sources of sand and hard rock aggregate in the Sydney construction market the following tools should be considered.

Standards & Product Accreditation

For recycled and substitute construction materials to be maximised in their use it is important that each product is accredited for use in various applications. For instance, manufactured sand should meet the Australian Standard 2758.1, "Aggregates and Rock for Engineering Purposes, Part 1 Concrete Aggregates" when used in concrete manufacture. Similarly, roadbase material should meet the various standards required by the RTA. Products meeting these standards, and validated through product accreditation schemes are likely to increase the confidence of councils and private industry to use substitutes. Industry certification of producers of recycled C&D materials based on their quality control procedures and on independent audit tests of their products would also increase confidence in substitutes.

Linking products to Standards and accreditation schemes can also assist in developing formal purchasing polices for recycled and other substitutes. If organisations can be assured of quality products then they are likely to be more willing to adopt purchasing policies which favour those products over natural products.

Research

As with all industries, research to improve products and technology to obtain those products is ongoing in the quarrying and construction industries. Areas of research which would assist increasing the use of substitute construction materials include:

- stability and strength of concrete and bitumen mixes containing recycled material, and manufactured sand
- research into admixtures which increase the acceptability of a wider range of particle shapes / sizes so that more substitute material could be used in concrete mixes
- improved crushing techniques to maximise retention of crusher fines
- investigation into markets and uses for iron rock, BF sand and steel rock, especially in the Illawarra and southern Sydney region.
- further investigation into alternative substitutes so that they may become more viable to produce (e.g. rubber crumb)

While such research is primarily the responsibility of industry, investigation into waste levy funding availability to augment industry investment in R&D should be made.

Education

This is an another ongoing area that requires attention to increase the awareness and acceptance of substitute construction materials, particularly in reporting improvements in technology and research findings. This information should include :

- directories and other information to support access to recycled products and reprocessing opportunities
- information disseminated by industry on products (recycled aggregate, manufactured sand) and the standards they meet and the products they are used to make (asphalt, concrete, bedding etc) in the construction industry
- trials and case studies about the performance of recycled and substitute products in order to promote increased use

Best Practice and System Improvement

Best practice guidelines for quarries are being developed as part of the Sydney Construction Materials Strategy and includes guidelines on maximising resource recovery, recycling of material on-site and reuse of materials. Other Codes of Best Practice that should be developed are a Code of Best Practice related to the on-site classification and separation of demolition materials and construction waste. This would be a supporting document to DCPs requiring sorting and recycling of C&D material on development sites. This includes development of best practice guidelines for various recycling systems, operation of reprocessing facilities, case studies relating to best practice and process improvement. It also includes infrastructure mapping to assist decision making, and materials flow analysis and transport modelling.

Planning Controls

The use of Development Control Plans (DCPs) that require construction and demolition material to be sorted, recycled and reused on development sites will minimise the amount of such material going to landfill and reduce the need to use natural sources of sand and aggregate on those sites. While such DCPs are in force in some city council areas the requirement for all Councils to adopt similar requirements would add significantly to the recycled C&D material used. Similarly, DCPs could also be used to ensure suitable excavated rock and soil is reused where possible on large development sites, further lessening the reliance on natural sources obtained from quarries.

In addition, Councils and government can impose development consent conditions which require use of substitute construction materials where those materials meet appropriate standards. For quarries, an example may be a requirement to utilise crusher fines.

Levy on use of Natural Materials

Currently natural sources of sand are used for a range of uses including ready-mixed concrete, bedding material, drainage medium, glass making, landscaping and golf course bunkers. In some cases sand of a particular size, shape or silica content is required and substitutes cannot be used because they do not have these specifications.

It is preferable that natural sources of sand and aggregate be used for the highest possible use (e.g. high silica content sand used for glass; fine-medium grained sand used for concrete manufacture) because there are no other suitable products to substitute for them. Sometimes high quality natural products are used for purposes that other cheaper, recycled or substitute products could be used as a matter of convenience – e.g. it is quicker to order sand than arrange for a substitute.

Similarly, substitutes such as manufactured sand may be used for lower end uses such as roadbase when they would be suitable for use in concrete mixes when blended with natural sand. Through product accreditation schemes and standards, suitable uses of substitute material could be specified and where a substitute could adequately fulfil the purpose then it should be favoured over a natural source.

A levy could be placed on the use of natural sources of sand and aggregate for lower specification products to ensure that the higher quality sands are being used for higher quality products, thus prolonging the life of quarries which produce such aggregates. Market forces would determine the levy needed to force use of alternatives in place of natural sources. A schedule defining the range of substitutes and their suitability for different products would also be required. Imposing a levy on use of natural materials in such circumstances is likely to increase the use of substitutes over natural sources.

Where to from here ?

The Sydney Construction Materials Strategy will include options for increasing the use of substitute construction materials to relieve pressure on natural sources of sand and hard rock aggregate. Comments on this Draft Discussion Paper are sought from relevant NSW Government agencies and suggestions on other alternatives and approaches are invited. Following agency input the Paper will be discussed with Council and Industry representatives before developing a Draft Strategy.

References

Bakoss, S.L. and Ravindrarajah, S. (1999) *recycled Construction and Demolition Materials for Use in Roadworks and Other Local Government Activities*, University of technology Sydney – Centre for Built Infrastructure Research.

Department of Environment and Conservation (2004) *Waste Avoidance and Resource Recovery in NSW – A Progress Report 2004.*

DIPNR (2004_1) *New South Wales State and Regional Population Projections 2001-2051*, Transport and Population Data Centre.

DIPNR (2004_2) *Supply and Demand of Construction and Industrial Sand for the Sydney Market – Background Report in the Sydney Construction Material Strategy*.

Gregory,O. and Jones,D. (2005) *World of Iron and Steel – A construction materials perspective*, prepared for Australian Slag Association Conference, Darling Harbour, Sydney, 1 March 2005.

Lee, L. and Sabaa, B. (1999) *Study of Alternatives to Fine Sand in Concrete and Fill Applications in the Sydney Region*, Proceedings of 19th Biennial Conference of Concrete Institute of Australia, Sydney 1999 pp302-313.

Love, E. and Rochfort, C. (2000) *Markets for Products Containing Recycled Construction and Demolition Materials*, NSW Waste Boards.

MacRae, G.P. (2001) *Structural Clay/Shale Resources of the Sydney Region GS2001/038*, Geological Survey of New South Wales, Department of Mineral Resources.

Pienmunne, J.T. (2000) *Supply and Demand for Coarse Aggregate in the Sydney Planning Region GS2000/525*, Geological Survey of New South Wales, Department of Mineral Resources.

Pienmunne, J.T. and Whitehouse,J. (2001) *Supply and Demand for Construction Sand in the Sydney Planning Region*. GS2001/086, Geological Survey of New South Wales, Department of Mineral Resources.

Resource NSW (2003) *Waste Avoidance and Resource Recovery Strategy 2003*.

Takahashi, T. and Yabuta, K. (2002). New Applications for Iron and Steelmaking Slag, *NKK Technical Review*, 87, p38-45.

Whitehouse, J. (1997) A Position Paper – Substitutes for Natural Fine Aggregate in Concrete and Related Applications GS1997/075, Geological Survey of New South Wales, Department of Mineral Resources

Appendix 1

Construction Materials and Uses in Sydney Construction Industry

Material	Use	Quantity Used (t/yr)
SAND[1]		
fine-medium sand	• readymixed concrete (59%) • mortar (18%) • general construction (14%) • concrete products (5%) • asphalt (2%) • fill (2%)	• 1,475,000 • 450,000 • 350,000 • 125,000 • 50,000 • 50,000
medium-coarse sand	• readymixed concrete (78%) • fill (7%) • asphalt (6%) • general construction (3%) • concrete products (3%) • other – eg horticultural (3%)	• 1,638,000 • 147,000 • 126,000 • 63,000 • 63,000 • 63,000
clayey/mortar sand	• mortar (32%) • readymixed concrete (30%) • general construction (17%) • concrete products (8%) • fill (6%) • industrial (4%) • asphalt (3%)	• 576,000 • 540,000 • 306,000 • 144,000 • 108,000 • 72,000 • 54,000
Total Construction Sand		**6,400,000**
industrial sand	• white glass sand (43-39%) • amber glass sand (50-42%) • foundry sand (10-16%) • other specialty silica sand (1-3%)	• 85,000 - 125,000 • 100,000 – 135,000 • 20,000 – 50,000 • 2,000 – 10,000
Total Industrial Sand		**207,000 – 320,000**
Total Sand		**6,607,000 – 6,720,000**
Hard Rock Aggregate[2#]		
Igneous rocks	• crushed and broken stone (CBS) • prepared road base (PRB)	• 2,709,162 • 1,909,907
River Gravel	• crushed and broken stone (CBS)	• 5,644,084
Sedimentary Rocks	• prepared road base (PRB)	• 1,655,895
Total Hard Rock Aggregate		**11,919,048**
Clay Shale[3]	• bricks / pavers (93%) • roof tiles (7%)	• 1,422,900 • 107,100
Total Clay Shale		**1,530,000**

1 = 1999/2000 figures
2 = 1998/99 for hard rock aggregate
3 = 1999/2000 figures
# = figures include 2.5m tonnes imported from outside Sydney region (divided proportionally between rock types)

Appendix 2

Standards and Specifications for Recycled C&D

Many of the applications of construction materials have industry standards that determine a range of different qualities that the material must have for a particular use. The following standards apply to use of sand and aggregates in concrete, roadbases and other applications.

Concrete

For use as a fine aggregate in concrete manufactured sand, fly ash, recycled C&D aggregate, slag sand and other substitutes must meet minimum specifications set in Australian Standard AS 2758-1-1998 "Aggregates and Rock for Engineering Purposes. Part 1 Concrete Aggregates". This specification sets limits for density, water absorption, particle size distribution, durability impurities and soluble salts.

Road base, select fill, bedding material and drainage medium

- Resource NSW has detailed specifications for materials used in road base, select fill, bedding material and drainage medium ("Specification for Supply of Recycled Material for Pavements, Earthworks and Drainage").
- RTA construction and maintenance specifications continue to increasingly allow for recycled content and waste minimisation. Recent changes to specifications included:
    - G35 and G36 for construction works – contractors are now required to propose recycled-content materials where they are cost and performance competitive and at least the environmental equivalent of the non-recycled alternative. The cost-competitiveness of a product or material must be assessed on a project lifecycle basis, considering issues such as impacts on construction practices and future maintenance and disposal requirements. Contractors are also required to report waste minimisation quantities, initiatives and barriers to the RTA.
- Other key specifications allowing major use of recycled materials include:
    - G34 for maintenance works – contractors are required to propose materials and products with recycled content where they are cost- and performance-competitive and environmentally preferable to the non-recycled alternative.
    - RTA QA Spec R116 Asphalt – allowing up to 15 per cent reclaimed asphalt pavement within asphalt. Percentages greater than this must be accompanied by appropriate testing and qualified technical assessment.
    - RTA QA Specs 3051/3052 allow for the use of recycled materials within base and sub-base of pavements.
    - RTA QA Spec 3071 allows for recycled content within selected formation material.
    - RTA QA Spec 3252 allows use of scrap rubber within certain modified binder classes.
    - Various concrete specifications allow for the use of fly ash, slag and silica fume within concrete mixes.
    - R73 for heavily bound pavement course permits the use of recycled materials as aggregates and binders at depths of around 170 to 300 mm within pavements.
    - RTA QA Spec R75 – In Situ Pavement Recycling by Deep-Lift Cementitious Stabilisation. Allows mechanical incorporation of existing pavement with binding agents (by-products of the steel and electricity industries).
    - RTA G38 and G39 allow for the use of recovered water for road projects.
    - RTA R63 permits the use of recycled materials in the manufacture of geotextiles.
    - RTA R50 allows for the use of slag/lime blends for stabilisation of earthworks.
- AUS-SPEC #2 Asset Owners Roadworks Specifications – for the use of recycled crushed concrete in road construction as granular sub-base.
- Sutherland Shire Council – Recycled Concrete for Base and Sub-Base Pavement Applications
- The RTA are revising their specification acceptance criteria for sands, covering both

natural and manufactured sands, for both asphalt and concrete mixes.