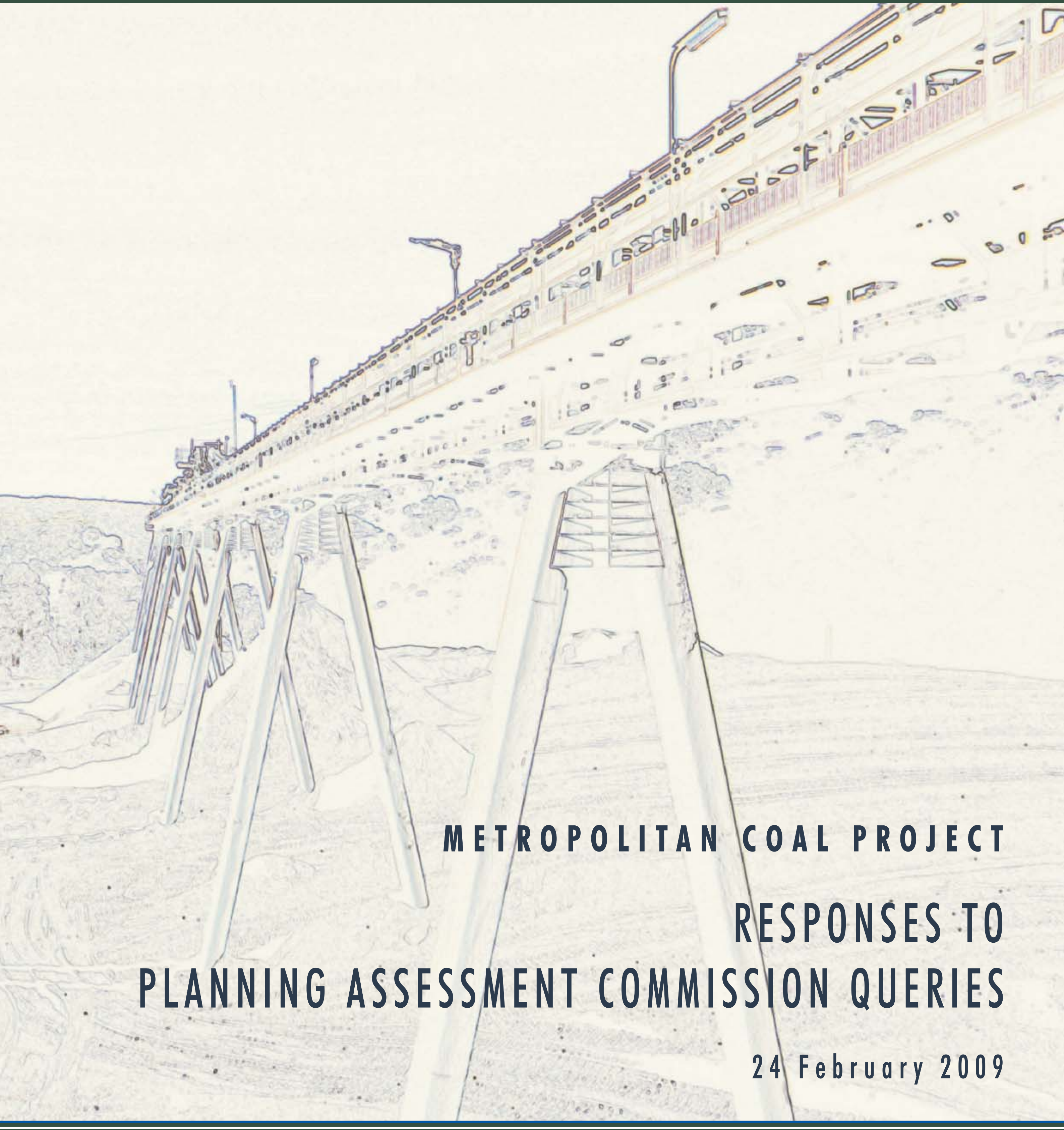
METROPOLITAN COAL PROJECT

RESPONSES TO SUBMISSIONS PART C

Peabody

HELENSBURGH COAL



METROPOLITAN COAL PROJECT

RESPONSES TO PLANNING ASSESSMENT COMMISSION QUERIES

24 February 2009

Peabody

HELENSBURGH COAL

PLANNING ASSESSMENT COMMISSION

METROPOLITAN COAL PROJECT INFORMATION REQUEST

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Cost Benefit Analysis (CBA)		
1.	The CBA is based on an assumed price(s) for product coal. What were those assumed prices(s)?	Page 1
2.	Which environmental costs were included in the CBA? Which were excluded? What valuations are provided for those environmental costs? What is the justification for these valuations?	Page 1
3.	It is noted that catchment values do not include a use component. Only non-use values have been assessed. What valuation is placed on current use of the catchment (including water supply?). If catchment use is changed over the life of the mine to, say, passive recreation, what change(s) in valuation(s) does this lead to?	Page 6
Costs Associated With Potential Barrier Pillars under Waratah Rivulet		
4.	The assessed costs of a 500 m setback on each side of Waratah Rivulet over longwalls 20-29 is reported in the EA and Appendix M as $114 M. What is the cost, calculated on the same basis, of the setbacks shown in Figures 5.4[i] and 5.4[ii] in Appendix A?	Page 7
5.	What other benefits are derived from such setbacks? Eg reduced impacts on Aboriginal sites, tributaries and swamps?	Page 12
6.	Barrier pillars beneath Waratah Rivulet (as discussed on p 5-12) could be based on exceedance of a variety of criteria. Probably only a pre-set criterion of a set number of metres allows for placement of cut-throughs to enable pre-planned relocation of the longwall. Other criteria (eg measured valley closure, initiation of minor/moderate/severe cracking) may not permit the longwall to be stopped for some distance (eg 40 m) and may be subject to debate at the time. Nonetheless, a pre-set distance lacks finesse. Please discuss the various criteria which might be used to establish barrier pillar configuration and the economic benefits and potential environmental costs of each. Which criterion would HCPL support, and why?	Page 15
Sensitivity Analysis		
7.	Please undertake and provide a sensitivity analysis for subsidence impacts, based on barrier pillars sufficient to generate no more than 100 mm; 200 mm; 300 mm; 400 mm and 500 mm of valley closure at any point on the Rivulet. Plans showing the resulting mine plans should be provided, together with total costs of the required setbacks (referenced to the methodology used in the Gillespie report). Detailed descriptions of anticipated subsidence impacts at the Rivulet for each of these five mine plans should also be provided.	Page 17
Regional Economic Benefits		
8.	More information is sought on potential labour market consequences of the mine not receiving approval, or approval on the basis of substantial setbacks from Waratah Rivulet. For example, what labour market changes are projected for coal mine workers in the Illawarra and NSW coal industries over the next 2-3 years? What flow-on effects to the Corrimal and Coalcliff Cokeworks and PKCT might be anticipated from mine closure at Helensburgh or production on the basis of substantial setbacks from Waratah Rivulet?	Page 28
Proposed Mine Layout		
9.	If HCPL are convinced that the current mining dimensions do not result in hydraulic connections to the surface, why is this layout not maintained beneath the Woronora Reservoir?	Page 29
10.	Why has the mine not considered mine layouts other than that which is based on the recommendations of the 1977 Reynolds Inquiry, given other mining practices in the Southern Coalfield (eg South Bulli and Dendrobium)?	Page 30

List of PAC Questions		Response Page Number
Proposed Mine Layout (Continued)		
11.	As an alternative to barrier pillars under each longwall beneath the Waratah Rivulet, has the mine considered taking all of every 3rd longwall beneath the stream. What are the potential costs and benefits of such an approach, cf the layouts shown in Figs 5.4[i] and 5.4[ii] in Appendix A?	Page 31
12.	Please provide a copy of the MineCraft Consulting report referred to on p 3-66.	Page 33
Predicted Subsidence Characteristics		
13.	Is there a survey line along the entire length of the southern section of Waratah Rivulet already undermined? If so, please provide associated incremental, cumulative and net subsidence profiles.	Page 33
14.	How does HCPL/MSEC account for the parts of the southern section of Waratah Rivulet already undermined which show less damage than at WRS4 and WRS3?	Page 34
15.	MSEC applied a calibration factor for vertical subsidence over longwalls mined to date to account for subsidence up to 50% greater than would have been predicted using its full data set. Why were calibration factors not also applied/required for upsidence and valley closure?	Page 34
16.	The MSEC impact criterion of 200mm of closure is premised on correlating their predictions of closure with observed impacts. It is not premised on measured closure. As such, the criterion is dependent on MSEC's (highly) empirical prediction procedure being suitable/accurate for the given conditions. Do the subsidence predictions call this into question? If so, what are the implications? (See, for further clarification, discussion in Environmental Assessment: Dendrobium Coal Mine – Modification of Consent (Area 3), November 2008, available at: http://www.planning.nsw.gov.au/asp/2008_ndetermination_other.asp	Page 35
17.	Appendix A contains a limited discussion of potential causes for increased vertical subsidence at Waratah Rivulet (pp 35-36). However, it does not present any consideration as to whether the increased subsidence at Waratah Rivulet may also affect upsidence or valley closure values and/or predictions. The discussion contained in the EA is not premised on a mechanistic analysis. A detailed analysis of the reasons for elevated subsidence parameters at Waratah Rivulet is requested.	Page 35
18.	Figs 3.12 and 3.13 in Appendix A show predicted and observed subsidence and strain profiles along the D survey line, but no data for predicted and observed tilt. Please provide this data. What accuracy is being assigned to predictions of tilt?	Page 36
19.	The EA relies extensively on MSEC's predictions of strain. Figures 3.12 and 3.13 in Appendix A suggest a poor correlation between predicted and observed strain, both in respect of magnitude and distribution. Predicted strain appears to be significantly less than observed to date. Clarification is sought on this matter and a discussion of its implications for the prediction of subsidence effects, impacts and consequences.	Page 36
20.	Drawing No: MSEC285-20 in App A shows total vertical subsidence in plan view over the whole study area. However, there are no similar plots of total net vertical displacement. Please provide plan view drawings for subsidence effects, including upsidence and closure, that cover the full study area (ref. Table 5.8 in Appendix A).	Page 40
21.	Section 5.6 of Appendix A states the following on numerous occasions: 'If the predicted strains were increased by factors of up to 2 times, the potential for (some impact e.g. cliff instabilities) would increase accordingly'. Please quantify 'accordingly' in each instance (double?).	Page 40
22.	Appendix H classifies a number of Aboriginal heritage sites as 'very significant'. The Panel requests a specific assessment of each of these sites in respect of potential subsidence effects and impacts. In regards to overhangs, HCPL's attention is directed to the assessment criteria discussed in Environmental Assessment: Dendrobium Coal Mine – Modification of Consent (Area 3), November 2008, available at: http://www.planning.nsw.gov.au/asp/2008_ndetermination_other.asp	Page 44

List of PAC Questions	Response Page Number
Catchment Yield	
35. SCA has provided data which indicates (on its face) a loss of flow in the Waratah Rivulet, and therefore a possible loss of catchment yield to Woronora Reservoir. Please provide a detailed response to SCA's analysis and its expression of concerns. In the light of the SCA data, please provide an assessment of confidence for HCPL's position that there is no significant loss of flow in the Waratah Rivulet.	Page 93
Water Quality	
36. What material(s) is causing the pale green opacity noticed in several pools (eg diatoms, algae, iron flocculant? What is the contribution of each such material? Why is this discoloration present in some pools but not others?	Page 112
37. Please provide evidence that the red staining visible from the air on tributaries and on the ground at Honeysuckle Creek is the same in nature, degree and primary cause as the red staining present in Waratah Rivulet in the area previously mined and downstream to the boulder field.	Page 112
38. The eastern tributary to Waratah Rivulet was observed from helicopter fly over to be heavily iron stained over most of its observed course. Is this a result of early longwall extractions beneath the upper reaches? Could similar staining in the western tributary be a result of mining? How long would the iron staining persist post mining?	Page 113
Site Water Management	
39. It is not clear from the EA what site water management improvements are proposed. Please detail any mine site water management measures that are proposed.	Page 113
40. Please outline the principles, practices and commitments which characterise current and proposed site water management.	Page 114
Groundwater	
41. Is it possible to obtain a (pdf) copy of Geosensing Solutions 2008 report referred to in the Groundwater report by Dr. Merrick?	Page 115
42. How many exploration holes have been drilled and geophysically logged in the proposed longwall area. Is there a sufficient density to establish continuity in geologic strata and absence of major structures (faults, dykes)?	Page 116
43. The EA provides general statistics of permeability tests conducted within the area (Merrick Report). How many holes have been subjected to core and packer permeability testing? Is the data set reported elsewhere?	Page 116
44. Groundwater modelling in the EA utilised Modflow while modelling in a more recent report utilised the Surfact variant. It would be useful to see and compare a vertical section plot for each model which clearly shows contours of formation pore pressures - say column 100 in the model (steady state). This section needs to be generated in sufficient detail to indicate the freely draining zone above goaves for current and proposed longwalling.	Page 117
45. Is Figure 12 in the surface waters report correct (the plot seems to suggest rapid falls in water levels - metres below top of casing)?	Page 121
46. PUR was observed in some remediated cracks at rock bar WRS4 to have lost adherence to the crack walls. What is the rated/specified life of this material?	Page 121
47. Please provide a valuation for expected costs associated with loss of access to groundwater in aquifers disrupted by the mineplan as proposed.	Page 121

PLANNING ASSESSMENT COMMISSION
METROPOLITAN COAL PROJECT INFORMATION REQUEST

DETAILED RESPONSES

Cost Benefit Analysis (CBA)

1. The CBA is based on an assumed price(s) for product coal. What were those assumed prices(s)?

As described in Section 2.4.1 of Appendix M, both demand and supply for coal influences current and projected prices.

Short term price projections for coal products used in the analysis were supplemented with a long term highly conservative continuing annual price of AUD$100/t for hard coking coal, AUD$95/t for semi-hard coking coal and AUD$70/t for thermal coal from 2016 (refer table below).

Product (AUD$/t)	2010	2011	2012	2013	2014	2015	2016 onwards
Coking Coal	288	259	185	159	133	109	*100*
Semi-Hard/PCI	231	207	148	127	107	87	*95*
Thermal Coal	173	151	139	113	89	74	*70*

In addition, an average of the thermal coal and semi-hard/PCI coking coal price was also applied to all Project coal production other than hard coking coal (even though almost all of this production is the higher priced semi-hard coking coal), making the EA benefit cost analysis even more conservative.

The benefit cost analysis therefore used an average price of AUD$123/t for hard coking coal and AUD$97/t for all other coal production over the life of the Project. The prices adopted in the benefit cost analysis were therefore highly conservative and well below reported 2008 peak coal prices (e.g. up to US$300/t for hard coking coal).

It is noteworthy that the average prices applied in the benefit cost analysis are below Macquarie Group 2009 predicted contract prices (e.g. US110/t for hard coking coal and US$75/t for thermal coal). Using a conservative $US-$AUD conversion assumption of 0.75 and applying these prices (i.e. AUD$147 and AUD$100 with a 1% growth per annum after 3 years) to the life of the Project gives a threshold value (net of greenhouse gas emissions, noise and infrastructure costs) of $839M which is considerably greater than that used in the benefit cost analysis in the EA ($436M - net of greenhouse gas emissions, noise and infrastructure costs) (Appendix M). This reinforces the conservatism of the EA coal price assumptions.

2. Which environmental costs were included in the CBA? Which were excluded? What valuations are provided for those environmental costs? What is the justification for these valuations?

Table 2.3 of Appendix M of the EA summarises the costs and benefits that were valued and those that remained unquantified.

The externalities that were valued in the EA benefit cost analysis were:

- operational noise from surface infrastructure on adjoining residential areas;
- road transport and road transport noise along Parkes Street in Helensburgh;

- impacts on infrastructure, roads and buildings; and
- greenhouse gas generation.

Externalities associated with underground mining which were considered to be potentially material, but for which estimates of value were not available (at the time) included:

- potential impacts on Aboriginal heritage sites (e.g. cracking of rock platforms or overhangs);
- potential impacts on upland swamps (subsequently excluded as negligible effects were predicted due to type of upland swamps present and natural variability);
- potential impacts on the Waratah Rivulet (cracking and local diversion of streamflow, iron staining, etc.); and
- social impacts of employment generated by the mine.

The above exclusions were addressed in Appendix M of the EA (pages 20-21), via a threshold analysis, which concluded:

> …
>
> *This gives a quantified net benefit of the Project of $436M. However, some of the environmental externalities of the Project have not been able to be quantified. These are the subsidence related impacts on streams and Aboriginal heritage sites.*
>
> *The quantified net benefits of the Project of $436M can therefore be considered as a threshold value. This threshold value is the opportunity cost to society of not proceeding with the Project. Interpreted another way, the unquantified environmental externalities of the Project, after mitigation by HCPL would need to be valued at greater than $436M to make the Project questionable from an economic efficiency perspective.*

These exclusions were then further addressed and ultimately valued via the Choice Modelling conducted for the Project (*Managing the Impacts of a Mine in the Southern Coalfield a Survey of Community Attitudes*, Gillespie Economics 2008) and provided to the PAC on 12 January 2009 (refer Attachment 1).

The Choice Modelling is also discussed in response to PAC Questions 3 and 4 below.

Based on specialist reports all other potential externality impacts were considered negligible or not material for the purpose of the benefit cost analysis. Environmental externalities associated with the Major Surface Facilities Area which were considered to not be of sufficient magnitude to warrant valuation included:

- Surface Water Management (managed in accordance with Environment Protection Licence No. 767 – with potential prosecution if compliance not achieved);
- Rail Transport Noise (no significant change);
- Off-Site Rail and Road Transport Vibration (no significant change);
- Non-Aboriginal Heritage (existing mine is LEP listed - impacts to be managed in accordance with Conservation Management Plan); and
- Air Quality (predictive modelling presented in Appendix K of the EA indicates that compliance with the relevant criteria is expected).

Potential environmental externalities associated with the Project Underground Mining Area which were not considered to be of sufficient magnitude to warrant valuation included:

- Flora and Fauna (As this is an underground mining proposal very little direct disturbance to flora and fauna is expected. No significant impacts to known or potentially occurring threatened species are expected. This is consistent with the findings of the Commonwealth Department of the Environment, Water, Heritage and the Arts [DEWHA] under the *Environment Protection and Biodiversity Conservation Act, 1999* [EPBC Act] [refer Attachment 2].)
- Non-Aboriginal Heritage (HCPL commitments are in place to minimise any impacts to the Garrawarra Complex - i.e. coal sterilisation to achieve negligible impact criteria. This included some reduction in mining in the final years of the Project to avoid impacts on the Complex. This reduction in mining extents was included in the benefit cost analysis.)
- Visual (Minimal alteration to the general visual attributes of the landscape are expected. However, this issue is further explored in response to PAC Questions 3, 23 and 30 below.)

Operational Noise from Surface Infrastructure

As described in Appendix J of the EA, the existing Metropolitan Colliery Major Surface Facilities Area contributes to the existing noise environment in Helensburgh.

Operational noise emissions are expected to be significantly reduced as a result of the Project at the majority of residential properties in the vicinity of the Major Surface Facilities Area (Appendix J).

Notwithstanding this noise reduction, some residences in very close proximity would continue to experience ambient noise levels in excess of the relevant criteria determined under the Industrial Noise Policy (EPA, 2000) (referred to as the Project Specific Noise Assessment Criteria [Appendix J]). Without the Project, ambient noise levels at these properties would return to baseline urban levels (assuming a non-industrial future use for the premises). Hence, while noise emissions would be reduced by the Project, the continued noise emissions of the Metropolitan Colliery would continue to be reflected in the property values of nearby properties.

A profile of the number of properties affected by noise was developed. The number of properties in the noise affectation zone (i.e. noise levels more than 5 dbA above Project Specific Noise Assessment Criteria) was estimated to reduce from 29 to 14 over the first six years of the Project. The number of properties in the noise management zone (1 to 5 dBA above Project Specific Noise Assessment Criteria) was estimated to increase from 6 to 14 over the first six years of the Project. This is because effectively 15 properties are falling from the noise affectation zone to the noise management zone, and seven are falling from the noise management zone to full compliance, reflecting the significant reduction in Metropolitan Colliery noise emissions associated with the Project.

Summary of Noise Impact Assumptions

	Existing	**2010**	**2011**	**2012**	**2013**	**2014**	**2015 onwards**
No. of properties in noise affectation zone	29	29	29	20	20	20	14
No of properties in noise management zone	6	6	6	10	10	10	14
No. of properties no longer in the noise affectation zone or noise management zone	-	-	-	5	5	5	7

Without the Project, it is assumed that none of these properties would be affected by the existing noise of the Metropolitan Colliery.

Based on internet searches, properties in the area were estimated to have a market value of approximately $700,000. A 10% property value impact was assumed for properties in the noise affectation zone while a 5% property value impact was assumed for properties in the noise management zone. These impacts were converted to annuities over the 23 year life of the mine to allow for the temporary nature of noise impacts on some properties.

It is considered that these effects on valuations are part of the existing situation at properties affected by current noise levels from the Metropolitan Colliery Major Surface Facilities Area.

Using these assumptions the estimated cost magnitude of noise impacts on adjoining properties is small ($1.5M). While the 5% and 10% property price assumptions are estimates of potential impacts and no specific property valuation study was undertaken, sensitivity testing indicates that even significant changes in the basic assumptions would make very little difference to the overall economic analysis of the Project.

In addition, this analysis is considered to be conservative - as closure of the Metropolitan Colliery (i.e. if Project Approval was not granted by the Minister) would be expected to also have a negative effect on property values, due to reduced demand from mine staff, contractors and suppliers. This has not been accounted for.

Road Transport Noise

As described in Appendix J of the EA, the existing Metropolitan Colliery contributes to off-site road transport noise effects along the transport routes, to and from the Major Surface Facilities Area, with the key transport contribution being the transport of product coal to local coke works facilities and coal reject to the Glenlee Washery.

With the Project, these activities would continue at the current levels, contributing less than 6.5% of daily traffic movements along Parkes Street and negligible traffic movements to the regional road network.

Project related traffic movements would then substantially reduce when coal reject road transport to Glenlee Washery is stopped by Year 12 of the Project due to HCPL's commitment to emplace this material underground. This is a significant environmental benefit that arises due to the capital development associated with the Project.

Without the Project, existing Metropolitan Colliery truck movements along Parkes Street would cease in 2010. Consequently, the Project may result in some continuing amenity impacts to houses located along Parkes Street, relative to without the Project. To place indicative estimates on this impact the benefit cost analysis assumed 120 properties along Parkes Street (valued on average at $700,000 each) would be affected to the value of 5% over the life of the mine ($3.9M PV). Again, sensitivity testing indicates that even significant changes in the basic assumptions would make little difference to the overall economic analysis of the Project.

Impacts on Infrastructure, Roads and Buildings

As identified in Appendix A of the EA, there is a range of other infrastructure located above or in close proximity to the Project Underground Mining Area that may potentially be adversely affected by subsidence effects. These include features such as:

- optical fibre cables;
- electrical transmission lines;
- water pipelines;
- the Princes Highway; and

- the F6 Southern Freeway.

Potential impacts on these items of infrastructure would be managed through the Subsidence Management Plan (SMP) process post Project Approval. Management measures would be implemented by HCPL where required and restoration works of subsidence effects would be facilitated by the Mine Subsidence Board, as required.

To value these impacts the replacement/repair costs approach has been used. An allowance of $2.5M has been made for these restoration costs, spread across the years when impacts are expected. This estimate was based on the experience of HCPL and knowledge of the man-made features present. Again, sensitivity testing indicates that even significant changes in the assumptions make little difference to the overall economic analysis of the Project.

Subsequent to the completion of the EA, two angled electricity transmission towers have also been identified on the 132 kV electricity transmission line located above the Project Underground Mining Area (refer Map 2, Appendix A of the EA) that may require additional management controls. It is estimated that up to an additional $1M may be required to provide additional bracing at these towers, with this expenditure occurring in approximately 2015. As above, this additional cost would have very little impact on the economic analysis of the Project.

Greenhouse Gas Generation

The Project will generate a range of greenhouse gas emissions. Appendix M discusses the concept of estimating the social damage cost of carbon and the alternative of using a market price for carbon credits, although it is noted that the value generated from this latter approach is ultimately a function of the characteristics of the scheme and the scarcity of permits, etc. and hence may or may not reflect the actual social cost of carbon. A range of estimates of the social cost of carbon are provided, e.g. Tol's (2005) review of the literature concluding that it is unlikely that the marginal damage costs of carbon dioxide emissions exceed US$14/t CO_2 (and are likely to be substantially smaller than that) and Nordhaus's (2008) modelling using the DICE-2007 Model which suggests a social cost of carbon with no emissions limitations of US$30 per tonne of carbon (/tC) (US$8/t CO_2).

Information was also provided on the price of carbon credits under various schemes, including a predicted price for carbon credits of AUS $35/t CO_2 cited by the National Emissions Trading Taskforce.

Ultimately the benefit cost analysis used what could be considered to be a conservatively high value of AUS$30/t CO_2-e, with sensitivity testing from AUS$8/t CO_2-e to AUS$40/t CO_2-e. These values were applied to not only Project Scope 1 emissions, but also Scope 2 emissions (e.g. electricity generation), and Scope 3 emissions associated with the transport of coal (to local coking works and Port Kembla) and coal rejects (to Glenlee Washery).

Since the EA was published, the Carbon Pollution Reduction Scheme: Australia's Low Pollution Future White Paper (Australian Government, 2008) has been released citing a carbon permit price of AUS$23/t CO_2 in 2010 and AUS$35/t CO_2 in 2020 (in 2005 dollars) for a 5% reduction in carbon pollution below 2000 levels by 2020. The central estimate of the social cost of carbon range considered in the benefit cost analysis lies within the range cited in the White Paper.

3. It is noted that catchment values do not include a use component. Only non-use values have been assessed. What valuation is placed on current use of the catchment (including water supply?). If catchment use is changed over the life of the mine to, say, passive recreation, what change(s) in valuation(s) does this lead to?

The Woronora Special Area is a special area, where public access is restricted. All access, either on foot or by vehicle, and including motorcycles, bicycles and horses, is prohibited. Activities such as swimming and boating are also prohibited.

It is considered very unlikely that these restrictions on public access would be lifted. In accordance with Section 44 (4) of the *Sydney Water Catchment Management Act, 1998*:

> *A special area must not be reduced in size, and an order declaring an area of land to be a special area must not be repealed, unless authorised by an Act of Parliament.*

Following the contamination of Sydney's water supply in 1998 (due to unacceptable levels of the parasites giardia and cryptosporidium), the NSW government has generally been pursuing tighter restrictions on activities in water supply catchments, rather than relaxations.

On this basis, no catchment use values are included in the benefit cost analysis because no use values are impacted by the Project. Non-use values associated with impacts on streams and Aboriginal sites were considered in the Choice Modelling conducted for the Project.

The Choice Modelling included surveying the views of 1,000 people (approximately 500 in the Illawarra Region and 500 in wider NSW). The Choice Modelling sample is considered to be representative of the NSW population and no significant differences were identified with respect to the responses from respondents in the Illawarra Region and the population of NSW as a whole.

Application of the Choice Modelling results to the benefit cost analysis using the highly conservative EA coal price assumptions indicates that the Project is economically desirable with quantified net benefits valued at approximately $1,000M (refer PAC Question 4 below).

The Woronora Special Area is primarily significant as a water supply catchment. Water supply has a use value on delivery to customers which can in theory be estimated based on the price elasticity of demand for water at the margin. To incorporate any value estimated for water into the benefit cost analysis requires estimation of a physical impact i.e. water loss per annum and the likelihood (probability) of this water loss occurring.

Analysis of the potential impacts on water supply that was conducted for the EA indicates that the Project would not result in material impacts on the quality or quantity of yield from the Woronora Reservoir. This analysis was Peer Reviewed by Dr Walter Boughton who concluded:

> …
>
> *None of the methods used showed any evidence that underground mining has had any effect to date on inflows into Woronora Dam.*

This was supported by the Southern Coalfield Inquiry Report which concluded:

> *No evidence was presented to the Panel to support the view that subsidence impacts on rivers and significant streams, valley infill or headwater swamps, or shallow or deep aquifers have resulted in any measurable reduction in runoff to the water supply system operated by the Sydney Catchment Authority or to otherwise represent a threat to the water supply of Sydney or the Illawarra region.*

Hence the value that the Special Area provides with respect to water supply would not be altered by the Project.

If some access to the catchment were to be permitted in the future for passive recreation, the consumer surplus value of this activity could potentially be estimated using the Travel Cost Method. Consumer surplus values for visits to NSW national parks have been estimated in a range of studies and vary from $19 per visit for Gibraltar Range National Park (Bennett, 1995), to $33 per visit for Dorrigo National Park (Bennett, 1995) and $28 to $44 per visit for Minnamurra Rainforest Centre, Budderoo National Park (Gillespie, 1997). Using a lower figure of say $20 to reflect the low key nature of any visitation to Sydney's drinking water catchment, a notional 5,000 visitors per year would be associated with $100,000 per year of recreation values. However, all these values would not be lost in the presence of cracking of the rivulet. Instead there may be some reduction in demand for visitation to the catchment.

There are no published reports on how stream cracking may impact demand for passive recreation. However, recreation values may be quite resilient to changes. A study by Crase and Gillespie (2008) found that a 50% reduction in water levels on Lake Hume reduced annual recreation values by 38%. A 90% reduction in water levels reduced annual recreation values by 50%. If cracking reduced the abovementioned hypothetical annual values for passive recreation in the catchment by 10% the annual impact would be $10,000. Over a 25 year period using a 7% discount rate this amounts to $117,000 present value. This level of impact would have little measurable impact on the benefit cost analysis.

Furthermore, this value would only be relevant if there was a 100% probability that this level of passive recreation were allowed in the catchment in the future. In reality, the probability of passive recreation access being allowed in the catchment in the future is very small.

Costs Associated With Potential Barrier Pillars under Waratah Rivulet

4. The assessed costs of a 500 m setback on each side of Waratah Rivulet over longwalls 20-29 is reported in the EA and Appendix M as $114 M. What is the cost, calculated on the same basis, of the setbacks shown in Figures 5.4[i] and 5.4[ii] in Appendix A?

HCPL has investigated and undertaken preliminary cost estimates on the alternative mine layouts (scenarios) as requested by the PAC. These analyses are based on comparative cost estimates with respect to full extraction under the Waratah Rivulet using estimates of the tonnages of coal sterilised and the additional costs associated with additional capital expenditure and additional workforce required to maintain mine development and gas drainage – plus estimates of the monetary environmental costs and benefits that have been determined by the Choice Modelling Study.

While the relative costs of implementing these mine layout scenarios have been estimated in terms of impact on the net benefits of the Project, mine layout variations that involve setbacks are also subject to technical considerations such as engineering, mine development and gas drainage requirements that impose risks (financial and logistical) on the continuity of mining. Hence, while in theory it may be possible to implement all of the setback scenarios, financial return on capital and continuity of mining risks are also relevant considerations for HCPL when making investment decisions. Any mining scenario that does not provide for the effective management of these issues is a relevant consideration with respect to the ongoing viability of Metropolitan Colliery as a whole.

Background

The cost benefit analysis conducted for the Project indicated that the threshold value of the Project would be $436M. However the costs of some key environmental externalities associated with underground mining (e.g. impacts on Waratah Rivulet and Aboriginal heritage sites) were not able to be incorporated in the analysis, as estimates of the social value of these impacts were not available.

The Choice Modelling conducted for the Project by Gillespie Economics included surveying a sample of 1,000 residents of NSW and was undertaken to determine an estimate of the social costs of such externalities. The results of the study indicate that the previously unquantified environmental impacts of the Project (e.g. impacts on Waratah Rivulet and Aboriginal heritage sites), if they remain unmitigated, would have an economic value (cost) to NSW households of $143M.

The Choice Modelling study also indicated that NSW households significantly value the ongoing employment (benefit) provided by the Project ($756M). Using the social cost and benefit values determined by the Choice Modelling, revision of the benefit cost analysis using the highly conservative EA assumptions indicates the net benefits of the Project would be approximately $1,000M.

Using the coal price assumptions described in the response to PAC Question 1, the net benefits of the Project would be up to $1,451M.

The EA considered a setback of 500 m for Longwalls 20-30, rather than Longwalls 20-29. This is due to the angle of draw and the cumulative effects of subsidence.

Page 23 of Appendix M states:

> *The quantified net costs of the setback of $114 M can therefore be considered as threshold value. This threshold value is the opportunity cost to society of mining adopting a 500m setback. Interpreted another way, the unquantified environmental benefits of a 500m setback would need to be valued at greater than $114 M to make such a setback desirable from an economic efficiency perspective.*

Further Analysis of Setback Scenarios - Figure 5.4, 5.4(i) and 5.4 (ii) of Appendix A

Further analysis of the relative costs and benefits of the setback scenarios shown on Figures 5.4, 5.4(i) and 5.4(ii) of Appendix A (herein described as Scenario Figure 5.4, Scenario Figure 5.4(i) and Scenario Figure 5.4(ii)) has been conducted.

The environmental benefits of these scenarios with respect to reduced environmental impacts on the Waratah Rivulet and Aboriginal heritage sites (refer response to PAC Question 5) and reduced greenhouse gas emissions due to mine life reduction have been estimated using the results of the Choice Modelling Study and a carbon price and range from approximately $58M to $111M.

These estimates of environmental benefits in comparison to the base case mine plan (i.e. full extraction) are highly conservative – as they assume that no stream restoration is implemented for the base case, however as described in the response to PAC Questions 30-31, significant stream restoration works are proposed for the Project.

The relative net production cost of implementing these setback scenarios would range from approximately $95M to $152M, with the loss of between approximately 4.6 Mt and 8.1 Mt of product coal and a reduction in the mine life of approximately 1.9 to 3.3 years.

The summary estimated incremental costs and benefits of Scenario Figure 5.4, Scenario Figure 5.4(i) and Scenario Figure 5.4(ii) are tabulated below.

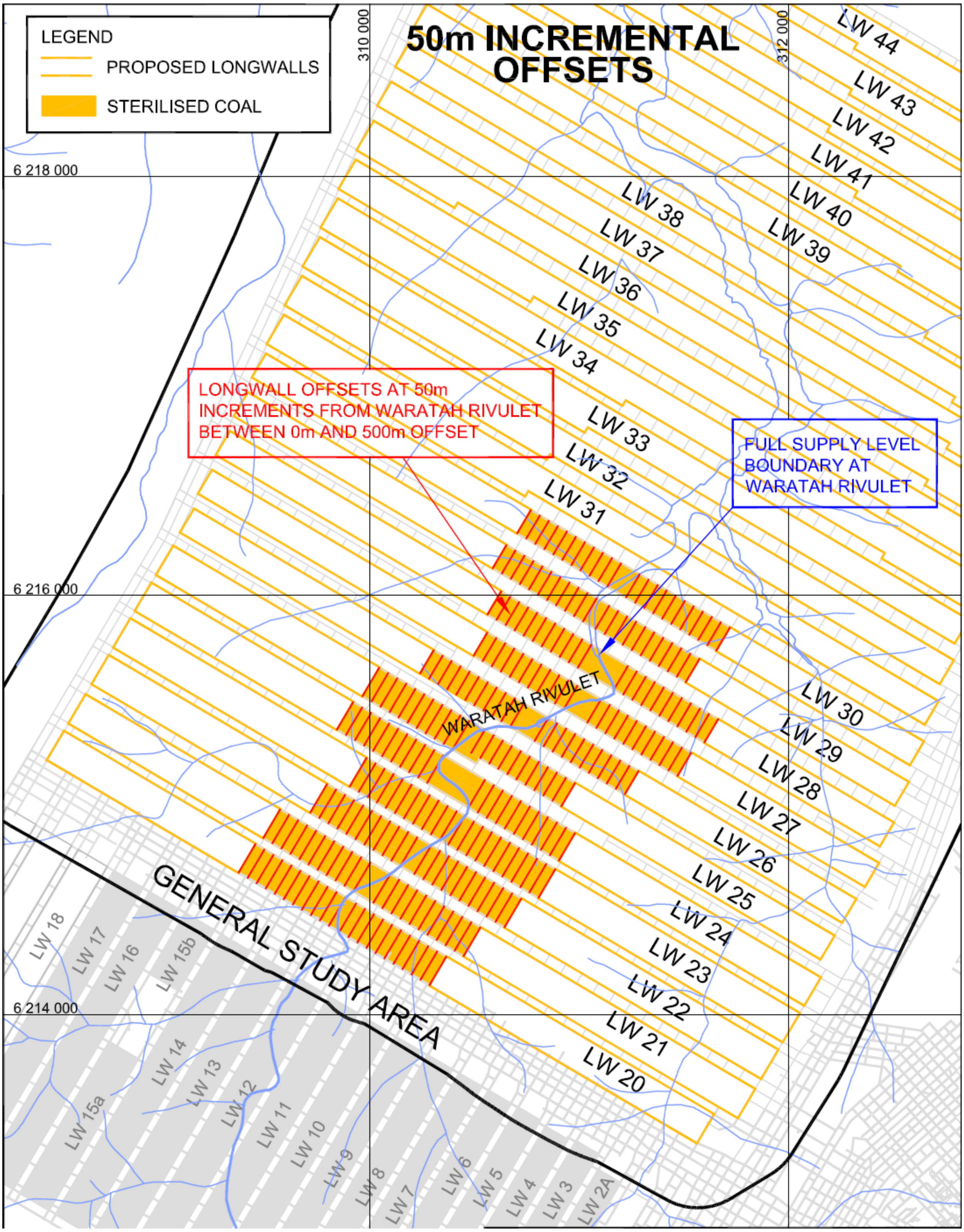


Fig. 5.4 Proposed Offset Distances from Waratah Rivulet

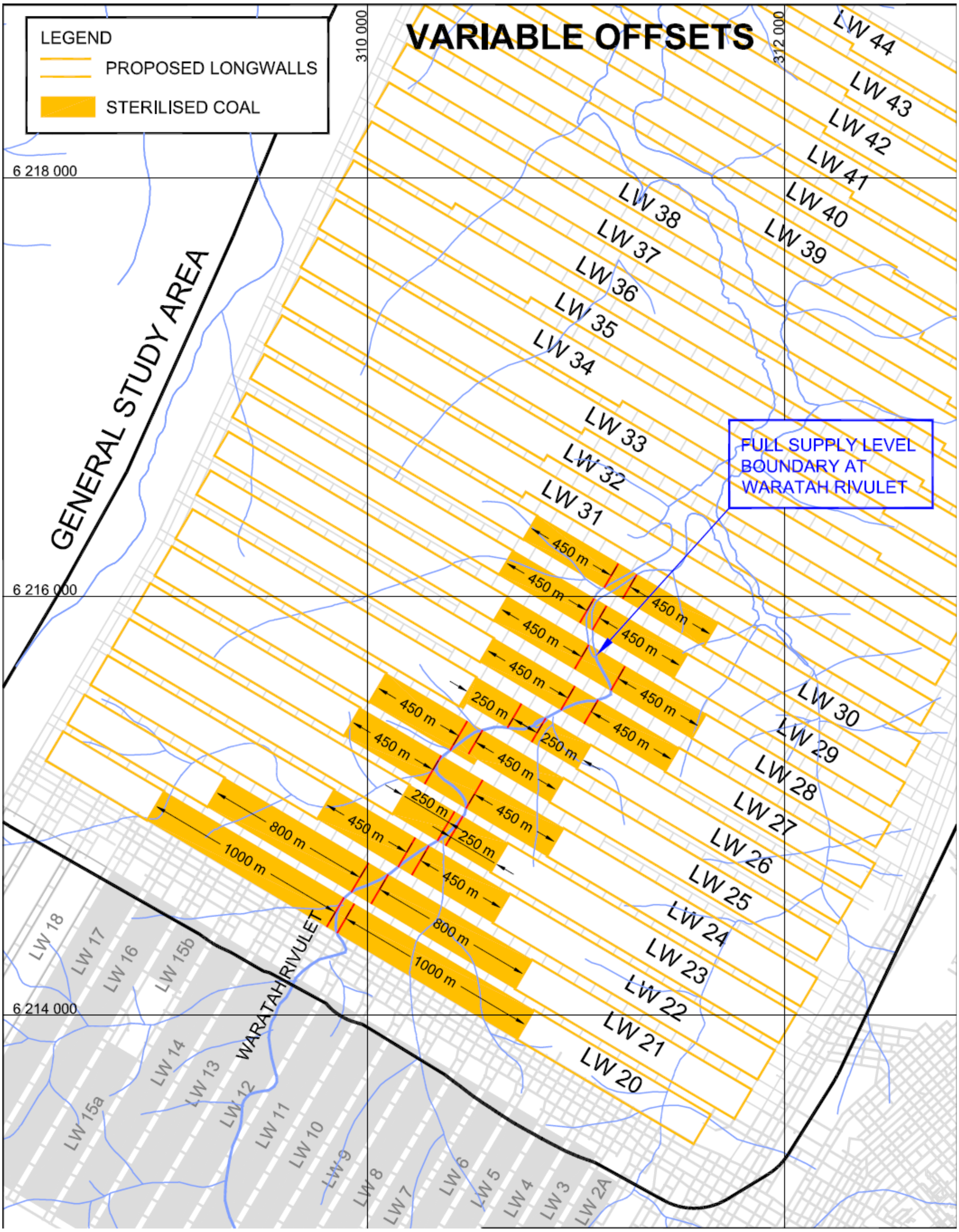


Fig 5.4 [i] Proposed Offset Distances from Waratah Rivulet - Variable

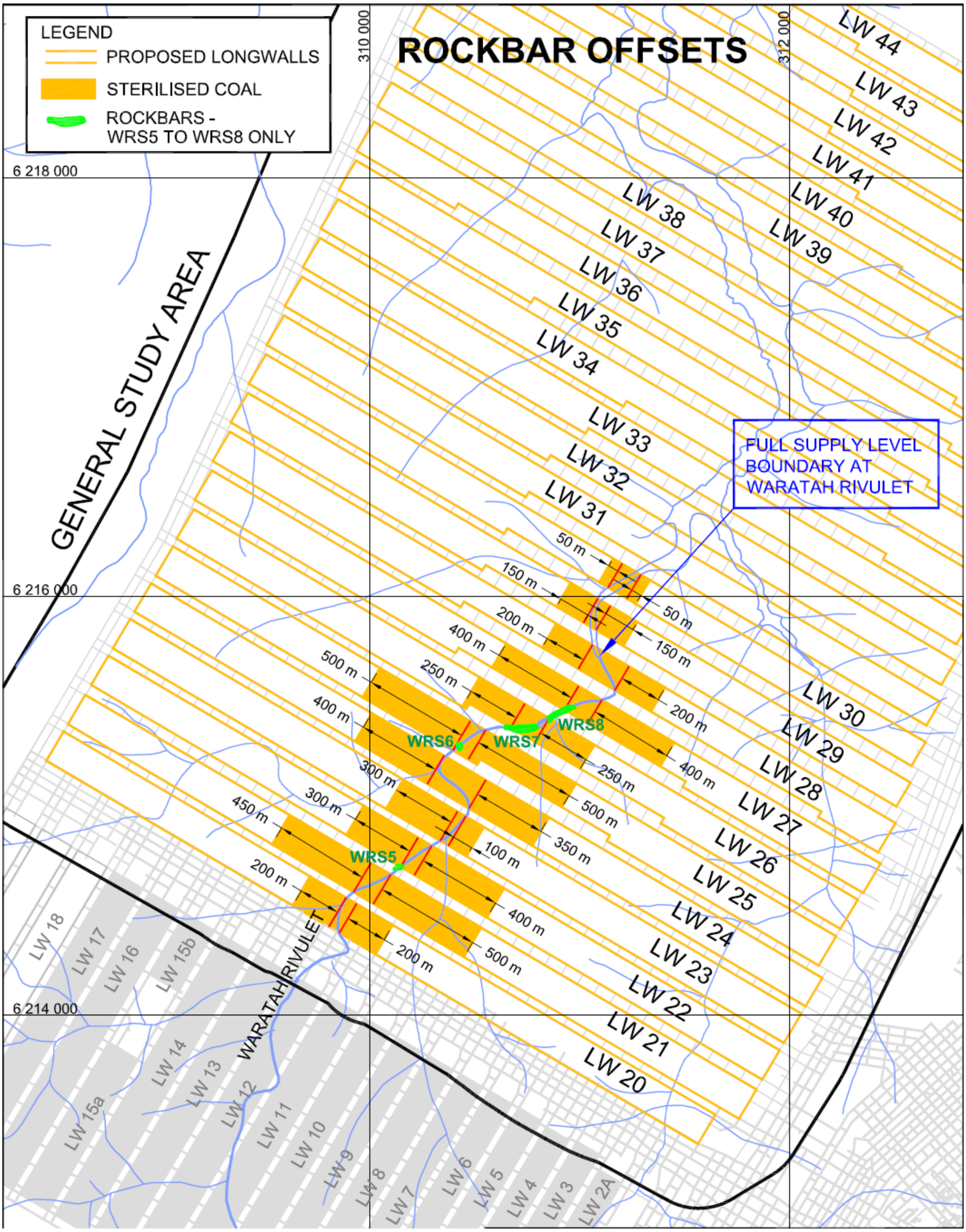


Fig 5.4 [ii] Proposed Offset Distances from Waratah Rivulet – Rock Bars WRS5-8

Component	Scenario Figure 5.4	Scenario Figure 5.4(i)	Scenario Figure 5.4(ii)
Incremental Net Production Benefit/Cost	-$147M	-$152M	-$95M
Incremental Estimated Environmental Benefit (due to reduced environmental impacts)	+$111M	+$111M	+$58M
Incremental Estimated Social Costs (due to reduced mine life)	-$106M	-$108M	-$63M
Incremental Net Community Benefit/Cost	**-$142M**	**-$149M**	**-$100M**

This analysis indicates that with the inclusion of the social community values estimated via the Choice Modelling Study – setbacks in Scenario Figure 5.4, Scenario Figure 5.4(i) and Scenario Figure 5.4(ii) are not economically efficient and all result in a significant net cost to society.

As described above, these setback scenarios also introduce additional engineering, mine development and gas drainage requirements that impose risks on the continuity of mining and therefore Metropolitan Colliery as a whole.

HCPL therefore does not advocate the implementation of a longwall setback from Waratah Rivulet (or alternative change in longwall geometry that results in coal sterilisation) unless the impacts that are measured over the Project life exceed the EA predictions and/or restoration works are not successful (refer response to PAC Questions 6 and 11).

5. What other benefits are derived from such setbacks? Eg reduced impacts on Aboriginal sites, tributaries and swamps?

In the event of the implementation of one of the Waratah Rivulet setback scenarios described in the response to PAC Question 4, some variation in the potential environmental impacts of the Project on other features would also occur.

Upland Swamps

Comparison of the area of coal sterilised for the setback scenarios shown on Figures 5.4, 5.4(i) and 5.4(ii) of Appendix A (herein described as Scenario Figure 5.4, Scenario Figure 5.4(i) and Scenario Figure 5.4(ii)) with the mapped locations of the upland swamps shown on EA Figure 4-5 indicates that the swamps are not located in close proximity to the rivulet. Depending on the scenario analysed, a small number of swamps, or portions of swamps, would be located above the outer margins of the sterilised coal areas.

For example, of the 135 swamps mapped in the vicinity of the Project Underground Mining Area, approximately nine swamps (<8 ha) would be located above the sterilised coal area for Scenario Figure 5.4, approximately seven swamps (<7 ha) would be located above the sterilised coal area for Scenario Figure 5.4(i) and approximately two swamps (<2 ha) would be located above the sterilised coal area for Scenario 5.4(ii).

Swamps located over sterilised coal would be expected to experience some reduction in the magnitude of subsidence effects.

However, the environmental assessments conducted for the EA indicate that the swamps above the Project Underground Mining Area would experience negligible environment impact when compared to natural variations. The DEWHA is of the opinion that there will be no significant impact on EPBC Act listed threatened species, including those that utilise upland swamp habitats, in determining the Project not to be a Controlled Action (see Attachment 2). Therefore no material environmental benefit with respect to upland swamps would be expected from the above setback scenarios.

Aboriginal Heritage Sites

As described in Section 4.8.2 of the EA, it is considered that the likelihood of direct damage to Aboriginal heritage sites is low. There is very little evidence of impacts to such features from the existing mine subsidence at the Metropolitan Colliery:

Appendix A states that:

> *Potential fracturing of the exposed sandstone is expected to be isolated and of a minor nature, due to the relatively low magnitudes of the predicted strains and the relatively high depth of cover. The potential for fracturing to occur at the grinding grooves would, therefore, be considered low.*

Appendix A also notes that although impact is possible, based on experience in the Southern Coalfield, the likelihood of significant impact on sandstone overhang sites as a result of mine subsidence is also low.

> *Monitoring of approximately 41 Aboriginal heritage sites (subject to mine subsidence) has been undertaken between 1995 and 2008 at the Metropolitan Colliery. Of the 41 sites monitored, 21 had maximum predicted tensile or compressive strains greater than 0.5 mm/m and/or 2 mm/m respectively.*
>
> *The majority of sites monitored had no observable change following mine subsidence, with observable change identified in six Aboriginal heritage sites. Changes noted during monitoring include: potential natural weathering; cracks noted in sandstone platforms away from engravings/grinding grooves; cracking along existing bedding planes; and rear wall blockfall (Appendix H).*

On this basis, it is estimated that up to 10 of the 188 Aboriginal heritage sites mapped within the vicinity of the Project Underground Mining Area may have some subsidence related effect of the nature described above over the life of the Project.

Comparison of the area of coal sterilised on Figures 5.4, 5.4(i) and 5.4(ii) of Appendix A with the known Aboriginal heritage sites shown on Figure 4-18 of the EA indicates that of the 188 known sites mapped within the vicinity of the Project Underground Mining Area, approximately 23 sites would be located above sterilised coal for Scenario Figure 5.4, approximately 24 sites would be located above sterilised coal for Scenario Figure 5.4(ii) and some 14 sites would be located above sterilised coal for Scenario Figure 5.4(ii). Sites located above sterilised coal would be generally expected to experience some reduction in subsidence effects. Based on the observed rate of subsidence effects to date, it can be conservatively estimated that between 0 and 2 sites would avoid the types of impacts described above (e.g. cracking, accelerated weathering, blockfall).

Refer also the response to PAC Question 22 with respect to HCPL's proposed sponsorship of Aboriginal community projects.

Tributaries

As described in Section 4.4 of the EA, impacts have been observed on tributary streams:

> *Tributary streams also contain numerous in-stream pools. The pools in tributaries of the Waratah Rivulet are generally much smaller in plan area, depth and volume relative to runoff flow rates, than those on the Waratah Rivulet (Appendix C).*
>
> *…*
>
> *The effects of subsidence on typical tributary pools can be seen as lower pool levels during the longer recessionary periods with little observable effect during periods of normal creek flow. In longer recessionary periods pool water levels can decline below the 'cease to flow' level at a rate faster than it did prior to being undermined. This response is consistent with the capture and underflow of small flows.*
>
> *…*
>
> *The observations of pools in the Eastern Tributary and in tributaries of Waratah Rivulet indicate that although mine subsidence has the potential to increase the rate of leakage (and consequently pool level recession) of pools, a portion of the pools subject to mine subsidence effects hold some water during prolonged dry periods. These latter pools remain full during most typical wetting and drying cycles (Appendix C).*

For each setback scenario, sterilising coal would also result in some reduction in the impacts of mine subsidence on the lower sections of some tributaries of the Waratah Rivulet.

Fixed 500 m Setback – Scenario Figure 5.4

Estimated environmental benefits from this setback scenario in addition to the reduction of impacts on Waratah Rivulet are estimated to include:

- reduced cracking and stream flow effects on the lower portion of some minor tributaries of Waratah Rivulet that overlie the area of sterilised coal; and
- reducing the number of Aboriginal heritage sites potentially materially impacted by the Project by two sites.

It is also estimated that this setback scenario would reduce the life of the mine by some 3.2 years with the sterilisation of approximately 8 Mt of product coal and result in a net cost to society of $142M. As described in the response to PAC Question 4, this setback scenario would also introduce additional engineering, mine development and gas drainage requirements that impose risks on the continuity of mining.

Variable Setback – Scenario Figure 5.4(i)

It is anticipated that the variable setback Scenario Figure 5.4(i) would have a very similar environmental consequences as the fixed 500 m setback – as the total volume of product coal sterilised by the setback would be very similar (8.1 Mt variable versus 8 Mt fixed).

On this basis, the estimates of the environmental benefits and reduction in the mine life are considered to be as per the scenario above. However, impacts associated with cracking or subsidence for individual surface features would vary as the coal would be sterilised in a different configuration (compare Figures 5.4 and 5.4(i) of Appendix A).

It is also estimated that this setback scenario would reduce the life of the mine by some 3.3 years with the sterilisation of approximately 8.1 Mt of product coal and result in a net cost to society of $149M. As described in the response to PAC Question 4, this setback scenario would also introduce additional engineering, mine development and gas drainage requirements that impose risks on the continuity of mining.

Rockbar Offsets Setback – Scenario Figure 5.4(ii)

This offset scenario is based on minimising impacts on the five key rockbars identified in the EA (i.e. WRS 5, 6, 7, 8A and 8B).

Estimated environmental benefits from this scenario include:

- reduced cracking and stream flow effects on the lower portion of a lesser length (when compared to the above) of minor tributaries of Waratah Rivulet that overlie the area of sterilised coal; and
- reducing the number of Aboriginal heritage sites potentially materially impacted by the Project by one site.

It is also estimated that this setback scenario would reduce the life of the mine by some 1.9 years with the sterilisation of approximately 4.6 Mt of product coal and result in a net cost to society of $100M. As described in the response to PAC Question 4, this setback scenario would also introduce additional engineering, mine development and gas drainage requirements that impose risks on the continuity of mining.

6. Barrier pillars beneath Waratah Rivulet (as discussed on p 5-12) could be based on exceedance of a variety of criteria. Probably only a pre-set criterion of a set number of metres allows for placement of cut-throughs to enable pre-planned relocation of the longwall. Other criteria (eg measured valley closure, initiation of minor/moderate/severe cracking) may not permit the longwall to be stopped for some distance (eg 40 m) and may be subject to debate at the time. Nonetheless, a pre-set distance lacks finesse. Please discuss the various criteria which might be used to establish barrier pillar configuration and the economic benefits and potential environmental costs of each. Which criterion would HCPL support, and why?

Background

As described in Section 3.9.2 of the EA, analysis of Project alternatives indicates that full extraction under the Waratah Rivulet is desirable from an economic efficiency perspective (i.e. in consideration of potential environmental costs and economic benefits) and this is proposed for the Project.

However, as described in Section 4.4.3 of the EA, HCPL is committed to undertaking progressive restoration activities at rock bars WRS5, 6, 7, 8A and 8B, where future monitoring indicates the need. This means that in contrast to the impacts that occurred in the past at the Metropolitan Colliery, progressive stages of restoration works would reduce the impacts of successive subsidence effects of each longwall on these features. Consequent potential environmental impacts such as the diversion of surface flows, alteration of pool behavior and change in aesthetic values at these features would occur for a significantly shorter period of time.

As described in Section 5.2.4 of the EA, proposed evaluation triggers that would result in a setback or alternative change in the longwall geometry include:

> <u>Observed Subsidence Triggers</u> - *...Where the trend of actual subsidence effect indicates that a substantial variance (i.e. exceedances) of subsidence effect is occurring or considered likely to occur, then the implementation of response measures would be triggered.*
>
> <u>Flow/Pool Level Triggers</u> - *Reduction in pool water levels and the reduction of flow-over some rock bars is an expected consequence of mine subsidence (Section 4.4.2) until restoration has occurred. Monitoring of the flow regime and pool levels would be used to evaluate the success of rock bar restoration works. If the restoration works were not successful, then response and/or contingency measures would be implemented in accordance with the WRMP* [Waratah Rivulet Management Plan].

Note that the success criteria for restoration works would be detailed in the Trigger and Response Plan (TARP) element of the WRMP. HCPL's proposed success criteria are currently under development and are expected to be based on an achievement of a statistical variation of the pre-mining rockbar pool behaviour for given stream flow conditions.

> *<u>Water Quantity/Quality</u> - … Localised diversion of a portion of surface flow and localised temporary effects on water quality are an expected consequence of mine subsidence effects (Section 4.4.2). If a mine subsidence induced effect on the water quality or quantity of the yield of Woronora Reservoir is detected as a result of the Project, then response and/or contingency measures would be implemented in accordance with the WRMP.*

As described in Section 5.2.7 of the EA modified longwall extraction geometry would be implemented as a contingency measure under the following circumstances:

> *<u>TARP Contingency Measure - Modified Longwall Extraction Geometry</u>*
>
> *In the event that stream restoration performance criteria are not achieved (including the timeframe within which the works are completed) then modifications to the longwall extraction geometry would be implemented for subsequent longwall panels so as to reduce the cumulative subsidence effect. … In addition, in the event that there is a measurable reduction in the quality or quantity of the yield of Woronora Reservoir as a result of the Project, modification of the longwall extraction geometry would be undertaken.*

Application of Contingency Measures

The application of contingency response measures in the form of modification of the longwall geometry would be subject to relevant Project Approval conditions and the specific criteria that would be defined in the WRMP TARP.

For example, in the event that stream restoration performance criteria are not achieved or that there is a measurable reduction in the quality or quantity of the yield of Woronora Reservoir as a result of the Project, the ability to modify the longwall geometry (via reducing the thickness of coal seam extracted, narrowing of the longwall panels and/or setback) would be available.

Because of the east-west geometry of the proposed longwall panels, each longwall panel is at approximate right angles to the north flowing Waratah Rivulet and hence only undermines a short section of the stream. This means that in the event that the measured impacts of one longwall panel were to exceed the key criteria in the Waratah Rivulet Management Plan, this exceedance could be limited, as the impacts of subsequent longwalls could be reduced by changing the extraction geometry and hence the impacts of subsequent longwalls could be managed to meet Project Approval limits.

As described in Section 5.2.7 of the EA, the distance required to undertake an unplanned recovery of the longwall machine to modify longwall geometry would be determined to some extent by the location of cut-throughs in the pillars that separate the longwalls:

> *…To effect a longwall recovery, a cut-through is required for movement of equipment and access to the longwall faceline. The area between the 600 m and 400 m distance from the Waratah Rivulet would generally contain three cut-throughs. The most suitable in terms of factors such as geology, roof conditions and logistics would be selected to recover the longwall machine.*

The location of regular pillar cut-throughs is a component of the development of the underground longwall geometry. The pillar cut-throughs are located approximately every 90 m along the entire length of the longwall and hence provide regular opportunities to cease mining and recover the longwall, if this is required.

Alternative Barrier Pillar Configuration and Cost

Section 5.2.7 of the EA describes the options that are potentially available to modify the longwall geometry and the significant costs associated with these measures:

- *reducing the thickness of coal seam extracted;*

- *narrowing of the longwall panels; and/or*
- *setback (i.e. not mining beneath or as close to Waratah Rivulet).*

…

The costs of modifying longwall extraction geometry would be significant. The relative cost of narrowing the panel, versus setback off a feature, would depend on the extent of modification to the longwall panel that would be required as informed by the upper bound limit method of subsidence prediction.

The selection of the most appropriate method of altering the longwall geometry would be determined by subsidence predictions to determine the volume of coal that is required to be sterilised, and mine engineering consideration of the alternative feasibility and costs associated with alternative longwall modification layouts.

Each of the three alternative modifications of the longwall geometry would have different cost and feasibility considerations, depending in part on the local geology, the volume of coal that is required to be sterilised and the additional development required to relocate and then return the longwall machine. While each of the options may have differing safety, efficiency and engineering considerations, the costs of each modification method are considered to be broadly comparable at this early stage in the process. This is because each option would require stopping the longwall mining operation, altering the mining geometry and then recommencement of mining following a period of downtime.

Over the life of the Project there may also be alternative or improved methods available to modify longwall geometry in the event that such alteration is required.

It would remain HCPL's financial risk that the company would be required to absorb the cost of implementing contingency measures, in the event that measured impacts exceed Project Approval specified limits.

Sensitivity Analysis

7. Please undertake and provide a sensitivity analysis for subsidence impacts, based on barrier pillars sufficient to generate no more than 100 mm; 200 mm; 300 mm; 400 mm and 500 mm of valley closure at any point on the rivulet. Plans showing the resulting mine plans should be provided, together with total costs of the required setbacks (referenced to the methodology used in the Gillespie report). Detailed descriptions of anticipated subsidence impacts at the rivulet for each of these five mine plans should also be provided.

Background

HCPL has investigated and undertaken preliminary cost estimates on the alternative mine layouts (scenarios) as requested by the PAC. These analyses are based on comparative cost estimates with respect to full extraction under the Waratah Rivulet using estimates of the tonnages of coal sterilised and the additional costs associated with additional capital expenditure and additional workforce required to maintain mine development and gas drainage – plus estimates of the monetary environmental costs and benefits that have been determined by the Choice Modelling Study.

While the relative costs of implementing these mine layout scenarios have been estimated in terms of impact on the net benefits of the Project, mine layout variations that involve setbacks are also subject to technical considerations such as engineering, mine development and gas drainage requirements that impose risks (financial and logistical) on the continuity of mining. Hence, while in theory it may be possible to implement all of the setback scenarios, financial return on capital and continuity of mining risks are also relevant considerations for HCPL when making investment decisions. Any mining scenario that does not provide for the effective management of these issues is a relevant consideration with respect to the ongoing viability of Metropolitan Colliery as a whole.

Sensitivity Analysis

A sensitivity analysis has been undertaken to prepare longwall layouts required to target maximum predicted total closures of 100 mm, 200 mm, 300 mm, 400 mm and 500 mm. The layout for each case is shown in Drawings MSEC285-R100 to MSEC285-R104.

A summary of the results of the sensitivity analysis is provided in Figure R-04. It should be noted that the predicted total closure resulting from the previously mined longwalls extends into the study area, as indicated by the cyan coloured line in Figure R-04. As a result, it is not possible to achieve the target closure value of 100 mm for the southern reach of Waratah Rivulet within the Study Area. In such cases, a layout was determined that would generate only minor additional predicted closures from the proposed longwalls.

It is expected that the layout for the predicted maximum total closure target of 100 mm, would result in a very low probability of minor fracturing or iron staining and extremely low probability of flow diversion occurring along Waratah Rivulet, but no noticeable diversion of surface flows. For the layout resulting in a predicted maximum total closure target of 200 mm, it is expected that there would be a low probability of minor fracturing and iron staining and a very low probability of flow diversion occurring.

For the predicted maximum total closure targets of 300 mm, 400 mm and 500 mm, it is expected that cracking of rockbars and flow diversion would occur (albeit at some variation of relative probability). The precise degree of change in potential environmental impact as a result of each of these increments in estimated valley closure cannot be reliability predicted. However, from a potential environmental impact perspective, it would not be considered to be material (i.e. the impacts would be similar with respect to flow diversion effects).

It should be noted that the variation in geological and topographical conditions that exist along the Waratah Rivulet will result in variation in the potential degree of impact due to the various longwall configurations.

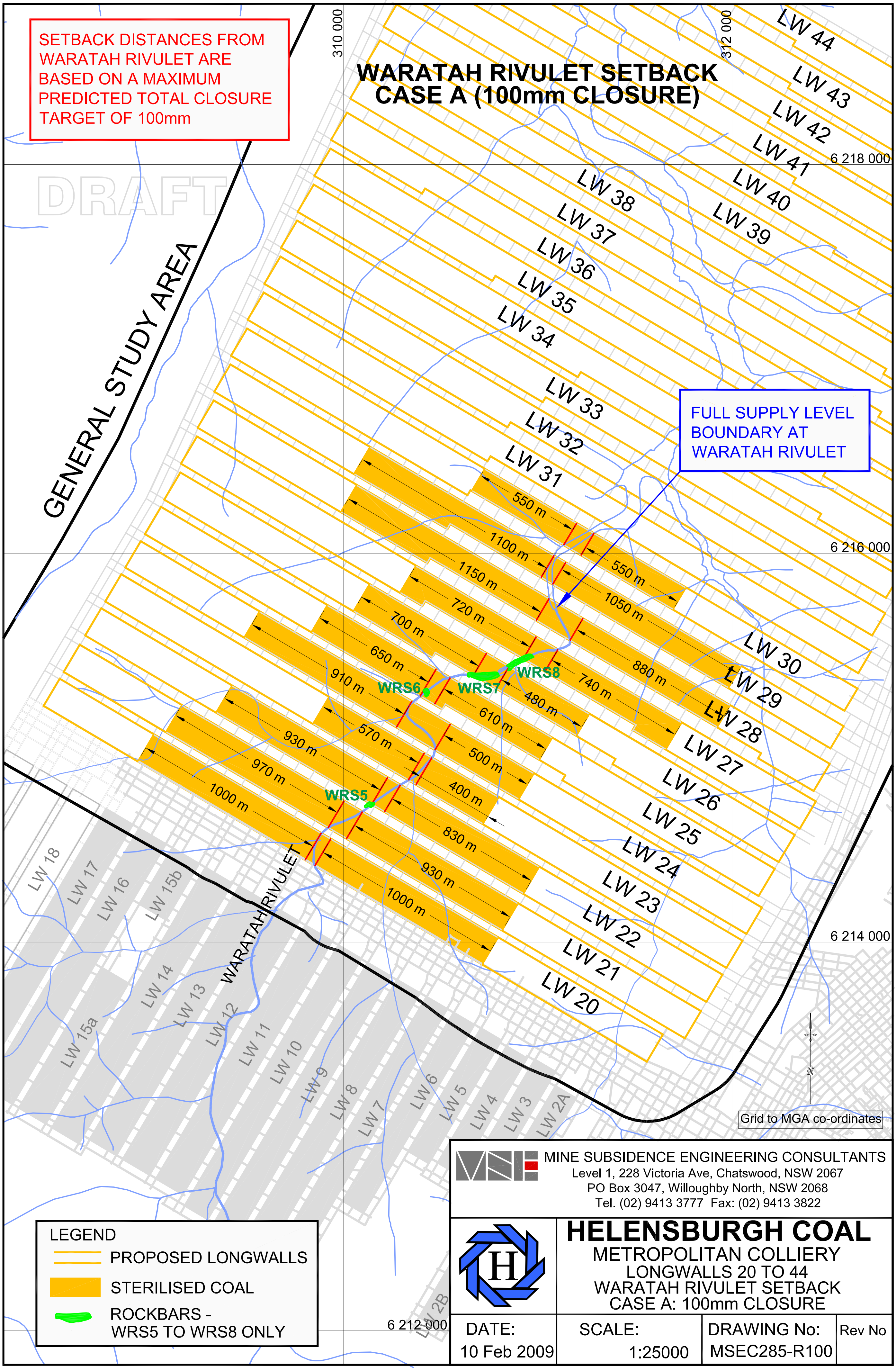
Marginal Environmental Benefits

Upland Swamps

Comparison of the area of coal sterilised for the 100 mm, 200 mm, 300 mm, 400 mm and 500 mm setback scenarios with the mapped locations of the upland swamps shown on EA Figure 4-5 indicates that the swamps are not located in close proximity to the rivulet. Depending on the scenario analysed, a number of swamps, or portions of swamps, would be located above the outer margins of the sterilised coal areas.

For example, of the 135 swamps mapped in the Project Underground Mining Area and surrounds, approximately 15 swamps (<30 ha) would be located above the sterilised coal area for the 100 mm scenario, approximately six swamps (<5 ha) would be located above the sterilised coal area for the 200 mm scenario, approximately two swamps (<1 ha) would be located above the sterilised coal area for the 300 mm scenario, one swamp (<1 ha) would be partially located above sterilised coal for the 400 mm scenario and no swamps would be located above sterilised coal for the 500 mm scenario.

Swamps located over sterilised coal would be expected to experience some reduction in the magnitude of subsidence effects.


WARATAH RIVULET SETBACK
CASE A (100mm CLOSURE)
SETBACK DISTANCES FROM WARATAH RIVULET ARE BASED ON A MAXIMUM PREDICTED TOTAL CLOSURE TARGET OF 100mm
DRAFT
GENERAL STUDY AREA
FULL SUPPLY LEVEL BOUNDARY AT WARATAH RIVULET
WARATAH RIVULET
310 000
312 000
6 218 000
6 216 000
6 214 000
6 212 000
LW 44
LW 43
LW 42
LW 41
LW 40
LW 39
LW 38
LW 37
LW 36
LW 35
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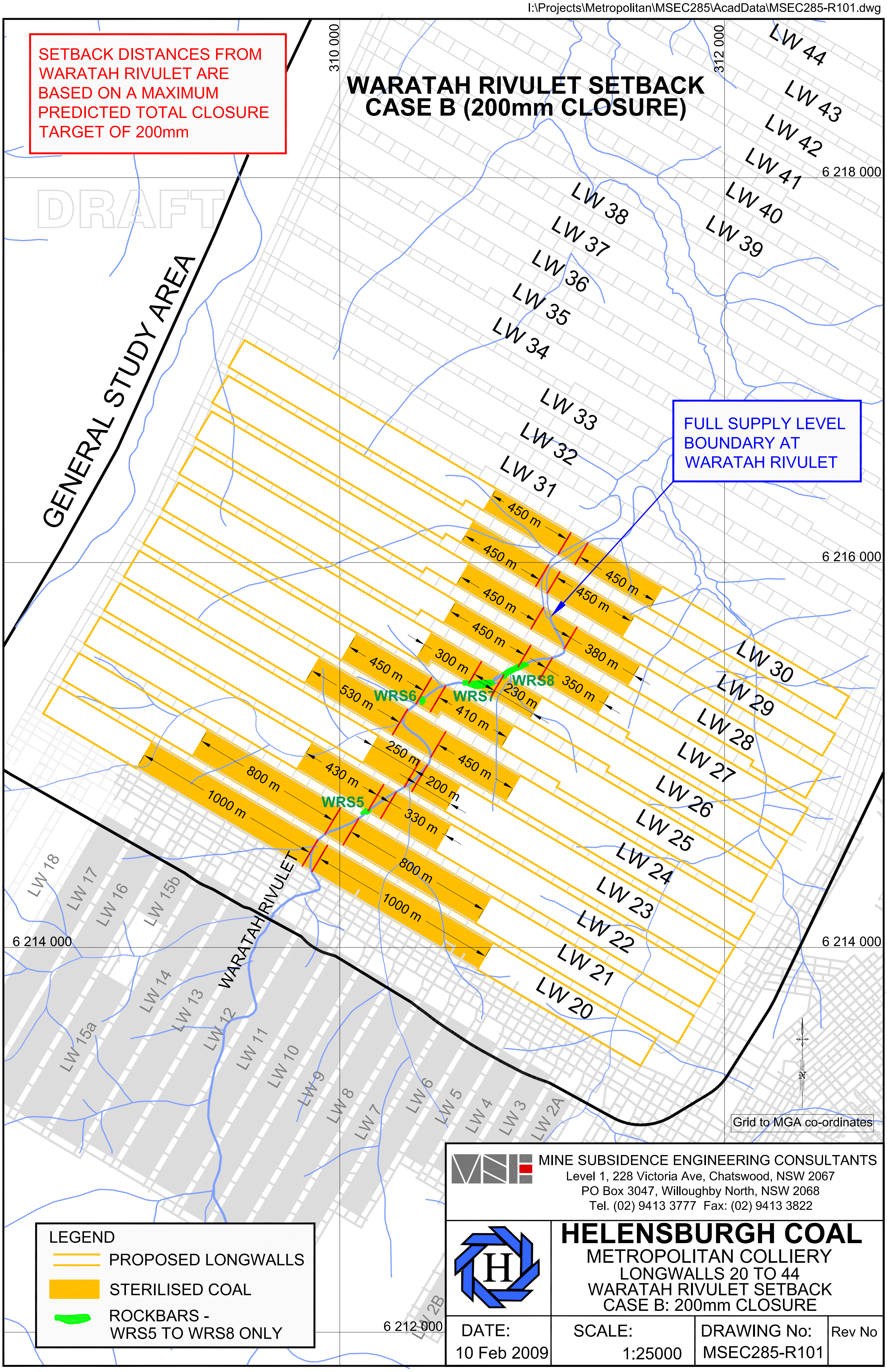
570 m
500 m
930 m
970 m
400 m
1000 m
830 m
930 m
1000 m
WRS5
WRS6
WRS7
WRS8
Grid to MGA co-ordinates
LEGEND
PROPOSED LONGWALLS
STERILISED COAL
ROCKBARS - WRS5 TO WRS8 ONLY
MINE SUBSIDENCE ENGINEERING CONSULTANTS
Level 1, 228 Victoria Ave, Chatswood, NSW 2067
PO Box 3047, Willoughby North, NSW 2068
Tel. (02) 9413 3777 Fax: (02) 9413 3822
HELENSBURGH COAL
METROPOLITAN COLLIERY
LONGWALLS 20 TO 44
WARATAH RIVULET SETBACK
CASE A: 100mm CLOSURE
DATE: 10 Feb 2009
SCALE: 1:25000
DRAWING No: MSEC285-R100
Rev No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SETBACK DISTANCES FROM WARATAH RIVULET ARE BASED ON A MAXIMUM PREDICTED TOTAL CLOSURE TARGET OF 200mm
WARATAH RIVULET SETBACK
CASE B (200mm CLOSURE)
DRAFT
GENERAL STUDY AREA
FULL SUPPLY LEVEL BOUNDARY AT WARATAH RIVULET
310 000
312 000
6 218 000
6 216 000
6 214 000
6 212 000
LW 44
LW 43
LW 42
LW 41
LW 40
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LW 6
LW 5
LW 4
LW 3
LW 2A
LW 2B
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450 m
450 m
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300 m
380 m
350 m
530 m
410 m
230 m
250 m
450 m
200 m
430 m
330 m
800 m
800 m
1000 m
1000 m
WRS5
WRS6
WRS7
WRS8
WARATAH RIVULET
Grid to MGA co-ordinates
LEGEND
PROPOSED LONGWALLS
STERILISED COAL
ROCKBARS - WRS5 TO WRS8 ONLY
MINE SUBSIDENCE ENGINEERING CONSULTANTS
Level 1, 228 Victoria Ave, Chatswood, NSW 2067
PO Box 3047, Willoughby North, NSW 2068
Tel. (02) 9413 3777 Fax: (02) 9413 3822
HELENSBURGH COAL
METROPOLITAN COLLIERY
LONGWALLS 20 TO 44
WARATAH RIVULET SETBACK
CASE B: 200mm CLOSURE
DATE:
10 Feb 2009
SCALE:
1:25000
DRAWING No:
MSEC285-R101
Rev No

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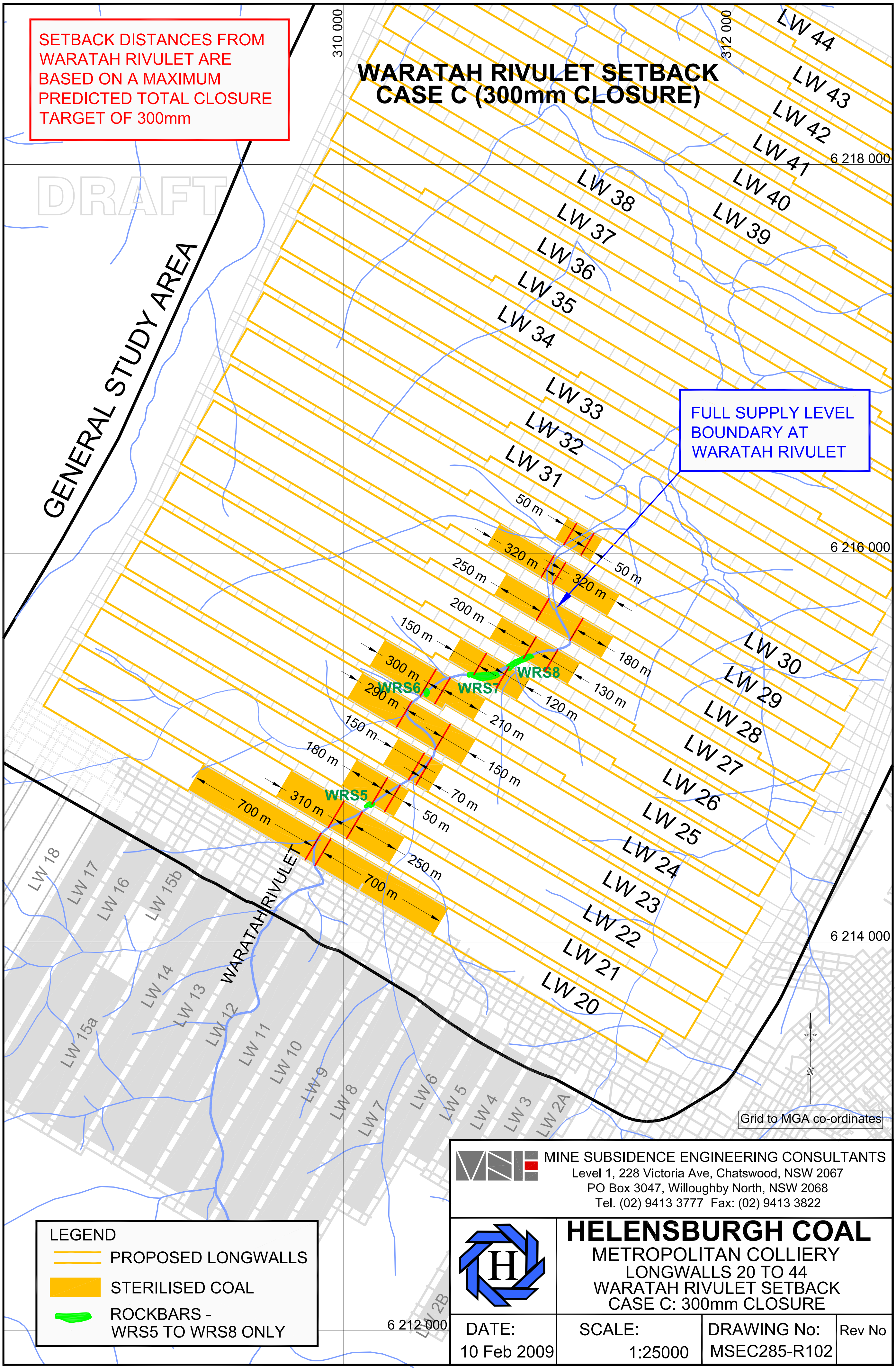

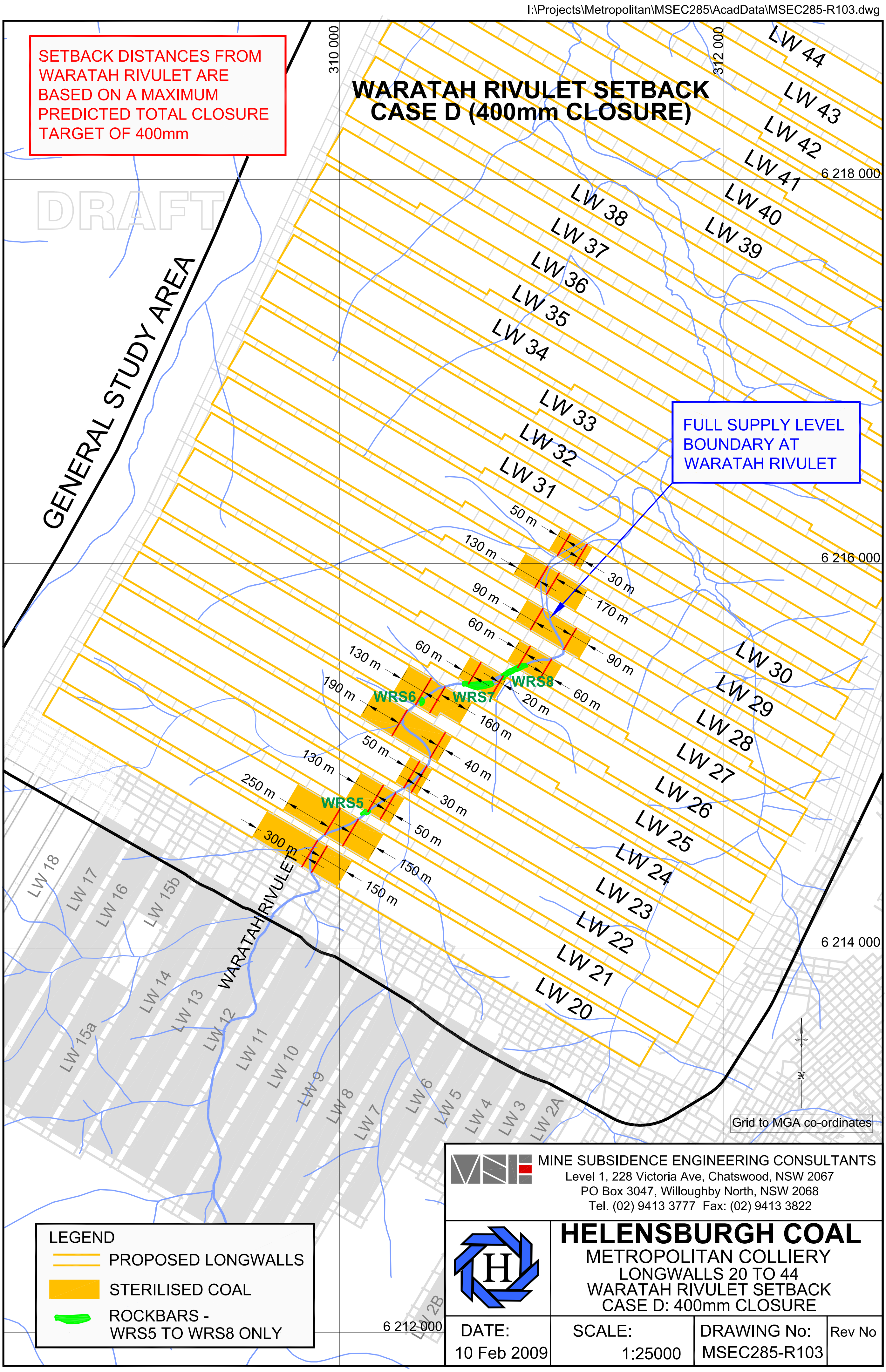

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SETBACK DISTANCES FROM WARATAH RIVULET ARE BASED ON A MAXIMUM PREDICTED TOTAL CLOSURE TARGET OF 400mm
WARATAH RIVULET SETBACK
CASE D (400mm CLOSURE)
DRAFT
GENERAL STUDY AREA
FULL SUPPLY LEVEL BOUNDARY AT WARATAH RIVULET
WARATAH RIVULET
310 000
312 000
6 218 000
6 216 000
6 214 000
6 212 000
LW 44
LW 43
LW 42
LW 41
LW 40
LW 39
LW 38
LW 37
LW 36
LW 35
LW 34
LW 33
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WRS7
WRS8
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30 m
90 m
170 m
60 m
90 m
60 m
130 m
60 m
190 m
20 m
160 m
50 m
40 m
130 m
30 m
250 m
50 m
300 m
150 m
150 m
Grid to MGA co-ordinates
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HELENSBURGH COAL
METROPOLITAN COLLIERY
LONGWALLS 20 TO 44
WARATAH RIVULET SETBACK
CASE D: 400mm CLOSURE
DATE:
10 Feb 2009
SCALE:
1:25000
DRAWING No:
MSEC285-R103
Rev No

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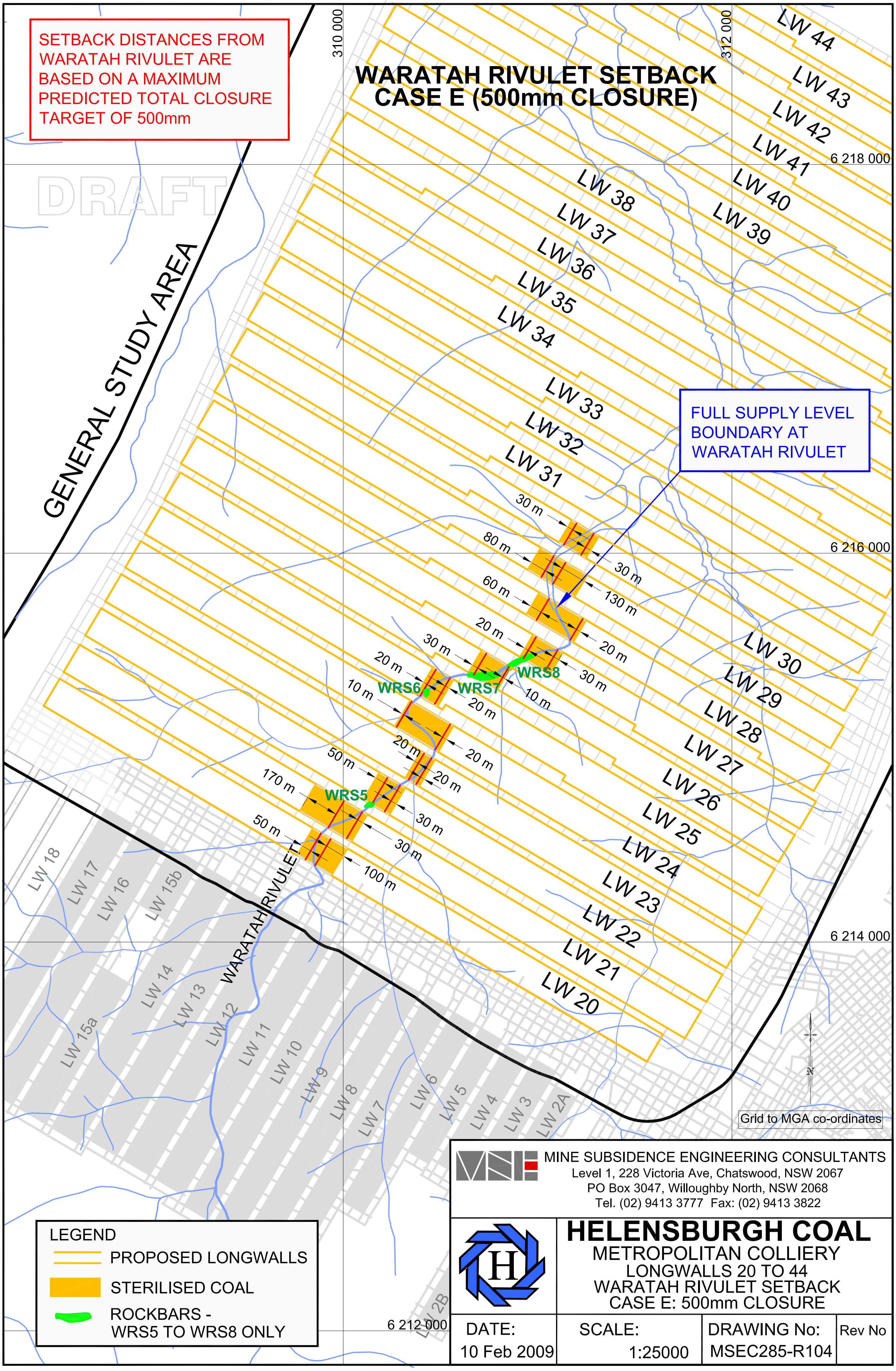


Metropolitan Colliery - Longwalls 20 to 44
Waratah Rivulet Long Section
Predicted Profiles of Upsidence and Closure

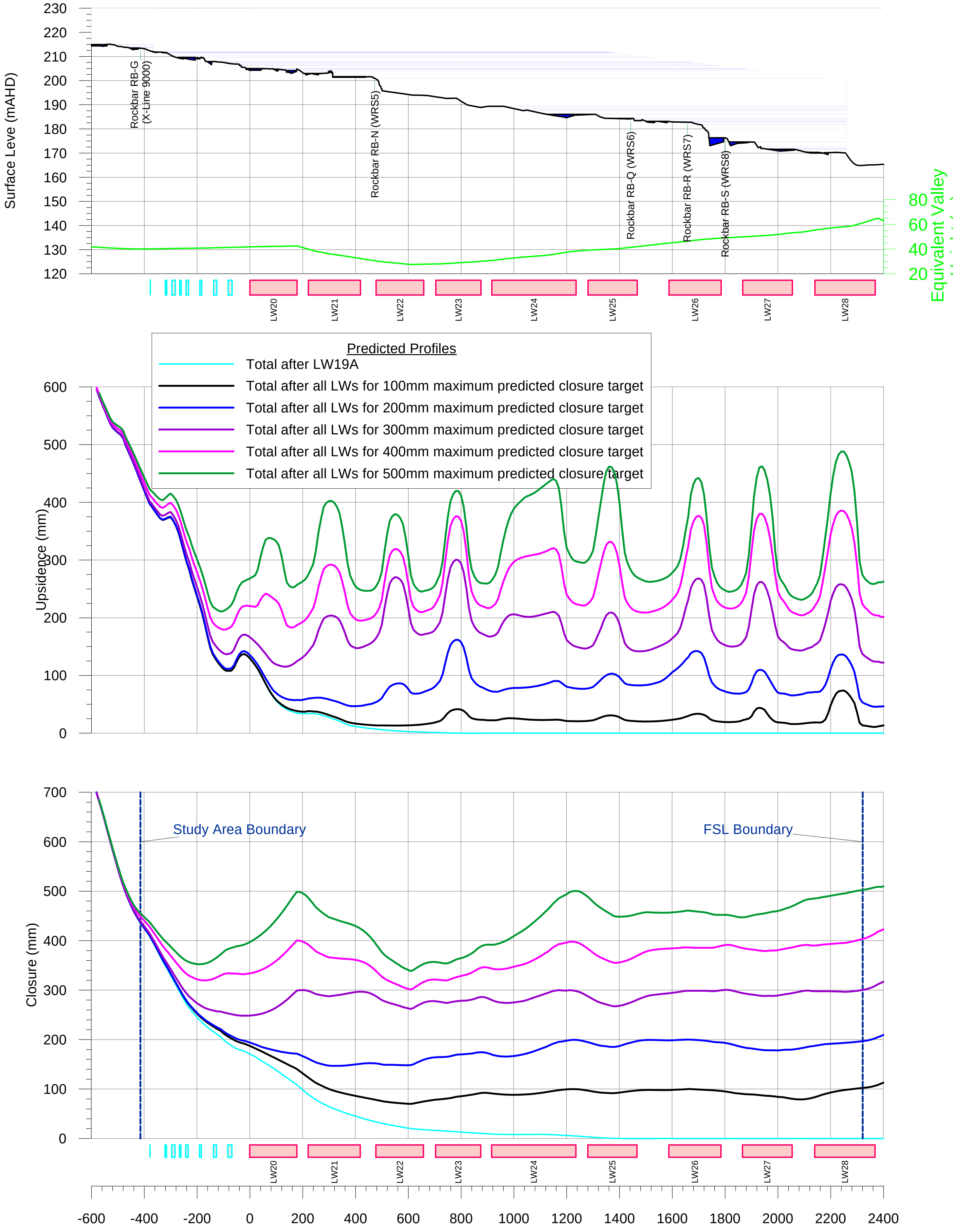


Fig. R-04

However, the environmental assessments conducted for the EA indicate that the swamps above the Project Underground Mining Area would experience negligible environment impact when compared to natural variations. The DEWHA is of the opinion that there will be no significant impact on EPBC Act listed threatened species, including those that utilise upland swamp habitats, in determining the Project not to be a Controlled Action (see Attachment 2). Therefore no material environmental benefit with respect to upland swamps would be expected from the above setback scenarios.

Aboriginal Heritage Sites

As described in Section 4.8.2 of the EA, it is considered that <u>the likelihood of direct damage to Aboriginal heritage sites is low. There is very little evidence of impacts to such features from the existing mine subsidence at the Metropolitan Colliery</u>:

Appendix A states that:

> *Potential fracturing of the exposed sandstone is expected to be isolated and of a minor nature, due to the relatively low magnitudes of the predicted strains and the relatively high depth of cover. The potential for fracturing to occur at the grinding grooves would, therefore, be considered low.*

Appendix A also notes that although impact is possible, based on experience in the Southern Coalfield, the likelihood of significant impact on sandstone overhang sites as a result of mine subsidence is also low.

> *Monitoring of approximately 41 Aboriginal heritage sites (subject to mine subsidence) has been undertaken between 1995 and 2008 at the Metropolitan Colliery. Of the 41 sites monitored, 21 had maximum predicted tensile or compressive strains greater than 0.5 mm/m and/or 2 mm/m respectively.*
>
> *The majority of sites monitored had no observable change following mine subsidence, with observable change identified in six Aboriginal heritage sites. Changes noted during monitoring include: potential natural weathering; cracks noted in sandstone platforms away from engravings/grinding grooves; cracking along existing bedding planes; and rear wall blockfall (Appendix H).*

On this basis, it is estimated that up to 10 of the 188 Aboriginal heritage sites mapped within the vicinity of the Project Underground Mining Area may have some subsidence related effect of the nature described above over the life of the Project.

Comparison of the area of coal sterilised for the 100 mm, 200 mm, 300 mm, 400 mm and 500 mm setback scenarios with the mapped locations of the known Aboriginal heritage sites shown on Figure 4-18 of the EA indicates that of the 188 known sites mapped within the vicinity of the Project Underground Mining Area, approximately 41 sites would be located above sterilised coal for the 100 mm scenario, approximately 26 sites would be located above sterilised coal for the 200 mm scenario, approximately 14 sites would be located above sterilised coal for the 300 mm scenario, approximately nine sites would be above sterilised coal for the 400 mm scenario and some five sites would be located above sterilised coal for the 500 mm scenario. Sites located above sterilised coal would be generally expected to experience some reduction in subsidence effects. Based on the observed rate of subsidence effects to date, it can be conservatively estimated that between 0 and 4 sites would avoid the types of impacts described above (e.g. cracking, accelerated weathering, blockfall).

Refer also the response to PAC Question 22 with respect to HCPL's proposed sponsorship of Aboriginal community projects.

Tributaries

As described in Section 4.4 of the EA, impacts have been observed on tributary streams:

> *Tributary streams also contain numerous in-stream pools. The pools in tributaries of the Waratah Rivulet are generally much smaller in plan area, depth and volume relative to runoff flow rates, than those on the Waratah Rivulet (Appendix C).*
>
> *…*
>
> *The effects of subsidence on typical tributary pools can be seen as lower pool levels during the longer recessionary periods with little observable effect during periods of normal creek flow. In longer recessionary periods pool water levels can decline below the 'cease to flow' level at a rate faster than it did prior to being undermined. This response is consistent with the capture and underflow of small flows.*
>
> *…*
>
> *The observations of pools in the Eastern Tributary and in tributaries of Waratah Rivulet indicate that although mine subsidence has the potential to increase the rate of leakage (and consequently pool level recession) of pools, a portion of the pools subject to mine subsidence effects hold some water during prolonged dry periods. These latter pools remain full during most typical wetting and drying cycles (Appendix C).*

For each setback scenario, sterilising coal would also result in some reduction in the impacts of mine subsidence on the lower sections of some tributaries of the Waratah Rivulet. Each setback scenario would result in a reduction of the length of tributary stream undermined and therefore some reduction in the potential subsidence effects.

Economic Analysis of Setback Scenarios – 100 mm, 200 mm, 300 mm, 400 mm and 500 mm Valley Closure

HCPL has conducted further analysis of the relative costs and benefits of the 100 mm, 200 mm, 300 mm, 400 mm and 500 mm valley closure setback scenarios shown on Drawings MSEC285-R100 to MSEC285-R104.

The environmental benefits of these valley closure scenarios with respect to reduced environmental impacts on the Waratah Rivulet and Aboriginal heritage sites and reduced greenhouse gas emissions due to reduced mine life have been estimated using the results of the Choice Modelling Study and a carbon price and range from approximately $2M to $293M.

These estimates of environmental benefits in comparison to the base case mine plan (i.e. full extraction) are highly conservative – as they assume that no stream restoration is implemented for the base case, however as described in the response to PAC Questions 30-31, significant stream restoration works are proposed for the Project.

The relative net production cost of implementing these setback scenarios would range from approximately $31M to $988M, with the loss of between approximately 1.3 Mt and 54 Mt of product coal and a reduction in the mine life of approximately 0.6 to 23 years.

The summary estimated incremental costs and benefits of the five scenarios are tabulated below.

Component	500 mm valley Closure	400 mm Valley Closure	300 mm Valley Closure	200 mm Valley Closure	100 mm Valley Closure
Incremental Net Production Benefit/Cost	-$31M	-$71M	-$90M	-$142M	-$988M
Incremental Estimated Environmental Benefit (due to reduced environmental impacts)	$2M	$6M	$8M	$110M	$293M
Incremental Estimated Social Costs (due to reduced mine life)	-$21M	-$34M	-$55M	-$99M	-$756M
Incremental Net Community Benefit/Cost	**-$49M**	**-$99M**	**-$137M**	**-$131M**	**-$1,451M**

The above summary analysis indicates that with the inclusion of the social community values estimated via the Choice Modelling Study – the valley closure setback scenarios from 500 mm to 100 mm are not economically efficient and all result in a significant net cost to society.

Relative to the Project base case the 100 mm valley closure scenario has the most environmental benefit, and very significant economic and social costs (refer response to PAC Question 8). However, as discussed above, achieving 100 mm valley closure is not technically feasible for some sections of Waratah Rivulet that already exceed this level within the Project Underground Mining Area.

The 200 mm valley closure scenario is very similar to Scenario Figure 5.4(ii) as described in the response to PAC Question 4 (i.e. has approximately the same environmental benefits) however, it has slightly lower net production costs, due to the adoption of an improved panel setback configuration. However, the net cost to society of adopting this scenario remains very high.

The environmental benefits of the 300 mm and 400 mm valley closure scenarios are very small, as there would be very little benefit with respect to flow diversion effects and only some limited benefits with respect to Aboriginal heritage sites and greenhouse gas reductions – with significant additional costs.

The 500 mm valley closure scenario would have very little environmental benefit, but would incur additional costs.

As described above, each of the valley closure setback scenarios also introduce additional engineering, mine development and gas drainage requirements that impose risks on the continuity of mining.

Regional Economic Benefits

8. More information is sought on potential labour market consequences of the mine not receiving approval, or approval on the basis of substantial setbacks from Waratah Rivulet. For example, what labour market changes are projected for coal mine workers in the Illawarra and NSW coal industries over the next 2-3 years? What flow-on effects to the Corrimal and Coalcliff Cokeworks and PKCT might be anticipated from mine closure at Helensburgh or production on the basis of substantial setbacks from Waratah Rivulet?

National and State Economic Context

The NSW and Australian economy is on the brink of a recession that is associated with rapidly rising unemployment across many sectors of the economy. Colonial First State Global Asset Management (Economic Research Note 15 January 2009) report that *the industries most impacted by the credit crisis and global slowdown will be financial services, property and business services and* ***mining****. Despite mining and financial services having a small share of total employment the indirect spill-over effect to the wider economy will be substantial.* CFSGAM report that *the unemployment rate is set to rise towards 6.0% over 2009.* Recent commentary suggests even higher unemployment rates.

Global mining companies such as Rio Tinto and BHP Billiton have announced layoffs of 14,000 and 6,000 employees respectively worldwide. A significant proportion of these employees are likely to be located in Australia. For example, BHP Billiton has announced about 1,100 jobs will be cut from its coking coal operations in Queensland.

Project Employment Effects – Implication of Mine Closure

The Project is estimated to provide continuing direct employment for some 320 employees and on-site contractors. <u>The regional economic impact assessment conducted for the EA estimated total employment impacts of the Project on the Illawarra Region of 700 jobs</u>, comprising direct, production-induced flow-on and consumption-induced flow-on jobs. Flow-on jobs in the Illawarra Region would occur across a range of sectors including the services sectors, transport sectors, manufacturing sectors, mining sectors and the wholesale and retail trade sectors.

<u>At State level, direct and indirect employment associated with the Project is estimated at 1,950 jobs</u>. Flow-on jobs in NSW would also occur across a range of sectors in the economy.

These estimates of the Illawarra Region and NSW socio-economic contributions of the Project include backward linkages (e.g. suppliers), but do not consider forward linkages to industry that may rely on the coal products of the Metropolitan Coal Project. For example, products from the Project are important inputs into the operation of the Corrimal and Coalcliff Cokeworks and continued coal export shipments would support the ongoing operation of the Port Kembla Coal Terminal, which employs approximately 60 people.

If the Project was not approved, the closure of the Metropolitan Colliery would occur by August 2010. All of the above positive effects would therefore not occur and it expected that direct and indirect employment effects of the Metropolitan Colliery in the Illawarra Region (up to 700) and wider NSW economy (up to 1,950) would cease.

Given the significant global downturn in the mining sector, general climate of rapidly rising unemployment and wide scale reductions in alternative employment opportunities, the re-employment prospects for people who lose either direct or indirect jobs as a result of closure of, or restrictions to, the Metropolitan Coal mine, are likely to be poor. Older mine employees (e.g. over 50 years) in particular may find it very difficult to find alternative employment if a large proportion of their working life and experience has been in coal mining in the Southern Coalfield.

Employees who lose positions as a result of closure of the mine or significant reduction in the scale of the Metropolitan Colliery would therefore most likely directly contribute to rising regional and State unemployment. Prolonged unemployment can generate a range of personal and social problems, among them increased risk of domestic violence, drug and alcohol dependency , crime and indebtedness, loss of self esteem, community dislocation and family difficulties (Resource Assessment Commission, 1992).

Implications of the Metropolitan Coal Project Decision for the Illawarra Region and NSW

Coal mining in the Southern Coalfield directly employs some 2,500 people (DPI, 2006). Including forward and backward linkages, the industry is estimated to support between 12,000 and 21,000 jobs in the Illawarra Region (this equates to between 9.6% and 16.7% of the Illawarra workforce). Iron and steel manufacturing alone directly employs 6,819 people in the region (ABS, 2006).

Government decisions that may put the future of the Metropolitan Colliery at risk due to closure or imposing significant restrictions on mining would also set a precedent for other mining operations in the Southern Coalfield, which are all required to hold Part 3A approvals by August 2010. This means that decisions taken for the Metropolitan Coal Project sets the precedent for the permissibility of underground mining in the Southern Coalfield. Significant restrictions on mining in the Southern Coalfield would result in significant direct effects, but also very significant flow-on effects on directly reliant industries such as the Bluescope Steelworks in Port Kembla.

In addition, the Southern Coalfield has proved and probable coal reserves of some 670 Mt of coal (DPI, 2006). These coal reserves have an undiscounted value of tens of Billions of dollars, even at currently depressed prices. Potential coal royalties from the development of these reserves would run into the Billions of dollars for the State of NSW.

An analysis conducted by Gillespie Economics in 2008 indicated that the impacts of adoption of a 500 m restriction on mining proximal to third or higher order streams (as defined by the Strahler system) in the Southern Coalfield would include (Gillespie Economics, 2008):

- $22 Billion in undiscounted lost saleable coal reserves across the Illawarra;
- $426 Billion in lost annual production;
- direct and upstream linkage employment losses of 5,800 in the Illawarra Region;
- additional downstream linkage job losses; and
- up to $17 million per annum in lost NSW State government royalties.

This magnitude of job and economic losses would result in significant social impacts for the individuals involved and the Illawarra community more generally, particularly given the current economic climate.

Proposed Mine Layout

9. If HCPL are convinced that the current mining dimensions do not result in hydraulic connections to the surface, why is this layout not maintained beneath the Woronora Reservoir?

HCPL has a comprehensive data set including geological, geomechanical, surface water hydrology, groundwater hydrology and mine water balance information that confirm that mining at the current panel and chain pillar dimensions has not caused hydraulic connections to the surface. The groundwater inflow to the mine is estimated to be <0.1 ML/day. The quantitative data has been accumulated since late 2006 and supports anecdotal evidence from long term employees (>15 years) that the mine is essentially dry.

The Dams Safety Committee (DSC) has authority within the Dams Safety Notification Zone (DSNZ) under the *Dams Safety Act, 1978*. HCPL has engaged with the DSC since 2006 and has developed a monitoring program in close consultation with the DSC to support future mining activities.

At the time of developing the proposed mine layout within the DSNZ (in late 2006), a very conservative approach was adopted in relation to panel width. The proposed panel width was approximately 1/3rd the minimum depth of cover which reflected the guidelines provided by the Reynolds Inquiry (1977). The DSC recognises that the Reynolds Guidelines are conservative and will consider any extraction geometry on its merits. In other words, the proposed layout would be recognised as a starting point in relation to panel width.

HCPL recognise that it has a strong case to present to the DSC in relation to increased panel widths and/or reduced chain pillar width.

For the purposes of bankable feasibility study for internal Peabody Pacific investment decisions, it is a requirement that the relevant government guideline is followed on a matter such as DSC approval until such time as a more relaxed position is provided by government. Any relaxation from the Reynolds Guidelines by the DSC would only be expected on the basis of continued measured performance over the Project life.

10. Why has the mine not considered mine layouts other than that which is based on the recommendations of the 1977 Reynolds Inquiry, given other mining practices in the Southern Coalfield (eg South Bulli and Dendrobium)?

The Dams Safety Committee (DSC) has authority within the Dam Safety Notification Zone (DSNZ). The DSC has indicated that the Reynolds Guidelines should be taken as a starting point for mine design below stored waters. Any variation to the guidelines would be considered by the DSC in due course.

In relation to longwall panel (void) width (133 m), the proposed layout generally complies with the DSC guidelines.

In relation to chain pillar width, the Project does not comply with the DSC guidelines. The proposed chain pillar dimension is 65 m (solid) whereas the guidelines suggest 1/5th the maximum depth of cover. In this case chain pillar dimension of approximately 100 m would be required. Whilst the proposed chain pillar dimensions are significantly less conservative compared with the DSC guidelines, the principal criteria of long term chain pillar stability is justifiable.

Future mining within the DSNZ will be informed by a growing database of field monitoring (deep nested piezometers and deep groundwater sampling) and refinement of the 3D computer groundwater model. This data in conjunction with the geological, geomechanical, and surface water model may provide justification for greater reserve optimisation in the future.

Based on the current mine plan, longwall mining would not enter the DSNZ until approximately Year 4 of operations (Longwall 23) and pass beneath the reservoir Full Supply Level until approximately Year 9 (Longwall 28). This provides opportunity to work with the DSC's engineers and gain the significant additional data sets described above.

It is understood that BHP Billiton - Illawarra Coal does not have final DSC approval for mining at Dendrobium and therefore it cannot be relied upon as a relevant case study. Notwithstanding, there are some important points of distinction between the Dendrobium example and the Metropolitan Coal Project, including:

(i) The longwalls do not mine directly beneath the stored waters of the Cordeaux Reservoir (Figure 1.1).

(ii) The longwalls have been specifically positioned so that they are setback from the full supply level of the Cordeaux Reservoir as a mine design objective – based on assessment of risks and different site specific conditions.

South Bulli initially extracted coal below the Cataract Reservoir generally in accordance with the Reynolds Guidelines. Once site specific monitoring had been conducted, variations to chain pillar width (reduction) was implemented. HCPL has proposed an extraction geometry that is generally in line with Reynolds Guidelines in terms of panel width but is significantly less conservative in terms of chain pillar width.

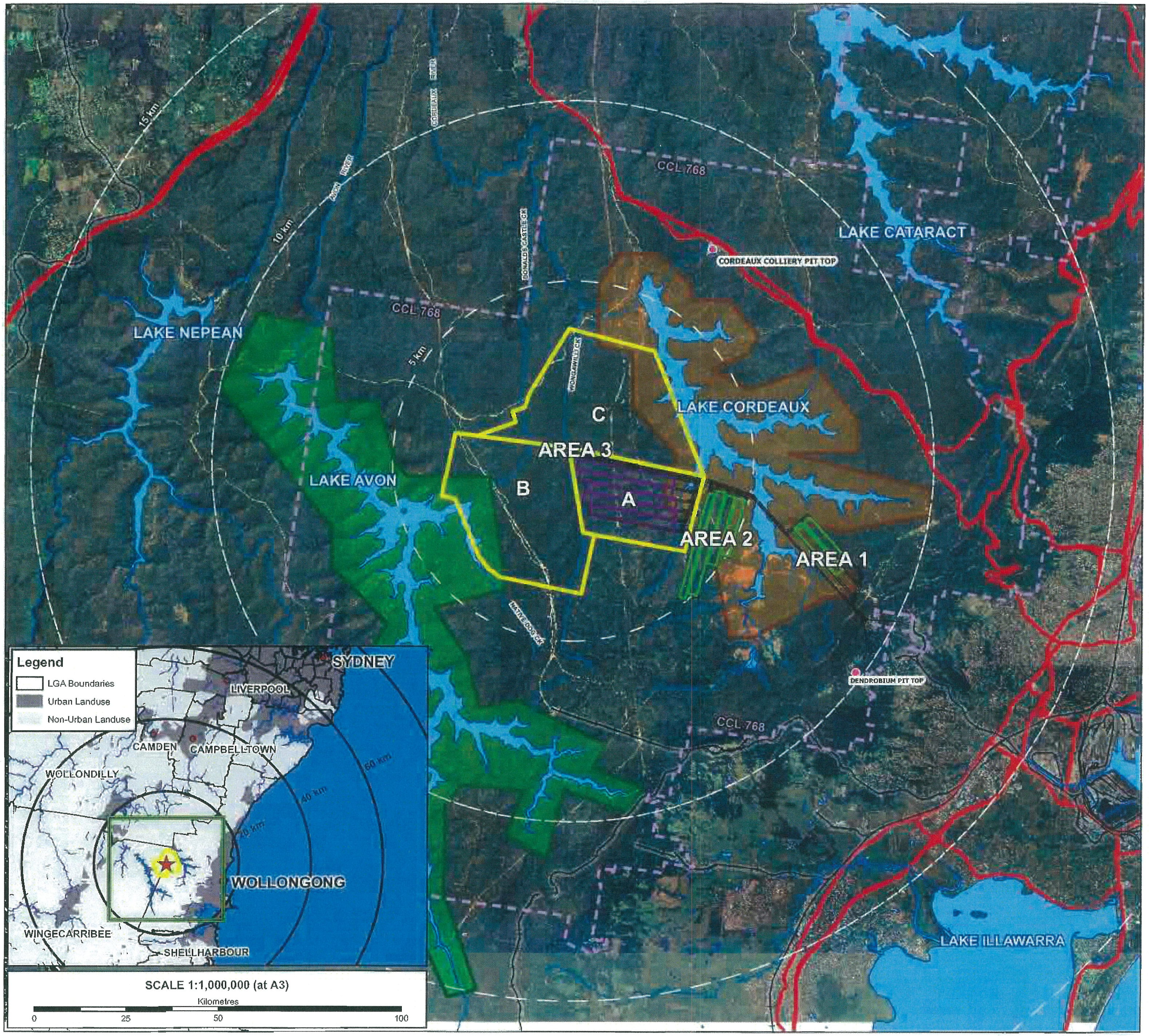
11. As an alternative to barrier pillars under each longwall beneath the Waratah Rivulet, has the mine considered taking all of every 3rd longwall beneath the stream. What are the potential costs and benefits of such an approach, cf the layouts shown in Figs 5.4[i] and 5.4[ii] in Appendix A?

HCPL has investigated and undertaken preliminary cost estimates on the alternative mine layouts (scenarios) as requested by the PAC. These analyses are based on comparative cost estimates with respect to full extraction under the Waratah Rivulet using estimates of the tonnages of coal sterilised and the additional costs associated with additional capital expenditure and additional workforce required to maintain mine development and gas drainage – plus estimates of the monetary environmental costs and benefits that have been determined by the Choice Modelling Study.

While the relative costs of implementing these mine layout scenarios have been estimated in terms of impact on the net benefits of the Project, mine layout variations that involve setbacks are also subject to technical considerations such as engineering, mine development and gas drainage requirements that impose risks (financial and logistical) on the continuity of mining. Hence, while in theory it may be possible to implement all of the setback scenarios, financial return on capital and continuity of mining risks are also relevant considerations for HCPL when making investment decisions. Any mining scenario that does not provide for the effective management of these issues is a relevant consideration with respect to the ongoing viability of Metropolitan Colliery as a whole.

The option of fully extracting every third longwall has not previously been considered for the Project – as the adjoining barriers (i.e. panel setbacks) would need to be proportionally increased to maintain the same amount of sterilised coal and achieve the same environmental outcome. The environmental outcomes would therefore be as per the response to PAC Question 5.

Notwithstanding, HCPL have analysed the cost implications of the implementation of this option and can advise that it would reduce setback management costs by a margin in some cases, as longwall relocations would be reduced by some three longwalls between Longwall 20 and Longwall 30 (i.e. for three out of 10 panels). However the implementation of this management option would not reduce overall setback management costs significantly, and in some cases may need additional capital and manning expenditure to maintain mine development and gas drainage. The implementation of this management approach may also shorten the extraction area in some of the adjacent setback panels to the point where mining of the whole longwall panel becomes sub-economic.



bhpbilliton
ILLAWARRA COAL

Locality Plan

DENDROBIUM AREA 3

Legend

- Colliery Pit Tops
- Railway (LPI)
- Main Roads (LPI)
- Drainage (LPI)
- Lease Boundaries
- Waterbody (LPI)
- Proposed Area 3 Footprint
- Proposed Longwall Layout
- Existing Longwall Layout

DSC Notification Area

- Avon Dam
- Cordeaux Dam

N W E S

Figure 1.1

Scale 1:100,000 (at A3)

Kilometres
0 1 2 3 4 5

Cardno Forbes Rigby

Map Produced by Forbes Rigby Pty Ltd
Date: 13 November 2007
Coordinate System: Zone 56 MGA/GDA 94
GIS MAP REF:
107055-01_1802_EIA_Locality_Plan_P1.mxd

The results of a simple economic analysis of the net production cost differential between Scenario Figure 5.4, Scenario Figure 5.4(i) and Scenario Figure 5.4(ii) (refer response to PAC Question 4) with and without every third panel extending under the stream are tabulated below and are small <$5M.

Scenario	**Figure 5.4**	**Figure 5.4 Every Third Panel Under**	**Figure 5.4(i)**	**Figure 5.4(i) Every Third Panel Under**	**Figure 5.4(ii)**	**Figure 5.4(ii) Every Third Panel Under**
Net Production Cost/Benefit	-$147M	-$148M	-$152M	-$148M	-$95M	-$92M
Net Community Cost/benefit	**-$142M**	**-$143M**	**-$149M**	**-$145M**	**-$100M**	**-$96M**

As the costs and benefits of having every third longwall under the rivulet and correspondingly extending the adjacent setbacks to sterilize the same quantity of coal are effectively the same, the analysis indicates that there would be very little alteration of the net community cost.

The analysis indicates that with the inclusion of the social community values estimated via the Choice Modelling Study – setbacks in Scenario Figure 5.4, Scenario Figure 5.4(i) and Scenario Figure 5.4(ii) remain economically inefficient with or without having every third longwall under the stream and all result in a significant net cost to society.

As described above, setback scenarios also introduce additional engineering, mine development and gas drainage requirements that impose risks on the continuity of mining.

12. Please provide a copy of the MineCraft Consulting report referred to on p 3-66.

A copy of the MineCraft Consulting report titled *Metropolitan Coal Project Mine Layout Review* was provided to the Planning Assessment Commission on 4 February 2009.

Predicted Subsidence Characteristics

13. Is there a survey line along the entire length of the southern section of Waratah Rivulet already undermined? If so, please provide associated incremental, cumulative and net subsidence profiles.

A survey line ('F' Line) was established along the reach of the Waratah Rivulet between Flat Rock Swamp and Flat Rock Crossing. The line was established in October 2003. The line meandered along the course of the rivulet however the usefulness of the measurements obtained was considered to be limited because the line generally missed the focus of the valley closure. No further measurements were taken after the end of Longwall 13.

Cross lines were established at regular intervals along the rivulet (sixteen in total), extending approximately 20 m each side of the valley floor. The cross lines continue to be re-surveyed (E Line across WRS3 rock bar every month) and others depending on the proximity of each longwall. The survey cross lines do not extend all the way to the ridgelines so the extent of valley closure measured by the cross lines is an underestimation of the actual total valley closure. The results do however provide a general indication of the zone of upsidence and the general sense and magnitude of movement.

The cross lines will continue to be monitored until all subsidence and/or restoration of that reach of the rivulet has stabilised over the long term (years). Whilst recognising the limited usefulness of the cross lines, the data is nevertheless of some value and more cross lines will be established ahead of mining in the Project Underground Mining Area. The mine is currently investigating more robust methods of measuring total valley closure (e.g. use of Total Stations, GPS receivers, a combination of GPS and Total Station, and Radar).

14. How does HCPL/MSEC account for the parts of the southern section of Waratah Rivulet already undermined which show less damage than at WRS4 and WRS3?

There is considerable variation in geological and topographical conditions that exist at the various pools and rockbars along the Waratah Rivulet. This variation is evident when one walks the length of the Waratah Rivulet. Such variations include the shape of the valley, length and width of exposed rockbars, varying extent of weathering, and orientation and frequency of cross bedding and joints. This variability will influence how valley closure manifests, or in other words, how the strain is distributed across the valley. It should also be recognised that the extent of pre-mining damage to strata (in this context existing opening along bedding or joint planes would be considered 'damage') would influence subsequent mining induced impact.

A research project funded by the Australian Coal Association Research Program (ACARP) will commence this year (2009) to further investigate the potential relationships between site geological and other conditions and the observed movements and impacts resulting from longwall extraction.

For the purpose of the EA it has been assumed that all rockbars may experience the type of impacts observed at WRS3 and 4. <u>On this basis it is considered that the adaptive management and restoration commitments in the EA are conservative.</u>

15. MSEC applied a calibration factor for vertical subsidence over longwalls mined to date to account for subsidence up to 50% greater than would have been predicted using its full data set. Why were calibration factors not also applied/required for upsidence and valley closure?

The predictions of upsidence and closure use a set of upper bound prediction curves to calculate predicted upsidence and closure. These curves encompass an estimated 95% of the data contained in our empirical database. The use of upper bound prediction curves provides a very conservative prediction of upsidence and closure.

There is no need to make an adjustment for upsidence and valley closure since the observed upsidence and closure data for Metropolitan Colliery is already incorporated in the upper bound prediction curve. In addition, the predicted maximum vertical subsidence is one of the factors used in the method for predicting upsidence and closure. Using the calibrated predicted maximum vertical subsidence will result in slightly higher values of predicted upsidence and closure.

16. The MSEC impact criterion of 200mm of closure is premised on correlating their predictions of closure with observed impacts. It is not premised on measured closure. As such, the criterion is dependent on MSEC's (highly) empirical prediction procedure being suitable/accurate for the given conditions. Do the subsidence predictions call this into question? If so, what are the implications? (See, for further clarification, discussion in Environmental Assessment: Dendrobium Coal Mine – Modification of Consent (Area 3), November 2008, available at: http://www.planning.nsw.gov.au/asp/2008_ndetermination_other.asp

There is currently insufficient data available to allow an adequate correlation of observed impacts with measured closures. MSEC appreciate the value of developing a correlation of observed impacts with measured closures, particularly for developing monitoring programs and for use with potential future prediction models.

At this stage, MSEC considers that the most reliable way of assessing the relationship between impact and closure is to consider all closure data as predicted values.

There is some probability, regardless of the approach, that potential impacts could occur at predicted closure values less than the minimum predicted total closure of 200 mm that has been identified to date. This can be validated as more data is gathered. There is no need to make an adjustment for upsidence and valley closure since the observed upsidence and closure data for Metropolitan Colliery is already incorporated in the upper bound prediction curve.

Further information can be provided if required.

17. Appendix A contains a limited discussion of potential causes for increased vertical subsidence at Waratah Rivulet (pp 35-36). However, it does not present any consideration as to whether the increased subsidence at Waratah Rivulet may also affect upsidence or valley closure values and/or predictions. The discussion contained in the EA is not premised on a mechanistic analysis. A detailed analysis of the reasons for elevated subsidence parameters at Waratah Rivulet is requested.

The discussion of increased vertical subsidence on pages 35 and 36 of Appendix A relates to the calibration of observed subsidence along the D Line at Metropolitan Colliery over the previously mined Longwalls 3 to 14 and did not refer to the Waratah Rivulet.

The predictions of subsidence over all of the proposed longwalls at Metropolitan Colliery have been based on a calibrated prediction model. The predictions of upsidence and closure are based on upper bound prediction curves and have a high degree of conservatism. Nevertheless, the increased vertical subsidence being predicted over the future longwalls (as a result of the calibration), are used for the prediction of upsidence and closure and therefore yield slightly higher values.

The observed valley related upsidence and closure values at Metropolitan Colliery fit within the data set used for predictions of upsidence and closure and were therefore not considered to be elevated, nor require model calibration.

Note: Further detailed analysis of mechanisms contributing to valley closure and the relationships between subsidence and valley closure are considered outside the scope of the empirical methods used. A need for further research into such mechanisms and relationships has been identified and will proceed through ACARP and by other researchers using mechanistic approaches.

18. ***Figs 3.12 and 3.13 in Appendix A show predicted and observed subsidence and strain profiles along the D survey line, but no data for predicted and observed tilt. Please provide this data. What accuracy is being assigned to predictions of tilt?***

Figs 3.12 and 3.13 in Appendix A (Report No. MSEC285) are reproduced below as Figure MSEC-7 and Figure MSEC-8 respectively with added data for predicted and observed tilt.

It can be seen from the attached comparison that there is a reasonable relationship between predicted and observed tilt. Deviations are observed at stream locations, which is expected as the predictions have not included tilt due to upsidence. As discussed in Report No. MSEC285, systematic tilts can be predicted to the same level of accuracy as subsidence (please refer Page 48, 1st sentence of 4th paragraph in Appendix A). The comparisons provided below support this statement.

19. ***The EA relies extensively on MSEC's predictions of strain. Figures 3.12 and 3.13 in Appendix A suggest a poor correlation between predicted and observed strain, both in respect of magnitude and distribution. Predicted strain appears to be significantly less than observed to date. Clarification is sought on this matter and a discussion of its implications for the prediction of subsidence effects, impacts and consequences.***

The observed strain plotted in Figures 3.12 and 3.13 of Appendix A include systematic, non-systematic and potential anomalous movements as well as normal survey tolerance. The plots of predicted strain profiles are plots of systematic strain only. As a result, there are expected to be several spikes in the observed strain profiles that would exceed the predicted systematic profiles. The D line passes through rocky, steep terrain and crosses six drainage paths. The difficult terrain also makes it difficult to maintain 20 m bay lengths and there are several shorter bay lengths down to approximately 10 m.

The results indicate that distinct valley closure movements have occurred in the tributary crossing above LW9 and in the Waratah Rivulet. In addition to this, some results have been confirmed as survey error, either as a measurement error or a disturbed peg.

In order to present a clearer comparison of the observed and predicted strains, the plots of observed and predicted incremental strain have been presented as individual plots for each of the longwalls from LW8 to LW14 and are presented in Figure R-03. Annotation has been added to these plots to identify any of the known non-systematic movements. The predicted closure strains at each of the drainage path crossings is plotted along the predicted line. The plots also show the expected range of survey tolerance for strain which is estimated to be ±0.5 mm/m. The survey tolerance was only applied to the predicted systematic strain plot, not the closure strain spikes.

It can be seen that the general distribution of the observed incremental strains match the predicted strains. The scatter created by survey tolerance can be seen more clearly in the individual plots on Figure R-03. There are several relatively significant spikes in the observed profiles for LW10, 11 and 12, at the hill from approximately Peg D57 to Peg D80. It is known that large horizontal movements occurred over these pegs during the extraction of LW10, 11 and 12 (both along and across the D Line) and that a large tensile crack occurred near the top (and on the western side) of this hill during the extraction of LW10.

It is recognised that measured strains can vary considerably from predicted strains. The main reasons for this variation are outlined in Appendix A. Appendix A (page 48) states:

> *The systematic tilts can be predicted to the same level of accuracy as subsidence, but the measured curvatures and strains can vary considerably from the predicted systematic values for the following reasons:-*

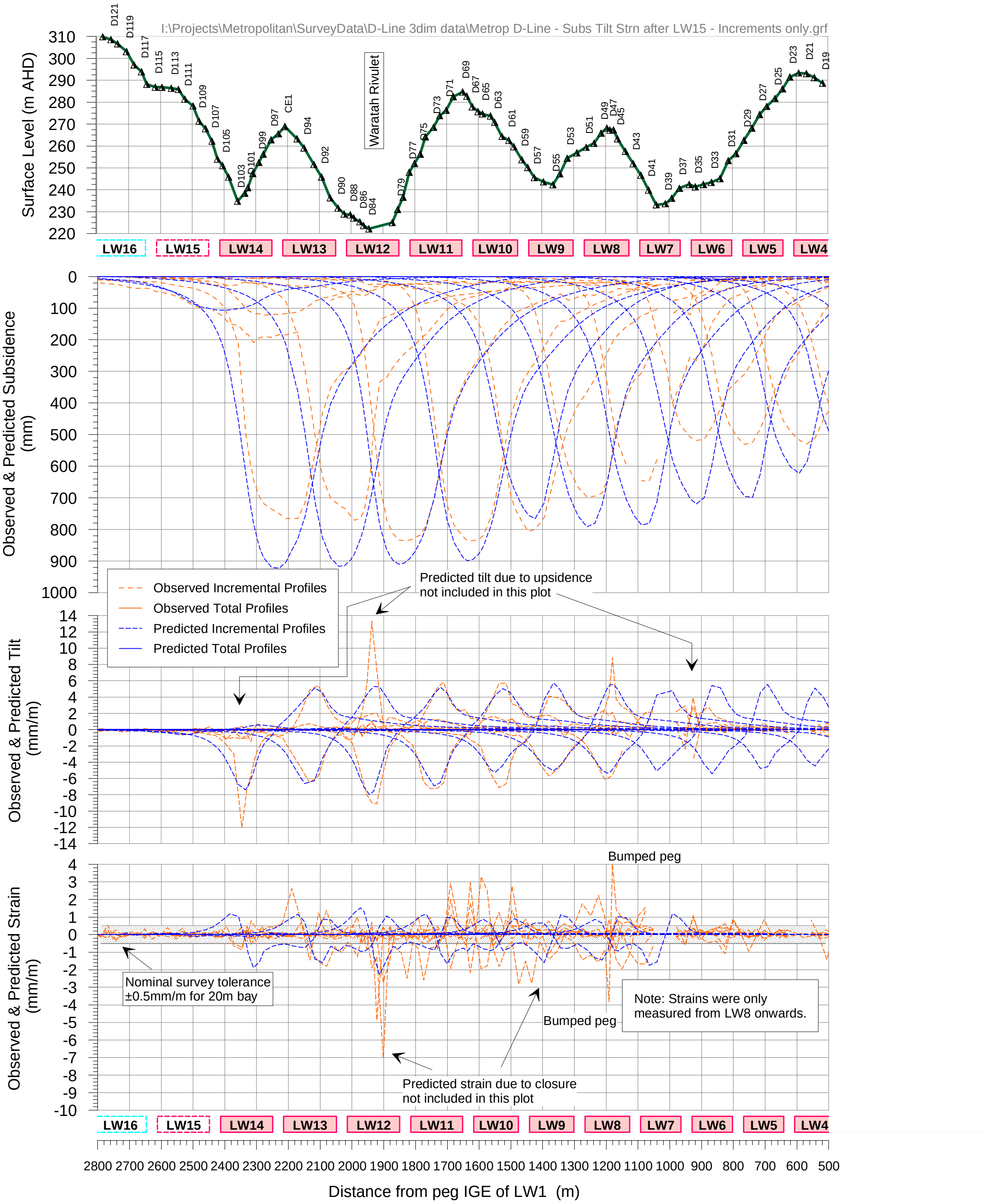


Figure MSEC-7 Comparison of Predicted Incremental Systematic Subsidence, Tilt and Strain with Observations along the D Line

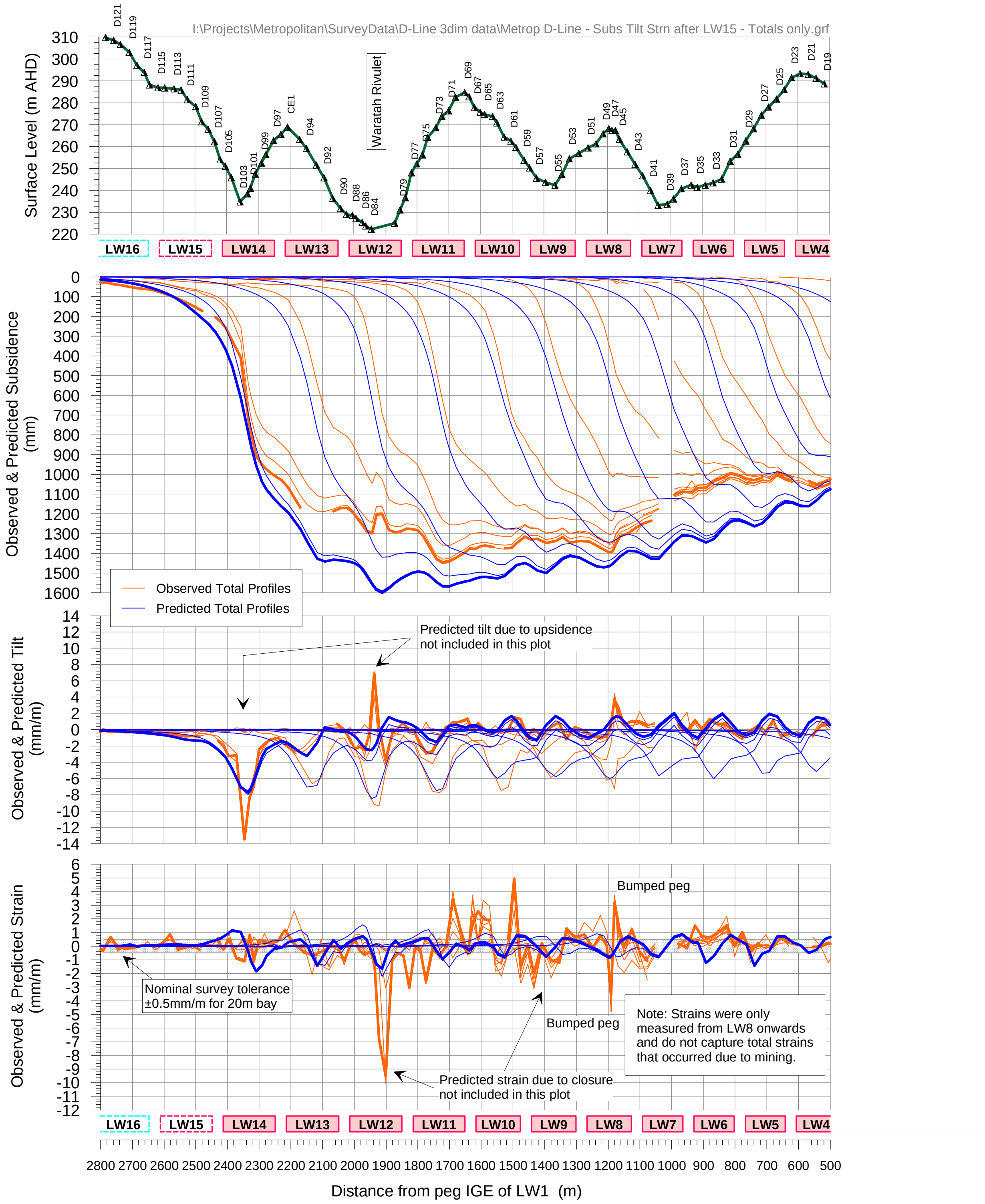


Figure MSEC-8 **Comparison of Predicted Total Systematic Subsidence, Tilt and Strain with Observations along the D Line**

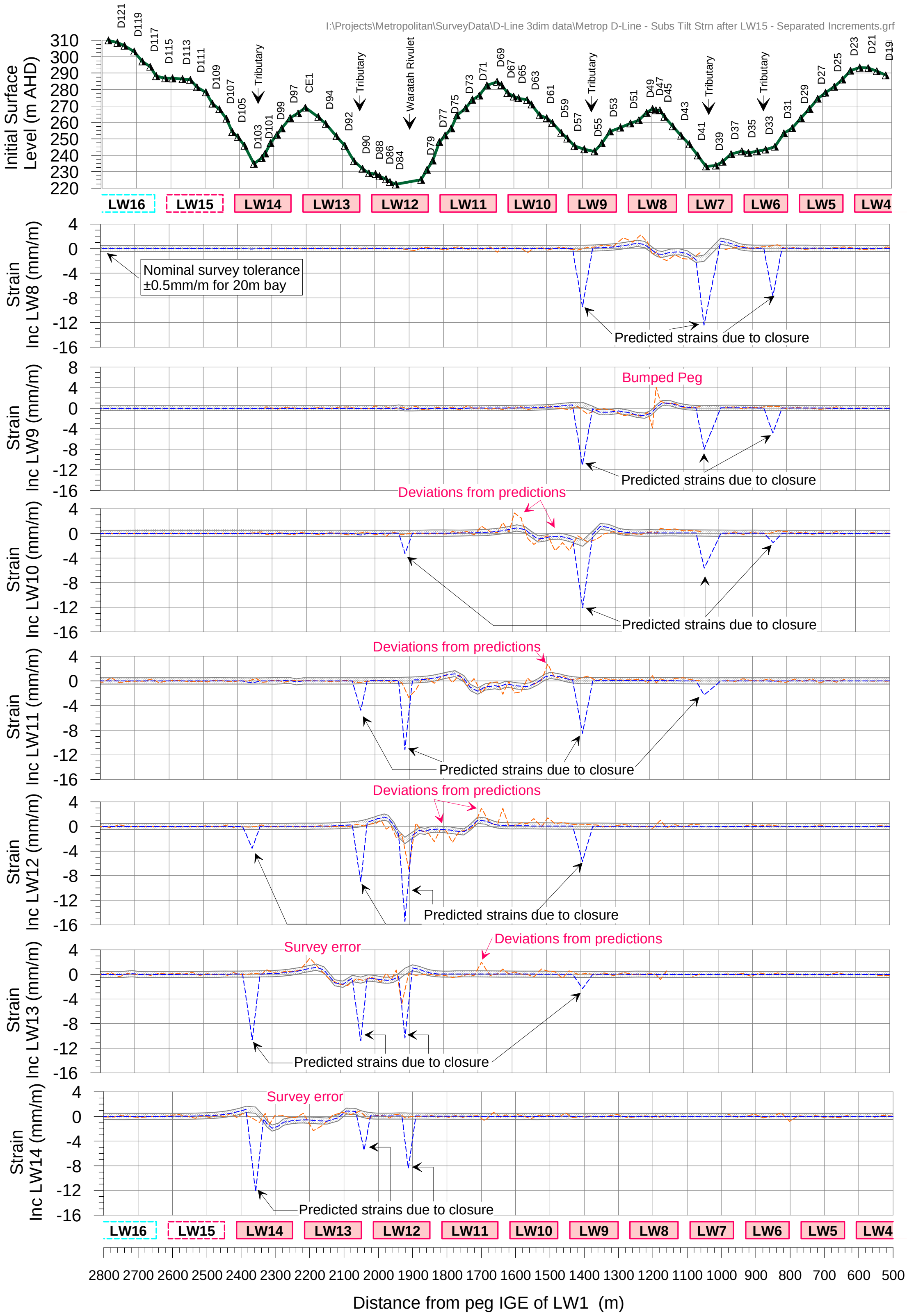


Figure R-03 Observed Incremental Strain Profiles along Monitoring Line D

- *Variations in local geology can affect the way in which the near surface rocks are displaced as subsidence occurs. In the compression zone, the surface strata can buckle upwards or can fail by shearing and sliding over their neighbours. If localised cross bedding exists, this shearing can occur at relatively low values of stress. This can result in fluctuations in the local strains, which can range from tensile to compressive. In the tensile zone, existing joints can be opened up and new fractures can be formed at random, leading to localised concentrations of tensile strain.*
- *Where a thick surface layer of soil, clay or rock exists, the underlying movements in the bedrock are often transferred to the surface at reduced levels and the measured strains are, therefore, more evenly distributed and hence more systematic in nature than they would be if they were measured at rockhead.*
- *Strain measurements can sometimes give a false impression of the state of stress in the ground. For example:*
  - *buckling of the near-surface strata can result in localised cracking and apparent tensile strain in areas where overall, the ground is in fact being compressed, because the actual values of the measured strains are dependent on the locations of the survey pegs.*
  - *where joints open up or cracks develop in the tensile phase and fail to close in the compressive phase, as they sometimes do if they are subsequently filled, the ground can appear to be in tension when it is actually in compression.*
- *Sometimes, survey errors can also affect the measured strain values and these can result from movement in the benchmarks, inaccurate instrument readings, or disturbed survey pegs. In these circumstances it is not surprising that the predicted systematic strain at a point does not match the measured strain.*

In sandstone dominated environments, much of the earlier ground movements can be concentrated at the existing natural joints, which have been found to be at an average spacing of 7 to 15 metres.

The impact assessments provided in Report No. MSEC285 have used predictions of systematic strain as a reference guide only and have not been relied upon as an exact science. The observation that observed strains have substantially exceeded predicted systematic strains was taken into account when assessments of impacts and consequences were made.

20. Drawing No: MSEC285-20 in App A shows total vertical subsidence in plan view over the whole study area. However, there are no similar plots of total net vertical displacement. Please provide plan view drawings for subsidence effects, including upsidence and closure, that cover the full study area (ref. Table 5.8 in Appendix A).

It is extremely difficult to prepare a meaningful contour plan of the total net vertical displacement over all of the proposed longwalls. In lieu of this, MSEC has prepared plots to show the effect of the predicted incremental upsidence on the incremental subsidence contours. These were prepared for two longwalls, LW25 and LW35, representing an area with larger values of subsidence and an area with smaller values of subsidence. MSEC has prepared contours showing the predicted incremental subsidence (Figure MSEC285-R01), predicted incremental upsidence (Figure MSEC285-R02), and predicted incremental subsidence plus upsidence or net vertical displacement (Figure MSEC285-R03).

21. Section 5.6 of Appendix A states the following on numerous occasions: 'If the predicted strains were increased by factors of up to 2 times, the potential for (some impact e.g. cliff instabilities) would increase accordingly'. Please quantify 'accordingly' in each instance (double?).

It is difficult to quantify the increase in impact that would result from an increase in predicted strain, largely because there is limited data available for calculation of the required information and the degree of variability that occurs in the natural environment. Below, MSEC has identified the sections that quote the term '*accordingly*' and provided comments on use of the term.

- Section 5.2.3 (Pg 77) Waratah Rivulet.
- Section 5.3.3 (Pg 82) Tributaries.

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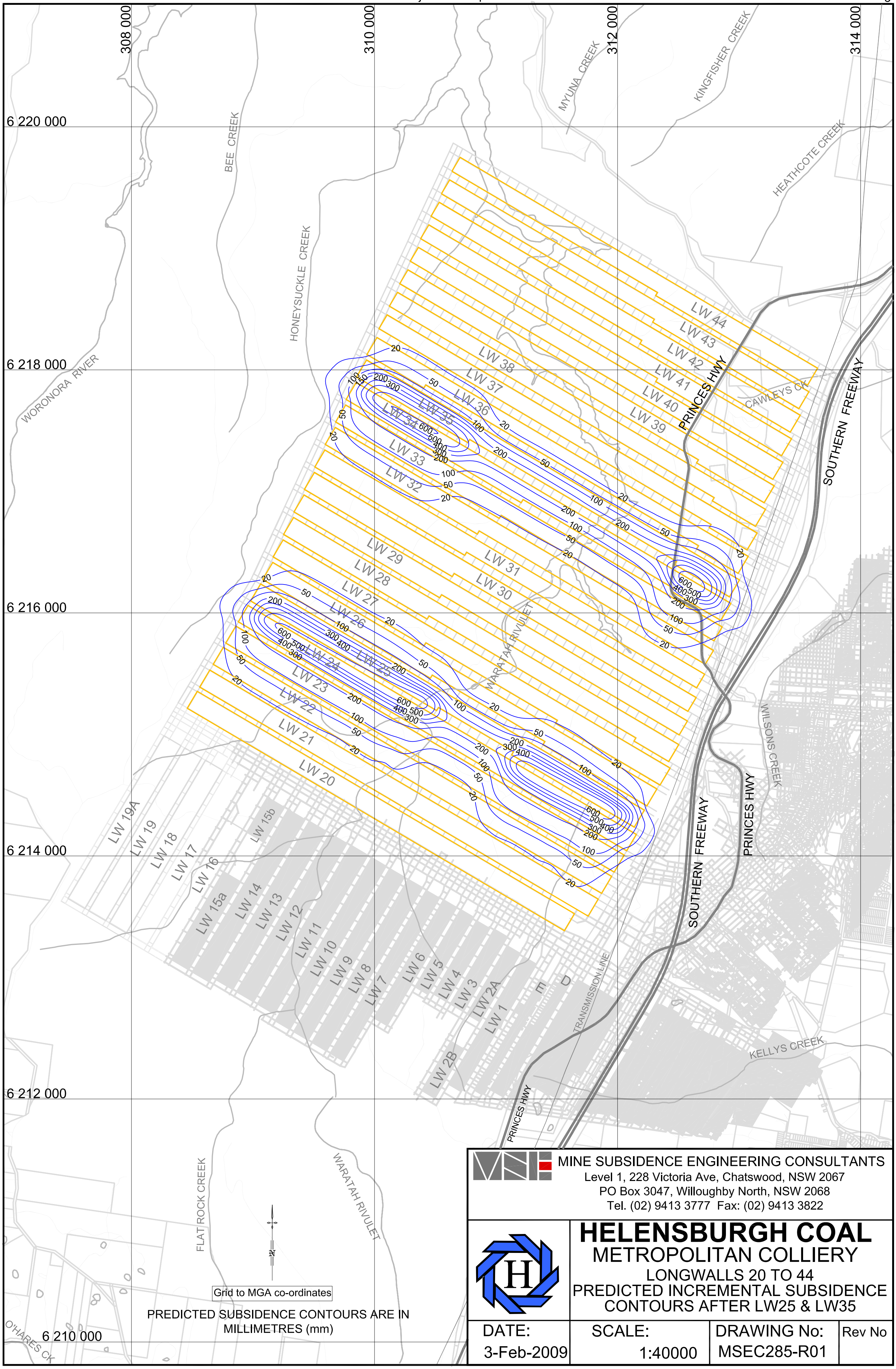

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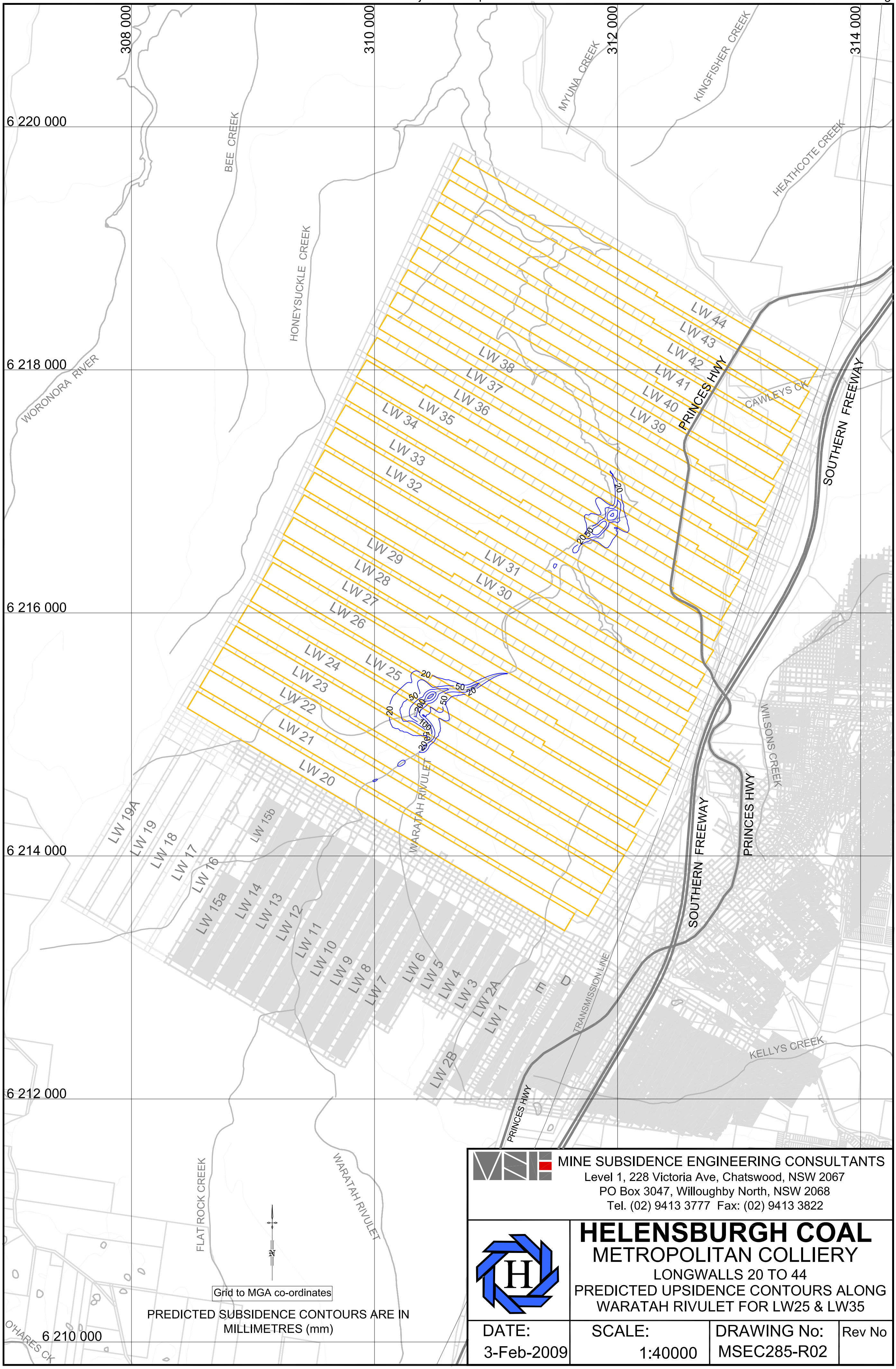

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HELENSBURGH COAL

METROPOLITAN COLLIERY

LONGWALLS 20 TO 44
PREDICTED UPSIDENCE CONTOURS ALONG WARATAH RIVULET FOR LW25 & LW35

DATE:	SCALE:	DRAWING No:	Rev No
3-Feb-2009	1:40000	MSEC285-R02	

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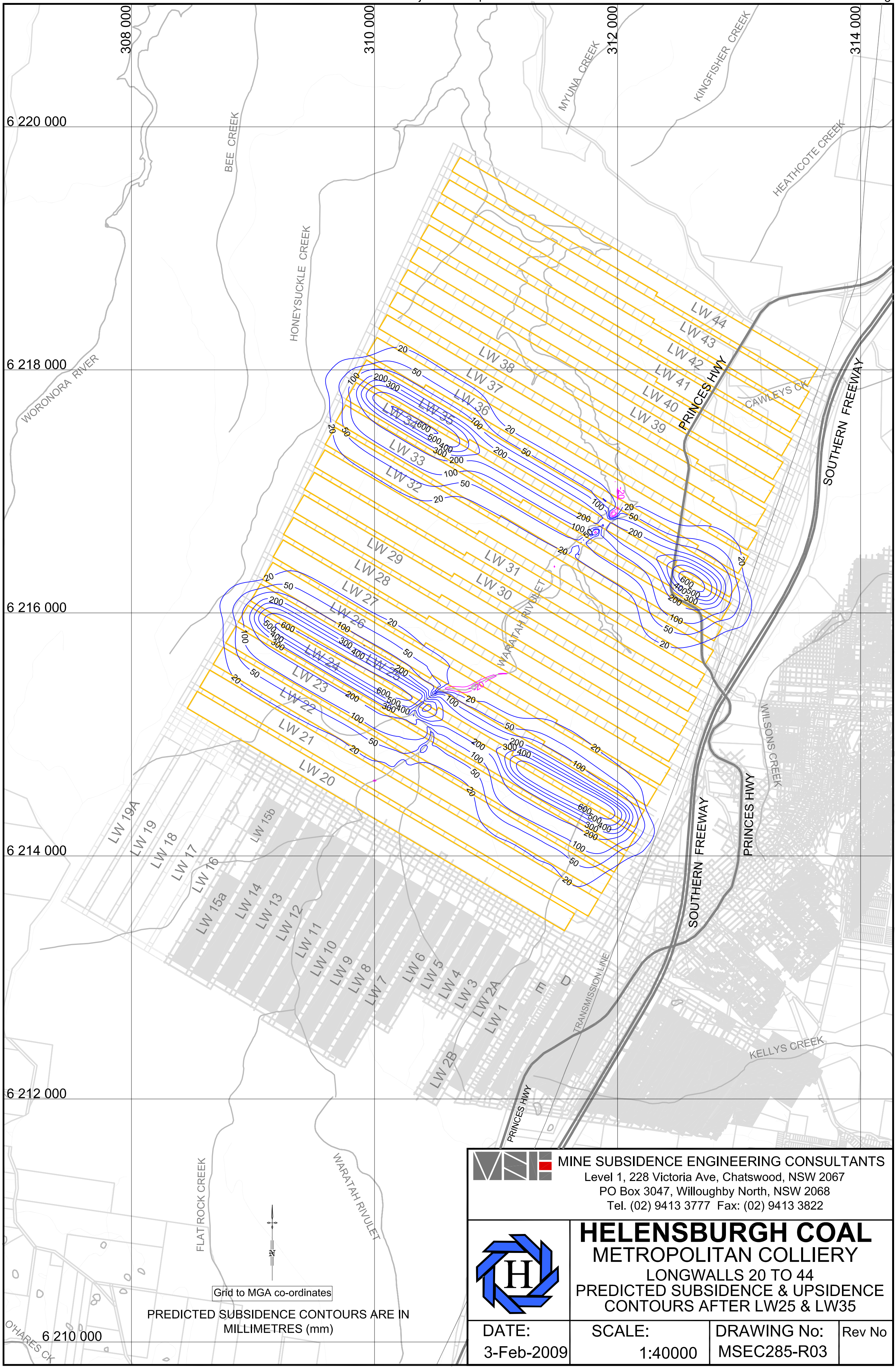

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HELENSBURGH COAL
METROPOLITAN COLLIERY

LONGWALLS 20 TO 44
PREDICTED SUBSIDENCE & UPSIDENCE CONTOURS AFTER LW25 & LW35

DATE:	SCALE:	DRAWING No:	Rev No
3-Feb-2009	1:40000	MSEC285-R03	

- Section 5.6.4 (Pg 92) Cliffs and Overhangs.
- Section 5.7.3 (Pg 95) Steep Slopes.
- Section 5.8.2 (Pg 98) Swamps.
- Section 5.9.3 (Pg 100) EECs.
- Section 5.12.3 (Pg 108) Princes Highway.
- Section 5.19.5 (Pg 123) Garrawarra Complex Buildings.
- Section 5.20.4 (Pg 126) Houses.
- Section 5.21.3 (Pg 129) Rural Building Structures.
- Section 5.22.3 (Pg 130) Tanks.
- Section 5.24.3 (Pg 135) Archaeological Sites.

In Section 5.6 the term 'accordingly' was used in a qualitative context. The intent was to infer that increasing the strain would generally increase the potential impact. As discussed in the response to PAC Question 19, impact assessments for surface features did not rely upon the predictions of systematic strain as an exact science. Many assessments relied on past experiences of mining beneath similar features (such as cliffs).

The predicted impacts to building structures are assessed according to a classification system which is presented in Tables 5.29 and 5.30 of Appendix A. A summary was presented in Appendix A of the associated category for various increases in predicted strain. The assessment also considered the potential for impacts due to non-systematic movements.

22. Appendix H classifies a number of Aboriginal heritage sites as 'very significant'. The Panel requests a specific assessment of each of these sites in respect of potential subsidence effects and impacts. In regards to overhangs, HCPL's attention is directed to the assessment criteria discussed in Environmental Assessment: Dendrobium Coal Mine – Modification of Consent (Area 3), November 2008, available at: http://www.planning.nsw.gov.au/asp/2008_ndetermination_other.asp

Section 7 of Appendix H includes both an archaeological and cultural significance assessment. In regard to archaeological significance, known Aboriginal heritage sites are assessed against set criteria and assigned an archaeological significance rating of low, moderate or high. In regard to cultural significance, Section 7 includes cultural comment from the Aboriginal community on both individual sites and on sites collectively. For the purpose of this response, it is assumed that PAC Question 22 relates to sites deemed to be of high archaeological significance.

Consistent with the assessment criteria utilised in *Environmental Assessment: Dendrobium Coal Mine – Modification of Consent (Area 3)* (November 2008) Appendix H of the Metropolitan Coal Project EA provided individual subsidence predictions, site position in the landscape, specific site characteristics, site dimensions, etc. The new information provided below in the re-formatted assessment of potential impacts for sites of high archaeological significance provides a "Risk of Impact" rating consistent with the referenced document *Environmental Assessment: Dendrobium Coal Mine – Modification of Consent (Area 3)* (November 2008). This risk rating has been determined by informed consideration by MSEC Pty Ltd, Kayandel Archaeological Services and HCPL.

FRC 12 ***52-2-0255*** ***Open Site***

This site is an open sandstone platform with low predicted systematic compressive and tensile strains. The site has a depth of cover of approximately 490 m and has maximum predicted compressive and tensile strains of 0.4 and 0.6 mm/m, respectively. The presence of pre-existing structures would tend to focus any systematic or non-systematic strains, thereby further reducing the likelihood of impacts. There is a negligible risk of impact to this site.

FRC 32 ***52-2-0194*** ***Open Site***

This site is an open sandstone platform with low predicted systematic compressive and tensile strains. The site is located over a pillar, has a high depth of cover and is positioned on a slope. The site has a depth of cover of approximately 450 m and has maximum predicted compressive and tensile strains of 0.5 and 0.4 mm/m, respectively. Non-systematic strains, if evident, would very likely concentrate about existing pot holes and the drainage channel, thereby providing protection for the grinding grooves present. There is a negligible risk of impact to this site.

FRC 62 ***52-2-0168*** ***Sandstone Overhang***

This site has a low predicted systematic tensile strain and it is positioned on a ridgetop. The site's volume is greater than 50 m^3 and it is located above a goaf area although it has a large depth of cover. The site has a depth of cover of approximately 530 m and has a maximum predicted tensile strain of 0.5 mm/m. The sandstone has an existing area subject to water seepage, which has resulted in the creation of a pool in the floor of the overhang. The sandstone has existing joints and cracks which would absorb much of the systematic and non-systematic (if present) subsidence strains. There is a very low risk of impact to this site.

FRC 68 ***52-2-0186/52-2-0326*** ***Sandstone Overhang***

This site has a very low predicted systematic tensile strain and it is positioned on a ridgetop. The site's volume is less than 50 m^3 which places it outside the risk category of larger sites and it is located over a pillar. The site has a depth of cover of approximately 450 m and has a maximum predicted tensile strain of 0.4 mm/m. There has been no observed/recorded water seepage through the sandstone. There is a negligible risk of impact to this site.

FRC 185 ***52-2-0223*** ***Sandstone Overhang***

This site has a low predicted systematic tensile strain. The site's volume is greater than 50 m^3 and it is located above a goaf area although it has a large depth of cover. The site has a depth of cover of approximately 445 m and has a maximum predicted tensile strain of 0.8 mm/m. A silica skin on the sandstone surface and some evidence of water seepage has previously been recorded. The sandstone has existing joints and cracks which would absorb much of the systematic and non-systematic (if present) subsidence strains. Fracturing and shear movements of strata, and rock falls associated with cliffs have been reported in similar situations. There is a low risk of impact to this site.

FRC 191 ***52-2-0183*** ***Sandstone Overhang***

This site has a low predicted systematic tensile strain. The site's volume is greater than 50 m^3 and it is located above a goaf area although it has a large depth of cover. The sandstone has existing joints and cracks which would absorb much of the systematic and non-systematic (if present) subsidence strains. The site has a depth of cover of approximately 445 m and has a maximum predicted tensile strain of 0.8 mm/m. There has been no observed/recorded water seepage through the sandstone. Fracturing and shear movements of strata, and rock falls associated with cliffs have been reported in similar situations. There is a low risk of impact to this site.

FRC195 ***52-2-0264*** ***Sandstone Overhang***

This site has a low predicted systematic tensile strain. The site's volume is only just greater than 50 m^3 and it is located above a goaf area although it has a large depth of cover. The sandstone has existing joints and cracks which would absorb much of the systematic and non-systematic (if present) subsidence strains. The site has a depth of cover of approximately 435 m and has a maximum predicted tensile strain of 0.6 mm/m. Damage due to water seepage has previously been recorded. Fracturing and shear movements of strata, and rock falls associated with cliffs have been reported in similar situations. There is a very low risk of impact to this site.

FRC 322 ***N/A*** ***Open Site***

This site is an open sandstone platform with very low predicted systematic compressive and tensile strains. The site is located over a pillar and is positioned on a slope. The site has a depth of cover of approximately 480 m and has maximum predicted compressive and tensile strains of 0.3 and 0.4 mm/m, respectively. The presence of pre-existing structures would tend to focus any systematic or non-systematic strains, thereby further reducing the likelihood of impacts. There is a negligible risk of impact to this site.

NEW 2 ***N/A*** ***Sandstone Overhang***

This site has a low predicted systematic tensile strain and it is positioned on a slope. The site's volume is greater than 50 m^3 and it is located above a goaf area. The site has a depth of cover of approximately 525 m and has a maximum predicted tensile strain of 0.6 mm/m. There is a negligible risk of impact to this site.

Summary of Risk of Impact to Sites of High Archaeological Significance

Site Number	Site Name	Site Type	Risk of Impact
52-2-0255	FRC 12	Open Site	Negligible
52-2-0194	FRC 32	Open Site	Negligible
52-2-0168	FRC 62	Sandstone Overhang	Very Low
52-2-0186/52-2-0326*	FRC 68	Sandstone Overhang	Negligible
52-2-0223	FRC 185	Sandstone Overhang	Low
52-2-0183	FRC 191	Sandstone Overhang	Low
52-2-0264	FRC195	Sandstone Overhang	Very Low
N/A	FRC 322	Open Site	Negligible
N/A	NEW 2	Sandstone Overhang	Negligible

* Single Aboriginal heritage site registered more than once on the AHIMS database (Illawarra Prehistory Group, 2007).

N/A Information provided to the DECC although not yet registered on the AHIMS database.

Although not directly relevant to PAC Question 22, HCPL would like to make the following points in regard to the Aboriginal Heritage Assessment.

Appendix H was peer reviewed by rock art specialist Robert Gunn, whose comments were as follows:

> "*In reference to your request to review Kayandel's Aboriginal Cultural Heritage Assessment for Helensburgh Coal Pty Ltd, I have undertaken this with an acknowledgement of the requirements of other involved parties and not simply regarding what I would see as required.*
>
> *In response to my comments, I confirm that all the issues raised have been dealt with to my satisfaction, and hence I consider the report to be a reasonable assessment of the Aboriginal Cultural Heritage and the recommendations to be appropriate and acceptable*".

In addition to the above, HCPL has committed to developing a protocol/program for the sponsorship of existing or new projects that benefit the wider Aboriginal community. Specifically, Sections 4.8.3 and 6 of Volume 1 of the EA state:

> *A protocol/program for HCPL to sponsor existing or new projects that benefit the wider Aboriginal community. These may include (for example): Aboriginal community field days; restoration of culturally significant buildings; rehabilitation/protection of areas with high cultural values; and/or potential employment/skill development opportunities. Any such sponsorship should be made available to the wider Aboriginal community with submissions presented to HCPL and projects selected by HCPL based on their individual merit and benefit to the wider Aboriginal community.*

As described in the EA, this protocol/program would be developed as part of the Aboriginal Cultural Heritage Management Plan in consultation with the DECC and the Aboriginal community. During consultation with the Aboriginal community as part of the EA, it became apparent that some Aboriginal community groups are actively committed to existing programs aimed at providing economic and cultural support/education to the Aboriginal community. During consultation, those community groups involved in the operation of these programs expressed the desire to both continue these existing programs and develop new programs.

An outline of such programs provided by one of the Aboriginal community groups consulted with is provided in Appendix H of the EA:

> *… the NIAC dairy at Menagle which supplies free A2 milk on a weekly basis to needy families throughout the region"; the "Bellambi Lagoon Landcare group"; "Aboriginal language books and CD's" for educational purposes; restoring the "historic UAM Colebrook Memorial Church on the Old La Perouse Mission" for use as a "community meeting place and craft centre, and possibly a day-care centre for Aboriginal children"; "restoring the Old Menangle Primary School" for use as an Aboriginal sports centre, "Aboriginal language school, and as a craft centre/shop"; and "developing picnic and bushwalking facilities … on and about the Elladale Homestead.*

HCPL has acknowledged the benefit of such programs to the wider Aboriginal community and as such is committed to supporting their continuation and/or development through the sponsorship protocol/program outlined in the EA (and quoted above) to be developed as part of the Aboriginal Cultural Heritage Management Plan should the Project be approved.

Natural Features

23. Please describe the "significance" of all key natural features (eg Waratah Rivulet, other streams, swamps and cliff lines found in the application area, within a regional context.

Summary Response

- HCPL considers the quality and quantity of water in the Woronora Reservoir to be of significance. Waratah Rivulet comprises approximately 29% of the total catchment area of Woronora Dam. Assessments indicate that potential impacts on the Waratah Rivulet and other streams would have no measurable effect on quality or quantity of the yield of Woronora Reservoir. Monitoring would be conducted to confirm the impact assessment as mining progresses.

- The Woronora Reservoir impoundment has altered the original ecology of Waratah Rivulet. The ecological significance of the Waratah Rivulet and other streams is considered unlikely to be altered by the Project.
- Public amenity and aesthetic values are provided by the Waratah Rivulet, even though the public cannot access or experience these values readily. The potential impacts on the aesthetic values of the rivulet are likely to vary based on aspects such as stream flow conditions (e.g. low versus moderate to high flows) and the status of iron staining (e.g. the red colour of newly precipitated ferrihydrite compared to the crystalline form of goethite which is darker red-brown in colour).
- Upland swamps contribute to the quantity and quality of water to the Woronora Reservoir. It is also recognised that upland swamps are of ecological significance – they are species rich and provide habitat for a range of flora and fauna including threatened species. The environmental assessments indicate that the potential impacts of the Project on upland swamps would not be of significant magnitude to impact on swamp hydrology, the quantity or quality of water to the Woronora Reservoir or upland swamp habitats. As a result, it is considered highly unlikely that the significance of the upland swamps would be altered by the Project.
- The landscape is characterised by sandstone ridges, steep slopes, valleys, rocky outcrops and cliff formations. These landscape features are typical of the Sydney Basin and the ecological attributes, Aboriginal heritage significance and visual amenity values are considered to be represented elsewhere in the region. The potential impacts of the Project on these landscape features are not considered significant in a regional context.

Detailed Response

In a regional context, and from a planning and assessment perspective it is important to note that the Project is **not** situated within the following environmentally sensitive areas:

- Land reserved as a State Conservation Area under the *National Parks and Wildlife Act*, *1974*.
- Land declared as an Aboriginal place under the *National Parks and Wildlife Act, 1974.*
- Land identified as wilderness by the Director, National Parks and Wildlife under the *Wilderness Act, 1987*.
- Land subject to a 'conservation agreement' under the *National Parks and Wildlife Act*, *1974*.
- Land acquired by the Minister for the Environment under Part 11 of the *National Parks and Wildlife Act, 1974*.
- Land within State Forests mapped as Forestry Management Zone 1, 2 or 3.
- Wetlands mapped under State Environmental Planning Policy (SEPP) 14 Coastal Wetlands.
- Wetlands listed under the Ramsar Wetlands Convention.
- Lands mapped under SEPP 26 Coastal Rainforests.
- Areas listed on the Register of National Estate.
- Areas listed under the *Heritage Act, 1977* for which a plan of management has been prepared.
- Land declared as critical habitat under the *Threatened Species Conservation Act, 1995*.
- Land reserved or dedicated under the *Crown Lands Act*, *1989* for the preservation of flora, fauna, geological formations or other environmental protection purpose.

The significance of Waratah Rivulet, other streams, swamps and cliff lines, within a regional context is discussed below.

Waratah Rivulet

In regard to the significance of Waratah Rivulet and other streams in the region, the Southern Coalfield Panel (SCP) Report (DoP, 2008a) provides:

> *While it is straight forward that all named rivers within the Southern Coalfield come within the Panel's Terms of Reference, careful consideration has been given to which smaller watercourses should be considered as 'significant streams'. The Panel accepts that the significance of a stream is not simply a measure of particular characteristics like whether it is perennial or ephemeral or whether it is regulated or not. Significance can reflect a wide variety of natural values or human uses. Consequently, there is no universally-agreed definition of stream significance, and this must be seen (to some degree) as being 'in the eye of the beholder'. Nonetheless, it seems clear that the significance of a stream is in some way connected to its size. For example, this is the case in respect of its hydrological significance and its contribution to the water supply catchments managed by the Sydney Catchment Authority (SCA).*
>
> *The way in which stream size or scale is most commonly measured is the internationally recognised Strahler system of stream order classification which identifies a catchment's tributary hierarchy.[2] Most submissions to the Panel which considered watercourses referred to streams which are third order or higher under this system. All such rivers and streams within the Southern Coalfield are shown on Maps 1, 3 and 7 while Table 3 lists examples. The Nepean River is the topographically lowest and the largest of the rivers.*

Table 3. Examples of Third and Higher Order Streams Potentially Impacted by Mining in the Southern Coalfield

Strahler Stream Order	***Stream Examples Within the Southern Coalfield***
3	*Wongawilli Creek, Waratah Rivulet (above Flat Rock Creek), Brennans Creek, Elladale Creek, Simpsons Creek, Flying Fox Creek (Nos 1,2 and 3), Kembla Creek, Sandy Creek, Native Dog Creek, Rocky Ponds Creek, Ousedale Creek, Foot Onslow Creek, Mallaty Creek, Harris Creek, Navigation Creek*
4	*Georges River, Cordeaux River (above Kembla Creek), Waratah Rivulet, Stokes Creek*
5	*Bargo River, Avon River, Cataract River (above Lizard Creek), Cordeaux River (below Kembla Creek)*
6	*Cataract River (below Lizard Creek), Cordeaux River (below Avon River)*
7	*Nepean River*

It is considered that the key attribute that makes Waratah Rivulet significant is:

(i) Water Supply – the quantity and quality of water that Waratah Rivulet delivers to Woronora Reservoir.

However, it is recognised that Waratah Rivulet also has the following attributes:

(i) Ecological Values – the habitats provided by Waratah Rivulet.

(ii) Social Values – aesthetic values provided by Waratah Rivulet.

These attributes are described below in a regional context.

<u>Water Supply</u>

The Waratah Rivulet flows to Woronora Reservoir which supplies water to areas south of Georges River including Sutherland, Helensburgh, Stanwell Park, Lucas Heights and Bundeena. Upstream of the Woronora Reservoir, Waratah Rivulet has a catchment area of approximately 22 square kilometers (km^2), which comprises approximately 29% of the total catchment area (75 km^2) of Woronora Dam.

The SCP Report provides the following regional context in relation to water supply catchments in the Southern Coalfield:

- *The single most important land use in the Southern Coalfield is as water catchment.* [page 24]
- *The catchments which support the SCA water supply system extend over 16,000 km^2.* [page 24]
- *The Upper Nepean River system is the largest sub-catchment, comprising the Upper Nepean River and most of its major tributaries - the Burke, Avon, Cordeaux and Cataract Rivers. The Bargo River, while also a tributary of the Nepean, is considered to be a separate, smaller sub-catchment (130 km^2). The Georges River, the Woronora River and the Hacking River are also smaller river systems with separate sub-catchments.* [page 25]

HCPL considers the quality and quantity of water in the Woronora Reservoir to be of significance in a regional context. The Project environmental assessments indicate:

- No connective cracking from the mined seam to the surface – i.e. water does not leak from the surface to the mine.
- No measurable effect on quantity or quality of yield from Woronora Reservoir.

Given the significance of the water supply, monitoring would be conducted to confirm these assessments as mining progresses. As discussed in response to PAC Question 9, Dams Safety Committee approval will also be required.

<u>Ecological Values</u>

In regard to aquatic ecology, Waratah Rivulet supports a diverse range of macroinvertebrates. Aquatic macrophytes are not naturally abundant in either Waratah Rivulet or the tributaries of Waratah Rivulet or Woronora Reservoir. The streams are naturally rocky with very little sediment habitat available for aquatic plants to establish. As a result, macrophytes are generally present at sampling sites in low species numbers and low population densities. Waratah Rivulet supports limited fish fauna and no threatened aquatic species have been recorded in the rivulet. The Woronora Reservoir impoundment, including the variable reservoir levels, has altered the original ecology of Waratah Rivulet.

No significant differences were detected in assemblages of macroinvertebrates (richness and abundance) in areas where mining has occurred, compared with reference locations sampled at the same time (Appendix D of the EA). Reference locations included Woronora River, Honeysuckle Creek and Bee Creek.

The very low fish species richness and abundance upstream of the Woronora Reservoir can be best explained by the inability of particular species to negotiate this barrier, rather than loss of habitat. Native fish species recorded in the Woronora River downstream of the Woronora Dam (in Sutherland) include the Common Jollytail (*Galaxias maculatus*), Flathead Gudgeon (*Philypnodon grandiceps*), Dwarf Flathead Gudgeon (*Philypnodon* sp.), Firetail Gudgeon (*Hypseleotris galii*), Striped Gudgeon (*Gobiomorphus australis*), Empire Gudgeon (*Hypseleotris compressa*), Cox's Gudgeon (*Gobiomorphus coxii*), Australian Smelt (*Retropinna semoni*), Long-finned Eel (*Anguilla reinhardtii*) and Short-finned Eel (*Anguilla australis*) (Harris and Gehrke, 1997).

Unlike other streams in the Illawarra region, the Waratah Rivulet does not support threatened aquatic species. For example, the Macquarie Perch is known to occur in the Nepean River and the Cataract River. BHP Billiton Illawarra Coal has proposed to setback their longwalls from Wongawilli Creek and Sandy Creek at Dendrobium. The Macquarie Perch has been recorded in Wongawilli Creek, the lower arm of Sandy Creek and Lake Cordeaux.

In regard to terrestrial ecology, Waratah Rivulet (and associated riparian zone) provides some terrestrial fauna species with opportunities (to varying degrees) for foraging, breeding, nesting, shelter and movement between areas. The Woronora Special Area and surrounding Woronora Plateau support a number of native and threatened fauna species that are typical of sandstone habitats in the Sydney Basin Bioregion.

The Project has the potential to impact on stream habitat and associated biota. The Project would result in a localised effect on stream habitat [e.g. diversion of a portion of stream flow below the stream bed - the effects of underflow would be most noticeable during periods of low flow and on the frequency of no flow, while the effects on the frequency and magnitude of high flows would be negligible; localised and temporary changes (spikes) in some water quality parameters and the presence of iron staining and iron-oxidising bacteria].

The characteristics of the Waratah Rivulet are considered to be represented elsewhere in the region. Assessment of the potential impacts of the Project on the ecology of Waratah Rivulet indicates the Project is unlikely to have any significant long-term impacts on aquatic biota and it is unlikely that any vertebrate population would be put at risk by subsidence-related impacts. The original ecology of the Waratah Rivulet has been altered by the Woronora Reservoir impoundment and it is considered unlikely that the ecological significance of the Waratah Rivulet would be altered by the Project.

The Department of the Environment, Water, Heritage and the Arts (DEWHA) is of the opinion that there will be no significant impacts on threatened species listed under the *Environment Protection and Biodiversity Conservation Act, 1999* (EPBC Act) that are known or have the potential to utilise the stream habitats of the Waratah Rivulet. In February 2009, DEWHA advised HCPL that it had determined that the Project is unlikely to have a significant impact on EPBC Act listed threatened species (refer Attachment 2).

<u>Social Values</u>

In addition to the above, public amenity and aesthetic values are provided by the rivulet.

Public access to the Woronora Special Area is restricted in that members of the public can only enter the area with the prior permission of the SCA and undertake permitted activities. Whilst public access to the Woronora Special Area is restricted, the social values of the Waratah Rivulet catchment are recognised (i.e. are considered valuable, even though the public cannot access or experience these values readily).

In the region, there are streams with recreational values. For example, the SCP Report states:

> *Recreational use of the natural areas of the Southern Coalfield is limited, largely because bushwalkers are excluded from SCA Special Areas. However, there is significant recreational swimming associated with a number of the rivers in the region. The Bargo River Gorge, particularly Mermaids Pool, is the most significant of these. Mermaids Pool is within a Crown reserve under the care and management of the NSW Scouting Association. The Scouts run a camp site within the reserve, and consequently this reserve and the adjacent Bargo River Gorge are probably used more intensively for recreation than any other site close to a coal mine within the region.*
>
> *Others sites with significant recreational use include Marnhyes Hole on the Georges River at Appin and the Cataract River, near Douglas Park. Bushwalking along the more accessible creeks and rivers is also popular, with the Bargo River Gorge again being the most significant. The Nepean River is also used for swimming, fishing and canoeing.*

The pools/rockbars and sandstone features present along the Waratah Rivulet have value in terms of visual amenity, however the features are not unique. Similar public amenity and aesthetic values can be observed elsewhere in the region (including those in publicly accessible areas).

Subsidence-induced cracking of sections of the Waratah Rivulet has resulted in low flows being diverted to near-surface groundwater for the affected sections of the stream. There has also been a corresponding reduction in the persistence of water levels in stream pools during periods of low flow. However, during periods of moderate to high flow, even the sections of the stream directly affected by subsidence function normally (i.e. pool levels persist, rockbars experience overflow and significant surface flows occur).

As described in the response to PAC Questions 37 and 38, the red staining is iron precipitate or ferrihydrite which is derived from iron in the naturally-occurring sandstone. After a period of several months to a few years the red ferrihydrite will convert to the crystalline form of goethite which is darker red-brown in colour. This is the same for areas subject to mining-induced iron staining and natural iron staining.

The response to PAC Question 3 also discusses the economic value of the amenity of the rivulet.

Other Streams

Other streams in the area also contribute to the quantity and quality of water to the Woronora Reservoir and provide habitat for flora and fauna.

<u>Streams located within the Woronora Reservoir Catchment</u>

A number of tributary streams situated in the Project Underground Mining Area flow into Waratah Rivulet or directly into the Woronora Reservoir. This includes four 1st order streams, five 2nd order streams and three 3rd order streams. The catchment areas of these tributary streams range from approximately 0.4 to 6.7 km^2. In comparison, the Waratah Rivulet is a 4th order stream and has a catchment area of approximately 22 km^2.

As reflected by the stream order and catchment size, the in-stream pools are smaller in size and extent than those on Waratah Rivulet. Some of the smaller streams are ephemeral or intermittent, while others contain upland swamps in their headwaters.

A large number of similar streams occur in the region, as illustrated by Map 7 of the SCP Report. As described for the Waratah Rivulet above, HCPL considers the quality and quantity of water in the Woronora Reservoir to be of significance. Assessments indicate that potential impacts on streams located within the Woronora Reservoir catchment would have no measurable effect on quality or quantity of the yield of Woronora Reservoir.

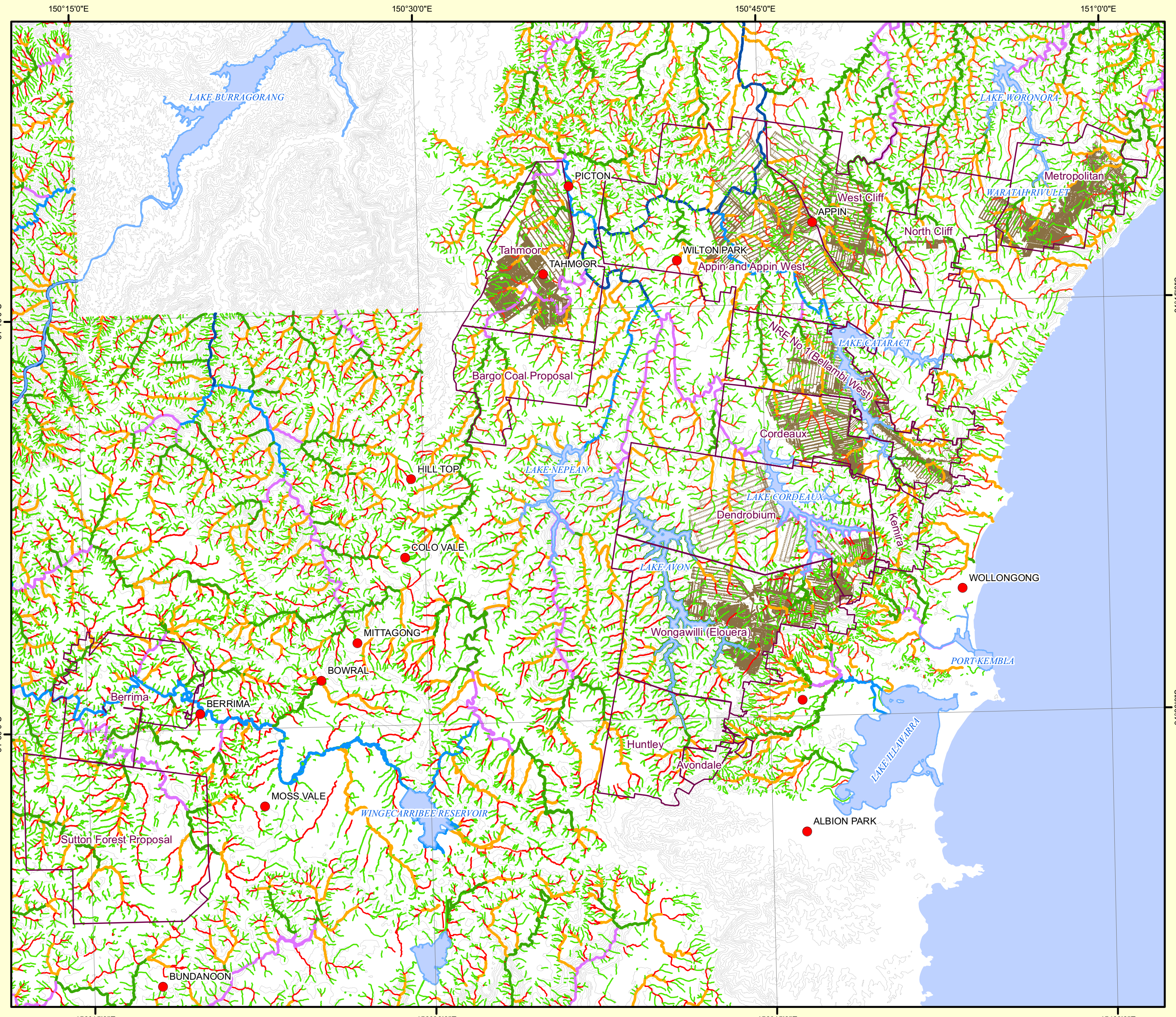
<u>Ecological Values</u>

Due to the size, extent and characteristics of aquatic habitat available, the Waratah Rivulet is considered to be of greater significance to aquatic ecology than other streams in the Project Underground Mining Area.

The tributaries of Waratah Rivulet and the Woronora Reservoir provide terrestrial fauna species with habitat, including threatened species (e.g. the Red-crowned Toadlet).

As described above, a large number of similar streams occur in the region, as illustrated by Map 7 of the SCP Report. Assessment of the potential impacts of the Project on tributaries of Waratah Rivulet and the Woronora Reservoir indicates the Project is unlikely to have any significant long-term impacts on aquatic biota and it is unlikely that any vertebrate population would be put at risk by subsidence-related impacts. It is considered unlikely that the ecological significance of these streams would be altered by the Project.

The DEWHA is of the opinion that there will be no significant impacts on threatened species listed under the EPBC Act that are known or have the potential to utilise stream habitats. In February 2009, DEWHA advised HCPL that it had determined that the Project is unlikely to have a significant impact on EPBC Act listed threatened species.



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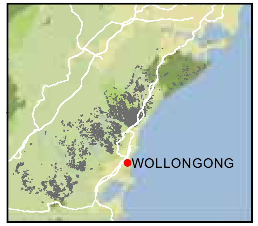
Locality Diagram



Legend

- Major Water Bodies
- Topographic Contour (10 m)
- Colliery Holdings
- Mine Workings

Watercourses

- 1st order
- 2nd order
- 3rd order
- 4th order
- 5th order
- 6th order
- 7th order

Note: Coal Mine Workings for Berrima, Huntley, Avondale and Kemira collieries and other historic workings not shown.

Disclaimer

The approximate location of coal mine workings is based on digital data supplied by the Department of Primary Industries- Minerals. No warranty is expressed or can be implied to any other person as to the accuracy of the data or that it is free from any error or omission. Accordingly the State of New South Wales, the Department of Planning and the Department of Primary Industries and their servants and agents expressly disclaim any liability whatsoever for the consequences arising from any act done or omission made in reliance by others on this locational information .

Map 7

NSW GOVERNMENT
Department of Planning

SOUTHERN COALFIELD INQUIRY

SOUTHERN COALFIELD - COLLIERY HOLDINGS, MINE WORKINGS AND DRAINAGE LINES

Edition Date: June 2008 | Author: S.Mavaddati

Upland Swamps

Upland swamps in the area also contribute to the quantity and quality of water to the Woronora Reservoir and provide habitat for flora and fauna.

Upland Swamps located within the Woronora Reservoir Catchment

As stated in the SCP Report (page 18):

> *The importance of swamps as significant water stores is evident from Map 6 and Figure 2 which illustrate their regional extent. Contained surface water and groundwater storage from the larger swamps contributes to base flow in respective catchments but contributions from some of the smaller swamps may be limited and seasonally variable. …..*

Map 6 from the SCP Report shows the regional distribution of upland swamps.

Shallow superficial cracks would terminate within the unsaturated low permeability Hawkesbury Sandstone. The volume of water and sediments to fill the cracks would not be of significant magnitude to impact on swamp hydrology, nor the quantity or quality of water to the Woronora Reservoir.

Ecological Values

Upland swamps are considered to be species rich and provide habitat for a range of flora and fauna including threatened species (e.g. the Prickly Bush-pea and the Eastern Ground Parrot).

As stated in the SCP Report (page 16):

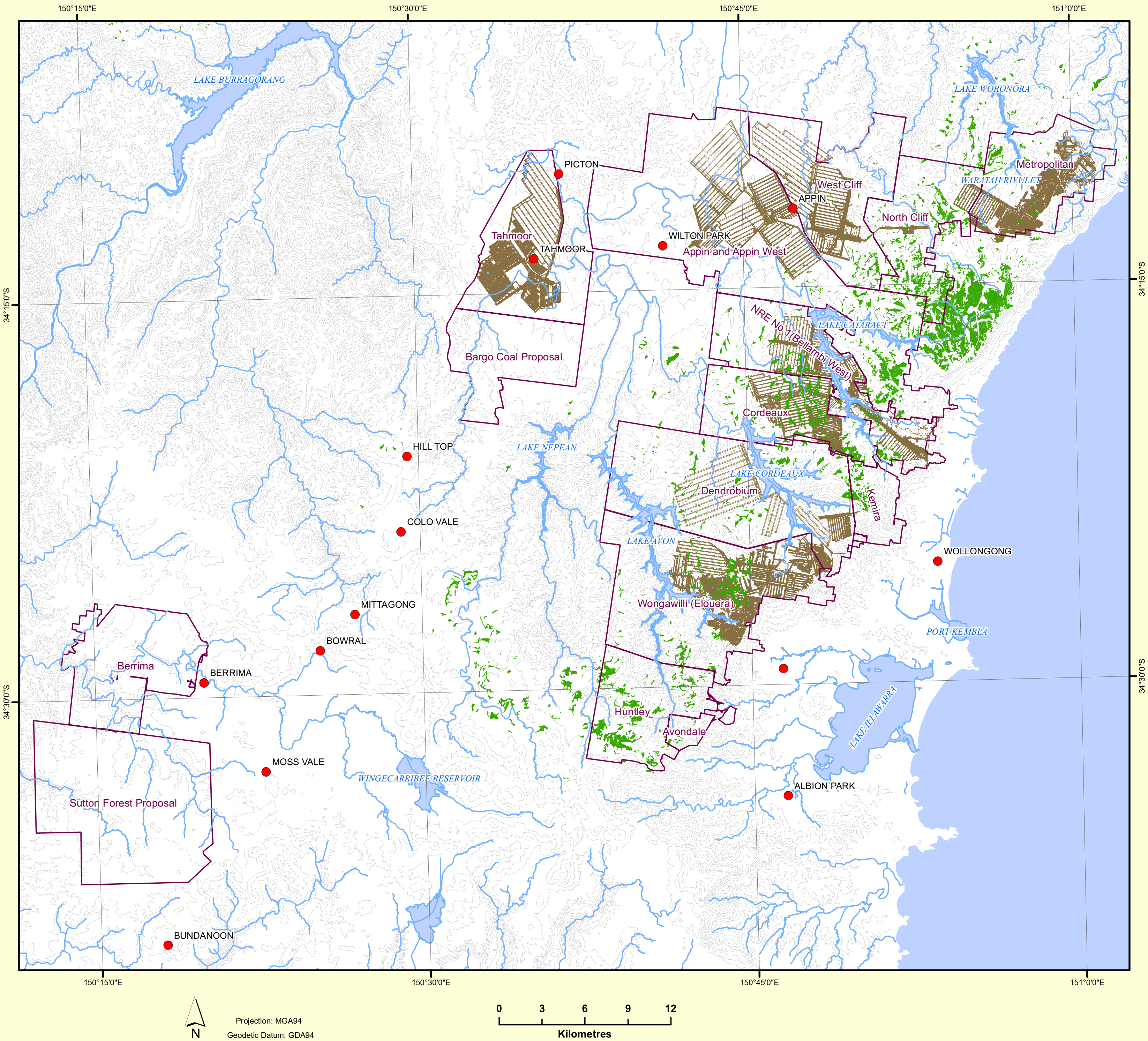
> *DECC has recognised four large clusters of headwater swamps on the plateau areas, which it considers have particular significance in providing large contiguous areas of related habitat. It has described these swamp clusters as Maddens Plains (O'Hares and Cataract catchments), Wallandoola Creek (Cataract catchment), North Pole (southern Avon catchment) and Stockyard (southern Avon catchment). The swamp clusters were identified following a vegetation survey of the catchments of Nepean, Avon, Cordeaux, Cataract and Woronora Rivers and O'Hares Creek by the NPWS and SCA during 2003 (NPWS 2003). A total of 6,444 ha of upland swamp was mapped by this project within the 105,039 ha of its study area (see Table 4).*

The upland swamps in the Project Underground Mining Area are not situated in the four key clusters of swamps identified by DECC as 'Significant Swamp Clusters' in Map 1 *Southern Coalfield Inquiry – Significant Biodiversity Features and Known Subsidence Impact Sites* of DECC (2007) *Submission on the strategic review of the impacts of underground mining in the Southern Coalfield* as being of particular significance.

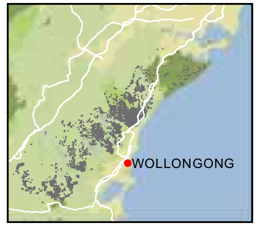
Notwithstanding, it is recognised that upland swamps are of ecological significance. There are four upland swamps that are larger in size in the Project Underground Mining Area. [Further discussion of upland swamps is provided in response to PAC Question 26 (below).]

It is highly unlikely that upland swamp habitats would be modified by mine subsidence (including those for threatened species such as the Prickly Bush-pea and Eastern Ground Parrot). Monitoring would be conducted to confirm the impact assessment as mining progresses. It is considered highly unlikely that the ecological significance of the upland swamps would be altered by the Project.

The DEWHA is of the opinion that there will be no significant impacts on threatened species listed under the EPBC Act that are known or have the potential to utilise upland swamp habitats. In February 2009, DEWHA advised HCPL that it had determined that the Project is unlikely to have a significant impact on EPBC Act listed threatened species.



Locality Diagram



Legend

- Major Watercourse
- Major Water Bodies
- Upland swamp
- Topographic Contour (10 m)
- Colliery Holdings
- Mine Workings

Note: Coal Mine Workings for Berrima, Huntley, Avondale and Kemira collieries and other historic workings not shown.

Disclaimer

The approximate location of coal mine workings is based on digital data supplied by the Department of Primary Industries- Minerals. No warranty is expressed or can be implied to any other person as to the accuracy of the data or that it is free from any error or omission. Accordingly the State of New South Wales, the Department of Planning and the Department of Primary Industries and their servants and agents expressly disclaim any liability whatsoever for the consequences arising from any act done or omission made in reliance by others on this locational information .

Map 6

NSW GOVERNMENT
Department of Planning

SOUTHERN COALFIELD INQUIRY

SOUTHERN COALFIELD - COLLIERY HOLDINGS, MINE WORKINGS AND UPLAND SWAMPS

Edition Date: June 2008	Author: S.Mavaddati

Cliff Lines

Cliff lines (and other natural sandstone features) provide habitats for flora and fauna and can contain Aboriginal heritage items. In addition, public amenity and aesthetic values can be provided by such features.

Ecological Values

The landscape is characterised by sandstone ridges, steep slopes, valleys, rocky outcrops and cliff formations. These landscape features are typical of the Sydney Basin.

Heritage Values

Some of the sandstone formations contain known Aboriginal heritage sites (e.g. grinding sites, engraving sites, sandstone overhangs with art and sandstone overhangs with artefacts and/or archaeological deposit). A total of 188 Aboriginal heritage sites have been identified within the Project Underground Mining Area and surrounds. Aboriginal heritage sites have, to varying degrees, significance to Aboriginal people and some people in the wider community.

The SCP Report states (page 23):

> *The Woronora Plateau is estimated by DECC to potentially contain over 15,000 Aboriginal sites.*

All Aboriginal heritage site types recorded within the study area are represented elsewhere on the Woronora Plateau.

The significance of Aboriginal heritage sites is discussed further in response to PAC Question 22 (above).

Social Values

Public amenity and aesthetic values are also provided by cliff lines and other natural sandstone features.

As described above for the Waratah Rivulet, public access to the Woronora Special Area is restricted in that members of the public can only enter the area with the prior permission of the SCA and undertake permitted activities. Whilst public access to the Woronora Special Area is restricted, the social values of the area are recognised.

The landscape features within the Project Underground Mining Area and surrounds are typical of the Sydney Basin. No features have been identified, for example, that are similar to the Sandy Creek Waterfall at Dendrobium from which BHP Illawarra Coal has proposed to setback the longwalls. The Sandy Creek Waterfall has a cliff face of around 25 m in height and a very substantial concavity behind the falling water (DoP, 2008b). The concavity (or rock overhang) has a maximum width of around 80 m at the face of the waterfall, a maximum depth in the order of 20 m and a height of between 0.5 and 15 m (*ibid*.). The Department of Planning has inspected this feature and considers that it is highly significant. No other similar natural feature has been reported to the Department of Planning within the Southern Coalfield (*ibid*.).

24. The EA is focused on the Waratah Rivulet, with some limited references to other tributaries eg Tributary A in Appendix A, which presumably is what has been referred to as the Eastern Tributary in Appendix C – Surface Water. The Panel requests more detailed information and analysis relating to other watercourses, in particular, Tributary A and the tributary that enters the Woronora Reservoir from the east, downstream of the Waratah Rivulet (eastern limb of the reservoir).

An extensive consultation process was undertaken for the Metropolitan Coal Project. Meetings were held with key government agencies (e.g. the Technical Working Group and Executive Working Group meetings) to facilitate information exchange and the progressive presentation and discussion of baseline data and assessment findings. Through this process, the key government agencies indicated that the EA should focus on the Waratah Rivulet (see Executive Working Group minutes provided to the PAC on 6 February 2009).

Notwithstanding, the EA assesses the other watercourses. On 17 October 2008 the Director-General of DoP (in consultation with the relevant government agencies) deemed that the EA adequately met the Environmental Assessment Requirements provided for its preparation. Information regarding other watercourses is provided below.

Section 4.4.1 of EA Volume 1 provides an overview of the local hydrology of the Project Underground Mining Area including Waratah Rivulet, tributaries of Waratah Rivulet, tributaries of Woronora Reservoir, Cawley's and Wilson's Creeks and the Woronora River inundation area.

In relation to tributaries of Waratah Rivulet, Section 4.4.1 (page 4-29) states:

> *<u>Tributaries of Waratah Rivulet</u>*
>
> *A number of tributaries flow into the Waratah Rivulet. The tributaries are situated within moderately steep incised gullies and contain numerous small in-stream pools. During the frequent occurrences of runoff producing storms, flow in the tributaries of Waratah Rivulet comprises shallow, high energy and high velocity flow (Appendix C). Flow patterns in smaller tributaries tend to be more variable responding to incident rainfall over a small area and therefore are less affected by baseflow (i.e. have lower flow persistence), particularly at higher elevations.*

In relation to tributaries of Woronora Reservoir, Section 4.4.1 (page 4-29) states:

> *<u>Tributaries of Woronora Reservoir</u>*
>
> *A number of tributaries in the Project Underground Mining Area flow direct to the Woronora Reservoir including the Eastern Tributary, Honeysuckle Creek and other tributaries with headwater upland swamps. The Eastern Tributary is situated in a moderately steep incised valley with numerous in-stream pools, while Honeysuckle Creek has a medium sized catchment and a relatively large upland swamp in its headwaters (Appendix C).*
>
> *A number of small tributary catchments that drain direct to Woronora Reservoir contain headwater upland swamps.*

The hydrology of the watercourses is described in Appendix C of the EA.

Appendix C (Section 2.4) of the EA and Figure 8 identifies 22 sub-catchments in the Project Underground Mining Area and surrounds, including tributaries of the Waratah Rivulet and tributaries of the Woronora Reservoir. The main features of these sub-catchments and associated watercourses were also tabulated in terms of location, past mining activities and proposed mining activities (Table 2 of EA Appendix C) and their catchment area, stream order, average bed gradient, stream length and key physical attributes (Table 3 of EA Appendix C).

The principal catchments within the Project Underground Mining Area comprise the lower reaches of Waratah Rivulet, the Reference Tributary, the lower reaches of the Central Eastern Tributary and Eastern Tributary, and a series of small first and second order tributary catchments which drain directly to the Woronora Reservoir.

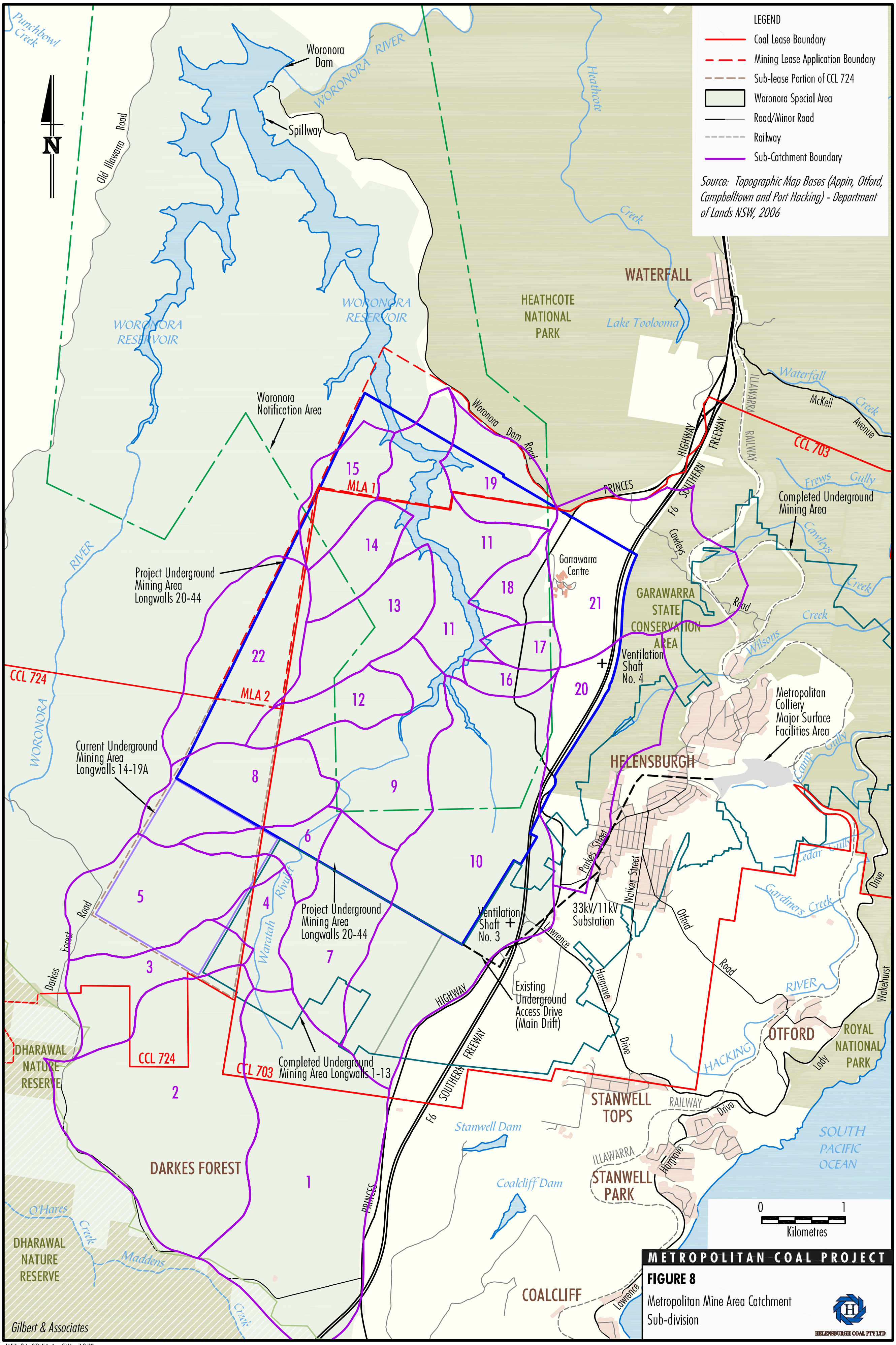


FIGURE 8
Metropolitan Mine Area Catchment Sub-division

MET-06-02 EA AppSW _107B

To clarify, the stream referred to as Tributary A in the subsidence assessment (Appendix A of the EA) is the same stream referred to as the Central Eastern Tributary in the hydrology assessment (Appendix C of the EA). This stream is described as sub-catchment 7 in Appendix C (refer to Figure 8, Tables 2 and 3).

The stream referred to as Tributary C in the subsidence assessment (Appendix A) is the same stream referred to as the Eastern Tributary in the hydrology assessment (Appendix C). This stream is described as sub-catchment 10 in Appendix C (refer to Figure 8, Tables 2 and 3).

The Central Eastern Tributary and Eastern Tributary have the characteristics described in Tables 2 and 3 in Appendix C (extracts below).

Table 2 Summary of Mine Area Catchments and Sub-Catchments

Sub-catchment No.	***Local Catchment/Sub-Catchment***	***Location***	***Past Mining Activities***	***Proposed Mine Activities***
7	*Eastern Central Tributary*	*Right bank tributary of Waratah Rivulet*	*LW 5, 6, 7, 8, 9 & 10*	*LW 20, 21 & 22*
10	*Eastern Tributary*	*Major right bank tributary*	*LW 1, 2, 3 & 4*	*LW 20 to 36*

Table 3 (Continued) Hydraulic and Geomorphic Attributes of the Sub-Catchments

Sub-catchment No.	***Local Catchment / Sub-Catchment***	***Location***	***Catchment Area (ha)***	***Stream Order***	***Average stream gradient (m/km)***	***Stream Length (km)***	***Comments***
7	*Eastern Central Tributary*	*Right bank tributary of Waratah Rivulet*	*205*	*2*	*43*	*2.78*	*Medium sized tributary on right bank of Waratah Rivulet. Moderately steep incised gully with numerous small in-stream pools*
10	*Eastern Tributary*	*Major right bank tributary*	*670*	*3*	*26*	*5.4*	*Main mid-reach tributary of Waratah Rivulet. Moderately steep incised valley with numerous in-stream pools. Pools in lower reaches are larger and similar to pools in Waratah Rivulet.*

Extensive ground reconnaissance has been undertaken by Gilbert and Associates and others. Section 5.3 of Appendix C also provides a general description of the physical characteristics of the Eastern Tributary based on field observations:

5.3 Eastern Tributary

The Eastern Tributary which appears as sub-catchment 10 on Figure 8, flows in a northerly direction from its headwaters near the southern limits of longwalls 1 and 2 and overlies the eastern end of proposed Longwalls 20 to 30. It commands an area of 6.7 km^2 and is long and narrow in shape. The valley floor is typically 60 to 100m below the surrounding ridgeline. In its upper and middle reaches the stream is characterised by:

- *simple relatively wide channel with low primary banks;*
- *a channel form which typically comprises a series of alternating chutes and cascades interspersed by small in-stream pools that form in natural depressions in the predominantly competent sandstone bedrock exposed in the mid sections of the catchments;*
- *limited bed sediment deposits which are restricted to areas with locally flatter bed slopes and in the bottom of some of the larger deeper pools; and*
- *dense riparian vegetation but with relatively little in-stream vegetation.*

In its lower reaches the stream channel becomes wider and the bed profile flatter. The pools in the area tend to be larger (longer and deeper than those upstream – refer Plate 3).

Plate 3 ***In-Stream Pool in Lower Reaches of Eastern Tributary***

Whilst there has been no flow gauging on this catchment to date it is reasonable to expect flows in this creek would mirror those observed in Waratah Rivulet when scaled according to catchment area.

Surface water quality monitoring data for the Eastern Tributary (sites ETWQ1 and FEWQ1) and other tributary streams is summarised in Attachment A of Appendix C.

Detailed stream mapping information for both the Waratah Rivulet and Eastern Tributary has been prepared by MSEC and will be provided separately. Field reconnaissance information/ photographs is also available should the PAC require further information (however, note that some of the field reconnaissance photographs for the Eastern Tributary are already included in Section 7.5 of Appendix C).

A description of the observed effects of subsidence on tributaries of Waratah Rivulet is provided in Section 7.4 and on pools in the Eastern Tributary in Section 7.5 (Appendix C). Section 4.4.1, Volume 1 (page 4-35) summaries, as follows:

Water levels have also been monitored in a number of pools in tributary streams at the Metropolitan Colliery. The effects of subsidence on typical tributary pools can be seen as lower pool levels during the longer recessionary periods with little observable effect during periods of normal creek flow. In longer recessionary periods pool water levels can decline below the 'cease to flow' level at a rate faster than it did prior to being undermined. This response is consistent with the capture and underflow of small flows.

Observations of the subsidence affected upper reaches of the Eastern Tributary by Gilbert and Associates (2008) also provide an indication of mine subsidence effects on pools in tributaries. Inspections of subsidence-affected reaches of the Eastern Tributary in the Completed Underground Mining Area were carried out in March 2006, February 2007 and July 2007. The Eastern Tributary was undermined by Metropolitan Colliery Longwall 2 in 1996. The observations of pools in the Eastern Tributary and in tributaries of Waratah Rivulet indicate that although mine subsidence has the potential to increase the rate of leakage (and consequently pool level recession) of pools, a portion of the pools subject to mine subsidence effects hold some water during prolonged dry periods. These latter pools remain full during most typical wetting and drying cycles (Appendix C).

The following descriptions were provided in the Aquatic Ecology Assessment (Appendix D of the EA):

Tributaries of Waratah Rivulet

Tributaries of the Waratah Rivulet are second or third order streams, ranging in length from approximately 2.4 to 2.8 km (Gilbert and Associates, 2008). The tributaries are situated within moderately steep incised gullies and contain numerous small in-stream pools (ibid.). The average stream gradients range from approximately 43 to 61 m/km (ibid.). Waratah Tributary 1[1] (sub-catchment 5 on Figure 4), Waratah Tributary 2[2] (sub-catchment 8 on Figure 4) and Central Eastern Tributary (sub-catchment 7 on Figure 4) are examples of Waratah Rivulet tributaries.

Waratah Tributary 2 (considered to be an example of a typical tributary) is situated within the proposed future mining area and has the following characteristics (Gilbert and Associates, 2008):

- *a shallow swale-like alluvial channel in the elevated relatively flat plateau areas which occur in the headwater of the catchment;*
- *a simple relatively wide channel with low primary banks in the steeper mid reaches;*
- *a channel form which typically comprises a series of alternating steep chutes and cascades interspersed by in-stream pools that form in natural depressions in the predominantly sandstone bedrock exposed in the mid sections of the catchments.*

  These pools are much smaller that those occurring in the rivulet and range in surface area from very small to 10 to 20 square metres (m^2) and with depths from a few centimetres to 50 to 200 centimetres (cm) but often have similar characteristics with rivulet pools immediately upstream of their confluence with the rivulet;
- *limited bed sediment deposits which are restricted to areas with locally flatter bed slopes and in the bottom of some of the larger deeper pools; and*
- *dense riparian vegetation but generally with relatively little in-stream vegetation.*

During the frequent occurrences of runoff producing storms, flow in the tributaries of Waratah Rivulet would comprise shallow, high energy and high velocity flow (Gilbert and Associates, 2008). As with most pools in the tributaries, the pools are small in comparison with flow volumes generated by rainfall-runoff events (Gilbert and Associates, 2008). In steep tributaries of Waratah Rivulet, peak flows would tend to be higher than the factored peak flows in Waratah Rivulet and the response to storms in these catchments would also be proportionately faster (ibid.). Flow patterns in smaller tributaries tend to be more variable responding to incident rainfall over a small area and therefore are less affected by baseflow (i.e. have lower flow persistence), particularly at higher elevations. However where upland swamps dominate particular tributaries, baseflows below upland swamps may be slightly elevated and more persistent than tributaries without upland swamps.

As described above, water levels in pools naturally decline during dry periods as a result of evaporation from the pool surface and natural leakage (Gilbert and Associates, 2008). The tributary pools are much smaller, in plan area, depth and volume relative to runoff flow rates, than those on the rivulet. The tributary pools are however typically shaded by riparian vegetation which would reduce the amount of evaporation from tributary pools. Under normal climatic conditions, tributary pools would be fed by rainfall-derived runoff and groundwater contributions. During dry periods, pools in tributaries have the potential to become dry, particularly those that are smaller and shallower in size (ibid.).

Eastern Tributary

The Eastern Tributary (sub-catchment 10 on Figure 4) is a third order stream and approximately 5.4 km in length (Gilbert and Associates, 2008). The stream is situated in a moderately steep incised valley with numerous in-stream pools (ibid.). The average stream gradient of the Eastern Tributary is approximately 26 m/km (ibid.).

---

[1] *Waratah Tributary 1 is also known as the 'Un-named Tributary' or 'Tributary D' in some Metropolitan Colliery assessments.*

[2] *Waratah Tributary 2 is also known as the 'Reference Tributary' or 'Tributary B' in some Metropolitan Colliery assessments.*

In its upper and middle reaches the Eastern Tributary is characterised by (Gilbert and Associates, 2008):

- *simple relatively wide channel with low primary banks;*
- *a channel form which typically comprises a series of alternating chutes and cascades interspersed by small in-stream pools that form in natural depressions in the predominantly competent sandstone bedrock exposed in the mid sections of the catchments;*
- *limited bed sediment deposits which are restricted to areas with locally flatter bed slopes and in the bottom of some of the larger deeper pools; and*
- *dense riparian vegetation but with relatively little in-stream vegetation.*

In its lower reaches the stream channel becomes wider and the bed profile flatter (Gilbert and Associates, 2008). Pools tend to be larger (longer and deeper than those upstream) and similar to those in Waratah Rivulet (ibid.). The flow characteristics would also be similar to Waratah Rivulet on a per catchment area basis. Observations of sections of the Eastern Tributary not subject to mine subsidence indicate that stream sections between pools during dry periods, cease to flow and pools may dry up (Gilbert and Associates, 2008).

Information relevant to the existing environment and assessment of other watercourses is also provided in other sections of the EA, as described below:

- Section 4.2 (Appendix D) describes the aquatic ecology sampling sites including those sampled on the Eastern Tributary.
- Section 5 (Appendix D) describes the water quality and aquatic ecology assemblage (e.g. macrophytes, macroinvertebrates and fish) characteristics of the watercourses sampled.
- Section 6 (Appendix D) provides a description of the potential impacts on watercourse habitats and their biota.
- Attachment B of Appendix D provides photographs of the aquatic ecology sampling locations, while raw survey data is provided in Attachments E to H.
- Table 7 of Appendix E outlines the quadrats sampled per vegetation stratification unit. Sandstone riparian scrub vegetation was sampled at representative locations, including one sampling site in the riparian zone of the Central Eastern Tributary.
- Figure 4 of Appendix E presents the vegetation communities mapped within the study area including vegetation along the other watercourses, while Section 4.1 provides a description of each vegetation community, including whether flora of conservation significance is known to occur.
- Section 4.2 of Appendix E describes the condition of the vegetation and Table 13 describes the regional conservation significance of the vegetation communities.
- Section 3.1.4 of Appendix F describes the riparian vegetation and watercourse habitat available to terrestrial vertebrate fauna. Attachment C provides a list of fauna species recorded during the fauna surveys and includes species likely to utilise the riparian and watercourse habitat.
- Appendix G assesses subsidence impacts on riparian habitat and associated watercourses, including potential impacts on threatened species.

25. The EA indicates that no "valley infill" swamps are found within the project area, however provides no basis on which swamps were categorised as either headwater or valley infill (or transitional or composite in respect of these two key categories). Please provide the basis on which the swamps were categorised, and by whom. Please demonstrate that no swamp within the project area is either valley infill or contains valley infill areas (ie is composite in nature). Particular reference should be made to linear and sub-linear swamp features associated with watercourses (eg swamps S76, S77 and S92 as shown in MSEC Drawing 07).

The EA does provide the basis on which swamps were categorised as either headwater or valley-infill. In relation to the classification of upland swamps as headwater upland swamps or in-valley upland swamps, Appendix B of the EA provides the following:

There is a spectrum of upland swamp types that differ according to the hydrological processes that are dominant. Broadly, upland swamps can be classified as headwater upland swamps or in-valley upland swamps, as illustrated in Figure 3 and as described below.

Headwater upland swamps (Figure 3a) occur in the headwaters or elevated sections of the topography on the plateau where the land surface is fairly flat. They are essentially rain-fed systems in which rainfall exceeds evaporation continuously. The water levels within the swamps fluctuate seasonally with climatic conditions, as rain adds to soil moisture and evapotranspiration slowly removes moisture from storage. Excess rainfall produces a permanent perched water table within the sediments that is independent of the natural regional water table in the underlying Hawkesbury Sandstone. During rain events, some stream flow and runoff along indistinct braided channels will infiltrate through the swamp sediments. The growth of dense vegetation and the low land gradient prevent the formation of an open channel that would otherwise transport water and sediments. In some headwater upland swamps, there could be minor groundwater seepage from the outcropping sandstone at the edges of the swamp.

In-valley upland swamps (also called in-stream or valley floor swamps) occur along well defined drainage lines in the more deeply incised valleys, and are less common than headwater upland swamps on the eastern Woronora Plateau. They occupy relatively flat sections of streams within deeper valleys and are thought to be formed by deposition of sediments behind barriers such as piles of logs at choke points in the stream (Tomkins and Humphreys, 2006), or terminate at 'steps' in the underlying substrate where the gradient suddenly becomes steeper (Earth Tech, 2003). In-valley upland swamps (Figure 3b) have multiple sources of water. Primarily, they are sustained by stream flow along distinct channels, supplemented by rain infiltration. Given the incised nature of the axial stream, they are more likely to receive groundwater seepage from the sandstone walls at the edges of the swamp. In most cases the hydrology of the swamp is independent of the deeper regional water table in the underlying Hawkesbury Sandstone, but there might be occasions when the regional water table intersects the swamp sediments. In the latter case, depending on the relative elevations of the perched and regional water tables, groundwater could supplement swamp moisture or swamp moisture could drain towards the underlying aquifer.

Headwater upland swamps and in-valley upland swamps can also be described in terms of vegetation (FloraSearch and Western Research Institute, 2008). Six upland swamp vegetation communities have been described for the Woronora Plateau (Keith, 1994; NPWS, 2003):

I. Fringing Eucalypt Woodland

II. Banksia Thicket

III. Restioid Heath

IV. Sedgeland

V. Cyperoid Heath

VI. Tea Tree Thicket

The first four communities are typically confined to headwater swamps, while Cyperiod Heath and Tea Tree Thicket vegetation occur in both headwater swamps and in-valley swamps.

In summary, and as presented to the Executive Working Group in May 2008 (see Executive Working Group minutes provided to the PAC on 6 February 2009), upland swamps have been characterised as follows:

- Headwater Upland Swamps
  - Occur in the headwaters or elevated sections of the topography on the plateau.
  - Dominant hydrological processes affecting moisture in the swamps - infiltration of incident rainfall resulting in retention of a shallow perched groundwater system in the swamp sediments, and losses to evapotranspiration.
  - Can comprise all six upland swamp vegetation communities.

- In-Valley Upland Swamps
  - Occur along well defined drainage lines in the more deeply incised valleys; relatively flat sections of streams within deeper valleys.
  - Dominant hydrological processes affecting moisture in the swamps - infiltration of incident rainfall and stream flow (including groundwater contribution from the valley sides) resulting in the retention of a shallow perched groundwater system in the swamp sediments, and losses to evapotranspiration.
  - Typically dominated by Cyperoid Heath and/or Tea Tree Thicket.

Based on the above classification by Merrick (2008) and FloraSearch and Western Research Institute (2008), and as informed by topography, aerial photography and on the ground inspections, the swamps within the Project Underground Mining Area (including swamps S76, S77 and S92) have been classified as headwater upland swamps (Figure 4-5).

One in-valley upland swamp is situated outside of the Project Underground Mining Area (Longwalls 20-44), but within the potential extent of mine subsidence effects (Figure 4-5). The in-valley swamp is situated on a tributary (a third order watercourse) of Waratah Rivulet to the south of Longwall 20. This in-valley swamp overlies completed Longwalls 7 and 8 and consequently has already experienced mine subsidence from Metropolitan Colliery's existing operations. Site inspections of this in-valley swamp indicate that although subsidence effects such as iron staining can be observed, there was no observable impact on vegetation vigour or community composition or abundance in the swamp. The Sydney Catchment Authority has also inspected this swamp in the past and expressly concurred with this position in the Executive Working Group.

There is no evidence to suggest the upland swamps within the Project area are composite or transitional in nature.

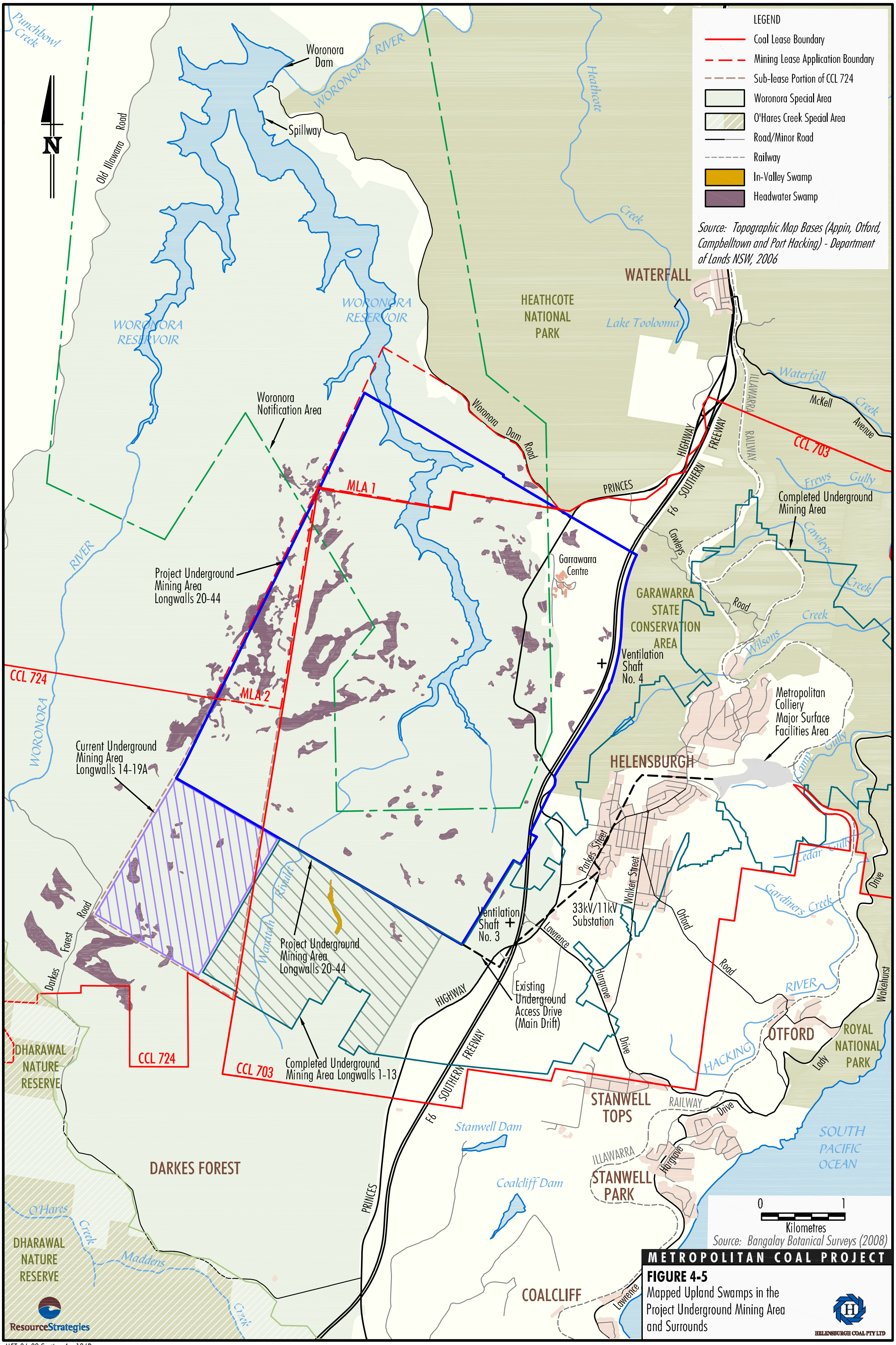


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FIGURE 4-5
Mapped Upland Swamps in the Project Underground Mining Area and Surrounds

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26. DECC has raised a number of concerns over the values and importance of headwater swamps. Please address each of these concerns.

As described in the response to PAC Question 24 above, an extensive consultation process was undertaken for the Metropolitan Coal Project. In the Executive Working Group meetings the key government agencies indicated the following in relation to upland swamps (see Executive Working Group minutes provided to the PAC on 6 February 2009):

<u>30 April 2008 Meeting Minutes:</u>

"…………

- *EWG members recognised that Dr Noel Merrick's presentation addressed the key groundwater assessment issues.* [Including the definition of swamp types; the associated hydrogeological processes; and the potential effects of the Project.]
- *No further presentation of technical groundwater assessment by Dr Noel Merrick required for this forum.*"

<u>27 May 2008 Meeting Minutes:</u>

"…………..

- *EWG members recognised that Mr Lindsay Gilbert's presentation addressed the key surface water assessment issues. No further presentation of technical surface water assessment by Mr Lindsay Gilbert required for this forum.* [Including the swamp hydrological processes and the potential effects of the Project.]

…………."

<u>20 June 2008 Meeting Minutes:</u>

" …………..

- *EWG members recognised that Dr David Goldney's presentation addressed the key ecological assessment issues for the Project. No further presentation of technical ecological assessment by Dr David Goldney required for this forum.* [Including the potential effects of the Project when considered in an integrated context – i.e. potential changes to hydrological/hydrogeological process; botanical characteristics; and the evidence of mining effects to date in the Southern Coalfield.]
- *EWG members stated that the consideration of avoidance and minimisation measures should focus on Waratah Rivulet particularly given the history of mining related impact to Waratah Rivulet.*

…………."

Notwithstanding the above, the Department of Environment and Climate Change (DECC) has raised the following concerns over the values and importance of headwater swamps:

1. Key Recommendation: set conditions of approval to achieve negligible environmental impacts to key swamps.
2. Key Issues: key swamps are of significance; fracturing of the bedrock in key swamps could occur; flora and fauna surveys considered inadequate.

The DECC's concerns are addressed below.

1. Key Recommendation

DECC's key recommendation relevant to upland swamps is as follows (pages 5 and 17 of the DECC submission):

> *Key Recommendations*
>
> *Ensure appropriate subsidence and upsidence limits are set as conditions of approval to achieve negligible environmental impacts to highly significant natural features in the Metropolitan Coal Project area. These features are:*
>
> *…….*
>
> – *key swamps; and*
>
> *……….*

In summary:

- HCPL recognises the ecological significance of upland swamps.
- DECC requests the Project achieve negligible environmental impacts to key swamps.
- The environmental assessments indicate that that any Project induced changes would not be of significant magnitude to impact on swamp hydrology or upland swamp habitats when compared to natural variability.

The DECC requests the Project achieve <u>negligible</u> environmental impacts to <u>key swamps</u>.

<u>Key Swamps</u>

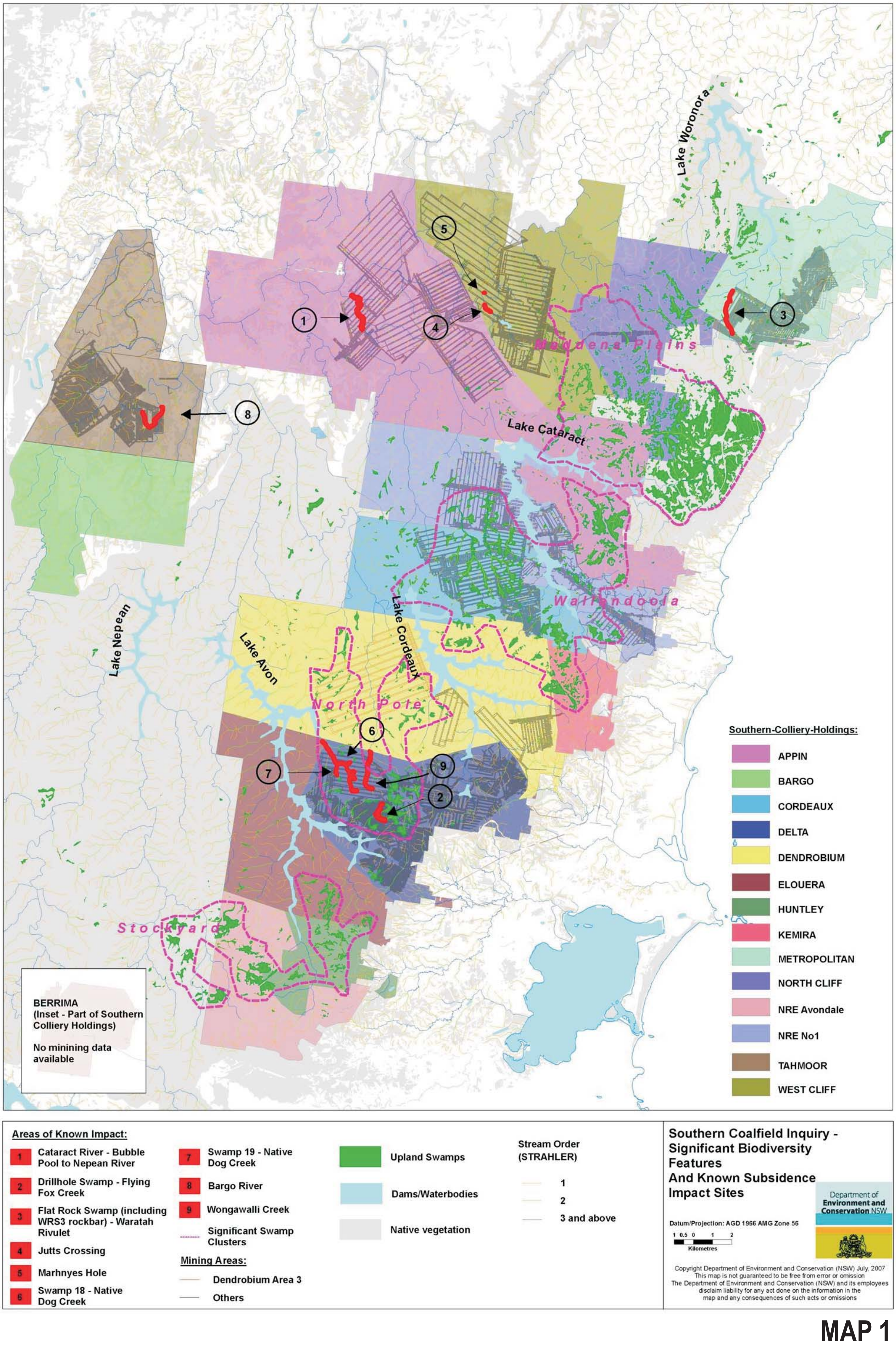
As reported by the Southern Coalfield Panel (DoP, 2008), the DECC previously identified four key clusters of upland swamps (Map 1) as being of particular conservation significance in the Southern Coalfield:

> *DECC has recognised four large clusters of headwater swamps on the plateau areas, which it considers have particular significance in providing large contiguous areas of related habitat. It has described these swamp clusters as Maddens Plains (O'Hares and Cataract catchments), Wallandoola Creek (Cataract catchment), North Pole (southern Avon catchment) and Stockyard (southern Avon catchment). <u>The swamp clusters were identified following a vegetation survey of the catchments of Nepean, Avon, Cordeaux, Cataract and Woronora Rivers and O'Hares Creek by the NPWS and SCA during 2003 (NPWS 2003</u>). A total of 6,444 ha of upland swamp was mapped by this project within the 105,039 ha of its study area (see Table 4).*

The upland swamps in the Project Underground Mining Area are not situated in the four key clusters of swamps previously identified by the DECC (Map 1).

However, the DECC submission to DoP dated 12 January 2008 (page 7) notes:

> *…. that the EA provided new information on the significant natural features in the area that were not identified in the DECC's original submission to the Southern Coalfield mining inquiry. For example the rediscovery of the Ground Parrot has reinforced the significance of clusters of upland swamps in the project area. The Ground Parrot is of the highest conservation concern in Greater Sydney where it had been thought to be extinct, before the rediscovery of the population in the Woronora Special Area. Ground Parrots are swamp-heath specialists and will not survive in other habitats, and are restricted to three populations in NSW.*



Lake Woronora
Maddens Plains
Lake Cataract
Wallandoola
Lake Nepean
Lake Avon
Lake Cordeaux
North Pole
Stockyard
BERRIMA
(Inset - Part of Southern Colliery Holdings)
No minining data available
Southern-Colliery-Holdings:
APPIN
BARGO
CORDEAUX
DELTA
DENDROBIUM
ELOUERA
HUNTLEY
KEMIRA
METROPOLITAN
NORTH CLIFF
NRE Avondale
NRE No1
TAHMOOR
WEST CLIFF
Areas of Known Impact:
1 Cataract River - Bubble Pool to Nepean River
2 Drillhole Swamp - Flying Fox Creek
3 Flat Rock Swamp (including WRS3 rockbar) - Waratah Rivulet
4 Jutts Crossing
5 Marhnyes Hole
6 Swamp 18 - Native Dog Creek
7 Swamp 19 - Native Dog Creek
8 Bargo River
9 Wongawalli Creek
Significant Swamp Clusters
Mining Areas:
Dendrobium Area 3
Others
Upland Swamps
Dams/Waterbodies
Native vegetation
Stream Order (STRAHLER)
1
2
3 and above
Southern Coalfield Inquiry - Significant Biodiversity Features And Known Subsidence Impact Sites
Datum/Projection: AGD 1966 AMG Zone 56
1 0.5 0 1 2
Kilometres
Department of Environment and Conservation NSW
Copyright Department of Environment and Conservation (NSW) July, 2007
This map is not guaranteed to be free from error or omission
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MAP 1

The DECC submission to DoP dated 12 January 2008 indicates the majority of upland swamps situated in the Project area or surrounds are considered to be key swamps (page 11):

The DECC has mapped key swamps in the project area and these are identified in Figure 1. These swamps were identified and mapped by (1) assigning a 250 m buffer around each upland swamp that has been mapped so far, and (2) choosing only those areas in which four or more swamps were clustered together. Vegetation communities included in upland swamps are those four identified by NSW NPWS (2003); that is, Upland Swamps: Banksia Thicket, Upland Swamps: Tea-tree Thicket, Upland Swamps: Sedgeland-Heath Complex, and Upland Swamps: Fringing Eucalypt Woodland.

It is recognised in the Project EA that upland swamps are of ecological significance. For example:

Sections 4.3.5, 4.6.2 and 5.2 of Appendix G state respectively:

The upland swamps within the Project area and surrounds are not situated in the four key clusters of swamps identified by DECC (2007a) as being of particular significance in the Southern Coalfield (Maddens Plains [O'Hares and Cataract catchments], Wallandoola Creek [Cataract catchment], North Pole [southern Avon catchment] and Stockyard [southern Avon catchment]). However, it is recognised that upland swamps are of particular ecological significance.

………………

Upland swamps support a high diversity of plant species (Keith and Myerscough, 1993; Keith, 1994) and are habitats of particular conservation significance for their biota. Most of the swamps are located within Special Areas jointly managed by the Sydney Catchment Authority (SCA) and DECC, or in conservation reserves. As a consequence, most are in near pristine condition.

………………

Many vertebrate species are known to utilise upland swamps, however many species are not dependent on this habitat type. However, a few species are dependent on upland swamp habitats (e.g. the Eastern Ground Parrot).

The records for the Eastern Ground Parrot were obtained by the comprehensive and targeted terrestrial fauna surveys conducted for the Project. The EA recognises the importance of upland swamps to flora and fauna and evaluates the potential impacts of the Project on individual threatened flora and fauna species, including the Eastern Ground Parrot. A detailed evaluation of the potential impacts of the Project on the Eastern Ground Parrot is provided in Section 5.6.4.2 of Appendix G.

<u>Negligible Environmental Impacts</u>

The DECC provides the following in regard to their definition of 'negligible environmental impacts':

Based on information presented in the EA and scientific literature available to date on subsidence impacts and environmental consequences in the Southern Coalfield to date, the following subsidence and upsidence limits are noted as achieving negligible environmental impacts:

1. < 0.5 mm/m systematic tensile strain (MSEC 2008)
2. < 2 mm/m systematic compressive strain (MSEC 2008)
3. < 2 mm/m predicted incremental compressive strain due to valley closure (MSEC 2008)
4. < 30 mm upsidence (Galvin, J. 2005).

On the understanding of the available science to date it is anticipated that the environmental outcomes to be achieved if these limits were applied to highly significant natural features is:
………………….
c. No temporary or permanent change in hydrological processes of key upland swamps
………………….

These limits and associated environmental outcomes are considered to define 'negligible environmental impacts'.

In relation to potential impacts to upland swamps, the DECC provides:

> *In the current proposal there is an extensive area of upland swamps and creeks or rivers that are proposed to be undermined. Impacts of longwall mining on swamps have been reported in the Southern Coalfield (Krogh 2007, Gibbins 2003). The Southern Coalfields Expert Panel noted that impacts from longwall mining do have potential consequences for swamps. If perched water tables associated with swamps are fractured and drained by the tensile strains above an advancing subsidence wave this could put at risk upland swamps and other groundwater-dependent ecosystems in its path (SKM 2007). The likelihood that any given swamp will undergo hydrological changes resulting from subsidence depends on: I) surface gradients within and surrounding the swamp; II) changes to these gradients that occur during the subsidence process; III) pre-existing jointing in bedrocks; IV) changes in bedrock permeability during and after the subsidence process; and V) independent events, such as bushfires and episodes of heavy rainfall, which occur at appreciable frequencies on the Woronora plateau. As these factors exhibit high levels of fine-scale spatial and temporal variability, the outcomes of subsidence are very difficult to predict with reasonable certainty and the risks of impacts on swamps may be substantial.*

The EA studies include a comprehensive assessment of the potential impacts of the Project on upland swamps. All upland swamps situated within the Project Underground Mining Area have been classified according to descriptions by Merrick (2008) and FloraSearch and Western Research Institute (2008) as headwater upland swamps (refer response to PAC Question 25). The groundwater assessment for the Project (Merrick, 2008) indicates that surface cracking resulting from mine subsidence within the upland swamps would not result in an increase in the vertical movement of water from the perched water table into the regional aquifer as the sandstone bedrock is massive in structure and permeability decreases with depth. Any surface cracking that may occur would be superficial in nature (i.e. would be relatively shallow) and would terminate within the unsaturated part of the low permeability sandstone. Any changes would not be of significant magnitude to impact on swamp hydrology. Any changes in swamp moisture as a result of cracking would be immeasurable when compared to the scale of natural changes in swamp groundwater levels.

There is considered to be adequate information available to assess the potential impacts of the Project on upland swamps. It is considered highly unlikely that the hydrology of upland swamp or upland swamp habitats would be modified by mine subsidence to an extent that would be material when compared to natural variability. The Project is considered to be generally consistent with the DECC's request for negligible environmental impacts to upland swamps.

The Project has been assessed by the Department of the Environment, Water, Heritage and the Arts (DEWHA) in accordance with the Commonwealth *Environment Protection and Biodiversity Conservation Act, 1999.* <u>The Project was determined 'Not a Controlled Action' as the Project was considered unlikely to have a significant impact on any matters of national environmental significance</u> including threatened species that are known to utilise upland swamp habitats. The EPBC Referral decision by DEWHA is provided in Attachment 2.

2. Key Issues

DECC's key issues relevant to upland swamps are as follows (page 13 of the DECC submission):

> ***Key Swamps***
>
> *Key Issues*
>
> - *The project area contains a high number of upland swamps and new information from the EA has reinforced the significance of clusters of upland swamps in the project area. For example the rediscovery of the Ground Parrot. The Ground Parrot is of the highest conservation concern in Greater Sydney where it had been thought to be extinct before the rediscovery of the population in the Woronora Special Area.*

- *Approximately 55 per cent of the swamps are predicted to undergo tensile strains greater than 0.5 mm/m which are of sufficient magnitude to result in the fracturing of the bedrock (MSEC 2008).*
- *Inadequate surveys for water-dependant flora and fauna, particularly targeting rare species, have been undertaken.*

In summary:

- HCPL recognises the ecological significance of upland swamps, including the significance of upland swamp habitat to the Eastern Ground Parrot and assessment has been conducted accordingly.
- Tensile strains greater than 0.5 mm/m are of sufficient magnitude to result in some fracturing, however, this is not expected to result in a material change in the hydrological processes of upland swamps.
- Comprehensive flora and fauna surveys have been conducted and extensive regional information is available for the Project. The studies have been subject to Peer Review by Adjunct Professor David Goldney. The Director-General of the DoP (in consultation with the DECC) deemed that the EA adequately addressed the formal Environmental Assessment Requirements on 17 October 2008.

<u>Ecological Significance of Upland Swamps</u>

The EA recognises the importance of upland swamps to flora and fauna, including the Eastern Ground Parrot. Evaluations have been conducted to assess the potential impacts of the Project on threatened flora, fauna, and their habitats in accordance with the draft *Guidelines for Threatened Species Assessment* (DEC and DPI, 2005). The evaluations conducted by Dr. Colin Bower and Dr. David Goldney indicate the Project is unlikely to have a significant impact on any threatened flora or fauna species, populations, ecological communities, or their habitats. The evaluations are provided in full in Appendix G of the EA.

As described above, the Project has been assessed by the DEWHA in accordance with the *Environment Protection and Biodiversity Conservation Act, 1999.* The Project was determined 'Not a Controlled Action' as the Project was considered unlikely to have a significant impact on any matters of national environmental significance including threatened species listed under the Act.

<u>Impact of Tensile Strains on Upland Swamps</u>

In relation to the potential impacts of subsidence on upland swamps, Appendix G of the EA states the following:

> *At Metropolitan Colliery, tensile strains greater than 0.5 mm/m may have the potential to result in cracking in the bedrock (MSEC, 2008). …………*
>
> *...*
>
> *A maximum total systematic tensile strain at headwater swamps of 1.4 mm/m is conservatively predicted to occur and therefore there is some potential for minor cracking (MSEC, 2008). Any cracking of the bedrock is expected to be isolated and of a minor nature, due to the relatively low magnitudes of the predicted strains and the relatively high depths of cover (MSEC, 2008). Further, the minor cracking within the swamp areas would generally not be expected to propagate through swamp soil profiles (ibid.). The only locations where such cracking is expected to be observed, based on previous monitoring over the previous longwalls at the Metropolitan Colliery, are located along the higher ridge top rock outcrops (MSEC, 2008).*

Given the minor nature of potential tensile cracking and the hydrogeological characteristics of headwater swamps, there is very little potential for any measurable change in swamp moisture conditions (Heritage Computing, 2008). Drainage of water from the perched water table in a headwater swamp to the regional water table in the underlying sandstone is not expected as the sandstone bedrock is massive in structure and permeability decreases with depth (Heritage Computing, 2008). It is expected that any surface cracking that may occur would be superficial in nature (i.e. would be relatively shallow) and would terminate within the unsaturated part of the low permeability sandstone (Heritage Computing, 2008). In addition, due to the low hydraulic gradient of the water table within a swamp, lateral movement of water through the swamp towards a crack would be very small and very slow (Heritage Computing, 2008). Any changes in swamp moisture as a result of cracking are expected to be immeasurable when compared to the scale of seasonal and even individual rainfall event based changes in swamp groundwater levels (Heritage Computing, 2008).

MSEC provide the maximum predicted values of systematic strain at the upland swamps within the Study Area, for the extraction of the proposed Longwalls 1 to 44, at any time during or after the extraction of the longwalls. The values provided are the maximum predicted parameters within a 20 metre radius of the perimeter of each swamp. It is noted that the maximum tensile strain predicted for some of the larger swamps is 0.6 mm/m for swamps S76, S77, S92 and S106 and 0.3 mm/m for swamp S14 (refer Drawing No: MSEC285-07 in Appendix A).

The EA recognises that tensile strains greater than 0.5 mm/m are of sufficient magnitude to result in the fracturing of bedrock, however the assessment indicates that the magnitudes of the tensile strains resulting from the Project would not result in a material change in the hydrological processes of upland swamps when compared to natural variability.

<u>Adequacy of Surveys</u>

The DECC consider that inadequate surveys for water-dependant flora and fauna in upland swamps, particularly targeting rare species, have been undertaken. The following is provided in response to this statement:

- Comprehensive flora and fauna surveys were conducted for the Project (<u>as evidenced by the extensive records for threatened species [e.g. the Eastern Ground Parrot</u>], refer Figures 4-16 and 4-17).
- Baseline flora surveys were conducted for the Project by Bangalay Botanical Surveys (2008) in spring 2006, summer 2006/2007, autumn 2007 and spring/summer 2007/2008. Previous surveys have also been conducted by Bangalay Botanical Surveys (2007) for the Longwalls 18-19A study area to the south in spring 2006, summer 2006 and autumn 2007. Field survey methods included random meanders, spot sampling, quadrat sampling, targeted searches for threatened flora (listed under the NSW *Threatened Species Conservation Act, 1995* [TSC Act] and Commonwealth *Environment Protection and Biodiversity Conservation Act, 1999* [EPBC Act]), targeted searches for flora of conservation significance and vegetation community mapping (including mapping of endangered ecological communities [EECs]).
- Baseline terrestrial vertebrate fauna surveys were conducted for the Project in spring/early summer 2006 and autumn 2007 (Western Research Institute and Biosphere Environmental Consultants, 2008). Twenty fauna sampling sites were surveyed using a variety of methods including Elliott traps, cage traps, spotlighting, hair tubes, herpetofauna searches, bird surveys, call playback, platypus surveys, echolocation call detector systems, identification of faunal traces and opportunistic observations. <u>Targeted surveys were conducted for threatened fauna species listed under the TSC Act and EPBC Act considered possible occurrences in the Project area and surrounds.</u>
- A Peer Review of the flora and fauna survey programmes was conducted by Dr. David Goldney prior to, during and following the completion of the surveys. The Project surveys are considered to be comprehensive.
- Recognised field survey techniques were utilised consistent with the Department of Environment and Conservation (2004) *Threatened Species Survey and Assessment: Guidelines for Developments and Activities.* Working Draft.

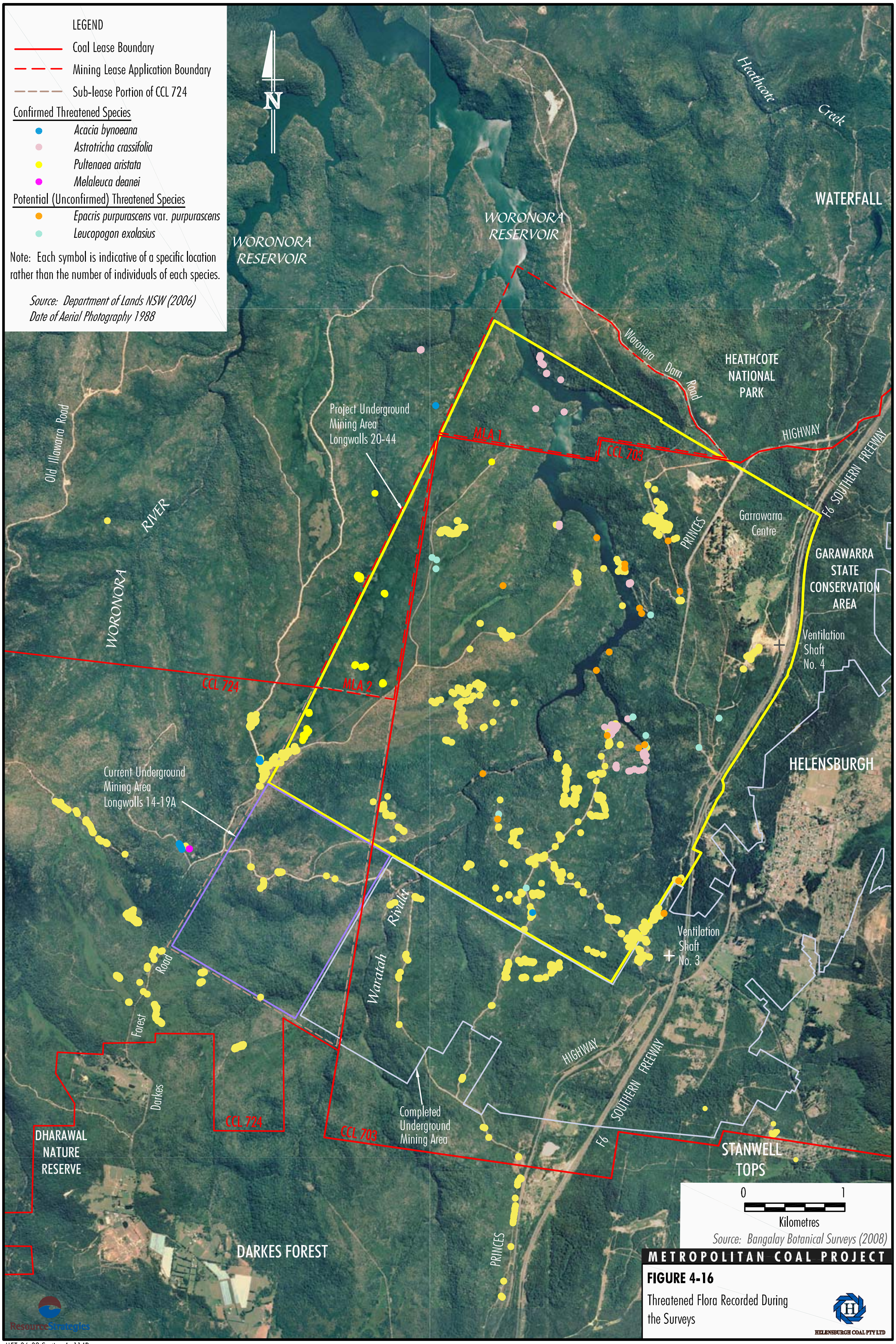
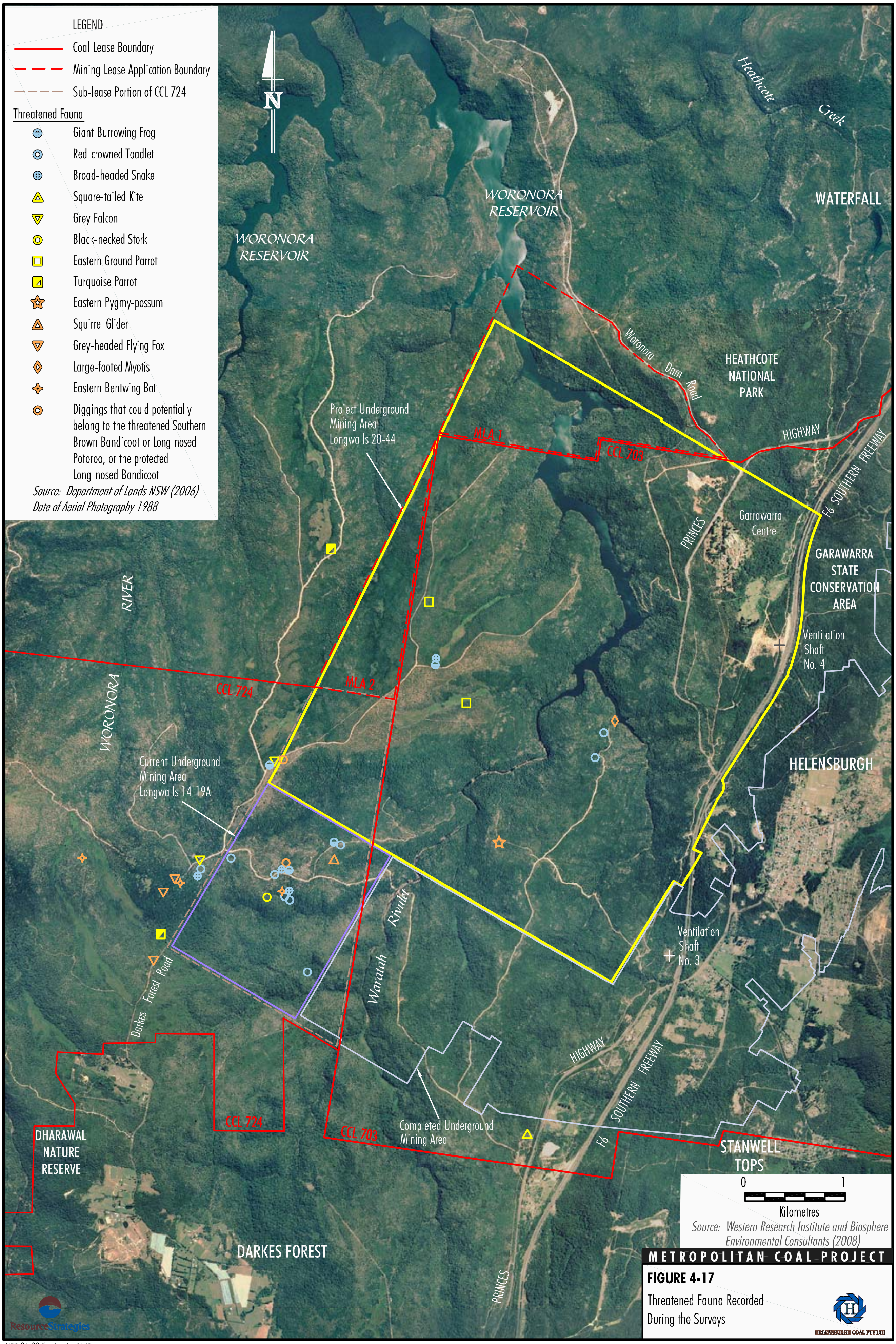


FIGURE 4-16
Threatened Flora Recorded During the Surveys

MET-06-02 Section 4_114B



METROPOLITAN COAL PROJECT

FIGURE 4-17

Threatened Fauna Recorded During the Surveys

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- As described above, targeted surveys were conducted for threatened flora and fauna species listed under the TSC Act and EPBC Act considered possible occurrences in the Project area and surrounds. In addition, a number of reference sources containing the results of local or regional flora and fauna surveys, database records and other scientific studies and literature were also reviewed. For example:
  - Department of Environment and Climate Change (2007a) *Terrestrial Vertebrate Fauna of the Greater Southern Sydney Region: Volume 1 – Background Report; Volume 2 - Fauna of Conservation Concern including Priority Pest Species; Volume 4 – The Fauna of the Metropolitan, O'Hares Creek and Woronora Special Areas – Summary of Findings and Recommendations*. A joint project between the Sydney Catchment Authority and the Department of Environment and Climate Change.
  - Department of Environment and Climate Change (2007b) Atlas of NSW Wildlife Records for the Wollongong and Port Hacking 1:100,000 map sheets.
  - National Parks and Wildlife Service (2003) *The native vegetation of the Woronora, O'Hares and Metropolitan catchments*.
- To assist in identifying whether the potential impacts of the Project are likely to have a significant effect on threatened species, evaluations were conducted. Evaluations were conducted for threatened flora and fauna species that could possibly occur in the Project area or surrounds (i.e. the evaluations were not limited to those threatened species recorded by the Project targeted surveys). The evaluations (provided in Appendix G of the EA) were based on the Draft *Guidelines for Threatened Species Assessment* (DEC and DPI, 2005).
- Rare species were also targeted in surveys and assessed for the Project. For example:
  - The Baseline Flora Survey (Appendix E) recorded species listed as being of national conservation significance under the *Rare or Threatened Australian Plant* classification (RoTAP: Briggs and Leigh 1996) and listed as regionally rare species (Wardell-Johnson *et al.* 1997; Sutherland Shire Council, 2000).
  - Based on DECC (2007) *Terrestrial Vertebrate Fauna of the Greater Southern Sydney Region: Volume 2 - Fauna of Conservation Concern including Priority Pest Species* the Terrestrial Vertebrate Fauna Survey (Appendix F) highlighted the regional priority of species. For example:
    - *The Broad-headed Snake is considered to be a species of high regional priority (DECC, 2007a).*
    - *The Eastern Ground Parrot is a species that was considered to possibly be locally extinct and is a species of highest conservation priority (DECC, 2007a).*
    - *During the surveys, diggings that could potentially belong to the threatened Southern Brown Bandicoot or Long-nosed Potoroo or protected Long-nosed Bandicoot were recorded in deep gully sites where there was dense ground cover present (Figure 4). The Southern Brown Bandicoot and Long-nosed Potoroo are species considered to be of highest conservation priority (DECC, 2007a).*
    - *The Largefooted Myotis is also considered to be a species of high regional priority (DECC, 2007a).*
- As described above, the Project has been assessed by the DEWHA in accordance with the *Environment Protection and Biodiversity Conservation Act, 1999.* The Project was determined 'Not a Controlled Action' as the Project was considered unlikely to have a significant impact on any matters of national environmental significance including EPBC Act listed threatened species. The finding was informed by the above data and could not be made if adequate data was not available.
- The Director-General of the DoP (in consultation with the DECC) deemed that the EA adequately addressed the formal Environmental Assessment Requirements on 17 October 2008.

Potential Rockbar Remediation, Costs and Alternative

27. Will remediation of a rock bar return the water in the pool that it is holding back to a clear state (visible bottom) or will discolouration remain? What is the basis for this opinion?

HCPL conducted a restoration trial at rock bar WRS4 (Pool F) on the Waratah Rivulet, approximately 200 m upstream of Flat Rock Crossing. The restoration trial was conducted from March to May 2008. The plate below taken in January 2009 illustrates that Pool F is clear and has a visible bottom. At no stage during or after the trial remediation activities has discolouration of the pool been observed.

This question may relate to the WRS3 rock bar where Pool A has been observed to be discoloured due to the presence of colloidal material. As described in response to PAC Question 36, fine particles from iron precipitation may be dispersed in a pool as a result of water flow. However, it is anticipated that remediation of a rock bar would return the water in the pool that it is holding back to a clear state once the final restoration works had been completed and iron precipitation, accelerated by mining, ceased. Previous drilling/remediation activities at the WRS3 rock bar are likely to have contributed to the amount of colloidal material in Pool A.

Pool F, January 2009

Restoration works are proposed to be undertaken at a number of rock bars if required to retain pools upstream of these rock bars. It is expected that there would be primary, secondary and final restoration works following each phase of subsidence effect (refer response to PAC Questions 30 and 31). This recognises that each longwall has an incremental subsidence effect and that longwalls may affect rock bars prior to undermining, during undermining, or from mining in adjacent panels that are not directly beneath the rock bar.

28. To what degree are Fe and other concentrations cumulative as fracturing extends along a watercourse?

The overall water quality of most indicator parameters has not been noticeably affected by mining at the Metropolitan Colliery. Mine subsidence effects on water quality in the Waratah Rivulet have resulted in localised and transient changes (spikes or pulses of a few weeks to months duration) in iron (Figure 4-10), manganese (Figure 4-11) and to a lesser extent aluminium and minor associated increases in electrical conductivity associated with bicarbonate ion (Figure 4-12) – all of these constituents are derived from water saturating the near surface sandstone and not from deep groundwater. Baseline water quality data is available from two independent data sets – i.e. from the Woronora Reservoir and from the Waratah Rivulet. The data indicates that although mining to date has included a significant proportion of the Waratah Rivulet catchment, it has not resulted in a significant cumulative effect in terms of iron or other concentrations.

The most likely mechanism for this appears to be from water saturating the near surface sandstone minerals and flushing freshly exposed fractures created by upsidence and valley closure followed by return of the water to Waratah Rivulet. By nature the pulses are isolated and non persistent. Iron is the main constituent in the precipitate in the form of ferrihydrite (an iron oxide), but will eventually settle out and become creek sediment. Iron has a natural source from sandstone which also has low concentrations of other heavy metals such as manganese, copper and zinc.

The accumulation of these other metals in iron precipitate is low because the concentrations in surface water arising from the sandstone are also very low (Associate Professor Barry Noller pers. comm.). Iron precipitation would continue to occur as fracturing extends downstream if near-surface sandstone becomes saturated with water and releases iron (*ibid*.). Ultimately the iron precipitates darken with time due to conversion of ferrihydrite to goethite (refer to response to PAC Question 37) and become part of the creek sediment (*ibid*.).

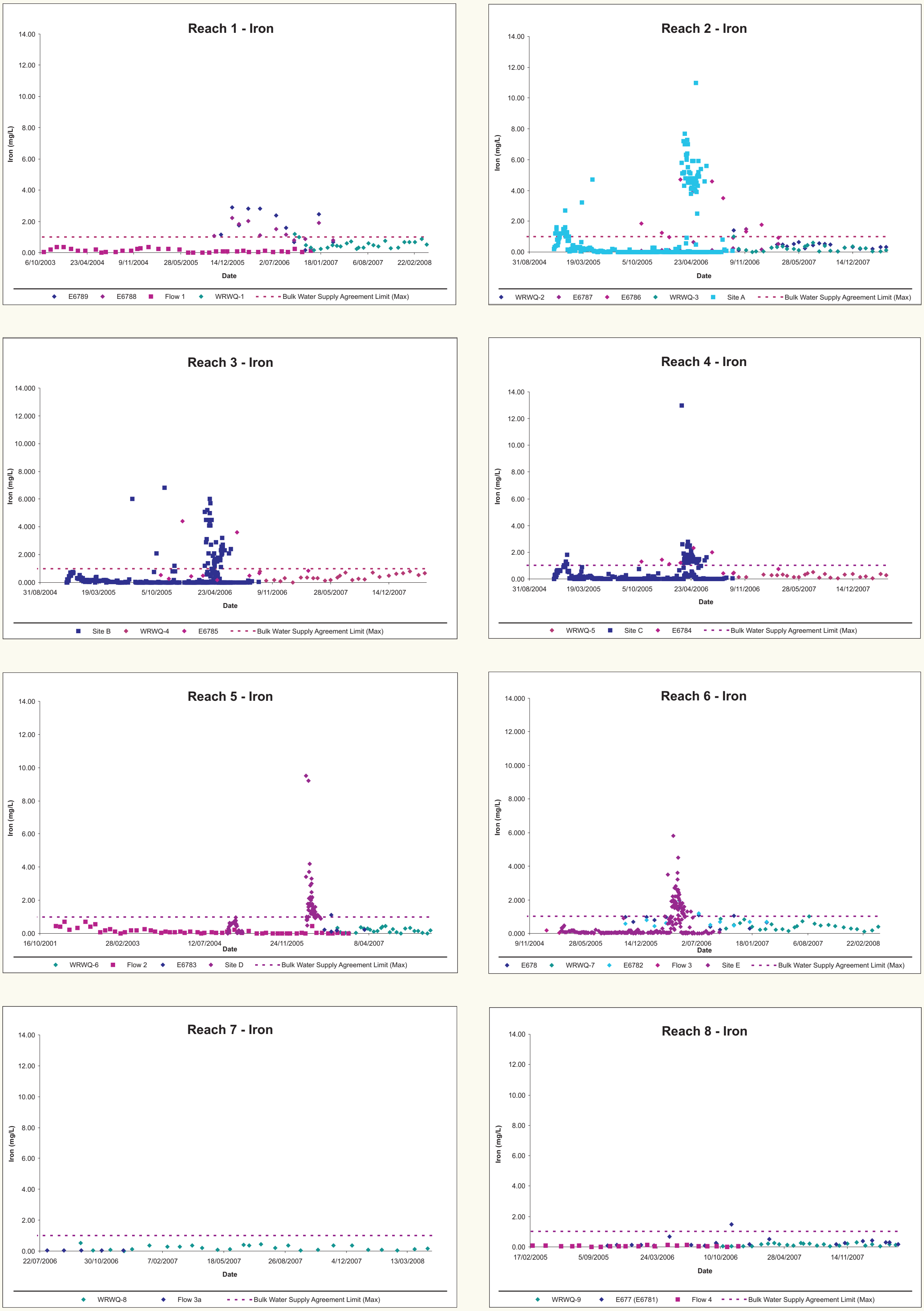
The pulses described above have not had any measurable effect on water quality in Woronora Reservoir downstream. This is evidenced by the recorded iron concentrations in the Woronora Reservoir in the period 1939 to 2007 (Figure 4-9). Recorded iron concentrations in Woronora Reservoir have not changed (increased) in the period since longwall mining commenced (1995) and in particular they have not been affected by the observed pulses seen in some upstream reaches in 2006. The trends in manganese concentrations in Woronora Reservoir mirror the trends in iron concentration.

There does not appear to be any noticeable link between subsidence effects and dissolved oxygen or the pH of water (i.e. the data sets do not show a response to cracking events).

29. It appears from the Panel's observations and reported data that WRS4 has started to leak following remediation, such that the water level in Pool F is dropping relatively quickly. What are the suspected causes of this, and what are the implications for proposed remediation of rockbars beneath the proposed longwalls?

The WRS4 rock bar is still within an active subsidence zone. Movement is visually evident along the large diameter holes drilled for the stress relief slot. Recent survey results indicate 20 mm of subsidence in late 2008. This evidence indicates that additional subsidence has caused some near surface (<0.5 m) flow pathways to develop or a flow connection has established from fracturing along the stress relief slot.

Comparison of recorded water level behaviour in pools A, F and H, both before and after the remediation trials at Pool F also provides a means of assessing the success of the trial. Water levels in Pool F were reportedly first affected during the longwall mining of Panel 12 in October 2005. Pool levels were further affected by mining of Longwall Panel 13. Water levels in Pool A were also affected by mining. The pool has not been fully remediated and continues to show obvious signs of subsidence induced underflow.



Note: Woronora Reservoir Bulk Water Supply Agreement maximum limit 1 mg/L

Source: Gilbert and Associates (2008)

METROPOLITAN COAL PROJECT

FIGURE 4-10

Observed Iron Concentrations
Waratah Rivulet

ResourceStrategies

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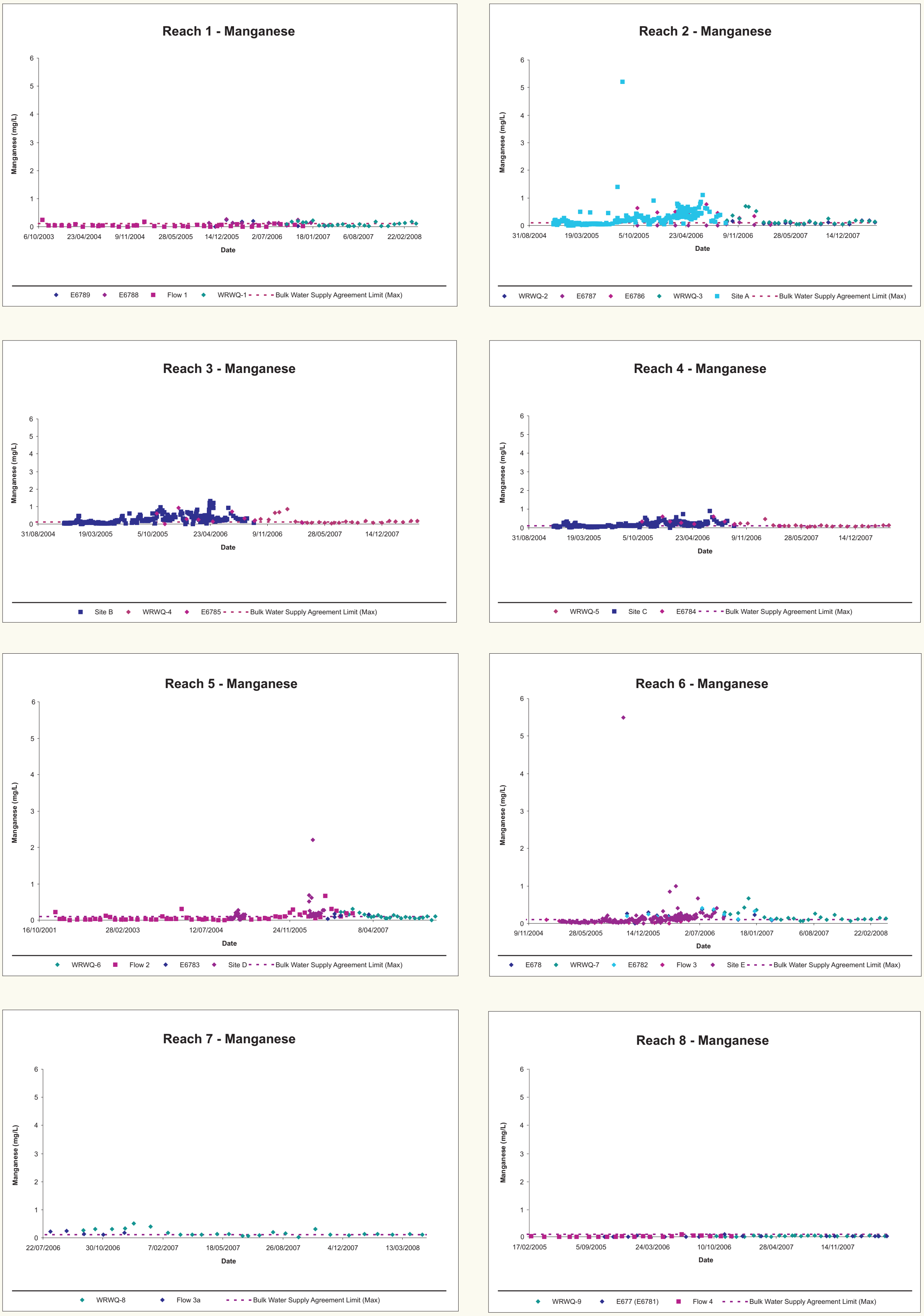
MET-06-02 Section 4_031B



Note: Woronora Reservoir Bulk Water Supply Agreement maximum limit 0.1 mg/L

Source: Gilbert and Associates (2008)

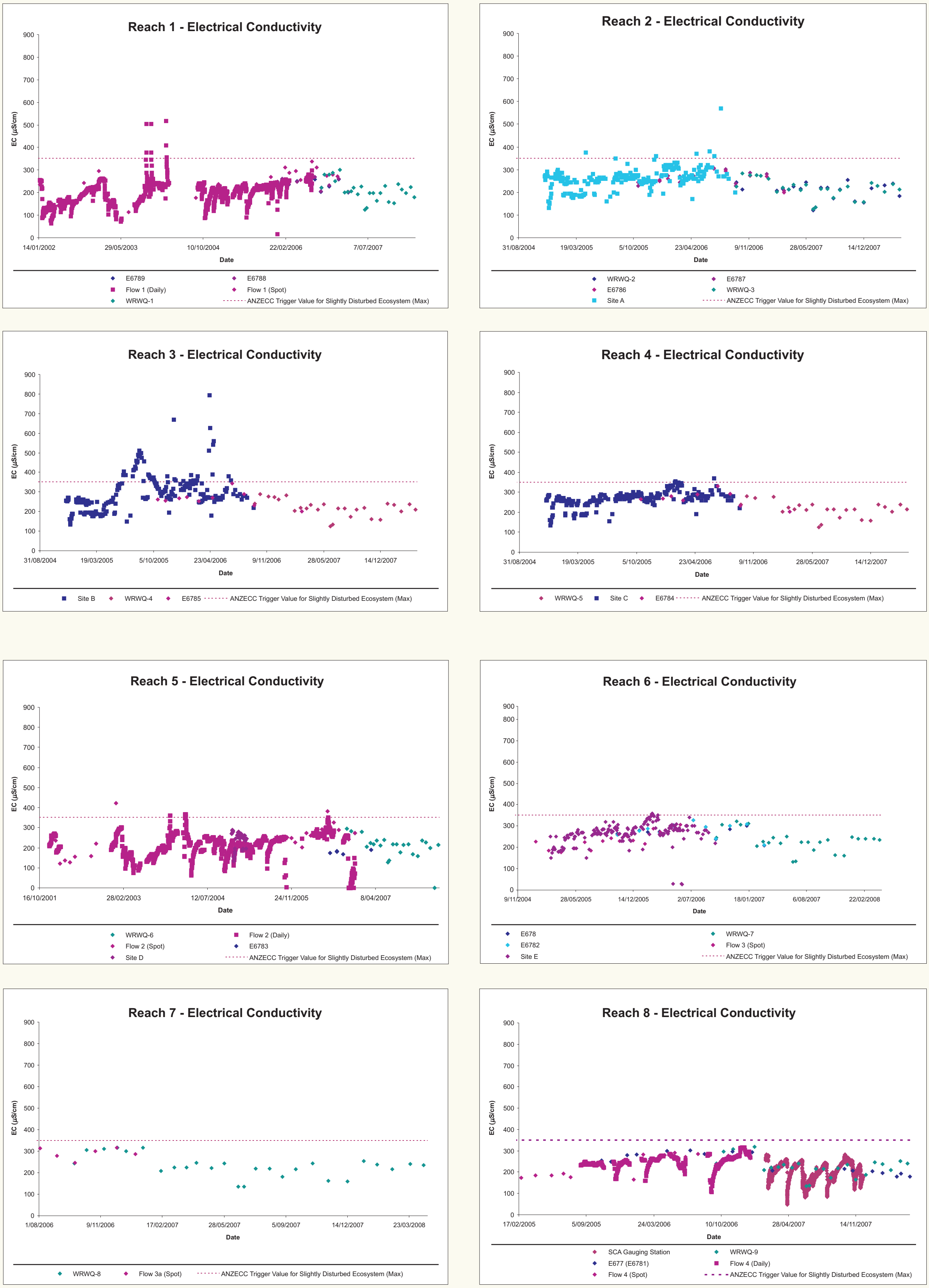
METROPOLITAN COAL PROJECT

FIGURE 4-11

Observed Manganese Concentrations
Waratah Rivulet

HELENSBURGH COAL PTY LTD

ResourceStrategies



Note: ANZECC (2000) Trigger value (maximum) for the protection of aquatic ecosystems in upland rivers, 350 μS/cm

Source: Gilbert and Associates (2008)

METROPOLITAN COAL PROJECT

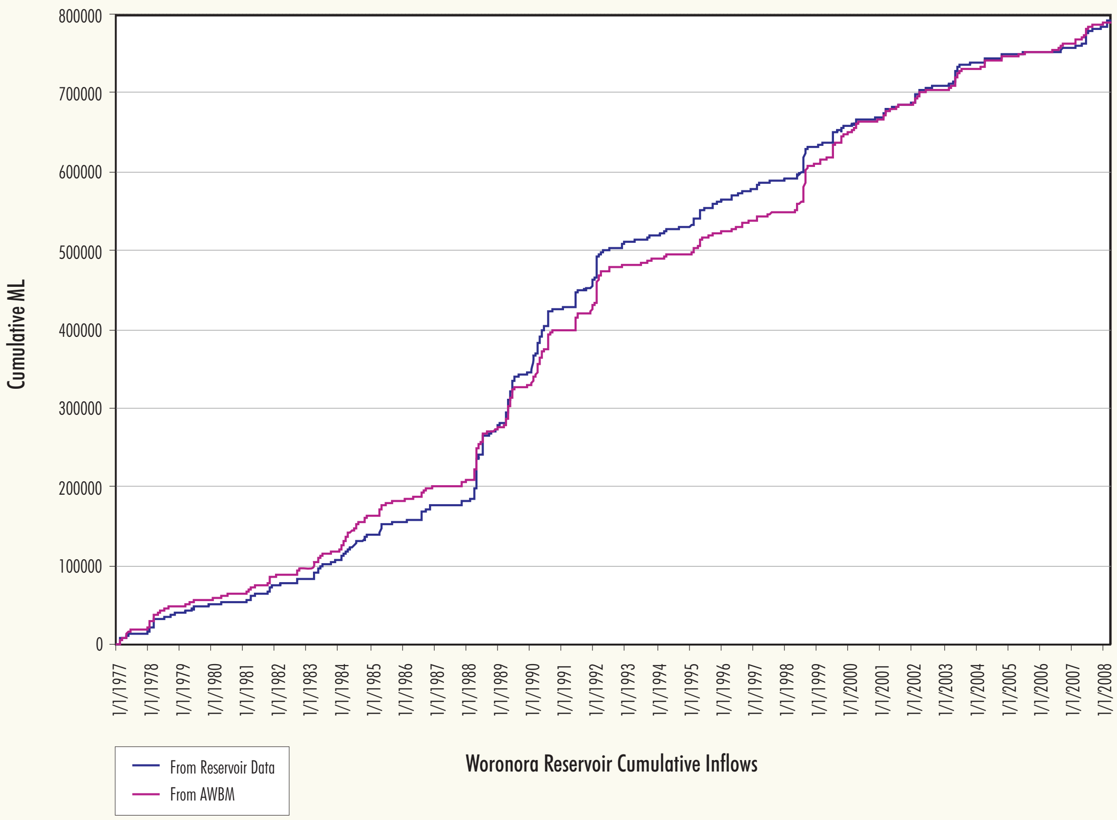
FIGURE 4-12

Observed Electrical Conductivities
Waratah Rivulet

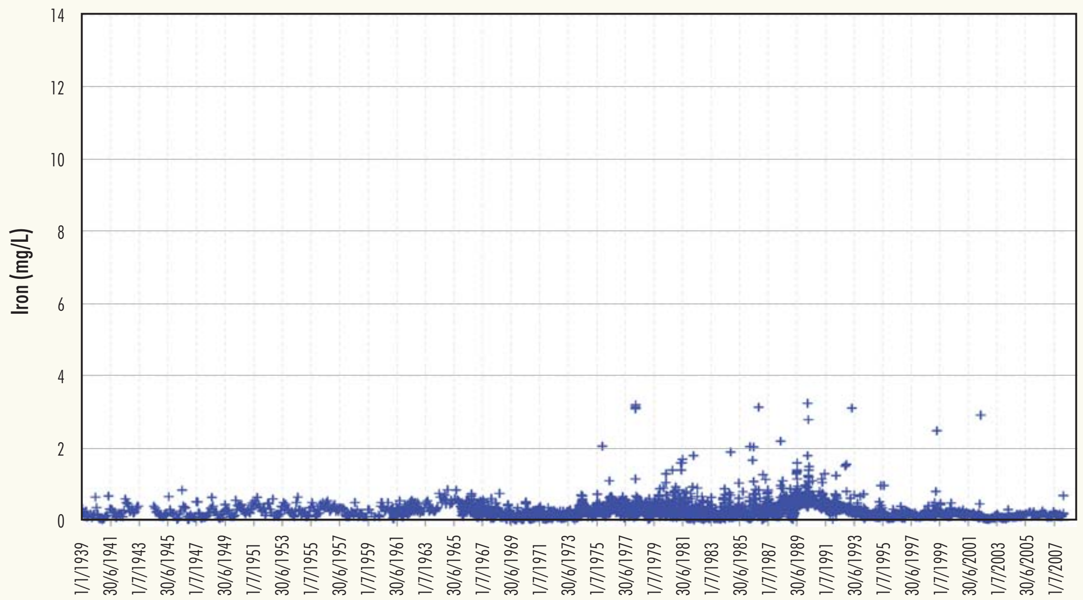
ResourceStrategies

HELENSBURGH COAL PTY LTD

MET-06-02 Section 4_033B



Woronora Reservoir Cumulative Inflows



Recorded Iron Concentrations - Woronora Reservoir 1939-2007

Source: Gilbert and Associates (2008)

METROPOLITAN COAL PROJECT

FIGURE 4-9
Woronora Reservoir
Cumulative Inflows and
Recorded Iron Concentrations

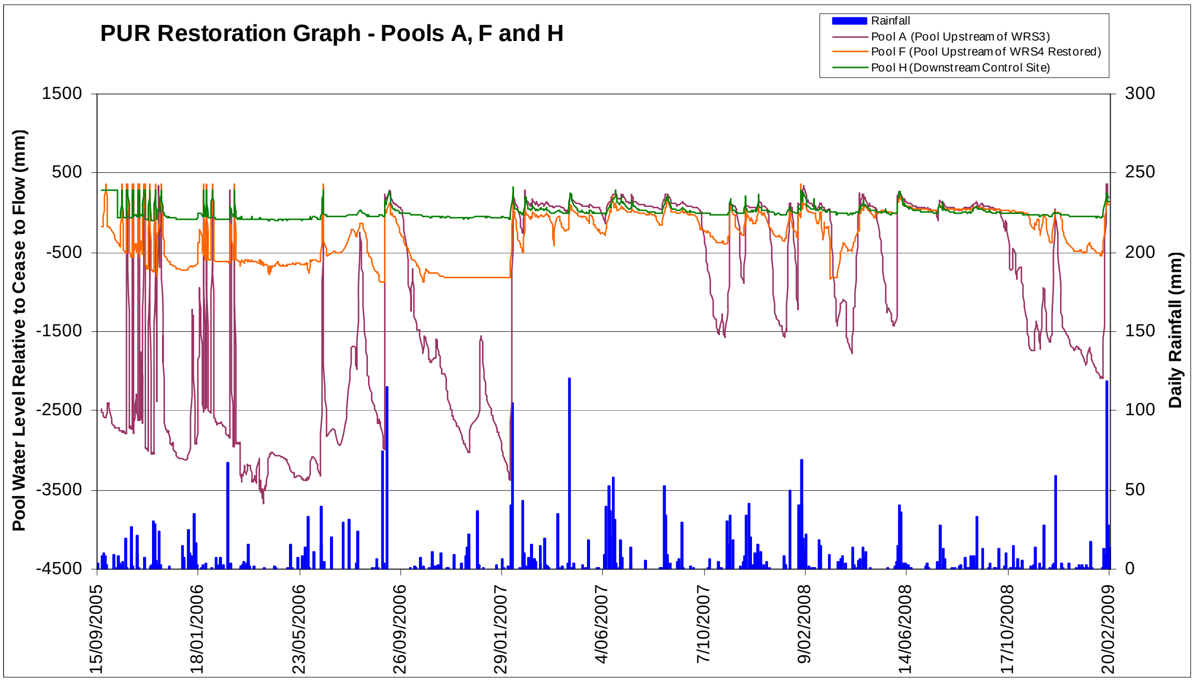
HELENSBURGH COAL PTY LTD

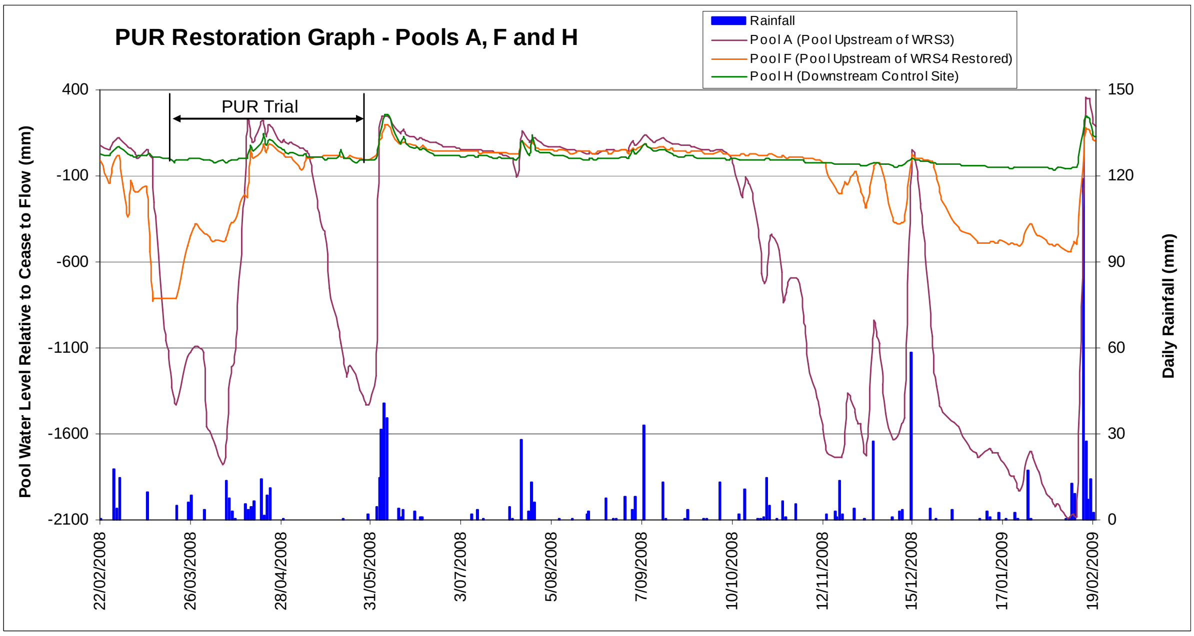
ResourceStrategies

Pool H is located downstream of Pool F and approximately 120 m downstream of previous longwall mining activities. The hydrological characteristics of Pool H have not been affected by subsidence. Pool H is a similar size to Pool F and has a similar pool/rock bar morphology.

During periods of moderate or high flow in Waratah Rivulet, the water level in subsidence affected pools is similar to a pool un-affected by subsidence. During dry periods when flows in the rivulet are in a low, recessionary regime the water level in pools affected by subsidence recede faster than they do in unaffected pools. Water levels in natural pools will decline below their 'cease to flow' level (i.e. stop overflowing) if the combined effects of evaporation from the pool surface and slow leakage through the downstream rock is greater than inflow rate.

The remediation trial at Pool F commenced on 17 March 2008 and was completed on the 13 May 2008. Even with the recent additional cracking, which monitoring indicates has occurred in late 2008, Pool F is continuing to maintain water and provide ecological utility/refuge under extremely dry conditions.





It is important to recognise that the aim of the WRS4 rock bar remediation was to decrease the gross permeability of the rock mass and to demonstrate the use of PUR in an environmentally sensitive area. The SCA has confirmed that the aims of the trial were met indicating "*The trial remediation of WRS4 rock bar met the aims of the Review of Environmental Factors*" and "*The SCA are happy to assess future applications of PUR in other rock bars in the Waratah Rivulet*."

The PUR injection method lends itself to repeated treatments. The Project adaptive management approach is based on the commitment to treat key rock bars after each phase of active subsidence (as informed quantitatively by measurement of impacts such as pool level and surface versus sub-surface flow). The PUR method also makes possible the pre-treatment of a rock bar to reduce the natural sub-surface flow to act as a buffer.

The Project adaptive management strategy will restore rock bars such that the duration and extent of impacts is maintained within acceptable limits. Repeat treatments with PUR will be required.

30. What are the detailed reasons for selection of only WRS5, WRS6, WRS7 and WRS8 for remediation? What is the assessed priority for remediation of each of the 19 rockbars (please number 1 -19, with reasons and costs).

In preparing the EA, HCPL was conscious of the importance that has been placed by some parties on the aesthetic impacts associated with the localised draining of pools and localised reductions in stream flow and the duration of such effects. Such concerns have been articulated by some members of the public, some government departments and some NGOs. The Executive Working Group meeting minutes provided separately to the PAC (6 February 2009) highlight some agencies concerns over the aesthetic and consequential potential political ramifications of drained pools within the water supply catchment.

Therefore, in consideration of the aesthetic and potential local aquatic ecology benefits that may be provided by the progressive implementation of restoration works at key rockbars over the life of the Project, HCPL selected WRS 5, 6, 7, 8A and 8B as being the most suitable sites for implementation of restoration works on the basis of analysis of the:

- the nature of the rockbar feature and its context in the stream, including the length and depth of the pond retained upstream behind the feature; and
- the morphology below the rockbar (e.g. presence of a waterfall or cascade below the feature).

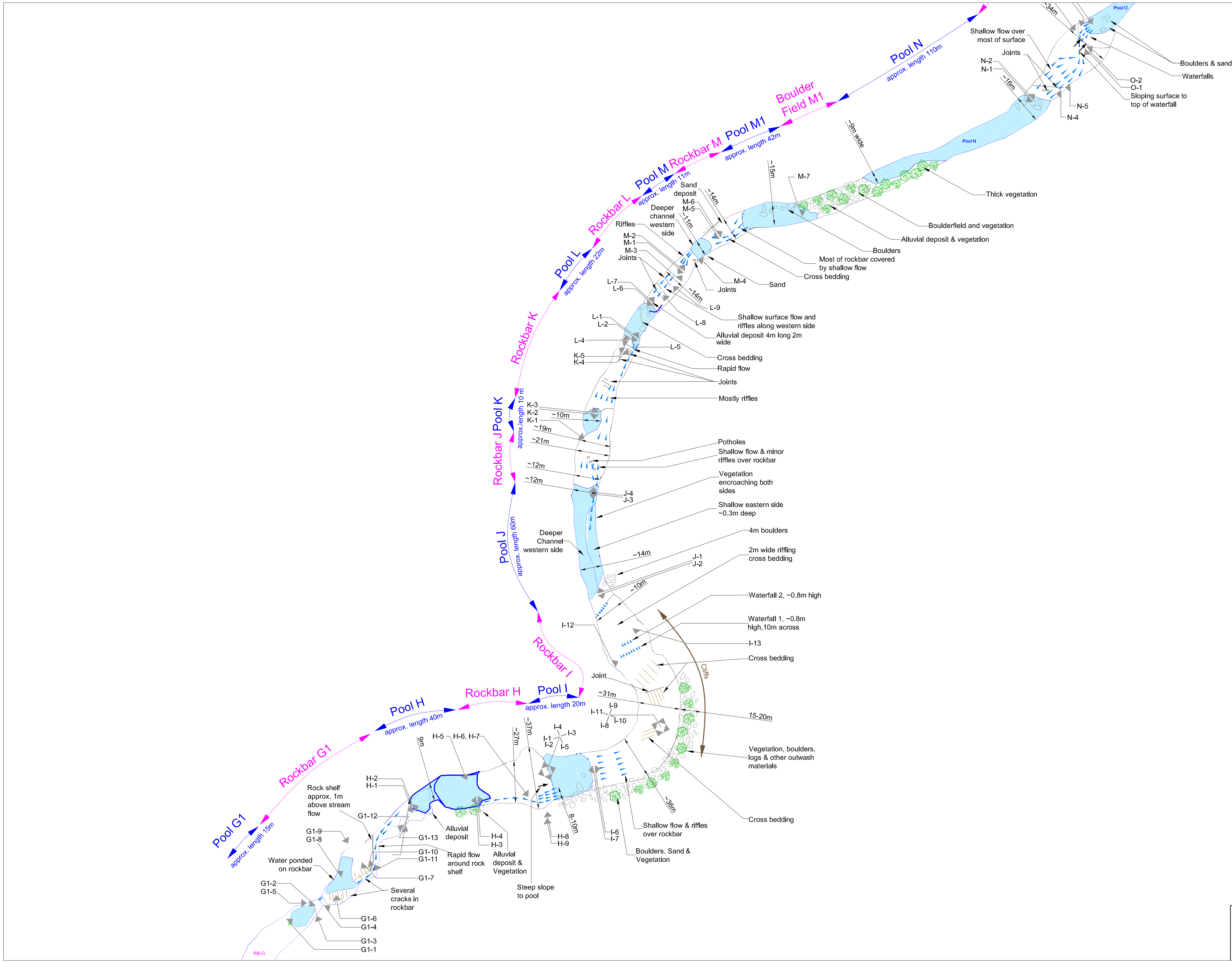
Section 5.2 of the EA states:

> *Rock bars WRS5, 6, 7 and 8* [8A and 8B] *on the Waratah Rivulet are associated with large pools that are similar in nature to those observed further upstream on the previously mined reach of Waratah Rivulet and contain similar habitat and aesthetic value (although not visible from existing fire trails).*

While these rockbars were selected on the basis of their role in retaining pools and potential aesthetic values of downstream features, it should be recognised that access to the Woronora Special Area is highly restricted (i.e. no public access) and the majority of the Waratah Rivulet over the Project Underground Mining Area is physically difficult to access, even if access to the Special Area was available.

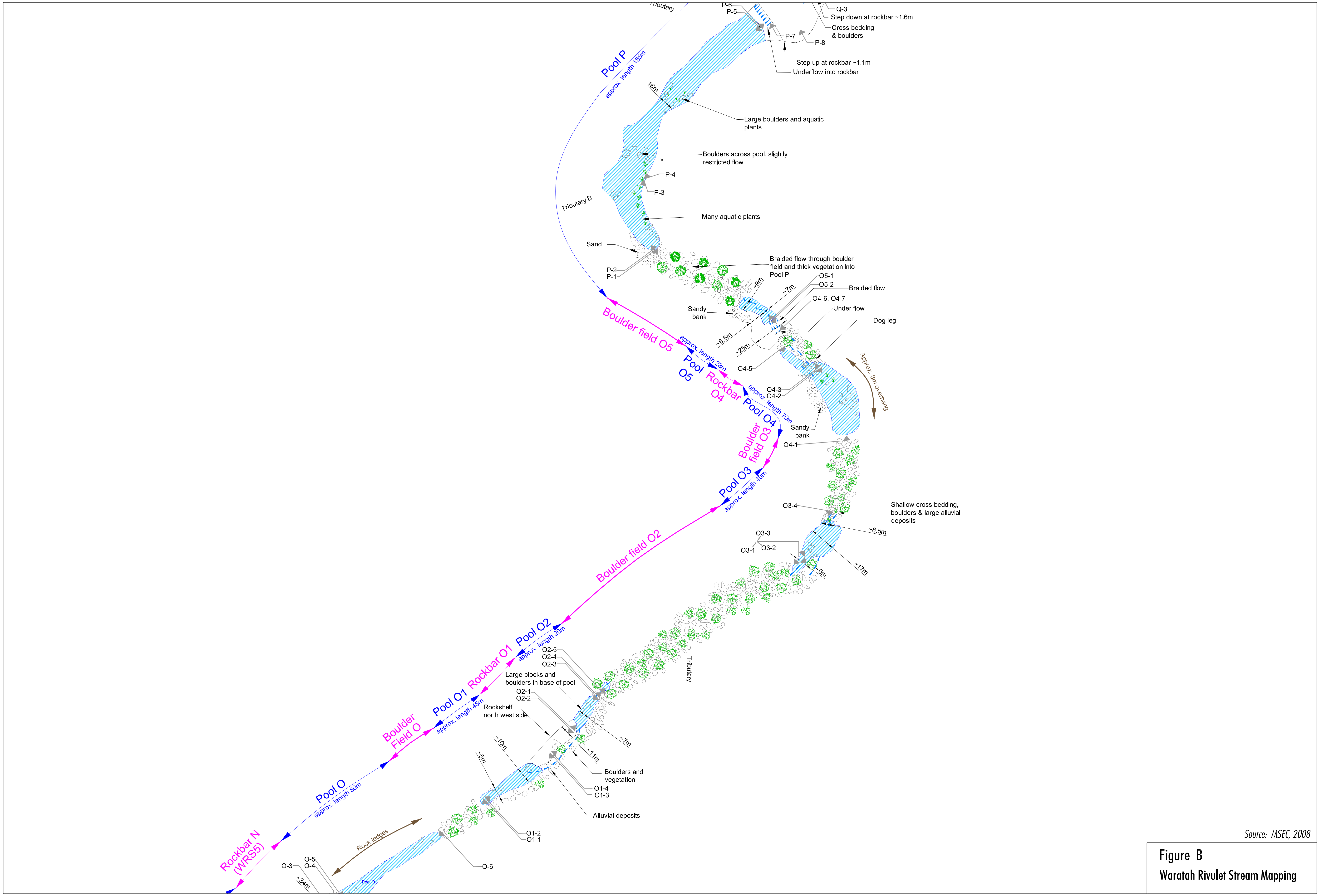
The aesthetic values present are therefore non-use values (refer response to PAC Question 3). These values have been considered where relevant in development of the Choice Modelling undertaken for the Project (refer response to PAC Questions 4, 7 and 11).

MSEC have undertaken detailed mapping of the features of Waratah Rivulet below Flat Rock Crossing and above the full supply level of the Woronora Reservoir. A series of A3 plans of the detailed mapping is provided on Figures A to C.



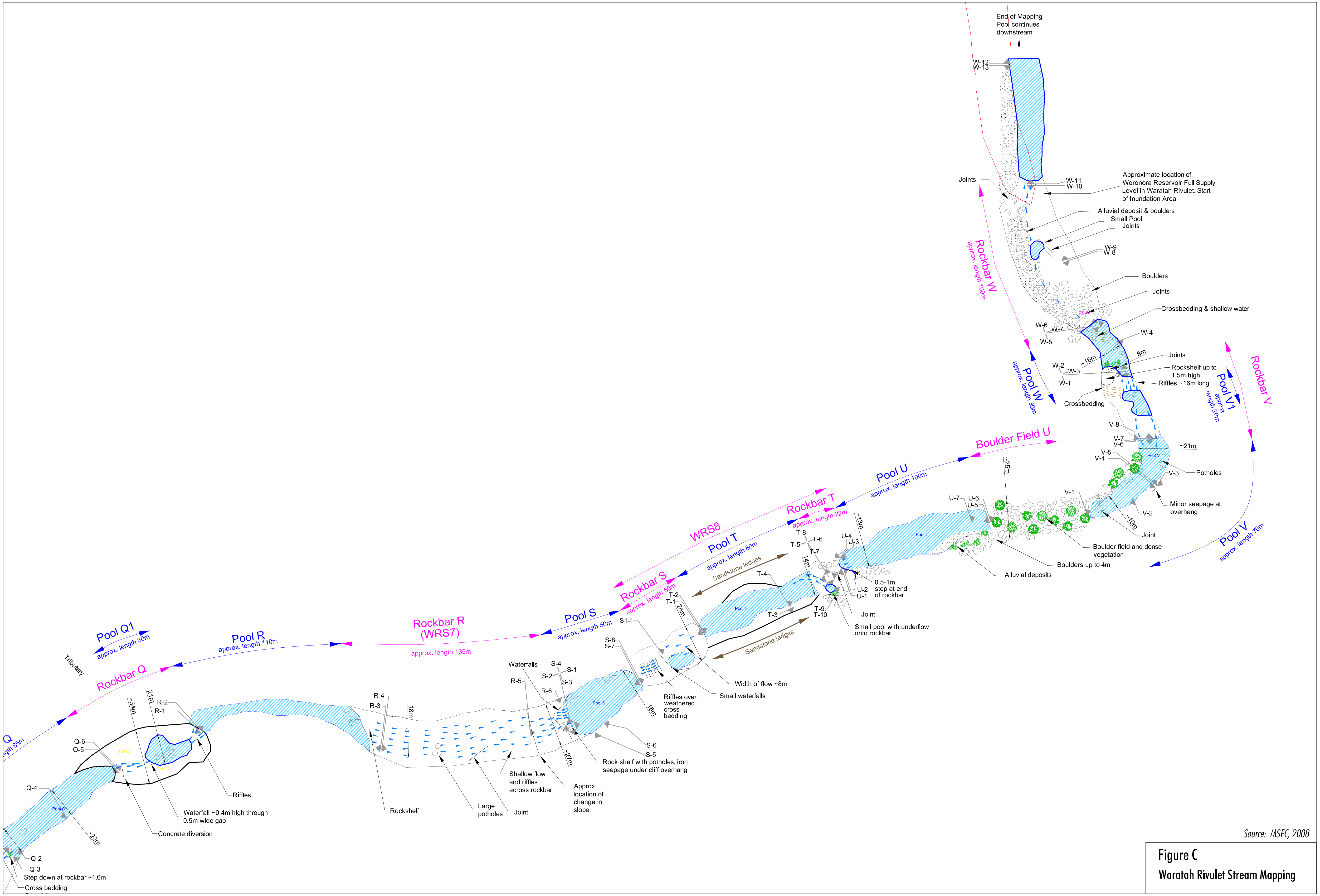
Source: MSEC, 2008

Figure A
Waratah Rivulet Stream Mapping



Source: MSEC, 2008

Figure B
Waratah Rivulet Stream Mapping



Source: MSEC, 2008

Figure C
Waratah Rivulet Stream Mapping

HCPL considers that the rockbars would fall into three main groups when considering their potential priority for Project stream restoration works:

- rockbar feature overlying the existing Metropolitan Colliery mining area (G1, H and I);
- rockbar feature overlying the Project Underground Mining Area - retaining small-moderate pools and/or associated with a lesser downstream features (J, K, L, M); and
- key rockbar feature overlying the Project Underground Mining Area - retaining a large upstream pool and/or associated with a key downstream feature such as a waterfall (N, P, R, S and T which were named WRS 5, 6, 7, 8A and 8B in the EA).

The rockbar attributes discussed above are tabulated in summary form below on the basis of the stream mapping.

	Rockbar Number - Name	Upstream Pool Length	Key Downstream Feature or Break in Long Section/Other
Above Metropolitan Colliery	G1	15m	Rock shelf approx. 1m above pool level
	H	40m	3 m drop from Pool H to Pool I
	I	20m	-
Project Underground Mining Area	J	60m	Almost continuous with Rockbar K
	K	10m	-
	L	22m	-
	M	11m	**-**
	N - (WRS5)	**110m**	5.5-6 m drop from Pool N to Pool O - 4 waterfalls, riffles
	O1	40m	-
	O4	70m	-
	P - (WRS6)	**185m**	Underflow entry approximately 9 m from downstream end of Pool P at a 1.1 m step up in rockbar
	Q	85m	1m drop from Pool Q1 to Pool R
	R - (WRS7)	**110m**	7 m drop from Pool R to Pool S - 4 waterfalls 0.4-1.2 m high
	S - (WRS8A)	**50m**	Waterfalls at u/s end of rockbar, 1.8 m in total height
	T - (WRS8B)	**80m**	4 m drop from Pool T to Pool U - underflow from internal pool to Pool U
	V	70m	1 m drop from Pool V1 to Pool W
	W	30m	Location of full supply level of reservoir

As described in the response to PAC Question 31 (below) the Project benefit cost analysis included an estimate of $12.5M for the restoration of WRS 5, 6, 7, 8A and 8B. A HCPL estimate of the additional restoration costs if a similar approach was applied to all of the other rockbars listed in the table above (including some in the existing mining area) would add an estimated additional $12.5M – giving a total remediation cost estimate of approximately $25M for the mapped rockbars G1-W.

However, a restoration commitment on this scale is not considered to be a rational commitment given the nature of potential environmental impacts described in the EA; the natural recovery processes that have been observed with time (Section 7.3.1. of Appendix C); and in consideration of the costs and benefits associated with such restoration works. (Refer also to PAC Questions 31 and 32.)

31. Total cost of remediating rockbar WRS4 has been reported as c. $1 M to date. What are the projected costs of fully remediating rockbars WRS5, WRS6, WRS7 and WRS8? What are the projected costs of remediating all 19 rockbars impacted by the proposed mine plan?

The projected costs of remediating the key rockbars identified for the EA (i.e. WRS5, WRS6, WRS7, WRS8A and WRS8B) is $12.5M over the first 10 years of the Project. After the first 10 years, no further rockbar restoration costs are anticipated, as mining would then be north of the full storage level of the reservoir.

An allowance of $12.5M was included in the EA benefit cost analysis. This included the following estimated expenditure profile:

- 2011 $1M
- 2012 $0.5M
- 2013 $0.5M
- 2015 $3M
- 2016 $3M
- 2017 $1.5M
- 2018 $2M
- 2019 $1M

The $12.5M estimate was based on HCPL's experience with the trial restoration works of WRS4 and a range of conservative assumptions, including the following:

- that all of the nominated rockbars would require restoration works – observation to date has shown that this is not necessarily the case (e.g. WRS1 and WRS2);
- that multiple (primary, secondary and tertiary) phases of restoration works would be required at each of the nominated rockbars – as per the Adaptive Management approach (Section 5.2 of EA Volume 1);
- that the primary phase of restoration works at each key rockbar would be expensive (e.g. $1M per rockbar) because natural and mining related fracture networks would be present;
- significant secondary restoration works stages have been assumed to be required for each rockbar (e.g. $0.5M) as moderate secondary cracking would occur;
- moderate tertiary restoration works stages have been assumed to be required for each rockbar (e.g. $0.25M) as lesser cracking would occur; and
- the restoration works would all be undertaken as separate campaigns and no mobilisation cost savings would be available due to multiple works occurring at the same time.

It is considered unlikely that such high levels of secondary and tertiary restoration works would be required at each rockbar.

In addition, it has been observed that the primary treatment at WRS4 resulted in restoration of stream condition for a considerable distance upstream. Pool levels were returned for in the order of 500 m and beyond and that a positive response in the return of low flows was also observed due to saturation of a portion of the sub-surface crack network (Figure SD-1). Therefore it can be reasonably expected that restoration of WR5, 6, 7, 8A and 8B would have beneficial aesthetic effects across a significant proportion of the total Waratah Rivulet stream length.

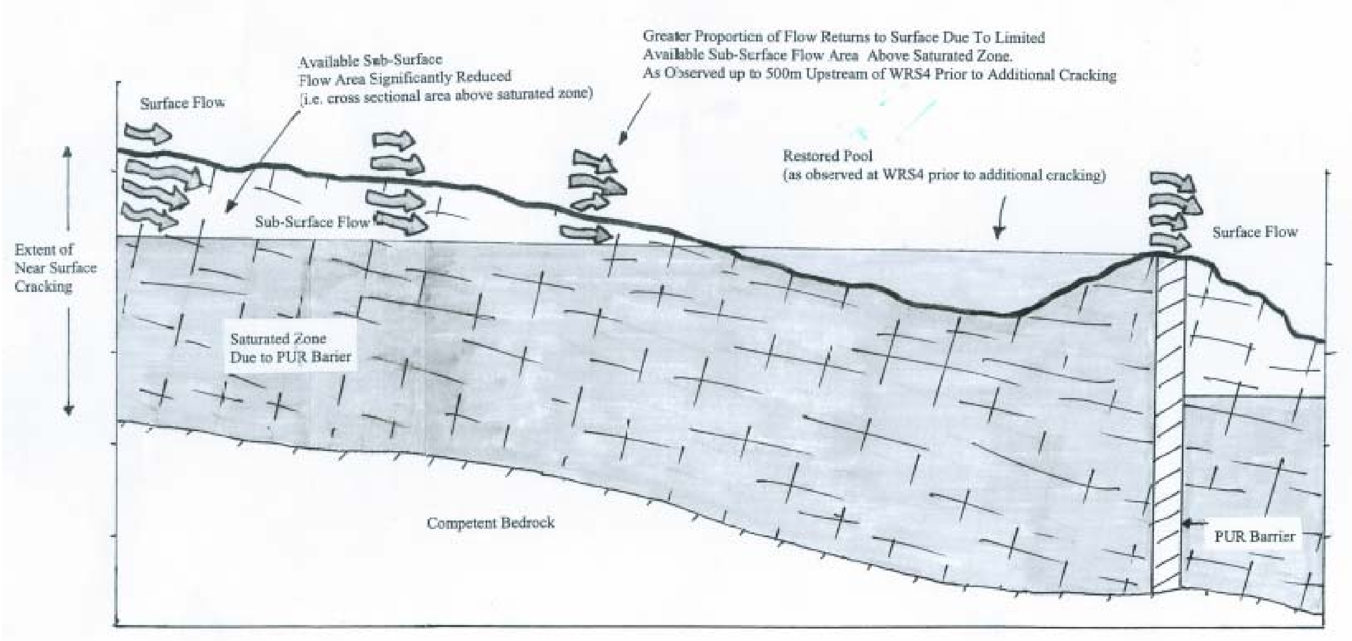


Figure SD-1: Schematic Diagram - Rockbar Restoration

Since additional cracking of WRS4 has occurred, changed pool level responses have also been observed for significant distances upstream (e.g. at Pool B) - this was evident at the time of the PAC inspection. WRS4 will require a secondary treatment.

It is not possible to predict which rockbars may require more treatment than others, however past experience at the Metropolitan Colliery indicates that some rockbar features are more resilient to valley closure effects and differing levels of near surface fracturing would occur. However, restoration cost estimates have not been discounted on this basis.

32. It is noted that HCPL has allowed $20 M in its project budget for stream remediation at Waratah Rivulet. What benefits might result from alternative use of $20 M to provide catchment benefits (eg Darkes Forest Mine rehabilitation, purchase of privately-owned catchment lands, spill traps, etc). Please be specific with potential alternatives for expenditure and resulting benefits (and costs, if any).

As described in the response to PAC Question 31 (above), HCPL estimated restoration costs at $12.5M for WRS5, 6, 7, 8A and 8B, and these costs were included in the benefit cost analysis.

A number of compensatory measures and other ecological initiatives have been proposed as a component of the Project and are described in Volume 1 of the EA. The compensatory measures and ecological initiatives proposed in the EA are outlined in table below.

Metropolitan Coal Project Compensatory Measures and Ecological Initiatives

Compensatory Measure or Ecological Initiative	Comment	Financial Contribution
Research Programmes		$250,000
• Research into subsidence effects on streams. • Research on techniques for remediating stream bed cracking, including: - Crack network identification and monitoring techniques.	Consistent with the Southern Coalfield Panel Report (SCPR).*	
- Technical aspects of remediation, such as matters relating to environmental impacts of grouting operations and grout injection products, life spans of grouts, grouting beneath surfaces which cannot be accessed or disturbed, techniques for the remote placement of grout, cosmetic treatments of surface expressions of cracks and grouting boreholes.	Consistent with SCPR Recommendation 14.*	
• Research comparing the outcomes of interventionist remediation with natural processes of remediation.	Consistent with SCPR.*	
• Research into the refinement of the prediction of non-conventional subsidence effects in the Southern Coalfield and the link to environmental effect. This will focus on valley closure and upsidence mechanisms.	Consistent with SCPR Recommendation 17.*	
	Sub-total Contribution	**$250,000**
Catchment Condition Work		$50,000/year for life of Project
• Financial contribution towards rehabilitation and revegetation works within the Woronora catchment and/or other SCA controlled catchments. This will include project management services as required.	Catchment residual impact offset.	
• Pest Control - Financial contribution to pest control programmes for pests such as the Red Fox, European Rabbit, Feral Deer, Feral Pig and Feral Cat within the Woronora catchment and/or other SCA controlled catchment.	Biodiversity initiative.	
• Weed Control - Financial contribution to weed control programmes for weeds such as Pampas Grass, African Love Grass, Lantana, African Boxthorn, Bridal Veil Creeper, Prickly Pear, Onion Grass and Blackberry within the Woronora catchment and/or other SCA controlled catchment.	Biodiversity initiative.	
	Subtotal Contribution	**$1,150,000**
Total HCPL Contribution		**$1,400,000**

* DoP (2008).

As described in the above EA extract, HCPL proposes to financially contribute $50,000/year for the life of Project towards rehabilitation works and/or pest/weed control programmes within the Woronora catchment and/or other SCA-controlled catchments.

Potential rehabilitation works that could be undertaken within the Woronora catchment include:

- Fire trail improvements (e.g. sealing of roads, runoff or sediment controls).
- Princes Highway improvement works (e.g. culvert maintenance [such as removing debris and rubbish], runoff or sediment controls, spill containment or trash traps).
- Rehabilitation of disturbance areas (e.g. Darkes Forest).

It is considered that all of these measures would result in improvements to the condition of the Woronora Catchment, including catchment water quality.

It is anticipated that the catchment improvement measures would be subject to consultation with regulatory agencies and detailed design through mechanisms provided in the Project Approval conditions.

Adaptive Management and Remediation

33. What criteria are proposed to apply for the application of each of the management measures mentioned on p 5-16?

The management measures mentioned on page 5-16 relate to the management of excessive erosion or sediment migration and the management of impacts on vegetation.

Specifically, page 5-16, Volume 1 of the EA states:

Regular visual monitoring (particularly along Waratah Rivulet) would be conducted to identify areas subject to excessive erosion and sedimentation. Where monitoring indicates the potential for excessive erosion or sediment migration, specific mitigation measures would be employed. Potential management measures include:

- *filling of cracks and minor erosion holes in the bed or banks of watercourses;*
- *installation of sediment fences downslope of subsidence-induced erosion areas;*
- *stabilisation of erosion areas using rock or other appropriate materials;*
- *stabilisation of banks subject to soil slumping; and*
- *implementation of vegetation management measures.*

Potential rehabilitation measures for impacts on vegetation include the implementation of weed control measures (e.g. mechanical removal or the application of approved herbicides) and the planting of endemic plant species. Any active planting would utilise flora species characteristic of the particular vegetation community in that area and would utilise seed collected from the Woronora Special Area.

In addition, consultation would be undertaken with the DoP and the SCA for any proposed revegetation works associated with subsidence impacts (e.g. impacts to riparian vegetation), should monitoring indicate the need.

As described on page 5-16, visual inspections/monitoring would be conducted to identify areas of excessive erosion or sediment migration requiring the implementation of management measures. This is a current requirement of the *Metropolitan Colliery Longwalls 14-17 Environmental Monitoring Programme* (HCPL, 2006) that is implemented in accordance with the Metropolitan Colliery's Longwalls 14-17 SMP Approval. To date, excessive erosion or sediment migration has not been identified by HCPL, the Sydney Catchment Authority or the Department of Primary Industries at the Metropolitan Colliery as a result of subsidence.

In a similar manner, visual inspections/monitoring would be conducted to identify areas requiring the implementation of vegetation management measures. For example, weed control measures have been implemented by HCPL at the WRS3 rock bar to control introduced weed species that have established (albeit as a result of surface disturbance activities as opposed to subsidence). The particular vegetation management measures selected would be dependent on the nature and extent of the vegetation impacts.

34. What criteria are proposed to apply for the application of monitoring, triggers and responses under the proposed TARP?

HCPL's proposed Waratah Rivulet Management Plan Trigger and Response Plan (TARP) is currently under development, however further details are proposed to be provided to the PAC in the near future. As described in Section 5.2 of the EA, the TARP will be developed in consultation with recognised experts in the relevant fields.

The TARP will be informed by the extensive monitoring database including pre and post-mining impacts and by the surface and groundwater models developed. Whilst actual subsidence movements would be included in the monitoring programme, the focus will be on subsidence impacts. This recognises that whilst subsidence movements can be measured very accurately, the consequential impacts for a given movement within a natural environment are difficult to predict with certainty. The focus on impacts and the use of quantitative information feeding into surface and groundwater models provides a robust method for establishing the extent of impact. Most importantly, the quantitative nature of the TARP will allow trends to be determined so that *potential* excedances can be identified and mitigated in a timely fashion.

The TARP will provide comparison of monitoring data against specific triggers by using quantitative measures where possible. For example, it is anticipated that the TARP will include:

- Trigger(s) that relate to the extent of impacts, for example:
    - Regular monitoring of water quality and quantity to monitor mine subsidence induced effects on the water quality or quantity of the yield of Woronora Reservoir. In the event impacts were detected as a result of the Project, then response and/or contingency measures would be implemented in accordance with the WRMP (see below).
    - Monitoring of shallow versus deep groundwater pressures (to inform the DSC requirement of reservoir yield).
    - Monitoring of shallow versus deep groundwater quality (to confirm the separation of the shallow and deep aquifer systems).
    - Monitoring of stream flows and comparison with the hydrological catchment model.
- Trigger(s) that relate to the duration of impacts - HCPL commits to undertaking the stream restoration works within a period of six months following the receipt of any necessary final approvals and once suitably low flow conditions occur (i.e. restoration works cannot be undertaken during periods of high stream flows).
- Trigger(s) that relate to efficacy of remediation on previously affected rock bars – as described in the response to PAC Question 6, the success criteria for restoration works are currently under development, however are expected to be based on an achievement of a statistical variation of the pre-mining rockbar pool behaviour for given stream flow conditions.
- Regular monitoring of subsidence cross lines and potentially valley closure would inform the current magnitude and trend in development of subsidence itself.

In regard to response measures, in the event that there is a measurable reduction in the quality or quantity of the yield of Woronora Reservoir as a result of the Project, modification of the longwall extraction geometry would be undertaken.

In the event that monitoring data indicates that rock bar restoration works have not met the predetermined performance criteria then restoration works would be repeated by HCPL until such time as the works are deemed to be successful.

In the event that stream restoration performance criteria are not achieved (including the timeframe within which the works are completed) then modifications to the longwall extraction geometry would be implemented for subsequent longwall panels so as to reduce the cumulative subsidence effect (refer response to PAC Question 6).

Other response measures may be implemented, subject to detailed technical investigation and Peer Review to inform their need, extent and/or design.

Catchment Yield

35. SCA has provided data which indicates (on its face) a loss of flow in the Waratah Rivulet, and therefore a possible loss of catchment yield to Woronora Reservoir. Please provide a detailed response to SCA's analysis and its expression of concerns. In the light of the SCA data, please provide an assessment of confidence for HCPL's position that there is no significant loss of flow in the Waratah Rivulet.

A detailed response to the SCA's concern regarding the potential loss of flow in the Waratah Rivulet is provided by Gilbert and Associates below.

The hydrological assessment undertaken by Gilbert and Associates and Peer Review by Dr. Walter Boughton (Attachment 3) provides HCPL with considerable confidence that there is no significant loss of catchment yield to the Woronora Reservoir. This position is reinforced by the outcomes of the groundwater study undertaken by Professor Noel Merrick. Further, the Peer Review of the groundwater study by Dr. Frans Kalf (Attachment 4) concludes:

> *Based on the reports provided above and evidence to date, I agree with the Merrick report conclusion that the predicted potential effects to surface systems as a result of groundwater depressurisation at depth are simulated to be so small as to be within the limit of accuracy of modeling. Based on the modeling results presented by Dr Merrick, the effects on surface water flow overall would not be measurable, given the usual method of surface flow monitoring.*

Metropolitan Coal Project Environmental Assessment
Response to SCA Submission

This response addresses surface water issues contained in the SCA's submission to the Department of Planning on the Metropolitan Coal Project Environmental Assessment. More recently (9/2/09) the SCA sent a letter to Helensburgh Coal repeating its opinions about mine subsidence induced losses from the Woronora Reservoir. This response addresses the issues raised in the original submission with further comment provided where additional or different arguments have been made by the SCA in their subsequent letter to Helensburgh Coal.

The approach used in the surface water assessment by Gilbert & Associates was to examine and analyse all of the available hydrological data to assess flow loss (if any) from the Waratah Rivulet as a consequence of longwall mining. The comprehensive assessment thereby included several different analyses and concluded there is no evidence to suggest mining-induced losses from the Waratah Rivulet at the inflow to Woronora Reservoir.

The SCA has dismissed each of the Gilbert & Associates analyses either because they claim there is insufficient data and/or because the methods used are invalid. The SCA then claim to have conducted their own analysis and modelling using data collected over the same period to conclude there was a loss of water equivalent to 5% of average annual inflow to Woronora Reservoir. The SCA has not provided their analysis report, the peer review, or modelling details so we are unable to comment on their work. We are however cognisant of significant errors in some of the data to which they refer which may explain their contrary opinions – refer Section 3 below.

It should also be noted that the views reached by the SCA are contrary to the peer reviewer (Dr Walter Boughton – an internationally recognised expert in hydrology and catchment modelling) who concluded that:

> "*The methodologies used in the assessment are appropriate and adequate to look for effects of underground mining on inflows into Woronora Dam."*

and that he concurred with the main findings of the surface water assessment:

> *"…that all evidence now available indicates that future proposed mining is not expected to have an effect on catchment yield.*"

We note also that the report from the recent inquiry into the Southern Coalfield[3] also state in their summary that:

> "No evidence was presented to the Panel to support the view that subsidence impacts on rivers and significant streams, valley infill or headwater swamps, or shallow or deep aquifers have resulted in any measurable reduction in runoff to the ***water supply system*** operated by the Sydney Catchment Authority or to otherwise represent a threat to the water supply of Sydney or the Illawarra region."

[3] Department of Planning (2008), "Impacts of Underground Coal Mining on Natural Features in the Southern Coalfield: Strategic Review".

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1.0 Water Quantity and Quality (Page 3 of the SCA Submission)

1.1 The SCA state at 2(b), p3 that:

> The SCA is not satisfied that the Environmental Assessment demonstrates that the project would not result in a reduction (other than a negligible reduction) in the quality and quantity of surface or groundwater inflows to Woronora storage or the potential for loss of water from the storage to outside of the catchment. In particular, the SCA's investigations and modelling (supported by an independent review) is suggesting a more significant impact on surface flows and groundwater resources would result from the current proposal. The SCA considers that the project will not a have a neutral or beneficial effect on water quality.

Although the SCA has provided some documents, it has not provided the specific investigations, the independent peer review, or the modelling upon which this statement is based, so we are unable to critically analyse their work. In particular it is not clear whether the SCA considered a limited portion of the available data or whether a comprehensive evaluation of all available data was conducted.

Our assessment of what has been presented by the SCA is that underlying data used in the analysis has significant errors. These errors would invalidate the SCA's conclusion "that there is a loss of flow from the Waratah Rivulet at the end of the system" – refer Section 3 below.

2.0 SCA's Assessment of EA Surface Water Assessment (refer Pages 8 and 9 of the SCA Submission)

2.1 The SCA state that they consider there are weaknesses in the assessment methods used and conclusions made in the EA surface water assessment report in regard to observed effects of past longwall mining on Waratah Rivulet and its tributaries, and assessment of impacts of the proposed longwall mining. In particular it is stated that there are several conclusions and statements in the assessment that are not supported by the monitoring data and quote what they believe there to be an example[4] of this at the bottom of page 8 of their submission in the following excerpt:

> **The report states "Extensive analysis of stream-flow data and data of [sic] inflows to Woronora Reservoir since 1977 has shown that there has been no loss of water to the reservoir as a result of mining". This conclusion is unconfirmed as there is no flow data available from the Waratah Rivulet from 1977 to 2007 to support this statement.**

[4] The SCA submission does not contain details of other instances where the SCA believe assessment methods used in the surface water assessment and conclusions are not supported by the monitoring data, however we believe all the assessments to be fully supported by the available data. This view is also supported by the assessment of peer reviewer Dr Boughton.

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The SCA provided HCPL with the following daily data records: reservoir water level, spillway overflow, extraction/release for water supply (regulated discharge) and environmental releases. As outlined in Sections 7.1.3 and 7.1.4 of the assessment report, this data was used in combination with the storage characteristics of the reservoir to estimate inflows using a daily water balance. In the absence of measured inflows from a gauging station this is an accepted and frequently used method in surface water hydrology and water resource modelling. Contrary to the SCA assertion, the conclusion of no loss of water to the reservoir is supported by the reservoir water balance data provided by the SCA.

The SCA repeat and expand on this same point at the second (2^{nd}) dot point on page 9 of their submission where they appear to be asserting that the comparison of reservoir inflows derived from the analysis of reservoir water balance data with inflows derived from catchment modelling is "not valid" because they mistakenly believe the modelled flows did not include (allow for) other sources to the reservoir (ie other than Waratah Rivulet) and which are needed to make such a comparison meaningful. They again expand on this point in their letter to Helensburgh Coal, where they again consider the analysis to be "flawed" because (paraphrased below):

1. **The AWBM used to generate inflows was calibrated against during mining conditions rather than a pre-mining condition.**

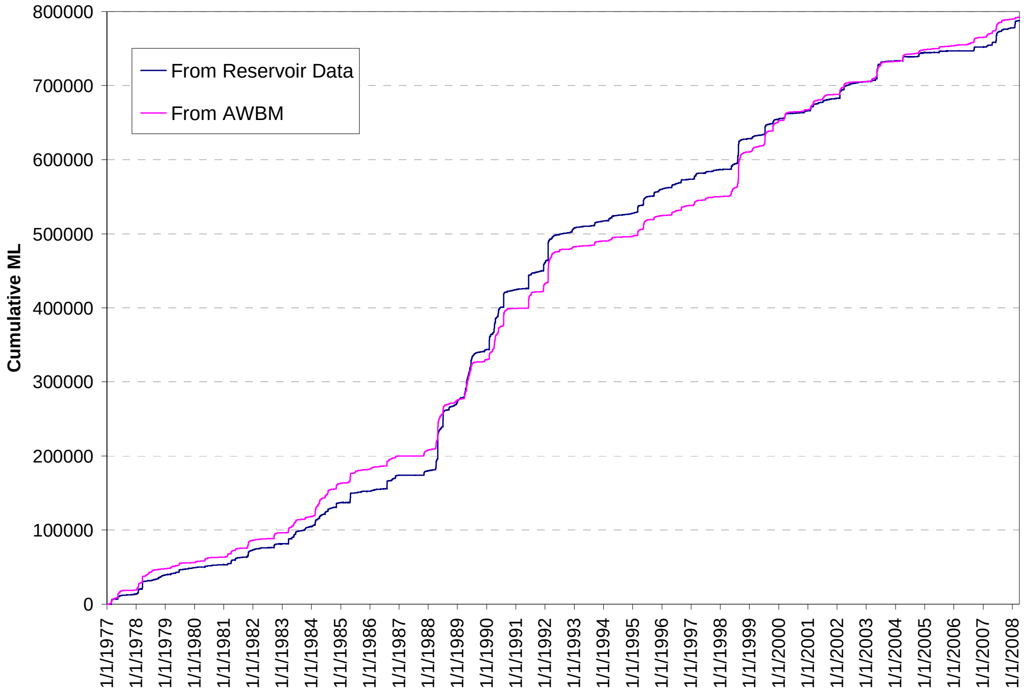
2. **That estimates of inflows from water balance calculations are approximate and subject to errors in storage volume, evaporation and rainfall and the failure to account for groundwater inflows/outflows – which is likely to be significant.**

3. **The AWBM estimates flow for the Waratah Rivulet only and not from all surface inflows.**

The objective of the reservoir inflow analysis was to assess whether there is any evidence of reservoir inflow reductions as a result of longwall mining. This was done by comparing cumulative inflows generated from the AWBM (applied to the *entire* catchment of the reservoir) and those from a water balance assessment of the reservoir. The available data enabled this comparison to be made over a long period including 18 years prior to longwall mining (1977 to 1995) and 12 years from the commencement of longwall mining. The fact that the AWBM was calibrated against data collected after longwall mining is irrelevant because the analysis is based on differences between cumulative inflows derived from AWBM modelling (representing constant catchment response behaviour) and from the reservoir water balance which reflects actual inflows (including pre and post mining periods). Any change in actual inflows as a result of longwall mining would show up as a systematic discrepancy between the slopes of the two lines pre-1995 and post 1995 (refer figure below).

Errors in data, unless systematically affecting either the pre-1995 or post 1995 periods, would not affect the results of the analysis for the same reasons outlined above.

The inflows generated using the AWBM included the entire inflow catchment – not just Waratah Rivulet.



The conclusion which can be drawn from this analysis is that there are no observable changes to inflows to the reservoir over the 12 years since longwall mining commenced compared to those that existed in the 18 years prior to longwall mining. It can then be validly concluded that the available data do not show any indication of a longwall mine related impacts. It then becomes an issue of the sensitivity of the analysis and its ability to be able to detect an impact if it had occurred. What can be said in this regard is that any impact that might have occurred is too small to make any difference to the useable yield and water supply security of the reservoir.

2.2 At the first (1st) dot point on page 9 of their submission the SCA further assert that interpretation of data in the surface water assessment is inaccurate. The SCA quote the following example:

The report includes a figure showing the logarithmic plot versus time (from 21/2/2007) to 22/3/2008) for the stream-flow hydrograph GS2132102 in the Waratah Rivulet. Interpretation of this plot is that "There is no evidence of flow loss at low flows in periods of prolonged dry weather and flow recession as might be expected if flow were being affected by mining activity". The interpretation based on the plot is unfounded. The simple plot of flow (ML/day) versus time cannot illustrate whether or not there is any loss of surface flow. The data provided is only for a short monitoring period and the trends should be compared with pre-mining data.

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The SCA's assertion that hydrographs cannot illustrate whether or not there is any loss of surface flow is incorrect. Hydrographs are in reality a valuable signature of a catchment's response to changing conditions and if properly interpreted can tell much about hydrological processes in a catchment including whether flow losses are occurring. This point was also made by Dr Boughton in his review when he pointed out that:

"*Any effect of underground mining on streamflow would be most evident on the very low flows, and would show as a transmission loss on the characteristics of the low flows. Therefore, the part of the assessment dealing with low flows is most important in looking for such effects.*

Figure 19 of the Gilbert & Associates report dated August 2008 shows the recorded streamflow on Waratah Rivulet. I have examined the raw data in addition to the plot in Figure 19, and can see no evidence of any transmission loss or similar loss in the low flows that might be attributed to effects of underground mining."

2.3 At the third (3rd) dot point on page 9 of their submission the SCA assert that comparison of flow data from different catchments presented in the assessment report is both inadequate and invalid.

The comparison of a data from a disturbed site with control data from other similar sites that have not been subject to the same disturbance is a well established standard and accepted method for identifying impact in surface water hydrology and many other fields of environmental science. In this case a comparison between flows recorded at the SCA's Waratah Rivulet gauging station, which was established in February 2007, has been made with flows recorded contemporaneously at 2 other similar catchments which have not been affected by longwall mining (Woronora River and O'Hares Creek).

The SCA point out that each catchment will have different hydrological responses.

The study and comparison of natural environments necessarily requires comparison between similar but not exact sites. Basic hydrological analysis includes normalisation of catchment yield with respect to area which allows reasonable comparison between catchments. It is hard to see how the fact that low flows observed in Waratah Rivulet are generally consistent, and if anything higher than, those recorded at the other two catchments could be interpreted as anything other than evidence that the catchments are behaving similarly and that Waratah Rivulet is not displaying any sign of longwall mining flow loss.

The SCA expand on this issue in their letter to Helensburgh Coal where they assert that Woronora River and O'Hares Creek are "hydrologically quite dissimilar particularly during low flow periods, irrespective of mining impacts". The SCA have provided no basis for this claim which is contrary to the recorded hydrographs from the 3 catchments – refer plots below. This is contrary to the recorded hydrographs from these three catchments which indicate that:

- the three catchments have similar (almost identical) rates of rise in response to rainfall;

- they produce similar amounts of runoff (per catchment area);
- they have similar (almost identical) recession rates following rainfall; and
- they have similar baseflow behaviour.

This is as would be expected with catchments of similar size in the same location, which have similar topography, vegetation and geology.

If there are differences (as would be expected between different catchments) these differences do not appear as lower baseflow in the Waratah Rivulet. It is reasonable to conclude that this is positive and clear evidence that longwall mining has not affected the hydrological response – and importantly low flows – in Waratah Rivulet.

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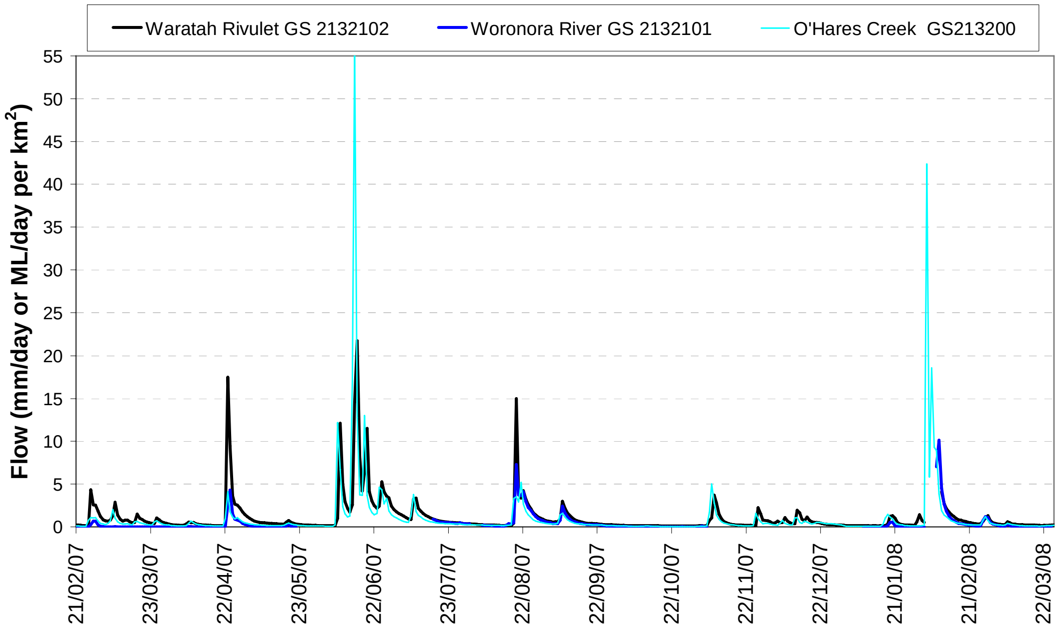

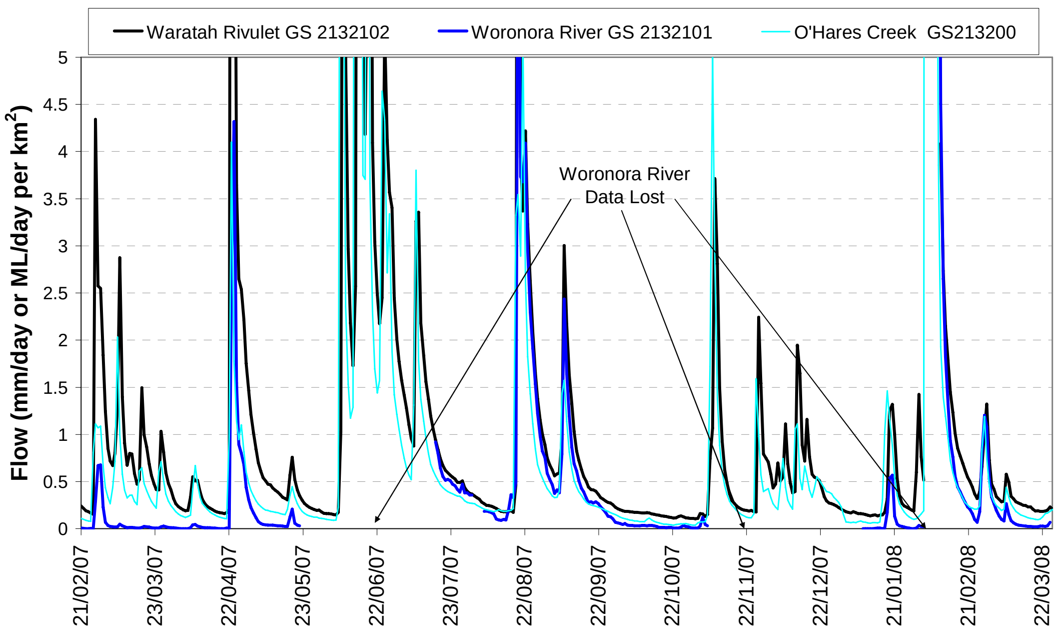

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2.4 At the fourth (4th) dot point on page 9 of their submission the SCA assert that

Calibration and validation of a streamflow model for the Waratah Rivulet for concluding there is no loss of surface flow due to mining is considered to be inappropriate.
The EA surface water assessment report states that "A streamflow model was able to be calibrated to recorded streamflow data on Waratah Rivulet. The model fit is good; model parameters are consistent with other regional stations and reflect the nature of the catchment". The SCA notes that the model was calibrated with data taken during mining. Calibration should be made with pre-mining data. Comparison with other catchments is not a valid way to determine whether the fit of the model is adequate. The model is not valid as it should be compared to baseflow gain-loss from pre-mining data.

The model was used in the surface water assessment studies to further test whether there is ay evidence of streamflow loss. The method adopted to do this is described in Section 7.1.5 of the surface water assessment report as follows:

"*3. A streamflow model was able to be calibrated to recorded streamflow data on Waratah Rivulet. The model fit is very good, model parameters are consistent with other regional stations and reflect the nature of the catchments.*

4. The model used does not have a loss term and it was found that it was not possible to obtain as good a fit if a loss term was introduced into the model – confirming that the observed behaviour is consistent with no losses occurring from the catchment."

The implication of point 3 above is that the model is able to reproduce the current hydrological behaviour of the catchment and is therefore a good representation of the hydrological processes that are occurring in the catchment. The implication of point 4 above is that the recorded hydrological behaviour (2007 to 2008) is consistent with there being no flow loss and inconsistent with flow losses of the magnitude used in the analysis.

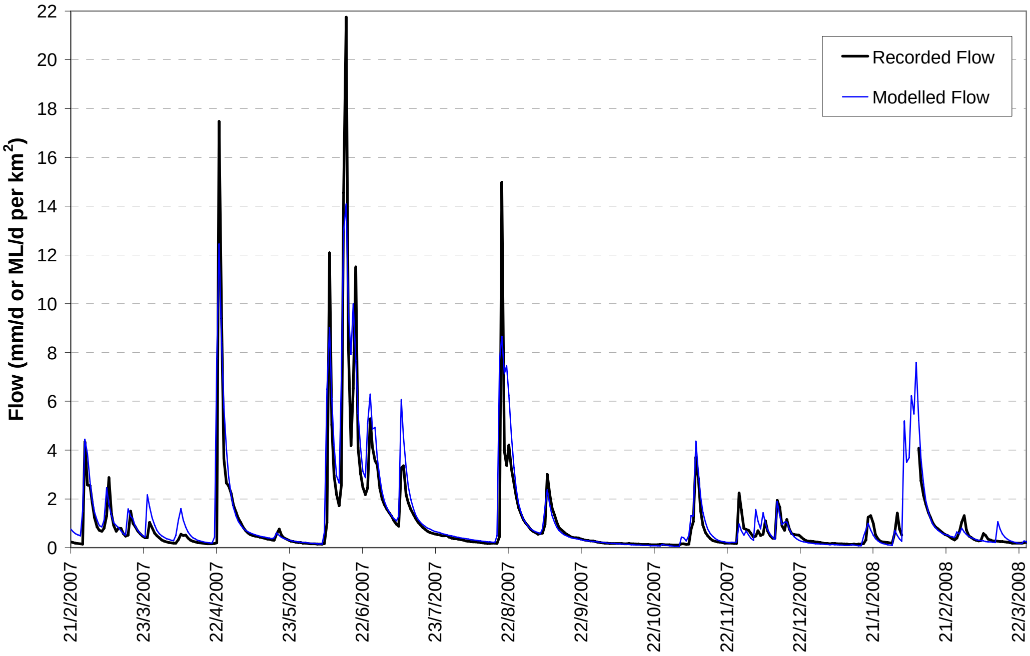
Given this it is difficult to see how a conclusion that this analysis is inappropriate could be reached. The fact that there is no pre-mine flow monitoring data for Waratah Rivulet which can be used to compare baseflow loss does not invalidate the conclusions made in the assessment report.

In their letter to Helensburgh Coal, the SCA use a somewhat different argument against the modelling used in the surface water assessment where they claim that the modelling conducted by Gilbert & Associates and reviewed by Dr Walter Boughton is unreliable due to significant discrepancies in the calibration which they then link to:

1. the short duration (16 months) of streamflow record used in the calibration and the fact that this data would incorporate any effects of longwall – as an inevitable consequence of it being collected after longwall mining commenced, and

2. a mistaken belief on their part that data from O'Hares Creek gauging station and/or Woronora River gauging station data was also used in the calibration.

The calibrated model gives a close fit to the observed data and is therefore well calibrated to the observed data – refer figure below from the Surface Water Assessment Report. Whilst the model was calibrated against recorded streamflows corresponding to a period after longwall mining commenced, that in itself does not make it an invalid tool for analysing components in a catchment water balance from a process perspective. Specifically the model was used to assess whether the recorded data showed any indication of flow loss. A version of the model which did not have a loss term was able to reproduce the observed flows while a model with a loss was not able to reproduce the observed flows as closely. This is a valid means of assessing whether losses are evident in the recorded flow data and taken with the results of the other analyses undertaken supports the conclusions reached in the report.



The second alleged discrepancy in the model calibration (i.e. using data from the O'Hares Creek and the Wornora River catchments) is incorrect because data from these catchments were not used in the calibration.

3.0 SCA Science Investigations (Page 10 and 11 of the SCA submission)

In their submission the SCA report-

> The SCA has investigated rainfall and flow records within the Waratah Rivulet for the period 2007-2008 and concluded that there is a loss of flow from the Waratah Rivulet

and further that the:

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SCA interpreted and evaluated the flow data in the Waratah Rivulet at three gauging stations (Metropolitan Colliery monitoring stations upstream of longwalls 1 to 14 mining area and downstream of longwall 1 to 14 mining area and SCA monitoring station at end of the system – Waratah Rivulet inflow into the Woronora Reservoir).

and further that:

Results of modelling undertaken in the Waratah Rivulet to assess whether any loss of surface flow is occurring indicate there is a loss of water of approximately 3.7 ML/day or 30% from the upstream Helensburgh Coal gauging station 300017 to the downstream SCA gauging station 2132102 from April 2007 to August 2008.
The SCA science investigations were independently reviewed and have been confirmed as appropriate.

There are no further details provided about the modelling. We have undertaken an analysis using data from the 2 HCPL gauging stations (3000016, near the upstream end of the Longwall 1 to 14 area, and 300017 downstream of Flat Rock crossing and the Longwall 1 to 14 mine area) and their “end of system” gauging station (2132102).

Figure 1 below shows the comparison between flows recorded at the two HCPL gauging stations (300016 and 300017).

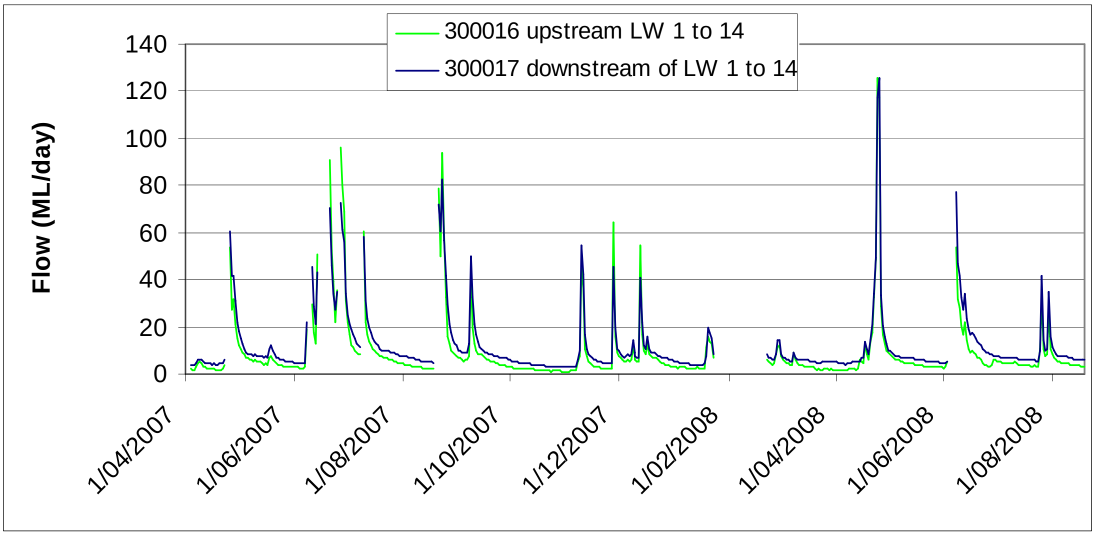

Figure 1 Comparison of Flows Recorded Upstream and Downstream of Longwall 1 to 14 Area

During periods of low flow, recorded flows at the upstream station (300016) are consistently lower than recorded flows the downstream site (300017). This comparison does not support the SCA claim that the recorded flow data indicate a loss of flow due to mining.

Figure 2 below shows the comparison between flows recorded at the downstream HCPL gauging station 300017, which is downstream of the Longwall 1 to 14 area, and SCA’s end of system gauging station (2132102).

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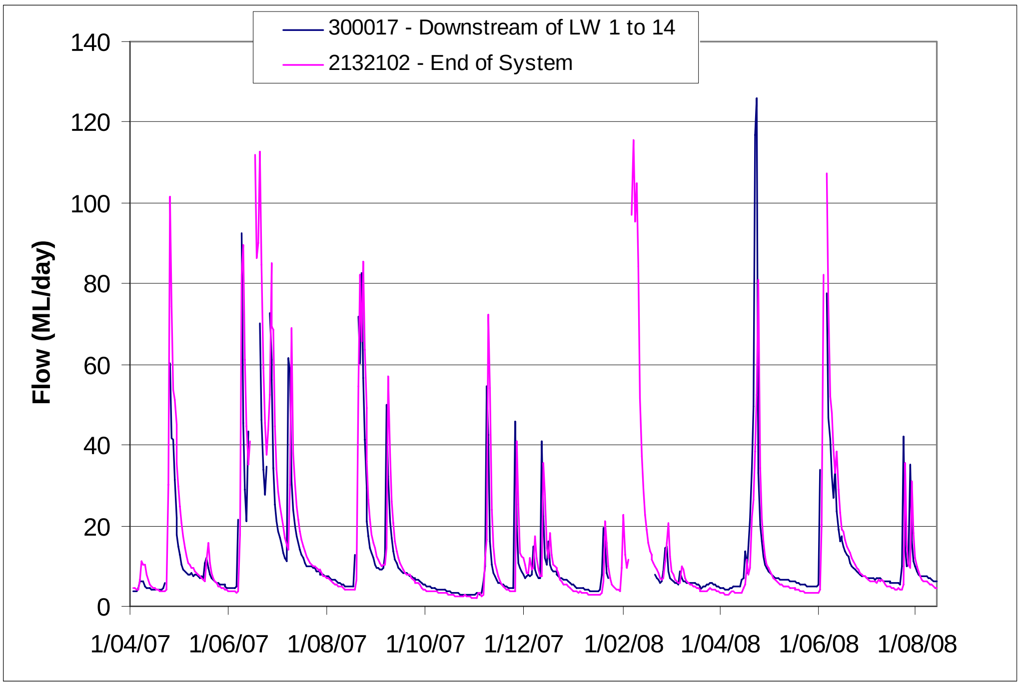

Figure 2 Comparison of Flows Recorded Downstream of Longwall 1 to 14 Area and End of System Flows

In this comparison recorded flow during periods of low flow are (generally) higher at the more upstream of the two sites being compared i.e. the HCPL gauging station below Flat Rock Crossing Station (300017). This is contrary to what would be expected and suggests a loss of low flows is occurring between the 2 locations. However given that there has been no longwall mining conducted between these two locations this does not seem to be evidence of losses due to longwall mining activities. It is understood that this is the comparison used by the SCA to conclude that there is a loss of flow from the Waratah Rivulet at the end of the system.

As this apparent loss is unexpected we have checked the accuracy of the data. Details of these checks which are provided in the attachment to this response show that:

1. The rating curve used to generate flows at the upstream gauging station (HCPL 300017) has a bias toward over estimation of low flows.

2. Checks on ratings at the downstream gauging station (2132102) by comparison indicate that the rating curve used to generate flows at that site significantly under estimates low flows.

3. The sensitivity of the HCPL gauging station (300017) is particularly low at low flows and this further limits the accuracy of recorded low flows at this site.

4. The systematic bias of over estimation of low flows at and low sensitivity of the upstream gauging station (300017) and the evidence of under estimation of low flows at the downstream (2132102) gauging station prevent any credence being given to the claimed loss in flow - rather the apparent loss is due to error in the low flow data used in the analysis.

5. If the recorded flows are adjusted to account for the apparent over estimation of low flows at the upstream site and the under estimation of low flows at the downstream gauging station there is no evidence of flow loss between the two locations. <u>In fact there is evidence of a flow gain.</u>

6. Significant improvement to the low flow control at the HCPL station (300017) (e.g. by construction of a weir) together with improvements to the low flow sections of the rating curves used to generate flows would be required before a meaningful comparison between low flows at the two sites could be undertaken. <u>It was for this reason and the fact that the SCA end of system gauging station is more relevant to an assessment of impacts on inflows to Woronora Reservoir that the analysis presented in the EA utilised the SCA gauging station data (i.e. the HCPL gauge is considered to be unreliable particularly at low flows).</u> HCPL has previously pointed this out to the SCA and requested permission to improve the flow control.

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Attachment

Check on the Accuracy of Flow records from Gauging Stations 300017 and 2132102 on Waratah Rivulet.

Rating Curves

Flow at these two gauging stations has not been measured directly; rather it has been calculated from recorded water levels via rating curves (water level versus flow) that have been developed for those gauging stations. The rating curves have been developed using results of manual flow measurements (known as gaugings), which have been conducted at different water levels.

The rating curve and the individual gaugings used in the development of the curve at the HCPL (300017) gauging station are shown on Figure 3 below. Figure 3 shows the low flow section of the rating curve with water levels between 0.3m and 0.4m which corresponds to rated flows between 0 and about 10 ML/day.

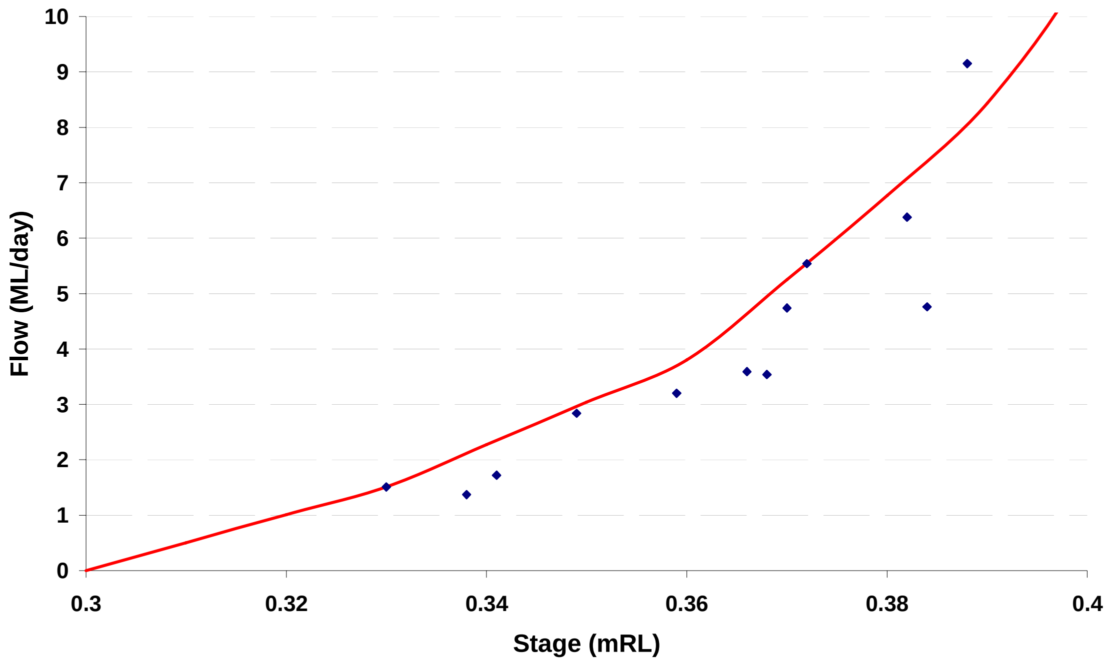

Figure 3 Rating Curve and Low Flow Gaugings – HCPL Gauging Station (300017)

It is apparent that there is significant scatter in the gauging results and that most (7 out of 11) of the gaugings undertaken over this flow range plot below the rating curve with only 1 plotting above the rating curve. This suggests that the rating curve is biased above the gauged flows over this part of the flow regime resulting in a systematic over estimate of flows generated using the curve. The magnitude of bias is probably in the order of 1ML/day with the overall scatter being up to 2ML/day.

We have been unable to obtain the individual gaugings used in the development of the curve at the SCA gauging station. As a check however we commissioned a gauging survey at the site. The survey involved some 15 gaugings at gauging heights (stage) ranging from 0.069 to 0.106m. Results of these gaugings are shown relative to the rating curve used to generate flows on Figure 4 below.

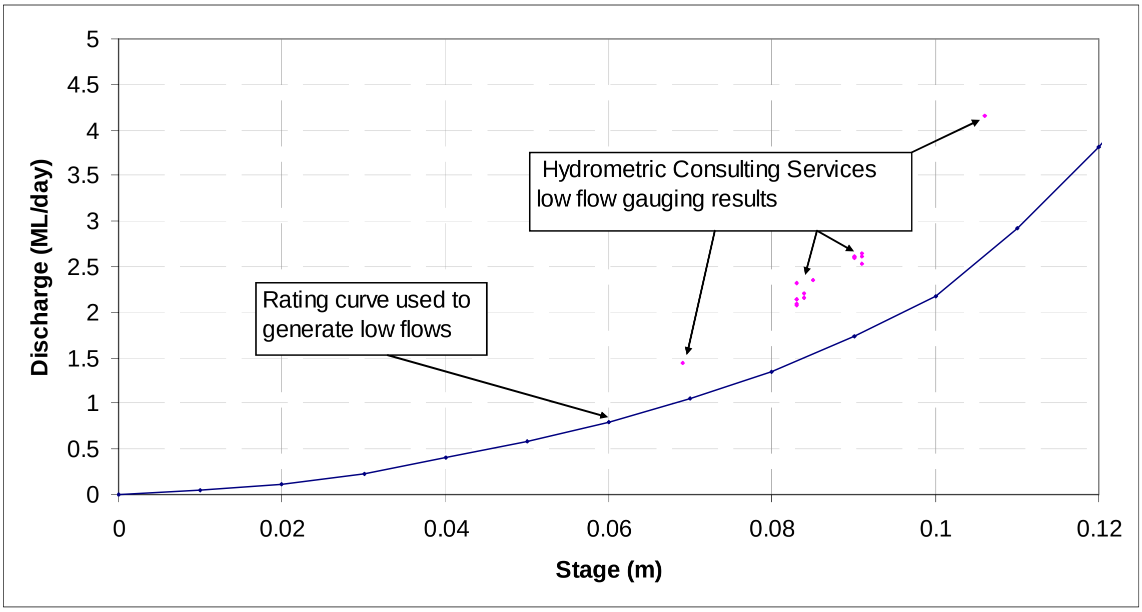

Figure 4 Rating Curve and Low Flow Gaugings – SCA Gauging Station

The gauging survey data suggest a systematic discrepancy (under estimation) between gauged flow and the rating curve over the range of the gaugings (1.5 – 4ML/day). The discrepancy appears to be in the order of 1 ML/day.

Sensitivity of Gauging Station Controls

The sensitivity[5] of flow measurement is also an important factor in assessing the reliability of flow records. The low flow sensitivity of the two gauging stations is shown in Figure 5 below.

[5] The sensitivity of a gauging station depends on how much a change in flow is reflected in a change in water level. A gauging station has low sensitivity, and therefore greater inherent measurement error, if a large increase in flow results in a small increase in water level.

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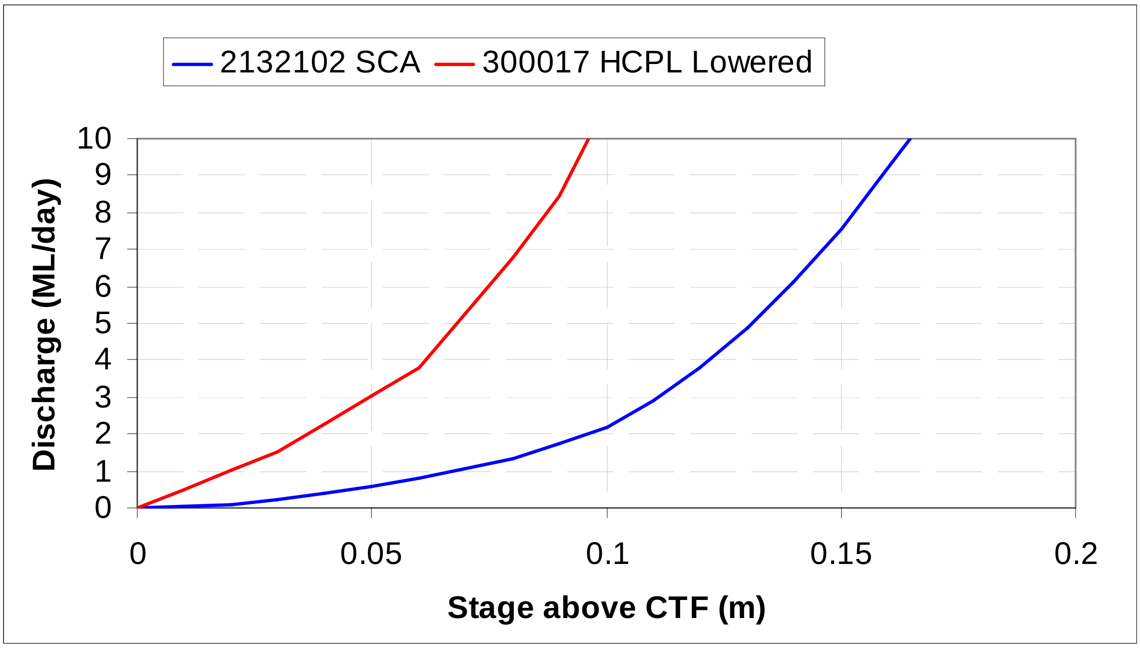

Figure 5 Low Flow Sensitivity of SCA and HCPL Gauging Stations

Figure 5 shows the rating curves used to generate flows from the two stations plotted so they have the same zero flow level. It is apparent that the SCA gauging station is significantly more sensitive at low flows than the HCPL gauging station. The increase in water level corresponding to an increase in flow from zero to 1ML/day is about 2cm at the HCPL gauging station and about 7cm at the SCA gauging station. The SCA site will therefore provide more sensitive estimates of low flow. <u>The SCA gauging station data is utilised for the analysis presented in the EA.</u>

Photographs of the low flow controls[6] of the two gauging stations are reproduced as Plates 1 and 2 below.

[6] The term low flow control used here refers to a constriction in the creek bed profile which controls water levels upstream. A typical gauging station comprises a pool where the water level sensor is located and the control section or constriction downstream of the pool which dictates water levels in the pool upstream.

Plate 1 **Low Flow Control at SCA Gauging Station - Viewed Looking Downstream**

The low flow control at the SCA gauging station is in a natural confined and uniform “slot” in the rock. A low concrete levee has been constructed on the right hand side of slot to further confine flows. The uniform flow conditions in the slot upstream of the control are more conducive to accurate low flow gauging than those that prevail at the HCPL site – refer discussion below.

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Plate 2 Low Flow Control at HCPL Gauging Station – Viewed Looking Across Control

Low flows at the HCPL low flow control section pass down a narrow channel on the right bank side (i.e. at the top of the photograph). As flow increases it breaks out over the central section of the channel as it has in this photograph. These central flows are too slow to gauge accurately and conditions in the right bank channel are difficult to gauge accurately[7]. HCPL has previously pointed this out to the SCA and requested permission to improve the flow control.

[7] Personal Communication: Steve Swanbury of Hydrometric Consulting Services.

Conclusions

1. The rating curve used to generate flows at the upstream gauging station (HCPL 300017) has a bias toward over estimation of low flows.

2. Checks on ratings at the downstream gauging station (2132102) by comparison indicate that the rating curve used to generate flows at that site is significantly under estimating low flows.

3. The sensitivity of the HCPL gauging station (300017) is particularly low at low flows and this further limits the accuracy of recorded low flows at this site.

4. The systematic bias of over estimation of low flows at and low sensitivity of the upstream gauging station (300017) and the evidence of under estimation of low flows at the downstream (2132102) gauging station prevent any credence being given to the claimed loss in flow - rather the apparent loss is due to error in the low flow data used in the analysis.

5. If the recorded flows are adjusted to account for the apparent over estimation of low flows at the upstream site and the under estimation of low flows at the downstream gauging station there is no evidence of flow loss between the two locations. In fact there is evidence of a flow gain.

6. Significant improvement to the low flow control at the HCPL station (300017) (e.g. by construction of a weir) together with improvements to the low flow sections of the rating curves used to generate flows would be required before a meaningful comparison between low flows at the two sites could be undertaken. It was for this reason and the fact that the SCA end of system gauging station is more relevant to an assessment of impacts on inflows to Woronora Reservoir that the analysis presented in the EA utilised the SCA gauging station data (i.e. the HCPL gauge is considered to be unreliable particularly at low flows). HCPL has previously pointed this out to the SCA and requested permission to improve the flow control.

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Water Quality

36. What material(s) is causing the pale green opacity noticed in several pools (eg diatoms, algae, iron flocculant? What is the contribution of each such material? Why is this discoloration present in some pools but not others?

The following response is provided by Associate Professor Barry Noller from the University of Queensland. Associate Professor Noller is familiar with the environmental processes of Waratah Rivulet and its characteristics following previous site inspections and involvement with scientific studies at the Metropolitan Colliery. Associate Professor Barry Noller also supervised an Honours study investigating iron chemical forms and associated sources of water entering Waratah Rivulet.

The pale green opacity observed in a few pools in Waratah Rivulet is the result of very fine material (i.e. colloids or nanoparticles less than 0.45 µm in size, generally finer than clay which is >2.0 µm) being present in the water column and the reflection/scatter of sunlight off these particles. Fine material results from the conversion of ferrous iron in contact with oxygen in air to give ferrihydrite (or iron precipitate). Because the reaction is fast, it promotes the formation of very fine particles. Note, the formation of iron precipitate/staining is described further in the responses to PAC Questions 37 and 38 below.

In still water, fine particles settle out of the water column according to Stokes Law. In areas with greater surface flow, underflow or seepage, fine particles may disperse into the water column. In pools where the fine particles attach to algae or aquatic vegetation, the amount distributed in the water column appears to be reduced.

Depending on the pool characteristics (e.g. the amount of flow, rate of ferrihydrite formation, presence of algae or aquatic vegetation), the formation of ferrihydrite can result in fine particles being dispersed in the water column. Light reflecting from the particles can give the appearance of a pale green opacity to the water.

37. Please provide evidence that the red staining visible from the air on tributaries and on the ground at Honeysuckle Creek is the same in nature, degree and primary cause as the red staining present in Waratah Rivulet in the area previously mined and downstream to the boulder field.

The following response is provided by Associate Professor Noller.

The red staining is iron precipitate or ferrihydrite which is derived from iron in the naturally-occurring sandstone. Iron staining occurs when water that has been in contact with naturally-occurring iron minerals in sandstone is reduced to the soluble ferrous form of iron (Fe^{2+}) (ferrous iron) giving rise to dissolution of iron minerals. When seepage comes in contact with air, the ferrous iron is oxidized to an insoluble ferric form (Fe^{3+}) (ferrihydrite). That is, water entering the shallow sandstone causes iron minerals to dissolve and be re-precipitated as red stain (ferrihydrite) when emerging water enters the stream flowing water. The whole cycle of iron dissolution and re-precipitation is a natural one and involves no input from man-made sources including deeper mining. When rainfall saturates the sandstone, more iron is precipitated. Natural iron staining is evident in a number of streams.

Mining causes sub-surface and surface cracking. Water enters the cracks in the sandstone and comes into contact with iron minerals. Iron staining occurs when the water is exposed to oxygen as it re-enters the stream. In essence, mining accelerates the natural process described above.

In areas previously mined it is evident that mining-induced iron staining extends only a limited distance downstream from the mining zone. In these areas, either surface cracking is evident or there are locations at which underflow re-enters the stream.

Honeysuckle Creek is situated a considerable distance from previous and current mining at the Metropolitan Colliery (i.e. it has not been subject to mine subsidence effects). The natural iron staining shown in the film footage of Honeysuckle Creek to the Planning Assessment Commission during the site visit has resulted from the natural process described above.

The iron precipitate (ferrihydrite) is red in colour. After a period of several months to a few years the red ferrihydrite will convert to the crystalline form of goethite which is darker red-brown in colour. This is the same for areas subject to mining-induced iron staining and natural iron staining.

38. The eastern tributary to Waratah Rivulet was observed from helicopter fly over to be heavily iron stained over most of its observed course. Is this a result of early longwall extractions beneath the upper reaches? Could similar staining in the western tributary be a result of mining? How long would the iron staining persist post mining?

The following response is provided by Associate Professor Noller and HCPL.

The formation of natural and mining-induced iron staining is described in the response to PAC Question 37 above. The headwaters of the eastern tributary (i.e. the section of the stream situated to the south of the Project Underground Mining Area) have been undermined by the Metropolitan Colliery. As a result, some of the iron staining in the eastern tributary would be a result of early longwall extraction beneath the upper reaches. Mining-induced iron staining extends only a limited distance downstream from the mining zone. In these areas, either surface cracking is evident or there are locations at which underflow re-enters the stream.

It is clear that iron staining in the lower reaches of the eastern tributary is a result of natural processes as this section of stream is well outside of the influence of mining.

Could similar staining in the western tributary be a result of mining?

It is not considered possible that the iron staining in the lower reaches of the Reference Tributary observed during the Metropolitan Colliery site inspection is a result of mining given the location of previous and current mining and their associated subsidence effects.

How long would the iron staining persist post mining?

After a period of several months to a few years the red ferrihydrite will convert to the crystalline form of goethite which is darker red in colour. The latter precipitate is commonly seen in natural creeks in sandstone environments where water passes over exposed surfaces.

Site Water Management

39. It is not clear from the EA what site water management improvements are proposed. Please detail any mine site water management measures that are proposed.

The key improvements proposed to the water management system are:

I. Preparation and implementation of a new Site Water Management Plan.

II. Increase in site water storage capacity.

III. Water treatment plant upgrade.

I. <u>Preparation and Implementation of a Site Water Management Plan</u>

The existing Site Water Management Plan (SWMP) was prepared to meet the requirements of Pollution Reduction Program (PRP) 7, in Environmental Protection Licence (EPL) No. 767.

It is recognised however, that Project upgrades will require the SWMP to undergo some amendment, specifically to incorporate changes to Project related activities such as the CHPP upgrade, increased consumption resulting from increased production, introduction of the proposed paste plant and the increase in site water storage capacity.

As such, the implementation of the SWMP is recognised as fundamental to efficient and effective site water management and thus forms a defined commitment of the Project proposal.

II. Increase in Site Water Storage Capacity

The existing treated water storage capacity on site is 600 kilolitres. This is the total available quantity that may be stored to meet operational demands. This capacity consists of three main tanks, being a 200 kilolitre tank (known as the 'hill tank') and two conjoined 200 kilolitre tanks (known as the two 'underground supply tanks'). All water used on site is treated prior to use, with the exception of any surplus drawn from the potable supply.

It is noted that while the sediment ponds and Turkeys Nest dams do incidentally capture some rainfall, their role in storm water management renders them unable to store water for operational needs (i.e. they must be kept low so as to enable sufficient capture of water during storm events).

Therefore, the proposed Project has included the addition of a 1 ML storage tank (located next to the existing hill tank). This additional storage tank would improve the capacity to store treated water onsite and therefore reduce the volume of treated stormwater needing to be discharged to Camp Gully under licence. The ability to conserve greater quantities of recycled water would also reduce the level of potable water consumption.

III. Water Treatment Plant Upgrade

The recycling water treatment plant is proposed to be upgraded as a component of the Project to increase the efficiency of the water treatment plant. Design options being investigated include:

- an upgrade of the water treatment plant pump capacity to increase the recycling capacity of treated water; and/or
- increasing the height of the thickener or lowering of the sand filters in the water treatment plant to improve the gravity feed of water.

40. Please outline the principles, practices and commitments which characterise current and proposed site water management.

There are a number of key principles, practices and operational commitments embodied in the design of the existing water management system. These are to:

I. Minimise disturbed areas.

II. Isolate and contain runoff.

III. Treat and recycle as much water as possible.

IV. Ensure erosion and sediment control.

V. Continually look for refinement and improvement opportunities.

These are discussed briefly as follows.

I. Minimise disturbed areas

The area of the surface facilities is naturally constrained due to the valley location and surrounding topography. This has enabled a minimal disturbance zone.

II. Isolate and contain runoff

The existing water management system is also designed to isolate and contain runoff, with a network of drains and culverts which catch and divert clean (upslope) runoff before it enters the site.

Rain falling directly onto site (as well as any incidental runoff, such as from dust suppression activities) is contained by a separate network of dirty water drains, pits, sediment ponds and dams. All water, except in very rare, intense rainfall events, is fed to the water treatment plant, where it is treated, before being recycled. Water pumped from the underground mine is also sent to the water treatment plant for recycling. This design provides the ability to isolate clean and dirty water.

III. Treat and recycle as much water as possible

All water used on site is treated prior to use, with the exception of any surplus drawn from the potable supply. This treatment allows recycling of site water, a key principle of the water management system.

The treatment process involves adding a single chemical (a generic coagulant).

Post water treatment, water is reticulated around site as required, stored for later use, or discharged to Camp Gully in accordance with EPL 767. As such, the vast majority of dirty water collected on site is recycled.

IV. Ensure erosion and sediment control

Erosion and sediment management measures are considered prior to the undertaking of any works within the surface facilities area. These considerations are assessed through the mandatory completion of an environmental checklist, within a HCPL 'Notification of Surface Works' form.

Various erosion and sediment control measures are also used across the site, including concrete spillways, concrete causeways, vegetated slopes, geotextiles, sediment pits and traps. Regular desilting of dams and ponds also occurs as necessary.

V. Continually look for refinement and improvement opportunities

Through initiatives such as the Water Savings Action Plan (WSAP), the site has already made significant reductions in the level of potable consumption. The Project would continue to build on the Metropolitan Colliery WSAP initiatives undertaken to date to increase the efficiency of water use and minimise the requirement for make-up water and off-site water releases. The WSAP will be reviewed and revised, where appropriate, as a component of the Project.

Groundwater

41. Is it possible to obtain a (pdf) copy of Geosensing Solutions 2008 report referred to in the Groundwater report by Dr. Merrick?

A copy of the Geosensing Solutions (2008) report titled *A Compilation of Surface Geological Features in the Western Portion of Metropolitan Colliery* was provided to the Planning Assessment Commission on 30 January 2009.

42. How many exploration holes have been drilled and geophysically logged in the proposed longwall area. Is there a sufficient density to establish continuity in geologic strata and absence of major structures (faults, dykes)?

Geological investigations have been conducted to support proposed mining within the Dams Safety Notification Zone. The geological investigations have been presented to the Dams Safety Committee. No major geological features are considered to be present within the future mining zone.

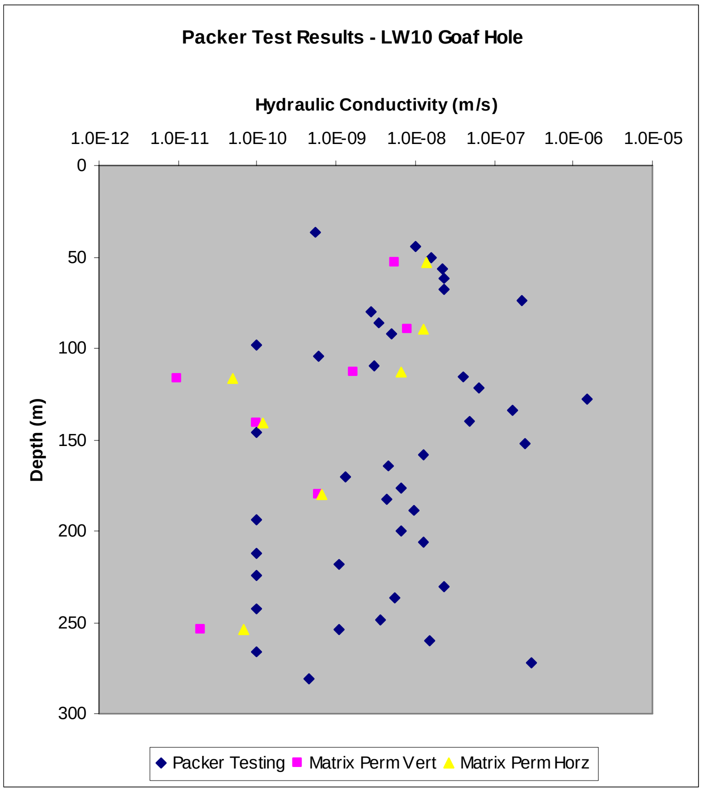
Additional geological investigations will be conducted well in advance of longwall mining by drilling long in-seam (1600 m) exploration holes. It is envisaged that approximately eight holes will be drilled at regular intervals from the gateroad of each longwall. As mining enters the Dams Safety Notification Zone, the exploration holes will overlap and provide a clear indication of the presence of major features if present.

The geological characterisation within the Dams Safety Notification Zone will be conducted to the satisfaction of the Dams Safety Committee.

43. The EA provides general statistics of permeability tests conducted within the area (Merrick Report). How many holes have been subjected to core and packer permeability testing? Is the data set reported elsewhere?

The LW10 goaf hole is the only hole that has been subject to core and permeability packer tests and are summarised in Table 6 of EA Attachment B. Packer tests show a range in hydraulic conductivity from 10^{-10} to 10^{-6} m/s, that is 10^{-5} to 10^{-1} m/d, with no clear depth dependence [see figure below]. The calibrated model (Model A) horizontal values range from 10^{-5} to 10^{-1} m/d (Table 9 of EA Attachment B).

Core tests have a narrower range from 10^{-11} to 10^{-8} m/s, that is 10^{-6} to 10^{-3} m/d, for Hawkesbury Sandstone, Bald Hill Claystone and Bulgo Sandstone [see figure below]. The calibrated model (Model A) for these formations has horizontal values ranging from 1.10^{-5} to 2.10^{-1} m/d and vertical values ranging from 4.10^{-6} to 5.10^{-1} m/d (Table 9 of EA Attachment B).



44. ***Groundwater modelling in the EA utilised Modflow while modelling in a more recent report utilised the Surfact variant. It would be useful to see and compare a vertical section plot for each model which clearly shows contours of formation pore pressures - say column 100 in the model (steady state). This section needs to be generated in sufficient detail to indicate the freely draining zone above goaves for current and proposed longwalling.***

As requested, cross sections have been prepared along column 100 from south to north for two models:

- Recent mining - Longwalls 1-14 (with fractured zone), including neighbouring old workings and first workings.
- Final mining - Longwalls 1-44 (with fractured zone), including neighbouring old workings and first workings.

The mining footprints are illustrated in Figure GW-1 (recent mining) and Figure GW-2 (final mining).

For each model, cross-section plots of total piezometric head are compared for two software approaches:

- Standard-MODFLOW.
- MODFLOW-SURFACT.

For the *recent mining* scenario, the comparison of simulated groundwater level contour maps is presented in Figure GW-3. The relatively thin coal seam (Layer 12) is colour coded where mining is active – yellow for neighbouring mines; and green for Longwalls 1-14 (in accordance with Figure GW-1). Figure GW-3(a) shows "dry" cells (purple) above the coal seam in Layer 11 (Coal Cliff Sandstone) for Standard-MODFLOW. MODFLOW-SURFACT [Figure GW-3(b)] shows continuity of heads across all layers, with significant depressurization over and above the longwalls, and apparent drainage towards the goaf. [*The height of depressurization can be gauged from the thickness of the bottom layer, which is 100 metres thick*.]

For the *final mining* scenario, the comparison of simulated groundwater level contour maps is presented in Figure GW-4. Layer 12 is colour coded to indicate mined cells - yellow for neighbouring mines; green for Longwalls 1-14; and pink for Longwalls 15-44 (in accordance with Figure GW-2). "Dry" cells are more extensive with Standard-MODFLOW [Figure 4(a)], rising up to Layer 7 (Stanwell Park Claystone). Figure GW-4(b) shows that MODFLOW-SURFACT is able to calculate consistent heads across the depressurized fractured zone above the longwall panels. The lateral extent of depressurization is greater (than for the recent mining case), but there is no apparent increase in the height of depressurization.

A Peer Review of the groundwater study was conducted by Dr. Frans Kalf and the findings are presented in Attachment 4. The review concludes:

> *Based on the reports provided above and evidence to date, I agree with the Merrick report conclusion that the predicted potential effects to surface systems as a result of groundwater depressurisation at depth are simulated to be so small as to be within the limit of accuracy of modeling. Based on the modeling results presented by Dr Merrick, the effects on surface water flow overall would not be measurable, given the usual method of surface flow monitoring.*

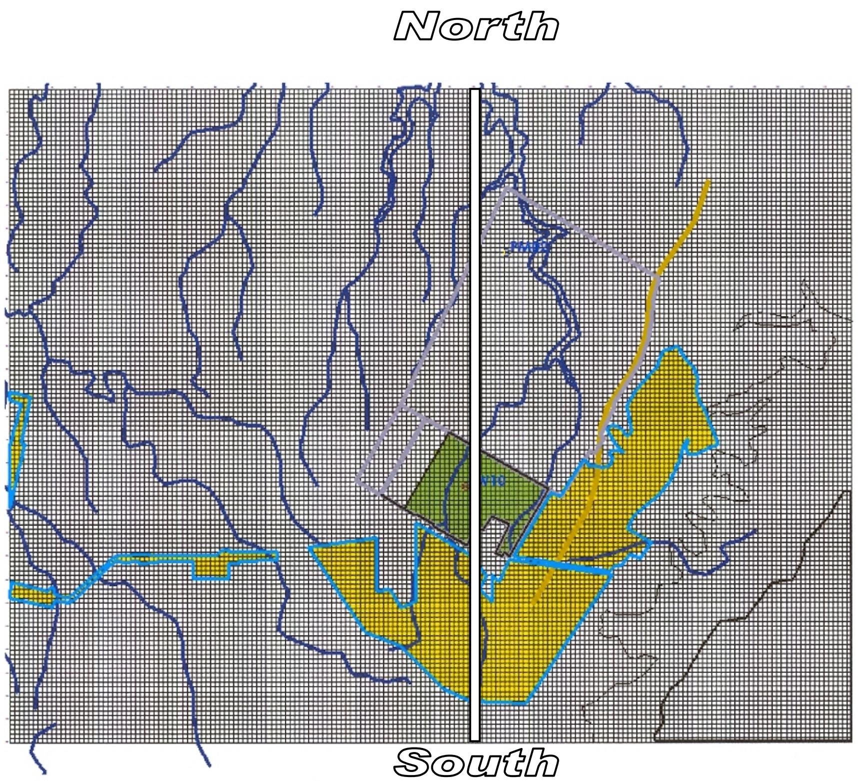


Figure GW-1. Mining footprint for “recent” mining consisting of Longwalls 1-14 (green) and neighbouring mines (yellow). Subsequent cross-sections refer to column 100 (white highlight).

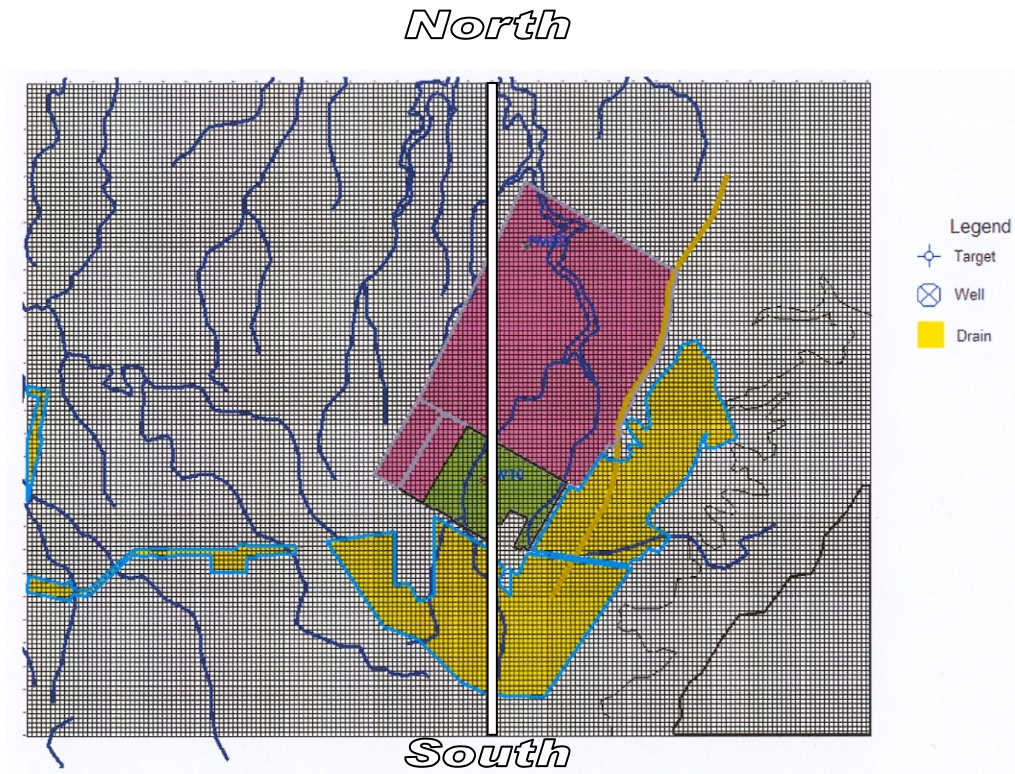


Figure GW-2. Mining footprint for “final” mining consisting of Longwalls 15-44 (pink), Longwalls 1-14 (green) and neighbouring mines (yellow). Subsequent cross-sections refer to column 100 (white highlight).

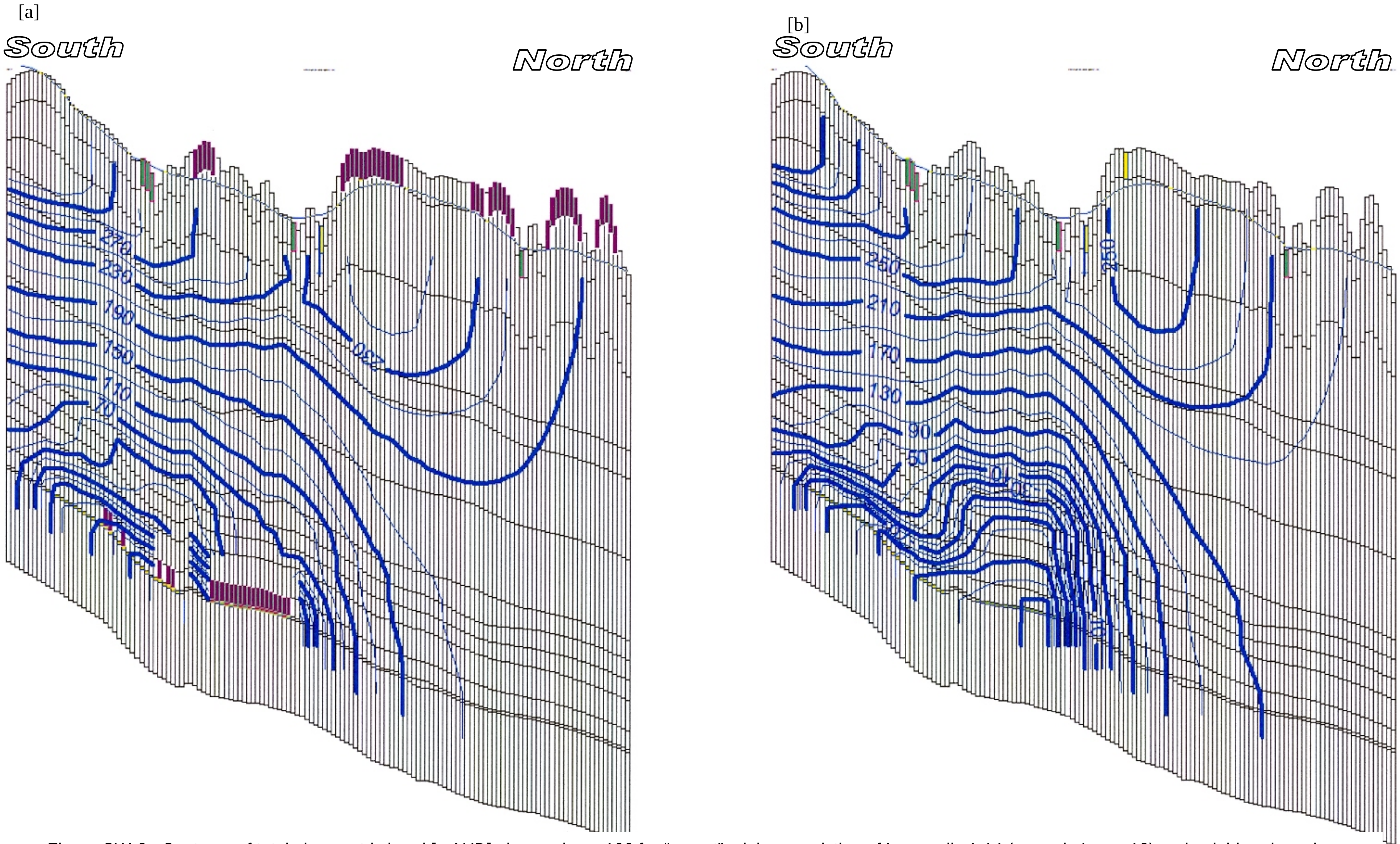
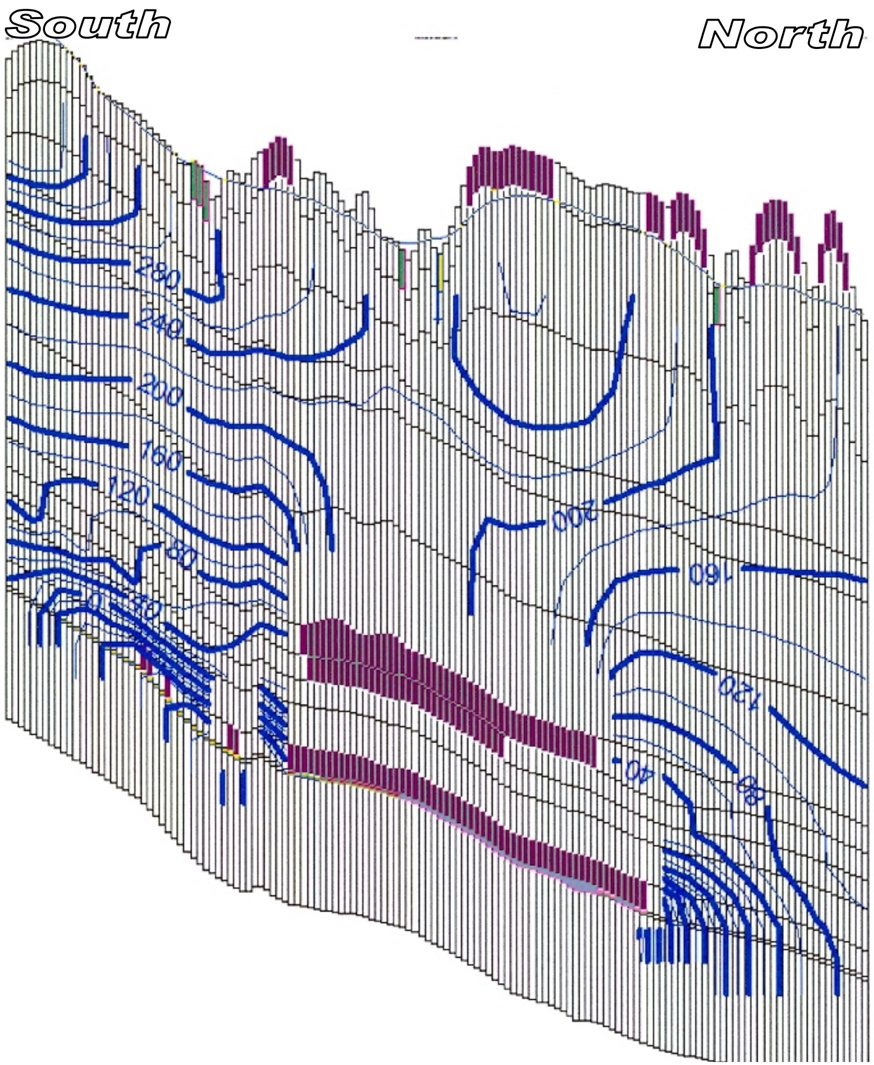


Figure GW-3. Contours of total piezometric head [mAHD] along column 100 for “recent” mining consisting of Longwalls 1-14 (green in Layer 12) and neighbouring mines (yellow in Layer 12): [a] Standard-MODFLOW; [b] MODFLOW-SURFACT

[purple rectangles are “dry” cells]

[a]



[b]

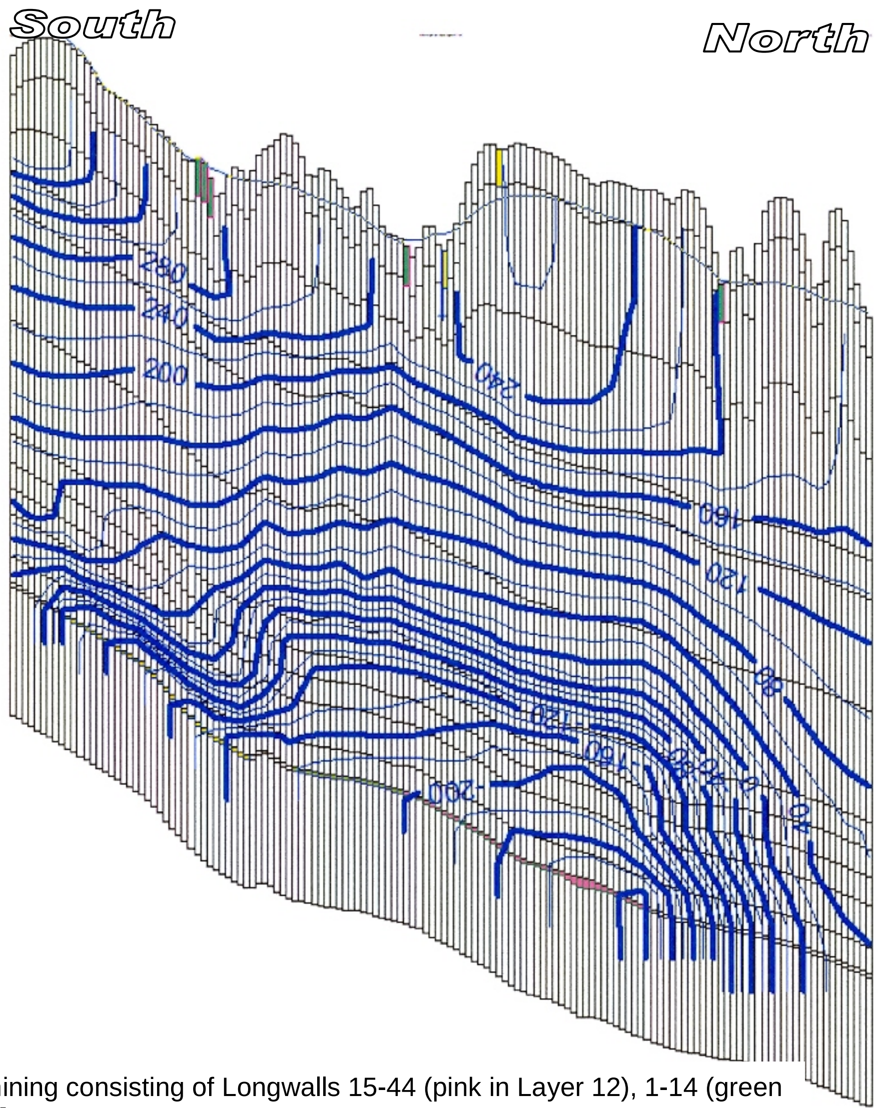


Figure GW-4. Contours of total piezometric head [mAHD] along column 100 for "final" mining consisting of Longwalls 15-44 (pink in Layer 12), 1-14 (green in Layer 12) and neighbouring mines (yellow in Layer 12): [a] Standard-MODFLOW; [b] MODFLOW-SURFACT

[purple rectangles are "dry" cells]

45. Is Figure 12 in the surface waters report correct (the plot seems to suggest rapid falls in water levels - metres below top of casing)?

Figure 12 in the Surface Water Assessment (Appendix C) is correct. The plot shows the groundwater level relative to a reference mark on the bore casing which may protrude by up to 1 m from the ground level (i.e. the datum point for these holes is not at the ground surface, but at a point taken on the bore casing). The plot shows swamp water levels responding rapidly to rainfall. Swamps 1, 2 and 3 shown on Figure 12 in EA Appendix C are situated to the north of the current mining area and outside the zone of potential subsidence effects. The Swamp 1, 2 and 3 monitoring locations are shown on Figure 7 in the Groundwater Assessment (Appendix B).

46. PUR was observed in some remediated cracks at rock bar WRS4 to have lost adherence to the crack walls. What is the rated/specified life of this material?

The polyurethane (PUR) grouting products used in the remediation trial activities are products typically used for consolidation, stabilisation and/or sealing of strata. The PUR products used are known to have excellent adhesive power, forming a strong bond with strata.

During PUR injection, PUR that extruded at the surface was removed (pulled) during the polymerisation process to maintain the site in a neat and tidy condition. This detached some of the PUR material from the crack surface prior to setting. That is, the above effect (loss of adherence to the crack walls) was noted during the injection procedure.

In addition to the above and as noted during the PAC site inspection, further subsidence movement has occurred at the rock bar (approximately 20 mm in late 2008) which may have further opened some of the existing surface cracks.

Resistance tests conducted by Ingenieurgesellschaft mbH (Ing. mbH, 2008) provide guidance on the mechanical properties (tensile and compressive) of PUR under a range of storage conditions over time. Storage conditions included: air, water, alkaline solution (pH 13), sulphate solution, and acid (pH 4) solution. Testing at 6 month intervals over a 24 month period indicated an *increase* in tensile strength with time in all storage solutions. Since the material gained mechanical strength over this time period, a reliable estimate of workable life could not be determined quantitatively. However, Ing. mbH (2008) concluded that its lifespan was '*a very long lifetime'*.

The CarboPUR material once cured is very stable and Minova has used it for water stopping throughout the world on projects that require 100 year plus design life.

Leaching tests with creek water on test pieces of CarboPUR material and removed PUR grout material conducted by the University of Queensland show insignificant removal of dissolved organic carbon indicating inertness of the formed PUR. Since chemical degradation is not indicated, and since mechanical strength is not likely to degrade for 'a very long lifetime', the only mechanism for PUR degradation in the application to rock bar restoration is physical abrasion due to weathering. This would primarily occur where the PUR is exposed to the stream surface and the PUR is most likely to erode at the same rate as the surrounding rock.

For all practical purposes, PUR injected into rock fractures is considered permanent.

47. Please provide a valuation for expected costs associated with loss of access to groundwater in aquifers disrupted by the mineplan as proposed.

Associate Professor Noel Merrick is of the opinion that no costs are expected to be associated with loss of access to groundwater in aquifers disrupted by the mine plan (i.e. the cost in dollar terms would be zero). The groundwater aquifer is not in commercial use and would not be expected to have a commercial use at any time in the future.

ATTACHMENT 1

GILLESPIE ECONOMICS

CHOICE MODELLING STUDY

MANAGING THE IMPACTS OF A MINE IN THE SOUTHERN COALFIELD

A SURVEY OF COMMUNITY ATTITUDES

Prepared for

Helensburgh Coal Pty Ltd

Gillespie Economics

December 2008

ABSTRACT

As part of Helensburgh Coal Pty Limited's (HCPL) application to Government to continue its underground coal mining operation at the Metropolitan Colliery, a benefit cost analysis (BCA) was undertaken for the Metropolitan Coal Project (the Project). A subset analysis was also undertaken of an alternative mine layout comprising a setback to minimise subsidence effects on the primary stream located in the underground mining area, Waratah Rivulet.

These BCAs focused on the net production benefits of underground mining or the net production costs of a setback. The monetary value of some of the environmental and socio-economic impacts of the Project or a setback was left unquantified, with the remaining trade-off expressed as a threshold value.

To further examine the values of these uncosted residual environmental impacts, a supplementary choice modeling study (CM) was undertaken. CM involves the design and implementation of a questionnaire that contains a number of choice sets that describe the environmental outcomes of alternative policy scenarios in terms of changing levels of a set of environmental and socio-economic attributes. By observing and modelling how people change their preferred policy scenario in response to the changes in the levels of the attributes, it is possible to determine how they trade-off between the attributes. That is, it is possible to determine the value that respondents hold for additional amounts of an attribute.

The CM study for Metropolitan Colliery involved:

- defining the environmental and socio-economic attributes of relevance to the Project;
- designing the CM questionnaire with the aid of focus groups and pretesting;
- compiling the CM experimental design;
- sampling the views of 500 households in the Illawarra Region and 500 households in the rest of NSW via completion of the questionnaire;
- analysing the data collected using conditional logit and nested logit econometric techniques; and
- estimating implicit prices for the environmental and socio-economic attributes included in the study.

The CM study found that respondents were on average willing to pay:

- $4.84 per household per year for 20 years to protect 1 km of stream being impacted;
- $0.43 per household per year for 20 years to protect 1 ha of upland swamp from being impacted;
- $0.37 per household per year for 20 years to protect 1 Aboriginal site from being impacted; and
- $4.17 per household per year for 20 years for every additional year that the mine will provide 320 jobs.

While the CM study found that the community values reducing the impacts of underground mining on environmental attributes, such as streams, upland swamps and Aboriginal heritage sites, it also found that the community values the employment that underground mining provides to the Illawarra Region and the state of NSW.

Conservative application of the CM results to the BCA of the Project indicates that the benefits of the Project to the community outweigh the costs and hence it is economically efficient and desirable from a community welfare perspective.

Application of the CM results to a BCA of a setback from Waratah Rivulet to minimise subsidence effects found that the costs of a setback to the community outweigh the environmental benefits. Consequently, a setback cannot be justified from an economic efficiency perspective.

TABLE OF CONTENTS

1.0 INTRODUCTION

Mining projects in New South Wales (NSW) invariably require Government approval, under Part 3A of the *Environmental Planning and Assessment Act, 1979.* An Environmental Assessment accompanies the application. These Environmental Assessments generally address not only the likely environmental impacts of a project but also consider potential socio-economic impacts.

Assessing the economic impacts of a project or providing economic justification for a project is not simply a matter of providing disparate information on production, employment, taxes and royalties or statements on the importance of a mine for exports or for regional economies (James and Boer 1988). Economics is concerned with the allocation of scarce resources in society (labour, capital and land) to maximise community well-being (Tisdell 1991).

Consequently, to evaluate the economic impacts of a project it is necessary to consider the costs and benefits of it to the community, where the community comprises both producers (e.g. mining companies) and consumers (e.g. households).

To provide economic justification for a project or policy it is necessary to demonstrate that the aggregate benefits of a project or policy to society exceed the aggregate costs to society i.e. that it will have net benefits to the community. The method used by economists to undertake this evaluation is benefit cost analysis (BCA) (James and Gillespie 2002).

In a simplified BCA framework, there is often a trade-off between net production benefits of a mining project and environmental impacts. The former accrue to the mining company and its shareholders, as well as the government through payment of royalties and company tax, whereas any environmental impacts that remain after mitigation accrue to society.

Net production benefits can be readily estimated from market data, including information on revenue, capital costs, operating costs, rehabilitation costs, opportunity cost of land and the residual value of land and capital. However, estimating the value of environmental impacts to the community is more problematic. It requires use of so-called non-market valuation methods. One of the key non-market valuation methods that can be used to estimate community values for a range of environmental impacts is choice modeling (CM).

As part of Helensburgh Coal Pty Limited's (HCPL's) application to government to continue its underground coal mining operation at the Metropolitan Colliery, located 30 kilometres (km) north of Wollongong in NSW, a BCA was undertaken of the Metropolitan Coal Project (the Project). A subset analysis was also undertaken of an alternative mine layout comprising a setback from the primary stream located in the underground mining area, Waratah Rivulet. These BCAs focused on the net production benefits of mining or the net production costs of a setback. The monetary value of some of the environmental and socio-economic impacts of the Project or a setback was left unquantified, with the remaining trade-off expressed as a threshold value.

To further examine the magnitude of the previously unquantified environmental impacts, a CM survey was undertaken to directly elicit community values. This approach is consistent with the findings of the Southern Coalfield Panel Inquiry which found that CM studies *could play an important role in assisting communities and the Government in their consideration of economic trade-offs* (NSW Department of Planning 2008).

Section 2.0 introduces the CM method while section 3.0 discusses the questionnaire development including attribute selections, questionnaire design and focus group feedback. Survey implementation is reported in Section 4.0. Econometric results and implicit price estimations are reported in Section 5.0, with guidance on how to use these values provided in Section 6.0. Overall conclusions are then presented.

2.0 CHOICE MODELLING

The CM technique originates from the marketing and transport literature where it has been used to analyse consumers' choices of products and transport modes (2000). CM is a non-market valuation technique that enables estimation of environmental changes that are outside the range of currently observed conditions.

CM uses questionnaires that describe a hypothetical policy or natural resource management scenario that will cause environmental changes. In a CM survey of a relevant population, respondents are presented with a series of questions (choice sets), where each question shows the outcome of alternative policy scenarios, including a 'status quo' or 'no policy change' scenario. These outcomes are described in terms of different levels of a monetary attribute (costs) and several non-marketed attributes. Respondents are asked to choose their preferred option from the array of alternatives. In choosing between alternative scenarios, respondents are expected to make a trade-off between the levels of the environmental attributes and associated costs. This allows the researcher to observe the relative importance of the different attributes (Bennett and Blamey 2001). Indeed it facilitates identification of respondents' willingness to pay to secure additional units of each of the environmental attributes or to avoid loss of additional units of each of the environmental attributes.

Environmental attributes for inclusion in CM studies can vary significantly and can be tailored to specifically reflect the relevant environmental issues associated with any specific project or policy.

Designing the application of the choice modelling methodology to the Metropolitan Colliery involved several tasks:

- defining the relevant attributes and their levels;
- designing the questionnaire with the aid of focus groups and pretesting;
- compiling the experimental design; and
- identifying the sample to be surveyed.

Each of the tasks is considered in more detail in the following section.

3.0 QUESTIONNAIRE DEVELOPMENT

3.1 Attribute Selection

Fundamental to the application of non-market valuation methods, such as CM, are projections of the biophysical condition of the environment under the current policy regime (in this case continued underground coal mining at Metropolitan Colliery) and how the biophysical condition may change under alternative policies that will be considered by policy makers (e.g. prohibition or restriction to coal mining at Metropolitan Colliery). The biophysical condition of the environment is described in terms of a change in level of different environmental attributes. These environmental attributes must be relevant from the operations/business, policy makers and scientific perspective (the ‘supply side’) but also relevant to the community (the 'demand side').

The first task in the study was to develop a set of attributes that could be used to describe the potential non-market impacts of underground mining at the Metropolitan Colliery. Mining in the Southern Coalfield is underground, and the potential impacts are largely linked to the effects of mine subsidence. Subsidence is the vertical and horizontal movement of the land surface as a result of the extraction of underlying coal.

Initial review of the literature on coal mining in the Southern Coalfield and meetings with HCPL elicited the following potential environmental attributes from the supply side:

- cracking of stream beds in affected sections of streams;
- draining of pools in affected sections of streams;
- reduced water flow in sections of affected streams;
- iron staining in affected sections of streams;
- ecological impacts in affected sections of streams;
- loss of water from the catchment;
- impacts on upland swamps above the underground mining area;
- impact on cultural heritage such as overhangs containing Aboriginal art above the underground mining area; and
- location of impacts – in or outside water supply catchments.

An important requirement of attribute definition in CM is that the attributes utilised are independent.

The first five attributes listed above are all related to the cracking of stream beds as a result of mine subsidence. Consequently, these impacts were amalgamated into a single attribute, length of stream affected, with the nature of effects described as including cracking, draining of pools, reduced water flow in streams, iron staining and ecological impacts.

While loss of water from the catchment, via stream bed cracking, had repeatedly been raised in some policy documents and the media, a comprehensive analysis of stream flow data and data on the yield behaviour of Woronora Reservoir as a component of specialist assessments conducted for the Project indicated that past mining at the Metropolitan Colliery has had no discernable effect on the inflow to, or yield from, the reservoir (HCPL 2008). This conclusion was supported by the Southern Coalfields Panel Inquiry (NSW Department of Planning 2008), which concluded: *No evidence was presented to the Panel to support the view that subsidence impacts on rivers and significant streams, valley infill or headwater swamps, or shallow or deep aquifers have resulted in any measurable reduction in runoff to the* ***water supply system*** *operated by the Sydney Catchment Authority or to otherwise represent a threat to the water supply of Sydney or the Illawarra region.* Consequently, loss of water from the catchment was not included as an attribute in the CM questionnaire.

As underground mining at the Project was primarily under the water supply catchment, a separate location attribute for impacts outside of water catchment was not necessary and this was also not included in the CM.

It has been recognised that as well as valuing environmental outcomes, the community may hold non-environmental, non-market values (Portney 1994). For instance, Johnson and Desvouges (1997) estimated the non-market value of employment effects of energy programmes and Morrison *et al.* (1999) performed a similar task in the context of wetland protection. More recently Bennett *et al.* (2004) estimated the values the community hold for the continued viability of rural communities.

The Metropolitan Colliery provides 320 direct jobs to the Illawarra Region, with mine life estimated at 23 years. Reducing environmental impacts is likely, in many instances, to reduce the length of time that the mine will provide 320 jobs. Hence, it was considered reasonable to test if the community hold non-market values for this socio-economic attribute.

So the supply side attributes selected were:

- total length of stream affected;
- total area of upland swamp affected;
- total number of Aboriginal sites affected; and
- period of time that the mine will provide 320 jobs.

However, it is also important that the identified environmental and socio-economic attributes are meaningful to the potential respondents of the CM questionnaire. Gillespie Economics undertook a number of focus group sessions to ascertain the relevance of the selected attributes to the community.

Four focus group sessions were held:

- two on 30 July 2008 in Parramatta; and
- two on 31 July 2008 in Wollongong.

In total 47 people attended the focus groups sessions, 24 in Parramatta and 23 in Wollongong. The age and sex distribution of attendees is provided in Table 1.

Table 1 – Age and Sex of Focus Group Attendees

Age	Male	Female	Total
<20	0	1	1
20-29	3	8	11
30-39	2	2	4
40-49	5	3	8
50-59	7	4	11
>59	5	6	11
Not spec.	0	1	1
Total	**22**	**25**	**47**

Average household size was 3.1. Thirty-two of the 47 focus group attendees had children with 30 children being under the age of 18.

The majority of attendees were diploma/certificate or tertiary degree qualified.

Table 2 - Education levels of Focus Group Attendees

Schooling	Number
Never went to school	0
Primary only	2
Junior/Year 10	9
Secondary/Year 12	6
Diploma or certificate	12
Tertiary degree	13
Post-graduate degree	4
Other	1
Total	**47**

The distribution of household income of attendees is provided in Table 3.

Table 3 - Household Income

Income Level	No.	Income Level	No.
Under $7,799	0	$62,400 to $72,799	3
$7,800 to $12,999	1	$72,800 to $88,399	8
$13,000 to $18,199	1	$88,400 to $103,999	10
$18,200 to $25,999	0	$104,000 to $129,999	7
$26,000 to $33,799	0	$130,000 to $155,999	2
$33,800 to $41,599	2	$160,000 or more	2
$41,600 to $51,999	4	Don't know	3
$52,000 to $62,399	2		

For each location, an early evening focus group session (6:00 pm) and a late evening session (8:00 pm) was undertaken. This was to facilitate attendance by a cross section of people including those in the workforce.

Recruitment to the focus group sessions was undertaken by a professional firm, Analyse Recruitment.

The focus group sessions incorporated a number of stages, including consideration of the attributes generated from the supply side analysis. Across all four focus groups sessions, the attributes identified by the supply side were also generally considered to be the attributes that were most relevant from a demand side.

A small number of attendees also suggested additional attributes e.g. number of species impacted in swamps and streams, release of methane, pollution or amenity from surface infrastructure and truck movements.

The relevance of these additional attributes was considered, however, none were deemed appropriate for inclusion as an extra attribute, for the following reasons:

- The description of upland swamps in the questionnaire already referred to the importance of them as a habitat for plants and animals e.g. frogs and birds. Furthermore, inclusion of an additional attribute relating to swamps would breach the independence requirement for the attributes.
- The discussion of stream affects already described the aquatic ecology impacts associated with stream bed cracking and inclusion of an additional attribute would breach the independence requirement for attributes.

- Release of methane was considered a minor issue associated with mine subsidence that did not warrant inclusion as a separate attribute. Estimates of damage costs of greenhouse gas are already available from the literature and were already included in the Project BCA.
- The potential for pollution or amenity (e.g. noise/air) impacts being generated from surface infrastructure was considered and already valued via the property valuation method in the BCA.

With respect to the socio-economic attribute that was included (number of years the mine provides 320 jobs) numerous respondents confirmed its relevance by highlighting the consideration they gave to this attribute when answering the draft questionnaire.

With the relevant attributes confirmed, it was necessary to determine the descriptor for each attribute and appropriate ranges over which the cumulative attribute levels could vary in the future, say over the next 20 years, under current management strategies (mining continuing as currently planned), and with new government decisions for the mine.

Table 4 summarises the attributes, attribute description and levels that were adopted.

Table 4 - Attributes and their Descriptions and Levels

Attribute	Description	Levels*
Cost	Compulsory annual payment ($) for 20 years	0; 10; 20; 50
Total length of stream affected	Length in kilometres	4; 8; 12; 15
Total are of upland swamp affected	Area in hectares	20; 80; 140; 200
Total number of Aboriginal sites affected	Number of Aboriginal sites	100; 160; 220; 270
Period of time that the mine will provide 320 jobs	Number of years	25; 18; 10; 2

* Cumulative of the existing Metropolitan Colliery and the Project.

In this context it is important to understand that mine subsidence effects (i.e. the lowering of the ground surface due to the extraction of underlying coal) occur over the general area that overlies the underground mine, however, the spatial expression of particular environmental impacts associated with these subsidence effects is highly variable (e.g. the location and nature of surface cracking of exposed sandstone stream beds would be highly dependent on local structural and topographical conditions).

While the descriptors for each attribute were relative straightforward (e.g. km, hectares and number), the description of the impact was more complex.

For streams, the impacts canvassed included cracking of the stream bed, water flow under the bed of the stream, reduction in surface flow in the stream, reduction in water levels in pools, staining of the water and stream bed downstream of where the water resurfaces and localised changes to the stream environment.

For upland swamps, impacts canvassed included cracking of the swamps, erosion and changes in the type of vegetation present.

For Aboriginal heritage impacts canvassed included cracking and collapse of rock features containing grinding grooves, engraving sites, rock art and artefacts.

Photographs were provided of the attributes that would potentially be impacted and, for streams, a range of photographs from the existing Metropolitan Colliery were provided of cracking, reduced stream flow, reduced water level in ponds and staining of the stream bed at the Waratah Rivulet. Photographs of stream flow and pool levels after rain in affected sections of Waratah Rivulet were also provided. Refer to the Example Questionnaire in Appendix 1.

While a cumulative upper level and a lower level for each attribute was set for the Metropolitan Colliery including the potential impacts of the Project with reference to opinion of environmental specialists, the two intermediate levels were established to provide coverage across the range. In general, it was considered appropriate that the upper levels of the attributes be conservative (i.e. overstate potential cumulative impacts of the mine) rather than to understate impacts, or to make the potential impacts appear trivial.

With four different levels for each of the five attributes there are 5^4 choices (full factorial) that could be provided to respondents. However, this would obviously be very onerous for a single respondent to consider.

To overcome this problem a main effects experimental design was used to produce 25 choice sets, with five choice sets embedded into five different versions of the questionnaire (i.e. there were five blocks of questionnaires – where the choice sets at the back were different, but the remainder of the questionnaire was unchanged).

3.2 Questionnaire Design

The draft questionnaire, within which the choice sets were embedded, contained the following elements:

- an introduction outlining the purpose of the survey and its importance to decision-making (so as to encourage participation);
- background information on mining in the Southern Coalfield and the particular mine that was the subject of the questionnaire;
- information (including photos) on how the mine could potentially impact streams, upland swamps and Aboriginal heritage;
- discussion of how potential environmental impacts could be reduced by government decisions on the future of the mine and that these decisions would also impact employment at the mine;
- identification of the employment provided by the mine;
- discussion about how reducing environmental impacts of the mine could affect the respondent, namely that the government would receive less royalties to fund public services and that an annual payment in the form of increased taxes and/or higher prices for public services would be required from each household;
- a framing statement reminding respondents that their income is limited and that other areas of NSW may also need funding for environmental improvement;
- five choice sets providing respondents with a choice of varying environmental and socio-economic outcomes for different payment amounts including the environmental and socio-economic outcome if no payment is made and no new government decision for the mine are taken;
- debriefing questions to detect payment vehicle protests and that respondents understood the information provided, were happy with the quantity of information provided and whether they found the choice sets confusing;
- questions to establish the socio-economic characteristics of respondents; and
- questions relating to respondents' attitudes towards development and the environment, assistance to impacted miners and links to environmental organizations or the mining industry.

The draft questionnaire was tested on the focus groups by asking them to complete it and then talking through the elements of the questionnaire design and content.

The draft questionnaire was generally well received by respondents in the focus groups, with verbal comments indicating that that it was clear, easily understood and that most did not have any difficulty with responding to the choice questions.

This verbal response was supported by the focus groups participants' response to Q7 of the questionnaire which sought to determine whether the information being provided to respondents was sufficient and whether respondents found the choice sets to be confusing. Refer to Table 5.

Table 5 – Information in Questionnaire

Likert Scale	1	2	3	4	5	6
	Strongly Disagree	Disagree	Neither Agree or Disagree	Agree	Strongly Agree	Average Likert Score
I understood all the information provided	3	1	8	27	7	3.7
I needed more information than was provided	3	12	7	21	1	3.0
I found answering Q1-5 confusing	5	25	9	4	1	2.2

The majority agreed that they understood all the information provided. The focus groups were split over whether more information was needed, while the majority disagreed that the choice sets were confusing. Most considered that answering five choice sets was not too onerous.

The time taken to complete the questionnaire ranged from 10 minutes to 30 minutes with most completing it within 20 minutes.

A range of ways to improve the questionnaire design was raised in the focus groups.

Two key issues identified from the discussions with focus groups were:

- The need for a context to be provided for environmental and employment impacts e.g. if 15 km of streams are potentially going to be impacted, what percentage of the total length of streams in the region, is this?
- Expression by some that they were relatively insensitive to the annual payment levels.

The former was addressed by including the relevant contextual information in the final questionnaire (refer Appendix 1), while econometric analysis of the focus group responses to the questionnaire indicated that respondents were sensitive to the annual payment levels (see below).

3.3 Focus Group Results

An attributes only conditional logit (CL) model was estimated from the 47 completed questionnaires to check for significance of the attributes and, in particular, the sensitivity of respondents to the cost variable, recognising that the sample size is too small for a full model specification.

This indicated that respondents were sensitive to the cost variable and years of mine life variable, with these being significant at the 5% level. The hectares of swamp variable was significant at the 10% level while the kilometres of stream variable was almost significant at the 10% level. The number of Aboriginal sites variable was not significant (Table 6).

Table 6 – Attributes Only Model from the Focus Groups

Variable	Coefficient	Standard Error	b/St.Er	P[Z]>z
Cost	-0.01420423	0.00619005	-2.295	0.0218*
Km of streams	-0.04959572	0.03087002	-1.607	0.1081
Ha of swamp	-0.00347966	0.00210170	-1.656	0.0978**
No. of Aboriginal sites	-0.00250964	0.00210503	-1.192	0.2332
Years of mine life	0.04242835	0.01501404	2.826	0.0047*
ASC	0.11122859	0.52453373	0.212	0.8321

* significant at the 5% level
** significant at the 10% level

3.4 Pre-test Results

Prior to full implementation of the questionnaire, an online pre-test was undertaken of a sample of 40 to examine if filling out the survey online affected the significance of the results.

The online pre-test results indicated that when respondents were answering the questionnaire online, they were still sensitive to the cost variable, hectares of swamp and years of mine life, with these being significant at the 5% level. Refer Table 7.

Table 7 – Attributes Only Model from the Online Pre-test

Variable	Coefficient	Standard Error	b/St.Er	P[Z]>z
Cost	-0.01830685	.00754796	-2.425	0.0153*
Km of streams	-0.02922930	.03778603	-0.774	0.4392
Ha of swamp	-0.00678959	.00253871	-2.674	0.0075*
No. of Aboriginal sites	-0.00244502	.00248531	-0.984	0.3252
Years of mine life	0.03865265	.01772460	2.181	0.0292*
ASC	-1.13974358	.66774892	-1.707	0.0879**

* significant at the 5% level
** significant at the 10% level

It was therefore considered that the questionnaire was suitable for full implementation.

4.0 QUESTIONNAIRE IMPLEMENTATION

4.1 Survey Logistics

There are a range of methods of implementing CM surveys including mail-out surveys, face-to-face, drop-off and pick-up.

Experience in recent CM surveys has demonstrated that mail-out surveys are becoming increasingly difficult to manage, mainly because of privacy laws which restrict access to up-to-date databases of potential respondents. Face-to-face methods are problematic due to the time required to complete CM questionnaire and hence drop-off and pick-up is tending to be used more often. This approach, however, does not lend itself to sampling of a geographically disperse population (e.g. the state of NSW), and can be expensive.

For this study, a relatively new approach to implementing CM questionnaires, of online surveying, was used. With over 70% of the population now online, these types of surveys are practical and cost-effective. Online surveying involves sampling from an existing Panel of pre-stratified and registered respondents. For this study the Panel of the Market Research company, I-View, was used.

Previous CM research has found it appropriate to involve both the community within the affected region and the community outside the region potentially affected by a proposal. This is because differences in values between these two types of respondents have been found in earlier studies (e.g. Van Bueren and Bennett 2004). Consequently, the aim was to draw a sample of 500 from the Illawarra Region in which the Project is located, and a sample of 500 from the rest of NSW. This sample size would result in 100 completed questionnaires per block for each of the samples, which is considered sufficient for use of “large number” statistic tests such as the t tests of significance.

The choice modelling questionnaires were implemented via online survey from 2nd October 2008 to 21st October 2008.

7,553 questionnaires were sent out in total and the system was automated such that when the quota of 1,000 questionnaires was reached, the questionnaire link was automatically de-activated.

1,028 completed questionnaires were received, 246 incompletes[1] and 110 quota fails[2], 525 were from the Illawarra with 503 from the rest of NSW.

4.2 Sample Characteristics

In the Illawarra sample, 75% of respondents were female while in the Rest of NSW sample respondents were evenly split between male and female.

The average age of respondents from the Illawarra was 45.8, while the average for the Rest of NSW sample was 46.5.

The comparative age and sex distribution of respondents is provided in Table 8.

[1] Incompletes are people who did not answer all the questions, however did open the survey link.
[2] The Quota fails happened when the location quotas were already filled.

Table 8 – Age and Sex of Respondents

	Illawarra			Rest of NSW			Total Sample		
Age	**Male**	**Female**	**Total**	**Male**	**Female**	**Total**	**Male**	**Female**	**Total**
<20	0	11	11	1	4	5	1	15	**16**
20-29	10	50	60	26	39	65	36	89	**125**
30-39	16	87	103	33	58	91	49	145	**194**
40-49	31	102	133	56	55	111	87	157	**244**
50-59	31	98	129	63	44	107	94	142	**236**
>59	43	46	89	75	49	124	118	95	**213**
Total	**131**	**394**	**525**	**254**	**249**	**503**	**385**	**643**	**1028**
%	25%	75%		50%	50%		37%	63%	
Average Age			**46**			**47**			**47**

The respondents from the Illawarra had an average household size of 3.2 people while respondents from the Rest of NSW had an average household size of 2.8 people. The average number of children living at home was approximately one for both samples (Table 9).

Table 9 – Household Size and Number of Children

	Illawarra		Rest of NSW		Total Sample	
Number	**HH size**	**Children**	**HH size**	**Children**	**HH size**	**Children**
0	1	265	0	327	1	592
1	47	102	68	74	115	176
2	162	95	201	62	363	157
3	109	46	93	28	202	74
4	113	10	81	8	194	18
5	61	5	39	1	100	6
6	22	2	14	3	36	5
7	7	0	4	0	11	0
8	2	0	3	0	5	0
9	1	0	0	0	1	0
Total	525	525	503	503	1028	436
Average	3.2	1.0	2.8	0.7	3.0	0.8

The majority of respondents were diploma/certificate or tertiary degree qualified (Table 10).

Table 10 - Education Level of Respondents

Schooling	**Illawarra No.**	**Rest of NSW**	**Total Sample**
Never went to school	0	0	0
Primary only	6	2	8
Junior/Year 10	107	96	203
Secondary/Year 12	98	97	195
Diploma or certificate	173	166	339
Tertiary degree	80	84	164
Post-graduate degree	44	44	88
Other	17	14	31
Total	**525**	**503**	**1,028**

The distribution of household income across respondents is provided in Table 11. The average household income was $61,034 for Illawarra Respondents and $63,309 for Rest of NSW Respondents (Table 11).

Table 11 - Household Income

Income Level	Illawarra No.	Rest of NSW No.	Total Sample No.
Under $7,799	5	4	9
$7,800 to $12,999	15	9	24
$13,000 to $18,199	31	28	59
$18,200 to $25,999	48	40	88
$26,000 to $33,799	36	44	80
$33,800 to $41,599	31	41	72
$41,600 to $51,999	55	60	115
$52,000 to $62,399	50	40	90
$62,400 to $72,799	40	33	73
$72,800 to $88,399	42	33	75
$88,400 to $103,999	35	52	87
$104,000 to $129,999	34	30	64
$130,000 to $155,999	19	23	42
$160,000 or more	13	17	30
Don't know	71	49	120
Average Household Income	**$60,859**	**$63,435**	**$62,147**

In both sub-samples, more respondents favoured protection of the environment than development, although the majority favoured development and the environment about equally (Table 12).

Table 12 - Favour Protection or the Environment

View	Illawarra No.	Rest of NSW No.	Total Sample No.
Favour protection of the environment	178	177	355
Favour development and environmental protection about equally	332	308	640
Favour development	15	18	33
Total	**525**	**503**	**1028**

Questionnaire respondents tended to favour the Government providing assistance when those working in mining are made worse-off by decisions to reduce the environmental impacts of the mine (Table 13).

Table 13 – Providing Assistance to Miners

View	Illawarra No.	Rest of NSW No.	Total Sample No.
Strongly Agree with providing assistance	86	53	139
Agree with providing assistance	225	209	434
Neither Agree nor Disagree with providing assistance	133	174	307
Disagree with providing assistance	60	52	112
Strongly Disagree with providing assistance	21	15	36
Total	**525**	**503**	**1028**

Eighty-two respondents or their close family were members of an environmental organisation while 100 respondents or their close family were associated with the mining industry. The proportion that was associated with the mining industry was greater for the Illawarra sample (Table 14).

Table 14 – Associated with and Environmental Organisation or the Mining Industry

	Illawarra No.	Rest of NSW No.	Total Sample No.
Member of environmental organisation	39	43	82
Associated with mining industry	60	40	100
Total	**99**	**83**	**182**

The majority of respondents agreed that they understood all the information provided. Most did not consider that more information was required and the majority did not find the choice sets confusing. This did not vary significantly between sub-samples. Refer to Table 15.

Table 15 – Information in Questionnaire

	Strongly Disagree (Score 1)	Disagree (Score 2)	Neither Agree or Disagree (Score 3)	Agree (Score 4)	Strongly Agree (Score 5)	Average Score
Illawarra Sample No.						
I understood all the information provided	7	32	70	287	129	4.0
I needed more information than was provided	36	195	184	97	13	2.7
I found answering Q1-5 confusing	102	227	115	69	12	2.4
Rest of NSW Sample No.						
I understood all the information provided	7	19	108	256	113	3.9
I needed more information than was provided	36	169	188	91	19	2.8
I found answering Q1-5 confusing	107	204	120	65	7	2.3
Total Sample No.						
I understood all the information provided	14	51	178	543	242	3.9
I needed more information than was provided	72	364	372	188	32	2.8
I found answering Q1-5 confusing	209	431	235	134	19	2.3

4.3 Comparisons with Australian Bureau of Statistics Data

Several of the socioeconomic characteristics of the sub-samples and total sample were compared with those from the Australian Bureau of Statistics (ABS) 2006 Census. Two types of statistical test were used. For category data, a chi-squared test was used to determine whether the observed number of individuals in different categories varies significantly from what would be expected based on the population. For continuous data, a single sample t-test was use to determine if the sample mean differed significantly from the mean of the population from which the sample was drawn.

Table 16 – Comparison of Sample to Population

	Illawarra Sample	Illawarra ABS	Rest of NSW Sample	Rest of NSW ABS	Total Sample	NSW ABS
Gender (% male 18) X^2 (5% critical value =3.84)	25% 116	48%	50% 1	49%	37% 51	49%
Household Size t-stat (5% critical value = 1.96)	3.2 10.5	2.5	2.8 3.1	2.6	3.0 8.6	2.6
% Tertiary qualification X^2 (5% critical value =3.84)	60% 3.3	56%	61% 2.8	57%	61% 3.9	57%
Mean age 18+ t-stat (5% critical value = 1.96)	45.8 -4.95	48.7	47.4 1.46	46.5	46.6 -0.09	46.6
Proportion with income levels greater than the median household income for the population X^2 (5% critical value =3.84)	51% 3.01	55%	41% 11.4	49%	41% 0.0007	41%

The gender of the Rest of NSW sub-sample was not significantly different from the population. However, the Illawarra sub-sample had significantly more females responding than males. Consequently, the full sample had significantly more female respondents than males.

Household size for both sub-samples was greater than the population means.

The proportion of respondents from both sub-samples with tertiary qualifications was not significantly different from the population, although for the combined sample tertiary qualifications were significantly higher than the population at the 5% significance level but not at any higher significance levels.

The mean age of the Illawarra sample population was significantly less than that for the Illawarra population, however, the mean age for the Rest of NSW sample and combined sample was not significantly different from the respective populations.

A comparison of household income is more problematic since mean income information is not reported by ABS, only median is. Income band information is also reported. Figures 1 to 3 compare the percentage of respondent households in each income band relative to the respective populations.

Figure 1 – Household Income Illawarra Sample

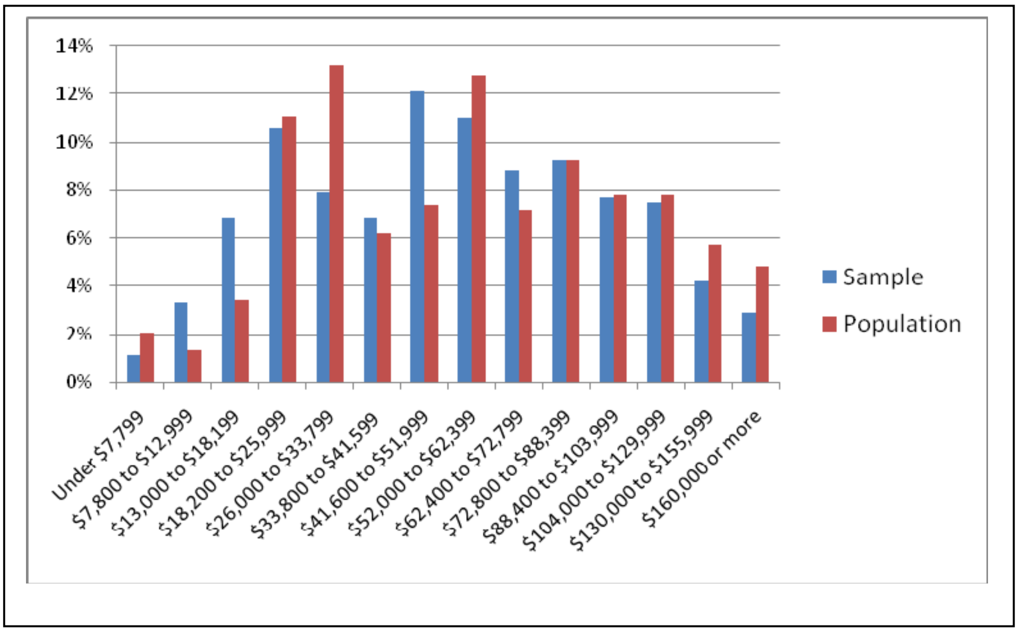


Figure 2 – Household Income Rest of NSW Sample

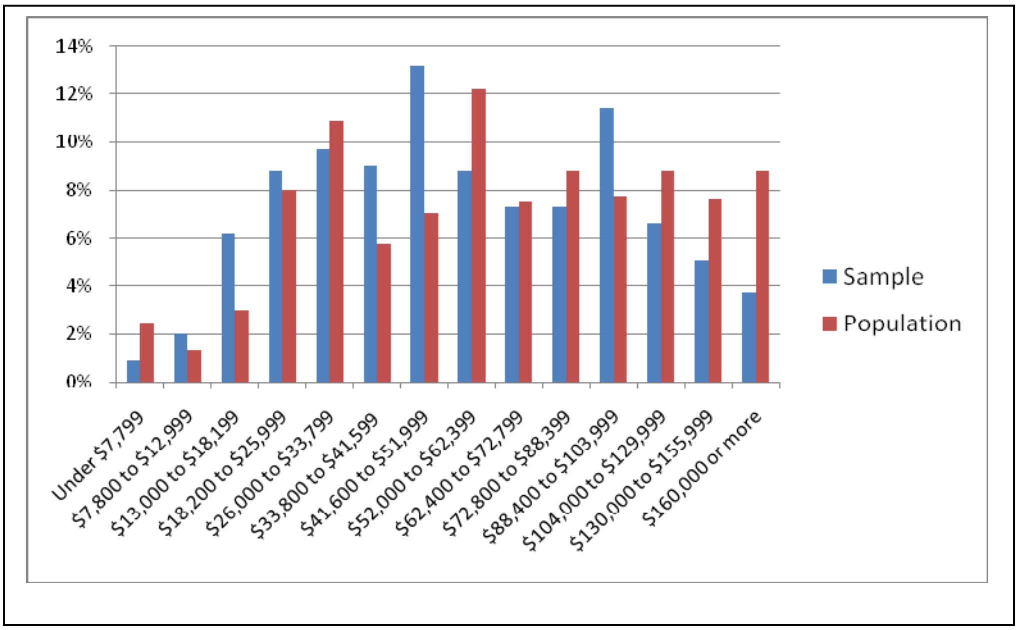
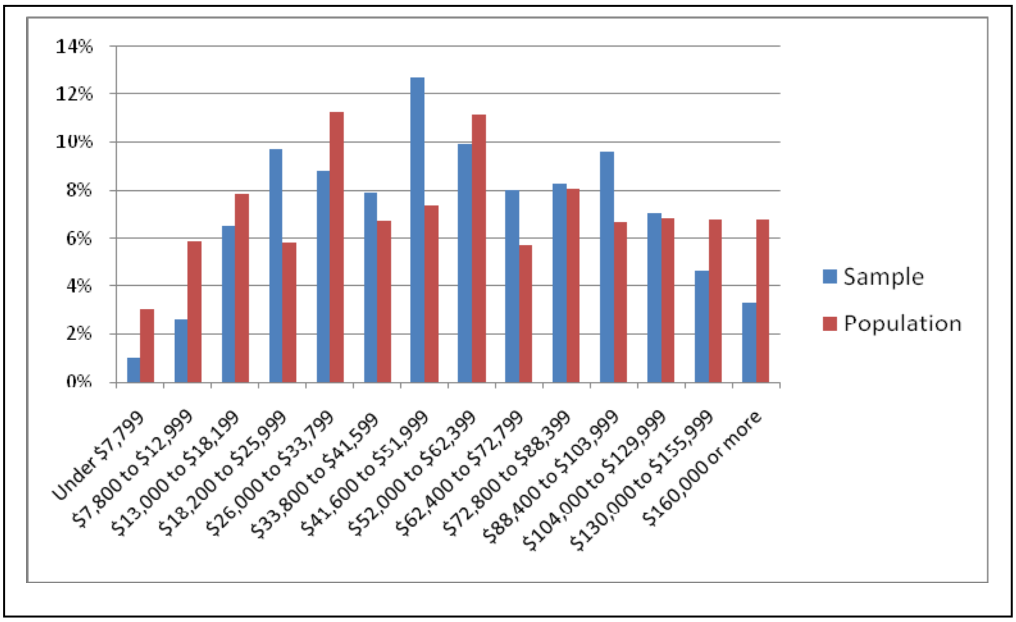


Figure 3 – Household Income Combined Sample



Chi-squared tests confirm that the samples are significantly different to the respective populations. However, this test does not provide any guidance on how it is different and the figures above indicate that for some categories there are more observations than expected and for other categories there is less.

A further Chi-squared test was undertaken to determine whether the samples had more respondent households in income categories greater than the income category that contains the median income level for the population. Respondents from the Illawarra sub-sample were no more likely to have higher household incomes than the medium whereas respondents from the NSW sub-sample had less numbers with household income greater than the median. However, overall the combined sample was not statistically different from the population.

While not representative of the population in all aspects, the sample is considered a reasonable basis on which draw inferences for the population.

5.0 MODELLING RESULTS

5.1 Conditional Logit Model Results

The survey data were analysed using conditional logit (CL) and nested logit (NL) models. The variables used in the choice models are shown in Table 17.

Table 17 - Variables used in the Choice Models

Variable Code	Description
ASC1	Alternative Specific Constant
Willingness to pay	Cost of choice alternative ($ pa over 20 years)
Km	Total length of stream affected (km)
Ha	Total area of upland swamp affected (ha)
No	Total number of Aboriginal sites affected (number)
Years	Period of time that the mine will provide 320 jobs (years)
ASC2	Nesting alternative specific constant
ascvis	Visited the area (1= visited) × asc
ascedu	Years of education × asc
ascint	Interested the issue (1= interested) × asc
ascsex	Respondent gender (1= female) × asc
ascloc	Respondent location (1 = Illawarra SD) × asc
ascincome	Respondent household income per year ($000) × asc
ascage	Respondent age × asc
ascchild	Respondent has children (1= children)
Aschhsiz	Number of people who live in respondents household × asc
ascnukids	Number of people under 18 years of age that live in respondents household × asc
ascenvde	Attitude to development and environment (1= tend to favour environment, -1 tend to favour development, 0= favour development and the environment evenly) × asc
ascassis	Attitude towards assistance to miners that are made worse off (1= agree with assistance, -1 disagree with assistance, 0= neutral) × asc
ascenvorg	Respondent or close family associated with an environmental organisation (1= yes)
ascmineo	Respondent or close family associated with an mining industry (1= no)

The choice attributes cost (WTP), kilometres of stream affected (Km), hectares of swamp affected (Ha), number of Aboriginal sites affected (No) and period of time that the mine will provide 320 jobs (Yrs) were modelled as continuous variables. The annual payment (WTP) was zero for the base alternative and 10, 20 or 50 dollars for the two alternative choice options. The environmental attributes were described as negative impacts, such that the attribute would decrease in the alternative choice options. The period of time that the mine would provide 320 jobs was shown as a decrease in the alternative choice options.

An alternative specific constant (ASC) was included to take up the effect of factors that were not measured in the course of the survey but have an impact on well-being. The ASC was normalised to one for alternatives 2 and 3 (‘new management’) and was zero for the base alternative. It is important to note that the socio-economic variables are introduced into the modelling as interactions with the alternative specific constant. Hence, the parameters of these interacted variables show the influence of the socioeconomic variable on the probability of the respondent choosing the alternative compared to the current situation.

A number of different model results are reported in Table 18. The first is an attributes only model that confirms that the respondents’ choices are significantly influences by the level of the attributes. All attributes are significant at the 1% level and have the expected sign. The negative and significant parameter on the ASC shows that there is a systematic tendency to choose the current situation over the choice alternatives and that there are unobserved effects that explain individuals’ choices.

A conditional logit model was run with attitudinal variables on ‘interest in the issue of mining under streams’ and ‘favouring development versus the environment’. Model results showed that these variables increased the probability of choosing one of the alternative options. This builds confidence in the data-set, as it shows that self-reported environmental disposition increases the likelihood of choosing for environmental protection. Other attitudinal variables that were modelled included ‘membership of an environmental organisation’ and ‘being a miner’. Whereas being a member increased the probability of choosing one of the alternative options, being a miner was not significant in explaining respondents’ choices.

More advanced model specification includes the socio-economic variables to estimate individual utility. A stepwise model selection based on model AIC was performed using the ‘swaic’ procedure in STATA. Variables that were initially included in the estimation but that were found to be insignificant are location (in the Illawarra or living in any other area of NSW), size of the respondent’s household and the number of people in the household under 18 years old. Age of respondents was found to be highly correlated with the education of respondents (a correlation coefficient of 0.85) and consequently was omitted from modelling. This resulted in lower information criteria in the subsequent model, indicating better performance than the model including age.

The model fit was further improved by including squared terms of education and income. This is shown by a higher χ^2 value (comparing the model to a base model – see Appendix 2) and by lower information criteria (AIC and BIC – see Appendix 2). The ASC in this model is also insignificant, indicating that there are no systematic unobserved components that influence individuals’ choices. The attributes are all significant and have the expected sign. Visitation is positive and significant, indicating that respondents who have visited the mining region are more likely to support new government decisions for the mine. Gender is significant and positive, meaning that women are more likely to choose the base option than men. Having children, years of education and income all have a negative sign. This indicates that respondents with children, more years of education or higher income are more likely to choose the base option over new government actions. However, the positive sign on squared education and squared income shows that this tendency may be decreasing in the level of education and income. It should also be noted that the coefficients on income and income squared are very small, indicating a negligible effect of income on individual’s choices. Finally, ‘ascenvorg’ is positive and significant, meaning that respondents who are a member of some environmental organisation are, on average, more likely to choose one of the new management options.

An important assumption in the CL model is the Independence-from-Irrelevant-Alternatives (IIA) property. The IIA assumption states that the relative probability of choosing one alternative over another (given that both alternatives have a non-zero probability of choice) is unaffected by the introduction or removal of additional alternatives in the choice set (Louviere *et al*., 2000). The IIA assumption implies that the error terms are independent across alternatives and provides a computationally convenient choice model. However, the IIA assumption is unlikely to hold if the preferences of respondents are heterogeneous (Louviere et al., 2000). In this situation, using a CL model will lead to biased estimators.

A Hausman specification test was used to determine whether the IIA assumption holds for the final CL model reported in Table 18 and it was found that the IIA assumption is rejected when removing the second choice option, but cannot be rejected at the 5% confidence level when removing the third option.

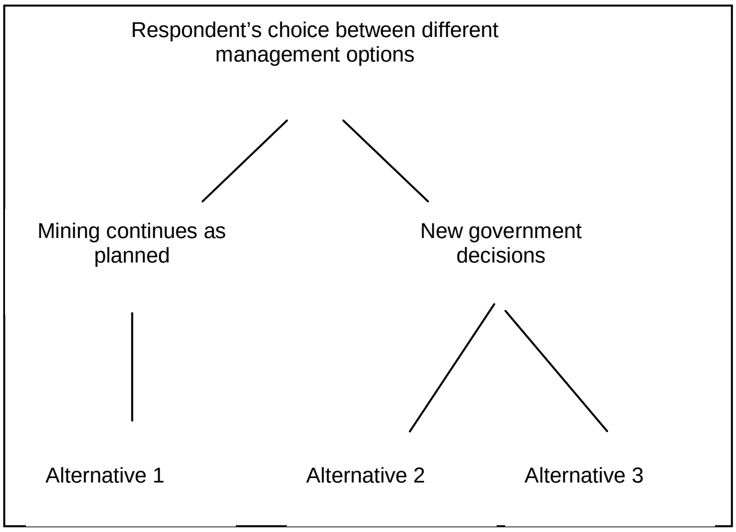
An alternative to the Hausman test is provided by running seemingly unrelated regressions. This approach confirmed the conclusion of the Hausman test, that the IIA assumption cannot be rejected at the 5% confidence level when removing the third option.

5.2 Nested Logit Model Results

Given the low pseudo R^2 of the CL models and the ambiguous results of the Hausman test, additional nested model (NL) specifications were estimated that allow for a relaxation of the IIA assumption. A fully degenerate NL tree structure was explored in NLOGIT (Hensher *et al*. 2005: 577). This procedure led to near-equal IV parameters for the two alternatives 'new government decisions', confirming the grouping of alternatives 2 and 3 within one branch. In this model, respondents are assumed to make their choice in two stages. First, the respondent decides between the base alternative (continue mining as planned) and a new government decision for the mine. In the estimated NL models, this choice is explained by the socio-economic characteristics of respondents (visitation, age, gender, having children, education, income and membership of an environmental organisation). Secondly, those respondents who choose 'new government decisions', make a choice between two alternative change options. The choice between the alternatives is modelled as being a function of the attributes.

Two alternative specific constants are specified in the NL model to account for any variation in utility across respondents that is not explained by the attributes and socio-economic variables. The first ASC1 = 1 for the base alternative and zero otherwise. The second ASC2 = 1 for the middle option (alternative 2) and zero otherwise.

Figure 4 - Tree Structure for the Nested Logit Model



The starting point for the NL model of the analysis was the final CL model with squared terms on education and income. However, this model specification did not converge. Therefore, the final NL model excluded the squared income and education terms. Similar to the CL model, age was found to have an insignificant effect on respondents' choices and was not included in the final model.

Despite the evidence of IIA violation, the results of the CL and the NL models are similar. Except for the education variable, the estimated coefficients have the same signs and similar magnitudes with comparable standard errors. The parameter on education is positive but small, indicating that respondents with a higher level of education are more likely to choose new government decisions. The negative sign on education^2 in the CL model indicates a diminishing effect of education on choice. Excluding education^2 leads to a reversal in the sign on the education variable. This may be a consequence of a relatively large proportion of the sample having higher education. Again, the coefficient on income is significant but has a negligible effect, as shown by its small parameter estimate. It is worthwhile mentioning that the ASC1 is positive and significant in the NL model, indicating a preference for the base alternative (option 1), all else equal. The ASC2 is not significant at the 5% level, indicating no systematic bias towards the second option specified in each choice set.

The pseudo R^2 for the NL model is no better than either of the estimated CL models. However, the information criteria are significantly lower for the NL specification, indicating a better model.

Table 18 – Modelling Results

Variable	CL Attributes Only	CL	CL squared	NL
ASC1	-0.8570501***	-2.014213***	0.9591795	0.0826903
Willingness to pay	-0.0112202***	-0.0118162***	-0.0118696***	-0.016496***
Km	-0.0575378***	-0.0565103***	-0.0569476***	-0.0798096***
Ha	-0.0050877***	-0.0051205***	-0.0051499***	-0.0071261***
No	-0.0048949***	-0.0048429***	-0.0048325***	-0.0061478***
Years	0.0551283***	0.0543003***	0.0544913***	0.0687627***
ASC2				2.838979***
ascvis		0.1461073**	0.168518**	0.1398366**
ascedu		0.0831486***	0.3021234**	0.0800081***
ascint				
ascsex		0.5195947***	0.540095***	0.5065874***
ascloc				
ascincome		-3.87e-06***	-0.0000195***	-3.81e-06***
ascage				
ascchild		-0.3014649***	-0.3027283***	-0.290263***
Aschhsiz				
ascnukids				
ascenvde				
ascassis				
ascenvorg		0.4421551***	0.4651325***	0.4216029***
ascmineo				
Educ2			0.0141862***	
Inc2			1.01e-10***	
LR chi2(6)	687.25	793.96	829.30	839.0753
AIC	10618.484	9546.012	9512.668	9504.894
BIC	10664.345	9636.646	9617.885	9610.634
Prob > chi2	0.0000	0.0000	0.0000	0.0000
Pseudo R2	0.0609	0.07770	0.0804	0.064
Log likelihood	-5303.2422	-4761.0059	-4743.3341	-4738.447

Significance levels: *0.1, **0.05, ***0.001

5.3 Implicit price estimates

Respondents are assumed to make a trade-off between the levels of the non-market attributes and the associated annual payments. The expressed trade-offs between attributes can be used to estimate the marginal utility of each attribute (Bateman *et al.*, 2006). If money is one of the attributes, this marginal utility is expresses as the ‘marginal willingness to pay’ for each individual attribute.

The models reported in Section 5.1 and 5.2 have been used to estimate the marginal willingness to pay (implicit prices) of the attributes Length of Streams Affected, Area of Upland Swamp Affected, Number of Aboriginal Sites Affected and Period of Time that the Mine will Provide 320 Jobs. Implicit prices are derived using the formula:

$$WTP = \frac{\beta_{attribute}}{\beta_{costs}}$$

where $\beta_{attribute}$ is the estimated coefficient of the (non-market) attribute, and
B_{costs} is the estimated coefficient of the cost attribute (see Appendix 2).

The implicit prices from all the models reported in the previous sections are shown in Table 19.

Table 19 Estimated implicit prices for MINING study (A$/household/year)

Attribute	CL Attributes Only	CL1	CL2	NL
Streams (km)	-$5.13	-$4.78	-$4.80	-$4.84
Upland swamp (ha)	- $0.45	-$0.43	-$0.43	-$0.43
Aboriginal sites (no)	-$0.44	-$0.41	-$0.41	-$0.37
Jobs (yrs)	$4.91	$4.60	$4.59	$4.17

It may appear from the results in Table 19 that streams and jobs are most important to respondents. However, it is important to note that the attributes are defined in different units when comparing the implicit prices across attributes (Bennett and Adamowicz 2001). Respondents are willing to pay $4.78 to $5.13 for every km of stream protected from adverse affects of the mine (per annum per household for 20 years). A value of $4.17 to $4.91 is attached to every additional year that the mine will provide 320 jobs (annual value per household for a 20 year period). The willingness to pay for the protection of upland swamps and Aboriginal sites from affects of the mine is a lot lower, with respondents willing to pay between $0.43 and $0.45 per annum for 20 years to protect an additional hectare of upland swamp from adverse affects and between $0.37 and $0.44 per annum for 20 years to protect an additional Aboriginal site from adverse affects.

Although econometric reasoning as well as the conducted Hausman tests suggest that the IIA property doesn't hold in the conditional logit specification, the implicit price estimates from the NL and CL models are not significantly different from each other. It should be noted that other studies (e.g. Wang *et al*. 2006, and Kragt *et al*. 2007) have also found insignificant difference between implicit price estimates from a NL and a CL model.

Nevertheless, it is recommended that the NL model results be adopted, as these provide the most econometrically rigorous model to fit the dataset.

6.0 APPLICATION TO BENEFIT COST ANALYSIS

6.1 Introduction

The implicit prices estimated from the choice data are directly applicable to the consideration of alternative mine management options. Specifically, they are compatible, as welfare change measures, with the principles of benefit cost analysis. The process of employing implicit prices in BCAs involves four basic stages.

1. Predicting the physical impact of a management change on the attributes used in the choice modelling exercise relative to the predicted continuation of the 'status quo'.
2. Converting the annual implicit prices for 20 years to a present value.
3. Multiplying the present value of implicit prices by the respective predicted attribute change to estimate the per respondent household willingness to pay for each attribute change.
4. Extrapolating across the relevant population, using the survey response rate, to estimate the societal willingness to pay for the management change.

Steps 2 and 4 involve a number of complexities that are considered in Section 6.2. Section 6.3 demonstrates the application of the CM results to the BCA of the Metropolitan Coal Project and the option of a setback from the Waratah Rivulet to minimise impacts on this natural feature.

6.2 Issues in the Application of CM Results

6.2.1 Converting the annual implicit prices for 20 years to a present value

The payment mechanism used in the CM survey was an ongoing annual payment for 20 years. This payment mechanism matched the context of the issue, which was the potential loss of annual royalties from ongoing mining over an extended period.

However, studies have shown that that WTP levels may differ significantly between different payment mechanisms. Windle and Rolfe (2004) examined WTP levels between lump sum payments and ongoing annual payments for a 20 year period. They found that there was a significant difference between annual and lump sum WTP amounts when lump sums were discounted at normal economic discount rates (e.g 7%). It was only at very high discount rates of 30%, and above, that the part-worths of the different WTP models started to become equivalent, and only a rate of 37% ensured that all part-worths were equivalent (Windle and Rolfe, 2004).

Further analysis by Rolfe and Windle (unpublished), using more sophisticated statistical methods, indicates that it is only at extremely high discount rates (between 45% and 59%) that confidence intervals for the amortised regular payment part-worth values overlap with the confidence intervals of the lump sum part-worths.

Because ultimately all values from CM studies must be expressed in present values or lump sum amounts, this suggests that the appropriate private discount rate to use for the CM results is up to 59%.

However, the Windle and Rolfe study is one of the few that have examined this issue empirically and until there is further evidence supporting these extremely high private discount rates, it is considered that a more conservative estimate of private discount rate should be used, such as the private borrowing rate for unsecured personal loans. Currently, this is in the order of 14.75% to 16.75%, although Credit Card rates are higher (in the order of 19%). For the purpose of this analysis a rate of 15% is used.

This is a very conservative discount rate relative to the results of the Rolfe and Windle studies.

6.2.2 Extrapolating Across the Relevant Population

WTP results per household from CM studies are not normally aggregated to the entire population from which the sample is drawn. This is because it is unclear whether non-respondents hold the same values as those of respondents. Consequently, it has been normal practice in mailed or drop-off surveys to conservatively only aggregate WTP values to the proportion of the population given by the survey response rate. However, this is likely to understate community willingness to pay as it assumes that all non-respondents have a zero willingness to pay.

An alternative is to use the method suggested by Morrison (2000) and supported by the results of van Bueren and Bennett (2001). In a study that involved the estimation of values derived from environmental improvements to wetlands, Morrison found that potentially, about one-third of non-respondents have value estimates similar to respondents. Similarly, van Bueren and Bennett (2001) in a follow-up telephone interview with non-respondents in a choice modelling application designed to estimate the non-marketed costs of land and water degradation found that about one third of non-respondents were highly likely to share the preferences of respondents.

Consequently, it is considered reasonable to aggregate values to the proportion of the population indicated by the response rate plus one third of the non-response rate.

The current study is an online survey where the email link is automated to close once the sample size is achieved, which then affects the subsequent response rate. At a minimum the response rate, based on the ratio of completed questionnaires to invites sent, is 13%. However, if the link were to remain open for an extended period, the response rate may have been higher, reflecting those received from typically mail-out/mail-back surveys i.e. 16% for the National Land and Water Audit CM (Van Bueren and Bennett 2000) to 38% for the NSW Rivers Study (Bennett and Morrison 2001).

Applying the Morrison approach to the minimum estimate of a response rate from the online survey (13%) would give an adjusted response rate of 42%. Assuming that the survey would have achieved a response rate similar to the NSW Rivers Study if the survey link was not deactivated and applying the Morrison approach gives an adjusted response rate of 59%. So for the purpose of the analysis a mid-point of 50% was used for the adjusted response rate.

6.3 Application of CM Results

6.3.1 Benefit Cost Analysis of the Metropolitan Colliery Project

The economic analysis for the Metropolitan Colliery EA (Gillespie Economics, 2008) indicates the following costs and benefits of the Project.

Table 20 - Benefit Cost Analysis Results of the Project (Present Values)

Benefits		Costs	
Production		***Major Surface Facilities Area Externalities***	
Net Production Benefits	$592 M	Operational noise from surface infrastructure	$1.5 M
		Air quality from surface infrastructure	Negligible
		Road transport and road transport noise	$3.9 M
		Rail transport noise	Negligible
		Offsite Rail and Road Transport Vibration	Negligible
		Non-Aboriginal Heritage impacts on surface infrastructure	Negligible
		Run-off impacts from surface infrastructure	Negligible
		Project Underground Mining Area Externalities	
		Stream impacts	Some impacts
		Groundwater impacts	Negligible
		Aboriginal heritage impacts	Some impacts
		Upland swamps impacts	Negligible
		Garrawarra Centre Impacts	Negligible
		Infrastructure, Roads and Buildings	$1.4 M
		Flora and fauna	Negligible
		Greenhouse gas generation	$149 M
		Visual impacts	Negligible
TOTAL QUANTIFIED	**$592 M**	**TOTAL QUANTIFIED**	**$156 M**
NET QUANTIFIED BENEFITS		**$436 M**	

The analysis indicates that the total net quantified production benefit of the Project is likely to be in the order of $592M. Quantified environmental externalities (e.g. greenhouse gas emissions) were valued at $156M. The net quantified benefit of the Project of $436M represents the opportunity cost to Australian society of not proceeding with the proposal.

Put another way, the unquantified environmental externalities from the Project, after mitigation by Helensburgh Coal Pty Ltd, would need to be valued at greater than $436M to make the Project questionable from an economic efficiency perspective.

The key unquantified environmental externalities of the Project relate to an estimated:

- 3 km of stream impacts (including a 2.5 km section of Waratah Rivulet) where cracking of near surface strata would be expected to affect pool persistence and stream flow behaviour; and
- up to 10 Aboriginal sites may be affected by cracking of sandstone, rockfall or other subsidence related impacts.

The above estimate of the length of stream affected is considered to be conservative and to overstate potential impacts of the Project. In addition, experience at the Metropolitan Colliery indicates that impacts on streams arising from mine subsidence effects vary across the mined area (i.e. the hydraulic capacity of the subsidence fracture network is not constant along affected stream reaches - HCPL, 2008).

Monitoring of previously subsided sites at Metropolitan Colliery indicates the majority of identified Aboriginal heritage sites subject to mine subsidence would experience no significant change as a result of the Project (HCPL, 2008). On this basis, the estimate of 10 Aboriginal heritage sites of the 188 in the Project underground mining area and surrounds, being subject to adverse impacts (e.g. cracking of a grinding groove or art panel) as a result of the Project is considered conservative.

No impacts on upland swamps are predicted as the type of upland swamps present above the Project underground mining area (headwater swamps) are not sensitive to near surface cracking effects. Any changes in swamp moisture as a result of cracking are expected to be immeasurable when compared to the scale of seasonal and even individual rainfall event based changes in swamp groundwater levels (HCPL, 2008).

Using the CM implicit prices for these environmental attributes reported above, and the suggested aggregation and discount rate assumptions, these environmental impacts would have an economic value to NSW households of $143M (Table 21).

Table 21 – Application of CM Results to the Project

Attribute	Step 1 Predicting Physical Impact	Step 2 Convert Annual Implicit Prices to Present Value		Step 3 Multiply Present Value of Implicit Prices by Physical Impact	Step 4 Extrapolate to the Relevant Population* $M
		Implicit Price/yr for 20 yrs	Present value (@ 15%)		
Streams (km)	3	$4.84	$30.28	$90.85	$114
Swamps (ha)	0	$0.43	$2.70	$0.00	$0
Aboriginal sites (no)	10	$0.37	$2.33	$23.35	$29
Years of mine life (yrs)	23	$4.17	$26.09	$600.04	$756

*50% of the estimated 2.5 million households in NSW.

The net benefits of the project to the community incorporating all significant environmental impacts, and ignoring mitigations measures to ameliorate these impacts, would therefore be in the order of $293M. Consequently, the Project would have net benefits and would be considered to be economically efficient.

However, there is an additional benefit of the Project that has not yet been included. This relates to providing employment for some 320 people for 23 years. The results of the choice modelling study indicate that NSW households value this employment at $4.17 per annum for each year that the mine continues (i.e. $0.013 per job per year). Using the same aggregation and discount rates as for environmental attributes, this has an economic value of $756M and adds to the net benefits of the Project.

With these socio-economic benefits included, the quantified net benefits of the Project would be valued at approximately $1,000M. This result is not particularly sensitive to reasonable changes in the estimated physical impact, annual implicit prices, the rate at which annual implicit prices are discounted to present values or the population that values are extrapolated to. A 25% increase in either physical impacts, implicit prices or the population that values are extrapolated to (or a 25% decrease in the discount rate) results in the Project having a net benefit of $1,200 M while a 25% decrease in either physical impacts, implicit prices or the population that values are extrapolated to (or a 25% increase in the discount rate) results in the Project having a net benefit of $895 M.

6.3.2 Application of Results to Examination of Longwall Panel Setbacks from the Waratah Rivulet

The results of the CM study can also be used to examine the cost and benefits of longwall panel setbacks from the Waratah Rivulet to minimise valley closure effects to an upper bound of approximately 200 mm at the stream, to minimise the potential for cracking of the stream bed that causes subsurface flow diversion.

Longwall panel setbacks to achieve a 200 mm valley closure limit would have a number of economic costs and benefits relative to the Project analysed in Section 6.3.1.

A longwall jump (i.e. relocation around a block of coal to be left behind) within the same panel would be required for each of the first ten longwalls, at an estimated capital cost of $2.75M per jump. The relocation of the longwall would take 23 days and result in 23 lost days of production with resulting losses in revenue. Some savings in variable costs of production such as ROM costs to CHPP, freight, marketing and port/sampling costs would occur to partially offset the lost revenue.

To maintain mining without a major stoppage for development (i.e. greater than 23 days) and resolve gas drainage issues would require development of a bleeder and faceline out to LW30 at a cost of $20M in capital equipment and 40 additional employees for 10 years.

The longwall jumps would also result in less ROM coal ultimately being extracted (approximately 9.5Mt of ROM) shortening the life of the mine by approximately 3 years with associated reductions in revenue, and some partially offsetting reductions in operating costs and sustaining capital costs in the lost years.

Decommissioning of the Major Surface Facilities Area would occur 3 years earlier than under the Project, imposing a small cost, while realisation of capital and land residual value would occur 3 years earlier than under the Project base case.

The setback is assumed to negate the need for stream remediation actions resulting in a cost saving. For the purpose of the analysis some greenhouse gas cost savings have also been assumed proportional to reductions in annual production.

The major benefit of these changes would be avoidance of potential subsidence impacts on the Waratah Rivulet.

The present values of these costs and benefits, using a 7% discount rate, are given in Table 22.

Table 22 - Benefit Cost Analysis Results of a 500m Setback or Alternative Variable Setback from Waratah Rivulet (Present Values)

Benefits		**Costs**	
Production			
Operating cost savings	$230 M	Additional capital equipment	$18 M
Reduced sustaining capital from shortened mine life	$14 M	Additional labour	$26 M
Reduced stream remediation costs	$7 M	Cost of longwall jumps	$18 M
Brining forward realisation of residual land	$2 M	Foregone revenue	$311M
		Bringing forward decommissioning	$0 M
Sub-total production benefits	***$253 M***	***Sub-total production costs***	***$373 M***
Environment			
Reduced greenhouse gas impacts	$16 M		
TOTAL QUANTIFIED	**$269 M**	**TOTAL QUANTIFIED**	**$373 M**
NET QUANTIFIED COST		**$104 M**	

Note: These results are slightly different to those reported in the EA (HCPL, 2008) and are based on the latest information.

Table 22 indicates that a setback to achieve a 200 mm valley closure limit would have net quantified costs to the community of $104 M. However, some of the environmental benefits of a setback have not been quantified in Table 22. These are the minimised subsidence effects on approximately 2.5 km of Waratah Rivulet and up to two Aboriginal heritage sites that may fall within the setback area. Table 23 uses the CM results to quantify these changes.

Table 23 – Application of CM Results to a 500m Setback or Alternative Variable Setback from Waratah Rivulet

Attribute	Step 1 Predicting Physical Impact	Step 2 Convert Annual Implicit Prices to Present Value		Step 3 Multiply Present Value of Implicit Prices by Physical Impact	Step 4 Extrapolate to the Relevant Population* $M
		Implicit Price/yr for 20 yrs	Present value (@ 15%)		
Streams (km)	2.5	$4.84	$30.28	$75.71	$95
Swamps (ha)	0	$0.43	$2.70	$0.00	$0
Aboriginal sites (no)	2	$0.37	$2.33	$4.67	$6
Years of mine life (yrs)	3	$4.17	$26.09	$78.27	-$99

*50% of the estimated 2.5 million households in NSW.

Using the CM results:

- reducing impacts on 2.5 km of Waratah Rivulet would be valued at $95M;
- reducing the number of Aboriginal heritage sites impacted from 10 to eight would be valued at $6M; and
- reducing the life of the mine by 3 years would be valued at -$99M.

Including these community costs into the analysis, results in a setback having a net economic *cost* of $101M.

These net economic costs would be partly offset by community values for the additional 40 jobs for 10 years that would be required to ensure no discontinuity in production and resolve gas drainage issues associated with the setback. Assuming that the community value a gain in these jobs the same as they value the loss of mining jobs, the additional jobs would have economic benefits to the community of $41M.

When all major environmental and socio-economic costs and benefits are included, a setback to minimise impacts on Waratah Rivulet would have a net *cost* to society of $60M. Consequently, from an economic perspective a setback could not be considered to be economically efficient. This result is not particularly sensitive to reasonable changes in implicit prices. A 25% increase in either physical impacts, implicit prices or the population that values are extrapolated to (or a 25% decrease in the discount rate) results in a setback having a net *cost* of $49 M while a 25% decrease in either physical impacts, implicit prices or the population that values are extrapolated to (or a 25% increase in the discount rate) results in a setback having a net *cost* of $71 M.

Furthermore, proposed mitigation measures that have the effect of remediating stream cracking to the extent that some of the impacts such as reduction in flows and iron staining are reduced or eliminated would reduce the community costs, making the economic efficiency of a setback even more questionable.

7.0 CONCLUSIONS

CM provides a way of estimating community values for environmental and socio-economic impacts of mines in dollar values so that they can be directly incorporated into BCA of projects. CM therefore enhances the role of BCA as a useful and practical aid to decision-makers, helping mining companies and decision-makers to directly examine the economic efficiency of projects and the economic efficiency of any proposed environmental restrictions on mining.

Because CM involves directly surveying representatives of the community it can provide clear guidance on community values, overcoming the often unsubstantiated qualitative statements from special interest groups about the general community acceptability or otherwise of environmental impacts.

This study demonstrates the application of CM to environmental and socio-economic attributes impacted by underground mining in the Southern Coalfield of NSW. The study found that the community value reducing impacts of mining on environmental attributes such as streams, upland swamps and Aboriginal heritage sites. However, it was also found that the community values the employment that mining provides to the Illawarra region.

Application of the CM results to a BCA of the Metropolitan Coal Project indicates that the Project is economically efficient and hence desirable from a community welfare perspective. Application of the CM results to a BCA of a setback from Waratah Rivulet to minimise subsidence effects, found that the costs of a setback outweigh the benefits. Consequently, a setback cannot be justified from an economic efficiency perspective.

Finally, there have been few applications of CM to the impacts of mining and as such the results of this study will not only be useful in any future consideration of underground mining by HCPL in the Southern Coalfield but also potentially benefit transfer to other underground mining considerations in Australia.

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APPENDIX 1 – EXAMPLE QUESTIONNAIRE

MANAGING THE IMPACTS OF A MINE IN THE SOUTHERN COALFIELD

A SURVEY OF COMMUNITY ATTITUDES

Gillespie Economics

September 2008

INTRODUCTION

In the following questionnaire you are asked to give your views about the management of the impacts of an underground coal mine.

This survey is being undertaken to provide an input into decision-making on the future management of the mine.

Your answers are important to this process.

THE SOUTHERN COALFIELD

The Southern Coalfield extends from the south of Sydney, past Nowra on the NSW south coast, and east of Goulburn (Figure 1).

MINING IN THE SOUTHERN COALFIED

The Southern Coalfield has been mined for over 100 years.

There are eight mines currently operating in the Southern Coalfield and these mines extract coal by underground mining methods.

The focus of this questionnaire is managing the impacts of one of these mines.

The mine:

- is underground;
- is located under Sydney's drinking water catchment which:
    - provides drinking water for Sydney households;
    - is an area recognised for its conservation values;
    - has no public access to it because of Government regulations.
- produces coal primarily for making steel;
- pays royalties and taxes to the NSW State Government that are used to pay for public services such as schools, hospitals, parks and roads;
- directly provides jobs for 320 people;
- contributes to the regional economy; and
- causes "subsidence" – where the ground surface above the mine shifts downwards, and in some localised areas upwards, causing the cracking of the land surface.

Mine subsidence can result in impacts on streams, swamps, rock formations and Aboriginal heritage sites.

Figure 1- Location of the Southern Coalfield

MINE IMPACTS

Streams

Rocks under streams can crack to a depth of up to 15 metres and a width of up to 5 cm as a result of mine subsidence (Figure 2).

This cracking can cause water to flow under the bed of the stream and alter the surface flow above the mining area.

During dry periods when the amount of water flowing in the streams is low:

- most water flows under the bed of the stream via cracks in the rock and re-appears at the surface further downstream (Figure 3); and
- water flows through cracks in rockbars that usually hold water in pools (Figure 4).

When the water re-surfaces it can carry iron from the rock it has flowed through. The iron causes the water and stream bed to have an orange/red colour. This occurs naturally but is increased by cracking of the stream bed.

Figure 2 – Cracking of a Stream Bed Because of the Mine

Figure 3 –Flows under the Bed of Streams Via Cracks in the Rock

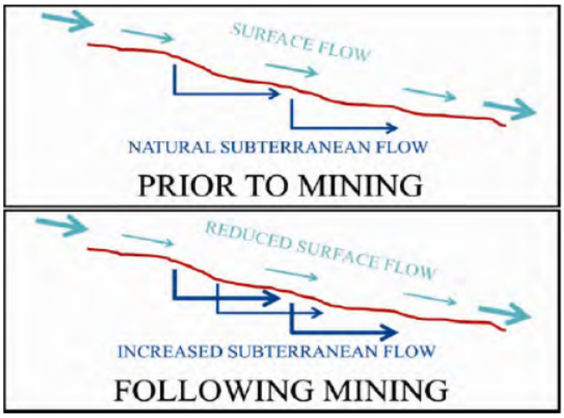
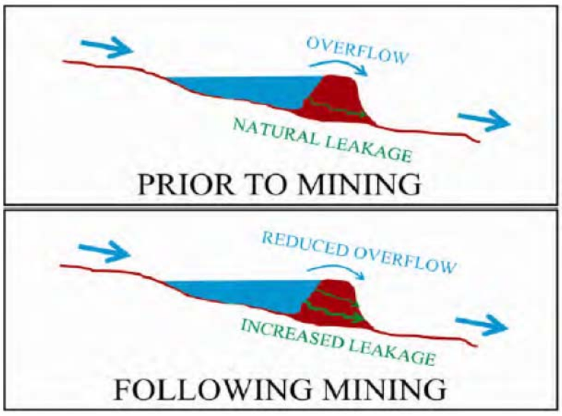


Figure 4 –Flows Through Rockbars that Usually Hold Water in Pools



This means that during dry times there can be:

- reduced water levels in stream pools (Figure 5);
- reduced water flows in sections of the stream downstream of cracking (Figure 6);
- staining of the water and stream bed downstream of where the water re-surfaces (Figure 7); and
- localised changes to the stream environment.

Figure 5 – Reduced Water Level of Natural Pools Due to Increased Rock Bar Leakage (in Low Flow Periods) Because of the Mine

Figure 6 – Reduced Water Flows in Sections of Stream Downstream of Cracking (in Low Flow Periods) Because of the Mine

Figure 7 - Staining of the Stream Bed Downstream of Where the Water Re-Surfaces (Low Flow Periods) Because of the Mine

There is no loss of flow downstream of where the water re-surfaces.

A Government inquiry found that the quality and quantity of Sydney's water supply is not impacted by these changes.

During average rainfall conditions, pool water levels stay high, water flows over rockbars and the appearance of staining is reduced (Figures 8 and 9).

Figure 8 – Stream Affected By the Mine After Rain

Figure 9 – Pool Affected By the Mine After Rain

- 4 kilometres of streams (out of a total of 1,500 km of streams in the Southern Coalfield) have been affected by subsidence above the mine, with these types of environmental impacts being observed.
- If mining continues as currently planned, it is predicted that a total of 15 km of streams (out of a total of 1,500 km of streams in the Southern Coalfield) will be affected by subsidence above the mine in 20 years time.
- Sydney's water supply would not be impacted by these changes.

Upland Swamps

- Upland swamps generally occur in gently sloping valleys.
- Upland swamps provide habitat for a range of plants and animals (e.g. frogs and birds).
- The mine subsidence can cause cracks in the swamps, erosion and changes in the types of vegetation present.
- 20 ha of upland swamps (out of a total of more than 6,000 ha of upland swamps in the Southern Coalfield) have been affected by subsidence above the mine, with these impacts being observed.
- If the mining continues as currently planned, it is predicted that a total of 200 ha of upland swamps (out of a total of more than 6,000 ha of upland swamps in the Southern Coalfield) will be affected by subsidence above the mine in 20 years time.

Figure 10 – Upland Swamp

Aboriginal Heritage

- Above the mine there are rock formations such as sandstone ridges, steep slopes, rocky ledges and overhangs.
- Some of these rock formations contain known Aboriginal heritage sites (e.g. grinding groove sites, engraving sites, rock art and artefacts).
- The mine subsidence can increase the chance that these rock formations, especially rock overhangs, will crack, have rock falls or collapse.
- 100 Aboriginal heritage sites (out of a total of up to 15,000 Aboriginal heritage sites in the Southern Coalfield) have been affected by subsidence above the mine.
- If mining continues as currently planned, it is predicted that a total of 270 Aboriginal heritage sites (out of a total of up to 15,000 Aboriginal heritage sites in the Southern Coalfield) will be affected by subsidence above the mine in 20 years time.

Figure 11– Sandstone Overhang

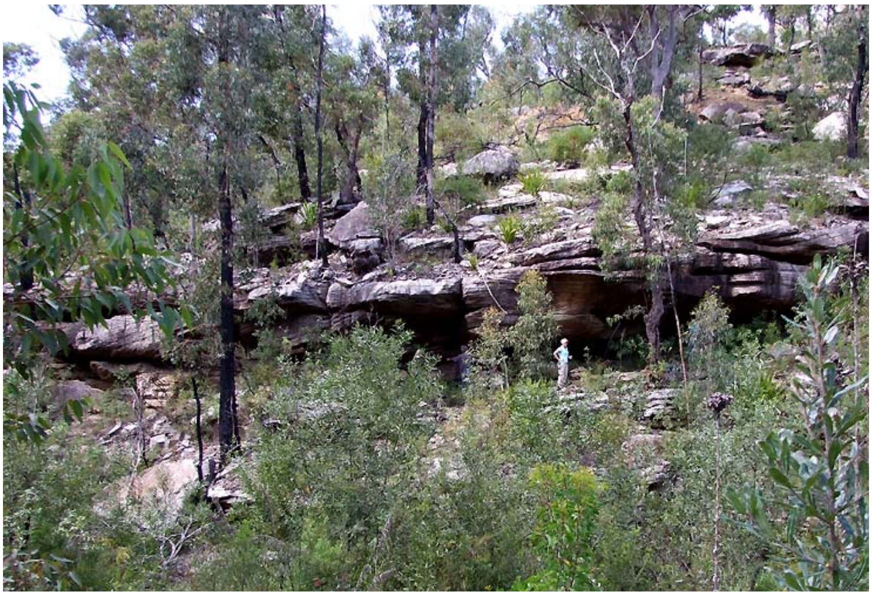
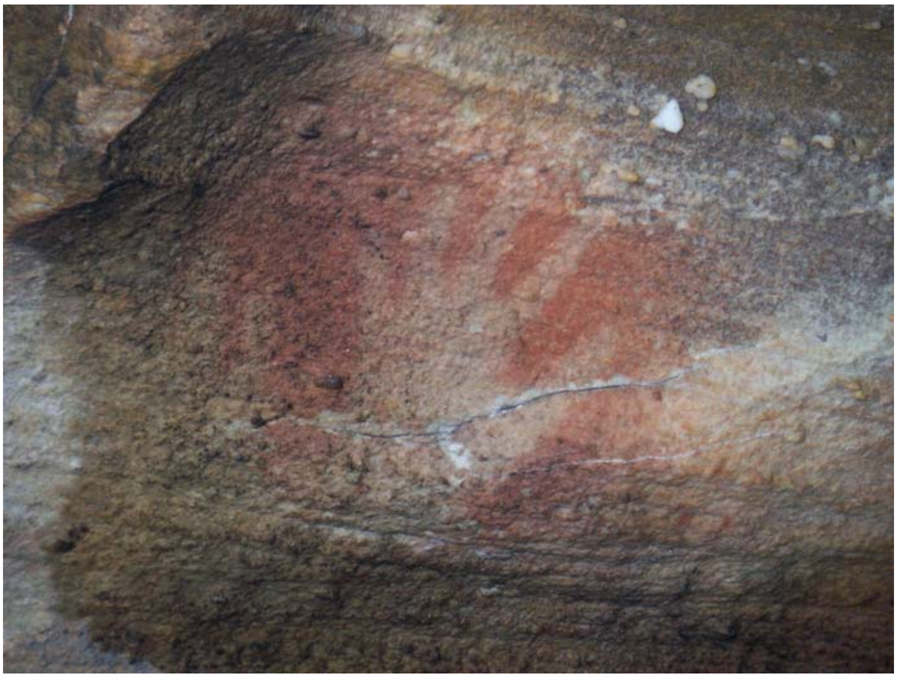


Figure 12 – Aboriginal Rock Art in Sandstone Overhang



REDUCING THE MINE'S IMPACTS ON STREAMS, SWAMPS AND ABORIGINAL HERITAGE

To reduce these impacts of the mine, the government could:

- prevent some future coal mining activities;
- require a change in the extent of mining; or
- require future mining to avoid areas that are located below or adjacent to streams, swamps and Aboriginal heritage sites.

Such government decisions would affect employment at the mine.

MINE EMPLOYMENT

- The mine currently directly employs 320 people.
- The mine also provides jobs indirectly to contractors and service providers.
- The mine contributes to the regional economy.
- If mining continues as planned, the mine will continue to provide 320 jobs for the next 25 years. There are 2,500 direct mining jobs in the Southern Coalfield.
- Government decisions that reduce the affects of the mine on streams, upland swamps and Aboriginal sites would shorten the life of the mine, and hence the length of time that the 320 jobs are provided.

Figure 13 - Mine Employment

HOW THIS COULD AFFECT YOU?

Government decisions to reduce the environmental impacts of the mine would reduce coal production and less money would be received by the State Government from royalties and taxes. This could reduce the level of public services provided by government for the households of NSW.

To reduce the environmental impacts of the mine, and keep the current level of public services that you receive from the State Government each year, every household in NSW would have higher costs (i.e. you would need to make additional payments to the State Government) over a 20-year period.

These payments would be to replace the royalties and taxes otherwise paid by the mine and would be in the form of:

- increased taxes; and/or
- paying higher prices for public services.

The size of the annual payments you would make, and the type and extent of reductions in environmental impacts, would depend on the type of government decisions made for the mine.

WHAT DO YOU THINK?

Options

In Questions 1 to 5 below, we want you to make some choices between **alternative government decisions** about how the mine operates.

Option 1 shows the impacts from the mine that will occur if the mine is permitted to continue to operate as currently planned.

- Options 2 to 11 involve new government decisions for the mine.
- Each of the options is described by the:
  - predicted impacts in 20 years time in terms of:
    - the total length of streams affected;
    - the total area of swamps affected;
    - the total number of Aboriginal heritage sites affected;
  - predicted impacts on the life of the mine; and
  - money it would cost you each year to achieve these outcomes.

When making your choices please consider:

- each question involves only three options – this is to make your choice easier;
- each option provides:
  - different environmental impacts over the next 20 years that would come from different government decisions;
  - different impacts on the life of the mine;
  - different annual payments that you would be required to make each year for 20 years to achieve these outcomes;
- your income is limited and you have other expenses; and
- other areas of NSW may also need funding for environmental improvement.

Note:

- Your answers are important to deciding the way that the environmental impacts of the mine will be managed in the future.
- Some of the option outcomes may seem strange to you. This is because each outcome depends on a different combination of policies that can lead to different outcomes.
- Each question should be considered **independently** of each other.

Question 1

Carefully consider each of the following three options for managing the environmental impacts of the mine. Suppose options 1, 2 and 3 in the table below are the **ONLY ones available**. Which one would you choose?

Option	**Your annual payment for 20 years**	**Total impacts of the mine in 20 years time**			**Period of time that the mine will provide 320 jobs**
		Total length of streams affected	**Total area of upland swamp affected**	**Total number of Aboriginal sites affected**	
Option 1 *Mining continues as currently planned*	$0	15 km	200 ha	270 sites	25 years
Option 2 *New government decisions for the mine*	$100	12 km	20 ha	160 sites	18 years
Option 3 *New government decisions for the mine*	$20	4 km	140 ha	100 sites	10 years

Which option would you choose? (Please tick)
Option 1 ☐
Option 2 ☐
Option 3 ☐
Not Sure ☐

Question 2

Carefully consider each of the following three options for managing the environmental impacts of the mine. Suppose options 1, 4 and 5 in the table below are the **ONLY ones available**. Which one would you choose?

Option	**Your annual payment for 20 years**	**Total impacts of the mine in 20 years time**			**Period of time that the mine will provide 320 jobs**
		Total length of streams affected	**Total area of upland swamp affected**	**Total number of Aboriginal sites affected**	
Option 1 *Mining continues as currently planned*	$0	15 km	200 ha	270 sites	25 years
Option 4 *New government decisions for the mine*	$100	4 km	140 ha	100 sites	18 years
Option 5 *New government decisions for the mine*	$100	12 km	80 ha	100 sites	18 years

Which option would you choose? (Please tick)
Option 1 ☐
Option 4 ☐
Option 5 ☐
Not Sure ☐

Question 3

Carefully consider each of the following three options for managing the environmental impacts of the mine. Suppose options 1, 6 and 7 in the table below are the **ONLY ones available**. Which one would you choose?

Option	**Your annual payment for 20 years**	**Total impacts of the mine in 20 years time**			**Period of time that the mine will provide 320 jobs**
		Total length of streams affected	**Total area of upland swamp affected**	**Total number of Aboriginal sites affected**	
Option 1 *Mining continues as currently planned*	$0	15 km	200 ha	270 sites	25 years
Option 6 *New government decisions for the mine*	$100	8 km	80 ha	220 sites	18 years
Option 7 *New government decisions for the mine*	$50	8 km	20 ha	100 sites	2 years

Which option would you choose? (Please tick)
Option 1 ☐
Option 6 ☐
Option 7 ☐
Not Sure ☐

Question 4

Carefully consider each of the following three options for managing the environmental impacts of the mine. Suppose options 1, 8 and 9 in the table below are the **ONLY ones available**. Which one would you choose?

Option	**Your annual payment for 20 years**	**Total impacts of the mine in 20 years time**			**Period of time that the mine will provide 320 jobs**
		Total length of streams affected	**Total area of upland swamp affected**	**Total number of Aboriginal sites affected**	
Option 1 *Mining continues as currently planned*	$0	15 km	200 ha	270 sites	25 years
Option 8 *New government decisions for the mine*	$20	8 km	140 ha	160 sites	18 years
Option 9 *New government decisions for the mine*	$20	12 km	20 ha	160 sites	18 years

Which option would you choose? (Please tick)
Option 1 ☐
Option 8 ☐
Option 9 ☐
Not Sure ☐

Question 5

Carefully consider each of the following three options for managing the environmental impacts of the mine. Suppose options 1, 10 and 11 in the table below are the **ONLY ones available**. Which one would you choose?

Option	**Your annual payment for 20 years**	**Total impacts of the mine in 20 years time**			**Period of time that the mine will provide 320 jobs**
		Total length of streams affected	**Total area of upland swamp affected**	**Total number of sandstone overhangs affected**	
Option 1 *Mining continues as currently planned*	$0	15 km	200 ha	270 sites	25 years
Option 10 *New government decisions for the mine*	$20	12 km	80 ha	100 sites	18 years
Option 11 *New government decisions for the mine*	$100	8 km	140 ha	160 sites	2 years

Which option would you choose? (Please tick)
Option 1 ☐
Option 10 ☐
Option 11 ☐
Not Sure ☐

WE WOULD NOW LIKE TO ASK YOU SOME FURTHER QUESTIONS ABOUT THE DIFFERENT GOVERNMENT DECISIONS AND RESULTING ENVIRONMENTAL IMPACTS FOR THE MINE

Question 6

When answering Questions 1 to 5, did you always choose Option 1 (mining continues as currently planned)?

☐ Yes ☐ No ***Go to Question 7***

If you answered "yes", which of the following statements most closely describe your reason for doing so? Tick one box only.

- ☐ I support mining continuing as currently planned and the associated environmental impacts
- ☐ I support changing mine environmental impacts, but could not afford a payment of any amount
- ☐ I support changing mine environmental impacts but object to a payment of any amount
- ☐ I didn't know which option was best, so I stayed with the current management and environmental impacts
- ☐ Some other reason. Please specify below:
  …………………………………

Go to Question 7

Question 7

Thinking about the information presented at the start of this survey on the environmental impacts of the mine and the questions asked earlier, please indicate how strongly you agree or disagree with EACH of the following statements. Tick the option that is closest to your view.

I understood all the information provided

- ☐ Strongly Disagree
- ☐ Disagree
- ☐ Neither Agree Nor Disagree
- ☐ Agree
- ☐ Strongly Agree

I needed more information than was provided

- ☐ Strongly Disagree
- ☐ Disagree
- ☐ Neither Agree Nor Disagree
- ☐ Agree
- ☐ Strongly Agree

I found answering Questions 1 to 5 confusing

- ☐ Strongly Disagree
- ☐ Disagree
- ☐ Neither Agree Nor Disagree
- ☐ Agree
- ☐ Strongly Agree

WE WOULD LIKE TO KNOW HOW FAMILIAR YOU ARE WITH THE NATURAL AREAS OF THE SOUTHERN COALFIELD

Question 8

Have you visited the natural areas of the Southern Coalfield (Illawarra, Wollongong or Southern Highlands) in the last 10 years?

- ☐ Never visited → go to Q10
- ☐ Visited only once
- ☐ Visited between once and 10 times
- ☐ Visited more than 10 times

Question 9

When you visited the natural areas of the Southern Coalfield (Illawarra, Wollongong or Southern Highlands), which of the following things did you do? (tick as many boxes as applies)

☐ Camping	☐ Visiting friends
☐ Bushwalking	☐ Fishing
☐ Sightseeing	☐ Picnicking
☐ Swimming	☐ Other (please specify) ……………….. ………………..
☐ Birdwatching	

Question 10

How interested are you in the environmental impacts of mining in the Southern Coalfield?

- ☐ Not interested at all
- ☐ Slightly interested
- ☐ Moderately interested
- ☐ Very interested

In this last section, we would like to ask you a few questions to help us understand why respondents' opinions may differ.

WE REALISE THAT SOME OF THESE QUESTIONS MAY BE SENSITIVE TO YOU BUT PLEASE BE ASSURED THAT THE INFORMATION IS CONFIDENTIAL

Question 11

What is your age? …………..

Question 12

What is your gender?

☐ Male	☐ Female

Question 13

Do you have any children?

☐ Yes	☐ No

Question 14

What is the postcode where you live? ……….

Question 15

What is the highest level of education you have obtained?

☐ Never went to school	☐ Diploma or certificate
☐ Primary only	☐ Tertiary degree
☐ Junior/Year 10	☐ Post-graduate degree
☐ Secondary/Year 12	☐ Other (please specify) ……………………….. ……………………….

Question 16

How many people live in your household?.............

Question 17

How many people in your household are under 18 years of age?

Question 18

Annual Household Income - Please indicate the approximate total household income (before taxes) earned last year. The ranges shown are consistent with those used in the 2006 Census.

As for all your answers, information provided here is **STRICTLY CONFIDENTIAL**.

☐ Under $7,799	☐ $62,400 to $72,799
☐ $7,800 to $12,999	☐ $72,800 to $88,399
☐ $13,000 to $18,199	☐ $88,400 to $103,999
☐ $18,200 to $25,999	☐ $104,000 to $129,999
☐ $26,000 to $33,799	☐ $130,000 to $155,999
☐ $33,800 to $41,599	☐ $160,000 or more
☐ $41,600 to $51,999	☐ Don’t know
☐ $52,000 to $62,399	

Question 19

When you have heard about proposed mining projects where there is a conflict between development and the environment, have you tended to:

- ☐ Favour protection of the environment
- ☐ Favour development and environmental protection about equally
- ☐ Favour development

Question 20

If people living in the Illawarra, Wollongong or Southern Highlands and/or working in mining are made worse-off by changing the environmental impacts of the mine, the State Government may provide some assistance, at a cost to taxpayers.

Would you:

- ☐ Strongly Agree with providing assistance
- ☐ Agree with providing assistance
- ☐ Neither Agree nor Disagree with providing assistance
- ☐ Disagree with providing assistance
- ☐ Strongly Disagree with providing assistance

Question 21

Are you, or a member of your close family, a member of an organisation that is associated with environmental conservation or regularly contribute to this type of organisation?

☐ Yes	☐ No

Question 22

Are you, or a member of your close family, associated with the mining industry?

☐ Yes	☐ No

If you would like to make any other comments about managing the impacts of a mine in the Southern Coalfield, or about this questionnaire, please make them in the following space.

…………………………………………………………………………

…………………………………………………………………………

…………………………………………………………………………

……………………………………………………………………….....

Thank you for completing this questionnaire. We hope that you enjoyed taking part in the survey.

APPENDIX 2 - TECHNICAL APPENDIX

Introduction

This appendix provides some theoretical background to the econometric techniques and the model specifications used to analyse the data from the web-based survey on underground mining impacts.

Random utility theory

Choice Modelling has its theoretical foundation in Lancaster's 'characteristics theory of value' (Hanley et al., 2006) and in the Random Utility Theory. The Random Utility Model describes utility U_{ij} that individual *i* derives from choice alternative *j* as a latent variable that is observed indirectly through the choices people make (Equation 1). Each utility value consists of an observed 'systematic' utility component V_{ij} and a random unobserved component "error term" ε_{ij}, which represents unobserved individual idiosyncrasies of tastes (Louviere et al., 2000).

$$U_{ij} = V_{ij} + \varepsilon_{ij} \qquad j=0,1,\ldots\ldots\ldots\ldots J \qquad \text{(Equation 1)}$$

The unobserved utility obtained from choosing alternative j, is influenced by the vector of attributes $\mathbf{X}_j$ of each alternative *j* (including non-market attributes), costs associated with each alternative C_j and individual *i*'s socio-economic characteristics $\mathbf{W}_i$ (Equation 2).

$$U_{ij} = f(\mathbf{X}_j, C_j, \mathbf{W}_i, \varepsilon_{ij}) \qquad \text{(Equation 2)}$$

Alternative *j* will be chosen if and only if the utility derived from that option is greater than the utility derived from any other alternative *k* (Equation 3). It is expected that if the quality of a 'good' attribute in an alternative rises, the probability of choosing that alternative increases, *ceteris paribus*.

$$\Pr(j \mid \mathbf{X}_j, C_j, \mathbf{W}_i, \varepsilon_{ij}) = \Pr\{(V_{ij} + \varepsilon_{ij}) > (V_{ik} + \varepsilon_{ik})\} \qquad \text{(Equation 3)}$$

The Conditional Logit model

The utility U_{ij} that individual *i* derives from choice alternative *j* is inferred indirectly through the choices people make. The model of respondents' choices follows from assumptions about the error distribution. If it is assumed that the error terms ε_{ij} are independently and identically distributed (IID, also called 'Gumbel' distribution), the probability of choosing alternative *j* can be estimated by a Conditional Logit (CL) model (Cameron and Trivedi, 2005: 490-503). This model is often called a Multi Nominal Logit model, and is the 'workhorse of all choice modelling applications. It is recommended that significant time is spend on analysing a CL specification for any CM dataset before estimating more complex models (Louviere et al., 2000).

In the CL model, V_{ij} is the systematic component of utility and is a linear, additive function of the environmental attributes of alternative *j* ($\mathbf{X}_j$), costs (C_j) and individual socio-economic characteristics ($\mathbf{W}_i$). An alternative specific constant (ASC) reflects the systematic, but unobserved component of the individual's choices (Equation 4). Including an ASC, normalising $ASC_{j=0}$ to zero, in the analysis allows for systematic differences in utilities for different alternatives that are not explained by the attributes, costs or socio-economic characteristics.

$$U_{ij} = f(\mathbf{X}_j, C_j, \mathbf{W}_i, \varepsilon_{ij}) = V_{ij} + \varepsilon_{ij} = ASC_j + \beta'\mathbf{X}_j + \alpha C_j + \gamma'\mathbf{W}_i + \varepsilon_{ij} \qquad \text{(Equation 4)}$$

The probability that individual *i* chooses alternative *j* out of J alternatives can then be estimated by a Conditional Logit (CL) model[3]:

$$\Pr(j \mid \mathbf{X}_j, C_j, \mathbf{W}_i, \varepsilon_{ij}) = \frac{\exp(V_{ij})}{\sum_{j=1}^{J}\exp(V_{ij})} = \frac{\exp(ASC_j + \beta'\mathbf{X}_j + \alpha C_j + \gamma'\mathbf{W}_i + \varepsilon_{ij})}{\sum_{j=1}^{J}\exp(ASC_j + \beta'\mathbf{X}_j + \alpha C_j + \gamma'\mathbf{W}_i + \varepsilon_{ij})}$$
$$\Pr(j \mid \mathbf{X}_j, C_j, \mathbf{W}_i, \varepsilon_{ij}) = \frac{\exp(ASC_j)\exp(\beta'\mathbf{X}_j)\exp(\alpha C_j)\exp(\gamma'\mathbf{W}_i)\exp(\varepsilon_{ij})}{\sum_{j=1}^{J}\exp(ASC_j)\exp(\beta'\mathbf{X}_j)\exp(\alpha C_j)\exp(\gamma'\mathbf{W}_i)\exp(\varepsilon_{ij})} \qquad \text{(Eq. 5)}$$

[3] XXXXXXX

In order to estimate Equation 5, an additional assumption of the error terms is necessary. It is typically assumed that the error terms are independently and identically distributed (IID) with a type I extreme-value (Weibull) distribution (Equation 6).

$$F(\varepsilon_{ij}) = \exp(-e^{\varepsilon_{ij}}) \qquad \text{(Equation 6)}$$

The CL model can now be estimated by Maximum Likelihood. To avoid a perfectly collinear set of measures, at most (J-1) ASCs can be specified in the CL model.

From Equation 5, it follows that terms that do not vary across alternatives – the individual characteristics - fall out of the expression (Greene, 2003). To account for socio-economic characteristics that may influence individual choices, they need to be interacted with the alternative specific constant when included in the probability expression. The coefficients of these interaction terms measure the propensity of different respondents to choose alternatives other than the 'no change' alternative. (Wielgus *et al*. 2006).

We can illustrate this for the MINING example, where the $ASC_{no\text{-}change}$ is normalised to zero. A positive coefficient on the 'asc*income' variable would indicate that respondents with higher incomes are more likely to choose new government decisions than continuing the mining as planned.

Comparing alternative model specifications

Many different utility functions (Equation 2) can be specified for every single data-set. It is the analyst's task to choose the 'best' model from a wealth of possible model specifications. While adding variables to a model may provide a better model 'fit', the increased complexity may lead to less reliable model estimates. Several selection criteria can be used to compare alternative model specifications and weight the trade-off between increased information and decreased parsimony.

1. Pseudo R^2

The R^2 statistic associated with logit models is not the same as the R^2 statistic of regular linear regression models (Hensher et al., 2005: 337). In general, a pseudo-R^2 of 0.2 and higher represents a reasonable model fit.

The pseudo-R^2 can be calculated using the model log likelihood (LL) function and the log likelihood of some base model:

$$pseudo - R^2 = 1 - \frac{LL_{Estimated\ \mathrm{mod}\ el}}{LL_{Base\ \mathrm{mod}\ el}}$$

Two points of comparison have been used in the literature: A base model that assumes equal choice probabilities for each alternative (the 'null' model); and a base model that uses the market shares as they exist within the data set (the 'constant only' model). The pseudo-R^2 given by different software packages may vary, depending on the base model used to calculate the pseudo R^2.

2. Model log-likelihood

Nested models can be compared using the LL of each model in a LL ratio test (LR-test). Generally, the model with the highest LL is preferred, but an increased LL may come at the costs of increasing model complexity. The LR-test is calculated as

$-2\ (LL_{Base\ model} - LL_{Estimated\ model}) \sim \chi^2(q)$
where q is the number of additional parameters in the estimated model.

The null hypothesis being tested is that the estimated model is not better than the base comparison model. The null can be rejected if $\chi^2(q) > \chi^2\text{-}critical$.

3. Information Criteria

Non-nested models cannot be compared using a LR-test. When different models are specified, *information criteria* can be used to compare the models. Two, often used information criteria are Akaike's information criterion (AIC) and Bayesian information criterion (BIC). As the LR-test, these criteria are based on the LL statistic but instead of using the LL itself, they take model parsimony into account. The AIC is defined as *AIC = -2 LL + 2q*. This criterion penalises for the number of model parameters *q*, as the LL will always increase by adding parameters. The BIC is defined as *BIC = -2 LL + (lnN)q*. This criterion penalises for both the number of model parameters *q* and the sample size *N*. This incorporates the idea that, in larger samples, a larger improvement in model fit is needed before the more complex model is preferred over a simpler one.

As long as models are fit on the same set of data, AICs and BICs can be used to compare models. The model with the smaller information criterion is preferred. There exists no general rule as to how much difference in information criteria is required before choosing the model with the smaller AIC or BIC. In general, a difference of more than 6 provides strong evidence that the model with the smallest information criterion is better (Raftery 1995).

Testing the IIA assumption

Hausman and McFadden (1984) propose a specification test to determine if the IIA assumption holds. This involves obtaining parameter estimates $\hat{\beta}$ for an unrestricted choice model with all alternatives and parameter estimates $\tilde{\beta}$ for a restricted model where one of the alternatives has been removed from the data. Under the IIA assumption, both $\hat{\beta}$ and $\tilde{\beta}$ will be consistent estimators. The null hypothesis is that there is no systematic difference between the estimated coefficients of the unrestricted model and the restricted model: $H_0 : p\lim(\hat{\beta} - \tilde{\beta}) = 0$. Rejection of the null provides evidence that the IIA property is violated.

A drawback of the often used 'Hausman test' in many software packages is that the test may pick up general model misspecifications. Running auxiliary regressions and comparing the results can test the same linear restriction as the Hausman test, but may be more appropriate if the estimates were obtained on overlapping data. STATA provides a convenient command to do this using Seemingly Unrelated Regressions (suest).

The Nested Logit model

An important assumption in the CL model is the Independence-from-Irrelevant-Alternatives (IIA) property (Equation 7).

$$\frac{\Pr(j|V_{ij})}{\Pr(k|V_{ik})} = \frac{\exp(V_{ij})}{\exp(V_{ij})} = \exp[(V_{ij} - V_{ik})\beta] \qquad \text{(Equation 7)}$$

The IIA assumption states that the relative probability of choosing one alternative over another (given that both alternatives have a non-zero probability of choice) is unaffected by the introduction or removal of additional alternatives in the choice set (Louviere et al., 2000). The IIA assumption implies that the error terms are independent across alternatives and provides a computationally convenient choice model. However, the IIA assumption is unlikely to hold if the preferences of respondents are heterogeneous (Louviere et al., 2000). Using a CL model will then lead to biased estimators.

The literature suggests several models that have less restrictive assumptions than the CL model. Nested Logit (NL) and Random Parameter Logit (RPL) models are increasingly used and do not require independently distributed error terms.

A Nested Logit model arises when the error terms ε_{ij} have a generalised extreme value distribution (Cameron and Trivedi, 2005: 509). The NL model specifies a tree structure with several branches that are divided into subgroups (Figure). The variance is allowed to differ across the branches, while maintaining the homogeneity assumption within the groups (Greene, 2003). This means that the NL model assumes error correlation within each branch, but uncorrelated error terms across branches. The probability of choosing alternative j ($\Pr_{jm}$) is now conditional on choosing branch m ($\Pr_m$) that leads to that alternative (Equation 8).

$$\Pr_{jm} = \Pr_{j|m} \cdot \Pr_m \qquad \text{(Equation 8)}$$

Where

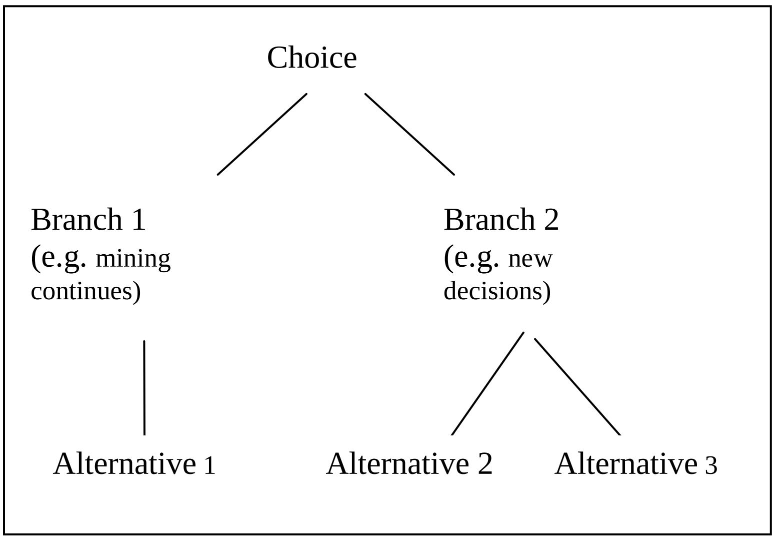
$$\Pr_{j|m} = \frac{\exp\left(V_{jm}/\alpha_m\right)}{\sum_{l=1}^{J} \exp\left(V_{jl}/\alpha_l\right)}$$

$$\Pr_m = \frac{\exp(\alpha_m IV_m)}{\sum_{k=1}^{M} \exp(\alpha_k IV_k)}$$

$$IV_m = \log\left[\sum_{i=1}^{J_m} \exp\left(\frac{V_{im}}{\alpha_m}\right)\right]$$

IV_m is the ‘inclusive value’ that captures the sum of the utility of all alternatives in branch m. The IV parameter α_m measures the substitutability across alternatives. α_m will lie between zero and one when substitutability is greater within rather than across branches (Blamey et al., 2000). The NL model can also be used to test the IIA assumption. If the α_m parameters in the model are not statistically different from one, all alternatives are equally substitutable and the model collapses into the single level CL model (Hensher et al., 2005). An IV parameter that is statistically different from one therefore provides evidence that the IIA property fails to hold.

Figure A2.1 - Example Structure for a Nested Logit Model



A typical NL model structure first estimates the probability of choice between a ‘no-change’ and a ‘new management’ option. The choice between these branches is often explained by the respondent’s socio-economic characteristics (e.g. Blamey *et al*. 2000, van Bueren and Bennett 2004). For example, it can be hypothesised that respondents who are a member of an environmental organisation are more likely to choose for new management. Within the ‘new management’ branch, a choice between two different options (scenarios 2 and 3) is assumed to depend on the level of the attributes associated with the policy change.

The Random Parameter Logit model

It is likely that preferences are different for each individual. This is included in the CL and NL models by adding individual socio-economic and attitudinal variables to the utility specification. But there may exist additional correlation in an individuals’ *unobserved* utility over repeated choices (Revelt and Train 1998). In that case, estimating one coefficient for each environmental attribute will not give a valid parameter estimate. The Random Parameter Logit model (RPL) is a way to generalise the CL model that allows for possible error correlation across alternatives and that accounts for variation in preferences across individuals (Hanley et al., 2006). As in the CL model, utility is specified as

$$U_{ij} = ASC_j + \beta' \mathbf{X}_j + \alpha C_j + \gamma' \mathbf{W}_i + \varepsilon_{ij} \qquad \text{(Equation 4)}$$

with IID errors following an extreme value distribution. In contrast to the CL model, parameters β_j', α_{Cj} and γ_i' are assumed to be randomly distributed with density functions $f(\beta_j|\theta), f(\alpha_{C_j}|\theta), f(\gamma_i|\theta)$. These density functions represent the taste differences in the population, with $\boldsymbol{\theta}$ a vector of parameters characterising the density function. The aim is to estimate $\boldsymbol{\theta}$ (Brey *et al*., in press).

The analyst needs to specify the distributional properties of each random parameter. Four common distributions are a lognormal, normal, uniform or triangular distribution. Using a normal distribution allows for both positive and negative estimates of the random parameters, whereas a uniform distribution may be sensible for dummy variables. A lognormal distribution is often used if the parameter needs to be non-negative, but typically has very long right-hand tails which is a disadvantage for WTP calculations. A triangular distribution with an upper or lower bound at zero can also be used to estimate parameters that are expected to be negative or positive.

The RPL model is estimated using maximum likelihood estimation that explicitly accounts for the randomness in β', α and γ'. As the model does not have a closed form solution, simulation methods are needed to obtain parameter estimates. Within the most basic RPL framework, random parameters are estimated drawing from all possible parameters in the sampled population. The parameter estimates derived are therefore *not conditioned* on individual choice patterns, but rather on the sample population as a whole. Individual specific parameters can also be estimated, which often provides very different results.

Estimating the utility functions for choice alternatives with random parameters can be complicated. For the MINING survey as an example, it would be possible to model the cost attribute with a constrained triangular distribution *t*, and all other choice attributes with a Normal *N* distribution. For the attribute-only model, the utility expressions for alternatives *J=(1,…,j)* become:

$$V_j = ASC + (\beta_{WTP} + \theta_{WTP} \cdot t) \cdot WTP_j + (\beta_{KM} + \theta_{KM} \cdot N) \cdot KM_j + (\beta_{HA} + \theta_{HA} \cdot N) \cdot HA_j +$$
$$(\beta_{HA} + \theta_{HA} \cdot N) \cdot NO_j + (\beta_{HA} + \theta_{HA} \cdot N) \cdot YRS_j$$

Implicit price estimates

Respondents are assumed to make a trade-off between the levels of the non-market attributes and the associated annual payments. The expressed trade-offs between attributes can be used to estimate the marginal utility of each attribute (Bateman et al., 2006). If money is one of the attributes, this marginal utility is expresses as the ‘marginal willingness to pay’ for each individual attribute.
Marginal values are expressed as estimates of parth-worths (*implicit prices*) for percentage changes in the individual attributes. The implicit prices are derived using the formula:

$$WTP = \frac{\beta_{attribute}}{\beta_{\cos ts}}$$

Where

$\beta_{attribute}$ is the estimated coefficient of the (non-market) attribute, and
B_{costs} is the estimated coefficient of the cost attribute.

Implicit prices provide a point estimate of the value of a unit change in the attribute. These are *marginal* values representing the value of a small change in the attribute considered assuming *ceteris paribus* that the levels of all other attributes are held constant.

Specifying the standard errors and confidence intervals for implicit price ratios can be complex. The calculation of the standard errors has been subject to numerous debates (see, for example, Poe et al., 1997, and Poe et al., 2005). Although the asymptotic distribution of the maximum likelihood estimator for the parameters $\tilde{\beta}$ is known, the asymptotic distribution of the implicit price ratio is not, since it is a non-linear function of the parameter vector (Hanley et al., 2001).

It is suggested to use a simulations approach to obtain the distribution of implicit prices. Confidence intervals can be obtained by bootstrapping techniques where repeated random draws are taken from the asymptotic distribution of the implicit price estimates. The variance in the bootstraps can then be used to estimate confidence intervals of the implicit price estimates.

ATTACHMENT 2

EPBC REFERRAL INFORMATION AND DEWHA CORRESPONDENCE

Peabody

HELENSBURGH COAL

19 February 2009

Attention: Carmel O'Connor
Coordinator, Planning Assessment Commission
Level 13, 301 George Street
Sydney NSW 2001

For provision to the Metropolitan Coal Project Planning Assessment Commission Panel Members

Re: Metropolitan Coal Project - Commonwealth EPBC Act Referral Decision

Under the *Environment Protection and Biodiversity Conservation Act 1999* (the EPBC Act), a person must not take an action that has, will have, or is likely to have a significant impact on any matters of national environmental significance without approval from the Australian Government Environment Minister. To obtain approval from the Environment Minister, a proposed action has to be referred to the Department of the Environment, Water, Heritage and the Arts (DEWHA) for the assessment of environmental impacts.

Helensburgh Coal Pty Ltd submitted a Referral for the Metropolitan Coal Project to the DEWHA in October 2008. In accordance with the EPBC Referral process, the Referral was also released to the public for comment via the DEWHA website.

The Environment Minister or his delegate decides whether the Project is likely to have a significant impact on any EPBC Act matters. This includes listed threatened flora and fauna species. Evaluations were conducted to assess the potential impacts of the Project on listed threatened flora and fauna species, including those that are known or have potential to utilise upland swamp habitats (such as the Prickly Bush-pea, *Pultenea aristata*) and stream habitats (such as the Giant Burrowing Frog, *Heleioporus australiacus*).

The evaluations are provided in Appendix G of the Project Environmental Assessment and assess whether there is a real chance or possibility that the proposal will:

- lead to a long-term decrease in the size of a population of a species;
- reduce the area of occupancy of a population;
- fragment an existing population into two or more populations;
- adversely affect habitat critical to the survival of a species;
- disrupt the breeding cycle of a population;
- modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline;
- result in invasive species that are harmful to a species becoming established in the species' habitat;
- introduce disease that may cause the species to decline; or
- interfere with the recovery of the species.

On 4 February 2009, the DEWHA advised that:

> *We have decided that the proposed action is not a controlled action and, as such, does not require assessment and approval by the Minister for the Environment, Heritage and the Arts before it can proceed.*

As such, it is considered by DEWHA that the Project is unlikely to have a significant impact on any EPBC Act matters, including listed threatened species that may utilise upland swamp and stream habitats.

A copy of the DEWHA correspondence is attached for your information.

Please do not hesitate to contact us should the Planning Assessment Commission require further information or clarification.

Yours sincerely,

NEVILLE MCALARY
General Manager

Australian Government

Department of the Environment, Water, Heritage and the Arts

Mr Neville McAlary
General Manager, Metropolitan Colliery
Helensburgh Coal Pty Ltd
PO BOX 402
HELENSBURGH NSW 2508

Date: 4 / 2 / 2009
EPBC Ref: 2008/4519
EPBC contact : Ms Lucy Butterfield
02 6274 2063
Lucy.Butterfield@environment.gov.au

Dear Mr McAlary

Decision on referral

Metropolitan Coal Project, 30km North Of Wollongong, NSW, (EPBC 2008/4519)

This proposed action, to continue, upgrade and extend the existing underground coal mining operations and surface facilities at the existing Metropolitan Colliery, 30 kilometres north of Wollongong, New South Wales, has now been considered under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

We have decided that the proposed action is not a controlled action and, as such, does not require assessment and approval by the Minister for the Environment, Heritage and the Arts before it can proceed.

A copy of the document recording this decision is enclosed.

Please note that this decision relates only to the potential for significant impact on the specific matters protected by the Australian Government under Chapter 4 of the EPBC Act.

There may be a need for separate state or local Government environment assessment and approval to address potential impacts on state, regional or local environmental values.

The Department has an active audit program for proposals that have been referred or approved under the EPBC Act. The audit program aims to ensure that proposals are implemented as planned and that there is a high degree of compliance with any associated conditions. You should be aware that your project may be selected for audit by the Department at any time and all related records and documents may be subject to scrutiny. Information about the Department's audit strategy is enclosed.

If you have any questions about the referral process or this decision, please contact the EPBC project manager and quote the EPBC reference number shown at the beginning of this letter.

Yours sincerely

C Skippington

Cathy Skippington
Assistant Secretary
Environment Assessment Branch

Australian Government

Department of the Environment, Water, Heritage and the Arts

Notification of
REFERRAL DECISION – not controlled action

Metropolitan Coal Project, 30km North Of Wollongong, NSW, (EPBC 2008/4519)

This decision is made under Section 75 of the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

Proposed action

person named in the referral	Helensburgh Coal Pty Ltd
proposed action	The Metropolitan coal project involves the continuation, upgrade and extension of existing underground coal mining operations and surface facilities, by mining within the Project Underground Mining Area - Longwalls 20-44, at the existing Metropolitan Colliery, 30 kilometres north of Wollongong, New South Wales.

Referral decision: Not a controlled action

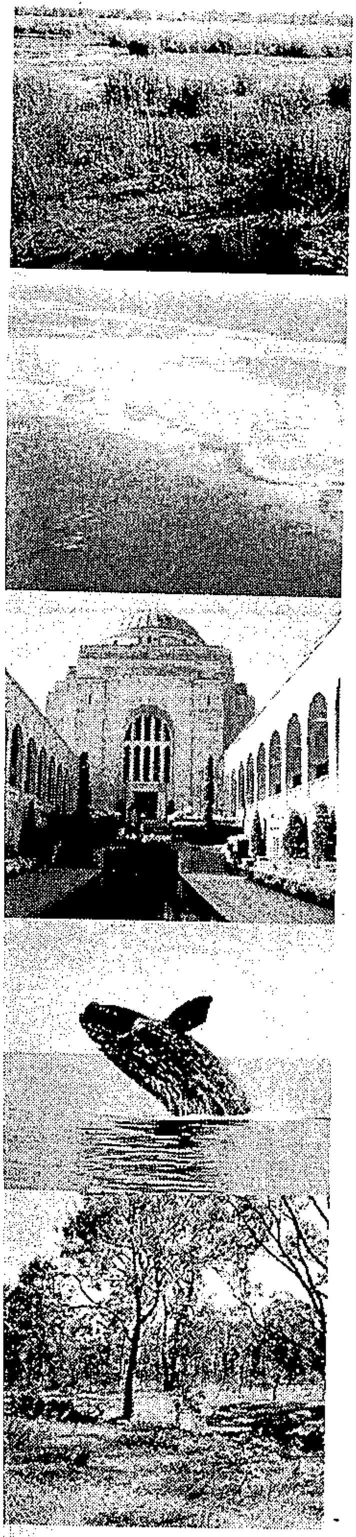
status of proposed action	The proposed action is not a controlled action.

Person authorised to make decision

Name and position	Cathy Skippington Assistant Secretary Environment Assessment Branch
signature	C Skippington
date of decision	4-2-09

Australian Government

Department of the Environment and Water Resources



EPBC ACT – COMPLIANCE AUDITING

Under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), an action will require approval from the Australian Minister for the Environment and Water Resources if the action has, will have, or is likely to have, a significant impact on a matter of national environmental significance (NES).

Actions likely to have a significant impact on matters of NES are referred to the Department of the Environment and Water Resources (the Department) and the Department decides whether the action is:

- a Controlled Action
- Not-controlled Action *or*
- Not-controlled Action – Particular Manner

Controlled Action approvals and Particular Manner decisions include special conditions which the proponent must comply with.

Audit programme

The Department is implementing a programme of compliance audits of all projects referred under the EPBC Act.

The audits will help to ensure projects with the potential to impact on matters of NES are implemented as planned. The audits will also help the Australian Government to understand how well approval conditions are being understood and applied, and contribute to improving the effectiveness of the Department's operations.

What is an audit?

An audit is an objective assessment of a project's compliance against selected criteria.

In relation to projects approved with conditions, the audits will use the approval conditions set on projects as the basis for each audit criteria.

The aim of an audit is to: gather information on levels of compliance; to communicate the findings to the person being audited (the auditee) and to the Department; and, if necessary, to recommend appropriate corrective action.

Why audit?

Information about compliance levels and EPBC Act performance, will be used to help the Department protect matters of NES.

Early intervention in the form of an audit reduces the risk of serious non-compliance issues arising inadvertently.

Audits also demonstrate to the community that there are systems in place for measuring and improving compliance, and increase community confidence in the regulatory system.

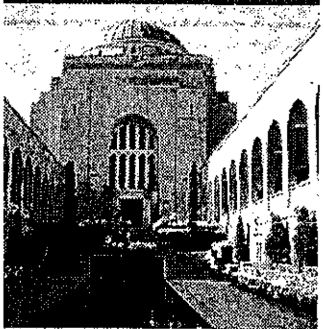
Who will be audited?

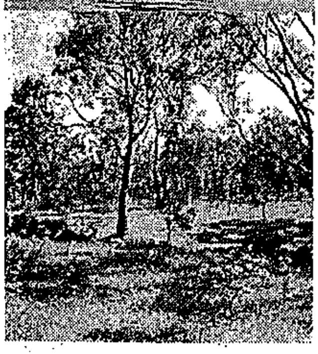
Audits will be conducted on projects across all areas including mining and energy, government, transport, ports and marine, urban development, tourism and recreation. As such, the range of auditees will include developers, land managers and landholders.

Projects will be selected from those referred to the Minister since the inception of the EPBC Act.

How will the audit be performed?

1. Once a project has been selected for auditing, a Departmental audit officer will contact the project's proponent or auditee to arrange a suitable time for an on-site visit. The officer will outline the audit process and explain any additional requirements.
2. An on-site assessment of the extent of compliance will be conducted.





Ramsar wetland, Bruce Gray
Great Barrier Reef Marine Park, iStockphoto
Australian War Memorial, Steve Wray/DEH
Southern Right Whale, Dave Watts
Box Gum woodland, J. Vranjic

Printed February 2007

3. At the completion of this assessment the findings will be discussed with the proponent.
4. Following the audit, a summary report will be provided to the proponent outlining the findings of the audit and any necessary corrective actions.
5. Audit officers will be available throughout the audit process to discuss any questions or concerns that may arise.
6. All audit activity and report summaries will be posted on the Department's web site. Selected cases will also be publicised through environmental industry and general media. This is to encourage best practice behaviour within the regulated community.

Audit principles

The Department will conduct compliance audits in accordance with the following principles:

Independence: Auditors should be independent of the activity being audited and free from bias and conflict of interest. They should maintain objectivity throughout the audit process to ensure that the audit findings and conclusions will be based only on the audit evidence.

Ethical conduct: Auditors must act in a professional manner and demonstrate trust, integrity, confidentiality and discretion.

Fairness: Auditors should present their findings, audit conclusions and audit reports truthfully and accurately. Problems encountered between the audit team and the auditee should be reported.

Due diligence: Auditors should exercise care when undertaking their work and respect the confidence placed in them by auditees and other interested parties. They must demonstrate the necessary level of competence, discretion and judgment.

For further information on the audit programme, please contact:

The Director
Compliance and Audit Section
Department of the Environment and Water Resources
GPO Box 787
Canberra ACT 2601

T 02 6274 1616
F 02 6274 1878
E audit@environment.gov.au
W www.environment.gov.au

ATTACHMENT 3

DR WALTER BOUGHTON

SURFACE WATER ASSESSMENT PEER REVIEW

Review of Metropolitan Coal Project Surface Water Assessment (Gilbert & Associates, 2008)

REVIEW BY DR WALTER BOUGHTON

August 2008

Background

Gilbert & Associates have undertaken a Surface Water Assessment as part of the environmental assessment required for regulatory approval of the Metropolitan Coal Project. I was invited by Helensburgh Coal Pty Ltd to review the Surface Water Assessment and comment on the work undertaken. My review focused on catchment hydrology related issues and did not include review of water quality related assessment.

I met with staff of Gilbert & Associates and Resource Strategies in the offices of the latter company on 11 April 2008 for a briefing on the project. I visited the offices of Gilbert & Associates on 16 April 2008 for more detailed briefings on the hydrological assessment. I visited the catchment area of Woronora Dam on 24 April 2008.

Gilbert & Associates gave me a copy of their report dated August 2008. The following is my review of their Surface Water Assessment.

Data

The underground mining is below the catchment of the Waratah Rivulet tributary of Woronora Dam. Approximately 13 months of streamflow data is available for Waratah Rivulet. This was supplemented with data from Woronora River (which also flows to the Dam) and from O'Hares Creek (an adjoining catchment). The use of data from streams close to Waratah Rivulet adds significantly to the information available for the stream that is the main focus of attention.

In addition, Gilbert & Associates have correlated 31 years of inflows into Woronora Dam (estimated from fluctuations in reservoir level) with estimated catchment runoff based on rainfall-runoff modelling. Overall, the use of these additional sources of information has added substantially to the data available for Waratah Rivulet.

Analysis of low flows

Any effect of underground mining on streamflow would be most evident on the very low flows, and would show as a transmission loss on the characteristics of the low flows. Therefore, the part of the assessment dealing with low flows is most important in looking for such effects.

Figure 19 of the Gilbert & Associates report dated August 2008 shows the recorded streamflow on Waratah Rivulet. I have examined the raw data in addition to the plot in Figure 19, and can see no evidence of any transmission loss or similar loss in the low flows that might be attributed to effects of underground mining.

In addition, a comparison has been made between the low flows on Waratah Rivulet and those on the adjoining Woronora River and O'Hares Creek (Table 10 of the Gilbert & Associates report). The low flows on Waratah Rivulet for the period of record 21 February 2007 to 27 March 2008 are significantly higher when adjusted for size of catchment area than those in the adjoining streams. Again, the comparison with adjoining streams gives no evidence of any water loss in Waratah Rivulet due to underground mining.

Rainfall-runoff modelling

Gilbert & Associates calibrated the AWBM model on flows in Waratah Rivulet and O'Hares Creek. I developed the AWBM model in the early 1990s so I am familiar with its capabilities and methods of use. The model has been calibrated on hundreds of catchments in Australia and has been used in many rainfall-runoff modelling studies. The model is quite suitable for the modelling in the present study, and the calibrations by Gilbert & Associates have been properly made.

The data available on Waratah Rivulet for the calibration is too short to calculate measures of calibration that are normally used when much longer periods of data are available. Instead, the plot in Figure 20 (Gilbert & Associates, 2008) showing recorded and modeled flows show substantial agreement, indicating that the calibration gives estimates of streamflow that are in close agreement with measured flows. I have examined the raw data used in preparing Figure 20 and can confirm that the figure gives a true indication of the results of modelling.

The calibrated model was used to estimate inflows into Woronora Dam for the 31 years from 1977 to 2008. These estimates were compared with estimates of inflows derived from records of storage in the dam. The lack of information on water lost by unmeasured or poorly measured flows over the spillway of the dam creates uncertainty in the comparison, except for the most recent years of drought when there were no spillway losses. In this recent period, there is good agreement between the modeled inflows into the dam and inflows derived from fluctuations in reservoir levels. This is a more stringent test of the model calibration than the comparison of streamflows given the continuous streamflow data available for calibration.

The calibrated values of parameters in the AWBM model for both Waratah Rivulet and O'Hares Creek (Table 10 of the Gilbert & Associates report) are consistent with calibrations on similar catchments in Australia. The average surface storage capacities shown in Table 10 are high by comparison with other Australian catchments but are consistent with the sandy nature of soils in the two catchments and the extensive "swamps" evident in maps of the catchment. I can see no evidence in the calibrations of the AWBM of any effect of underground mining on the streamflow in Waratah Rivulet.

Report by Gilbert & Associates dated August 2008

The report by Gilbert & Associates gives an accurate record of the work undertaken and the results that they have obtained. I have reviewed all of their data files and calculation files that produced the results in the report, and can confirm that the work undertaken and the report are consistent. I found no evidence of any omissions or results that would conflict with the report or its conclusions.

Summary

The methodologies used in the assessment are appropriate and adequate to look for effects of underground mining on inflows into Woronora Dam. There were four methods used to look for such effects – analysis of low flows in Waratah Rivulet, comparison of low flows in Waratah Rivulet with corresponding flows in Woronora and O'Hares Creeks, rainfall-runoff modelling in Waratah Rivulet and O'Hares Creek and a comparison of the modeled streamflows in Waratah Rivulet with recorded inflows into Woronora Dam.

None of the methods used showed any evidence that underground mining has had any effect to date on inflows into Woronora Dam. I agree with the conclusion made in Section 7.1.5 of the Gilbert & Associates report that all evidence now available indicates that "future proposed mining is not expected to have an effect on catchment yield". I note that the independent inquiry titled "Impacts of underground coal mining on natural features in the Southern Coalfield: strategic review" prepared by the NSW Department of Planning (2008) says in the Executive Summary:

"No evidence was presented to the Panel to support the view that subsidence impacts on rivers and significant streams, valley infill or headwater swamps, or shallow or deep aquifers have resulted in any measurable reduction in runoff to the water supply system operated by the Sydney Catchment Authority or to otherwise represent a threat to the water supply of Sydney or the Illawarra region."

This adds confirmation to the Conclusions of the Gilbert & Associates' report.

I confirm that the study by Gilbert & Associates has been carried out in a professional and detailed manner. The conclusions of the report are amply supported by the studies undertaken. I can see no other studies that might have produced any other conclusions.

Acknowledgements

I am grateful to the staff of Resource Strategies who facilitated my inspection of the catchment of Woronora Dam, and I am grateful to the staff of Gilbert & Associates for their cooperation in giving me ready access to all of their data and calculation files relevant to the project.

Walter C. Boughton

Dr Walter C. Boughton, M.E., PhD.

21 August 2008

ATTACHMENT 4

KALF AND ASSOCIATES PTY LTD

GROUNDWATER ASSESSMENT PEER REVIEW

KALF AND ASSOCIATES Pty Ltd
Hydrogeological, Numerical Modelling Specialists

Independent Review of Hydrogeological Assessment and Modelling Report of Proposed Mining Longwalls 20 to 44

Metropolitan Coal Project

A Peer Review was conducted of the following reports prepared for Helensburgh Coal Pty Ltd in relation to the Metropolitan Coal Project:

- Merrick N P 2008 *A Hydrogeological Assessment in support of Metropolitan Colliery Longwalls 20 to 44 Environmental Assessment. Report HC2008/5 August.*
- Merrick N P 2009 *Metropolitan Coal Project Groundwater Assessment Additional Groundwater Modelling in Support of Metropolitan Colliery Longwalls 20 to 44 Environmental Assessment. Report HC2009/1 January.*

Also referred to was the surface water report by Gilbert and Associates Pty Ltd 2008 *Metropolitan Coal Project – Surface Water Assessment. Aug. Jo604-4.rgmain4.doc*

Overall, given the available data, the Merrick (2008) assessment report presents and discusses in reasonable detail many of the hydrogeological issues related to mining impacts to a satisfactory level. In addition, given the model limitations the groundwater simulation of mining as far as it goes has also been conducted in a professional manner in my opinion. The proposed monitoring programs for groundwater levels and water quality are considered suitable including the proposed investigation program.

The steady state simulation reported in the Merrick (2008) assessment report was considered to be unnecessarily conservative and it was recommended that further simulations be conducted. On this basis, the Merrick (2009) modeling report presents and compares results from two different modeling software packages. They include standard MODFLOW (SM) code for saturated flow and MODFLOW-SURFACT (MS), a more advanced computer code that can handle variably saturated flow. In accordance with the Peer Review recommendations, transient simulation of the mine plan with progressive evolution of the identified fracture zone was also conducted.

Based on the reports provided above and evidence to date, I agree with the Merrick report conclusion that the predicted potential effects to surface systems as a result of groundwater depressurisation at depth are simulated to be so small as to be within the limit of accuracy of modeling. Based on the modeling results presented by Dr Merrick, the effects on surface water flow overall would not be measurable, given the usual method of surface flow monitoring

Dr F Kalf
Kalf and Associates Pty Ltd
18 February 2009

52 York Terrace Bilgola NSW 2107 AUSTRALIA
Phone: 61 02 99187478 Fax: 61 02 99182667 A B N 67 079 152 462 Email: frkalf@aol.com