

The Impact of Coal Mining on the Gardens of Stone



by Keith Muir

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Discharge point for the heavily mineralised Baal Bone Colliery effluent (Photo: K. Muir, Mar. 2009)

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*Cover: View toward "Star Gate Tunnel"; threatened by longwall mining,
Baal Bone Colliery (Photo: K. Muir)*

Summary

The juxtaposition of outstanding floral diversity and superlative rock formations make the Gardens of Stone¹ a unique natural landscape. One that plays a vital role as a headwater catchment area for surrounding settlements, nearby power generation plants and the vast adjoining World Heritage listed Wollemi Wilderness to the east.

Coal mining continues to degrade the Gardens of Stone as environmental management by mining companies and government agencies is woefully ineffective.

The damaging consequences of land subsidence associated with intensive underground coal mining include hundreds of cliff falls, the draining of headwater streams, detrimental alterations to surface water chemistry, the deterioration of nationally significant and endangered upland swamps and widespread surface cracking. In most cases this damage has been unmitigated and not remediated.

Environmental reporting by the mining companies on these operations is narrowly focused on regulatory requirements and has not adequately represented the full extent to which coal mining affects the Gardens of Stone. By and large the reporting has also had no influence on mining operations at all, regardless of the damage caused, even when that damage is sudden and significant. Except in a handful of cases, mine management has not adapted to reduce damage, and has also chosen to under play damage when reporting to regulatory authorities.

While there are some notable exceptions, the serious environmental damage inflicted on the Gardens of Stone area by coal mining operations continues unabated. It is the task of government to establish adequate regulation for environmental protection, as mining companies have not and will not voluntarily protect this superlative natural area.

This report makes an overwhelming case for more effective environment protection for the Gardens of Stone. Actions are proposed in relation to coal mining to prevent further deterioration of the valuable ecosystems and landforms that comprise the Gardens of Stone.

Unless the intensity of underground mining is curbed, no further development consents should be issued for coal mining in the area due to the destruction of heritage values and water resources.

¹ In this report, unless otherwise stated, a reference to the Gardens of Stone means the proposed state conservation area reserves in the Gardens of Stone Park Proposal – Stage Two, as proposed by the Colong Foundation, the Blue Mountains Conservation Society and the Colo Committee in October 2005.

Open cut coal mining in the Gardens of Stone should be considered unacceptable and should be terminated as soon as possible. Rehabilitation of current open cut coal mining operations must be carried out thoroughly, in an on-going manner, with the utmost consideration for hydrology and utilizing endemic plant species.

Lower impact mining operations – a way forward

Damage avoidance is the only proven method of protecting heritage values and can only be achieved by reducing the intensity of underground coal mining. More coal needs to be retained in situ to reduce surface subsidence movements and thereby prevent surface damage to key heritage values. The protection zones for existing underground longwall coal mining operations are clearly inadequate, as items of national environmental significance are not being protected.

Over ten years ago Clarence Colliery adopted less intensive methods, and consequently the rate of damage to water resources and heritage values arising from that mine has declined. The discharges of treated mine effluent, however, still continue to increase and to accommodate the pollution, effluent pollution standards have been weakened (for more information see – **the Clarence Colliery water transfer scheme case study**).

The Airly mine will operate with extensive subsidence protection zones over many of the outstanding features of the Airly-Genowlan Mesa. The colliery will use bord and pillar methods, demonstrating the viability of these lower-impact operations in today's market conditions. Another mine, Baal Bone, is set to terminate longwall operations when the current mining area is completed in 2012. The Baal Bone Colliery development consent will be reviewed in 2010 and it is hoped that the remaining outstanding areas within this colliery's holdings will be protected at that time.

Whether lower impact mining methods, which may adequately protect the area's values, are adopted elsewhere remains to be seen. Unfortunately, mining so often fails to modify operations which damage heritage values, unless required to do so by regulation. Companies in effect condone serious environmental abuse, through monitoring damage, and drag government regulatory agencies into their acceptance of such environmental abuse.

In such a regulatory environment, on-going political action is necessary to highlight poor management and to establish adequate environment protection. As a first step, political intervention is urgently needed to impose subsidence protection zones over streams and headwater swamps, as well as over the pagodas and internal cliff lines throughout the Gardens of Stone. Enough damage has already been caused to demonstrate that the current intensive longwall methods so destructive to swamps, streams, cliffs and pagodas as to warrant a complete review of current management arrangements.

The coal industry and the NSW Government will come under increasing pressure to respond to the growing community calls for a State Conservation Area to protect all of the Gardens of Stone. A

political response that perpetuates mere monitoring of mining damage so as to defer improved environmental protection, will only elevate the conflict.

The Gardens of Stone is a 'microcosm' of the problems that need to be addressed in order to adapt to human-accelerated climate change. If we are to adapt, then surely the first steps to reduce the footprint of damage caused by the intensive carbon economy should be to protect areas of outstanding natural beauty, like the Gardens of Stone, ensuring their essential water catchments are not further compromised by mining operations.

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1. Introduction

THE GARDENS OF STONE STAGE TWO PARK PROPOSAL located on the western edge of the Blue Mountains near Lithgow encompasses more than 40,000 hectares and adjoins the Greater Blue Mountains World Heritage Area. This western side of the Blue Mountains cradles many hidden secrets that can be discovered by the average family on a relaxed weekend outing and also provides significant challenges to attract the most ardent adventure seekers.

The Gardens of Stone is a unique region of fragile beauty from its imposing cliff lines and startlingly beautiful 'pagoda' sandstone formations to gentle grassy woodlands with interspersed upland swamps or dells. The area contains a wealth of cultural heritage both European and Aboriginal. It is truly a wonderland.

The landform, formed over millions of years, centres on Newnes Plateau, the coldest and highest sandstone plateau of the Sydney Basin. Its ecosystems support threatened and endangered indigenous flora and fauna. Another priceless resource, the area's water, flows into its diverse upland swamps and in turn these contribute to a number of water supplies, including the headwaters of the Cocks River, a key catchment of Warragamba Dam.

Coal mining in this area has caused substantial damage to the natural environment primarily through the effects of surface subsidence, but also through, associated groundwater and surface water loss, water pollution and consequent weed invasion, and the fragmentation and clearing of habitats for mining infrastructure.

This report seeks to present a critical review of this record of environmental abuse that is markedly different from the picture presented by the mining industry.

1.1 Collieries in the Gardens of Stone

Five coal mines operate in the Gardens of Stone. Under Newnes Plateau three collieries owned by Centennial Coal are in operation: Clarence; Springvale; and Angus Place. Just to the west of the Plateau under the Great Dividing Range, Baal Bone Colliery operated by Coalex is entering its final phase of operation. Invincible Colliery, a small open cut mine operated by Coalpac, to the south of Baal Bone, recommenced as an open cut operation after years of inactivity. A new mine, Airly, also by Centennial Coal, is about to commence operations under the isolated Airly-Genowlan Mesa situated in the dramatic Capertee Valley.

Statistical Data on Collieries in the Gardens of Stone¹

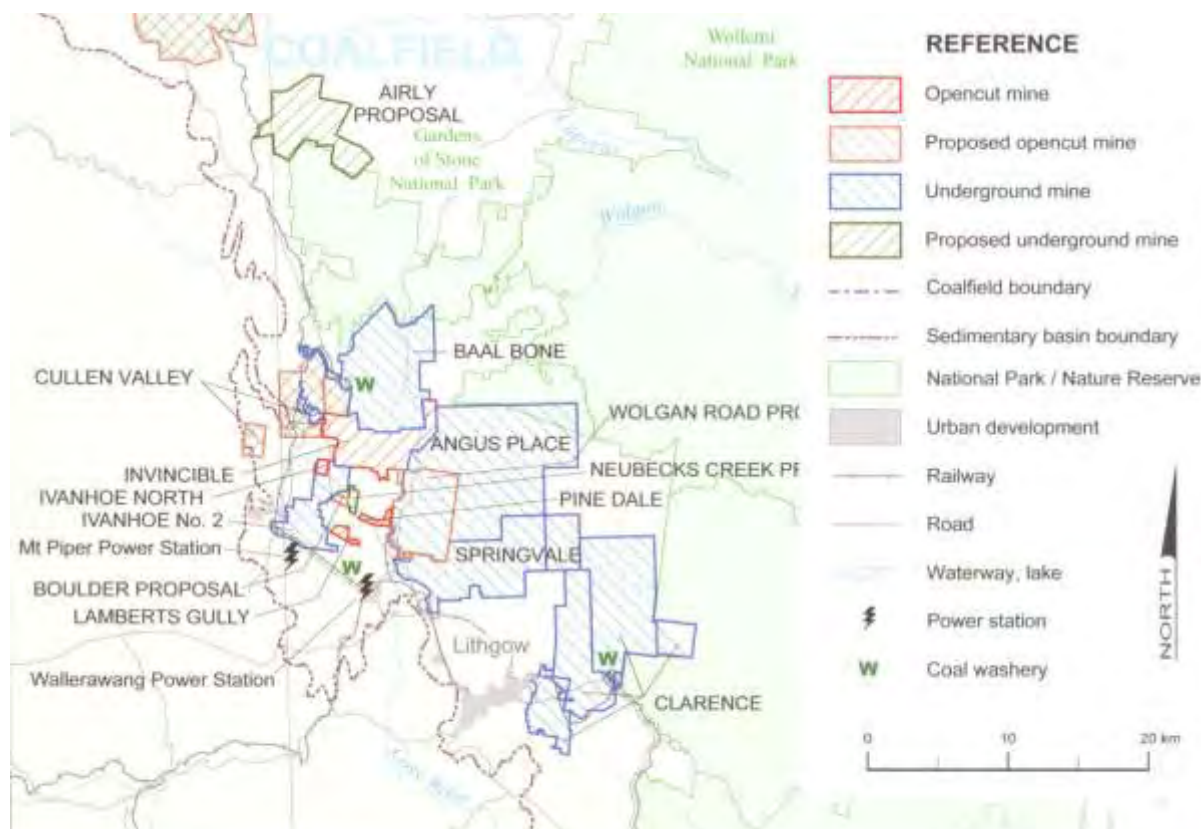
Colliery	Company	Marketable Reserves (mt)	Mining Method; seam mined and its thickness	Salable Production (mtpa)
Clarence	Coalex Pty Ltd, Centennial Coal, SK Corporation Pty Ltd.	50.4	Bord and Pillar; Katoomba	1.44
Angus Place	Centennial Coal, SK Corporation Pty Ltd, Kores Aust. Pty Ltd	30	Longwall; Lithgow 2.4-3.4	2.5
Springvale	Centennial Coal, Kores Aust. Pty Ltd	63	Longwall; Lithgow	3.35
Baal Bone	Coalex Holdings Pty Ltd	4.2	Longwall; Lithgow	1.8
Invincible	Coalpac Pty Ltd.	Not stated	Open-cut and auger; Lithgow, Irondale	² 0.7
Airly	Centennial Coal Pty Ltd	27.8	Board and Pillar; Lithgow 3.0-3.5	³ to be 1.8

¹ Department of Primary Industries, 2008, NSW Coal Industry Profile – incorporating Coal Services Pty Ltd Statistical Supplement, Sydney, NSW DPI.

² cetresources.com/files/Invincible_Colliery_Overview_May_07.pdf

³ M. Gray, 2008, Airly Coal Mine Annual Environmental Report, Jan-Dec 2007, Centennial Coal Ltd

For a description of the above mining methods, see Appendix 4



Location of Clarence, Springvale, Angus Place, Invincible and Baal Bone Collieries, and the proposed Airly Colliery (under construction). (Map from the 2008 NSW Coal Industry Profile)

For further details on the collieries in the Gardens of Stone Stage 2 park proposal area, see Appendix 1

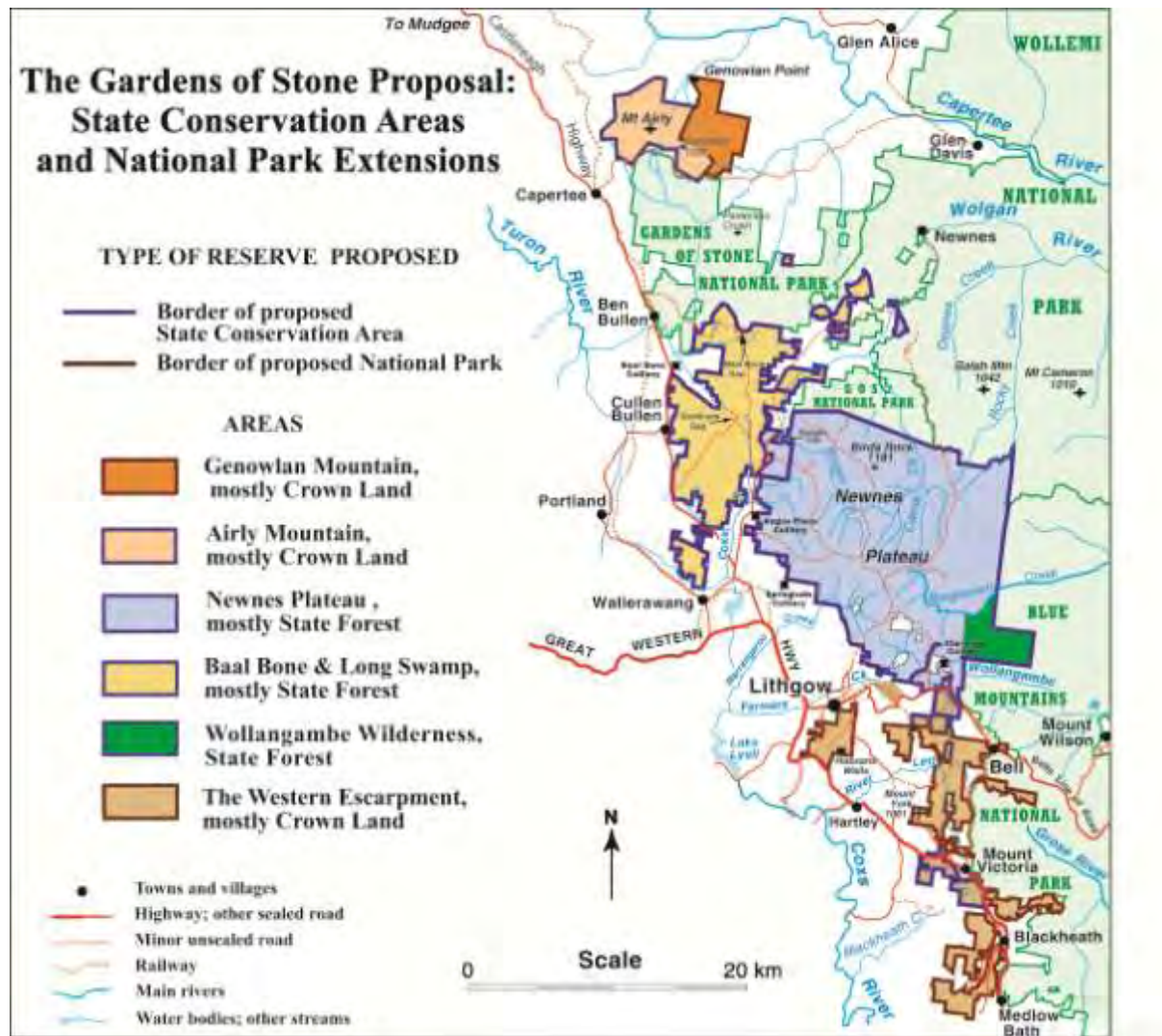
1.2 Natural Heritage Values of the Gardens of Stone impacted by coal mining

The Gardens of Stone north of Lithgow extends over 40,000 hectares, and contains outstanding scenic, recreational and natural heritage assets not found elsewhere in the Mountains. These include sandstone pinnacles known locally as ‘pagodas’ that are created by joint widening, and localised weathering and undercutting of closely spaced bedding planes within the sandstone. It is worth noting that pagodas (often called sandstone towers) are recognised world-wide as distinctive features worthy of preservation and are conserved in major world heritage areas, such as the Bungle Bungle Ranges of Western Australia (Young, Wray and Young, 2009).

The proposal area probably has the highest density of rare plants in the Mountains, and supports the nationally endangered Newnes Plateau shrub swamps.

The Gardens of Stone is a place worth saving and has great potential for quiet, family-based recreation. Reservation of the State Conservation Area and National Park extensions of the stage two park proposal would greatly enhance potential tourism in the western Blue Mountains (Brown, 2009).

The Gardens of Stone is a wonderland of coloured escarpments, narrow canyons, nationally endangered upland shrub swamps, rock arches, cave overhangs, lonely sandstone peninsulas and pagoda mazes. All these values are vulnerable to damage arising from coal mining.



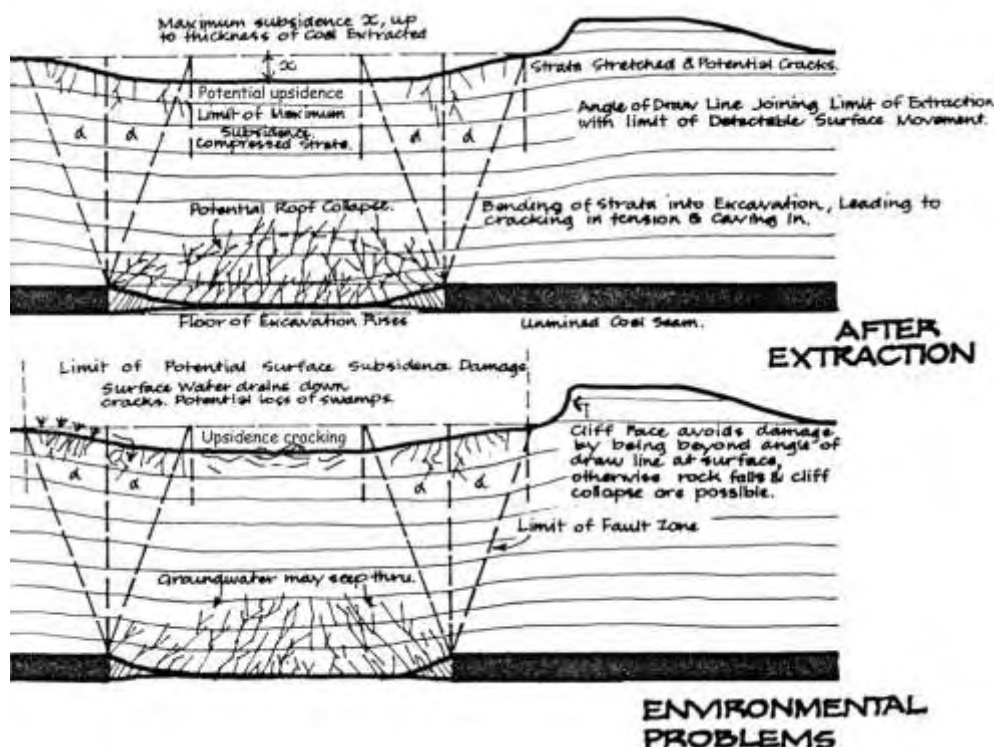
For further details on the key natural heritage values of the Gardens of Stone Stage 2 park proposal area threatened by coal mining, see Appendix 2

2. Damage to Heritage Values

While debate continues regarding the environmental impacts of coal mining, many of the impacts are easily observed.

2.1 Subsidence related impacts associated with coal mining

Surface subsidence is caused during underground coal mining when the immensely heavy overlying rock strata collapses into the large cavern created when the advancing machine-cutter removes a large part of coal seam leaving insufficient coal to support the strata above. Mathematical equations can predict the movements of the land surface known as mine subsidence, although these predictions are of variable reliability. Despite the forty years of mine subsidence monitoring, and extensive empirical modelling based on the data collected, predictions have not reduced the observed damage. In fact, over this period the damage associated with underground longwall mining operations has generally increased in direct proportion to the substantial increase in mining intensity.



The impacts arising from mine subsidence (adapted from Angel and Hayes, 1980)

The longwall mining operations in the Lithgow region cause a downward surface displacement of 1-2 metres, with a strong horizontal component, up to 450mm being recorded in the area (Baal Bone, Feb. 2010, pg 11). These earth movements cause tremendous tensile and compressive stresses in

the overlying rock. These stresses can cause extensive fracturing of surface rocks that contain near-surface groundwater aquifers which directly interact with streams and swamps. Cracks up to 300mm wide in soil have been recorded in association with longwall 29 at Baal Bone Colliery (C. Jonkers, pers. comm., Feb. 2010)

Subsidence-related cracking of rock formations is revealed on cliffs, along rock plateau slopes near cliffs and steep slopes, on pagodas, as well as in streambeds. Numerous examples of cracking have been logged in sites directly above and in close proximity to mining operations in the Gardens of Stone, some are sufficiently wide to be called crevasses, rather than cracks. A substantial number have been photographed and their location logged by Mr Chris Jonkers and Ms Julie Favell.



Crevasse at Baal Bone Colliery (Photo: C. Jonkers, 2009)

2.2 Subsidence Damage to Geodiversity

Coal mining can accelerate by many orders of magnitude the natural rates of cliff fall and rock fracturing. These cliff falls and sandstone fractures may occur in a manner unlike natural processes, for example across vertical joints. Two mechanisms of mine induced cliff falls are proposed, toppling and block sliding. Back-tilting and sliding collapse is a mechanism that produced the spectacular Nattai cliff fall on the southern side of Lake Burragorang (Cunningham, D.C. 1988). In the Western Coalfield, despite thirty years of subsidence monitoring, the actual processes controlling cliff falls have not been adequately investigated by mining companies.

Understanding the geomorphologic processes involved in natural cliff falls is essential to the proper design of subsidence protection barriers for cliff lines. If back-tilting and sliding operates in the region, then allowing mining operations to tilt cliffs backwards would not make cliffs more stable, as has been assumed. Such a measure would increase the risk of cliff falls (Young, A. 2010).

Pagoda formations are also degraded by rock fracturing and rock spalling, as well as by rock falls following longwall mining. Like all geodiversity, pagodas are an irreplaceable and a limited resource that cannot be repaired once damaged (Washington, 2001).



*Pagoda collapses at Baal Bone Colliery
(Photo: C. Jonkers, 2009)*



Pagoda edge fracturing about to collapse, Angus Place Colliery (H. Washington, circa 1986)

2.2.1 Cliff falls caused by Angus Place Colliery

At the Angus Place Colliery 55 cliff collapses were monitored by the NSW Department of Mineral Resources between June 1985 and October 1988 (Dr Lax Holla, 1991). The cliff collapse damage includes the Lambs Creek area within the Angus Place Colliery. These large cliff collapses were contrary to the development consent conditions for the colliery. Condition 8 states: *The Applicant shall consult and comply with the requirements of the Department of Mineral Resources and the Department of Industrial Relations in order to establish a program of the most acceptable practices and techniques that will prevent damage and disturbance occurring to the escarpment of the Newnes Plateau or other escarpments or important or unique features within or near the lease area, and will prevent alteration of surface drainage.*



*Rock fall, Angus Place Colliery on western escarpment towards
Wolgan Gap (Photo: C. Jonkers, 2008)*

2.2.2 Cliff falls caused by Baal Bone Colliery

From September 1989 to December 1991, 124 cliff collapses were recorded at the Baal Bone Colliery by Mr D Kay, a Subsidence Engineer for the NSW Department of Mineral Resources. In December of 1991 he reported the findings of his \$95,000 research grant funded by the Commonwealth Government's National Energy Research, Development and Demonstration Program. Mr Kay found that cliff falls and collapses of rock faces at Baal Bone Colliery represented 16% of the 3,820 metres of rock faces undermined in the monitoring areas.

Mr Kay's report recommended that cliffs be protected by an environmental protection zone defined by an angle of draw of 40-50 degrees. The Department criticised the report at the 1991 Commission

of Inquiry into the proposed Airly Colliery stating that this recommendation was “*contrary to the interests of coal conservation*”.

Sixteen years later, in April 2007, Mr. Ken Mills summarised the surface subsidence caused by longwall operations at Baal Bone Colliery. He found that on average 10–20% of the total length of sandstone cliff formations were likely to experience rock falls when mined underneath. Extensive surface cracking was also found to be associated with the coal mining. These results confirm Mr. Kay's earlier damage findings and yet no management action was subsequently taken to reduce the cliff fall damage.

2.2.3 Monitoring at Baal Bone Colliery did not improve cliff protection

Baal Bone's monitoring has been focused on a technical debate. It has sought to minimise cliff protection barriers in the spectacular Gardens of Stone. In this process, data has been collected on severe and on-going levels of cliff damage for almost two decades.

For the design of cliff protection barriers and subsidence control measures Mr Mills studied how mine subsidence affects high sandstone cliffs. The cliffs examined included those above longwall 20 that were 50 metres high and ‘located over the start of the longwall panel’ (Mills, April 2007).

Subsequent mining extensively damaged these cliffs and the ‘rock fall occurred during the period where vertical subsidence greatly increased, and the panel width went from 133m to 165m’ (Mills, April 2007). In other words, longwall panels that are less than 133 metres wide were necessary to limit subsidence and give protection to these high cliffs.

Mr. Mills (April 2007), however, claimed that ‘mining geometries formed may not be economically viable’ when longwall panel widths are reduced for cliff protection, that is, when less than 133m wide.

Surely it would have been better to shorten that particular longwall panel by a very small amount to avoid deliberate collapse of that particular 50 metre high cliff line? Through moving the area affected by surface subsidence zone away from the base of the cliff, the now destroyed high internal cliff line could have been protected.

If, for arguments sake, longwall panels of less than 150 metres wide are uneconomic for the Baal Bone Colliery, then proving that longwall panels must be less than 133 metres wide to prevent cliff damage is a pointless exercise. It is a certainty that the overlying rock strata would have collapsed into the mine void created by the removal of the coal seam well before this new panel was 150m wide. The resulting surface subsidence would then bring about cliff collapse, and in that case shortening longwall 20 by a few metres to protect the cliffs above it would have been a more appropriate action than monitoring.

Mr Mills found that mining the next longwall panel, number 21, caused 25% of the length of the cliff line to fall, with local high fall densities up to 50%. ‘These cliffs were orientated in a direction likely to

experience maximum impact' and 'this is considered to represent an upper limit on the likely extent of damage to cliff formations' (Mills, April 2007). Allowing such mining and monitoring, the actual consequences of which are predicted to be extreme environmental damage, approaches unethical behaviour. The prediction of maximum environmental impact could instead have led to an alteration of longwall panel design to reduce the damage.



Maximum damage cliff fall, Baal Bone Colliery (D. Burgess, 2007)

'The long history of subsidence monitoring at Baal Bone Colliery has focussed on continuous improvement of subsidence monitoring and impact prediction techniques' (Radloff and Mills, 2001). This long history is just one of several examples where monitoring of severe damage has not resulted in any further environmental protection.

2.3 Damage to Aboriginal heritage

The damage shown in the following images has not been reported in subsidence management plans or subsidence management status reports.



Damaged Aboriginal hand art, Angus Place Colliery (C. Jonkers, 2006)



Damaged cave near Gardiners Gap, Baal Bone Colliery (C. Jonkers, undated)



Damaged art stencil of an Aboriginal foot, Angus Place Colliery (C. Jonkers, 2006)

2.4 Damage to groundwater aquifers and related impacts

The following generic description of the groundwater impacts associated with longwall coal mining can be used to understand the mining-related damage to streams and swamps in the Gardens of Stone, in the same way as a description of disease can help understand the symptoms of an illness:

Firstly “Groundwater levels drop as confined aquifers become rapidly unconfined.

Second, topographically high or perched aquifers drain to lower aquifers and zones through aquitards fractured by subsidence.

Third, increased fracture permeability over the panel decreases hydraulic gradients, lowering heads up-gradient.

Fourth, drawdown spreads out around and ahead of the primary head drop in the subsided area, to an extent varying with transmissivity” (Booth, C., 2009). If overlying rock aquifers above a mined coal seam become hydraulically connected with surface waters, then the stream may lose its permanent base flows, particularly if associated near-surface aquifers are compromised by rock fracturing.

During longwall mining, the rock strata containing near-surface groundwater aquifers can be affected by the surface cracking to a depth of about 10 to 15 metres. In the Springvale Coal’s current subsidence management area alone, there are 39 hanging swamps (Springvale Coal, July 2008,

Attachment 3). These perched aquifers can and have been damaged by longwall mining under Newnes Plateau, but only one, **Junction Swamp**, has been monitored during mine operations.

2.4.1 Mine effluent pumping rates associated with aquifer damage

Damage also occurs to the groundwater aquifers in the coal measures and rock mass above and close to the workings. Such aquifers have experienced an increase in permeability and storage capacity by three orders of magnitude or more following longwall mining in this region (Sinclair Knight Merz, 2009, 5-2). As a result of this damage around 35 megalitres of effluent a day (12,775 ML/yr) is being currently extracted from the collieries operating under Newnes Plateau. These pumping rates are necessary to prevent flooding of mine operations and will increase as mining continues.

The Springvale mine (Lithgow coal seam) under Newnes Plateau is said to discharge around 15 megalitres of effluent a day to the surface from aquifers damaged by mining. The Angus Place Colliery, to the north of the Springvale mine, discharges a further 6.7 megalitres of effluent a day. To the south, the Clarence Colliery on Newnes Plateau is reported to pump around 15 megalitres. The amount of water discharged from the mine (Katoomba coal seam) increases with rain, demonstrating a direct hydraulic link between this mine and the land surface (Internat. Env. Consultants, 1999, pg. 6). The severe cracking of groundwater aquifers and surface catchments necessary for hydraulic connectivity is said to be a legacy of the mine's previous longwall mining operations.



The 450mm polypipes for Springvale Colliery's pump station six on Carne Creek, which will boost mine effluent pumping rates toward 25 ML/day by 2015 (Photo: K. Muir, 2009)

Groundwater flooding into mines associated with leakage from near-surface groundwater aquifers and loss of surface waters is typical of longwall mining at Baal Bone Colliery (Lithgow Coal Seam), as effluent discharges there are closely associated with rainfall. The Baal Bone discharge point above longwall 19 has the capacity to discharge 12 megalitres a day to Baal Bone Creek. The average level of groundwater seepage into the mine (after rain) is in the order of 3.9 ML/day (Baal Bone Colliery, August 2009).

2.4.2 Aquifer damage in the Coxs River headwaters

At Long Swamp, the headwaters of the Coxs River were observed by *Streamwatch* to have a permanent flow, even during the 2006 drought. *Streamwatch* monitoring recorded regular flows over three years from October 2006 to February 2010. Water flows through the upper reaches of the swamp stopped in November 2009 (C. Jonkers, pers. comm., Feb. 2010), following the sudden drop in near-surface groundwater levels reported in observation bores after mining of longwall 29 commenced in July 2009 (Baal Bone, 2010, pg 8). Only after heavy rainfall of 100mm over a week, did the stream through Long Swamp recommence flow (C. Jonkers, pers. comm., Feb. 2010). A reduced stream flow pattern has apparently persisted with continued rain since the damage event. The extent to which flow has declined will not be known for several months, after further stream monitoring.

The drop in groundwater levels was observed approximately 400 metres distant from longwall 29. The angle of dewatering influence, the furthest extent of groundwater drawdown (Booth, 2009), is for longwall 29 and Long Swamp well beyond the area affected by mine subsidence.



Dead patch on Long Swamp, the headwaters of the Cocks River, believed to be associated with the mining of longwall 10, Baal Bone Colliery (Photo: C. Jonkers, 2004)

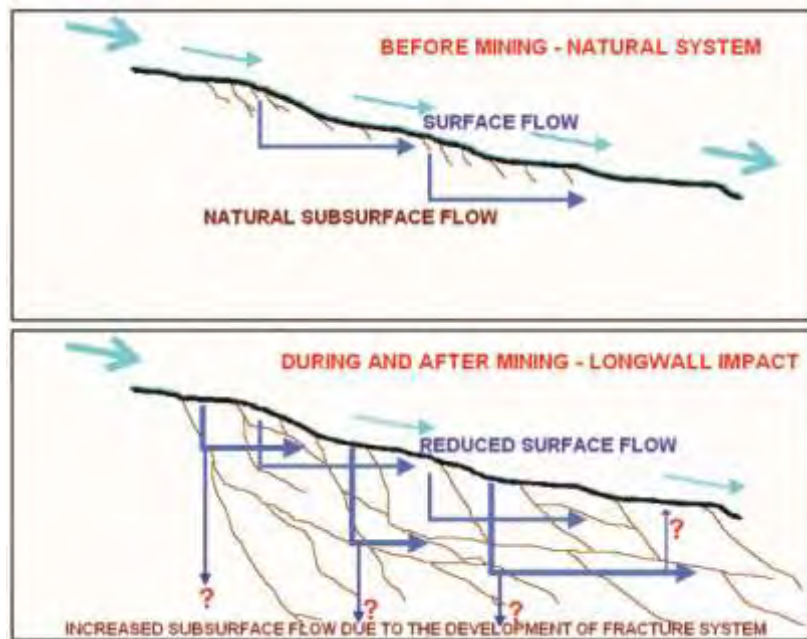
At this time, there is no evidence of a strong association between surface rainfall and mine water make in relation to Springvale and Angus Place Collieries. A less direct leakage of surface waters and near-surface aquifers through mining-related reactivation of vertical joints, faults and fracture zones is possible. Such an association could be established by special surface water detection techniques.

2.5 Damage to swamps and streams by mining-induced surface subsidence

2.5.1 Mining-related rock fracturing impacts on stream flow

“A reduction in streamflow may not only be the result of fracturing streambeds and rockbars in the main stream overlying an active longwall mine; mining-induced fracturing can extend across the catchment and its tributaries, generally bounded by the limit of subsidence. Whereas the primary head drop from increased fracture porosity occurs in the subsidence trough defined by the angle of draw, the extent of the transmitted drawdown itself defines the vaguer angle of dewatering influence” (Booth, C., 2009).

“Increased fracturing allows rainfall to infiltrate and recharge fractured aquifers, reducing runoff available for recharging streams. Although rainfall recharge to the shallow aquifers can increase, groundwater levels can also decline due to the mining-induced fracturing of the rock mass, causing the dewatering of shallow aquifers and reducing base flow discharge” (Jankowskia, J, 2009).



Model of longwall mining damage to near surface groundwater aquifers (Jankowskia, 2009)

Expressed another way, the cracking across large areas of headwater catchments would increase the downwards permeability in the near-surface aquifer. This cracking of a catchment may greatly reduce the capacity of near-surface groundwater to support stream flow, such as in the case of Junction Swamp and across the headwaters of Kangaroo Creek on Newnes Plateau.

Mining companies claim that much of the water disappearing from fractured streambeds may re-emerge further downstream. There is no published evidence from the Gardens of Stone area that supports re-emergence of lost stream flows, although there is evidence to the contrary for East Wolgan Swamp. Such re-emergent surface water could be heavily contaminated with groundwater polluted with salt and metals. This re-emergent, potentially eco-toxic water could not help a swamp or affected stream reach upstream that had suffered water losses. Any downstream sensitive instream environments and riparian environments, such as some shrub swamps, could be impacted by eco-toxic groundwater effluent.

2.5.2 Loss of stream flow in Kangaroo Creek and the Wolgan River

The flow of Kangaroo Creek has been much reduced since May 1996 when longwall operations commenced under a swamp in its headwaters. Very low flows from the headwaters of Kangaroo Creek have continued ever since. A small dam located on Kangaroo Creek downstream of the mined area has never been full since 1997. The bed of the dam is now vegetated. Aerial photography from the 1980s shows the dam full. Since mining by Springvale Colliery, upper Kangaroo Creek only flows very rarely after heavy rain and usually has no flow at all (Centennial Angus Place, June 2009). These flow patterns appear abnormal. An unmined headwater swamp should store water from heavy rainfall

events and afterwards provide at least some persistence of downstream flows. Since mining, no persistent stream flow has been observed. An area of leptospermum die back has been noted (Centennial Angus Place, Dec. 2009), suggestive of a permanent ecological change in downstream riparian conditions.

Downstream of the abovementioned small dam, western ends of longwalls 930 to 980 of Angus Place Colliery pass under Kangaroo Creek with a depth of cover of 260 metres above the coal seam. These six longwall panels make up the current mine Subsidence Management Plan (SMP) area. On 16 April 2007, stream flow monitoring on Kangaroo Creek downstream of the SMP showed a loss of flow (Centennial Angus Place, 28 August 2007). The groundwater monitoring site on Kangaroo Creek Swamp then indicated a sharp fall in groundwater levels on 17 June 2008 with the passage of longwall 940 under the swamp. The fall was attributed to subsidence cracking and the creek stopped flowing at that point (Centennial Angus Place, August 2008). Creek flows above longwall 940 were reported to occur “through fractures in the underlying rock” (Centennial Angus Place, August 2008). Subsequent monitoring has revealed continued low water flows in the creek (Centennial Angus Place, Dec. 2009).



Dieback of the swamp on Kangaroo Creek above longwall 940 indicate a permanent change in groundwater conditions (Photo: C. Jonkers, 2009)

The natural Wolgan River flows are also believed to be reduced, and are associated with a bright orange sediment in the reach that passes through the Emirates Wolgan Valley Resort. Relative to the river's pristine eastern tributary, Carne Creek, the main Wolgan River is in a poor condition within the resort property (Joost Heymeijer, 2009, pers. comm. and Lithgow Mercury 23 Jan, 2010).



Pristine Carne Creek (left) flows into the Wolgan River (right) at the Emirates Wolgan Valley Eco-resort. The red stain is a metal precipitate of iron and manganese, and this same mine effluent was used directly in the Wallerawang Power Station in 2007 (Photo: Jack Wolfenden, Dec. 2008)

2.5.3 Impacts caused by tilted surface rocks due to mine subsidence

Stream beds and swamps are further damaged when the rock strata supporting them are tilted by mine subsidence. Mine subsidence is never uniform, but tilts the original terrain. The streams then flow heavily against a downward tilted bank, causing erosion. An upward tilted stream bank will dry out, perhaps resulting in ecological change, such as the drying of shrub swamps comprising sedges, reeds, ferns and mosses. When upland swamps are tilted, they are highly prone to erosion and desiccation. Under subsequent heavy rainfall, swamps subjected to tilt and/or a loss of soil moisture can develop a 'nick point' from which the entire earth profile of the swamp may be washed downstream (A. Young, 1982).

Mining companies have suggested that damage by subsidence is lessened when a claystone stratum is present (e.g. the Mt York claystone), which they say absorbs some of the energy by deforming plastically and preventing the development and interconnection of cracks in the overlying strata. This claim does not explain tilting of the land surface due to subsidence or the increase in the downwards permeability of surface rock in near-surface groundwater aquifers caused by possible cracking.

2.5.4 The combined effects of the tilting and fracturing of surface rocks



A swamp following longwall mining at Baal Bone Colliery, showing a nick point (right), erosion and desiccation, before flood irrigation with mine effluent (Photo: C. Jonkers)

Undermined swamps tend to suffer reduced soil moisture from tilting and/or a lowering of near surface groundwater levels due to surface cracking in the rocks under the swamp. The organic matter then decomposes over time as the swamp soils become more exposed to air. Once the swamp dries out and/or soil organic matter is lost the swamp declines. The ecosystem evolves into a drier type of plant community, and the swamp becomes susceptible to fires that can burn down into their sediments and destroy the swamp entirely.

Upland Swamps on the Newnes Plateau are extremely sensitive to minor fluctuations in moisture content. Given the lower and less regular rainfall relative to swamps located on Newnes Plateau relative to those on the Illawarra Escarpment, surface cracking or surface tilting due to subsidence does not have to be large to have a dramatic effect. For example, even when near-surface groundwater levels under Junction Swamp recovered for a short period to just one metre below pre-mining levels, flows over the v-notch weir on the stream associated with this headwater swamp still did not return (Centennial Angus Place, February 2008). During 2001, prior to being mined under, Junction Swamp in the headwaters of the Wolgan River had permanent flows during dry conditions.

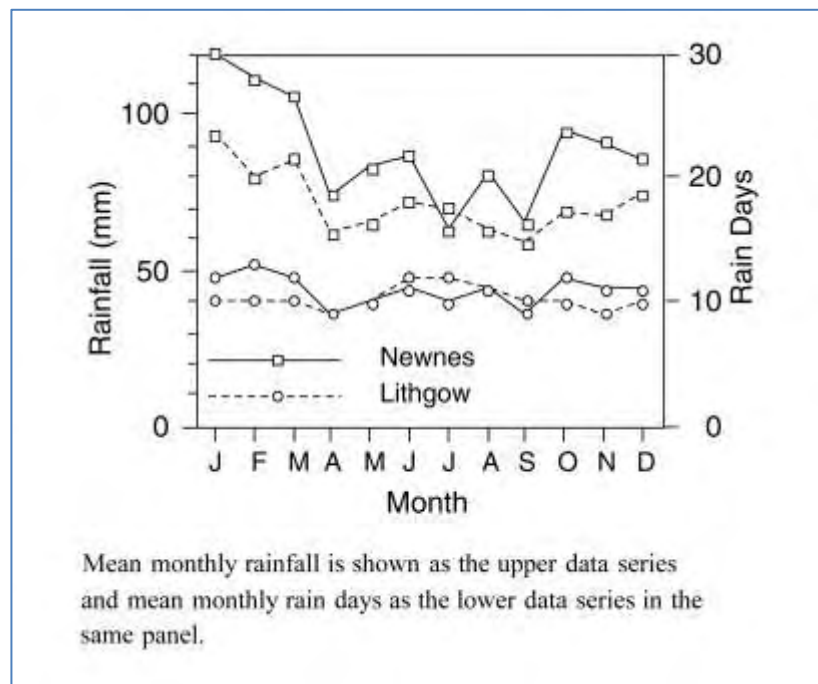
Connell Wagner (2005) reported that discharge from a V-notch weir had declined to zero as longwall mining approached the second half of Junction Swamp in March 2004, and was associated with a fall in the groundwater level. "The conclusion suggested by the data is that the extraction of Longwall 409 has impacted on the groundwater regime beneath the swamp" (Connell Wagner, 2005, page 14).

2.5.5 Weak explanation of observed changes: ephemeral streams, “dry swamps” and droughts

Centennial Coal has described swamps in mined areas as “dry swamps”, and the streams associated with these swamps as ephemeral, including the stream clearly marked on Springvale’s mining lease and the Lithgow 1:25,000 map sheet as the Wolgan River.

The association of mining and currently dry swamps is a major cause for concern. Some of the dry swamps, such as West Wolgan Swamp and Sunnyside West Swamp, do have a somewhat different suite of plant species and soils with a less well developed organic content. It is unclear, however, whether this condition is not affected by the mining. Such drier swamps, being in the borderline conditions for swamp development, would be more vulnerable to adverse alterations in the hydrological environment governing these swamps. These are the swamps highly likely to become a dry land environment due intensive coal mining.

Centennial Coal has explained that the “most likely” reason for declines in stream flows and near-surface groundwater levels is “the ongoing drought conditions” (e.g. Springvale Coal, March 2007, pg 13 and Attachment 4, conclusion; July 2008, Attachment 8, page 2; and again in March 2009, pg 39, section 7.7.1).



The average rainfall for the Newnes Plateau is 1047mm, with a summer peak. Normal rainfall for any year could be described as anything from 750mm to 1,350mm. As only about 300 mm of rain fell in 2006 this was a drought year for Lithgow. Since then, rainfall has been more or less normal for the last three years. In 2007, Lithgow received almost an average rainfall of around 980mm, about

810mm fell in 2008 and in 2009 approximately 740mm. Beyond 2006, rainfall could not adequately explain persistent loss of stream flows and the drying out of swamps on Newnes Plateau.

Delta also should not have alleged a “drought” when in 2008 it came to explain its problems with the Wallerawang power station (e.g. in the notes from the Delta Community Reference Group meeting of 30 July 2008, page 2 [see also the case study on the Springvale water transfer scheme]).

2.6 Swamps impacted by Springvale Colliery

The first swamp to be undermined by Springvale Colliery was located in the headwaters of Kangaroo Creek in 1997. The swamp has been dry since that time, with most of the *Leptospermum* shrub layer dead and a sparse unhealthy groundcover. Eucalypts are now colonising the swamp area, as is apparent when aerial images from the 1990s are compared with current high quality Google Earth imagery.

Junction Swamp was the second swamp to be undermined in 2003-2004. It is described as a small swamp fed by a perched water table (Centennial Angus Place, 2005). Its *Sphagnum* moss, coral fern, sedge and rush species were healthy in 2001. These species had declined by 2006 (Springvale Coal, Nov. 2006, Attachment 5, table 4). Emergent eucalypt saplings were reported in March 2007 (Springvale Coal, Attachment 4, section 3.4) indicating the swamp may be evolving into a woodland. The swamp’s stands of *Leptospermum* are dead or in a poor condition. Certain other swamps, including West Worgan Swamp above the Angus Place Colliery, have also shown an increase in abundance of Eucalypt species (Centennial Angus Place, June 2009, page 42).



Groundwater 2001



Groundwater 2007

Paired images: Junction Swamp vegetation and groundwater changes following longwall mining

2.6.1 The East Wolgan Swamp fiasco

The third endangered swamp to be undermined was East Wolgan Swamp, located on Newnes Plateau 330 metres above the Lithgow coal seam. The northern end of the swamp was cracked along an existing faulted zone when longwall 411 passed under the swamp commencing in March 2006 (Springvale Coal, July 2006, page 4 and 12). In November 2006 groundwater levels in the swamp were reported to have rapidly declined and continued to show limited response to rainfall (Springvale Coal, Nov. 2006, page 13 and Nov. 2007, pg 14). A surface cracking report was then prepared which incorrectly described the cracking as “minor” (Springvale Coal, Nov. 2006, page 33).

Subsequent monitoring again reported the damage as “minor”, with “sequential photographs ... demonstrating that the cracks are rapidly weathering and filling with silt” (Springvale Coal, Mar. 2007, pg 10), and then as having a “minimal impact” (Springvale Coal, Mar. 2007, Attachment 5, pg14). Evidence of subsidence apparent to even the most amateur observer is described as minor by the subsidence monitoring and reporting (Springvale Coal, Mar. 2007, Attachment 5, pg 8). Yet the very obvious damage to the swamp was indeed serious and the degree of damage was instantly apparent to anyone who inspected it.

2.6.2 Inaction over the disappearance of stream flows through East Wolgan Swamp

Following the commencement of longwall 411, discharges of up to 14 megalitres/day of saline mine effluent from licensed discharge point 4 were said to have “no effect on the East Wolgan’s flows” (Springvale Coal, Mar. 2008, pg 15). This major anomaly apparently did not trigger any concern by the company, its consultants or departmental regulators. No flows leaving from East Wolgan Swamp have been recorded since, including during above average rainfall periods and all subsequent discharges from licensed discharge point 4.

From November 2006 and the cracking report, Springvale Coal should have been fully aware of the significance of the cracking and its impact on stream flows. Instead, up until November 2008, Springvale Coal concluded “there is no requirement to instigate additional monitoring due to impacts nor is there any need to undergo additional consultation” (page 39).



*Alleged minor [upsidence] cracking claimed to have no effect on East Wolgan Swamp
(Photos: C. Jonkers, 2008)*

The extent of damage continued to be heavily downplayed until finally in March 2009 it was proposed to conduct more investigations into the flow of water through East Wolgan swamp (Springvale, page 41). This response was prompted after the Blue Mountains Conservation Society showed the company's staff the gaping crevasse through which all mine effluent and surface flows "disappeared".

Up to 14 megalitres a day of mine effluent had flowed down a crevasse at the northern end of East Wolgan Swamp for periods ranging from weeks to months (Springvale, Mar. 2009, pg 17) over almost three years. No mine consultant had adequately reported its significance, although access to the crevasse site is well trampled by visitors.

The Springvale Mine Subsidence Management Plan requires that anomalies, such as crevasses that swallow megalitres of mine effluent a day, be immediately reported to the Department of Industry and Investment, Mineral Resources Division.

In November 2009, Springvale Coal reported it had "found that water was entering a cavity and not resurfacing. Several inspections in adjacent drainage lines as well as inspections downstream of where the cavity is located did not locate the water. Monitoring from a nearby piezometer array indicates that the water is travelling to a depth of approximately 60-70m underneath the swamp and most probably travelling laterally and pooling within the bedding partings. The investigation found that the water, however, did not enter the mine workings" (page 14).

Following mining of longwall 411 and 412, there have been no natural flows through East Wolgan Swamp (Springvale Coal, Nov. 2009). Prior to mining, flows from the East Wolgan Swamp would have been in the order of a megalitre per day. Although there is no data on natural flows recorded prior to mining, Sunnyside Swamp, an adjoining swamp of similar size typically has flows well above a megalitre a day.



The crevasse (left) in East Wolgan Swamp that can receive 14 ML/day (right) (Photo: C. Jonkers, Nov. 2008)



Subsidence cracking of the sandstone bedrock has drained and dried out East Wolgan Swamp (Photo: M. Wilkinson, 2009)

2.6.3 Impact on hanging swamps is largely ignored by monitoring efforts

Prior to mining, the flows of both East Wolgan and Sunnyside swamps would probably have been augmented to some degree by seepage from the several hanging swamps located above them. Seven hanging swamps in Springvale Coal's current SMP area have been mined under and probably impacted by mine subsidence. No monitoring of these swamps has occurred.

Junction Swamp, a swamp associated with a perched aquifer, has been damaged, so the chances of damage to other hanging swamps are high.

2.7 Damage to Swamps by Angus Place Colliery

Longwall mining at Angus Place Colliery has impacted on swamps, including the swamp on Kangaroo Creek above longwall 940. The loss in 2008 of groundwater due to surface cracking has doomed this groundwater dependent swamp. No further detailed monitoring, let alone restoration action, has been undertaken for this swamp. Other swamps on Lambs Creek downstream of the current SMP area are believed to have been destroyed in earlier Angus Place mining operations.



Eucalypts growing in what appears to be a former swamp on the lower reaches of Lambs Creek (Photo: C. Jonkers, 2009)

On the 3 July, 2007 extraction of longwall 940 was reported to have caused cracking associated with Narrow Swamp, which is situated on the headwaters of the Wolgan River downstream of Springvale's discharge point 5 (Centennial Angus Place, 28 August, 2008, section 4). Greater than expected subsidence of 1.456 metres was associated with surface cracking and is associated with a fault/fracture zone known as the "Wolgan Lineament" at the northern end of the swamp (Centennial Angus Place, Feb., 2008, pg 2). Coral fern, one of the indicator species for swamp health, has shown a decline in condition (Centennial Angus Place, April 2008, pg 41).

A significant reduction in flow has been observed between the 8 ML/day at Springvale's discharge point LDP5, above Narrow Swamp, and 4 ML/day at the weir downstream of Narrow Swamp (Centennial Angus Place, Aug., 2008, pg 26). This discrepancy amounted to 244 megalitres over the discharge period from May to July 2008 (Centennial Angus Place, Aug., 2008, pg 11). A second monitoring effort found a discrepancy of 217 megalitres situated upstream, apparently associated with

the yet to be mined northern half of the swamp (Centennial Angus Place, Dec., 2008, pg 11). Once emergency discharges ceased, the near-surface groundwater fell rapidly below the base of monitoring bores (Centennial Angus Place, Dec., 2009, pg 10). It is probable that the mine related cracking and fracturing, possibly also exacerbated by the Wolgan Lineament, has increased downwards porosity of the rock strata under the southern end of swamp. The large stream flow discrepancies and rapid falls in groundwater levels within Narrow Swamp may be explained by the rapid downward drainage in the damaged aquifers. A possible drawdown of an unconfined surface aquifer within the northern part of the swamp may be somehow associated with the losses. A similar loss of surface flows has been observed with faults associated with Long Swamp on the Cocks River.

2.8 Impact of saline mine effluent discharges on the environment

Discharged mine water from collapsed shallow workings varies in salinity because of its accessibility to infiltrating rainwater (Sinclair Knight Merz, 2009, pg 5-2). Groundwater salinity refers to the total amount of salts, including metal salts, dissolved in the groundwater. The effluent discharged from the Baal Bone and Clarence collieries are known to be a varying mixture of groundwater and infiltrating rainwater. The effluent from Invincible is probably also a mixture, while Angus Place and Springvale are presumed to be entirely groundwater, although this has not been fully tested.

When the fractured aquifers contain sulphide minerals or are connate aquifers devoid of oxygen, the dissolved metal concentrations relative to receiving surface streams can be very high to extreme. Stream salinity can increase by up to two orders of magnitude when effluent from a Western Coalfield colliery is discharged into surface waters.

The introduction of mine effluent water into receiving surface and associated unconfined surface groundwater systems can damage riparian ecosystems. For example, saline mine effluent can contaminate and persist in the peaty soils of shrub swamps. Damage may occur due to the effluent water chemistry or temperature being unlike that of the receiving waters (or area of reintroduction, in cases where the discharge is onto a swamp). These chemical and temperature impacts increase with the longevity of dewatering points.

The surface waters of the Gardens of Stone are naturally very low in salinity (typically 30 μ S/cm). At its source near Ben Bullen, the Cox's River salinity rests at 30 μ S/cm (Jonkers, 2009). The high salinity of mine effluent will significantly impact these aquatic and riparian ecosystems that have evolved naturally under very low nutrient conditions.



Results of saline, metal rich, Invincible Colliery effluent discharge into an arm of Long Swamp near the headwaters of the Coxs River

The immediate effects of increased salinity on inundated native vegetation, say a swamp, include stunted growth, leaf burn and drop, leading to plant death. In less severe cases, germination is suppressed by salinity, which can be broad scale downstream of the discharge point. Local native plant populations decline and native plant diversity changes as indigenous plants are replaced with more adaptable and salt tolerant plant varieties.

Loss of vegetation compounds the salinity problem by producing soil exposure, known as soil scalding, and erosion.

2.8.1 Apparent revitalisation of dead swamps

The introduced mine effluent may initially rejuvenate a swamp that has suffered vegetation dieback arising from loss of soil moisture due to surface fracturing associated with longwall mining. Effluent from collieries can have high levels of metals and a lower acidity than the natural receiving waters. When this effluent water enters a drying swamp, the areas covered by dead plant material and peat soils can be rapidly colonised by other plant species and the swamp appears revitalized. This recolonisation, however, is detrimental to the original ecosystem, and the new growth prevents indigenous species re-establishing themselves once discharges cease. Another issue associated with unusual stream chemistry is the deposition of a carbonate like substance, as can be seen at Baal Bone Creek in Baal Bone Colliery's lease at one dewatering point. This clearly shows extremely high mineral content. The habitat for endangered species, such as the Giant Dragonfly, may well have been destroyed.



Apparent rejuvenation of a swamp by mine Baal Bone Colliery effluent following its desiccation after longwall mining where salt tolerant plants replace the pre-existing ecosystem (Photo: C. Jonkers 2006 and 2009)

2.8.2 The effects of elevated temperatures and long term discharges

Elevated effluent water temperature at a discharge point raises the overall temperature of the body of water into which it is introduced. Many aquatic animal species have a narrow optimum temperature range for metabolic activity. Changes to water temperature affect species' viability and, if increased sufficiently, will eliminate certain, more sensitive species. Another effect of increased water temperature is the introduction and colonization of algae. Testing of water temperatures within Springvale Colliery's lease area has revealed water temperatures from discharge points of up to 26°C. The longer a dewatering point is active the more severe its effects.

The discharge of effluent from Springvale Colliery into streams and swamps in the Wolgan River headwaters on Newnes Plateau was continuous for almost ten years, until 2006. These discharges have continued intermittently since 2006 when the Springvale Water Transfer Scheme was established.

Streamwatch Co-ordinator Ms Julie Favell was concerned about the impact of "emergency discharges" on certain of the nationally endangered shrub swamps on Newnes Plateau. On January 14, 2009 Ms Favell found the salinity in the effluent discharging from LDP 4 and LDP 5 to be 1,000 EC on the Newnes Plateau, which was 33 times higher than nearby creek of 30 EC. The macroinvertebrate numbers in the undisturbed swamp sites nearby appeared to Ms Favell, an amateur naturalist, to be very high, but non-existent in streams below discharge points LDP 4 and 5 located on other tributaries of the Wolgan River above swamps.



Licensed Discharge Points 4 (left) and 5 (right) above Narrow and East Wolgan Swamps respectively. Both points are capable of discharging over 10 ML/day (Photos: A. Valja, Jan. 2006 and K. Muir, 2009)

2.8.3 Impact of Springvale discharges on Newnes Plateau shrub swamps

These discharges appear to have poisoned the native vegetation of the endangered swamps. At one vegetation monitoring site on East Wolgan Swamp, teatree vegetation cover had fallen from 20-50 per cent of the site (condition 5) to less than five per cent of the site (condition 2) (Springvale July, 2008, Attachment 4, section 3.3). The monitoring site is in a constricted section of the swamp probably impacted by saline mine effluent. Within three or four months, the saline mine effluent was impacting on swamp vegetation at the other site on East Wolgan Swamp. Prickly-leaved Grevillea (*Grevillea acanthifolia*) had suffered a decline of a similar extent to that experience by the teatree at the other monitoring site (Springvale Dec., 2008, Attachment 3, section 3.3).



East Wolgan Swamp death: tea tree condition fell from condition 5 to 2 at a not so constricted site (Photo: C. Jonkers, 2009)

Saline surface water can also damage critical infrastructure, for example pipes and concrete structures, such as bridges over saline streams. The Mt Piper and Wallerawang coal-fired power stations receive large volumes of saline groundwater that is evaporated to cool the power plants. Through evaporation the salinity concentrates in the reused water. This concentrated salt is a problem when power stations are not designed to operate on highly saline water. In the case of Delta's power plants it has necessitated the construction of desalination plants, the rebuilding of condensers and allocation of scarce surface waters to dilute the saline effluent. Mt Piper Power Station desalination operations generate 16 ML/year of brine at 115,000 $\mu\text{S}/\text{cm}$, or three times saltier than seawater, which is disposed of within ash dams in the Cocks River catchment (Jonkers, 2009) [see the Springvale Water Transfer Scheme case study].

2.9 Ineffective swamp monitoring and management

The monitoring data collected for mining companies regarding swamps, surface water and groundwater has failed to report on obvious swamp and stream damage.

The monitoring has not provided the necessary information to assist decision-makers regarding the damage to these swamps and streams. This could be as simple as the provision of clear images to regulators of the worst examples of dead swamp vegetation and streambed cracking. Groundwater monitoring bores, for example, meet regulatory requirements but do not appear to identify problems.

Management measures to protect heritage values have also proven ineffective. Springvale Colliery for example, was required to prepare a Newnes Plateau Shrub Swamp Management Plan by March 2006, following its application for a SMP area for Longwalls 411-418 in May 2005. Under this plan, experimental remediation measures are to be considered only after additional monitoring of any serious damage to swamps. To date, no experimental remediation has been proposed for the catastrophic damage to Narrow Swamp and East Wolgan Swamp. Instead, more intensive monitoring is being implemented (Springvale Coal, EPBC Act referral 2009/5258, 22 Dec., 2009).

Monitoring of water table levels and swamp conditions by the collieries has been poorly planned and is confusing. Springvale Colliery, for example, has a number of piezometers in marginal swamp locations. These monitoring sites are scarcely even within the swamp boundaries and frequently do not record any data, as near-surface groundwater levels are typically below the bottom of the monitoring hole.

Some swamps in the Gardens of Stone are used as controls for current mining activity. These swamps should be separate from any mining activity and represent natural ecosystems by which to determine the effects of underground mining on other swamps. However a swamp that was the control for Springvale environmental monitoring has subsequently fallen into the lease area of Angus Place Colliery and is set to be undermined. This mining would nullify its value as a control.

Swamp vegetation condition monitoring programs do not refer back to the original vegetation condition at the time of the preparation of the environmental impact statement. The monitoring examines seasonal variations in vegetation that mask major changes caused by coal mining. When a decline in vegetation condition is reported, it is never illustrated with a photograph. Paired comparative images of the affected area are never provided, which would show the damage to a plant community relative to its condition prior to mining.

In June 2008, the then Department of Environment and Climate Change produced a map of Newnes Plateau swamp vegetation vastly different from maps of swamp vegetation previously reported. The mapping includes 29 hanging swamps that were previously not reported (Springvale Coal, July 2008, Attachment 3). These swamps, being dependent upon perched aquifers, would be highly sensitive to mine subsidence impacts, as illustrated by Junction Swamp. Swampy heaths were also identified. These data have had no influence on the monitoring program nor apparently Centennial's understanding of the area it is mining. The extensive arrays of hanging swamps establish the existence of a higher level aquifer in the sandstone strata than those recognised in the current groundwater monitoring effort.

3. Case Studies on mine effluent transfer and reuse

3.1 Clarence Colliery Transfer Scheme – impact on drinking water supplies

One aspect of saline mine wastewater effluent is of particular concern to human health. “For several years [Lithgow] Council has drawn all of its water from the Clarence transfer system” (L. Ashworth, 8 May 2008). While this allegation is really only correct during periods of prolonged low rainfall, Lithgow residents are drinking treated colliery effluent.

From 1985, when the transfers to Farmers Creek commenced, until 2006, this discharge to stored drinking waters from Clarence Colliery was illegal. The Clean Waters Regulation 1972 prevented any discharges entering the stored drinking waters of Farmers Creek as these waters were mapped as Specially Protected. The Clean Waters Regulation 1972 was repealed on 1 May 2006, having the effect of legitimising discharges into this water supply.

The discharge has caused three deep erosion gullies in a large Newnes Plateau Shrub Swamp in the catchment of Lithgow's drinking water supply. Nothing has been done to monitor, report or repair the damage to the swamp within the dam's inner catchment for several decades.

The three gullies have three nick points that are progressively moving upslope eroding currently intact areas of the swamp. The resultant 'channelisation' is akin to digging a ditch through the middle of the swamp, lowering the watertable across the affected areas of swamp, and causing it to dry out.



Two of three erosion gullies in Farmers Creek Swamp caused by the Clarence Colliery discharge to Lithgow's drinking water supply (A. Valja and C. Jonkers, 2010)

A year before the regulation was to be repealed, the Clarence Water Transfer Scheme was proposed to reuse the partly treated mine effluent water from Clarence Colliery, for augmentation of

the Fish River Water Supply (Fish River Water Supply, 2005). One of several subsequent variants of the proposed project involved construction by Delta Electricity and operation by Lithgow City Council. The water was proposed to be transferred from the colliery's treatment plant to a point below a disused dam on Farmers Creek, to supplement the Cox's River catchment flows into Lake Lyell. The water from this proposal was to, at least in part, supplement Delta's voracious water requirements for energy production, particularly during drought periods. Despite these plans, no modifying works to improve the originally illegal scheme effluent discharging into the water supply eventuated.

The tonnes of sediment that have been lost from the swamp partly ends up in Farmers Creek dam, reducing its water holding capacity. It is worth pointing out that erosion and siltation have already filled both the Bungleboori and Marrangaroo Dams with sediment. It is very difficult and expensive to clean out a dam without causing further problems downstream.

The Clarence Colliery wastewater is often rich in dissolved metals, even after treatment by aeration, and dousing with lime, potassium permanganate and alum floc at the mine site (Byrnes, 2000). The clean looking but sometimes still oxygen depleted effluent is mostly groundwater with dissolved iron, manganese, zinc metal ions in a reduced form, and also nickel. A CSIRO study indicates that elevated levels of manganese, cobalt, nickel and zinc are entering the Wollangambe River, the primary receiving water for Clarence effluent (Corkery, 1993). The metals oxidise and precipitate through chemical and biological reactions that remove the dissolved oxygen in surface waters and can cause significant ecological damage. These oxidation processes do not fully occur in the colliery's water treatment plant. It should be remembered, however, that at least this mine has a large capacity treatment plant, while most other collieries do not. On mixing with surface receiving waters the metals continue to be precipitated in stored waters on Farmers Creek, as well as in the Wollangambe River in the World Heritage listed Blue Mountains National Park.



Up to 18 ML/day of Clarence Colliery mine effluent can be discharged to the Wollangambe River, a wild river in the largest wilderness in NSW, within a World Heritage listed national park (Photos: K. Muir, 1998; K. McLaughlin, 2010).

In 1999, a consultant's report for Clarence Colliery stated that 'if the current system is allowed to continue indefinitely, the discharge of such waters into the Wollangambe [River] would be considered a breach of the Clean Waters Act, rendering the mine liable to prosecution. It is therefore evident that this is not an option that is acceptable to Centennial' (Byrnes, 1999). Yet this Wollangambe discharge continues, and the inter-catchment diversion flows to the Farmers Creek water supply catchment have increased to meet increased water demand.

The discharge into the swamp above Farmers Creek stored waters, by a drain pipe at the head of the swamp without any discharge structure, is usually 5ML/day (Byrnes, 2000, pg 4-7) with a maximum of 8.7ML/day (Department of Commerce, 2005, pg 4-2).

In 2004, the transfer scheme pumped over a gigalitre of mine effluent a day into Farmers Creek Dam, and it is believed that the amount transferred has increased in recent years. The erosion of this nationally endangered shrub swamp will increase as flows become more regular and larger.

In 2007, the Department of Environment and Climate Change reduced the compliance limit for discharges following repeal of the Clean Waters Regulation, in effect admitting defeat despite the above admission (DECC, 2007).

Dissolved nickel in the water supply for the Lithgow region is on average 50% above drinking water guidelines of 0.02mg/L for samples taken between January 2002 and December 2005 (Alam, Corbett and Ptolemy, 2008; and NSW Dept. of Health, 2005).

The elevated nickel levels can be traced back to the mine wastewater being introduced into the Farmers Creek drinking catchment by the inter-catchment transfers from the Clarence Colliery. Apparently the drinking water treatment plant's regular failure to meet the required standards for nickel is due to the plant being overwhelmed by metal concentrations in the mine effluent.

Discharge of this mine effluent, with elevated levels of nickel and manganese, to the World Heritage Area and Lithgow's drinking water supply continues.

3.2 Case Study: the Springvale Water Transfer Scheme – A Mismanagement Farce

Delta Electricity's Wallerawang and Mt. Piper power stations can call on 23 GL/yr from the Cocks River and a further 8 GL/yr from the Fish River Scheme, primarily from Oberon Dam. Delta is obsessed with water security and wants more water. Delta Electricity has provided Lithgow Council with plans and studies that assessed increasing pump-transfer of water from the Clarence coal mine to the Cocks River. Lithgow Council plans to secure funding to proceed with the scheme. Delta has also investigated additional water supplies from abandoned mines (Delta, 2008). Yet these plans were not enough.

While Delta's storage dams, Lake Wallace and Lake Lyell, on the Cocks River were still at 40 per cent (24 GL of storage) they renegotiated with State Water, further access to Oberon Dam, which in November 2009 stood at just 12.8 per cent capacity. This meant that Delta could continue to take 9 megalitres a day from Oberon Dam till that storage dropped to 5 per cent capacity, significantly lowering the water security of Oberon township and its timber plant that employs 1,000 people (Oberon Review, Oct/Nov 2009). By 4 March 2010 Oberon Dam stood at only 10.2 per cent and falling, triggering level six restrictions throughout the Oberon local government area (Oberon Council, 2010). It is in the context of Oberon Dam levels plummeting to these record low levels, and local political outrage over Delta's water grab, that Delta's access to saline mine effluent should be examined.

The Springvale Colliery had historically pumped up to 20 megalitres per day via the pit dewatering system through licensed discharge points into the Wolgan tributaries. This discharge into the Wolgan tributaries was causing unnatural water flows on the Newnes Plateau and in the Gardens of Stone and Wollemi National Parks.

In 2002, Springvale Mine entered into a pollution reduction program with the then Environment Protection Authority and began looking for alternative discharge points (Australian Mining, 2008). As a result of this program, Centennial Coal proposed to provide a substantial part of the water that Delta Electricity needed for its power stations to operate.

The scheme now pumps at 15 megalitres a day from the Springvale Colliery and a further 6.7 megalitres a day from the Angus Place Colliery. Dr Hua Guo, CSIRO Exploration & Mining's mining systems research leader, has identified that the transfer scheme will handle 25 megalitres of water per day by 2015. As a result, the scheme was constructed to handle up to 30 megalitres a day or about 11 gigalitres a year.

The water was initially transferred by a 10 kilometre pipe directly to the Wallerawang power station. In 2006 the Scheme was awarded the Water Recycling and Conservation Leadership Award at the Department of Water and Energy's 2006 Energy and Water Green Globe Awards.

Shortly after being commissioned in 2007, the scheme developed serious problems and ceased to be operational in 2008. Issues arose with the integrity of the pipeline, and the use of mine effluent water in the Delta's power plants, apparently due to its high salinity and grit. While the transfer scheme was out of action, Springvale Colliery conducted an "emergency discharge" initially for seven months. Two discharge points from Springvale, LDP 4 and 5, were in use sending around 15 megalitres a day into a tributary of the Wolgan River.

On July 30, 2008, pollution licence 766, which then covered the Wallerawang and Mt Piper power stations, was varied to require a program of works to treat Springvale mine water and reduce suspended solids by 1 October 2008 (DECCW, 2008). The works also involved discharge of water into Sawyer Swamp Creek (DECCW, 19 Feb, 2009), rather than directly into the Wallerawang power

station (Delta, 2009). The diversion was completed and the “emergency discharges” ceased regular operation in February 2009. Delta and Centennial then built a joint venture “water treatment plant” at the Kerosene Valley Ash Repository to reduce suspended solids in the effluent. This settling pond was completed in mid 2009 and has a capacity of 30 megalitres a day. To ensure electricity production was maintained during these works, a reverse osmosis plant to treat water to reduce salinity was temporarily installed at Wallerawang power station (Delta, 2008).

On 30 July 2008, the Community Reference Group for Delta’s Mt Piper Power Station was advised that “drought conditions” had affected the condensers at the Wallerawang Power Station, requiring works costing \$35 million. The drought conditions had necessitated the use of untreated saline and turbid mine effluent in condensers designed to run on fresh water. The replacement condenser tubes are of a material able to handle prolonged exposure to water with higher saline levels (Macdonald, 2008).

The brand new Springvale Water Transfer Scheme was so defective that it required the construction of a water treatment works (i.e. settlement pond) and repair of several major pipeline failures.

These failures arose because the Springvale transfer scheme was pushed through under the arcane *Pipelines Act, 1967*, as pipelines for mining operations are deemed complying development under the 2007 State Environmental Planning Policy for Mining. Approvals under that Act do not require prior community consultation. In effect, the public comment and review processes that provide free access to the accumulated experience of the community were not available to Delta and Centennial Coal.

“Cutting red tape” does not always result in improved economic outcomes, while it almost certainly lowers environment performance. A letter to Centennial Coal in 2007 by the Colong Foundation warning that saline effluent would play havoc with power station infrastructure was ignored. Time and money would have been saved had an adequate environmental impact statement, with public consultation and review processes, been undertaken. These processes would have exposed the problems inherent in the constructed design.

The Springvale scheme also means that the Cocks River has become saline. The Blue Mountains Conservation Society is hoping to reduce the pollution of the river and has commenced proceedings in the Land and Environment Court against Delta Electricity.

Through more open planning processes, perhaps the Department of Environment, Climate Change and Water could gain the political leverage to impose stronger water cleansing programs for the power stations and mines to restore stream health. Maintenance of clean waters would significantly lower the operational costs for drinking water suppliers and for the power generators.

4. Mine Subsidence Regulatory Failure

Coal mining is governed by Ministers, bureaucrats, legislation and mining regulations. Critically, development consent is granted by the Minister for Planning before a lease for coal mining is issued by the Minister for Mineral Resources. Making a planning consent a prerequisite for a mining title establishes a healthy tension between protecting the public interest in other natural resources, social welfare and the mining of coal for profit.

Unfortunately, once the planning consent and mining title are issued, it seems that healthy tension dissolves. Any future approvals to actually mine the coal are issued under the *Mining Act 1992* by the Minister for Mineral Resources alone.

The Mineral Resources Division of the Department of Industry and Investment and its Minister are captives of the mining industry. The very close association between industry, its regulators and the Minister for Mineral Resources means that subsequent Subsidence Management Plan (SMP) approvals do not produce adequate environment protection.

Approval of SMPs has improved consultation and information flow regarding underground coal mining between mining companies, government agencies and, in some cases, the community, but not much else. The SMP process does not respond to the sensitivity of the area, as promised for the area affected by the application (DMR, Transitional Provisions, 2003, pg 1). The SMP process does not add additional environment protection zones beyond those in the development consent.

The SMP process does not adapt to environmental impacts that arise during mining, it monitors these impacts, and in some cases undertakes showcase experimental repair. In the case of the Gardens of Stone, the SMP process is yet to attempt experimental repairs to damaged swamps, although this may eventuate from continued community agitation. Such results may be achieved without the SMP process, as for example longwall mining operations at Angus Place that were reorientated 90 degrees in the 1980s without such processes, following representations made by the Colo Committee.

In 2003, the then Minister for Mineral Resources, the Hon Kerry Hickey, introduced the SMP process with these words: *Coal mining is a major contributor to our economic and social wellbeing. However, the industry still bears a significant legacy of past mining practices and policies. The community no longer accepts that its environment and amenity will diminish significantly as a result of mining – and nor should it. ... We must balance present-day needs without compromising the future of our children. We have a clear responsibility to future generations and a duty to protect our environment while maintaining a strong, diverse economic base.*

The Minister's words echo the ecologically sustainable development vision of the 1987 Brundtland report "*Development that meets the needs of the present without compromising the ability of future generations to meeting their own needs.*" They apparently also seek to implement the definition of Environmentally Sustainable Development in the *Environmental Planning and Assessment Act, 1979*.

In retrospect it is obvious that retaining all decision-making power within the domain of a government department aligned with mining interests was going to perpetuate environmental abuse. In February 2006, Centennial Coal objected to the Gardens of Stone State Conservation Area proposal on the grounds that it would create long-term uncertainties.

Essentially Centennial Coal does not want to protect this outstanding environment. In a letter to the Colong Foundation, Ms Donna Dryden of Centennial stated that *the reservation of SCA's can only achieve more specific environmental management outcomes by restricting activities through imposition of barriers for cliffs, streams, etc. as is suggested by the proposal.*

The former Environment Minister, the Hon Bob Debus, MP advised in August 2006 that the NSW Government intended to pursue, among other reserves, an Airly-Genowlan State Conservation Area in consultation with the Department of Primary Industries (Minerals) and Centennial Coal. The Department of Environment, Climate Change and Water then prepared a draft plan of management for the proposed reserve. Yet Centennial Coal remained insistent that the 2007 State Environmental Planning Policy for mining created an impediment, in that certain surface infrastructure, such as pipes, powerlines and air vents, require the concurrence of the Environment Minister for any approval. In effect, a State Conservation Area reserve over the entire Gardens of Stone, would prevent Centennial Coal from making further costly blunders, such as those outlined in the two case studies above.

The history of longwall coal mining is similar to that of the native forest logging, which presents a salutary lesson. Both the clear felling of native forests and longwall coal mining have increased in intensity over time. Intensive logging caused extensive environmental damage, which led to a broadening of community protest against native forest logging. These protests resulted in political intervention in the logging industry but reform was long delayed by an intransigent regulator, the Forestry Commission. The financial and social impacts of the necessary industry reforms, when they came, were more extreme and abrupt than necessary because change was delayed.

It is necessary to bring to an abrupt end the ongoing environmental abuse of the coal industry. It is not a question of when, but how. Further delays will only increase social and economic of disruption and delay the necessary environmental remedies. The coal mining industry should seek to adjust to the coming changes by embracing proposals like the Gardens of Stone, which will enable it to adapt and gain new skills.

5. Conclusions

The most beautiful parts of the Blue Mountains and the headwaters of Sydney's drinking water catchment should not be degraded so that the mining industry can meet its profit targets. Such intensive mining is unfair on future generations. The 2004 policy framework for subsidence management has been a failure from the outset and needs extensive amendment, particularly in relation to how environmental protection is secured.

Management of subsidence damage that does not adapt to ensure environment protection, is no management at all. Monitoring that fails to observe and adequately report obvious swamp and stream damage, is not monitoring but obfuscation. Monitoring the maximum cliff and pagoda damage of the noble Gardens of Stone landscape is a perversion masquerading as science.

To lower water quality standards to allow the pollution of drinking water supplies and wild rivers with hazardous metals, borders on collective insanity. To top it off, to run power station condensers on saline mine effluent that were designed to operate on fresh water instead and then to award a Green Globe Award for doing so, beggars the imagination.

The sum of thirty years of disregard, obfuscation and bungling in the Gardens of Stone gives just one snapshot of how the coal mining industry has earned its thoroughly deserved reputation for environmental abuse.

Subsidence Management Plans are exact only in estimating levels of land surface movement along certain survey lines. The impacts caused by this subsidence on near-surface groundwater levels, swamps and even predictions of surface cracking, are very poorly estimated and often underestimated.

Flood irrigation of dying swamps with mine effluent is inappropriate. It kills native swamp vegetation and can generate adverse impacts downstream (e.g. eco-toxic water pollution, unsightly orange precipitates and stream turbidity).

6. Recommendations

6.1 Additional protection measures

The Gardens of Stone Park Proposal – Stage Two – should be reserved to ensure all heritage values are respected, and seen to be respected through approval concurrence processes by the Environment Minister.

No further mining leases should be issued within the Gardens of Stone unless the industry agrees to adequately protect all heritage values of the area and the environmental performance of existing collieries dramatically improves.

Subsidence protection zones should be established around all important geological, ecological or cultural features, including vulnerable features like streams, swamps, cliffs and rock overhangs. These protection measures should be made mandatory for current, as well as future longwall mining operations, effective immediately.

Only mining that does not impact upon a catchment's capacity to collect or convey water and does not cause pollution should be permitted.

The approval process of a Subsidence Management Plan (SMP) should be linked to planning approvals, which should extend for a maximum of ten years.

Under no circumstances should mining operations which cause surface cracking be permitted.

The NSW Government should reject the mining industry's demands to weaken any protection afforded by the reservation of a state conservation area, and it should be noted that the industry's position is not justified in the light of its past behaviour.

6.2 Improvements to regulatory enforcement

Subsidence Management Plan approval should not be automatic and should require mining companies to protect the environment and amenity.

Failure to meet acceptable community standards to protect the environment, and to tell the truth, should ensure refusal of the next approval and even mine closure.

Forfeited mining tenure should be put out for competitive tendering that selects the best environmental outcomes for future generations.

Government agencies and the Land and Environment Court should have the power to issue stop work orders, when significant damage is caused to geodiversity, threatened species, threatened ecosystems and water systems, similar to the wording in the *Environment Protection and Biodiversity Act (1999)*; “A person must not take an action that is likely to have a significant impact on a listed threatened species included in the endangered category” and “A person is guilty of an offence if the person takes action and the action results or will result in a significant impact on a listed threatened species”.

Where companies are in violation of legislation, fines need to be imposed that are much greater than the cost of remediation measures.

Breaking conditions of approval should never prove more profitable than remaining within the law for a mining company (In 2008, Coalpac was fined for producing more coal than allowed by their lease. The case resulted in a fine of \$200,000 [+ \$55,000 prosecutor’s cost] however within the transcript it was clear that Coalpac made hundreds of thousands if not millions of dollars from their violation and hence still profited from their actions).

Review of pollution licensing under the *Protection of the Environment Operations Act* for Clarence Colliery discharging to Farmers Creek (and by implication the Wollangambe River also), to prevent discharge of any mine effluent into this catchment, unless treated to a drinking water standards.

Review pollution licensing under the *Protection of the Environment Operations Act* for Springvale Colliery to prevent pollution of the Wolgan and Coxs River with water below drinking water standards. (It would be wrong to allow more recently approved mines than the Clarence Colliery to continue to operate under weaker water pollution control requirements).

6.3 Better monitoring of subsidence impacts

Subsidence monitoring should be accountable to a third party government agency, such as the Department of Environment, Climate Change and Water.

In SMP areas, more representative sites for piezometers should be chosen for groundwater monitoring.

Adequate surface flow and near-surface groundwater monitoring in SMP areas should create a comprehensive picture of these water systems and how these systems are affected by mining over time.

Pumping rates for bores discharging mine effluent should be logged and reported over time and with respect to local rainfall data.

Terms describing the condition of indicator plant species and the general condition of ecosystems require a more stringent description and guidelines.

Vegetation survey sites need to be considered on a long-term scale with comparisons being drawn on yearly evidence and not month to month differences which may misrepresent changes in condition due to natural seasonal changes.

Notable changes in site condition should be presented to regulators in well exposed, wide angle images. A reference image taken prior to mining in the area should be provided for comparative purposes.

The definition of drought should be more than one standard deviation below mean average annual rainfall.

7. Appendices

7.1 Appendix 1 – the coal mines within the Gardens of Stone Stage 2 area

Clarence Colliery is approximately 10km east of Lithgow off the Chifley Road, close to the catchment divide separating Wollangambe River, a tributary of the Colo River, from Farmers Creek, a tributary of the Coxs River.

Approved in 1979 with a 7,350 hectare coal lease, the colliery commenced longwall mining in 1981 and continued until February 1998, when operational difficulties with the technique forced mine closure. It then reopened using the bord and pillar mining method in August of that year.

A lease extension was approved in December 2005 over the easterly 'outdent' of Newnes State Forest. Centennial Coal can now sustain the mine at current rates of production for another thirty years.

The successful use of the bord and pillar mining method causes significantly less surface subsidence than its former longwall mining operations, provided the coal pillars are not fully extracted subsequently. This partial extraction method can reduce the surface subsidence to just two centimetres, compared with up to two metres when longwall mining is in operation.

About 9 to 12 megalitres of treated mine effluent is discharged each day to the Wollangambe River, a designated wild river within the World Heritage listed Blue Mountains National Park (Dept. Of Commerce, 2005, pg 4-2).

Water from the mine is also pumped to a second discharge point beside the old Bells Line of Road. The discharge effluent then flows by gravity pipeline to a swamp just above the Farmers Creek Dam, which is a key part of Lithgow's drinking water supply (see the **Clarence Colliery Transfer Scheme Case Study** for more details).

Angus Place Colliery was approved in 1978 and longwall mining operations commenced in 1979. It is located in the headwaters of the Coxs River, 16 kilometres north of Lithgow on the Wolgan Road. After only five years of operation, an extension to the mine was granted and by 1992 Centennial Coal had secured itself a contract with the local Wallerawang and Mount Piper power stations for 2.2 mtpa of coal for 15 years.

In 2002, a further extension to operations was sought bringing production to 2.5 mtpa for 12 years and on the 13 September 2006 approval was granted for 18 years to increase production to 3.5 mtpa and mine longwalls 930 to 980.

The depth of cover strata above the mined coal seams at Angus Place can range from between 250m to 390m (Angus Place Subsidence Management Plan Application, 2005). The colliery discharges about 6.5 megalitres of mine effluent a day.

Since 2007, the Angus Place Colliery has discharged mine effluent through the Springvale Water Transfer Scheme. The colliery has previously discharged effluent at the lower end of Kangaroo Creek, a tributary of the Cocks River. When there are operational difficulties with the transfer scheme, discharges are now permitted to Kangaroo Creek and to the tributary of the Wolgan River containing Narrow Swamp.

Springvale Colliery was approved in July 1992 and is located 12 kilometres north of Lithgow. Like Angus Place, this Centennial mine also uses longwall mining techniques and provides 3.5 million tonnes per annum (mtpa) coal to the local power plants and for export. A mine lease extension has increased reserves by 75 Mt that permits current operations to continue until 2024.

The depth of cover strata above the mined coal seams at Springvale can range from between 250m to 430m (Springvale Subsidence Management Plan Application, 2005).

Centennial Coal installed a water transfer system in 2006 that initially redirected 15 megalitres of effluent a day from the mine to Delta Electricity's Wallerawang power station. Later, the Springvale-Delta Water Transfer Scheme, which was designed to deliver 30 megalitres of mine effluent a day, sent these wastes to Lake Wallace via Sawyers Swamp Creek for indirect use by the power station in a diluted form (see **Case Study: the Springvale Water Transfer Scheme**).

Baal Bone Colliery located 24 kilometres north-west of Lithgow on the Mudgee Road, received development consent in 1982 to produce 1.03 mtpa for both domestic and international markets. Production increased up until 2003, and since then production is steady at 1.7 mtpa until the current consent lapses in 2010. Alternative coal supplies for the Mount Piper and Wallerawang power stations will be needed from 2012 when mine production by longwall operations ceases at Baal Bone Colliery. The depth of cover from the coal seam to the surface varies from 20 metres at the pit to 250 metres to the eastern extremity of the mine title.

The colliery tenure has one small area available for mine development, but Coalex Holdings considers this area to be uneconomic and is not currently seeking to renew its development consent for this area (Xstrata, 2009).

Invincible Colliery on the western margin of the Gardens of Stone is situated 20 kilometres northwest of Lithgow on the Mudgee Road. From 1901 till 1998 operations were for the most part underground, sporadically ceasing due to a drop in coal prices. Underground workings are presently on a care and maintenance program (NSW Dept. of Planning, 2006).

In 1998 approval was granted by the Minister for Planning for an open-cut mine at the colliery, allowing the extraction, by Coalpac, of 300,000 tons of coal per annum over 5 years. Operations were then placed under a care and maintenance program until 2006.

Then in 2006 Coalpac secured a 350,000 tpa coal contract from Delta Electricity to supply Mount Piper power station for a 3 year period.

In September 2006, the Minister for Planning granted project approval for extensions to the mine and rehabilitation activities. Between 7 September 2006 and 6 September 2007, Coalpac produced 635,277 tonnes of saleable coal from the mine. The approval only permitted an annual production cap of 350,000 tonnes of coal in a year. Coalpac pleaded guilty to a breach of section 125 for carrying out development without the approval of the Minister under section 75D(2) of the EP&A Act (Environmental Law News, 2009).

Coalpac made a further successful application, to increase production from 500,000 tons per year for 3 years to mine 1.2 million tonnes of coal per year for 8 years, which was approved in December 2008. These operations are scarring of the Gardens of Stone. The operation is clearly visible from the Castlereagh Highway as the mining follows the road along the western slopes of the Great Dividing Range. Coalpac claimed in its environmental assessment that the operations would not be visible from the highway (Coalpac, 2006) but this proved not to be the case. Coalpac's assessment may have mislead the Department in relation to its finding that visual impacts would not be significant (DoP, 2006).

On 23 March 2007, CoalPac Pty Ltd lodged an application to vary their Protection of Environment Operations (POEO) Licence Number 1095, to recommence discharging up to 4 ML/day of mine water from their borehole in Ben Bullen State Forest (LDP01).

The licence variation was approved, and pumping commenced in June 2007. The discharge was observed in the latter half of 2007 to have a salinity ranging from 1600 – 1750 $\mu\text{S}/\text{cm}$ (Jonkers, 2009). The saline effluent water from the underground workings flowed into a western branch of Long Swamp and then into the headwaters of the Coxs River. This arrangement maintains access to the mine's underground workings and provides Delta Electricity with additional water for power plant operations. These discharges severely damage the ecology of Long Swamp.

Airly Colliery is located approximately 40km north-west of Lithgow and around 4km north-east of Capertee off the Glen Davis Road. The Airly coal project was approved by the Minister for Planning in April 1993 and was acquired by Centennial Coal in January 1997.

Construction of Airly Colliery began in early 2009 with the first coal expected in 2010. The operation will use bord and pillar mining methods to produce up to 1.8 Mtpa of thermal coal for both export and domestic use.

A Special Monitoring Committee of community and conservation representatives is required to meet under the conditions of consent for the mine. Only one meeting has ever been held, in July 1999. The 2007 Annual Environmental Monitoring report stated that a meeting of stakeholders would be convened if there was a plan to reopen the mine in the near future. By February 2010 the mine under construction has been underway for over a year. Mine production is due to commence and still there has been no such meeting.

A proposal for a State Conservation Area over the proposed mining lease, meanwhile, is under active consideration by government agencies. The new reserve is opposed by Centennial Coal due to an alleged increase in regulatory obligations for surface works.

7.2 Appendix 2 – the key Natural Heritage Values of the Gardens of Stone area likely to be affected by coal mining

Cliffs, Pagodas and other Geodiversity

The Gardens of Stone near Lithgow lies on the western margin of the Sydney Basin where cliff-forming Triassic sandstones, mainly assigned to the Grose and Burrallow Formations of the Narrabeen Group, present an exposed stratigraphic column of some 800 metres. Sandstone cliffs, slot canyons, mesas and pagodas comprise the outstanding geodiversity of the Gardens of Stone.

The swamps of the Plateau also are important geomorphological features of the area (Ann Young, pers. comm.). Shrub swamps on the Newnes Plateau have evolved over millennia on poorly drained and sandy soil substrates that enable the development of organic matter (peat) in the soil profile. Swamps play a key role in the ecology of the Gardens of Stone and regulate stream flows.

Blue Mountains sandstone geology typically has vertical jointing and these numerous joints intersect, forming sandstone blocks. The magnificent soaring cliffs of orange sandstone that characterise the Blue Mountains are the result of repeated block falls. While cliff collapse is a natural process, subsidence increases its frequency and its severity greatly. The mechanisms of cliff fall could be toppling or back tilting and sliding of the sandstone blocks. The precise nature of natural cliff falls in the Gardens of Stone is poorly understood. At the base of some cliffs, rock overhangs, locally known as caves, which sometimes contain Aboriginal art, can be found.

The sandstone's vertical joint planes are subject to greater chemical and mechanical weathering than the plateau surface. The orientation of streams on Newnes Plateau typically follows these underlying joint planes. Rock fissures and canyons have also developed on the plateau in response to vertical joint planes and these latter environments can support rainforest species.

The Burra Moko and Banks Wall sandstone formations of the Narrabeen Group of Triassic sediments tend to form stone pagodas (Washington, 2001). Pagodas are house-sized stone monuments, often with jagged silhouettes reflecting the differential erosion of the constituent rock.

The thin bedding of these sandstones (sometimes enhanced by harder ironstone bands and softer intervening bands) in the Gardens of Stone area permit differential weathering that is responsible for the beehives, domes and plates in the rock outcrops, locally called 'pagodas'. The solution and deposition of iron occurs in other sandstones but in this area the process occurs to an extreme degree. Ferruginised sandstone shelves project up to 0.5 metres from the pagoda flanks.

Pagodas are located across the Gardens of Stone, on escarpments, and along secondary rocky ridges and spurs that descend into creek valleys. Pagodas increase their relief relative to the spurs upon which they stand at a rate of 3-14 metres every million years until they collapse via flank retreat (25 m/My) or spur slopes are consumed as gorges widen (Wilkinson et al., 2005).

Note the extremely slow rates of natural change! These features change imperceptibly under natural conditions and are part of a landscape more than 50 million years old (Young, Wray and Young, 2009).

The thin bedding and hardened ironstone layers allow the formation of not only platey pagodas but smooth beehive domes and exquisite platform morphologies (Washington, 2001).

Nationally Endangered Upland Swamps

Newnes Plateau Shrub Swamps are restricted to the Newnes Plateau and some adjoining areas of the Blue Mountains over 1,000 metres on poorly drained, acid, sandy peat soils (DECC, Feb 2008). In these swamps, a closed heath or shrubland plant community (which varies with fire history) may dominate, but localised patches of closed to open sedgeland including herbs and sparse shrubs may also be interspersed throughout these swamps. Newnes Plateau Shrub Swamps cover less than 650 ha in total and only 160 ha are reserved in adjoining national parks, making it one of the rarest plant communities in Australia.

In May 2005, the Commonwealth Scientific Committee listed Temperate Highland Peat Swamps on sandstone as an Endangered Ecological Community under the *Environment Protection and Biodiversity Conservation Act, 1995*.

The Scientific Committee, established by the NSW *Threatened Species Conservation Act, 1995* has also listed the Newnes Plateau Shrub Swamp in the Sydney Basin Bioregion, as an Endangered Ecological Community in Part 3 of Schedule 1 of the Act (Hughes, 2005a). The Scientific Committee also listed longwall mining as a key threatening process impacting on these swamps (Hughes, 2005b) [see Appendix 3].

Newnes Plateau Shrub Swamps are regarded as distinct from the general classification of upland Blue Mountain swamps. The DECCW explains: "*Blue Mountain Swamps are restricted to the Blue Mountains from 500m to 1000m where it intergrades into Newnes Plateau Shrub Swamps between Bell and Clarence. This community has a higher diversity of sclerophyllous shrub species, a lower diversity of soft-leaved shrub species, grasses and herbs than Montane Peatlands and Swamps, and*

typically occurs on low fertile sandstone soils. Some areas are dominated by closed to open sedgeland with a more open or scattered shrubland or heathland overstorey” (Hughes, 2005a).

At least two endangered swamp animals are known to be at risk from longwall coal mining in the area. The endangered Giant Dragonfly has been located in Sunnyside Swamp (Ian Baird, pers. comm., 2010), where Springvale Colliery has just commenced longwall mining. Just to the east of that swamp, several tributaries of Carne Creek support both the Blue Mountains Water Skink, which is also an endangered species, and the Giant Dragonfly. Both of these species are strongly associated with seepage areas and may be at risk in swamps where groundwater levels are lowered. The groundwater dependent Giant Dragonfly is reliant upon wetter areas of these swamps with suitable organic-rich substrate for egg-laying and larval burrowing. Reduced water quality is also likely to adversely affect breeding habitat of this species. This species is not amenable to monitoring, and any impacts upon breeding sites that adversely affect the species will not be able to be identified before it is too late (Ian Baird, pers. comm., 2010). According to Dubey and Shine (2010), most populations of the Blue Mountains Water Skink are genetically distinct, with low levels of gene flow between them. They recommend that each swamp population of this species should be managed as a separate unit, and that loss of a single population will diminish the genetic diversity of the species. Consequently, a high priority should be given to preservation of each of the unique montane swamps that houses these lizards.

Streams and Groundwater

Coxs, Capertee, Turon, Wolgan and Wollangambe Rivers all rise in the Gardens of Stone which straddles both the continental watershed of the Great Dividing Range and the Newnes Plateau, and is part of the Blue Mountains Range watershed. In the headwaters of these rivers there are countless small, relatively pristine and ecologically significant creeks, such as Carne Creek. These streams play a key role in supporting the surrounding unique habitats, and their dependent faunal populations, such as those found in slot canyons and associated with upland swamps.

The headwaters of the Coxs River rise at Ben Bullen in the Gardens of Stone. This iconic component of Sydney’s main water storage, Warragamba Dam, is much compromised by coal mining and power generation. Another stream in the Gardens of Stone, Farmers Creek, provides drinking water for Lithgow.

Near-surface groundwater is the means through which surface and groundwater systems are connected and it can be damaged by mining subsidence. As its presence governs the viability of upland swamps and regulates stream flow, it is vital to prevent damage to this all important aquifer.

Hydrogeological investigations have shown that complex multi-layered sandstone aquifers occur within the Blue Mountains Sandstone GMU and there is a high degree of connectivity with surface water systems. The shallow and intermediate aquifers are critical to spring flow and to stream baseflow in the upper plateau rivers. These aquifers will be typically the ones that support

groundwater dependent ecosystems, such as wetlands and hanging swamps (Green, R. et. al., 2009).

Aside from the intrinsic, scientific importance and resource values of these scenic streams and swamps, they are of cultural significance to the Gundungurra and the Wiradjuri people.

Aboriginal Heritage

Many sites within the Gardens of Stone contain Aboriginal artefacts and art, and are important to contemporary Aboriginal communities, historians and scientists.

The upper Cocks River has a recorded history of Aboriginal occupation, probably affiliated with the Dharug and Wiradjuri nations for the best part of 11,000 years. It is probable that the Gardens of Stone have been occupied by Aboriginal nations for an equivalent period.

The perimeter of the upland swamps has the highest densities of aboriginal artefacts due to the wealth of game and as a stable water source for these communities. One of the most outstanding and accessible examples of rock art within the Gardens of Stone is found at Blackfellows Hand Cave, now protected from mine subsidence by an Aboriginal Place covering 491 hectares (Gov. Gaz. 18 July, 2008).

Blackfellows Hand Cave houses good examples of aboriginal stencil art. An expanse of hand stencils may be seen radiating from the base of this sandstone overhang.

Other sites have more diverse evidence of occupation, from grinding grooves and engravings to artefacts and artwork. The nature of this area and archaeological surveys undertaken to date within it suggest that there is a potential for more discoveries. All artefacts should be protected against detrimental human activities, like mine subsidence. Aboriginal sites, like the area's geodiversity, can never be restored once damaged.

7.3 Appendix 3 – Longwall mining as a Key Threatening Process to Endangered Swamps

The shrub swamps of the Newnes Plateau are listed as an endangered ecological community, with the following threatening processes:

The Newnes plateau is underlain by extractable coal seams at varying depths, with underground longwall mining occurring, or proposed to occur, beneath the majority of the swamps. Subsidence of the land surface, and associated fracturing of bedrock between the coal seam and the surface, occurs after longwall mining, and this may change the hydrology of catchments and swamps they contain. Specifically, the conversion of perched water table flows into subsurface flows through mine-related voids may significantly alter the water balance of upland swamps (Young and Wray 2000). Changes

to surface morphology within or near the swamps as a result of mine subsidence may also create nick points which become the focus of severe and rapid erosion (Young 1982). These changes pose threats to the persistence and integrity of, the community. Alteration of habitat following subsidence due to longwall mining is listed as a **Key Threatening Process** under the Threatened Species Conservation Act, 1995 (Hughes, 2005 a and b).

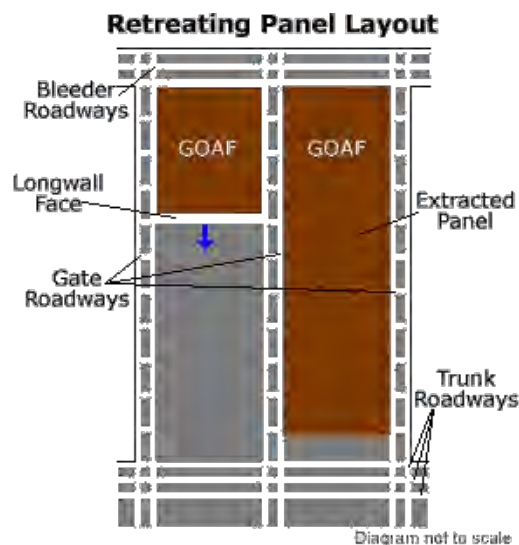
7.4 Appendix 4 – Mining Methods

7.4.1 Longwall mining

Longwall mining is the dominant form of underground coal mining carried out within the Gardens of Stone.

In these mines, the longwall retreat system is the most common method used. This system requires two corridors (called roadways) of predetermined length (<4km) to be excavated (between 150m–400m apart) and joined creating a very large rectangular longwall block to be mined. The mined panel created is between 2-4m thick and up to 400m in width.

Longwall mining increases coal retrieval rates by up to 60% more than bord and pillar methods. The typical longwall panel can take a year to mine. Longwall panels are located in parallel, separated by coal pillars.



(fig. from University of Wollongong)

When the coal panel is being mechanically cut, the strata above the advancing machine-cutter are propped up by very powerful roof supports, protecting the operatives. But as the supports are moved

forward with the advance of mining operation, the immensely heavy overlying rock collapses into the cavern created by the removal of the coal seam.

Fractured rock may extend to a height above the seam of 25 to 35 times the thickness of the mined coal panel. Above this level, the surface rocks settle and may crack – perhaps in a creek or under a swamp. Cracking and subsequent water loss can result in permanent changes to water catchments and groundwater aquifers.

In addition to cracking, surface subsidence can cause hill slopes to collapse, escarpments to topple, increased erosion and eco-toxic stream pollution. In hilly country, the surface damage may occur as far as 1.5 kilometres from the mined area. Surface subsidence impacts upon both the natural environment and human infrastructure.

7.4.2 Bord and Pillar Mining

Another method of underground coal mining is bord and pillar. This method creates a subsurface labyrinth of rooms within the coal seam. First workings of such a mine extract coal along specific channels (the bords) with the remaining seams forming pillars that allow for the safe removal of the first workings by a continuous miner. Legislation regarding NSW mines enforces a minimum width of 10% of the depth for pillars and bords are required to be at least 5.5m wide.

Second workings of bord and pillar mines extracts coal from the support pillars which allows for the collapse of portions of the overburden of the mine resulting in surface subsidence. This subsidence may not necessarily be immediate, which may complicate the accountability of the mining companies.

7.4.3 Open-cut

Open-cut coal mining is a surface method of extraction, employed where overburden is relatively thin and unsuitably weak for underground mining. It involves the formation of terraces with intervals of 4m–60m. Shallower mines do not require terracing.

The vertical section (batter) is mined at an angle to minimize rock falls, but further support may be necessary in the form of rock bolts. However the rock bolts may themselves cause failures in the rock face.

Waste rock is piled in stepped waste piles at the rim of the mine, and may be toxic and need to be flattened during remediation to stabilize them. This waste may exude acid mine drainage due to the leaching of sulphides following rain, with harmful consequences for the surrounding ecology.

Depending on the depth to the local water table, the abandoned mine may drastically alter groundwater flow and have detrimental effects on water quality and flow to streams and rivers.

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