BULLI SEAM OPERATIONS

PAC REPORT

JULY 2010

NSW Planning Assessment Commission
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EXECUTIVE SUMMARY

The Bulli Seam Operations Project relates to the continuation of longwall mining operations at the Appin Mine and West Cliff Colliery within existing coal leases and new mining leases and extends the life of the mine by approximately 30 years. The Colliery is located about 25km north-west of Wollongong in NSW. It is owned and operated by Illawarra Coal Holdings Pty Ltd (ICHPL), a wholly owned subsidiary of BHP Billiton Pty Limited.

The Minister for Planning referred the Project Proposal to the Planning Assessment Commission (PAC) for review and advice on the significance and acceptability of the potential subsidence related impacts of the project on significant natural features, built infrastructure and the values of Sydney's drinking water catchment, and for recommendations as to appropriate measures to avoid, control, or offset these impacts. The Minister also requested that the PAC hold public hearings and provide comment on issues raised in submissions and public hearings.

The Commission (Panel) was constituted by Professor Jeffrey Bennett, Emeritus Professor Jim Galvin, Dr Col Mackie, Dr John Tilleard and Dr Neil Shepherd AM (Chair). The Panel proceeded by way of examination of the Environmental Assessment (EA) and of other relevant documents, the receipt of submissions, public hearings, examination of experts, field inspections and meetings of the Panel. The Panel also directed formal questions to the Proponent and to a number of government agencies.

The Project proposes to produce 260 million tonnes of product coal over 30 years, the primary product being coking coal. The Project is estimated to create 3300 jobs directly and indirectly for the region. The EA assesses net production benefit at AUD 10.31b.

By any standards this is a very substantial and complex project proposal.

The Study Area covers more than 220 km^2, is within 60 km of a capital city (Sydney) and a number of regional cities (including Wollongong, Campbelltown, Liverpool, and Penrith), is adjacent to the population growth centre of Macarthur, and straddles the main transport and services corridor connecting Sydney with Canberra and Melbourne. It encapsulates towns and villages, elements of the water supply system for Sydney, a national highway, a national railway line, national gas supply pipelines, national telecommunication networks, industrial complexes, farms, recreational areas, air strips, and all the services that support such infrastructure (water, sewerage, gas, electricity, communication systems, survey control stations etc). As such, it contains a vast number and range of built structures, including 1294 houses, 4356 rural buildings, kilometres of hardware (e.g. water supply lines and optical cables), major roads and bridges, commercial and retail premises, large factories, etc. The vast majority of this built infrastructure is in the western portion of the Study Area (i.e. West Cliff Area 5 and Appin Areas 7, 8 and 9).

There is also a multitude of significant natural features in the Study Area including 632 identified Aboriginal Heritage sites, 634 cliffs, 226 upland swamps, 47 streams of 3rd order or above (compared with two in the Metropolitan Study Area) and a substantial number of Endangered Ecological Communities (EECs) and threatened species. The majority of the significant natural features are found in the eastern and southern portions of the Study Area (i.e. North Cliff, Appin Area 2 and Appin Area 3) which also overlap substantially with Dharawal State Conservation Area and the Sydney Catchment Authority's (SCA's) Metropolitan Special Area. Substantial parts of this area are in pristine or near-pristine condition and the area is also a significant contributor to drinking water supply for the Sydney Region.

Guided by the Terms of Reference, the Panel has focused on the potential subsidence related impacts of the Project. The Southern Coalfield, including the Project Area, is prone to both conventional and non-conventional forms of subsidence. Non-conventional subsidence is concentrated in valley floors and valley sides can impact severely on natural and man-made features in these areas because it causes uplift and buckling of valley floor strata and closure of the valley. This can result in cracking of the bed of watercourses, diversion of water from the surface to subsurface fracture networks, and contamination of water flowing within these networks, and compression and distortion of man-made structures that cross valleys. Conventional subsidence usually results in less severe impacts, but these can be distributed over a much larger region.

Mining-induced subsidence has the capacity to impact on both built infrastructure and natural features and the impacts can range from negligible to destruction of form and function. The complexities of predicting subsidence effects and impacts, the possible consequences for infrastructure and natural features that may arise from these impacts and the possible management approaches to avoid, mitigate or remediate them, are the subject of a substantial part of this Report. Overall, much more is known about both impacts and their management in relation to built infrastructure than is known about impacts and management for natural features.

The adequacy of the information on which to base an assessment of the Project Proposal and provide advice pursuant to the Minister's direction (Annexure 1) was a major concern for the Panel. Summarised, the Panel's conclusions are that the basis for any advice from the Panel as to whether the threshold for in-principle Approval has been reached should depend on:

(i) whether the public process has allowed both the public and government agencies to consider the fully-disclosed risks of negative consequences of the proposed Project;

(ii) whether the Panel's enquiries have been able to provide satisfactory answers to concerns;

(iii) whether the impacts from the project on built infrastructure and natural features in the Project Area have been characterised sufficiently to allow assessment of both the likely consequences from those impacts and the significance of those consequences; and

(iv) whether the relative magnitudes of the positive and negative consequences of the proposed project have been assessed by a rigorous process that properly estimates both the proposed mining benefits and the potential costs.

If the Panel considers there is insufficient information for a proper assessment to be made to support a recommendation for Approval, then the Panel appears to have only two options available in giving advice, namely:

(i) recommend rejection of the Project Proposal;

(ii) recommend consideration of Approval, but only contingent on performance criteria that are sufficiently robust to ensure that appropriate protection is afforded to the built infrastructure and natural features from the potential adverse impacts of the proposal, and that the subsequent processes are tightly controlled to give a very high level of assurance that the performance criteria and other conditions in the Approval will be met by the proposed extraction.

The Panel found the information provided by the Proponent to be deficient in many circumstances. Either the information was not available at the time the EA was exhibited (and therefore unable to be scrutinised by the public and other groups including government agencies) or the information was simply inadequate for the purposes of rigorous assessment of the proposal. In the latter context the expressions 'inadequate' and 'manifestly inadequate' appear throughout the report in relation to the information on which the Panel was meant to assess the likely subsidence-related impacts of the proposal on significant natural features, including groundwater. The weakness in the information base for natural features was recognised by all government agency submissions (including DII, NOW, SCA and DECCW), submissions and comment by the three relevant councils (Wollondilly, Campbelltown and Wollongong), by most Special Interest Groups, and by many individuals.

The information deficiencies are compounded by inclusion in the proposal of a capacity to alter the Base Case mine layout – both in terms of longwall location within the Mining Area and longwall panel width. The Panel has noted the considerable increase in potential subsidence-induced impacts that could arise from the as yet unspecified increases in longwall panel width.

The Panel is of the view that the deficiencies in the information supporting the Proposal are sufficient to warrant a recommendation of no Approval for the eastern and southern portions of the Study Area. The consequences of allowing the project to proceed in these areas are potentially very significant: the various protections for significant natural features are 'turned off' by the Part 3A process, the timeframe is at least 30 years and the opportunity for third parties to appeal on the merits is extinguished.

However, the Panel considered it may be possible to construct an Approval that would cope with the deficiencies in information and still produce an acceptable outcome. As noted above, it would require setting rigorous performance criteria in the Approval

Conditions (essentially outcomes to be met in relation to protection of infrastructure and significant natural features) and ensuring that any subsequent processes were tightly controlled so that the regulator was satisfied that the proposals for extraction of individual longwalls would meet the performance criteria.

Two broad options for proceeding down this path are suggested in this Report. The first is to set the performance criteria for each category of infrastructure or significant natural feature (or individual items or features where this is more appropriate) across the entire Study Area. The suggested criteria are contained within the individual Chapters and the formal recommendations in Chapter 18. The main problem with this option is that some key information for assessment of 'special significance' of some significant natural features is not available (some of the work has not been commenced, or undertaken at all) and this may warrant deferral of any Approval until the information is available.

The second is to take a different approach based on known aggregations of significant natural features and provide adequate protection to the aggregation on the basis that this will produce a better overall result for both the mining proposal and the environmental and cultural heritage attributes of the Study Area. This is the Geographically-Based Alternative described in Chapter 17. The Panel recommends that this approach be adopted (described as 'Defined Area' in Chapter 17) and that the Defined Area shown in Figure 61 be adopted as the minimum area for protection of significant natural features under this option.

What both of these approaches do is allow mining to proceed in the west and north of the Study Area while the Proponent proves that it is capable of meeting the outcomes required in the east and south.

The Panel is clearly of the view that the level of impacts proposed in the BSO Project Proposal for some significant natural features are no longer acceptable practice. A simple example will suffice to make the point. The level of subsidence-induced damage to Waratah Rivulet (Woronora Catchment) that was allowed to occur in 2004 was determined to be not acceptable in the Approval issued for the Metropolitan Coal Project in 2009. The Panel's assessment is that there are more than 50 km of streams in the Study Area with similar stream characteristics to Waratah Rivulet. Some of these are protected by the Proponent in the Base Case mine layout. But others are proposed to be subjected to the same (or worse) subsidence impacts as occurred at Waratah Rivulet. The Panel is of the view that it is no longer a viable proposition for mining to cause more than negligible damage to pristine or near-pristine waterways in drinking water catchments or where these waterways are elements of significant conservation areas or significant river systems. As noted in the Metropolitan PAC Report,[1] this level of damage would not be acceptable in any other assessment of water resource use.

The Panel also concludes that there is a problem with allowing the Proponent to assess what is of 'special significance' and what is not. Attribution of special significance to an item or feature carries with it a requirement for a much higher level of scrutiny and consideration of protection and may therefore require changes to the

[1] DoP (2009a), p.58.

mining proposal. The Panel in the Metropolitan PAC Report noted that there was an element of subjectivity in the allocation of special significance status. The Proponent's subjective view yielded one (possible) item of special significance in the whole 220 km^2 of the Study Area – the Nepean River. None of the other 46 streams classed as 3rd order and above, none of the 226 upland swamps, none of the 634 cliffs (including Appin Falls) and none of the 632 Aboriginal Heritage Sites in the Study Area succeeded in crossing the Proponent's threshold for special significance. This was in stark contrast to the submissions by government agencies, special interest groups and the public, which identified many such items, usually supported by credible evidence.

The Panel's conclusion is that the Proponent's assessment of 'special significance' is not credible and cannot be relied upon. The Panel's assessments of special significance for individual items and classes of features are contained within the relevant Chapters of this report.

There are detailed findings and recommendations in the Report covering the matters specified in the Terms of Reference for each of the categories of significant natural features identified in the report of the Southern Coalfield Inquiry. Likewise, there are detailed findings and recommendations covering the various major items and categories of built infrastructure that may be impacted by the proposed Project. These findings and recommendations are summarised in Chapter 18 for the whole report.

Undoubtedly there will be claims that the Panel's recommendations will either jeopardise the Project as a whole or substantially reduce its life and/or profitability.

The Panel's recommendations clearly do not do the first of these: the Project Proposal would be relatively intact in the western and northern areas. As for the eastern and southern areas, the recommendations will only affect the mining proposal to the extent that the mining company is precluded from causing unacceptable damage to significant natural features and some built infrastructure (dams, tunnels, etc). Mining is not prohibited: unacceptable outcomes are prohibited.

The Panel has not had access to commercial-in-confidence information that would allow a detailed assessment of the impact of its recommendation on the financial profitability of the mining operation. It has however attempted to gain an appreciation of the impact of its recommendations on the overall well being of society given the relativities of the benefits and costs involved. The analysis reported in Chapter 17 shows that the benefits of protecting significant natural features in the eastern and southern areas are likely to be of a similar magnitude to the mining profits that would have to be given up to ensure that protection. So while protection of the significant natural features would involve lower mine profitability, it is likely that society as a whole would gain more from the environmental protection recommended than it would lose in terms of foregone profits.

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GLOSSARY

ACARP: Australian Coal Association Research Program, an industry-wide research program administered by the Australian Coal Association and funded by a per-tonne levy on all coal production.

Aquatic dependent: aquatic dependent species and ecological communities occur primarily in aquatic or wetland habitats, as well as species that may use terrestrial

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Aquatic dependent: aquatic dependent species and ecological communities occur primarily in aquatic or wetland habitats, as well as species that may use terrestrial habitats during all or some portion of their life cycle, but that are still closely associated with, or dependent upon, aquatic or wetland habitats for some critical component or portion of their life-history.

Aquiclude: an impermeable body of rock that may absorb water slowly but does not transmit it.

Aquifer: a permeable body of rock or regolith that both stores and transmits groundwater.

Aquitard: a layer of rock having low permeability that stores groundwater but delays its flow.

ARTC: Australian Rail Track Corporation.

AWBM: Australian Water Balance Model.

Banksia Thicket: characterised by a tall dense shrub layer of *Banksia* and *Hakea* with a low shrub layer and sedges. Occurs patchily around the periphery of large swamps on damp soils.

BHPB: BHP Billiton.

BSO: Bulli Seam Operations.

CBA: Cost Benefit Analysis

CCC: Campbelltown City Council.

CM: Choice Modelling.

Cyperoid Heath: heath characterised by a dense stratum dominated by cyperaceous sedges. Widespread on relatively deep organic sands in wet areas surrounding drainage lines of large swamps and in the wettest parts of smaller swamps.

DECC: Department of Environment and Climate Change. This agency regulates impacts to air, flora and fauna, water and Aboriginal heritage.

Director-General's Requirements: requirements provided by the Director-General of the Department of Planning for an environmental assessment or environmental impact statement.

DoP: Department of Planning.

DII: Department of Industry and Innovation.

DPI: Department of Primary Industries.

DEECW: Department of Environment, Climate Change & Water.

EA: Environmental Assessment.

EEC: Endangered Ecological Community.

EP: Extraction Plan.

EPBC: Environment Protection and Biodiversity Conservation.

GDE: Groundwater dependent ecosystem.

ICHPL: Illawarra Coal Holdings Pty Limited.

LEC: Land and Environment Court.

MSB: Mine Subsidence Board.

MSEC: Mine Subsidence Engineering Consultants.

NGO: Non Government Organisation.

NOW: NSW Office of Water.

NPWS: National Parks and Wildlife Service.

PAC: Planning Assessment Commission.

Panel: The Commission constituted to review the Metropolitan Coal Project

Pore Pressure: the groundwater pressure applying to a pore space at a nominal depth. Often expressed in metres head of water or kPa.

Primary Porosity: the intergranular or matrix storage in between pore spaces in an aquifer – often expressed as a percentage (by volume) of a rock mass

Piezometer: a non-pumping well or borehole, generally of small diameter, used to measure the elevation of the water table or potentiometric surface.

Restioid Heath: has a low, open shrub layer and a groundcover dominated by forbs. Widespread wet heath community occurring where drainage is moderately impeded, on relatively drier sites.

Regolith: the blanket of soil and loose rock fragments overlying bedrock. It includes dust, soil, broken and weathered rock, and other related materials.

Riparian Zone: the area of land adjacent to a river or stream. It includes the riverbanks and land immediately adjacent to riverbanks.

RMZ: Risk Management Zone

Sedgeland: dominated by a continuous stratum of small restionaceous and cyperaceous sedges. Restricted to local seepage zones on shallow soils around the margins of larger swamps and on sandstone benches perched on the sides of gullies.

SCA: Sydney Catchment Authority, the lead agency controlling water supply infrastructure for both Sydney and the Illawarra.

SCI: Southern Coalfield Inquiry

SMP: Subsidence Management Plan, required under any mining lease granted for underground coal mining under the *Mining Act 1992*.

Special Areas: areas surrounding SCA's dams which are subject to additional management measures to protect the quality of drinking water. These areas are declared under the *Sydney Water Catchment Management Act 1998* for their value in protecting the quality of the raw water used to provide drinking water to greater Sydney and for their ecological integrity.

SRMP: Swamp Risk Management Plan.

Subsidence: the deformation of the ground mass surrounding a mine due to the mining activity. The term is a broad one, and includes all mining-induced ground movements, including both vertical and horizontal displacement and curvature.

THPSS: Temperate Highland Peat Swamp on Sandstone.

TSC: Threatened Species Conservation.

Ti-Tree Thicket: has a tall to short, relatively dense stratum dominated by ti-tree and Banksia and a tall, very dense understorey of sedges and ferns. Occurs in major seepage zones of large swamps, which typically have deep, highly organic waterlogged soils.

ToR: Terms of Reference

Upsidence: relative upward movement, or uplift, created by the horizontal compression and buckling behaviour of the rock strata in the vicinity of a valley floor. It reflects shearing and buckling of near surface strata, generally at or close to the valley centreline, caused by valley closure.

Valley closure: a phenomenon whereby one or both sides of a valley move horizontally towards the valley centreline, due to changed stress conditions beneath the valley and its confining land masses.

WSC: Wollondilly Shire Council.

Risk Assessment Terms

Acceptable risk / acceptable level of risk: the outcome of a decision process of determining an acceptable option. The choice of an option (and its associated risks, costs and benefits) depends on the set of options, impacts, values and facts examined in the decision-making process.

Consequence: outcome or impact of an event, which may be multiple, may be positive or negative, can be expressed qualitatively or quantitatively, and are considered in relation to the achievement of objectives.

Ecological risk assessment: a set of formal scientific methods for estimating the likelihoods and magnitudes of effects on plants, animals and ecosystems of ecological value resulting from human actions or natural incidents.

Environmental impact: any change to the environment, whether adverse or beneficial, wholly or partially resulting from an organisation's activities, products or services.

Environmental objective: the overall environmental gain, arising from the environmental policy, that an organisation sets itself to achieve, and which is quantified where possible.

Likelihood: used as a general description of probability or frequency.

Probability: a measure of the chance of occurrence expressed as a number between 0 and 1.

Risk: the chance that something happening that will have an impact on objectives.

Risk analysis: systematic process to understand the nature of and to deduce the level of risk.

Risk assessment: the overall process of risk identification, analysis and evaluation.

Risk management process: the systematic application of management policies, procedures and practices to the tasks of communicating, establishing the context, identifying, analysing, evaluating, treating, monitoring and reviewing risk.

Tolerable risk: risk which is accepted in a given context based on the current values of society.

Uncertainty: a lack of knowledge arising from changes that are difficult to predict or events whose likelihood and consequences cannot be accurately predicted.

1.0 INTRODUCTION AND TERMS OF REFERENCE

On 13 November 2009, the former Minister of Planning issued three directions to the Chairperson of the Planning Assessment Commission (PAC), the first being to:

1.

(a) Carry out a review of the potential subsidence related impacts of the Bulli Seam Operations Project on significant natural features, built infrastructure and the values of Sydney's drinking water catchment, taking into consideration the recommendations of the Southern Coalfields Inquiry;

(b) advise on the significance and acceptability of these potential impacts, and to recommend appropriate measures to avoid, minimise, manage, remediate or offset these impacts; and

(c) identify and comment on any other significant issues raised in submissions regarding the Bulli Seam Operations Project or during the public hearings.

The Terms of Reference (ToR) stated that the Commission (Panel) was to be constituted of the following members:

- A member of the PAC
- Professor Jeffrey Bennett
- Emeritus Professor Jim Galvin
- Dr Col Mackie
- Dr John Tilleard

Dr Neil Shepherd, a member of the PAC, was appointed as Chair of the Panel.

The ToR also directed that public hearings were to be conducted as part of the review and that the Commission was to provide its report by 30 April 2010.

A copy of the full ToR is provided in Annexure I.

On 1 April 2010, the Chair of the Commission wrote to the Minister requesting an extension to the reporting time from 30 April 2010 to 16 July 2010. This request was granted by the Minister.

The Bulli Seam Operations Project relates to the continuation of longwall mining operations at the Appin Mine and West Cliff Colliery within existing coal leases and new mining leases and extends the life of the mine by approximately 30 years. The Colliery is located approximately 25km north-west of Wollongong in NSW. It is owned and operated by Illawarra Coal Holdings Pty Ltd (ICHPL), a wholly owned subsidiary of BHP Billiton Pty Limited.

2.0 METHOD OF OPERATION

2.1. PANEL MEETINGS

Through the course of the review, the Panel convened several meetings and met with external parties on several occasions. Meetings with external parties are detailed in Table 1 below.

Table 1: Dates of PAC Meeting with External Parties

Date	Meeting with	Location
16/11/09	Department of Planning (DoP)	PAC offices
17/1109	The Proponent (ICHPL) and their consultants	PAC offices
23/12/09	SCA	Field Inspection (see Table 2)
12/01/10	Sydney Catchment Authority (SCA)	PAC offices
06/01/10 07/01/10 08/01/10	The Proponent (ICHPL)	Field inspections (see Table 2)
16/01/10	Department of Environment, Climate Change and Water (DECCW)	PAC offices
16/01/10	Department of Industry and Investment (DII)	PAC offices
11/03/10	Wollondilly, Wollongong and Campbelltown Councils	Wollondilly Council Chambers – also a field inspection (see Table 2 below)
25/3/10	NGOs and residents	Field Inspection (see Table 2)

2.2. PUBLIC HEARINGS AND SUBMISSIONS

In accordance with the Panel's ToR, Public Hearings were held on 17 and 18 February 2010 at Appin House. A total of 23 verbal submissions were made to the Panel at the hearings, comprising 2 from Local Governments, 11 from special interest groups, 9 from individuals and 1 from a mining company.

2.3. DOCUMENTATION

Through the course of the review, the Panel accessed a wide range of documents including:

- the Southern Coalfield Inquiry (SCI) Report;
- the Metropolitan Coal Project Review Report (2009)
- the Proponent's Environmental Assessment (EA) Report;
- the Proponent's Response to Agency Submissions dated April 2010;
- the Proponent's Draft Response to Public Submissions dated February 2010;

- The Proponent's Response to Questions from the PAC Panel (excluding Questions 9-28) dated February 2010;
- The Proponent's Response to the Department of Climate Change and Water Submission. March 2010.
- the Proponent's Response to the Public Hearings dated 25 March 2010;
- the Proponent's Response to Wollondilly Shire Council Submission undated;
- the Proponent's Response to Questions 9 to 28 from PAC Panel dted April 2010;
- additional information provided by the Proponent and their consultants;
- submissions from Government Agencies and the public; and
- additional information from government agencies.

2.4. INSPECTIONS

Several field inspections were conducted by members of the Panel, details of which are provided in Table 2 below.

Table 2: PAC Field Inspections

Date	Air/Ground	Features Inspected
23/12/2009	Air	• BSO Project area
	Ground (with SCA)	• Swamp WOR-S5a, North Cliff; • Cataract Reservoir Tributary 2 & "Green Swamp" (CT1-S5), Area 2.
6/1/2010	Ground (with ICHPL)	• Jutts Crossing • Marhnyes Hole • Georges River – Current mining area • Lower Stokes Creek • Lower O'Hares Creek and Cobbong Creek • O'Hares Creek at confluence of Dahlia Creek • Swamp STC-24
7/1/2010	Ground (with ICHPL)	• Moolgun Creek Bridge • Douglas Park Drive • Allen's Creek • Morton Park Bridge • St James Church, Menangle • Razorback • Douglas Park Twin Bridges • Main Southern Railway • Nepean River • Douglas Park Twin Bridges • Cataract River • Broughton Pass Weir • Picton Road Bridge • Simpson Creek • Upper Canal - Longwall 409 • Undermined section of Mallaty Creek • Gas pipeline mitigation • St Beddes Church, Appin • West Cliff Colliery
8/1/2010	Ground (with ICHPL)	• Wallandoola Creek (Wal1) • Swamp 18
29/01/2010	Ground	• Cordeaux Colliery – borehole core
11/3/2010	Ground (Panel only)	• Allens Creek • Tahmoor Township - Surface subsidence of
12/3/2010	Ground (with ICHPL)	• Undermined sections of Stokes Creek
25/3/2010	Ground (with NGOs)	• Dahlia Creek swamp and downstream section

3.0 CONTEXTUAL MATTERS

3.1. MINING APPROVALS PROCESS

In 2005, major changes to the mining approvals process were introduced via the *State Environmental Planning Policy Major Projects 2005* (now the Major Development SEPP) and Part 3A of the *Environmental Planning and Assessment Act* 1979 (EP&A Act). One effect of these changes was that the statutory exemptions which many existing coal mines (including Metropolitan Colliery) had held from any requirement to obtain development consent were removed. However, transitional provisions in both the Major Projects SEPP and the *Environmental Planning & Assessment Regulation 2000* have the effect that any underground mine has until December 2010 to obtain project approval.

Proponents for new project approvals, including operating coal mines such as the Bulli Seam Operation, must first prepare a brief Preliminary Environmental Assessment. This assessment is then used by the Department of Planning (DoP) to determine the key issues of the project and formulate Director General's Requirements (DGRs) that must be addressed by the Proponent in a detailed EA Report.

The DoP and other key government agencies then assess the Proponent's EA to ensure it has adequately satisfied the DGRs. If considered adequate, the EA is publicly exhibited for a minimum of 30 days during which time public and agency submissions are received by the DoP. These submissions are then forwarded to the Proponent who prepares a 'response to submissions' and, in some cases, a Preferred Project Report (PPR) which may include a revised mine plan.

If a Response to Submissions is produced, it is then assessed by the DoP which recommends approval or refusal to the Minister for Planning. A recommendation of approval includes conditions of approval. These typically require a Proponent to prepare and implement a number of management plans and strategies to the satisfaction of the Director General of the DoP and/or other agencies.

The Minister for Planning may request the Planning Assessment Commission to provide a review of all or any part of a Project at any stage in this process.

After approval by the Minister for Planning, the Proponent must obtain a mining lease from the Minister for Mineral Resources which, under Part 3A, must be substantially consistent with the project approval granted by the Minister for Planning.

Further information regarding the mine approval process is contained in Section 5.1 and Appendix A of the Southern Coalfield Inquiry (SCI) Report (NSW Department of Planning 2008).

3.2. SOUTHERN COALFIELD INQUIRY

The Southern Coalfield Inquiry (SCI) was established in December 2006 by the NSW Government to address concerns held by Government over both past and potential future impacts of mine subsidence on significant natural features in the Southern Coalfield. These concerns first surfaced in the community in 1994 when the bed of the Cataract River suffered cracking and other subsidence impacts.

The ToR for the Bulli Coal Operations Project Panel require the Commission to take into consideration the recommendations of the SCI that were tabled in July 2008. These have been previously been applied to the assessment of Metropolitan Coal Project and the reader is referred to the Panel's report in that matter for a comprehensive list of the issues. Suffice to state that recommendations of particular importance to assessing the BSO Project are:

1. Risk Management Zones (RMZs) should be identified for all significant natural features which are sensitive to subsidence impacts including from both conventional and non-conventional sources. Significant features include *inter alia* rivers, significant streams, significant cliff lines, aboriginal heritage sites and upland swamps.

2. RMZs for watercourses should be applied to all streams of 3rd order or above, in the Strahler stream classification. RMZs should also be developed for major cliff lines and overhangs not directly associated with watercourses.

3. Environmental assessments for project applications lodged under Part 3A should be subject to the following improvements in the way in which they address subsidence effects, impacts and consequences:
   a. a minimum of 2 years of baseline data, collected at an appropriate frequency and scale, should be provided for significant natural features, whether located within an RMZ or not;
   b. identification and assessment of significance for all natural features located within 600 m of the edge of secondary extraction;
   c. better distinction between subsidence effects, subsidence impacts and environmental consequences;
   d. increased transparency, quantification and focus in describing anticipated subsidence impacts and consequences;
   e. increased communication between subsidence engineers and specialists in ecology, hydrology, geomorphology, etc;
   f. key aspects of the subsidence assessment should be subject to independent scientific peer review and/or use of expert opinion in the assessment process; and
   g. increased use of net benefit reviews by both mining Proponents and regulatory agencies in assessing applications.

4. Due to the extent of current knowledge gaps, a precautionary approach should be applied to the approval of mining which might unacceptably impact highly significant natural features (Highly significant natural features are classified as features of 'special significance' in this report).

5. Approved mining within identified RMZs (and particularly in proximity to highly significant natural features) should be subject to increased monitoring and assessment requirements which address subsidence effects, subsidence impacts and environmental consequences.

6. Part 3A of the Environmental Planning & Assessment Act 1979 should be the primary approvals process used to set the envelope of acceptable subsidence impacts for underground coal mining projects. This envelope of acceptability should be expressed in clear conditions of approval which establish measurable performance standards against which environmental outcomes can be quantified.

7. The acceptability of impacts under Part 3A (and, in the interim, the Subsidence Management Process) should be determined within a framework of risk-based decision-making, using a combination of environmental, economic and social values, risk assessment of potential environmental impacts, consultation with relevant stakeholders and consideration of sustainability issues.

8. Mining companies should ensure that they consult with key affected agencies as early as possible in the mine planning process, and consult with the community in accordance with applicable current industry and Government guidelines. For key agencies (eg DECCW and SCA), this engagement should begin prior to the planning focus stage of a project application.

9. Government should provide improved guidance to both the mining industry and the community on significance and value for natural and other environmental features to inform company risk management processes, community expectations and Government approvals. This guidance should reflect the recognition that approved mining would be expected to have environmental impacts.

10. The coal mining industry and Government should undertake additional research into the impacts of subsidence on both valley infill and headwater swamps.

11. The coal mining industry should undertake additional research into means of remediating stream bed cracking.

12. Coal mining companies should develop and implement:
    a. approved contingency plans to manage unpredicted impacts on significant natural features; and
    b. approved adaptive management strategies where geological disturbances or dissimilarities are recognised after approval but prior to extraction.

13. The coal mining industry should escalate research into the prediction of non-conventional subsidence effects in the Southern Coalfield and their impacts and consequences for significant natural features, particularly in respect of valley closure, upsidence and other topographic features.

14. Coal mining companies should provide a minimum of two years of baseline environmental data, collected at appropriate frequency and scale, to support any application under either Part 3A of the Environmental Planning & Assessment Act 1979 or for approval of a Subsidence Management Plan.

3.3. General Parameters for the BSO Project

3.3.1. Project Area

The Bulli Seam Operations (BSO) for which the Environmental Assessment (EA) was prepared is referred to in the EA as *'the Project'* and stated to *'provide for the continuation of existing underground operations at the Appin Mine and West Cliff Colliery'*[2]. These underground coal mines are owned and operated by Illawarra Coal Holdings (ICHPL), a subsidiary of BHP Billiton Pty Limited (BHPB). Appin Mine has two pit tops, namely Appin East (formerly known as Appin Colliery) and Appin West (formally known as Tower Colliery).

The EA states that the main activities associated with the Project would include:

- continued development of underground mining operations within existing coal leases and new mining leases;
- ongoing exploration activities within existing exploration tenements;
- upgrade of the existing West Cliff Washery;
- continued mine gas drainage and capture for beneficial utilization at the West Cliff Ventilation Air Methane Project (WestVAMP);
- continued generation of electricity by the existing Appin-Tower Power Project utilizing coal bed methane drained from the underground mine workings;
- upgrade of existing surface facilities and supporting infrastructure;
- continued and expanded placement of coal wash at the West Cliff Coal Wash Emplacement;
- continued road transport of product coal from the West Cliff Washery via the public road network to BlueScope Steelworks, Port Kemble Coal Terminal and Coalcliff Coke Works;
- ongoing surface monitoring and rehabilitation and remediation of subsidence impacts; and
- other associated minor infrastructure, plant, equipment and activities.[3]

[2] EA, Vol. 1, Executive Summary, p.ES-1.
[3] EA, Vol. 1, Executive Summary, pp.ES-1 to ES-7.

Figure 1 shows the location of these proposed activities on a regional scale.

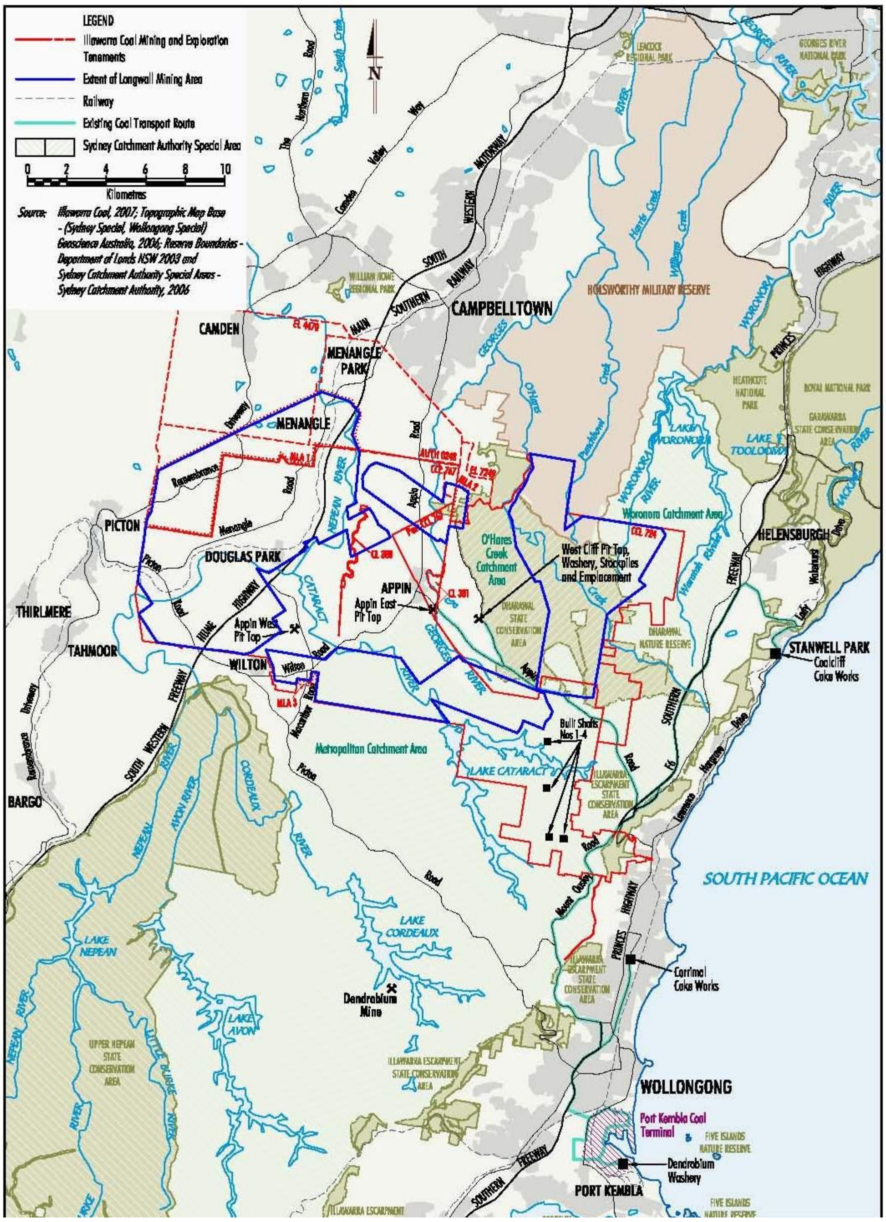

Figure 1: Location of Activities Associated with the BSO Project[4]

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[4] Extract from EA, Vol. 1, Executive Summary.

The underground mining areas for the Project have been divided into seven *mining domains* which define the *Extent of Longwall Mining* as shown in Figure 2. The longwall layout in each mining domain is referred to variously in the EA as the *'EA Base Plan Longwalls',* the *'EA Base Plan Longwall layout'* and the *'Base Case layout'*. The concept of 'Base Case' arises because ICHPL propose that this mine layout may change over the life of the Project. The Panel has adopted the terminology *'Base Case layout'* to mean the longwall panel layout defined in Figure 2**.**

Appendix A (Subsidence Assessment) defines the surface area that is likely to be affected by longwall mining in the proposed mining domains as constituting the *Study Area*. This Study Area comprises the area within the Extent of Longwall Mining for each mining domain and that extending 600 m beyond the Extent of Longwall Mining, Figure 2. The 600 m extend zone around the Extent of Longwall Mining is based on subsidence effects dissipating over this distance. The Study Area as shown in Figure 2 has been adopted in most studies related to the EA. In the case of the Aboriginal Cultural Heritage Assessment, for example, an east-west line has been drawn to connect the northern extremity of the Study Area in Area 5 with that of North Cliff so as to encapsulate the existing and proposed workings, surface facilities and the coal wash emplacement area within the Study Area[5].

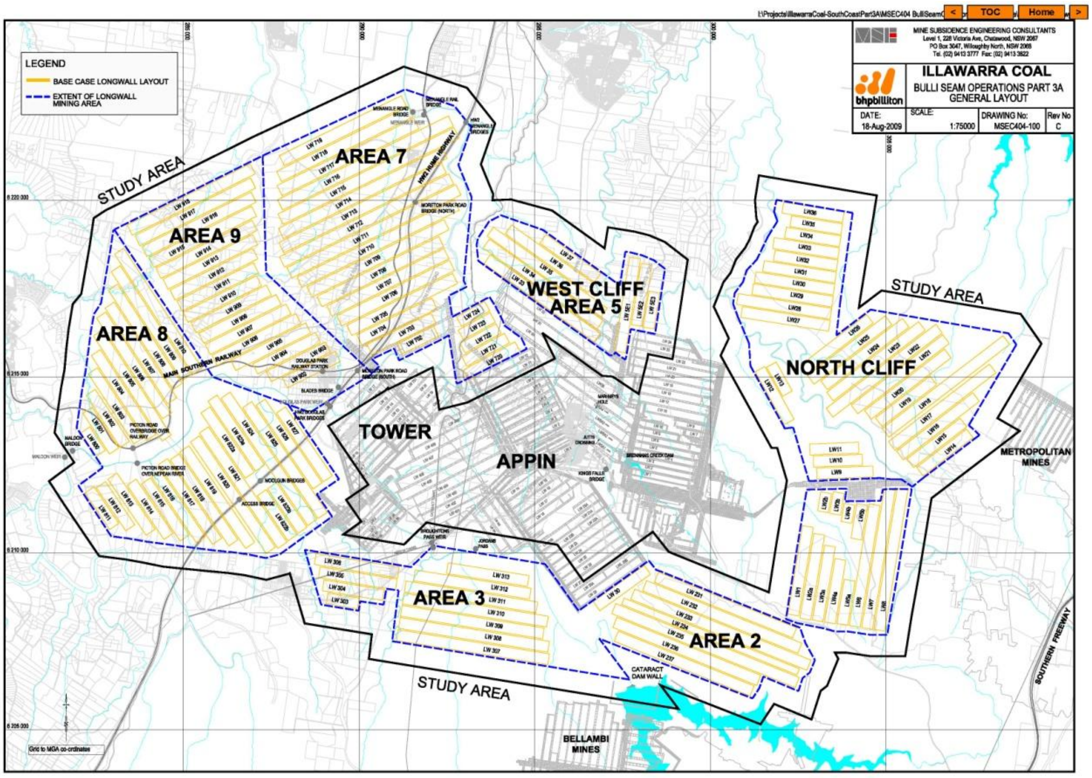


Figure 2: Mining Domains Associated with the BSO Project

[5] Ea, Appendix G, Figure 10.

The Extent of Longwall Mining boundary effectively encapsulates the footprint of the longwall panels in each mining domain. In some cases, it also includes areas reserved for underground access roads to the longwall panels and areas where longwall panels have been offset in order to limit subsidence impacts on overlying natural and man-made surface features[6].

ICHPL states[7] that *'subject to detailed design, underground mine development workings (i.e. non-subsiding) may also occur outside of the extent of longwall mining area*'. This proposition is open-ended. It places no limit on the extent of so-called 'non-subsiding' mine workings that the Panel is being requested to approve. The Panel is unaware of any other EA related to underground coal mining that has not addressed the design and layout of development roadways in order to permit an assessment of the likelihood that they will indeed result in a non-subsiding outcome. The matter assumes added importance in this case because such workings are likely to be located within the buffer zones left to protect significant or sensitive surface features.

In order to progress this assessment, the Panel adopted the following approach:

1. The outline of the Study Area constitutes the limit of main development workings permitted under any approval that may flow from this assessment.

2. Main development roadways are the only form of mining permitted within the 600 m zone between the Extent of Longwall Mining and the boundary of the Study Area.

3. Longwall mining and main development roadways are the only forms of mining permitted within the Extent of Longwall Mining under any approval flowing from this assessment.

4. Provided that the design of main development roadways results in negligible subsidence-related impact on natural and man-made surface features, the layout of all main development roadways within the Study Area can be approved through the Extraction Plan process prior to commencement of such development.

There are numerous references throughout the EA to the *Project area* and a wide range of studies, surveys and management measures which underpin the EA are reported in the context of the Project area. However, the term has not been defined in the EA and has been used in a number of contexts. For example, Appendix O (Upland Swamp Risk Assessment) equates the 'Project area' to the Study Area associated with the proposed seven new mining domains[8] whilst reference to 'Project area' in Volume 1 in respect of air quality encapsulates Appin Mine and West Cliff Colliery surface facilities[9]. Appendix I (Noise Impact Assessment) refers to the '*Project area and surrounds'* supported by a Figure which shows the Extent of

[6] The Base Case layout does not preclude developing access roadways in these offset or 'buffer' zones.
[7] EA, Section 2, p.2-1.
[8] EA, Appendix O, p.OB-16.
[9] EA, Volume 1, ES-17.

Longwall Mining for the proposed mining domains, existing mining facilities and surrounding districts[10].

Given the wide and often generalised usage of the term 'Project area' in the EA, the Panel has chosen to associate the term 'Project area' in the context of a particular study attribute as indicated by the examples given above.

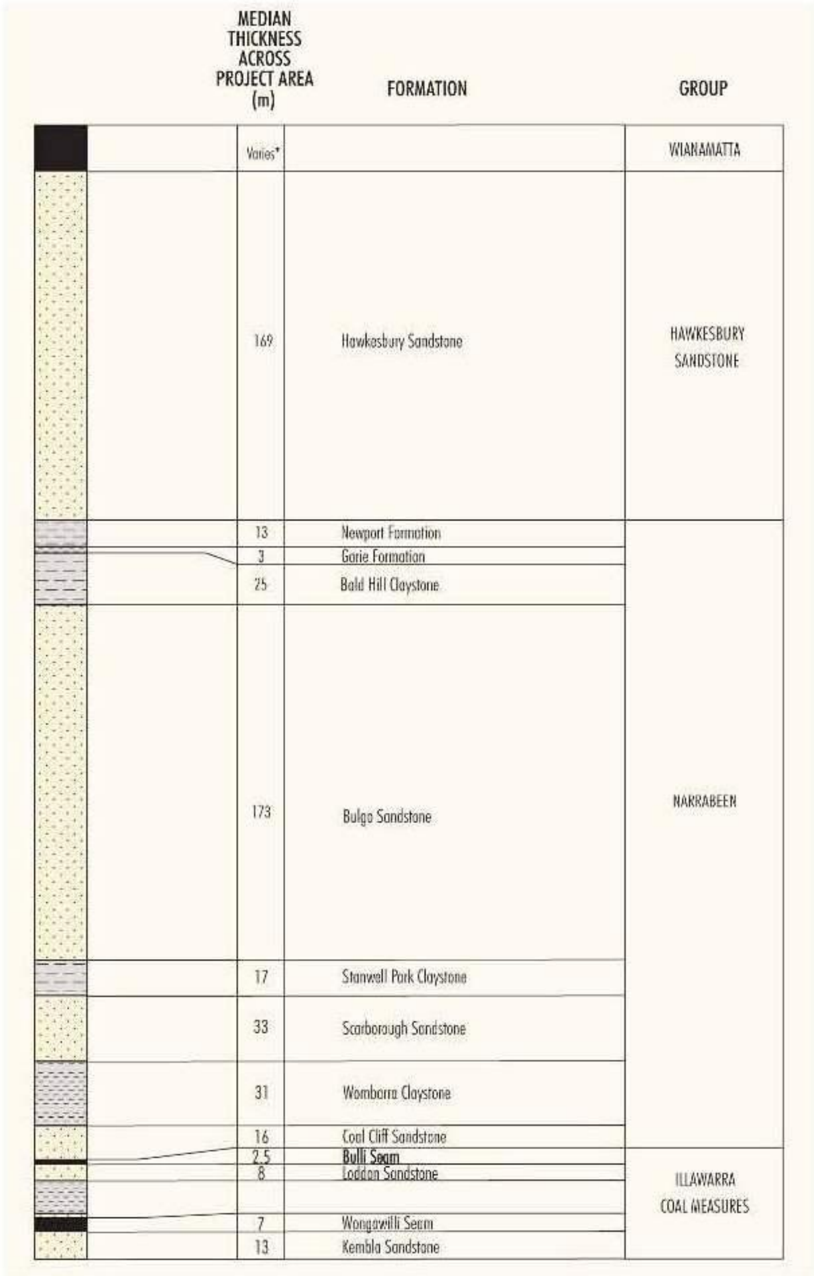
3.3.2. Regional Setting and Mining Parameters

A stratigraphic section which the EA presents as indicative for the BSO Study Area is shown in Figure 3.

The uppermost geological unit identified in the section is the Ashfield Shale of the Wianamatta Group (often referred to as Wianamatta Shale) which comprises chocolate coloured shales and '*is prominent in the West Cliff Area 5, Appin Area 7, Appin Area 8 and Appin Area West [Area 9] domains.*[11]' This unit outcrops over much of the western part of the BSO Project Area while relatively minor occurrences are noted in eastern parts of the area as indicated by the geological map (green shaded areas on Figure 4). This unit weathers to a more subdued topography and more favourable soil type than the steeply dissected terrain associated with the underlying Hawkesbury Sandstone. As a result, much of the shale domain within the Project Area has been exploited for farming and agriculture; swamp lands are rare in this terrain.

The Hawkesbury Sandstone underlies the Ashfield Shale in western areas but outcrops over much of the eastern part of the project area (North Cliff and Appin Areas 2 and 3 Extended). The unit comprises thickly bedded or massive quartzose sandstones varying from fine to coarse grained and exhibiting variable and often favourable permeability and porosity conducive to groundwater storage and transmission. Sandstone terrain is commonly identified with a dissected plateau yielding steep sided gorges, extensive cliff lines and a drainage system that is largely joint controlled. The SCA Special Areas and the Dharawal State Conservation Area constitute a large part of this terrain within the Study Area while eastern parts of the plateau host extensive swamp lands.

[10] EA, Appendix I, Figure I1-2.
[11] EA, Appendix B, p.11.



Source: Heritage Computing, 2009

Figure 3: Indicative Stratigraphic Section for the BSO Study Area[12]

Below these stratigraphic units there is a variable sequence of sandstones and claystones overlying the Bulli Seam. The Bald Hill Claystone resides at the base of the Hawkesbury Sandstone.

The Bulgo Sandstone resides beneath the claystone. This sandstone unit is frequently interbedded with siltstone layers, the interval of interbeds being typically 2 to 5 m. The bedding planes in the sandstone and the interfaces between sandstones and siltstones are horizons of weakness along which bed movements and bed separation

[12] EA, Appendix A, Fig 1.1.

might occur when undermined. The Bulgo Sandstone has been previously targetted for injection of waste water and has more recently been the focus of research to assess bed separation and the potential for coal waste injection[13]. Remaining deeper strata are summarised in Appendix B of the EA.

The depth of cover over the Bulli Seam varies between a minimum of around 300 m in Area 2 to a maximum of around 850 m in Area 9. Average depth across the seven mining domains ranges between 400 m and 600 m, which characterises the BSO Study Area as 'deep' by Australian coal mining standards. Seam thickness varies from a minimum of 1.5 m in Area 2 to a maximum of 3.6 m in Area 9 but typically ranges from 2 to 3 m across the Project Area.

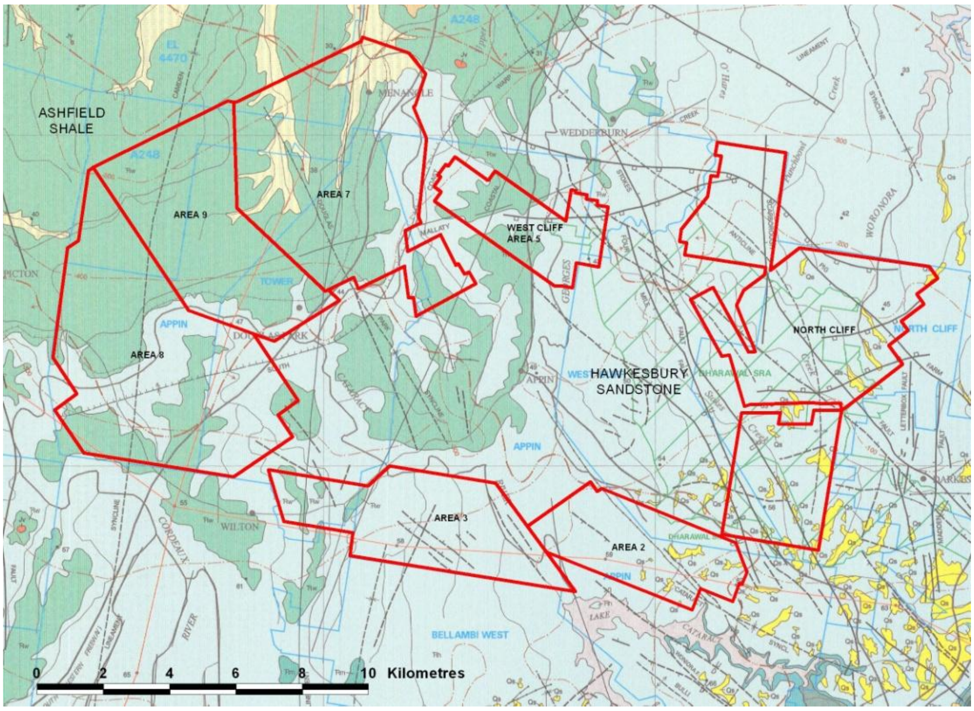


Figure 4: Geological map showing Ashfield Shale and Hawkesbury Sandstone

In the Base Case layout, the voids created by the longwall panels are generally 310 m wide, although some range up to 340 m. The EA presents some limited sensitivity analysis related to increasing void width in increments to 500m (whilst remaining within the outline of the Extent of Longwall Mining).

3.3.3. Subsidence Statutory Processes

Under Section 138 of the Coal Mines Regulation Act 1982, no method of mining other than bord and pillar mining (first workings) was permitted except with the approval of the Minister (responsible for Mineral Resources) given on the recommendation of the Chief Inspector of Mines and subject to such conditions as the

[13] ACARP Report C16023

Minister may impose. When the Coal Mines Regulation Act 1982 and its associated regulations were replaced in December 2006 with the Coal Mine Health and Safety Act 2002 and the Coal Mine Health and Safety Regulation 2006, these requirements were captured in Clause 88 of the Regulation. These acts were originally administered by the Department of Mineral Resources (DMR), which was then incorporated into the Department of Primary Industries (DPI) which, in 2009, was incorporated into the Department of Industry and Innovation (DII).

Risks relating to safety and surface subsidence are important considerations in the mining method approval process. Therefore, the Mines Inspectorate Branch and the Subsidence Engineering Branch, which reside within the Department of the day administering mining legislation (DMR/DPI/DII), have considerable input into the approval process, as may the Mine Subsidence Board (MSB) which is also administered by the same government Department. Since March 2004, approval to use an underground mining method other than bord and pillar mining would not be granted by DPI/DII without the preparation of a *Subsidence Management Plan (SMP)* which, amongst other things, incorporated groundwater and surface water management[14].

Part 3A of the Environmental Planning and Assessment Act 1979 (EP&A Act) was passed in August 2005 specifically to deal with the complexities of major projects, such as coal mines. The legislation exempts approved major projects from requiring a significant number of other statutory approvals. Furthermore, other statutory approvals cannot be refused for an approved project, and those approvals must be 'substantially consistent' with the project approval. Amendments made to the Mining Act 1992 in association with the passage of Part 3A of the EP&A Act now require mining methods and safety measures to be addressed in project approvals and development conditions.

The SCI Report provided a flow sheet of the approvals process envisaged for Southern Coalfield coal mines as at 2010[15]. This showed how the Part 3A assessment process was intended to result in a suite of management plans as part of any conditions of approval. One of these management plans was a SMP and was notable from the other management plans in the process in-so-far as regulatory responsibility for it was assigned to DPI (which administers coal mining legislation) rather than to DoP (which administers Part 3A).

Subsequently, the PAC has assessed the EA for the Metropolitan Coal Project[16]. The DoP has incorporated subsidence related approval conditions for this project into a so-called *Extraction Plan (EP)*, which must be prepared to the satisfaction of the Director-General of DoP. However, the approval conditions require that those components of the Extraction Plan which relate to resource recovery and subsidence must also be prepared to the satisfaction of the DII[17].

There are three areas of particular relevance to DII in respect of subsidence, namely:

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[14] The EA for the BSO Project, this PAC report, submissions and supporting documentation make a number of references to DPI requirements and responsibilities which now reside within DII.
[15] DoP (2008), p.100, Figure 44.
[16] DoP, 2009a.
[17] DoP, 2009b, p.6.

1. Regulation of safety. A range of safety hazards are associated with the undermining of surface features. Examples relevant to the BSO Project include:

    - Train derailment
    - Fractures and humps in road surfaces
    - Rupture of gas pipelines
    - Dam and weir failure
    - Rock falls

    The Minerals and Petroleum Division of the DII is represented in a range of forums concerned with safety risks arising from subsidence. These include the Dam Safety Committee and various Technical Committees concerned with the subsidence effects on critical items of infrastructure (railways, water supply systems, highways, bridges etc).

2. The Mine Subsidence Board (MSB). The MSB is charged with administering the (NSW) Mine Subsidence Compensation Act 1961 (MSCA) and is funded by a levy on coal producers. The Board of the MSB comprises:

    - Director-General of DII or their nominee
    - Chief Inspector of Coal Mines
    - Department of Commerce representative
    - Colliery Proprietors representative
    - Owners of Improvements (i.e. community) representative
    - Local Government or the Department of Planning representative

    Under Section 15(1) of the MSCA, areas can be proclaimed a *Mine Subsidence District.* Once declared, all new structures in the district are required to comply with construction standards stipulated by the MSB. The MSB funds the cost of repairing subsidence induced damage to surface improvements, including the cost of replacing structures if this damage leaves them in an unserviceable state. Surface improvements undertaken in an area prior to it being declared a Mine Subsidence District are covered automatically. Subsequent improvements are covered provided they were constructed in accordance with MSB criteria.

    Under Section 13A of the MSCA, the MSB may also *carry out or cause to be carried out such works as, in its opinion, would reduce total prospective liability of the Fund by preventing or mitigating damage that the Board anticipates would, but for those works, be incurred by reason of subsidence, whether or not the damage anticipated is damage to improvements or household or other effects on the land on which the works are to be carried out.*

3. The DII is still the approving authority for SMPs for those mines which do not have a Part 4 or Part 3A approval (that is, an approval under the EP&A Act) issued since 2005.

Hence, currently there are dual processes operating within government for approving subsidence management systems, these being SMPs approved by DII and Extraction Plans approved by DoP.

Under the DII process for approving SMPs, an SMP is advertised after lodgment by the leaseholder to provide an opportunity for community, stakeholders and government agencies to input. The MSB is one these agencies. Although the MSB functions as an underwriter of costs arising from subsidence related damage, it has no right of veto over the approval of mine plans. This potentially exposes the MSB to situations where it may not have sufficient funds available to cover these costs. This risk exposure carries considerable weight with industry producers who fund the MSB and with the DII who administer the MSB, such that SMPs for situations that expose the MSB to high financial risk may not be approved by the DII. Depending on the circumstances, these types of situations may be resolved by a mine owner underwriting a portion or all of the costs to remediate subsidence induced damage to structures.

The Metropolitan Coal Project was the first project to be granted an approval that incorporated an Extraction Plan. Since that Project had minimal infrastructure of significance associated with it[18], the DoP process for approving Extraction Plans that involve subsidence of significant infrastructure is yet to be tested. Some principal stakeholders have also raised concerns with the Panel that there is a lack of clarity about the Extraction Plan process and its potential effectiveness in this area. The issue needs to be resolved so that all parties are clear on rights and obligations pursuant to any Approval.

Another key issue raised with the Panel was whether the public are to be excluded from the Extraction Plan process. If they are excluded, then the only opportunity to provide comment on the risks associated with the total mining proposal is at the pre-Approval stage. Previously there was opportunity to comment at intervals during the life of the mine as each new SMP was developed. The significance of this issue is that, if the public will only have a pre-Approval opportunity for comment, then the quality of information in the EA will have to be sufficient to allow comment on the fully disclosed risks of the total project. This issue is discussed further in Chapter 16 (Adequacy of Information).

3.3.4. Mine Economic and Social Impacts

The proposed Bulli Seam Operations are projected to produce 260.4 million tonnes of product coal over a 30 year time period. The annual volume of coal production varies around 9 million tones. At an assumed price of AUD180 per tonne for coking coal and AUD97 for thermal coal, this production yields a revenue stream of AUD18.2b in present value terms. This is the amount of earnings generated by the mining operation adjusted through the process of ‘discounting’ to reflect society’s preference

[18] Infrastructure mainly comprised fire trails, fences, gates and the like

for returns now rather than in the future. The rate of this 'time preference' used in the analysis (akin to the interest rate paid on savings) is seven per cent.

The prices of both coking and thermal coal fluctuate through time and are dependent on a wide range of factors not the least of which are the rate of global economic growth, the availability of substitute resources and the availability of supply. Recent declines in economic growth associated with the global financial crisis saw coal prices fall below AUD180 and AUD97 for coking and thermal coal respectively. However, the return of buoyant conditions, especially with growth in the Chinese and Indian economies, has currently pushed spot prices above the assumed levels. In March 2010, the quarterly contract price secured by BHP Billiton was AUD220 with the spot price exceeding AUD250 per tonne.

It is the Panel's view that the cyclical variations in coal prices are likely to average at levels above those assumed over the next 30 years given the prospects for further growth in the BRIC (Brazil, Russia, India and China) nations. Cost-effective substitutes may emerge within that time frame for thermal coal, especially as pressure is exerted internationally for reductions in the greenhouse gas emissions produced by coal burning thermal power plants. Even though technological advances are progressing in renewable power generation it remains unlikely that these will advance to the stage of replacing coal-fired thermal plants over that time period. However, the majority of the Bulli Seam Operations production is metallurgical coal. The potential for the development of cost-effective substitutes for steel are less likely, particularly as there is no immediate pressure in markets to see such substitutes developed. With the known reserves of coking coal being depleted over time and demand growing with increasing economic prosperity, the AUD180 price assumption appears to be conservative.

Given a present value of expected revenues in the order of AUD18.2b and accounting for discounted capital and operating costs, the present value (at seven per cent) of the net production benefits of the mine's operation is estimated in the Environmental Assessment at AUD10.31b.

This net production benefit will be distributed between the shareholders of BHP Billiton and the taxpayers of Australia. Around 60% of the benefit (AUD6.135b) will be enjoyed by the company's shareholders. A little over 25% (AUD2.629b) will be paid to the Federal Government as company tax and 15% (AUD1.546) will be retained by the people of NSW through the company's payments of royalties to the state government.

The project is also estimated to have large scale impacts on the economic conditions both in the region and across the state. For the region, the project will involve nearly 3300 jobs directly and indirectly and the business turnover related to the project will be in the order of AUD2b per annum. Across the state, including the region, project related employment will be around 5800 jobs and the associated business turnover will be more than AUD2.8b per annum. The project itself (without the associated regional and state impacts) will involve the payment of AUD1.194b in wages over the period of operation (discounted at seven per cent). This will trigger the payment of AUD45m in pay roll tax and this represents a transfer of wealth to the state government.

In summary, the project would have a significant impact on the wealth of the people of the region, the state and the nation. This wealth would be experienced in the form of employment opportunities and wages earned, taxation revenue, business profits and shareholder returns.

4.0 SUBSIDENCE IMPACTS AND CONSEQUENCES

The term *subsidence* has two meanings in subsidence engineering. In the most general case as adopted by the Panel, it encapsulates all ground movements that result from mining. Its second meaning, which features in some submissions to the Panel, relates specifically to the vertical component of mining induced surface ground movement. Both sub-surface and surface subsidence in isolation or collectively, have implications for the integrity of natural and man-made features.

The SCI defined the meaning of the terms *effects, impacts*, and environmental *consequences* as they pertain to subsidence of natural features and the Metropolitan Coal Project extended these definitions to incorporate subsidence of man-made features. In the case of the BSO Project, the Panel is working to the definitions adopted for the Metropolitan PAC Report, being:

- The term *effect* describes subsidence itself;
- Any physical change to the fabric of the ground, its surface, or man-made features is described as an *impact;*
- The environmental *consequence* is used to describe any change in the amenity or function of a feature that arises from an impact.

The Panel notes that this terminology has not been applied in a consistent manner throughout the EA for the BSO Project.

The *Subsidence Assessment Report*, Appendix A of the EA, was prepared by Mine Subsidence Engineering Consultants (MSEC). This review of it by the Panel presents some introductory principles of subsidence engineering as a basis for commenting on the reasonableness and accuracy of the predicted subsidence effects, impacts and consequences contained in the EA. More detailed subsidence engineering information is available in the report of the SCI (DoP, 2008) and from MSEC's website[19].

The prediction of subsidence effects constitutes an important foundation for the Panel to be able to assess the reliability and acceptability of impacts and consequences and to recommend performance outcomes. These predictions give direction to the nature and magnitude of potential impacts and consequences, to approval conditions, and to the development of risk management strategies to achieve designated performance outcomes. Since the introduction of the Part 3A process and of SMPs, the primary purpose of monitoring subsidence has shifted from verification of the accuracy of predicted effects to one of providing a check on the adequacy of impact and consequence risk management plans.

On this occasion, there is a vast number and variety of natural and man-made features that have the potential to be impacted by subsidence. Some of these have a low tolerance to subsidence and impacts. Compounding this situation is the fact that the Base Case mining layout is open-ended and premised on longwall panel widths that

19 http://www.minesubsidence.com/

may increase over the life of the project. This gives rise to considerable potential for the magnitude of negative impacts and consequences to similarly increase over the life of the project. Hence, the reasonableness and accuracy of the predictions of subsidence effects for the Base Case layout are especially important.

4.1. SUBSIDENCE FUNDAMENTALS

4.1.1. Sub-Surface Subsidence

Figure 5 shows a conceptual model of subsurface behaviour above a mining excavation. As *excavation width, W,* is increased a point is reached where caving of the immediate roof is initiated. Caving progresses higher into the roof with further increases in excavation width, until it is arrested due to bulking of the caved material upwards from the excavation floor. This typically occurs at a distance of 3 to 10 times the *mining height, h*, into the roof and defines the *caved zone*.

The strata immediately above the caved zone sag onto the caved material and compact it to some extent. Bedding planes are sheared, pre-existing geological joints are opened and fresh vertical and horizontal fractures are induced in the sagging process. This produces a vertical and horizontal fracture network that defines the *fractured zone*. Fracture frequency and connectivity (vertical to horizontal) are high at the base of the zone but diminish with increasing height. As a result, the capacity of the subsided rock strata to transmit and drain groundwater reduces with increasing height.

If the *depth of mining, H,* is sufficiently great or the excavation width, W, is restricted, then a point is reached where the stresses in the sagging upper rock mass are too low to cause joints to open or new fractures to develop on a regular or continuous basis. Sliding on bedding planes can still occur and new horizontal fracture planes and bedding partings may develop but the magnitude of displacements on these surfaces and the connectivity of fractures is insufficient to measurably enhance vertical drainage. This behaviour constitutes the *constrained zone*. In the absence of major geological discontinuities such as faults and dykes, water inflow to mine workings through this constrained zone is determined by the natural permeability of the rock mass within it.

Near surface rocks comprise the *surface zone*. Strata within this zone are usually weaker as they are not confined and may have undergone a degree of weathering. Because they constitute the outer surface of a sagging beam, they are subject to bending and to shear, tensile and compressive forces. This results in a zone of vertical fracturing and horizontal shear that extends a limited depth into the ground. This zone may promote connection to more or less permeable strata. If the deeper strata are more permeable then alternate groundwater flow systems may develop in those strata.

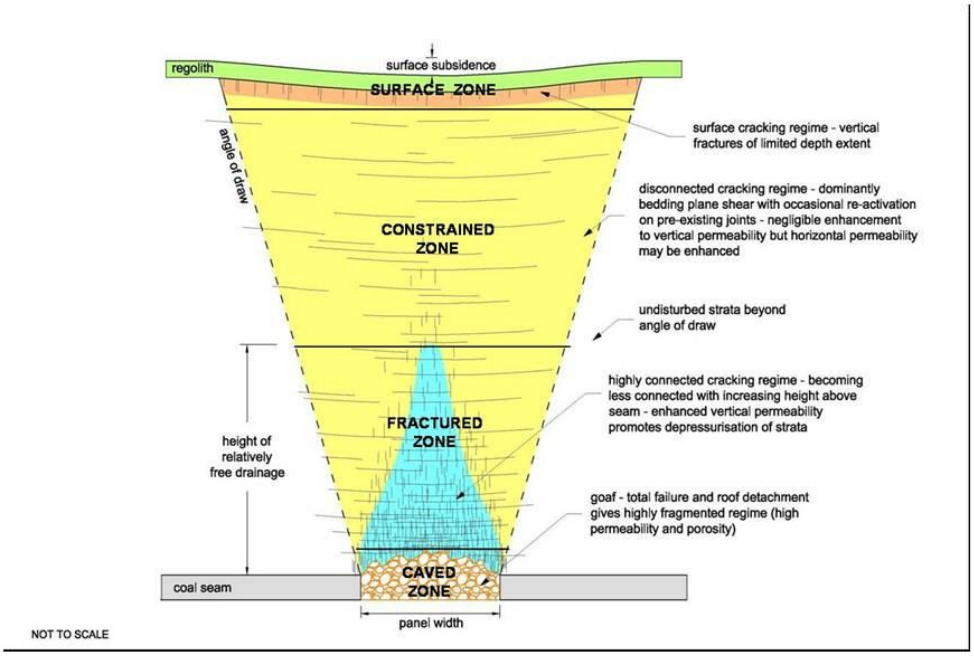

Figure 5: Conceptual Model of Caving and the Nature of Fracturing above a Mine Excavation[20]

The issue of hydraulic connections between surface stored waters and deep mine workings in the Southern Coalfield of NSW was the subject of a major inquiry commissioned by the State Government in the mid 1970s and conducted by Justice Reynolds. The Reynolds' Commission concluded that at depths of cover greater than 120 m, excavation width (panel width) should not exceed one third of the cover depth, provided that the panels were separated by pillars that had a width of one fifth of the cover depth or fifteen times the height of extraction[21]. Effectively, this was to prevent pillar failure and maintain a constrained zone above each mining panel.

A range of field, laboratory and computer simulation studies indicate that these recommendations are overly conservative in many circumstances. In the case of the Southern Coalfield, a number of very low permeability claystone strata (eg. Bald Hill claystone, Figure 3) are now considered to function as aquicludes or hydraulic barriers to surface water flowing into mine workings, thereby adding additional conservatism to Reynolds' recommendations. Based on these developments, mine owners have successfully petitioned the Dam Safety Committee and other government regulators on a number of occasions to approve less conservative mine layouts than those recommended by Justice Reynolds.

4.1.2. Surface Subsidence

The Subsidence Assessment Report (Appendix A of the EA) identifies two components of surface subsidence, namely a *systematic* component and a *non-systematic* component. The SCI recommended that these terms be renamed *conventional* and *non-conventional* respectively, albeit that the term 'non-

[20] Sourced from DoP (2008).
[21] Reynolds (1977).

conventional' is still a misnomer. This review is structured around the terminology recommended by the SCI.

4.1.2.1. Conventional Surface Subsidence

The conventional or general model of subsidence at the surface assumes ideal conditions in that:

- the surface topography is relatively flat;
- the coal seam is level;
- the surrounding rock mass is relatively uniform and free of major geological disturbances or dissimilarities;
- the surrounding rock mass does not contain any extremely strong or extremely weak strata; and
- the mine workings are laid out in a regular pattern.

In flat topography, the surface above coal mine workings usually subsides in the form of a trough, taking on a saucer-shaped appearance. The *angle of draw*, Figure 5 and Figure 6, defines the limits of the subsidence trough. In NSW, the limit is taken to be the 20 mm vertical displacement contour because it is very difficult to distinguish mining induced movements from seasonally induced changes below this value. When the surface subsides, it curves outwards near the perimeter of the trough and inwards towards the centre of the trough, as shown in a grossly exaggerated manner for a single extraction panel in Figure 6. This behaviour is referred to as *curvature*.

Hence:

- Curvature results in points on the surface moving in both a vertical direction and a horizontal direction as they subside. Vertical movement is referred to in subsidence engineering as *vertical displacement*, V_z. In longwall layouts, horizontal movement is broken into two components, being *transverse horizontal displacement*, V_x, across the width of a panel and *longitudinal horizontal displacement*, V_y, along the length of a panel.
- When two adjacent points undergo a different amount of vertical displacement, the *slope* of the ground surface between them changes, which then induces *tilt* in features located on the surface. Slope and tilt are expressed in terms of millimetres change per metre run, or mm/m.
- Curvature in an outwards direction (convex curvature) results in the ground 'stretching' or 'hogging'. The ground is subjected to *tensile strain*, ε_t, which is measured in terms of millimetres of extension per metre length, or mm/m.
- Curvature in an inwards direction (concave curvature) causes the ground to sag and move closer together. The ground is subjected to *compressive strain*, ε_c, also measured in terms of mm/m.

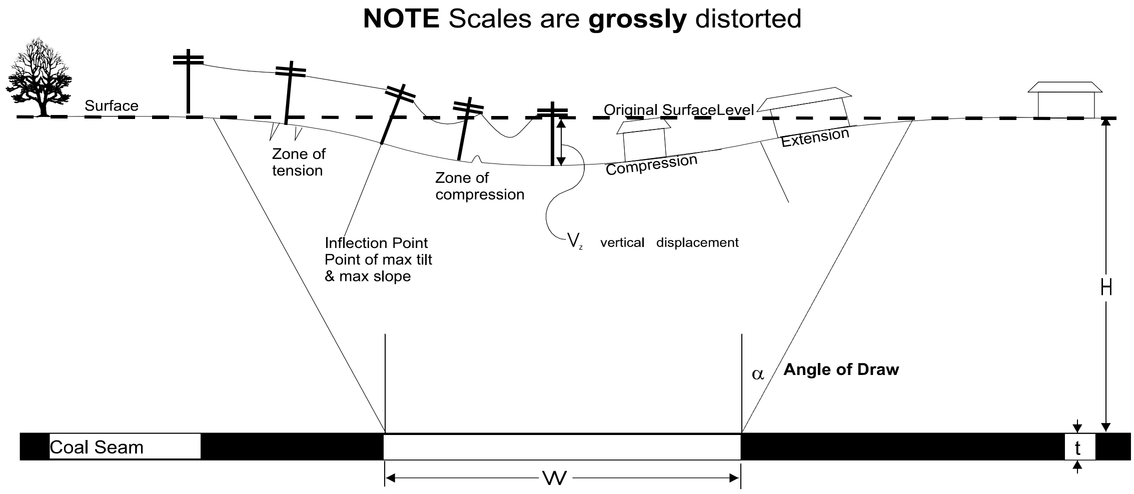

Figure 6: Diagrammatic Representation of Surface Subsidence Components in Flat Topography[22]

The rock mass above a mining excavation can be visualised to behave as a sagging beam. Vertical displacement of this rock mass increases as the excavation width (W) increases and as the thickness of the overburden (H) reduces. That is, vertical displacement is directly proportional to the W/H ratio. In theory, if the W/H ratio is sufficiently large, vertical displacement can equal the mining height (h). In practice, bulking and rotation of the subsiding overburden and the opening of bedding planes result in vertical displacement at the surface being a fraction of the mining height. This fraction is known as the *subsidence factor,* V_z/h. Figure 7 shows W/H ratio plotted against V_z/h ratio for a number of international mining provinces.

In a multiple mining panel layout, such as that associated with longwall mining, a portion of the weight of the strata overlying the panels is transferred onto the pillars between each panel. These pillars are referred to generally as *interpanel pillars*, and in the case of longwall mining, specifically as *chain pillars*. The extra load of the strata overlying the panels causes compression of the interpanel pillars and of the strata immediately above and beneath them, resulting in additional vertical displacement of the surface. Pillar system compression increases as the *pillar height, h,* is increased and as the *pillar width, w,* is reduced. That is, vertical displacement is also inversely proportional to the *pillar width to height ratio, w/h*.

[22] Sourced from Galvin (2004)

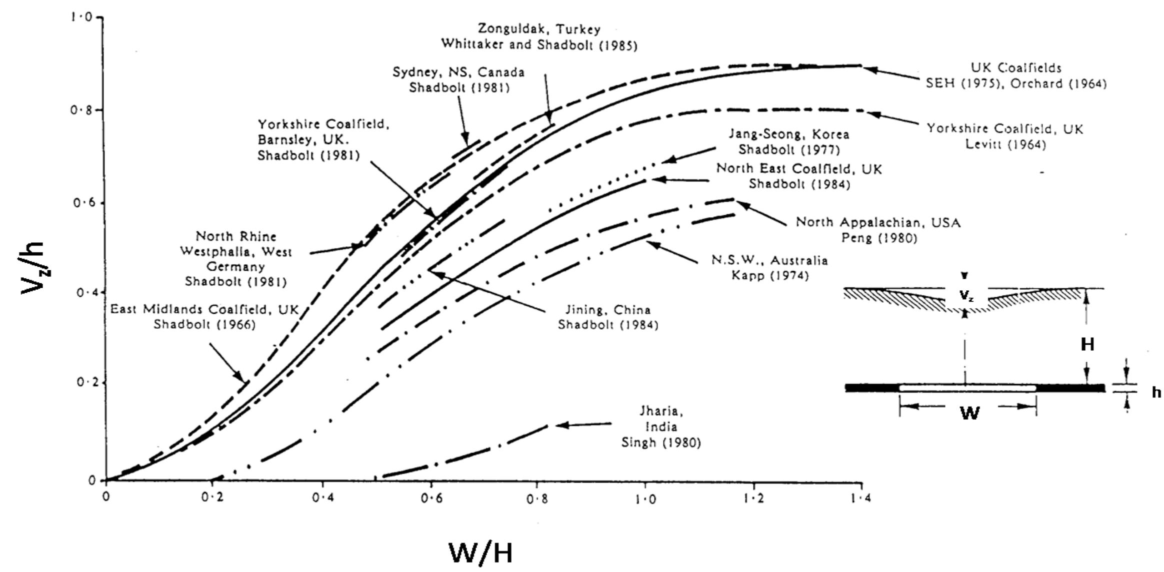

Figure 7: Effect of Panel Width (W) and Depth of Mining (H) on the Magnitude of Surface Subsidence, V_z[23]

At relatively shallow depth, say of the order of 100m, up to 90% or more of the final vertical displacement may occur at a point above a longwall panel within a few months of it being undermined. However, as depth of mining increases, roof sag above an extracted panel and compression of the pillar system can increase each time a subsequent panel is extracted. This gives rise to additional vertical displacement, referred to as *incremental vertical displacement* which in turn, generates *incremental tilt* and *incremental strain*.

Although there are a variety of approaches to predicting surface subsidence effects, basically they are all premised on predicting the profile of vertical displacement, V_z. Because tilt is the rate of change of vertical displacement, a tilt profile can then be produced by mathematically differentiating the vertical displacement profile curve. In turn, because curvature is the rate of change of tilt, a curvature profile can be produced by differentiating the tilt profile. Engineering logic suggests that the strain profile should be determined by the curvature profile. However, no precise relationship between the two has yet been established. It is common practice, therefore, to derive the strain profile by simply multiplying the curvature profile by a fixed ‘calibration’ factor, which can vary from mine site to mine site. All points are multiplied by the same factor irrespective of whether they fall within a tensile, compressive or neutral zone.

This approach to predicting subsidence effects means that any error in predicting the magnitude and distribution of vertical displacement will flow over to the prediction of tilt, curvature and strain. Typically, if local data is already available for calibration purposes, vertical displacement can be predicted to an order of accuracy of ±15%. In turn, tilt magnitudes can be predicted to this order of magnitude, although the distribution of tilt along the surface may be slightly offset to that predicted.

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[23] Adapted from Whittaker and Reddish, 1989

However, there can be a considerable degree of variability in strain behaviour, both in terms of magnitude of strain and distribution of strain. This variability arises from both the manner in which strain is calculated theoretically and from the manner in which the ground surface responds to curvature in practice.

Predictions of tilt, slope, strain and curvature are usually presented in terms that suggest that the associated ground responses are distributed uniformly over the surface. For example, tensile strain may be predicted to be 1 mm/m, which implies 1 mm of ground extension over a distance of 1 m. In practice, however, slope sometimes changes in a step manner and strains can be concentrated at specific locations. The nature of the surface material and the depth of mining have a significant influence on the likelihood and expression of this behaviour. When strain does concentrate at select locations, it usually results in strain relief in the adjacent ground. A number of empirical relationships and statistical approaches exist for estimating worst case, concentrated values of strain.

4.1.2.2. Non-Conventional Surface Subsidence

Non-conventional surface subsidence refers to situations where subsidence behaviour is dominated by site specific conditions. Four such conditions of particular relevance to the BSO Project are steep topography, valleys and gorges, far field horizontal displacements and geological structures.

In steep topography, gravity can result in high levels of ground movement in a downhill direction. Hence, rather than being distributed over the mining area as shown in Figure 6, tensile strain may accumulate towards the top of hill sides, where it can result in one or more wide open surface cracks.

Some coalfields, including the Southern Coalfield of NSW, are characterised by high horizontal stresses. Steep, incised topography which is typical of the Southern Coalfield interrupts the transmission of horizontal stress, causing it to be redirected from the hills and into the floor of valleys and gorges. This can lead to overstressing of valley floors, with the near-surface rock strata bending and buckling upwards. In association with weathering, the valley is deepened which then causes a further increase in the horizontal stress redirected into the floor of the valley. This very slow, self perpetuating natural process is referred to as *valley bulging*. It can result in the formation of voids beneath water courses, often in the form of open bedding planes which may act as underground flow paths for groundwater and stream water. The Panel has observed many instances of this during site visits in the Southern Coalfield.

Mining causes further disruptions on a regional scale to this natural horizontal stress system, contributing to two responses, namely:

- *Valley closure* whereby the two sides of a valley move horizontally towards the valley centreline. Valley closure is not significantly influenced by the orientation of the valley relative to the mining layout or to the goaf and can develop outside of the angle of draw; and

- *Uplift* of the valley floor due to valley bulging and buckling and shearing of the valley floor and near surface strata. The difference between the amount of vertical displacement that could have been anticipated in the absence of a valley and that which eventuates is referred to as *upsidence*. In some instances, upsidence can result in the final absolute level of a valley floor being higher than that prior to mining.

Buckling and shear in the near-surface strata can generate an extensive network of fractures and voids in the valley floor. Ground movements due to conventional subsidence may also contribute to this network if the upsidence occurs within the angle of draw of the mine workings. The formation of an upsidence fracture network has been monitored in detail for a number of years at Waratah Rivulet, above Metropolitan Colliery workings, using an array of surface and subsurface instrumentation. This has revealed that the fracture network becomes deeper with the passage of each longwall in its vicinity. Ultimately, the main fracture network extends to a depth of about 12 m and bed separation extends to a depth of some 20 m, as shown in Figure 8. Studies have also revealed that upsidence extends some tens of metres beneath valley sides and does not necessarily follow the line of a watercourse. Rather, it can cut across valley headlands and bends in a watercourse.

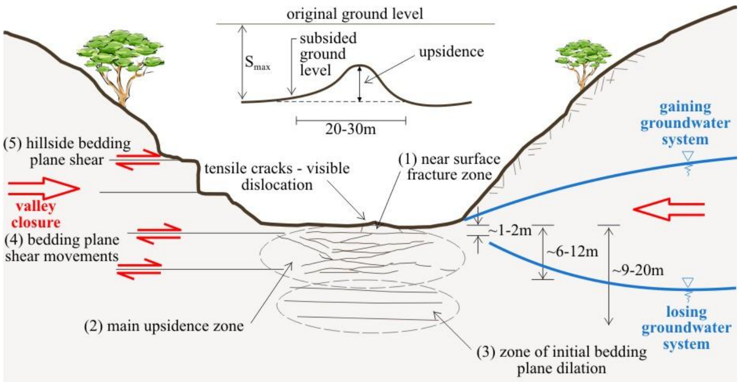

Figure 8: Upsidence Fracture Network Determined from Surface and Subsurface Monitoring at Waratah Rivulet, Metropolitan Colliery (Mills, 2008)

Standard survey techniques can be used to measure closure reasonably accurately. However, upsidence measurements are prone to considerable error because survey stations are susceptible to extreme localised movements caused by buckling of near surface strata.

4.1.3. Relevance to the BSO Study Area

The preceding principles find a range of applications in assessing the EA for the BSO Project since:

- Ideal conditions associated with conventional subsidence do not exist across the BSO Study Area;

- The BSO Study Area underlies numerous watercourses and swamps, raising concerns about direct hydraulic connections to mine workings;

- Excavation width to depth ratio (W/H) and pillar width to pillar height ratio (w/h) may change over the life of the BSO Project. Those adopted in the Base Case layout effectively only constitute points of reference;

- No experience base exists in Australia with longwall panels of the W/H ratio proposed at some depths in the Base Case layout. Therefore, care has to be exercised in extrapolating results from other Australian coalfields and other mines within the Southern Coalfield and making impact comparisons;

- The Base Case layout will result in subsidence effects developing incrementally. Hence, movement at a point on the surface may not stabilise until a number of adjacent longwall panels have been subsequently extracted;

- Some surface features are likely to experience concentrated strains rather than uniformly distributed strains, whilst predicted strains may not eventuate at other surface features;

- Large portions of the BSO Study Area are exposed to non-conventional subsidence effects, especially closure and upsidence.

- The longwall panel widths to be utilised over the life of the BSO Project are open-ended and could increase substantially from that used for the Base Case layout. Given the lack of experience with wide and deep longwall panels in Australia, a high reliance will have to be placed on theoretical subsidence principles in predicting and assessing subsidence effects and impacts in these circumstances.

4.2. OVERVIEW OF BSO METHODOLOGY FOR PREDICTING SUBSIDENCE

4.2.1. Sub-surface Subsidence

4.2.1.1. Mechanisms in BSO Study Area.

Appendix A of the EA[24] states that for the purpose of the BSO Project, the following descriptions as advanced by Singh and Kendorski (1981) and Forster (1995), have been utilised in sub-surface subsidence assessments:

- *Caved or Collapsed Zone* comprises loose blocks of rock detached from the roof and occupying the cavity formed by mining. This zone can contain large voids.

- *Disturbed or Fractured Zone* comprises in-situ material lying immediately above the caved zone which have sagged downwards and consequently suffered bending, fracturing, joint opening and bed separation.

[24] EA, Appendix A, pp.258-259

- *Constrained or Aquiclude Zone* comprises confined rock strata above the disturbed zone which have sagged slightly but, because they are constrained, have absorbed most of the strain energy without sufferi*ng significant fracturing or* alteration to the original physical properties. Some bed separation or slippage can be present as well as discontinuous vertical cracks, usually on the underside of thick strong beds, but not of a degree or nature that would result in significant increases in vertical permeability. Some increases in horizontal permeability can be found. Weak or soft beds in this zone may suffer plastic deformation.

- *Surface Zone* comprises unconfined strata at the ground surface in which mining induced tensile and compressive strains may result in the formation of surface cracking or ground heaving.

These zones generally accord with the zones identified in Figure 5.

Fracturing in the *Surface Zone* has the potential to fracture perched water tables, to increase the permeability of the zone, to connect near surface water to deeper aquifers and to provide an enhanced flow path for near water to report to upsidence fracture networks. These impacts warrant careful consideration in the BSO Project because of the consequences they can have for swamps, Endangered Ecological Communities (EECs)[25], and other natural features which have an association with surface or near surface water.

The risk presented by fracturing in the surface zone is increased if it interacts with the fractured zone associated with subsidence above longwall panels. The EA relies on a model developed by MSEC for predicting the height of the fractured zone in order to assess the potential for such interaction. MSEC states that it *'understands that no simple equation can properly estimate the heights of the collapsed and fractured zones and a more thorough analysis is required'*[26]. MSEC proceeds to present what it describes as a *'simplified analysis'* to show the factors that the *'possible height of the fractured zone'* is dependent upon. This process and the outcomes have generated considerable confusion and uncertainty amongst many stakeholders.

MSEC's predictive model is illustrated in Figure 9 and is defined by the equation:

[25] This should not be interpreted taken as a comprehensive list. The onus for identifying features at risk resides with a Proponent.
[26] EA, Appendix A, p.260.

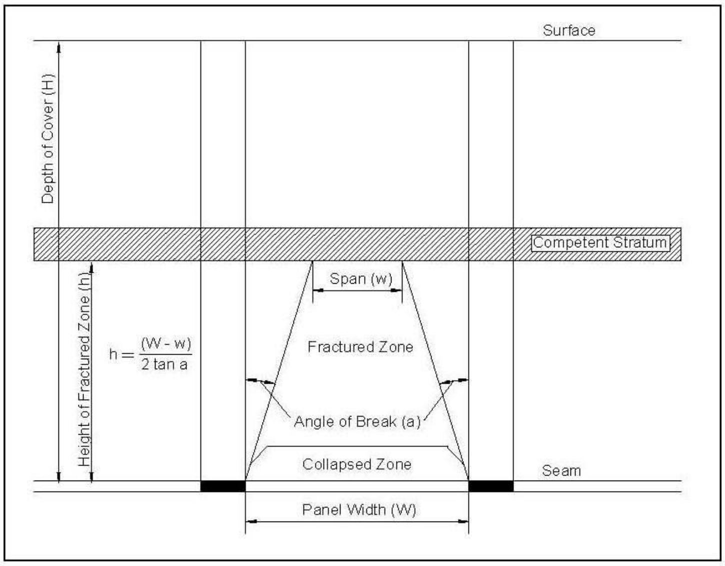

Figure 9: Model Utilised in the EA to Calculate the Height of the Fractured Zone

The Panel notes that this predictive model was neither peer reviewed nor validated prior to being adopted in the EA. Because of the manner in which it relates the height of the fractured zone to longwall panel width, fracturing is predicted to extend at least 385 m above the mining horizon of a 310 m wide longwall panel, being the predominant panel width in the Base Case layout. As such, the fractured zone is predicted to extend through to the surface in portions of Area 2, Area 3 and North Cliff. Given technological advances in the last 20 years, it is plausible that the Base Case longwall panel widths could more than double over the life of the project[27], in which case the MSEC model would predict the fractured zone to extend from seam level to the surface at most points in the entire BSO Study Area.

The EA has utilised MSEC's predicted height of the fractured zone as one risk criterion for assessing subsidence impacts associated with undermining swamps. The parameter is also particularly important to assessing impacts and consequences on other features such as deep groundwater systems. Therefore, the Panel has inquired into the model in some detail through questions of ICHPL[28] and agencies, and through its own studies.

Forster (1995) summarised the outcomes of a literature review undertaken as part of the process to define the extent of the various deformation zones above mine workings. This summary is reproduced in Table 3. It is noteworthy that nearly all the prediction techniques identified by Forster are based on the height of the fractured zone being a multiple of the mining height. Furthermore, none are based on panel width. In contrast, MSEC's model gives no consideration to mining height but is premised on panel width.

[27] A 410 m wide longwall panel has been operating in NSW for a number of years and the EA presents predictions of subsidence effects for panel widths up to 500m (Table 4.3 of Appendix A)
[28] EA, Appendix A, p.2, Table 1.3.

The difference in predictions based on MSEC's methodology and those listed in Table 3 are substantial, approaching an order of magnitude (10 fold) in some instances. For example, adopting the average proposed mining height of 2.5 m in the North Cliff mining domain[29] gives the most extreme height of the fractured zone predicted by the approaches in Table 3 as 160 m with most predictions falling in the range of 40 to 100 m. Forster's model predicts a height of fracturing of 82 m. In contrast, MSEC's model predicts 385 m. Whilst Forster's model was developed for the Newcastle Coalfield, it is inconceivable that differences in geological conditions between the two coalfields could account for such large differences in height of the fractured zone.

[29] EA, Appendix A, Section 1.3

Table 3: Thickness of Strata Deformation Zones above Mine Workings as Reported by Forster (1995)

Author	Country	Thickness of Deformation Zones				Remarks
		Caved Zone	Fractured Zone+	Constrained Zone*	Surface Zone	
Kenny (1969)	UK	2-4 t				Caving observations
Silitsa & Vasilenko (1969)	USSR		16 t	4 t		Measured results using dyes
Kapp & Williams (1972)	Australia		<30 m		15 m	Estimates of zone thicknesses
Ropski & Lama (1973)	Poland	1.5-2 t	3-3.5 t			Borehole observations
Orchard (1974)	UK	6-9 m	18-36 m	30 m	<30 m	Constrained zone should contain 50% shale
Morton (1975 & 1976)	NSW (Wongawilli & Kemira)	<30 m	34 t (94 m)		12m	Based on measurements of permeability and piezometric pressures
Wardell (1975)	NSW (Newcastle)	<5 t	<10 t	50 t - S	S	S = assumed surface zone thickness
(1973 & 1976)	NSW (Sth Coast)		10 t	60 m	12-15 m	Recommendations based on overseas experience
Singh & Kendorski (1981)	UK	3-6 t	30-58 t	9-27 m	<15 m	Constrained zone thickness depend on lithology
Holla & Armstrong (1986)	NSW (H. Valley)	2 t	10-13 t (36-45 m)			Borehole anchors used to determine strains
Singh (1986)	UK	3 t 5 t	100t/(3.1t+5) 100t/(1.2t+2)	8 t 15 t	<15 m 15 m	Weak strata Strong strata
Kesseru (1984 & 1987)	Hungary		20-40 m	15-25 m		Field experience

t = seam thickness *includes caved zone thickness +recommended safe thickness for subaqueous mining

The outcomes from applying MSEC's fractured zone model to a range of longwall panel widths are summarised in Table 4. They highlight the manner in which the height of the fractured zone increases with increasing panel width. A comparison between Table 3 (column 3) and Table 4 (columns 3 and 4) demonstrates the large differences in outcomes predicted by MSEC's model and those predicted by other models.

Table 4: Height of the Fractured Zone Predicted by MSEC's Model for a Range of Longwall Panel Widths

Panel Width, W (m)	**Height of Fractured Zone, h_f (m)**	**Height of Fractured Zone as a Multiple of Mining Height, t**		**Height of Fractured Zone to Panel Width Ratio, h_f/W**
		t = 2.0 m	**t = 2.5 m**	
300	371	186 t	148 t	1.24
400	508	254 t	203 t	1.27
500	646	323 t	258 t	1.29
600	783	391 t	313 t	1.31

MSEC's model is premised on a number of assumptions including:

- The boundary of rock fracturing in the vertical direction is defined by a straight line orientated at some *angle of break, a*, from the vertical.

- The fractured zone will encounter a competent bed towards the top of the zone.

- This competent bed will span a distance of 30 m, arresting the fractured zone as shown in Figure 9.

The Panel considers these assumptions to be unrealistic. In particular:

- Whilst the notion of an 'angle of break' is a convenient way to conceptualise rock behaviour and finds application in geotechnical engineering, in reality such a well defined failure plane is rarely present other than in a caved zone immediately above the mining horizon.

- The height of the fractured zone is variable, depending on panel width. Geology is also variable. Hence, it is a matter of chance if a competent bed is present towards the upper limit of the fractured zone.

- Should such a bed be present, it needs to have characteristics that, perchance, enable it to span a distance of 30 m.

The model is empirical and as for all empirical models, considerable care has to be exercised in extrapolating it to conditions outside those of the database used to derive and calibrate it. The raw database is not presented in the EA but Figure 10[30] shows the plot used to calibrate the model to data reported in literature. On the basis of this plot, Appendix A concludes that *'the height of the fractured zone in the data base is reasonably well presented by the theoretical model (Equation 1) using an angle of break of 20 degrees'*. When this value of 20° is substituted into Equation 1, it reduces to:

[30] Reproduction of Figure 12.8 in Appendix A of the EA.

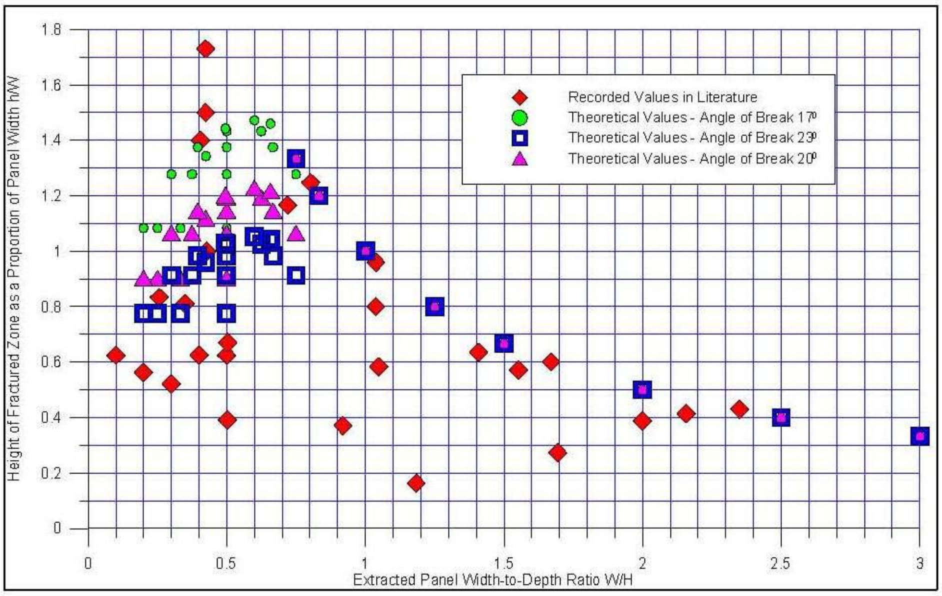

Figure 10: Height of the Fractured Zone as a Proportion of the Panel Width for Different Panel Width to Depth Ratios[31]

The Panel has serious reservations about the process used to calibrate MSEC's model. These relate to:

- The manner in which the data have been plotted in Figure 10. Since the plot is intended to illustrate the correlation between the recorded height of the fractured zone in the field and that predicted by MSEC's model for angle of breaks of 17°, 20° and 23°, four outcomes should be plotted against the width to depth ratio (W/H) corresponding to each field data point. Figure 10 does not depict this.

- The conclusion that the height of the fractured zone in the data base is reasonably well presented by the theoretical model. Based on the trend in Figure 10 of the predicted height of the fractured zone at different panel width to depth ratios, the recorded height of the fractured zone for more than half of the data points is less than 50% of that predicted by the model.

- The discounting of the data points represented in Figure 10 by the three red diamonds that have a panel width to depth ratio of around 0.4 and a recorded fractured zone height of that falls well above that predicted by MSEC's model. These data points relate to Longwall 2 at Ellalong Colliery and Longwall 3 at Tahmoor Colliery. Ellalong Colliery operated the deepest longwall panels to date in Australia, whilst Tahmoor Colliery extracts the Bulli Seam to the south west of the BSO Study Area. It is plausible, therefore, that these three points may have been more representative of the BSO situation than the points in the data set.

[31] Reproduction of Figure 12.8 in Appendix A of EA.

- In providing reasons for discounting the Ellalong Colliery and Tahmoor Colliery data points, no consideration appears to have been given to the fact that the MSEC model cannot mathematically accommodate situations where the height of fractured zone exceeds 1.37 times the panel width[32].

Other aspects of the EA that are confusing in respect of height of the fractured zone include the statement that *'Where the panel width-to-depth ratio is low, and where the depth of cover is high, it is clear that the height of the fractured zone would represent a high proportion of the depth of cover'*[33]. The Panel can make no sense of this statement. In a report referred to by its author as a *'brief peer review of the model'*[34] that accompanies ICHPL's response to the Panel's questions, Professor Hebblewhite has also noted that *'the logic for this statement is not clear'*[35].

Hebblewhite also concluded that:

> *'It is therefore considered that the description of the Fractured Zone adopted by MSEC is again appropriate and consistent with this expanded discussion of geotechnical behaviour'*[36].

ICHPL's responses to the Panel include the following statements:

- *....it should be noted that the theoretical height of the fractured zone referred to in the MSEC model is not considered to be the height of potential vertical connective cracking.*[37]
- *Foster (1995) indicates that the fractured zone in the study area lies between 21 and 33 times the seam thickness, but this is based upon loss of water as indicated by piezometer readings, or more relevantly, height of connective cracking.*

  Forster (1995) notes in the conclusions to the paper that:

  > *"Fracturing of the strata was also evident in the constrained zone, (above the fractured zone) but was not of a degree or nature which would result in significant drainage."*

The Panel cannot reconcile these responses. It is quite clear from the Forster quote that the Forster definition of the height of the fractured zone, adopted by MSEC and confirmed by Hebblewhite, is based on the height of connective cracking.

ICHPL's response also quoted from Gale (2008):

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[32] From Equation 2, $H_f/W = 1.37 - 30/W$. Therefore, as panel width, W, approaches infinity, H_f/W approaches 1.37. The trend towards this upper limit is apparent in the analysis outcomes presented in Table 4.
[33] EA, Appendix A, p.259.
[34] ICHPL (2010e), Attachment 1, p.2.
[35] ICHPL (2010e), Attachment 1, p.8.
[36] ICHPL (2010e), Attachment 1, p.7.
[37] ICHPL (2010e), Responses to PAC Questions 9 and 12.

'The height that mining related fractures may form has been established from monitoring and computational studies as being 1 – 1.5 times the panel width. However, the creation of these fractures alone does not necessarily imply that a direct hydraulic connection exists over this zone'.

That fracturing can occur above the fractured zone is not in dispute. The issue is the height of the connected fractured zone as opposed to the height of fracturing. It remains unresolved. Irrespective of this, MSEC's model is deficient in that it neither provides for height of fracturing to be influenced by mining height nor for height of fracturing to reach a plateau value as panel width increases. Both behaviour modes are intuitive, are evidenced in the field and were commented upon in Hebblewhite's review, viz[38]:

..there must come a point (just as in surface subsidence prediction) where once a critical width is achieved, greater widths will not change the height of the fracture zone, and in fact the mined thickness will define a limiting height (associated with bulking and void spaces) in the intervening rock material – hence the fracture height must be some function of both mined thickness and panel width.

The responses by ICHPL[39] to the Panel's questions in regards to this matter were technically detailed, comprehensive and helpful[40]. On the basis of these and other inquires, the Panel has concluded for the purpose of progressing its assessment that:

- When the MSEC model is applied to conditions similar to the calibration data, it could produce reasonable predictions of the height of fracturing even though it has mechanistic shortcomings for that purpose, with the maximum height being 1.37 times panel width;

- Based on other studies including Gale (2008), a potentially worst case outcome appears to be fracturing extending up to a height of 1.5 times panel width but with increasing disconnection of fracturing;
- It is unlikely that the highly connected and freely drainable fractured zone will extend upwards into and beyond the Bald Hill Claystone for longwall panel widths up to 310 m. This is suggested by a range of field measurements and observations, the most recent being extensometer measurements conducted over LW32 (310 m width) at West Cliff Area 5[41] where more than 90% of fracture displacements seem to have occurred at or below the claystone;
- The potential height of connected fracturing[42] for wider longwall panels has not been addressed in the EA (except by general inference to pore pressure distributions) and is unknown;

[38] ICHPL (2010e), Attachment 1, p.8.
[39] ICHPL (2010b); ICHPL (2010e).
[40] Lengthy delays in responses to the Panel's questions in relation to the height of fracturing, resulted in the Panel undertaking its assessments based on information supplied in the EA. Subsequent information supplied by ICHPL, has been assessed, and the Panel has framed its recommended Performance Criteria accordingly.
[41] ACARP Project C16023, 2010.
[42] As opposed to the height of *all* fracturing.

- Both the extent of the impacted area and the level of impact will increase as longwall panel width is increased.

4.2.1.2. Application to BSO Study Area

The EA predicts that fracturing above longwall panels will extend to the surface over extensive portions of Area 2, Area 3 and North Cliff mining domains for the Base Case layout and over more extensive areas as longwall panel width is increased. This interaction with the surface zone presents an elevated risk of mining impacting on the hydrology of the surface zone. This is an important consideration in the BSO Study Area, particularly in respect to swamps[43], Endangered Ecological Communities (EECs)[44], and other natural features which have an association with surface or near surface water systems.

The currently available database and predictive capability provided in the BSO Project Proposal is inadequate for predicting and managing the impacts that mining may have on surface hydrology. Hence, for any proposed Extraction Plan where water-dependent systems are a relevant consideration, the Panel recommends that the studies outlined below are completed prior to consideration of the proposed Plan. The purpose of these studies is to improve the predictability of impacts so that the approving authority can be confident that any impacts resulting from the proposed Extraction Plan will remain within the Performance Criteria established in the Approval. For example, if 'negligible impact' on hydrology is designated at the site of a natural feature or for a catchment then the studies will assist in confirming whether the proposed extraction will or will not achieve a 'negligible impact' standard. The recommended studies are:

- Exploration drilling and core testing to establish the mechanical and hydraulic properties of rock strata in proximity to water dependent systems including swamp systems and water supply catchments;[45]
- Sediment profiling in swamp systems to characterise type, thickness and sensitivity to differential subsidence;
- Installation of a regional network of shallow piezometers targeting water dependent systems (especially swamp systems) and underlying rock strata (to at least 30m depth) to inform an understanding of the hydrology, the potential for hydraulic connections between the surface zone, and climatic implications[46];
- Establishment of a network of deep pore pressure monitoring bores to assess/quantify the impacts of fracturing within the subsidence zone. The Panel considers it is especially important to target areas where extracted panel

[43] Swamps are considered to be particularly vulnerable in view of their limited sediment thickness, typically in the range 0.5 to 2 m (available reports and Dr. A. Young)

[44] This should not be interpreted taken as a comprehensive list. The onus for identifying features at risk resides with a Proponent.

[45] Detailed inspections to ascertain lithofacies parameters will promote a more complete understanding of potential failure modes and horizons in the sub strata

[46] The purpose of these piezometers is to provide a more complete understanding of hydrological processes.

widths are similar to the proposed Base Case widths (310m) in order to validate the prediction process[47];

- Utilisation of numerical modelling to enhance the prediction of subsidence zone fracture distributions, connectivity and potential fracture conduit (groundwater) transmission capacities.

4.2.2. Surface Subsidence

4.2.2.1. Conventional Subsidence

The prediction of conventional subsidence effects by MSEC has been based on the so-called *Incremental Profile Method (IPM)*. The engineering principles that underpin this methodology have been known for decades. Basically, they are:

- Vertical displacement effects are additive.

- A mathematical equation can be used to describe the characteristic shape, or profile, of the vertical displacement associated with surface subsidence.

The IPM technique utilises large databases of subsidence information relating to the Southern Coalfield and the Newcastle Coalfield of NSW to define a suite of characteristic shapes (or profile functions) for each increment of vertical displacement resulting from the successive extraction of mining panels[48]. The summation of these increments produces the final vertical displacement profile. Tilt and curvature profiles are derived by mathematically differentiating the vertical displacement profile. Strain predictions for the BSO Study Area have been based on multiplying curvature profiles by a factor of 15.

The IPM is an empirical technique and therefore its accuracy is dependent on it being calibrated to a database that is representative of site specific conditions. It has significant advantages over many other empirically based techniques because it provides for evaluating how changes in any of the following parameters affect each increment of vertical displacement and, hence, the shape of the final vertical displacement profile from which all the other subsidence parameters are derived:

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[47] Suggested monitoring locations include Longwall 34 in Area 5 and Longwall 703 in Area 7, with transducers targeting the Coal Cliff Sandstone, Wombarra Claystone, Scarborough Sandstone, Bulgo Sandstone, Bald Hill Claystone and the Hawkesbury Sandstone.

[48] A detailed description of the IPM method is available at http://www.minesubsidence.com

- Mining height;
- Mining depth, which can vary due to changes in seam gradient or topography;
- Excavation width and length; and
- Interpanel pillar (chain pillar) width.

This results in final vertical displacement profiles that are quite sensitive to local changes in the mining environment. Furthermore, it allows predictions to be made at any point on the surface. These attributes are important in the case of the BSO Project because the depth of mining varies considerably due to seam dip and to changes in topography, mining height is variable, longwall panel width and interpanel pillar width are variable, and surface features of interest are scattered throughout most of the mining area. Hence, the prediction technique itself is considered appropriate.

As with all subsidence prediction techniques, the poorest correlations between measured and predicted ground movement relate to strain. Here the problem is twofold. Firstly, there are shortcomings in the manner in which strains are calculated theoretically. Secondly, due to factors such as localised variations in ground properties and natural defects in this material, ground movements at the surface often do not develop in the uniform manner that subsidence engineering theory predicts. The BSO EA provides a more in-depth discussion of some of the reasons for this behaviour.[49]

Appendix A of the EA presents four approaches to strain prediction. The first is based on plotting the relationship between measured curvature and measured strain recorded over previously extracted longwalls in the Southern Coalfield, Figure 11. The Figure shows the running average and a line of best fit through the running average as well as a line based on strain being equal to 15 times curvature.

Throughout the EA, it is erroneously stated that applying a factor of 15 to the maximum curvature provides a reasonable estimate for the *average predicted strain*[50]. As reference to Figure 11 shows, in fact it provides a estimate of the *maximum* strain for hogging and sagging curvatures greater than 0.05 km^{-1}, which is consistent with the manner in which this relationship has been used for many years in NSW. Figure 11 also shows that this approach produces a reasonable upper bound prediction for compressive strains but underestimates upper bound tensile strains by 15 to 20%. DECCW raised this issue in one of its submissions to the Panel, stating that the relationship was *'clearly non-liner [sic] and does not adequately capture the variation in data'*[51]. ICHPL responded that *'This figure [Figure* 11*] shows that this linear relationship provides a reasonable estimate of strain, and is particularly*

[49] EA, Appendix A, Section 4.5.
[50] The Panel considers that *average strain* is not a meaningful concept is and liable to inadvertently mislead. The Panel has not addressed this matter further as it is not utilised for decision making in the EA, albeit that many tabulations are labelled (erroneously) as being 'average' values of strain.
[51] DECCW (2009b).

conservative at higher levels of hogging and sagging curvature'[52]. The Panel concurs with DECCW.

In the interval -0.05 km^{-1} to 0.05 km^{-1}, there is both a wide scatter in strain values and a lack of correlation between curvature type and strain type (hogging/tensile, sagging/compressive). This reflects to a considerable degree the inaccuracies involved in calculating low levels of curvature from measured vertical displacements and in measuring small strains.[53]

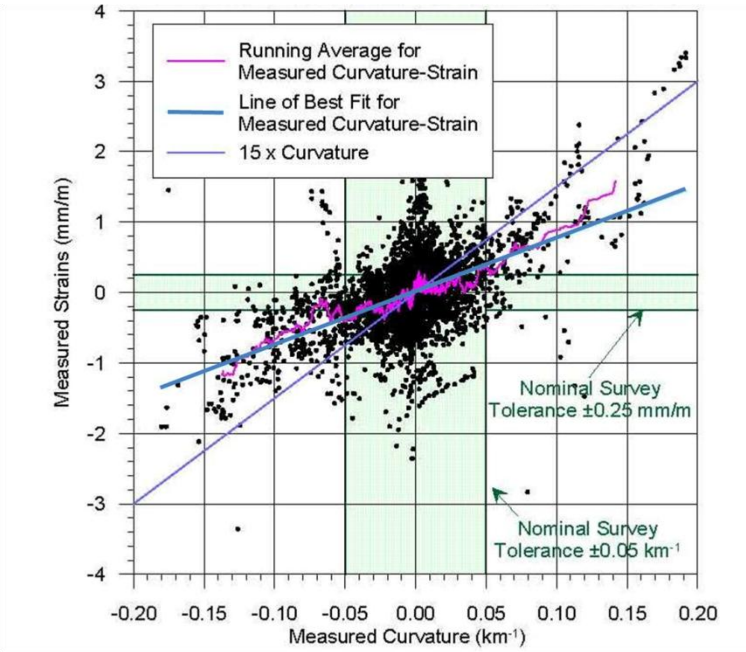

Figure 11: Relationship between Measured Curvature and Measured Strain Recorded during the Extraction of Longwalls in the Southern Coalfield[54]

The second approach to strain prediction by MSEC is intended to provide a statistical approach to account for the considerable scatter of strain values shown in Figure 11. It is premised on frequency plots of the maximum tensile and the maximum compressive strain measured at over one thousand survey stations along monitoring lines at any time during longwall mining operations[55]. These plots have been assigned a statistical relationship from which probabilities for exceeding specific strain values have been computed.

From a statistical perspective, this approach has merit provided that it is based on an unbiased data set. Very limited information is provided in the EA as to the basis for selecting data points; however, it appears highly likely to the Panel that this basis data was not sufficiently discerning for the purpose. Data values are a function of both their spatial position relative to the longwall footprint and to the position of the longwall working face at any point in time. Consequently, there is a high potential for

[52] ICHPL (2010c), p.5.
[53] See Section 4.5.1 of Appendix A for further information.
[54] Reproduction of Figure 3.4 of Appendix A of EA.
[55] EA, Appendix A, Section 3.9.1 and 3.9.2.

outcomes to be influenced by factors such as the location of survey lines and the frequency that these lines are surveyed.

The third approach is specific to predicting the maximum value of strain that very long structures (linear features), such as roads and railways, may experience[56]. Instead of plotting maximum strain values within each survey bay along a survey line, only the maximum values of tensile and compressive strain along each entire survey line have been included in the data set for statistical analysis. This data has been plotted in the form of frequency diagrams and conclusions drawn as to how often a specific maximum strain has been recorded. Whilst the need still remains to carefully scrutinise the input data base, the process is more likely to produce a reasonable estimate of maximum (worse case) tensile and compressive strain.

The fourth approach is premised on deriving curvature from measured profiles of vertical displacement[57]. Because curvature is the second differential of vertical displacement (that is, it is the rate of change of tilt which, in turn, is the rate of change of vertical displacement), minor localised 'steps' in the profile of vertical displacement can result in spurious spikes in predicted curvature profiles. Therefore MSEC has applied an algorithm to produce smooth vertical displacement profiles from which to derive curvature profiles. Predicted and measured curvature profiles have then been compared to gauge the accuracy of the IPM technique. The Panel considers this approach to be sensible and to have produced outcomes of reasonable accuracy for the purpose to which they are put.[58]

The four approaches to strain prediction presented in Appendix A are concerned with improving the accuracy of strain prediction and quantifying confidence levels in these predictions. In the end, MSEC has moved away from predicting strain in terms of millimetres per metre of tension or compression and instead, expressed most predictions in the EA (not just confined to Appendix A) in terms of curvature. Whilst from a theoretical perspective, strain derives from curvature, this approach limited the Panel's capacity to conceptualise and assess the significance of the subsidence movements and to draw comparisons with information in the public domain. With the exception of houses for which the EA provides recent research findings that correlate curvature with structural impact, the Panel had no point of reference for assessing impacts associated with curvature.

Accordingly, the Panel requested ICHPL to retabulate all curvature predictions in terms of strain. As the EA also does not provide points of reference for the significance of strain predictions on ground behaviour, the Panel reverted to those provided in Appendix A of the Metropolitan Coal Project, being:

> *'Fracturing of sandstone has generally been observed in the Southern Coalfield where the systematic tensile and compressive strains have exceeded 0.5 mm/m and 2 mm/m, respectively'*[59].

[56] EA, Appendix A, Section 3.9.3.
[57] EA, Appendix A, Section 4.5.1, p.27.
[58] Comparisons between strain predicted on the basis of curvature and strain measured in the field are constrained in the Southern Coalfield because the predicted strain is based only on conventional subsidence whilst the measured strain may include a component due to non-conventional subsidence.
[59] EA for Metropolitan Coal Project, Appendix A, p.88.

The EA reports that *the standard Southern Coalfield profiles from the empirical database, based on monitoring data predominantly from the Bulli Seam, were used to predict the systematic subsidence, tilt and curvature profiles for the longwalls*[60]. The Panel is of the understanding that the bulk of the Southern Coalfield data is related to Appin, Tower and West Cliff Collieries. In applying the standard Southern Coalfield incremental profiles, the EA acknowledges that this approach has previously resulted in vertical displacement being under-predicted at Tahmoor Colliery, which is to the south-west of the Area 8 mining domain, and at Metropolitan Colliery, which is immediately to the east of the North Cliff mining domain, Figure 2.

In the case of Tahmoor Colliery, Appendix A reports that there has been one exceptional (*rare*) case where measured vertical displacement was more than twice that predicted by the IPM technique. The Panel is aware from its assessment of the Metropolitan Coal Project that the IPM technique under-predicted vertical displacement over Longwalls 1 to 14 at Metropolitan Colliery by up to 50%. In both cases, MSEC attributed the causes to changes in geology. Reference to Figure 2 shows that the BSO Project is some 30 km wide, of which Appin, Tower and West Cliff Collieries occupy the middle third. Therefore, the Panel considers it quite plausible that geology could change over this distance.

This raises the question of how much confidence should be placed in subsidence predictions in the BSO Study Area as mining operations move away from the central section for which the subsidence prediction model was developed. In the absence of an assessment of changes in geology, it appears to the Panel that it would be wise to undertake sensitivity analysis based on the outcomes at Metropolitan Colliery in the east and Tahmoor Colliery in the west[61]. Appendix A does not directly address this matter, simply advising that:

> *It is expected, therefore, that the standard Incremental Profile Method should generally provide reasonable, if not slightly conservative predictions for systematic subsidence, tilt, and curvature resulting from the extraction of the longwalls. Allowance should, however, be made for the possibility of observed movements exceeding those predicted as the result of anomalous or non-systematic movements, or for greater subsidence, to occur in some places, such as observed at Metropolitan and Tahmoor Colliery.*

The Panel has been conscious of this advice in assessing critical features, particularly in the North Cliff domain immediately adjacent to Metropolitan Colliery.

Figure 12 shows the correlation between predicted and measured vertical displacement, tilt and curvature for one of the subsidence monitoring lines utilised in the EA to illustrate the order of accuracy of the IPM technique. The impact of upsidence on these predictions is clearly evident. Another factor that accounts for 'spikes' in the measured tilt and curvature profiles is that subsidence movements are not necessarily uniformly distributed in accordance with theoretical predictions.

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[60] EA, Appendix A, p.13.

[61] The Panel acknowledges that, at this point in time, the Tahmoor Colliery behaviour appears to have been associated with very localised conditions and that the 'standard' Southern Coalfield profiles may still be generally applicable in this mining region.

Appendix A reports that in sandstone dominated environments, much of the earlier ground movements can be concentrated at the existing natural joints, which have been found to be at an average spacing of 7 to 15 metres. This is conducive to tensile strains of, say, 2 mm/m being expressed in the field as 14 mm wide fractures every 7 m, or 30 mm wide fractures every 15 m. Due to the influence of gravity, ground movements are also less likely to be distributed uniformly in steep topography. These and other limitations noted in Appendix A of the EA are associated with all subsidence prediction methodologies.

It is sometimes the case that the magnitude of predicted vertical displacement may be well replicated in the field but the profile of this vertical displacement may be offset laterally to that predicted. This can have significant implications for tilt and strain at specific sites on the surface. Hence, MSEC has based its assessment of subsidence movements at surface features on the highest predicted values of vertical displacement, subsidence, tilt, curvature and strain within a radius of 20 metres of each feature, rather than on the values predicted at the point. The Panel considers this an appropriate approach.

The Panel concludes that:

- The IPM technique utilised by MSEC to predict the conventional component of subsidence is appropriate and has produced predictions for existing mine workings associated with the BSO Project that are at least as reliable as those associated with alternative techniques.

- As with all subsidence prediction techniques, the poorest correlations between measured and predicted ground movement relate to strain.

- The maximum conventional tensile strains predicted for the BSO Study Area could be underestimated by 15 to 20%.

- As the BSO Study Area is very large and site conditions (such as geology) could vary across the Study Area, the IPM technique may need to be recalibrated periodically as a precursor to preparing Extraction Plans over the course of the project.

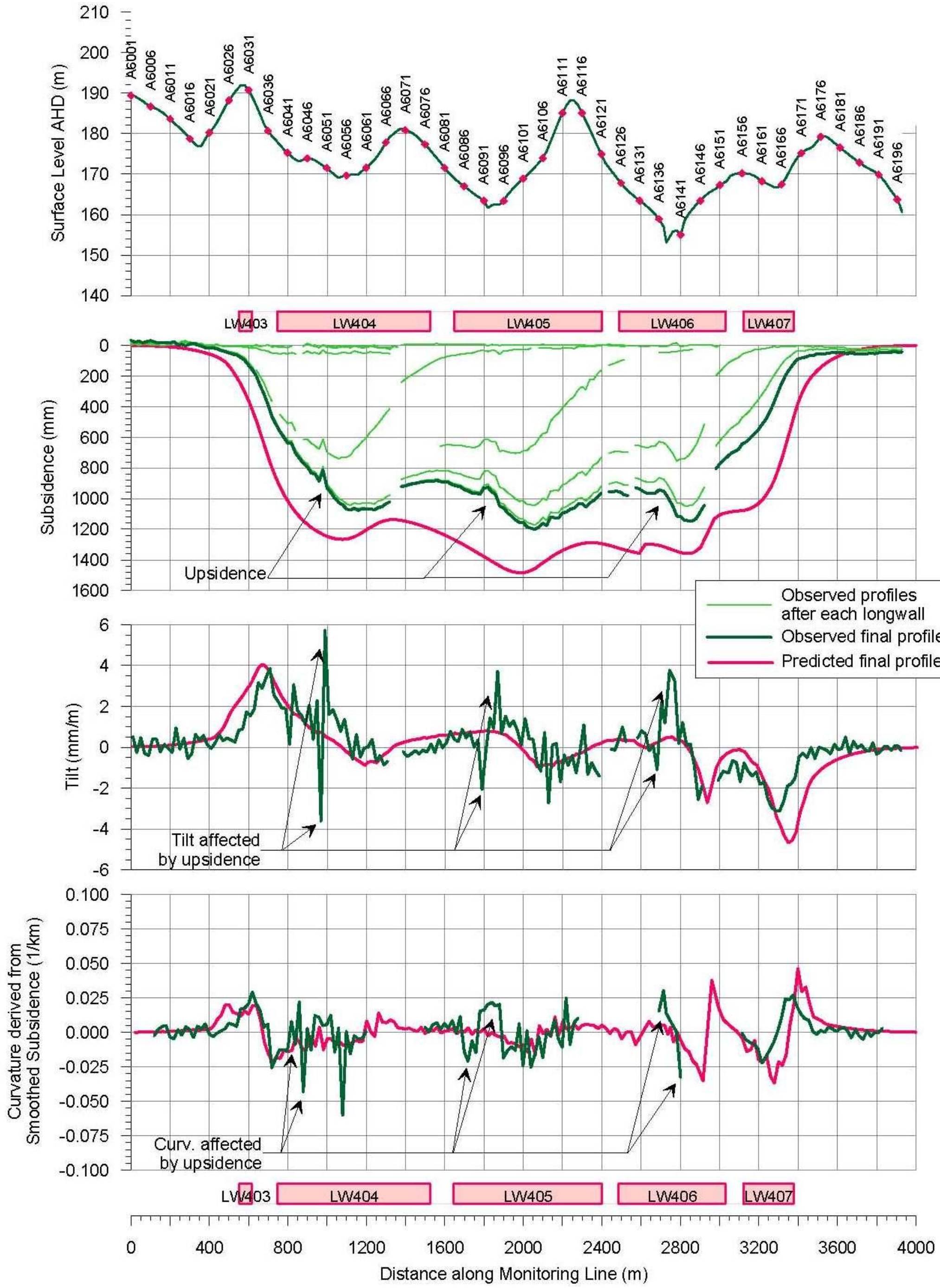

Figure 12: Observed and Predicted Profiles of Incremental Subsidence, Tilt and Curvature along the A6000-Line due to Appin Colliery Longwalls 401 to 408[62]

[62] Figure 4.5 of Appendix A of the EA for the BSO Project

4.2.2.2. Non Conventional Subsidence

The phenomena of valley upsidence, closure and far field horizontal movements have only come to be recognised in the last 15 to 20 years as a result of ground behaviour observations in the Southern Coalfield of NSW. The theoretical knowledge base to fully explain this behaviour is still evolving. In the interim, predictions of upsidence and closure are most often based on the methodology developed from coal industry funded research undertaken by MSEC some 8 years ago[63] and upon which its predictions for the BSO Project have been based.

The EA reports that the level of confidence in the prediction methodology is not as high as that associated with the prediction of systematic subsidence but that it can be used *'so long as sensible factors of safety are applied'*[64]. No guidance has been provided on the value of these factors of safety.

The EA notes that whilst the major factors that determine ground movement have been identified, there are some that are difficult to isolate. Three factors that are *'thought to influence upsidence and closure movements'* have been identified and commented on in the EA, namely:

- In-situ horizontal stress. Appendix A reports that the prediction methodology is based predominantly upon the measured data from Tower Colliery[65], where the in-situ horizontal stress is high. It is conjectured that the methods (for predicting closure and upsidence) will, therefore, tend to over-predict the movements in areas of horizontal lower stress. The EA does not identify what portions of the BSO Study Area may be subjected to lower levels of horizontal stress.

- Near surface geology, particularly in stream beds, with thin beds responding differently to thick beds.

- Geomorphology, with recent monitoring showing variations in ground response around bends in valley alignments.

The MSEC prediction methodology is based on a profile of *equivalent valley height*, which is calculated by multiplying the measured overall valley depth by a factor intended to reflect the shape of the valley. MSEC has undertaken such an assessment for streams and stream sections and produced plots of equivalent valley height in Appendix A[66] and in Appendix P (Stream Risk Assessment). This process is another source of error in the prediction methodology.

Figure 13 shows comparisons between measured incremental closure and incremental upsidence and those predicted by MSEC's methodology[67]. The wide scatter in

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[63] Waddington and Kay (2002)
[64] EA, Appendix A, p.36.
[65] Tower Colliery is now known as Appin West Colliery.
[66] EA, Appendix E of Appendix A.
[67] The summation of the incremental values produces the final value.

outcomes is obvious. However, as Appendix A reports, the prediction methodology over-predicts valley related movements in more than 95% of cases.

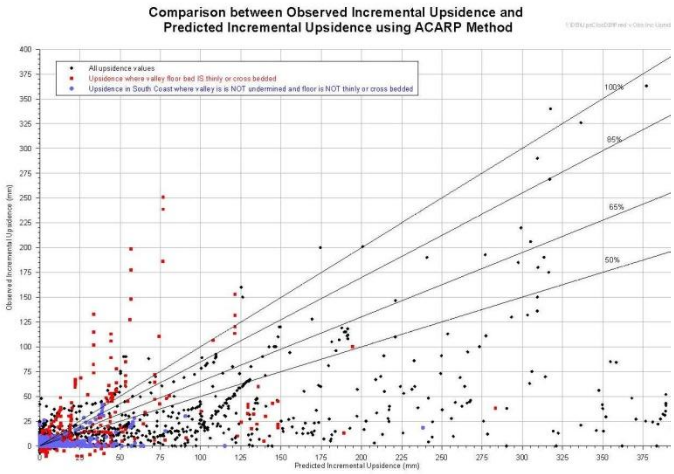

Fig. 4.11 Comparison of Predicted and Observed Upsidence Movements in Database

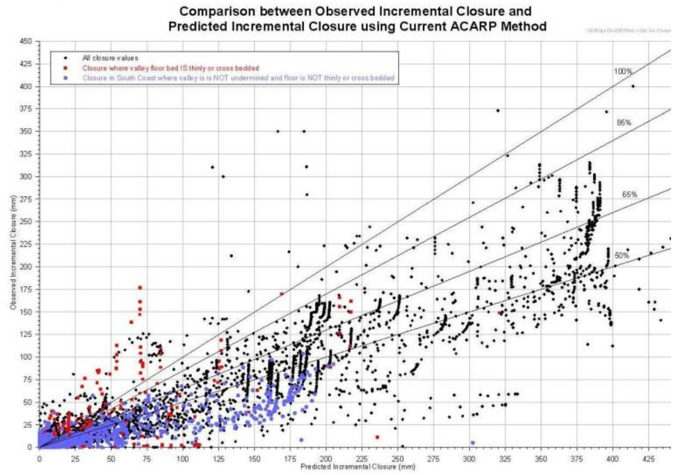

Fig. 4.12 Comparison of Predicted and Observed Closure Movements in Database

Figure 13: Plots Showing Comparisons between Measured and Predicted Closure and Upsidence Based on MSEC's Prediction Methodology[68]

Appendix A goes on to report on research currently being undertaken into upsidence and closure prediction, stating that:

- *'Lower values of upsidence, closure and strain have been observed within valleys that have not been undermined (in the immediate vicinity) by current or previously extracted longwalls'*[69].

- *'Wherever the geology of the bedrock in the base of the valley comprises think highly jointed layers, the resulting upsidence and closure can be higher than where the bedrock comprises strong thick homogenous strata layers'*[70].

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[68] Reproduced from Appendix A of the EA.
[69] EA, Appendix A, p.73 and multiple other references in Appendix A.
[70] EA, Appendix A, p.42.

On this basis, the EA concludes that a reduction factor of about 0.5 could be applied when predicting upsidence and closure for those creeks that have not been undermined by current or previous longwalls. However, *'to be conservative, for now, a reduction factor of 0.7 has been adopted until the ongoing current research proves that lower reduction factors would be appropriate'*[71]. The 0.7 factor was only applied to points along a stream that are not directly mined beneath anywhere along their length within a distance of one depth of cover from a goaf area by the current longwall or any previous longwalls. It is reported that after applying this reduction factor, the majority of the observed closures were still less than half of those predicted and only 2% of the observed exceeded those predicted.

The application of a 0.7 reduction factor represents a change in the closure prediction methodology that the Panel assessed in the Metropolitan Coal Project. Arising out of the Panel's difficulties in reconciling closure values quoted in the main text of Appendix A of the BSO EA with the corresponding closure stream profiles presented in Fig. 100-01 to Fig. 200-35, the Panel has been informed that the plotted upsidence profiles, but not the corresponding text, have already been modified to incorporate the reduction factor of 0.7[72]. Hence, for example, a predicted closure value previously computed to be 285 mm might now have been plotted as a predicted value of 200 mm. Therefore, care must be exercised when using closure values reported in the main text of Appendix A and in earlier reports[73] as points of reference for impact assessment.

A number of subtleties are associated with the manner in which non-conventional subsidence effects and associated impacts have been predicted in the EA, such that conservatism in the prediction of closure and upsidence effects does not translate into conservatism in the prediction of closure and upsidence impacts. There is a 'disconnect' between the methodology used to predict effects and that used to predict impacts.

Usually, impact categories would be assigned to measured effects.[74] However, although it is well established that the vertical and lateral extent of upsidence fracture networks increase with the level of upsidence, which in turn increases with the level of closure, impact categories have yet to be assigned to measured closure or upsidence effects. This is challenging because:

- Upsidence does not correlate well with closure. This is due to factors such as difficulties in measuring upsidence accurately (for reasons noted earlier) and to different amounts of upsidence being induced by the same amounts of closure, depending on rock type (sandstone, shale, claystone etc).

- Different levels of impact can be associated with the same level of upsidence, depending primarily on local rock type, rock fabric and structure (massive, laminated, cross bedded, jointed etc) and the orientation of the structure relative to the direction of valley closure.

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[71] EA, Appendix A, p.44.
[72] MSEC (2009).
[73] For example, Appendix A of EA for the Metropolitan Coal Project.
[74] Impacts on houses provide a good example of this later in the Panel's report.

- In the case of some features, some high consequence impacts occur at very low levels of movement. Further increases in the magnitude of the effect (movement) do not always result in an incremental increase in the magnitude of the impact and its consequences, albeit that they might increase other impacts and consequences. Field observations[75] reveal that this is the case in particular for watercourses controlled by rock bars.

The impact assessment presented in the EA and expanded upon in response to the Panel's inquiries of ICHPL, attempts to deal with these limitations by basing impact assessment on a threshold value of predicted closure, rather than measured values of closure. Figure 14, reproduced from the EA, provides the basis for this approach to impact assessment, which is premised entirely on impacts on rock bars that controlled stream pools. The approach means that conservatism in the MSEC methodology for predicting effects has already been taken into account when associating levels of observed impact with predicted closure movements.

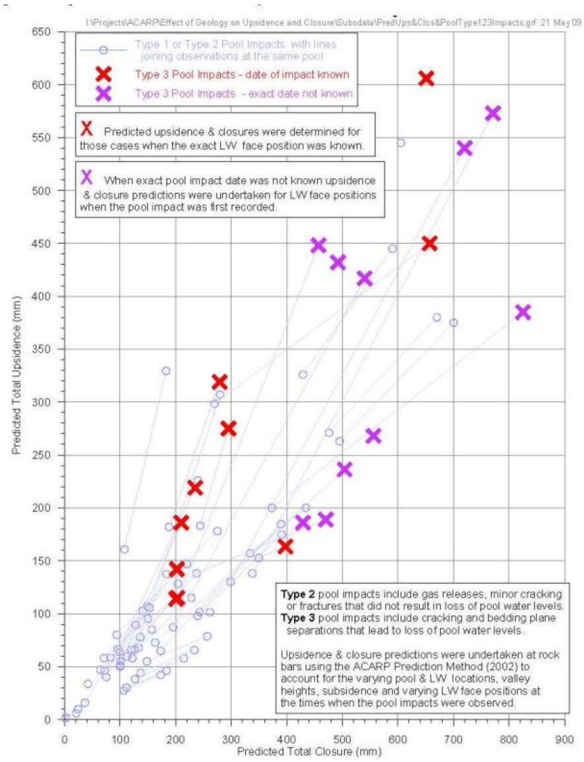

Figure 14: Correlation between Predicted Total Closure and Total Upsidence at Time of Pool Impacts in the Southern Coalfield[76]

Three categories of impact at rockbars controlling pools have been identified in the EA and identified in Figure 14, namely:

- Type 1: *Nil or negligible*. The terms *nil* and *negligible* have not been defined in Appendix A or elsewhere in the EA[77].

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[75] e.g. Galvin (2005); Mills (2008).

[76] Figure is reproduced from Fig. 4.21of Appendix A.

- Type 2: Includes isolated fracturing, gas releases and iron staining.

- Type 3: Those in which the pool water levels were observed to drop more than expected after considering the rainfall and surface and groundwater flow conditions.

Appendix A reports that Figure 14 '*indicates that no pool impacts have been observed, to date, where the predicted total closure was less than 200 mm*[78]*'*. Based on the database accumulated to date, it concludes that there is around a 10% probability of a Type 3 impact being associated with a 200 mm to 215 mm closure range. The Panel concurs with this finding but notes that it is sensitive to the size of the database and the timely detection of impacts. Therefore, the probability may increase or decrease as more case studies become available.

The Panel cautions against the following conclusion in Appendix A:

> *'The adoption of 200 mm predicted total closure as an impact criterion is also considered conservative for future mining cases where many longwalls are near a creek or river, especially after recognising that the data shown in Fig. 4.21*[79] *is derived from historical case studies where the Type 3 impact sites are almost all located either directly above the mined longwalls, or, to the side of a series of longwalls. Only one type 3 impact was observed beyond the end of a series of longwalls, where the offset distance was 74 metres'*[80].

This caution is specific to the BSO Project and arises for two reasons:

- The conservatism to which the text refers has already been accounted for in the (updated) closure profiles for streams presented in Fig. 100-01 to Fig. 200-35 of the EA[81].

- The impact assessment methodology used in the EA applies only to pools controlled by rockbars. In responding to the Panel's questions, ICHPL has reported that in addition to there being 169 pools upstream of rockbars, another 175 pools are upstream of boulder fields and another 14 are upstream of other obstructions.[82] ICHPL makes a series of statements as to:

  > *'boulder field controlled pools are less likely to have increased leakage as a result of subsidence movements'.*

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[77] In its report on the Metropolitan Coal Project, the Panel stated that it considers *negligible consequence to mean no diversion of flow, no change in the natural drainage behaviour of pools, and minimal iron staining, and is assumed to be achieved in circumstances where predicted valley closure is less than 200mm.* The approval conditions for Metropolitan Coal Project defined *negligible* to mean: *Small and unimportant, such as to be not worth considering*

[78] The Panel notes that this statement should be qualified with the inclusion of the word *Type 3;* that is *.........no Type 3 pool impacts......*

[79] Figure 14 of the Panel's report

[80] EA, Appendix A, p.48.

[81] EA, Appendix A, p.52.

[82] ICHPL (2010b), response to PAC Question 52.

and if

'leakage through the sediments is enhanced due to cracking of the sediments they are more likely to infill with local and transported sediments during subsequent flow and flood events within the stream'.

and

'Where boulder fields or sediment accumulations occur over bedrock there could be fracturing of the underlying bedrock as a result of subsidence movements. These fractures are likely to infill over time due to the immediate availability of sediments to the fracture network'.

These and other related statements are not supported in the EA by any factual observations or measurements. They may well prove to be accurate but in the absence of any supporting evidence, the Panel has no option but to consider them conjecture. In so doing, it notes that ICHPL does not commit to these pools experiencing negligible impact, being the performance standard applied to rockbars throughout large portions of the BSO Study Area.

Total closure across a valley is particularly important in its own right when structures span across a valley as they are exposed to the total closure movement. On the other hand, because the valley sides tend to move en-masse, closure may hold few implications for features located on the flanks of a valley. However, closure becomes critical for features located in the base of a valley because this is where most of the closure displacement occurs. The most important aspect of this movement is the generation of very high compressive strains (in the valley floor), as evidenced in upsidence. This being the case, it would be much more logical and useful if closure movements were assessed in terms of these compressive strains. The DII placed a high emphasis on this approach in its presentations to the Panel and supported it with a range of measured strains that correlated reasonably well with resulting subsidence impacts.

The Panel notes that the Swamp Matrices presented in Attachment OB of Appendix O (Upland Swamp Risk Assessment) report predicted closure strain in addition to closure. This is considered to be a significant step forward.

The Panel concludes that:

- There is considerable uncertainty associated with the methodology used in the EA to predict non-conventional subsidence effects. However, currently there is no better alternative technique available and predictions of effects are more likely to be over-estimated because they are based on a conservative upper bound approach.

- The relationship between the prediction of non-conventional subsidence effects and the impacts and consequences that result is poorly defined and too limited in scope.

- In the case of rock bars that control pools on watercourses, there is a 'disconnect' between the methodology used to predict effects and that used to predict impacts. Hence, conservatism in the prediction of closure and upsidence effects does not translate into conservatism in the prediction of closure and upsidence impacts.

- The prediction in the EA of closure strain at swamps is a significant step forward.

The Panel notes that although the impacts at rockbars in the BSO Project and the Metropolitan Coal Project have been assessed on the basis of predicted closure, this approach is illogical and unsatisfactory. This is because it is based on a correlation between predicted closure (an estimate) and observed impact (a fact) rather than measured closure (a fact) and observed impact (a fact). The illogical nature of this approach is reinforced when it is realised that it is mainly employed because of the poor correlation between measured closure and observed impact.

4.2.3. Implications of Increasing Longwall Panel Width

The prediction and assessment of subsidence effects, impacts and consequences in the EA are premised on the Base Case layout. Appendix A reports that this layout could change within the Extent of the Longwall Mining Areas as a result of:

- Shifting the location of the longwalls

- Re-orientating the direction of the longwalls

- Modifying the length of the longwalls

- Modifying the widths of the longwalls and/or the chain pillars

According to Appendix A, the first three modifications are unlikely to result in any significant changes in the maximum predicted systematic subsidence parameters which have been provided in the EA for the Base Case layout. However, the locations of the maxima are likely to change depending on the final locations of the longwalls. The Panel notes that critical isolated features and linear features have been assessed in the EA on the basis of the maximum predicted systematic subsidence effects across the whole mining domain in which they are located and, therefore, these worse predictions should not be affected by a change in longwall panel location or orientation. However, they can impact on predictions at specific sites, causing them to be either greater or less than predicted depending on their location relative to the longwalls. The Panel agrees with these assessments.

The fourth manner in which the longwall layout may be modified in time to come, namely by increasing the panel width, has much greater implications because it results in changes in the predicted maximum subsidence effects. As noted in the EA, the extent of these changes depends on a number of factors, including the modified panel widths, the chain pillar widths, the depth of cover, and the geology of the overburden. The EA reports that as longwall mining technology improves, it is likely that it will become more efficient to extract wider longwalls. However, it acknowledges that there are no longwall panels wider than 325 m in the Southern Coalfield and none wider than 410 m in Australia. Hence, there is no longwall database for deriving incremental subsidence profiles and calibrating the IPM technique for wider longwall panels.

MSEC has approached this problem by utilising subsidence data associated with multiple pillar extraction panels at Tahmoor Colliery, to the south west of the BSO Study Area, and at Coal Cliff and Metropolitan Collieries to the east of the Project Area. The IPM technique was applied to *generic mine layouts* to determine increases in subsidence effects for longwall panel widths of 350 m, 400 m, 450 m and 500 m. These are reproduced in Table 5 of this PAC report.

Table 5: Predicted Increase in Subsidence Effects Associated with Wider Longwall Panels[83]

Table 4.3 Changes in the Maximum Predicted Systematic Subsidence Parameters for Longwall Void Widths of between 350 and 500 metres

Depth of Cover (Mining Domains)	Longwall Width (m)	Change in the Predicted Maximum Systematic Subsidence Parameter from those Based on the Base Case Longwall Layout			
		Subsidence	Tilt	Curvature	Average Strain
300m to 450m (Area 2, Area 3 and North Cliff)	350	x 1.05	x 1.15	x 1.05	x 1.05
	400	x 1.10	x 1.20	x 1.10	x 1.10
	450	x 1.13	x 1.25	x 1.20	x 1.20
	500	x 1.15	x 1.35	x 1.30	x 1.30
450m to 550 m (Areas 5, 7, 8, 9 and North Cliff)	350	x 1.10	x 1.20	x 1.10	x 1.10
	400	x 1.25	x 1.25	x 1.20	x 1.20
	450	x 1.30	x 1.40	x 1.30	x 1.30
	500	x 1.35	x 1.50	x 1.40	x 1.40
550m to 700m (Areas 7, 8 & 9)	350	x 1.15	x 1.25	x 1.20	x 1.20
	400	x 1.30	x 1.30	x 1.30	x 1.30
	450	x 1.35	x 1.50	x 1.40	x 1.40
	500	x 1.40	x 1.60	x 1.50	x 1.50

The subsidence numbers presented in Table 5 are comparative and do not enable a ready assessment of the scale of the changes arising from wider longwall panels. One needs to refer to the actual predictions for each mining domain in the Base Case layout in order to appreciate both the increase in subsidence effects in each mining domain and the absolute magnitude of the subsidence effects. For example, one cannot determine from Table 5 if the projected 35% increase in tilt for a 500 m wide longwall in Area 2, Area 3 and North Cliff results in a smaller or larger increase in absolute tilt than the corresponding 60% increase in Area 7, Area 8 and Area 9.

More critically, the assessment does not address changes in non-conventional subsidence effects and provides no insight into changed subsidence impacts and consequences.

The Panel concludes that:

- Performance criteria need to be framed such they are insensitive to any changes in the Base Case layout.

[83] Note: the term *average strain* is erroneous. It represents *maximum strain* as derived from maximum curvature.

4.3. MANAGEMENT OF EFFECTS AND IMPACTS

4.3.1. Options Relating to Risk

Consistent with risk management principles, there are three options for dealing with risk associated with subsidence impacts, namely:

- Eliminate
- Mitigate
- Tolerate

Adaptive management and remediation can find application across all three options. Adaptive management is concerned with monitoring subsidence effects and impacts and, based on these outcomes, modifying the mining plan as mining proceeds so as to maintain effects, impacts and/or consequences within predicted or designated ranges[84]. This can involve actions such as reducing the extent of mining within a panel, altering mining height, or changing the dimensions of subsequent panels based on early warning signs of deviation from planned outcomes.

Remediation refers to the activities associated with partially or fully repairing or rehabilitating impacts and, as such, is a recovery measure for limiting the consequences of an impact.

Elimination of subsidence impacts is achieved by not mining within a zone of influence of the feature to be protected. This zone is usually defined by an angle measured between two lines drawn from the edge of the mine workings, one a vertical line and the other a line drawn out over unmined coal to the outer boundary of the feature to be protected. This effectively defines an angle of draw that is based on achieving zero vertical displacement beneath the structure. Greater certainty against impacts can be achieved by incorporating a buffer zone around the feature and measuring the angle of draw from the outer boundary of this buffer zone. For example, in the case of a dam wall, Justice Reynolds recommended that no mining be permitted within a zone defined by a 35º angle of draw taken from a line on the surface 200 m from the edge of the structure.

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[84] The NSW Land and Environment Court has recently defined adaptive management as:
'Adaptive management is a concept which is frequently invoked but less often implemented in practice. Adaptive management is not a "suck it and see", trial and error approach to management, but it is an iterative approach involving explicit testing of the achievement of defined goals. Through feedback to the management process, the management procedures are changed in steps until monitoring shows that the desired outcome is obtained. The monitoring program has to be designed so that there is statistical confidence in the outcome'.

Newcastle and Hunter Valley Speleological Society Inc v. *Upper Hunter Shire Council and Stoneco Pty Limited* [2010] NSW LEC 48.

Mitigation involves measures undertaken to reduce the impacts of subsidence on features. Six common means are:

4. Restriction of ground movement, which may be achieved in one of two ways:

    - Selecting mining dimensions so as to increase the width of pillars between panels, and/or restrict mining height and/or excavation width and/or the distance that mining can approach within a feature. Mining layouts in which percentage extraction is restricted for the purpose of controlling subsidence are referred to in general as *partial extraction* mining systems. A reduction in longwall panel width from 310 m to 163 m, for example, results in about an 8.5% reduction in percentage extraction.

    - *Backfilling* of mine voids, also referred to as *stowing*. Backfilling of the mining void immediately behind a longwall face has been practiced extensively in coal mines in Europe to reduce surface subsidence typically by 50 to 70%. It is an expensive process that requires mining to be slowed in order to provide time to place the fill. This, in turn, impacts adversely on productivity. It may also affect safety if ground conditions deteriorate as a result of the slow rate of mining[85]. Many of the European mines that utilized this technique have become uneconomic and closed over the last two decades.

      A second subsidence reduction stowage technique practiced in Europe and China is the injection of backfill into the partings planes that form in the roof strata in the vicinity of a longwall face as it retreats out of a panel. This restricts closure of the partings as the strata sags after the passage of the longwall, resulting in a reduction in surface subsidence of typically 10 to 30%.

5. Isolation of ground movement: This involves isolating a feature from ground displacements, strains and shear displacements. Techniques include placing bearings beneath structures (such as bridges), uncovering buried structures (such as pipelines), and constructing slots in the ground at strategic locations adjacent to a feature to encourage ground movements to concentrate at the slots. The success of slots is dependent on a number of factors including selecting the correct locations and directions for the slots, having access to these sites, and constructing the slots a sufficient time in advance of mining. The slots may be cut mechanically or formed by drilling a pattern of closely spaced, large diameter drill holes. This control measure is still in a development stage but has produced encouraging results at Waratah Rivulet and Marnhyes Hole on the Georges River.

6. Rigid 'floating' foundations: By placing a structure on a rigid raft foundation that can 'slip' on the ground surface, the structure can move as one entity and so be protected from curvature and horizontal strain. However, it is still susceptible to tilt. This technique is often applied to houses in mining areas.

[85] The strength of weak rock under load can reduce over time.

7. Flexible construction: Structures may be designed such that they can sustain a degree of differential movement whilst remaining safe, serviceable and repairable[86]. For example, weather board structures generally have a higher tolerance to tensile strain than masonry structures, whilst the tolerance of masonry structures to differential movements can be increased through the use of strategically located expansion and contraction joints.

8. Maintenance responses: This involves measures which aim to maintain the physical state and function of a feature, albeit that it may be impacted by subsidence during the mining process. Examples include increasing flow volume in a fractured section of a watercourse in order to maintain surface flow at pre-mining levels, installing support in overhangs and cliff faces prior to undermining, and periodically relevelling and realigning man-made structures.

9. Preservation responses: Objects and structures at risk from mine subsidence may be removed on a temporary or permanent basis prior to undermining, or logged and recorded in a visual format for posterity.

Toleration of subsidence impacts usually requires that no action be taken to control or remediate the impacts. This practice is common in very deep mines (because subsidence effects are restricted and dissipate gradually over a large area) and at locations that have no significant sub-surface and surface features.

There are a variety of remediation options available to respond to subsidence impacts. Remediation of the built environment usually involves re-levelling and restoring surface finishes, although reconstruction is sometimes undertaken. In the case of natural features, options include backfilling and/or grouting of cracks and fracture networks, stabilisation of slopes, and implementation of drainage and erosion control measures. Fractures may also infill naturally in watercourses that have a moderate to high sediment load; otherwise they may have to be grouted.

Grout can be either cement-based or composed of various plastics or resins (e.g. polyurethane) and can be utilised in one of two ways. The first is the creation of a grout curtain to act as a vertical barrier to the transmission of fluid. The second is shallow pattern grouting to seal the immediate bed of a watercourse. Pattern grouting is not targeted to seal deeper underlying fracture networks.

Some grouting agents used for sealing similar types of fracture networks in other civil and mining environments have not been permitted in sections of the Southern Coalfield because of concerns regarding pollution of water supplies. Until recently, the SCA did not permit any form of grout to be used within its Special Areas. Consequently, in sections of the Waratah Rivulet, unconsolidated sand was used in attempts to fill cracks within the river bed. This material quickly washed out of the cracks during high flow events and now can be found downstream within various pools in the watercourse. More recently, injection of polyurethane has produced

[86] *Safe* means no danger to users; *Serviceable* means available for its intended use*; Repairable* means damaged components can be repaired economically. (DoP, 2009b).

mixed but promising results at this site. The main concerns appear to relate to potential breakdown of the sealant at the surface and long term durability.

The degree of success of grouting is dependent on the accessibility of the site, on the type of grouting materials used and on timing. If the site of fracturing is affected by a number of mining panels, several episodes of grouting may be required over a number of years. In the interim, mitigation measures are required to sustain surface water flows if the local ecology is not to be impacted.

In the case of watercourses, it is not yet feasible to remediate an entire upsidence fracture network. Hence, remediation efforts in the Southern Coalfield have to date focused on sealing the fracture network at strategic locations, such as rock bars. At these sites, the fracture network can extend some distance laterally under the toe of valleys and be overlain by talus. It can also be covered by boulder beds within watercourses. These types of settings restrict access for grout injection equipment. If the site of fracturing is affected by a number of mining panels, several episodes of grouting may be required over a number of years. In the interim, mitigation measures are required to sustain surface water flows if the local ecology is not to be impacted.

4.3.2. Application in General to BSO Study Area

In the course of this Inquiry and previous Inquiries, Panel members have inspected a broad range of sites and measures invoked for eliminating, mitigating and tolerating subsidence impacts in the Southern Coalfield. The Panel has also been made aware of and observed a number of rehabilitation and adaptive management techniques. These matters were well canvassed in submissions to the Panel. Many are dealt with in detail in the context of specific features in later sections of this report.

Appendix A has identified a very large number and variety of man-made structures that could potentially be impacted by subsidence in the BSO Study Area. The EA invokes a wide range of options for managing these impacts so that they do not present an unacceptable level of risk.

Mitigation measures involving isolating structures from ground movement, allowing structures to move en-masse, and/or building flexibility into structures should have been implemented during construction in areas already declared a Mine Subsidence District at that time. This is the case for many houses in the BSO Study Area. Mitigation measures have been implemented for other structures, such as the Main Southern Railway and the Upper Canal, prior to them coming within the influence of mining. On occasions, additional mitigation measures have also been undertaken for structures built in compliance with MSB construction requirements.

Extensive remediation of the built environment has occurred in areas affected by previous mining in the BSO Study Area. This ranges from repair of minor hairline cracks in plaster walls through to the realignment of the Twin Bridges on the Hume Highway at Douglas Park. Mining in the vicinity of the Twin Bridges also serves as an example of adaptive management, with the nearby Longwall 17 Panel at Tower

Colliery[87] being cut short and mining proceeding in approved increments of 50 m to avoid exceeding a threshold level of movement at the Twin Bridges.

A detailed review of potential impacts and consequences associated with subsidence of the man-made features in the BSO Study Area is presented in a later chapter of this report. In general, the Panel is satisfied that technologies, processes and controls are sufficiently well developed to enable risk to built environment presented by subsidence to be effectively managed.

In regards to natural features, the Panel is unaware of any example of where it has been decided to eliminate subsidence effects at a natural feature in the BSO Study Area by not mining within its zone of influence. However, it is possible that the BSO Study Area was defined so as to provide this level of protection to one or more natural features.

The mining layout assessed by the Panel in the case of Metropolitan Coal Project invoked restricted mining dimensions as a subsidence management control measure, with longwall panel width being reduced from 163 m to 133 m beneath Woronora Dam. The Base Case layout for the BSO Project does not utilise this type of mitigation measure. Appendix P (Stream Risk Assessment) and Appendix O (Upland Swamp Risk Assessment) report that alternative mine plans were used to examine the relative costs and benefits of modifying the BSO Base Case layout in the Area 2, Area 3 and North Cliff mining domains by narrowing the longwall panel width to 163 m. The analysis indicated this would result in a substantial cost increase whilst not significantly altering the expected environmental consequences[88].

The basis for this conclusion in respect of environmental consequences for streams is premised on the very high level of closure and upsidence already predicted for Dahlia Creek, Wallandoola Creek and Allens Creek as indicated on Figure 15. The Panel concurs that the 100 to 200 mm reduction in closure afforded by reducing longwall panel width to 163 m is unlikely to cause a meaningful change in the severe environmental consequences for these streams.

[87] since renamed Appin West Colliery
[88] Page P-25 of Appendix P and Page O-36 of Appendix O

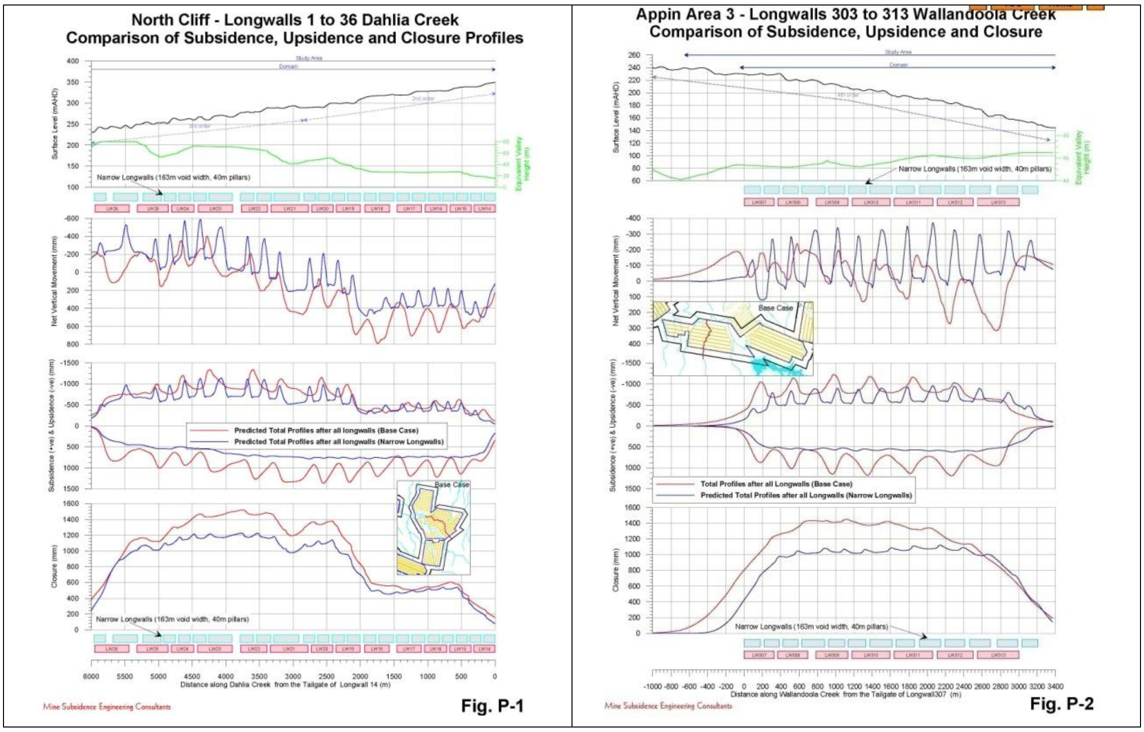

Figure 15: Profiles of Predicted Closure and Upsidence for Dahlia Creek and Wallandoola Creek Showing Effect of Narrower Longwall Panels[89]

The Base Case layout makes extensive use of buffer zones between the start and/or finish points of the longwall panels and many of the natural (and man-made) features as a means to mitigate subsidence impacts on these features. In these circumstances, the effectiveness of the measure and the opportunity to implement adaptive management practices may be very dependent on the direction of longwall mining relative to the feature. If longwall mining retreats away from a feature, there is little opportunity to practice adaptive management in that longwall panel. However, because subsidence effects are cumulative across a number of panels, the opportunity exists to change the start or finish lines of subsequent longwalls in order to manage subsidence impacts. As reported in the EA, this concept can also be applied to mining on either side of features such as watercourses[90].

The Panel concludes that the Base Case layout is amenable to adaptive management to control impacts on some features that are located at the start or finishing lines of the longwall panels and has been well utilised for this purpose. It also concludes that the direction of longwall panels in the Base Case may be able to be changed without unduly jeopardising this situation. However, the approach is not universally applicable and the effectiveness of it is likely to reduce with any increase in longwall panel width both because a larger increment of subsidence will be associated with the extraction of a wider longwall panel and because this increment will affect a larger area of the surface.

89 Sourced from Appendix P of the EA.
90 EA, Appendix A, p.61.

The EA makes no mention of backfilling the mining void immediately behind the longwall face in order to mitigate subsidence. The Panel notes the submission of the New South Wales Mineral Council (NSWMC) to the Southern Coalfield Inquiry in this regard:

> *The mining industry in Australia has investigated the feasibility of backstowing with a view towards reducing subsidence impacts on the surface. At this stage it has been found not only is the practice extremely uneconomical, there are significant practical and mine safety issues to address with this methodology in Australia. Technological advancements may one day lead to backstowing however. Backstowing does not completely reduce subsidence to zero. The amount of subsidence reduction achieved to date is approximately 50 to 70%*[91].

The EA also makes no mention of filling parting planes in the roof strata in the vicinity of a longwall face. However, the Panel is aware that pre-trial feasibility studies of this technique utilizing coal washery waste were recently undertaken at West Cliff Colliery under funding from ACARP (Shen et al, 2010).

The Panel has inspected the sites of slotting operations on the Waratah Rivulet and on the Georges River, the latter site being within the BSO Study Area. At Waratah Rivulet, the full array of slot holes could not be drilled in the allocated time frame. A limited amount of horizontal ground movement was observed in some of these holes. At the Georges River, a stress relief slot cut in the river bank adjacent to Marhnyes Hole[92], Figure 16, is reported to have delayed the onset of fracturing and reduced its extent at this site[93] The Panel concludes that the technique has shown promising results to date. However, practical considerations related to factors such as topography, site access and availability of services, limit the scope of this mitigation measure in the BSO Study Area.

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[91] NSWMC submission to the SCI, p.14.

[92] Marhnyes Hole is the general name for the prominent rockbar and the two pools upstream and downstream of the rockbar overlying Longwall Panels 27 and 28 (EA, Appendix C, p.161).

[93] BHP Billiton (2006), Attachment 13 of ICHPL (2010b).

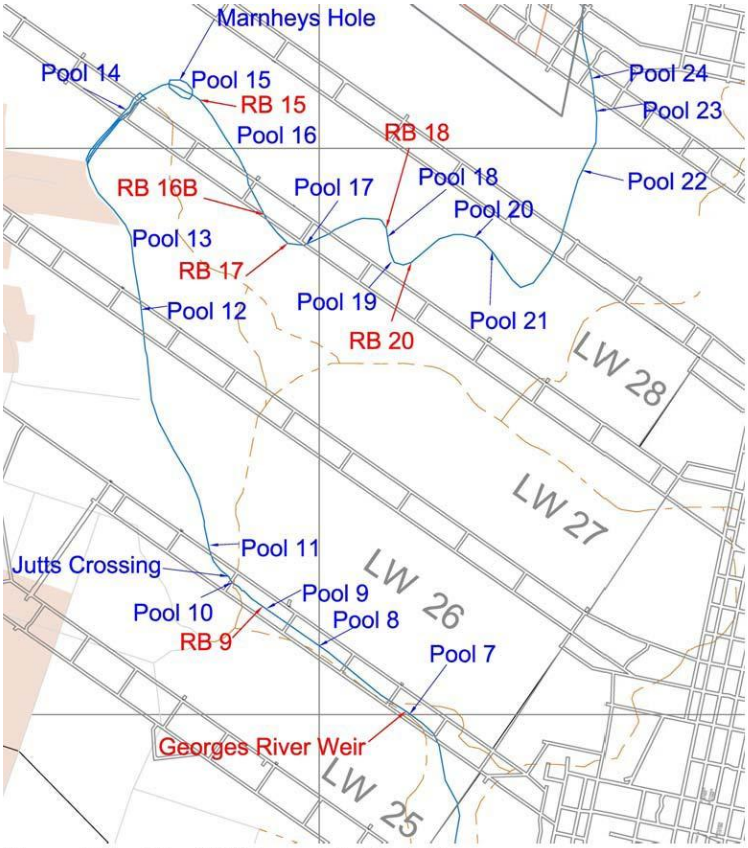

Figure 125 West Cliff Longwalls 25 to 28

Figure 16: Location of the Georges River over West Cliff Longwalls 25 to 28[94]

Cement based grout injection has been utilised in the immediate vicinity of the BSO Study Area in attempts to form grout curtains in the Cataract River Gorge and along the Georges River (e.g. Jutts Crossing, Figure 16) and to seal the base of ponds along Georges River (e.g. Marnhyes Hole). The EA reports that flow monitoring data suggest that up to 1 ML/day was being diverted (post mining) via the subsurface fracture network in some sections of the Georges River[95]. It states that remediation works have been successful in re-establishing flow over rockbars during normal low flow conditions but there is little evidence of recovery in adjacent groundwater levels. It was concluded from the grouting activities that underflow bypassed rockbar RB16 by cutting across the bend in the river.

It is reported that remediation at the site of Marhnyes Hole consisted of backfilling the stress slot, pattern grouting of the top 1 to 2 metres of Pool 14, repairing some of the visible fractures using hand mortaring with cement and natural oxides, and removing a rock fall that had occurred below the overhang at Marhnyes Hole during undermining[96]. Further movement of the rock bar occurred after the fractures were grouted, resulting in minor fracturing of the grout that was subsequently repaired.

[94] Figure 125 of Appendix C of EA; Note – 'Marnheys' is misspelt on source drawing, and Longwalls 25, 26, 27 and 28 are numbered as LW5A1, LW5A2, LW5A3 and LW5A4 in BHP Billiton (2006).
[95] EA, Appendix C, p.162.
[96] BHP Billiton (2006).

The Panel inspected Marhnyes Hole in early 2010, Figure 17. It noted that some fractures that had not been grouted appeared to have a degree of fresh (but minor) movement on them, Figure 18, and that some grouted fractures may have recently undergone another cycle of repair, Figure 19.

Figure 17: Overview of the rockbar at Marhnyes Hole, 6/1/10

Figure 18: Examples of cracking at Marhnyes Holes as at 6/1/10 which appeared to be associated with past mining in the area

Figure 19: Cosmetic cement based remediation of mining induced cracking at Marhnyes Hole as at 6/1/10

Against this background, the Panel does not accept without qualification the claim in the EA that: *'Remediation of fractured rockbars has been successfully undertaken within the Southern Coalfield'*[97].

The BSO Panel made a number of observations related to 'self-healing' of fractures during its field inspections. On a number of occasions it observed that although fractures gave a superficial impression that they had sealed naturally, excavation revealed that the fracture planes were still quite porous and permeable. It was also deduced with a reasonable level of certainty that there was substantial sub-surface flow at some of these sites. The Panel concludes that the knowledge base relating to self healing is inadequate for it to be relied upon as a remediation measure, at least in sandstone settings.

The SCI Panel reported that it was not aware of any attempts to remediate fracture networks beneath swamps. However, current grouting techniques did not appear suitable for this purpose. ICHPL has reported that grouting has not been used to remediate a pool retained by boulder field, although it has been used previously within sediment accumulations[98]. The SCI Panel was also not aware of any remediation having been undertaken of mining induced cracks in cliffs and overhangs. It concluded that the remediation of subsidence impacts on natural features was in its infancy and, consequently, the level of risk currently associated with the successful remediation of natural features ranked as medium to high. It identified a number of

[97] EA, Appendix A, p.79.
[98] ICHPL (2010b), response to PAC Question 52.

aspects that warranted more detailed consideration and research in order to reduce this level of risk. The BSO Panel considers the situation reported by the SCI to be largely unchanged.

Based on the accumulated field inspections of its members, the Panel concurs with the NSWMC submission to the SCI that:

> *The discussion of subsidence mitigation and remediation needs to balance a number of pertinent issues. These include:*
>
> .....
>
> 1. *The level of required mitigation and remediation needs to be clearly understood in terms of both safety and also the impact the rehabilitation measures themselves may have. Active rehabilitation at the remote location of many of the areas subject to subsidence in the Southern Coalfield may require the disturbance of otherwise undisturbed habitat. It will be important to ensure that the level of impact for the remediation is comparably less than the subsidence related impacts they seek to remediate*[99].

The Panel is of the view that the consequences of having to undertake mitigation and remediation have been underestimated to date and need to be given a higher level of consideration when assessing underground mining projects and framing approval conditions.

The Panel concludes that:

1. There are extensive lengths of watercourses, including rock bars, which are not amenable to remediation utilising grouting techniques.

2. Techniques for effectively sealing upsidence networks such that there is no subsurface flow are yet to be demonstrated.

3. The knowledge base relating to self healing is inadequate for it to be relied upon as a remediation measure in sandstone settings.

4. There is no experience base of either natural processes or engineered measures for remediating swamps impacted by fracturing.

5. Mitigation and remediation measures associated with subsidence constitute subsidence impacts in their own right. Furthermore, high negative consequences can be associated with these impacts.

Based on these findings, remediation cannot be considered at this time to be an alternative to prevention where the functionality of water-dependent natural features is an objective. At best, remediation is a strategy that may have limited application to a limited range of natural features (i.e. some rock bars), either where:

[99] NSWMC submission to the SCI, p.18.

1. Performance Criteria have been exceeded and some attempt to repair is feasible in addition to application of appropriate sanctions, or where

2. Performance Criteria have not been drafted to allow for some impacts and remediation attempts may be a way of restoring some level of functionality.

The Panel recommends:

1. That at this time neither Approval conditions nor Extraction Plans should rely on remediation as a means of maintaining (or restoring) functionality of water-dependent natural features that are potentially exposed to subsidence-related impacts; and

2. That research should continue to explore remediation techniques with a view to improving their effectiveness, expanding the range of impacts and features to which they may be applied, demonstrating their longevity, and minimising collateral impacts.

5.0 GROUNDWATER IMPACTS AND CONSEQUENCES

The SCI identified two fundamental groundwater domains for consideration in project impact assessments:

1. The deep systems generally associated with geological strata at depths greater than 20m or so. These strata include the greater part of the Hawkesbury Sandstone down to and beneath the Bulli Seam. The system is typically confined and pressurised except for the uppermost parts which are unconfined. The shallowest units in the project area are either Hawkesbury Sandstone or Wianamatta Shale.

2. The shallow systems associated with surface drainage lines and swamps. These are typically unconfined systems where the stream courses tend to act as 'hydraulic sinks' attracting groundwater flows from adjacent strata then draining the system via surface flows. There are also perched systems where for example, some swamps in elevated terrain provide a water store which is located above the regional water table and which may sustain downwards leakage into underlying strata.

In consideration of the deep groundwater system(s), the SCI determined that environmental impacts arising from historical mining operations were not easily characterised but were related mostly to the extent of deep strata depressurisation associated with drainage of the fractured subsidence zone above extracted longwall panels. The magnitude of these impacts depends upon the depth of cover above the coal seam, the strata permeability and the mine plan – a shallow depth of cover could lead to hydraulic connectivity from the surface to the underlying mine workings with potentially significant impacts on shallow groundwater and surface water systems. However the SCI also noted that '*more commonly, mining is conducted at a sufficient depth to support the long term presence of a constrained zone*' which is a zone where vertical connectivity is negligible and downwards flow is governed by the natural (vertical) permeability of the strata.

In consideration of the shallow systems, the SCI determined that the potential impacts of mining included cracking of stream beds and rock bars as a result of tensile failure and/or bedding shear associated with normal subsidence, or with valley closure mechanisms. Tilt was also noted in relation to upland swamps. Consequences of these mechanisms on stream beds are known to include partial to complete loss of surface flows as water is redirected into underlying fractures, draining of pools upstream of cracked rock bars, erosion of swamp materials as flows are reconcentrated (from tilts), changes to the water table in swamps and associated changes to habitat, and water-rock geochemical interactions along newly exposed fracture pathways. The latter is typically associated with iron (Fe) staining along creek beds and on rock bars, bacterial matting, reduced oxygen levels and unnatural discolouration of stream waters.

A precautionary approach for impact assessments was advocated by the SCI for both shallow and deep groundwater systems. In addition, the SCI noted a need for improved accuracy in the prediction of subsidence impacts, expanded monitoring systems, and the employment of 3D groundwater modelling to quantify flows (including losses to stream and swampland baseflows) and strata depressurisation. The SCI further noted a need for improved strata hydraulic properties measurement (permeability and porosity) using borehole tests, core inspections and analyses, and geophysical wireline logging. An accurate mine water balance for existing or future operations was considered especially important since it provided a means of validating predicted underground flows to a mining operation, and a first indication of anomalous conditions that might be associated with hydraulically charged structures like faults or intrusives.

The SCI categorisation of groundwater domains into deep and shallow systems and the associated potential impacts have been adopted by the Panel in the current assessment.

5.1. OVERVIEW OF BSO GROUNDWATER STUDIES

Groundwater issues are reported in Appendix B of the EA (Heritage Computing). In reviewing Appendix B, the Panel notes that the content focuses largely on the deep groundwater systems and computer modelling of those systems. Shallow and perched systems, while reviewed in the context of setting and historical monitoring, are not included in the groundwater modelling effort due to scale - these systems tend to be localised. However, the potential impacts on baseflows to the major rivers and streams were considered as part of the modelling effort.

Shallow groundwater system impacts are also addressed by ICHPL in Appendix A of the EA (Subsidence Assessments), Appendix C (Surface Water Assessments) and Appendix O (Upland Swamp Risk Assessment).

The Panel has adopted a similar division by providing overview and findings with respect to shallow groundwater systems in Chapter 6 (Swamps) and Chapter 7 (Surface Waters and Aquatic Ecology) of this report.

5.2. HYDROGEOLOGIC SETTING FOR GROUNDWATER SYSTEMS

A generalised stratigraphic section for the BSO Project Area is summarised in Chapter 4 along with a brief description of the stratigraphic sequence.

Briefly, the uppermost unit is the Ashfield Shale which outcrops over much of the western part of the BSO Project Area as indicated by the geological map, Figure 4. The unit exhibits low primary intergranular (matrix) permeability and as such, groundwater flow rates are likely to be extremely low. It is regarded as an aquitard or aquiclude[100].

The Hawkesbury Sandstone underlies the Ashfield Shale in western areas but outcrops over much of the eastern part of the Project Area. It comprises bedded and cross bedded quartzose sandstones with bedding thickness varying from relatively thin (less than a few centimetres) to more commonly massive. The permeabilities and porosities of the different layers are known to vary with some layers being

[100] An aquitard is strata of low permeability that restricts flow within or across it. An aquiclude is essentially an impermeable strata.

particularly conducive to groundwater storage and transmission[101]. These may be regarded as aquifers.

The Bald Hill Claystone resides at the base of the Hawkesbury Sandstone. This claystone unit is generally recognised as an aquitard which impedes groundwater flow across it. Beneath the claystone is the Bulgo Sandstone, a regionally continuous sandstone unit which can host frequently interbedded siltstone layers. This unit is relatively thick and has been previously used to dispose of waste water using injection wells[102]. The Stanwell Park Claystone resides at the base of the Bulgo Sandstone. This claystone probably acts as an aquitard in its undisturbed state but is a candidate for subsidence induced fracturing above longwall panels. More detailed descriptions are provided in Appendix B of the EA.

The Panel has inspected many catchments hosting shallow groundwater systems and noted the steeply incised terrain, extensive rock outcrop and joint controlled drainage lines associated with Hawkesbury Sandstone terrain. The Panel has also noted the more subdued terrain generally associated with Ashfield Shale catchments. The Razor Back Range situated in Area 8 and Area 9, is an exception where steeper slopes prevail in shale terrain. However drainage lines tend not to be as sharply incised when compared to sandstone terrain to the east (see Chapter 7 for a more detailed overview of surface water systems).

5.2.1. Conceptualised Groundwater Flow Systems

The conceptual hydrogeologic cycle associated with the region was described in the SCI and is adopted herein. Fundamentally, the hardrock systems have been recharged by rainfall and runoff over a very long period of time. This recharge sustains a water table that commonly resides in the shallower strata at elevations equal to or higher than the beds of the creeks and rivers throughout the region. Where the water table is at shallow depths, it is observed to respond quite rapidly to rainfall but with increasing depth, it tends to respond more slowly.

Natural groundwater flow systems are established by the rainfall recharge process. The flow paths within these systems are largely governed by the prevailing drainage lines - groundwater reports to these drainage lines as baseflow from adjacent areas of elevated water tables. Both porous matrix flows and groundwater flows associated with joints, shears and faults, have been identified or inferred in most catchments throughout the Project Area. The deeper matrix type flows are apparently constrained in some areas to near horizontal flows by the presence of aquitards and aquicludes like the Bald Hill Claystone while fracture flows may follow tortuous and somewhat unpredictable pathways.

Swamp lands in upland catchment areas act as water stores and baseflow contributors by virtue of their composition (unconsolidated sandy materials), fabric and location. Rainwater falling on swamps is capable of infiltrating the porous soil matrix if that matrix is unsaturated, or being retarded in its surface flow to the outlet of a swamp system by the presence of dense hydrophidic vegetation.

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[101] See for example the Proposed Kangaloon water supply area. SCA Metropolitan Water Plan Groundwater, Project Technical Reports (2005-2009), Vol.1 and 2.
[102] EA Appendix B, Section 2.11.1

Two categories of swamps were identified in the SCI and are adopted herein. These are the upland headwater swamps located in upper parts of the catchments where topographic grades are generally slight, and valley infill swamps that are situated within established and incised drainage lines. Headwater swamps can occupy very large areas of the upper catchments while valley infill swamps tend to be more localised and elongate depending on the host drainage line. The Panel visited a number of swamps and observed the sandy nature of the contained sediments, the generally limited thickness of sediments (typically 0.5 to 2 m), the often shallow topographic grades, and the presence of dense vegetation (see Chapter 6 on Swamps). Headwater swamps are reported to be perched above the regional water table while valley infill swamps may be partly perched or fully connected to the groundwater table.

5.3. SUBMISSIONS IN RELATION TO GROUNDWATER

- Concerns raised in submissions to the Panel can be categorised into:
- the deep system and the potential for loss of surface waters via connected cracking in the subsidence zone, or the loss of strata pore pressures affecting boreholes or other water supplies;
- the shallow systems and the potential for redirected surface water flows into underlying strata, leading to reduction or loss of flows, degradation of aquatic habitat and impairment of stream water quality;
- the surficial systems and the potential for degradation of swamp lands via changed surface and subsurface flow paths.

While many submissions highlighted specific issues, a number raised concern about the generalised nature of the outcomes from hydrogeologic analyses conducted by ICHPL and the potential for changed conditions in the event of departures from the BSO Base Case mine plan.

SCA noted that the groundwater assessment '*has shortcomings which are likely to result in the failure to identify probable impacts and under-estimate the extent of impacts*'[103]. Particular issues that were identified included insufficient groundwater monitoring, under-estimation of the height of fracturing in the subsidence zone, limited site-specific data, inappropriate groundwater model grid size, inappropriate hydraulic properties adopted in groundwater modelling, and no assessment of perched groundwater levels (swamp systems implied). SCA also maintained concerns previously raised in the Metropolitan Coal Project Review in relation to diversion of surface waters to shallow groundwater systems as a result of enhanced cracking noting that '*SCA is therefore concerned that the Project may reduce catchment yield to Cataract Dam, Woronora Dam and Broughtons Pass Weir*'. Additional to these concerns were important issues relating to surface water quality changes arising from re-directed flows, and the accumulation of metals like iron and manganese as a result of minerals dissolution in the shallow groundwater systems.

DECCW raised numerous areas of concern noting the conceptual nature of the proposal and the limited survey with respect to swamps, streams and related

[103] SCA (2009), p.23.

ecologies[104]. In particular, DECWW noted the sparse monitoring of groundwater interactions for upland swamps and identified potential loss of groundwater associated with mining beneath swamps as a key concern. Swamp 1 located in Area 2 at Dendrobium Colliery was provided as an example where groundwater monitoring piezometers suggest significant draining of contained groundwaters as a consequence of undermining. DECWW suggested monitoring of conditions at a further 5 swamps in Area 3A at Dendrobium which are due to be undermined '*should be used to inform further swamp risk assessment*'[105] prior to any approval to undermine any swamps in the BSO Study Area. In view of the uncertainties in predicting the consequences of mining on the natural features including streams and swamps, DECWW also recommended '*staging of the mining, so that the Eastern domains be delayed until the science of predicting environmental consequence and developing preventative measures, is improved*'.

NOW identified numerous issues relating to surface water impacts /losses and interaction with shallow groundwater systems[106]. In particular '*NOW consider the groundwater impact assessment does not answer very significant questions related to the long term potential impacts... ... and the potential for long term changes in surface/ground water interchange'*. NOW also identified a number of issues relating to computer modelling of the deep groundwater system and potential ambiguities or errors arising from limited extents of the groundwater model and calibration based on a steady state flow system. NOW indicated to the Panel that macro Water Sharing Plans for the Greater Metropolitan Region Groundwater Sources 2010 and Greater Metropolitan Region Unregulated River Water Sources 2020, are imminent. These plans will effectively embargo any further entitlements for extraction (or diversion-loss) under the Water Management Act 2000. This may have implication for ICHPL if it is demonstrated in future monitoring-measurement of surface water systems, that losses in catchment yield are occurring.

Issues arising from Special Interest Groups and the wider public domain overwhelmingly focused on interactions between surface water systems (including swamps) and the shallow groundwater systems. Specific concerns related to changed flows (swamps), diversion and loss of flows in streams, and water quality degradation. Except for the potential loss of borehole water supply yields in the Wedderburn area, issues relating to the deep groundwater systems were not raised. Dr. A. Young also drew the Panel's attention to the potential impacts of mining on swamps[107].

5.4. DEEP GROUNDWATER SYSTEMS ASSESSMENTS

In a mining context, deep groundwater systems once disturbed, are not easily manipulated or engineered to achieve a desired outcome, at least not within a short time frame. Indeed it may take many hundreds of years for a disturbed groundwater system to re-equilibrate after the cessation of mining. Accordingly the depth of study undertaken in characterising and assessing these systems needs to be sufficient to provide a high level of confidence in impact predictions especially with regard to

[104] DECCW (2010c).
[105] DECCW (2010c), p.4.
[106] NOW (2009).
[107] Young (2010).

potential baseflow losses from creeks and rivers, storage losses from swamps and deeper aquifers, and yield reductions at existing bore water supplies. For these reasons, BSO groundwater studies (Appendix B) have been rigorously reviewed by the Panel. The process has involved discussion with the Proponent, field inspections to assimilate the hydrology of differing catchments, inspections of rock core in order to gain an appreciation of strata properties, review of additional data provided by the Proponent, and careful analysis of groundwater flow modelling procedures and outcomes.

The Panel notes that after extensive consultation with Government Agencies, the consensus view held that insufficient study and analyses had been conducted to provide a high level of confidence in the impact predictions relating to the deep groundwater systems. The Panel found that:

1. The density of testing to assess the permeability of subsurface strata (a key property which underpins a groundwater model and the subsequent impact predictions), was entirely inadequate for a project of the scale and magnitude envisaged. Only one borehole was subjected to permeability testing in a Project Area comprising some 220 km^2 and no data were presented in the EA to support such testing. Rather, permeabilities that were subsequently adopted in computer based simulations of the BSO Base Case longwall panel layout, were apparently informed by SCA studies at Dendrobium Mine 12 km to the south, Kangaloon some 30 km distant, Metropolitan Mine a few kilometres to the east (one borehole), and Mangrove Mountain more than 100 km to the north-east;

2. The expected height of connected (drainable) fracturing within the subsidence zone was poorly defined. The height of this zone is noted to be in the order of 130 m at Metropolitan Colliery where a panel width of the order of about 140 m was employed. The actual height of connected cracking adopted for the Base Case layout is not reported but has apparently been inferred from groundwater model simulations and calibrations. The increased ICHPL Base Case panel width of 310 m (compared to 140 m at Metropolitan Colliery) together with a stated height of fracturing of 385 m suggested to the Panel that the drainable fractured zone might logically be greater than the 130 m;

3. Computer simulations of the deep groundwater systems reported in Appendix B of the EA, illustrate a subsidence zone which does not exhibit any strata desaturation above extracted panels. This scenario conflicts with reported groundwater modelling studies at the nearby Metropolitan Colliery[108] where a zone of desaturation was predicted to extend upwards from the Bulli Seam into the Stanwell Park Claystone. The Panel therefore concluded that the negligible desaturation of strata above mined panels (as represented in the BSO groundwater model) was implausible. In contrast, model results showed complete desaturation of strata to a depth of at least 40 m below the Bulli seam floor, reflecting a seemingly unrealistic situation – pore pressures would normally be zero at the seam floor with increasing pressures below the floor. The Panel also considered this scenario to be implausible;

[108] Re-modelling of Metropolitan Colliery Impacts, 2009.

4. The groundwater model extents (perimeter boundary) appeared to be insufficient to accommodate the calculated depressurisation regime, potentially influencing the depressurisation of strata in internal parts of the model in an ambiguous way;

5. Model calibrations were based on steady state conditions which essentially replicated a situation which was unchanging in time. Mining operations and the induced strata depressurisations are changing continually and the Panel therefore considered this type of calibration to be unacceptable in view of the long history of mining in the region;

6. The groundwater model failed to properly account for cumulative impacts of surrounding mining operations including operations at Metropolitan, Bulli and Tahmoor Collieries. Inappropriate model storage (porosity) parameters were found to have been adopted in the model resulting in substantial or complete recovery from groundwater impacts related to these operations within a completely unrealistic period of less than 5 years. Recovery of impacts from BSO operations was also noted to be more rapid than experience would suggest;

7. Modelling results inadequately quantified impacts on baseflows for many of the drainage systems and swamps.

Given the numerous issues and identified problems with respect to groundwater assessments, and the identified abnormalities in the groundwater model, the Panel indicated to ICHPL that the reported studies were considered to be inadequate for assessment purposes. The characteristics and impacts of strata depressurisation, impacts of that depressurisation on shallower groundwater systems and on surface drainages and swamps could not be sensibly assessed from the information provided.

5.4.1. Additional Groundwater Studies Conducted by the Proponent

In response to questions posed by the Panel, the proponent undertook a number of additional studies including:

- a review of reported and measured heights of fracturing in the subsidence zone;
- core sampling and testing to expand the knowledge base with respect to strata hydraulic properties (permeability and porosity);
- modifications to the groundwater model.

The additional studies have not been consolidated into a summary report. The Panel has therefore had to formulate its views in relation to deep groundwater systems by relying in part upon the reported studies in the EA and in part upon the answers to questions asked of the proponent.

5.4.2. Height of Fracturing in the Subsidence Zone

ICHPL provided an expanded review of the height and nature of fracturing within the subsidence zone. A critical analysis (by the Panel) of that review has been addressed in Chapter 4. While the proponent's review is less than convincing, it is acknowledged by the Panel that given the weight of empirical data, the height of fracturing may well extend to 385 m above the Bulli Seam for the Base Case panel layout, but the height of *connected and relatively free draining* fracturing is likely to be lower than 385 m since the frequency and magnitude of vertically transmissive fractures which provide the connectivity, tend to diminish with increasing height.

There is a distinct lack of deep pore pressure monitoring within strata overlying ICHPL subsided areas which might cast some light on the groundwater flow systems and the height of free drainage within the subsidence zone. The nearest observations which provide a continuous vertical profile record above a previously mined longwall panel are reported to be those associated with borehole LW10 at Metropolitan Colliery but at that site, monitoring only extended down to the Bulgo Sandstone. In response to Panel questions, ICHPL note that monitoring results for LW10 indicate the '*highly connected fractured zone extends to the vicinity of the Stanwell Park Claystone (approximately 130m above the mined seam)*'[109]. At this location the depth of cover is 460 m and the extracted panel width was 140 m. Groundwater flow is inferred to be downwards within the Bulgo Sandstone but since there are measurable pore pressures in the sandstone, it is inferred that the Stanwell Park Claystone acts as an aquitard.

Injection trials into the Bulgo Sandstone together with limited monitoring data from an extensometer installation above LW32 at West Cliff[110] also suggests the Stanwell Park Claystone may act as an aquitard that would impede desaturation of overlying strata. However, another ICHPL vertical array piezometer identified as S1997 located near to the old Darkes Forest Mine, exhibits an increasing loss of pore pressure from the shallowest piezometer in the Hawkesbury Sandstone to the deepest piezometer in the Bulli Seam. Pressure loss at the base of the Bulgo Sandstone and below the Stanwell Park Claystone appears to be of the order of 200m head of water indicating the Stanwell Park Claystone may not be an impediment to downwards flow[111] in subsided areas.

While there remains some doubt as to the hydraulic connectivity within the fractured zone and hence the specific height of a freely draining zone for longwall panels up to 310 m wide, the Panel accepts that the available (but limited) monitoring history suggests the desaturation interface (zero pore pressure) is most likely to remain below the Bald Hill Claystone and possibly below the Bulgo Sandstone in the course of time. However, the Panel also notes that there is an extremely sparse knowledge base and limited understanding of the connectivity and drainability of groundwaters contained within this zone. Increased longwall panel width is likely to increase the height of the freely draining fracture zone and so lead to more widespread reductions in strata pore pressures.

5.4.3. Increased Sampling of Strata Hydraulic Properties

In addressing Panel questions relating to hydraulic properties sampling, ICHPL undertook additional core analyses at 10 locations, 8 being within the Project Area. Of these 10 locations, only one fully cored borehole identified as S2037 and located

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[109] DECCW (2010c), p.16.
[110] Shen et al (2010).
[111] DECCW (2020c), p.75, Figure 51.

in Area 9, seems to have provided information from the Hawkesbury Sandstone down to the Coal Cliff Sandstone-Bulli Seam. The remaining locations are understood to have been only partly cored and as such, only discrete stratigraphic sections below the Bulgo Sandstone appear to have been sampled and tested.

Information relating to laboratory measured permeabilities and porosities has only been supplied to the Panel in the form of summary statistics[112]. Specific core depths and lithological descriptions have not been provided. It has therefore been difficult for the Panel to correlate permeability values with specific rock types, and to assess regional variance in hydraulic properties and its relevance to the groundwater modelling effort. In addition, very limited geophysical wireline logging data has been supplied in response to requests and as such, it has not been possible for the Panel to gain an appreciation of the distribution of geophysical properties that might correlate to strata hydraulic properties within particular formations like the Hawkesbury or Bulgo sandstones, or to consider the continuity or otherwise, of such properties in a regional context.

Notwithstanding the data limitations and the manner in which the data has been provided, the results of the core testing program tend to support a regime of generally low permeabilities with occasional high permeability strata. The Panel believes the range of values point to the likelihood of low rates of groundwater flow in undisturbed deeper strata which are likely to impede strata depressurisation that might otherwise impact upon surface water resources in a measurable way.

5.4.4. Modifications to the Groundwater Model and Revised Outcomes

ICHPL has generated a revised groundwater model. The model extents and number of layers have been increased, hydraulic properties distributions amended, and transient calibrations conducted in response to Panel concerns.

The proponent has utilised the revised groundwater model in responding to questions but has not indicated that the revised model supersedes the model reported in the EA. Indeed in responding to some questions posed by the Panel, there is a continuing reference to the model reported in the EA while in responding to other questions, the revised model takes precedence. In the absence of any clear direction from ICHPL, the Panel has assumed the revised groundwater model supersedes the model provided in the EA.

In developing the revised model the proponent has utilised hydraulic properties data derived from limited core testing. This has resulted in a general reduction in the adopted values for strata permeabilities with the revised model being based on a vertical permeability distribution (governing the rate of downwards flow) that is typically between 5 and 75 times lower than the model presented in the EA. The revised model also includes a gradational trend in fracture (subsidence) zone permeability from the highest enhancement value at the coal seam, to the lowest enhancement in the Bulgo Sandstone. This 'ramp' is considered by the Panel to more appropriately reflect the fracture connectivity regime than the distribution employed in previous modelling, and is more likely to promote the upwards migration of a zero pore pressure interface within the subsidence zone. While these changes represent

[112] DECCW (2010C), p.35.

significant departures from the original EA model, they appear to be more consistent with measured properties and field observations.

Transient calibration of the revised groundwater model has apparently been undertaken for a 40 year period of mining commencing in 1969. The calibration has been demonstrated in the form of matching of observed and calculated vertical head profiles at 10 piezometer locations over a limited period of observation from mid 2007 to the first quarter of 2009, together with matching of mine water seepage rates at four sites.

Revised model outputs have been generated to illustrate the strata depressurisation impacts likely to result from the Base Case layout. These impacts are indicated on Figure 48c[113], which clearly illustrates regional depressurisation of the Bulli Seam extending from Metropolitan Colliery in the east, to Tahmoor Colliery in the west; BSO and existing-historical mining operations at West Cliff, Appin, and Appin West exhibit a merged and continuous head loss regime consistent with the expected cumulative impacts.

The most common and widely accepted means of assessing predicted impacts of mining on the hydrogeologic systems is through the calculation of drawdown from the model outputs. That is, the impacted piezometric surface at any time during or after mining, is subtracted from the pre-mining piezometric surface to derive the difference. Unfortunately, ICHPL has provided impact drawdown plots calculated as the difference in piezometric heads immediately prior to simulating the Base Case, and heads generated by the Base Case mine plan. By adopting this procedure, the reported impact plots do not show the substantive cumulative impacts resulting from the long history of mining in the region prior to simulation of the Base Case. Hence historical areas of mining and areas currently being mined, appear to exhibit no impacts when represented as drawdowns[114]. It is therefore not possible to assess in a robust way, the likely magnitude and extent of cumulative impacts arising during the period of mining. Instead the Panel has relied upon the 'differential' drawdown impacts provided by the proponent in the interest of progressing the assessment.

Revised drawdown plots generated for the end of mining differ significantly from plots provided in the EA. An example can be found in the lower Hawkesbury Sandstone where numerous existing boreholes were identified by the proponent as being at risk. Figure 20 provides output from the EA[115] which clearly shows significant drawdown attributed to mining in Area 8 and Area 9 with a maximum 26 m indicated in the north-eastern part of Area 8. The remainder of the Project Area exhibits drawdowns (relative to the commencement of the Base Case mining) of the order of 1 to 4m. The consequences of significant drawdown relate almost entirely to bore water supplies insofar as there may be significant loss of yield at boreholes situated within this province.

In contrast, Figure 21 provides output for the revised model which shows much reduced drawdowns ranging from 3 to 8 m in Area 8 and Area 9 or about one third the impacts represented in the EA. However, a significant drawdown of up to 26 m is

113 DECCW (2010c), p.71.
114 DECCW (2010c), pp.54-59, Figures 31 to 36.
115 EA, Appendix B, Figure 57,

indicated adjacent to and north of Area 3, and extending southwards into Area 3. This feature is reportedly associated with the Bulgo Sandstone injection trial (decay of the elevated pore pressure regime following cessation of injection) and should not affect other stakeholders. ICHPL seem to have inadvertently omitted the injection trials from the original modelling. The much reduced drawdowns in Appin Area 8 and Area 9 suggest yield related impacts on the 40 identified boreholes[116] accessing groundwater from the lower Hawkesbury Sandstone would be significantly reduced but not removed when compared to the original EA predictions. Boreholes located in shallower strata are unlikely to be yield affected according to the revised model.

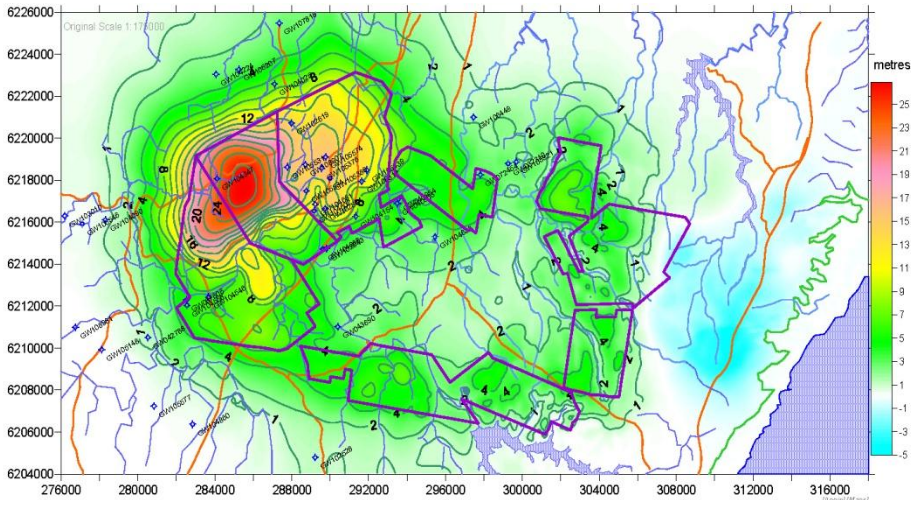

Figure 20: Differential drawdown in lower Hawkesbury Sandstone[117]

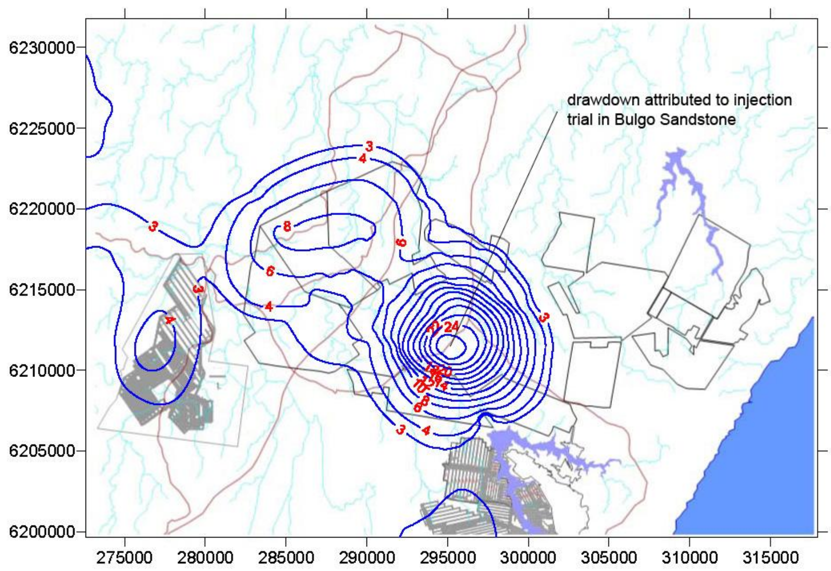

Figure 21: Revised differential drawdown in lower Hawkesbury Sandstone[118]

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116 EA, Appendix B.
117 EA, Appendix B, Figure 57.

118 EA, Appendix B, Figure 36.

Mine inflows generated by the revised model are broadly similar to inflows previously reported. Accordingly the mine water balances are expected to remain close to the range previously reported.

Impacts on baseflows to surface drainages and swamps have been re-assessed by ICHPL in response to Panel questions[119]. These impacts potentially arise from depressurisation within the deep groundwater system resulting in loss of piezometric head in the water table which translates to a reduction in the baseflow contribution to surficial systems and swamps. In respect of major streams and rivers, ICHPL predict a reduction in baseflows but the reported outcomes from the revised modelling are lower than those provided in the EA. Reported baseflow changes in Table 9[120] are not easily equated to the characteristics of a particular drainage system. One measure compares the losses to catchment area which loosely correlates to runoff. Calculations based on catchment area indicate that all baseflow losses are likely to be small and inconsequential. The Panel concurs with these findings.

Recovery of pore pressures throughout the strata has been addressed in the revised model. Reported outcomes differ significantly from those reported in the EA as a result of changed model porosities in the coal seam and overlying layers. These changed porosities are mostly associated with the open voids created by roadways and headings, and the fragmentation of collapsed roof materials in goaf. Revised results indicate a period of 200 to possibly more than 400 years for full recovery of pore pressures in stark contrast to predictions made in the EA. The Panel concurs with these findings.

With respect to the above noted findings, and findings summarised in Chapter 5 the Panel recommends the following studies be undertaken prior to the preparation and submission of any longwall panel Extraction Plan. The purpose of these studies is to improve the accuracy of prediction of impacts in order to ensure they remain within any Performance Criteria established as part of an Approval. The Panel recommends studies in relation to the following issues pertaining to deep groundwater systems:

- While the number of bore locations at which permeability tests have been conducted, has been increased from 1 to 11, the Panel considers this to be an under-sampling for the proposed extent of mining. Further core sampling and hydraulic properties testing should be undertaken to validate assumptions with respect to regional continuity of those properties, particularly in the North Cliff area where no hydraulic properties testing has been conducted;
- The Panel considers that any predicted vertical drainage induced by mining, should be confined to strata below the Bald Hill Claystone or to drainage rates that will have no impact on surface water resources or dependent ecosystems. In order to establish the mining parameters that will achieve this, the Panel recommends the establishment of a network of pore pressure monitoring bores and vertical arrays of pore pressure transducers, to assess/quantify the height of connected and freely drainable fracturing as recommended in Chapter 5.2.1.2. Installations should be targeted above extracted panels with similar dimensions to the proposed Base Case layout;

[119] Specifically Question 28.
[120] Table 9, in Response to Panel Questions Part 2.

- The predicted (revised) drawdowns in the Hawkesbury Sandstone may still affect the yield of bore water supplies and certain locations may also be affected in the long term after cessation of mining. A borehole census should be conducted on all potentially yield (or structurally) affected boreholes, and a long term monitoring program initiated. The census should catalogue bore location, construction parameters, pumping equipment and usage together with any other parameters considered necessary in the event of water supply replacement. Monitoring should include depth to standing water, basic water quality parameters (pH and EC), ionic speciation and any other parameters necessary to characterise the location to the satisfaction of the Director-General of the Department of Planning. Monitoring data should be regularly reviewed and trends in water levels and water qualities assessed using appropriate methodologies to establish the likelihood of sustained long term impacts on yield. The Panel notes that ICHPL have provided a commitment to repair, replace or compensate any landholder suffering partial or complete loss of productive yield. Such commitment must include provision for post mining conditions.[121]
- In view of the numerous abnormalities identified in (EA) modelling outcomes, and the marked changes in outcomes reported for the revised groundwater model, the Panel also recommends a comprehensive independent audit of the revised groundwater model be undertaken.

5.5. SHALLOW GROUNDWATER SYSTEMS

Shallow groundwater systems impacts are addressed in various parts of the EA including Appendices A, B and C. They include potential impacts associated with surface flow diversions along stream channels, and potential impacts associated with swamp systems. ICHPL acknowledge the likelihood of these impacts and have designed the Base Case longwall layout to mitigate impacts on rivers. However numerous 3rd and higher order streams and many swamps and lower order streams that provide baseflow from swamps, are proposed to be undermined.

The Panel has considered the associated groundwater systems and impact consequences with respect to swamps and streams (diverted flows). Detailed findings are provided in Chapter 6 (Swamps) and Chapter 7 (Surface Water and Aquatic Ecology).

5.5.1. Diverted Waters in Upland Swamps

Upland headwater swamps constitute a large part of the North Cliff Area and Appin Area 2. These swamps which dominate the Woronora Plateau and large areas of the SCA Special Areas and Dharawal State Conservation Area, act as significant regional water stores providing baseflow to the drainage systems of the plateau.

The porous matrix of swamp soils is comprised of unconsolidated sands derived from weathering of the Hawkesbury Sandstone, and peaty matter. These materials are limited in thickness from less than 0.5 m to typically no more than about 2 m above

[121] Pore pressure losses are predicted to continue for many years after cessation of mining before recovery commences. This may affect certain borehole supplies accessing groundwater in deeper parts of the Hawkesbury Sandstone or below the Bald Hill Claystone.

the sandstone base. They serve to retard catchment runoff by infiltration of rainwater during rain events (until runoff is initiated) and exfiltration of stored groundwater after those events. This groundwater contributes to downstream baseflow. During dry or drought spells, exfiltration is likely to occur progressively down slope with the most elevated and peripheral parts of a swamp draining first. This process will be governed to a large extent, by the topographic grade, saturated thickness and hydraulic properties of the soils, and the prevailing floral habitat. In sustained dry spells, baseflow may fall to very low levels, especially where swamp size (aggregated within a catchment) is low and the material thickness is small.

The SCI noted that upland headwater swamps are generally perched systems based on information supplied to it. ICHPL also state in Appendix B and Appendix C and elsewhere that the swamps in the Project Area are perched and are '*independent of the regional water table in the underlying Hawkesbury Sandstone*'. The Panel has not been provided with any data that establishes such independence for swamps. Indeed the Panel finds it disturbing to note that no groundwater monitoring has been instigated on any swamp within the Project Area. Rather, perching and independence seem to be inferred from piezometric monitoring data in the Kangaloon area some 30 km beyond the Project Area to the south.

Potentially, the headwater swamp systems while contributing to baseflow in surface drainage systems, could also contribute significantly to the deeper regional groundwater systems when it is considered that:

1. the swamps are saturated water stores that are essentially permanent, and

2. they provide a sustained driving head for downwards migration of water into the underlying sandstones which are semi-perveous, and

3. downwards seepage may be very significant where swamp lands occupy large areas, especially within North Cliff Area and eastern parts of Area 2. This contribution would logically support regional groundwater flows within the Hawkesbury Sandstone.

It is possible that a number of upland headwater swamps are also directly connected to the underlying hardrock groundwater system (rather than being perched) since they occupy very large areas of the Woronora Plateau.

The valley fill swamp systems within the BSO Study Area probably exhibit slightly greater sediment thicknesses than headwater swamps simply because they occupy more incised parts of the stream systems. They are also more likely to be connected to the groundwater systems.

The Panel regards the hydrology of swamps to be especially vulnerable in view of their thin plate-like structure extending typically over areas of 1 ha or more. Indeed the Panel observed a number of areas where the sediment thickness appeared to be less than 0.5 m. Any subsidence induced changes of this magnitude would clearly have the potential to impact upon the hydrology of swamps as would any diversion or loss of water via subsidence induced cracking in the sub-strata. Diversion of flows may in turn have implication for downstream water quality in a similar manner to that observed for surface streams. These issues are dealt with in Chapter 6.

5.5.2. Diverted Flows in Surface Streams

The SCI and Metropolitan PAC assessments provide a comprehensive overview of the impacts of subsidence on streams:

- *Draining of rock pools as a result of rock bar cracking*, leading to partial or complete loss of aquatic habitat. The rate of draining of a pool is governed by the extent and connectivity of cracking in a rock bar and underlying strata which in turn is governed by many parameters, some of which were outlined in Chapter 4.
- *Diversion and loss of surface flows over significant sections of streams* via an extended subsurface network of connected cracks. This process can be naturally occurring or be stimulated by subsidence. Both have been observed by the Panel however diversions resulting from subsidence are more common and generally coincidental with numerous fresh and commonly unweathered crack faces. Appendix B of the EA reports that such systems show a variable response to deep mining which depends '*on the randomness of surficial cracks or bedding plane separations*'. Mining induced diversions with complete loss of flow over stream lengths of more than 100 m can be observed in Lizard Creek and over shorter distances in Waratah Rivulet and numerous other channels. Permanent losses may also be generated but the extent to which this is occurring is the subject of considerable debate. SCA have highlighted the probability of such losses in Waratah Rivulet through analysis of stream flow records. NOW has also pointed to the possibility of these same losses. An alternative view was advanced by Peabody Resources[122] in the course of the Metropolitan PAC based on catchment runoff modelling. That view held that no permanent losses could be identified. In the Panel's view the issue remains unresolved.
- *Iron staining resulting from water-rock geochemical interactions*. The process is based upon the dissolution of iron bearing minerals like marcasite, hematite and siderite, by stream waters migrating along new sub surface fracture pathways and emerging (as springs) at some point downstream. Where the redirected waters emerge as surface flows, the iron precipitates in the form of oxy-hydroxides leaving the characteristic iron staining. SCA notes that manganese dissolution and precipitation accompanies iron dissolution, and that remobilisation of both iron and manganese may be contributing to an increasing presence in the sediments of Woronora Reservoir. [123]
- *Bacterially mediated opaqueness of pooled (stagnated) waters*. During periods of low or intermittent stream flow, the presence of iron oxidising bacteria often results in the growth of bacterial mats on submerged litter and plants. This matting also leads to reduced oxygen levels and discolouration of pooled water. The recurrence of continuous flows can remove the matting and clarify stream waters.

These issues are dealt with in more detail in Chapter 7.

[122] The Proponent for the Metropolitan Coal Project.
[123] SCA (2010), p.17, response to Question No. 6.

6.0 SWAMP IMPACTS AND CONSEQUENCES

6.1. INTRODUCTION

The Woronora Plateau contains the largest concentration of upland swamps on the Australian mainland, with 226 of these identified in the BSO Project Area. The vast majority of these 226 are found in the North Cliff and Area 2 mining domains, Figure 22. These upland swamps have been raised as a significant issue in the EA, in government agency submissions and in public submissions.

This Panel has been presented with a substantial volume of written material and strongly conflicting opinions on the potential impact of mining on upland swamps. The Panel has therefore had discussions with the Proponent's experts, government agency experts (SCA, DECCW) and an independent expert. The Panel also sent formal requests for additional information to the Proponent and to government agencies.

6.2. DESCRIPTION OF UPLAND SWAMPS

The Southern Coalfield area contains numerous habitat areas defined broadly as *'upland swamps'*. These swamps are identified by their distinct wetland vegetation composition (primarily sedges and heaths), compared with the surrounding dry sclerophyll forest which occurs on the better-drained ridge-tops and hill slopes. They are mostly hosted on Hawkesbury sandstone and can be classified broadly into *'headwater'* and *'valley infill'* swamps.[124]

Headwater swamps occur in the higher catchment reaches and systems where relatively shallow topographic grades prevail. Rainfall usually exceeds evaporation in these swamps and, as a result, there is a perched water table within the sediments that is independent of the regional water table in the underlying Hawkesbury sandstone.[125] In headwater swamps the degree of saturation varies, depending upon climatic conditions. During and following rainfall events, surface runoff prevails. As runoff recedes, groundwater seepage dominates through gravity drainage towards the lowest drainage point in each particular swamp. It is this drainage which, importantly, contributes to downstream baseflow within the host drainage system. There are six different vegetation associations found in headwater swamps.

Valley infill swamps occur within well-defined drainage lines in the more deeply incised valleys. Their formation may be associated with sediment deposition behind temporary barriers (e.g. log jams) or steps in the underlying substrate where the gradient suddenly becomes steeper. They may receive water from multiple sources (e.g. rainfall, streamflow, and groundwater seepage) and may also be in contact with the regional water table in some cases. Only two of the six vegetation associations found in headwater swamps are generally found in valley infill swamps.

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[124] DoP (2008), p.16.

[125] Whilst this is the 'conventional wisdom' reported in the SCI and there is evidence for this perched water table from a very limited number of investigations, the Panel is not aware of any substantial studies that confirm this situation for a large number of swamps. It may well turn out to be the case that some of these swamps have very little or no independence from shallow groundwater systems.

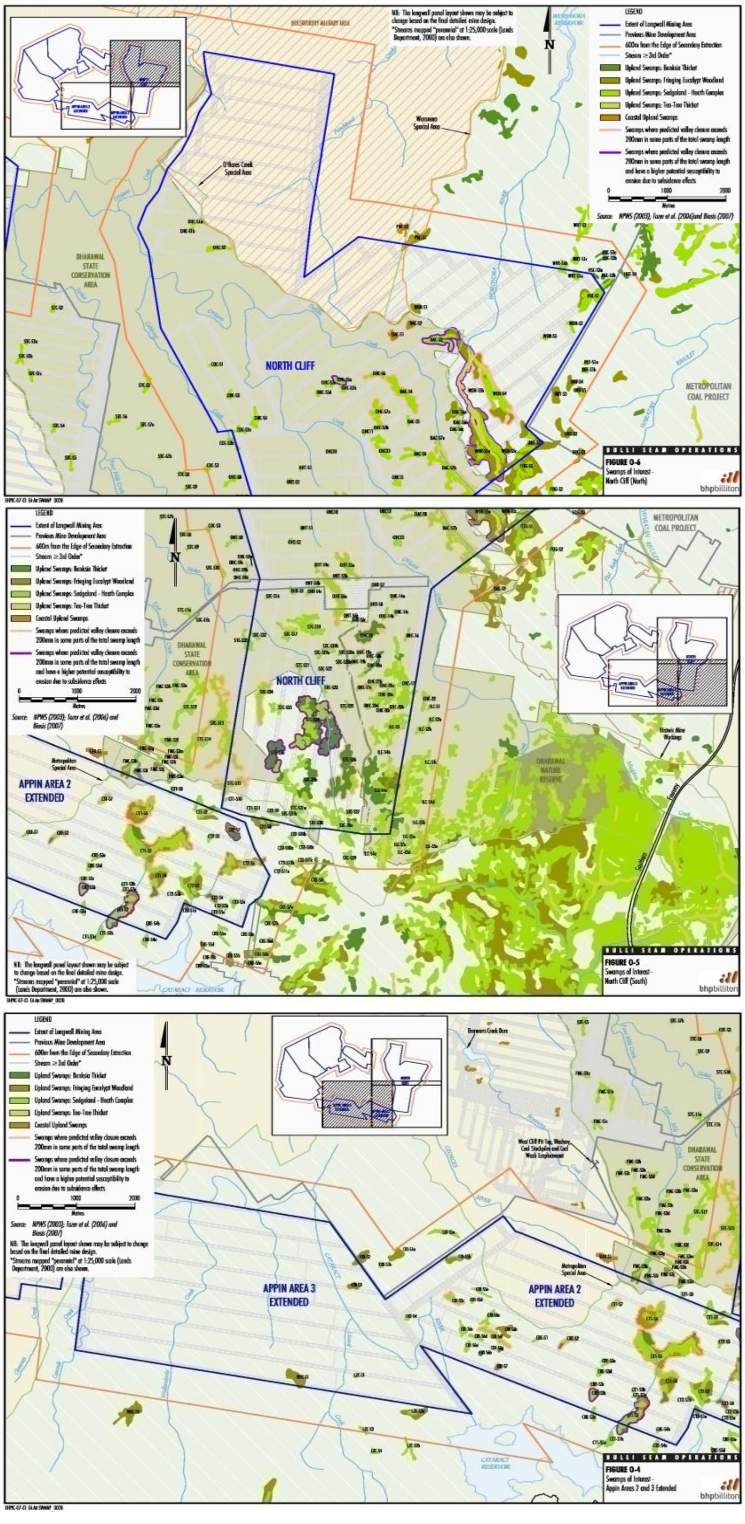

Figure 22: Distribution of Swamps in North Cliff and Area 2 Mining Domains[126]

[126] Reproduced from Appendix O of the EA.

As with any sub-classification along an ecological continuum, some characteristics overlap between upland swamp categories and some of the larger swamps may be clearly headwater in one part, transitioning to valley infill in another.

The swamps in the BSO Study Area vary substantially in size and complexity, (Figure 22). The EA for the Metropolitan Coal Project Proposal utilised the distinction between headwater and valley infill swamps extensively to demonstrate that swamps in the Metropolitan Study Area were not valley infill and were, therefore, less likely to suffer negative environmental consequences. Thus, it was of some interest to the Panel to note that the EA for the BSO Project Proposal did not seek to make the distinction between headwater and valley infill swamps in the BSO Study Area and that ICHPL reinforced this in its response to submissions.[127] The answer may lie in the very large number of swamps (115) *'which are located near the bases of valleys within the Study Area'*[128]. This is over 50% of the 226 swamps in the BSO Study Area.

All upland swamps are considered by the Panel to be fragile groundwater systems in so far as their sediment thickness is typically between 0.5 and 2 m while their areas are commonly more than 1 ha (10 000 m^2). They are, in effect, very thin plate-like aquifers.

6.3. POTENTIAL IMPACTS ON UPLAND SWAMPS

6.3.1. Subsidence Effects

The assessment of the exposure of swamps to subsidence impacts is reliant on the adequacy of the prediction of these effects and the manner in which this information has been analysed to predict impacts. The EA for the BSO Project contains deficiencies in both these aspects and this has created considerable confusion amongst a range of stakeholders. The Panel sought clarification from ICHPL on a range of these issues and undertook a considerable amount of analysis in order to try and better understand them. The following are some of these issues as they relate to assessing subsidence impacts on swamps:

1. The calculation of strain. As already noted, Appendix A (Subsidence Assessment) of the EA does not report predictions of strain, a fundamental parameter when assessing subsidence impacts. Instead, it presents predictions of maximum curvature. The Panel requested ICHPL to express all curvatures in the EA as strains, which was done by multiplying maximum curvatures by a calibration factor of 15, based on Figure 11.

   Whilst Table D.2 of Appendix A presents predicted *maximum* subsidence effects at each swamp without any mention of strain, Attachment OB of Appendix O does present strain predictions. However, these are referred to as *estimated average strain* predictions. The use of the term *average* strain has introduced an additional source of confusion. Confusion around both these

[127] ICHPL (2010c), p.16.
[128] EA, Appendix A, p.93.

issues is evident, for example, in DECCW's second submission to the PAC, in which it states that:

> *'the method [used in the BSO EA] does not appear to use an incremental profile method where predicted peak strains should be provided rather than average strain across an area, as used in this EA'*

and

> *'The subsidence prediction method used in the EA is different to that used for the Metropolitan Coal Project.............the Department requests a clear explanation of why the change has occurred'*[129]

In its response to DECCW's submission, ICHPL has pointed out that conventional (systematic) strain can be calculated by multiplying curvature by a factor of 15. ICHPL's response does not address the discrepancy regarding *average* strain and *maximum* strain. The Panel can confirm that the maximum conventional strains predicted for the Metropolitan Coal Project were based on this same methodology of multiplying curvature by a factor of 15. However, the use of the term *average* strain in the BSO Project is erroneous and should more correctly be referred to as predicted *maximum* strain.

DECCW has also expressed concern that most of the data points on which predictions have been based relate to mine layouts in which panel widths were considerably smaller and interpanel widths considerably larger than in the BSO Project.[130] This is probably correct but because the strain prediction methodology is based on an upper bound approach, it is likely that the maximum predicted values of strain are based on the more extreme mining dimensions employed in the Southern Coalfield to date. Nevertheless:

- The Panel does not accept without qualification, ICHPL's response to DECCW that:

  '...this linear relationship [between curvature and strain] provides a reasonable estimate of strain, and is particularly conservative at higher levels of hogging and sagging curvature'[131].

  As reference to Figure 11 shows, the relationship does not provide an upper bound prediction of tensile strain.

- The Panel is concerned that end-users are aware that although strain predictions in the EA have been based on an upper bound approach, they are only relevant to the Base Case layout. Longwall panel width is open-ended in the future. An increase in longwall panel width to 500 m, for example, could result in up to a 40% increase in strain, Table 3.

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[129] DECCW (2009b), p.3.
[130] DECCW (2009b), p.3.
[131] ICHPL (2010c), p.5.

1. The EA provides no points of reference as to the significance of either predicted conventional curvatures or predicted conventional strains. This is despite the EA relying on tensile strain as a criterion for assessing risk associated with undermining swamps. The Panel reverted, therefore, to points of reference for strain provided in the EA for the Metropolitan Coal Project, namely:

   'Fracturing of sandstone has generally been observed in the Southern Coalfield where the systematic tensile and compressive strains have exceeded 0.5 mm/m and 2 mm/m, respectively'[132].

   The Panel has assumed that a similar approach was adopted by ICHPL in respect of tensile strain in the Upland Swamp Risk Assessment (Appendix O), where an *average tensile strain* (once again, erroneously named) of 0.5 mm/m has been applied without explanation as a criteria for assessing risk to swamps presented by subsidence.

2. The EA provides no points of reference as to the significance of non-conventional strain. The Panel notes that the Swamp Matrices presented in Attachment OB of Appendix O report both *Maximum Predicted Closure (mm)* and *Maximum Observed Closure Strain (mm/m)*[133]. The inclusion of maximum closure strain as a subsidence effect parameter is considered to be a significant and valuable advancement in subsidence prediction and is discussed in more detail in Section 6.4.1. However, because it has not been correlated to some measure of impact, the Panel has only been able to make limited use of this information when assessing impacts and consequences.

   The Panel notes that the higher levels of *Maximum Observed Closure Strains* fall into one of three categories, being 9.5 mm/m, 13.5 mm/m, and 20 mm/m of strain and that these categories are distinguished by being highlighted in green in Attachment OB. The EA does not provide an explanation for the colour coding or a discussion of the significance of these closure strain predictions. The Panel can only hazard an educated guess that the green highlighted values have been distinguished as such because they exceed the maximum predicted non-conventional strain of 8.9 mm/m for swamps in the Metropolitan Coal Project[134].

6.3.2. Subsidence Impacts

In the absence of mine-related surface works or other direct disturbance, the primary source of any impact on swamps in the BSO Project Area will be subsidence. In addition to the preceding discussion on subsidence, it has been dealt with at length in the report of the SCI, in the Metropolitan PAC Report, in the EA for the BSO Project, and in Chapter 4 of this report.

[132] EA for Metropolitan Coal Project, Appendix A, p.88.
[133] The concept that closure strain has already been 'observed' at swamps that are yet to be undermined is another concept that has confused some stakeholders, accounted for in part by an incorrect reference in Attachment OB as to where the concept is explained in the EA. It is based on closure strains measured in the past across valleys of an *equivalent valley height* to those associated with each respective swamp. The correct reference to the source material is Section 4.6.4 of Appendix A.
[134] EA for Metropolitan Coal Project, Appendix A, p.97.

For swamps to experience adverse environmental consequences, changes to swamp hydrology would have to occur that were large enough and of sufficient duration to create conditions that were favourable for drying, erosion, fire, or changes in species composition. In the case of species compositional change, there may be a substantial biological lag (up to decades) before any impact is apparent.

Three broad mechanisms by which subsidence could cause changes in swamp hydrology were identified in the Metropolitan PAC Report. The first two of these are caused by conventional subsidence and the third is caused by non-conventional subsidence (valley closure and upsidence). Additional mechanisms that must be added to the conventional subsidence group are:

- Fracturing of the bedrock beneath a swamp as a result of systematic compressive strain. This can result in a fissured failure plane within the bedrock and buckling of near surface strata, which although under compression, may promote increased permeability of fractures. Once the subsidence wave has passed through a compressive zone and the strata relaxes, the permeability of fissured failure planes can be expected to increase further. It is highly probable that such planes will provide a pre-existing surface for any subsequent tensile strain to concentrate[135].
- Reduction in the elevation of the water table in a subsided area of a swamp, relative to an unsubsided area leading to a localised redistribution of groundwater. One potential consequence of this is a favouring of some existing and/or new vegetation associations both within the subsided swamp and around the un-subsided flanks of a swamp.

These mechanisms can be summarised in terms of impact pathways as follows:

1. The bedrock below the swamp cracks as a consequence of tensile or compressive strains and water drains into the fracture zone. Here the fracture zone provides enhanced storage and the water loss impact may be temporary[136] until the storage is filled.
2. The bedrock below the swamp cracks as a consequence of tensile or compressive strains induced by conventional and non conventional subsidence processes and water drains into the fracture zone. If the fracture zone is connected to a source of escape (e.g. a deeper aquifer or bedding shear pathway to an open hillside) then it is possible for sufficient water to drain to alter the hydrologic balance of the swamp. This pathway is considered to be similar to re-directed flows encountered beneath stream channels in the region.
3. Some parts of the swamp subside more than others (e.g. a longwall only impacts part of a large swamp or a series of longwalls have different impacts on parts of a swamp), causing the elevation of the water table to drop in the subsided area relative to surrounding areas, so leading to localised redistribution of groundwater. This could result in the favouring of some existing and/or new vegetation

[135] This mechanism did not feature in the Metropolitan Coal Project because the maximum predicted systematic strain for this Study Area was less than 2 mm/m.
[136] Depending upon prevailing climatic conditions – eg. the effects of drought may be exacerbated

associations over others, both within the subsided section of the swamp and around the flanks of the subsidence area.

4. Tilting of sufficient magnitude occurs to either re-concentrate runoff leading to scour and erosion, potentially allowing water to escape from the swamp margins (possibly affecting the whole swamp) or to alter water distribution in parts of the swamp, thus favouring some vegetation associations over others.

Consequences of these impacts depend upon a wide variety of factors such as how much water is lost, over what period, whether 'self-healing' occurs and to what degree, and whether there are severe rainfall events or fire events. Depending on these factors and their interactions, a swamp could show no evidence of change, or be severely damaged over a relatively short space of time.

6.3.3. Information Available on Undermining of Upland Swamps

The impacts and consequences for upland swamps associated with longwall mining have been examined in the reports of the SCI and the Metropolitan PAC. In both cases, the reports noted the lack of robust scientific information that would support a conclusion about the relationship between longwall mining, risk of impact and possible consequences.

Those in favour of the low or no risk view base their case on the fact that many swamps have been undermined in the Southern Coalfield without apparent impact. Where impacts have occurred they have argued that there were other factors present (pre-existing scouring, erosion, drought etc) and mining could not be judged to be the cause. There are a number of problems with this view.

The first problem is that there is no long term robust scientific information showing before and after mining outcomes for swamps and, as yet, there is no accepted approach to obtaining it. The approach adopted in the EA was to walk the length of a select number of undermined swamps and record *'significant'* negative environmental consequences, including buckling/cracking, erosion or scour, vegetation dieback, or dessication of vegetation or peat materials on a broad scale. The EA notes that:

> *'It is recognised that there are limitations associated with the assessment …*
>
> *No carefully designed quantitative monitoring program has been implemented. As such, the assessment of environmental consequences is based on anecdotal observations …*
>
> *Evidence of cracking and minor erosion was observed during the site inspections, however no evidence of significant*[137] *environmental consequences was observed.'*[138]

The second problem is that most of the swamps that have been undermined previously were undermined by either bord and pillar techniques or much narrower longwall

[137] *'significant'* is not defined, although it appears many times in the quoted criteria. There is no information concerning the rigour of the assessment.
[138] EA, Appendix O, pp.22-23.

panels than those proposed in the Base Case layout. This calls into question the relevance of many of the observations.

The SCI approach to this issue was to note that:

> *'there is as yet no scientific consensus over the role that mining subsidence may play in impacting swamps ... What is clear to the Panel is that the interaction between subsidence effects and impacts such as vertical displacement, strata fracturing, buckling and uplift (possibly leading to water loss) do have potential consequences for swamps.'*

and

> *'no unaffected or 'healthy' valley infill swamps were observed where longwall extraction had taken place beneath them. In most cases, where swamps appeared largely unaffected by mining beneath, it was where mining had been restricted to either narrow panels, or some form of partial extraction only (ie bord and pillar operations) which restricted surface subsidence '*[139]

The Metropolitan PAC Report noted the following on the issues generally:

- *'a large number of swamps in the Southern Coalfield have been undermined using a variety of methods;*
- *some of these have been undermined by longwall mining;*
- *apart from a headwater swamp in Dendrobium Area 2 which has been drawn to the Panel's attention on multiple occasions, no headwater swamp appears to have been adversely affected; and*
- *a number of valley infill swamps have been adversely affected and this may be associated with mining.*

These conclusions are consistent with the findings of the SCI. However the Panel notes that there are some limitations to the information on which these conclusions are based:

> *i. The estimates of environmental effect utilise visual estimates of swamp health. This may be a valid approach, but to the Panel's knowledge the technique has not been published in a reputable refereed scientific journal and, as such, the results must be treated with caution.*
>
> *ii. For vegetation-based indicators (other than those associated with severe water loss) there may be significant biological lags before an effect is observable.*
>
> *iii. Direct observation and measurement of subsidence impacts in swamps using conventional techniques is a difficult undertaking.'*[140]

The Metropolitan PAC Report then went on to conclude that, with the vast majority of swamps appearing to be headwater swamps, and the substantial depth of cover and

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[139] DoP (2008), p.73.
[140] DoP (2009a), p.84.

narrow longwall panel width for that Project, the risks to upland swamps from conventional subsidence were probably low.[141] However, it took a different view of the risks to some specific swamps from non-conventional subsidence and was highly critical of the information provided in the EA on this issue.[142]

In the 18 months or so since the Metropolitan Coal Project information was collated, the focus of some government agencies and NGOs has been on gathering information on some swamps that have been recently undermined by longwalls. The information points to significant impacts on the hydrology of the swamps in question and the potential for serious environmental consequences. The swamps brought to the Panel's attention are Dendrobium Swamp 1, East Wolgan Creek Swamp-Newnes Plateau, Kangaroo Creek-Newnes Plateau, Junction Swamp-Springvale Colliery, Swamp 18-Elouera Colliery, and Swamp 32. In addition to these, the Panel observed that multiple swamps either side of an undermined (and severely impacted) reach of Lizard Creek appeared to be dry and undergoing compositional change from invasion by wattles and eucalypts. Swamps associated with the unaffected reaches of Lizard Creek did not show these same characteristics.

This Panel and previous Panels[143] have sought examples of dessicated swamps that have not been undermined but none have been forthcoming to date. The limited monitoring data that is available is not adequate to preclude mining induced subsidence as the root cause of changes in the hydrology of at least some, if not all, of the swamps noted above. At this point in time, neither conventional nor unconventional subsidence effects, singly or in unison, can be eliminated as the source of changes in swamp hydrology.

There are compounding problems in the current lack of ability to detect and quantify all but the most obvious change and the possibility that vegetation compositional changes will take time (possibly decades). However, the bottom line appears to be if mine subsidence has the potential to impact on near surface formations to an extent that could cause changes in the hydrology of a swamp, then the swamp is at risk of serious negative environmental consequences in whole or in part.

6.4. RISK ASSESSMENT

For the BSO Project, the Panel has used the same approach for assessment of risk to upland swamps from subsidence as was used in the Metropolitan PAC Report.[144] The steps are:

Step 1. The mine parameters and likely types of subsidence impacts relevant to swamps are described.

Step 2. All swamps in the Project Area are identified, have their vegetation

[141] But not beyond doubt, hence the recommendation by the Metropolitan PAC Panel for substantial further research on swamps undermined by the early longwalls - DoP (2009a), p.87.
[142] DoP (2009a), p.86.
[143] The SCI Panel and the Metropolitan Coal Project Panel
[144] ICHPL notes in the EA (Vol. 1, Section 5, p.15) that it has followed the risk assessment approach set out in Section 9.4.1 of the Metropolitan PAC Report which is the approach summarised here.

mapped and fauna surveyed, and have their topographic and hydrologic characteristics identified and recorded. Any features of particular significance, e.g. presence of threatened species or endangered ecological communities, should also be recorded. To the extent possible, the overall significance of the swamps in the regional context will be assessed.

Step 3. Any swamps or associations of swamps that are of special significance (particularly in the regional context) are identified. The approach to this is set out in Section 6.4.3.1.

Step 4. The risks of impact and consequences are then assessed for each individual swamp. The first action is to draw the appropriate RMZ around the swamp and calculate the predicted subsidence effects for the swamp from all potential sources (i.e. both conventional and non-conventional subsidence). Then the risks need to be assessed based on the relevant characteristics of the swamp, the mining operations and the predicted impacts from all the potential subsidence effects.

The purpose of this is to identify individual swamps that are at real risk of negative environmental consequences[145] if they are undermined.

Step 5. The question of acceptability of negative environmental consequences for swamps must be addressed at this point.

The standard adopted in the Metropolitan PAC Report is that negative environmental consequences are considered undesirable for all swamps, and

a) swamps of special significance will be protected from negative environmental consequences;

b) a presumption of protection from significant negative environmental consequences will exist for all other swamps unless the Proponent can demonstrate for an individual swamp that costs of avoidance would be prohibitive and mitigation or remediation options are not reasonable or feasible. Under circumstances where the decision is to allow significant negative environmental consequences to occur and remediation is not feasible, offsets may be considered appropriate.

6.4.1. Step 1 – Description of the Mine Parameters and Subsidence Impacts for Swamps in the BSO Study Area

For conventional subsidence, the mine parameters of significance for swamps are the depth of cover, longwall panel width, mining height and chain pillar width. Minimum depth of cover for swamps in the BSO Study Area ranges from 301m to 518 m. Of the 226 identified swamps, 60 have a minimum depth of cover between 301 and

[145] Negative environmental consequences are the outcome of real interest, but they may not be possible to assess reliably with current knowledge. Although the relationship between predicted subsidence impacts and negative environmental consequences is poorly defined, current practice is usually to focus on predicted impacts in assessing risk to a swamp.

399 m, 147 between 400 and 499 m and 19 between 500 and 518 m. The Base Case longwall panel width in North Cliff and Area 2 is typically 310 m.

Some sections of the EA and some parts of ICHPL's responses to submissions and PAC questions appear to extrapolate conclusions from the Metropolitan PAC Report in regards to environmental consequences from subsidence impacts, without the level of analysis required to support such extrapolation. Whilst mention of this issue will be made in subsequent parts of this report, the explanation as to why the Panel considers this to be unsafe is set out below.

Table 6 to Table 10 set out some of the differences. Key points of note are:

- Only one swamp (0.8%) was predicted to experience more than 6 mm/m maximum tilt in the Metropolitan Study Area, whilst 28 (12%) are predicted to experience more than 6 mm/m maximum tilt in the BSO Study Area, Table 7

- No swamps (0%) were predicted to experience more than 2 mm/m maximum compressive systematic strain (MSEC threshold to cause rock to fracture) in the Metropolitan Study Area, whilst 30 (13%) of swamps are predicted to experience more than 2 mm/m maximum compressive systematic strain in the BSO Study Area, Table 8.

- Sixty-five swamps (53%) were predicted to experience more than 0.5 mm/m maximum systematic tensile strain (MSEC threshold to cause rock to fracture) in the Metropolitan Study Area, whilst 89 (39%) are predicted to experience more than 0.5 mm/m maximum systematic tensile strain in the BSO Study Area, Table 9.

- Only six (5%) of Metropolitan swamps were predicted to be subjected to a maximum systematic tensile strain of greater than 1 mm/m, whilst 39 (17%) of BSO swamps are predicted to experience a strain greater than this, Table 9.

- No swamps in the Metropolitan Study Area were predicted to experience systematic tensile strains greater than 1.5 mm/m, whilst 8 swamps in the BSO Study Area are predicted to experience strains greater than this, Table 9.

- In the BSO Study Area, 21 swamps are predicted to experience a greater closure strain, ε_{cl}, than the maximum predicted for swamps in the Metropolitan Coal Project, Table 10.

- None of these comparisons make provision for the greater subsidence effects predicted by MSEC if longwall panel width were to increase from the Base Case layout in time to come.

Table 6: Comparison between Mining Dimensions in Areas Containing Swamps in the Metropolitan Project Area and in the BSO Study Area

Parameter	Typical[a] Range for Metropolitan Coal Project	Typical Range for North Cliff and Area 2 in BSO Project
Depth of mining, H	420 – 540 m	340 – 500 m
Seam thickness, t (assumed to equal mining height, h)	2.5 – 3.3m	1.8 – 3.0 m
Interpanel pillar width, w	35 m	35 – 45 m
Longwall panel width, W	163 m	310 m
Number of swamps	122	233[146]
W/H range	0.3 - 0.39	0.62 - 0.91
EA (MSEC) predicted height of fracturing above mining horizon	183 m	385 m
Thickness of unfractured strata overlying top of fractured strata	237 – 357 m	-45 – 115 m[b]

a. There is an extreme range in some mining parameters. However, extremes tend to be localised and it is feasible to assign *typical* values which represent the range over the majority of the mining domains.
b. The height of fracturing above the mining horizon as predicted in the EA is greater than the depth of mining in some parts of the BSO Study Area.

Table 7: Comparison between Predictions of Maximum Conventional Tilt in Swamps in the Metropolitan Project Area and in the BSO Study Area

Tilt	Metropolitan Coal Project	BSO Project
0 - ≤ 2 mm/m	60	115
2 - ≤ 4 mm/m	39	50
4 - ≤ 6 mm/m	22	40
6 - ≤ 8 mm/m	1	17
8 - ≤ 10 mm/m	0	8
10- ≤ 12 mm/m	0	3
Metropolitan maximum tilt	7.9 mm/m	-
No of predicted exceedances for BSO Project	-	12

146 The number of swamps identified in the BSO Study Area is slightly different in different parts of the EA, in some submissions, and in this Report, depending on the extent to which small 'satellite' swamps immediately adjacent to larger swamps are either aggregated or treated separately. In the Panel's view, the apparent discrepancy is not material.

Table 8: Comparison between Predictions of Maximum Conventional Compressive Strain in Swamps in the Metropolitan Project Area and in the BSO Study Area

Maximum Conventional Compressive Strain	Metropolitan Coal Project	BSO Project
0 - ≤ 2 mm/m	122	200
2 - ≤ 4 mm/m	0	23
4 - ≤ 6 mm/m	0	7
Metropolitan maximum compressive strain	1.7 mm/m	-
No. of predicted exceedances for BSO Project	-	46

Table 9: Comparison between Predictions of Maximum Conventional Tensile Strain in Swamps in the Metropolitan Project Area and in the BSO Study Area

Maximum Conventional Tensile Strain	Metropolitan Coal Project	BSO Project
0 - ≤ 0.5 mm/m	57	141
0.5 - ≤1 mm/m	59	50
1.0 - ≤1.5 mm/m	6	31
1.5 -≤2.0 mm/m	0	7
2.0 - ≤2.5 mm/m	0	1
Metropolitan maximum tensile strain	1.44 mm/m	-
No. of predicted exceedances for BSO Project	-	17

Table 10: Comparison between Predictions of Non-conventional Closure Strain in the Metropolitan Project Area and in the BSO Study Area

Closure Strain	Metropolitan Coal Project	BSO Project
$9 < \varepsilon_{cl} \leq 9.5$ mm/m	0	14
$9.5 < \varepsilon_{cl} \leq 13.5$ mm/m	0	6
$13.5 < \varepsilon_{cl} \leq 20$ mm/m	0	1
Metropolitan maximum closure strain	8.9 mm/m	-
No. of predicted exceedances for BSO Project	-	21

It is important to note that the PAC Panel for the Metropolitan Coal Project considered that the substantial depth of cover and the narrow longwall width were key factors in allowing it to reach the conclusion that impacts from conventional subsidence would be inconsequential[147] given the substantial thickness of the unfractured zone between the mine workings and the swamps.

Furthermore, as noted in Section 4.2.2, subsidence predictions for the North Cliff mining domain have been based on an empirical model using the standard Southern Coalfield subsidence profiles developed predominantly on the basis of outcomes at Appin Colliery and Tower Colliery to the west. When this model was applied to Metropolitan Colliery, immediately to the east of the North Cliff mining domain, it significantly under-predicted subsidence outcomes and had to be recalibrated[148]. Geological features were advanced as the explanation for the difference in behaviour, which the Metropolitan PAC Report noted as plausible, but not verified.[149] The Metropolitan PAC Report went on to conclude that, provided conditions were the same in the rest of Metropolitan Study Area, use of the calibration factor was reasonable (whilst also noting that, if it had been applied erroneously, it would decrease risk of consequences by over-predicting effects rather than under-predicting them).

The Panel is not aware of any investigations in relation to the reliability of using the Southern Coalfield standard calibration in the North Cliff mining domain. It notes that if the Metropolitan calibration were applicable, then the predictions for conventional subsidence parameters in the North Cliff domain would be considerably higher than those presented in the EA. Hence, the differences shown in Table 6 to Table 10 could be expected to be greater than they already are.

The Panel’s considered view is that:

- The risks to swamps from conventional subsidence impacts is considerably higher in the BSO Study Area than it was in the Metropolitan Study Area.
- Without the appropriate research and analysis, it is unsafe for conclusions about subsidence-related environmental consequences in the Metropolitan Study Area to be extrapolated to the BSO Study Area.

The risk of impact from non-conventional subsidence is based in the EA on the measurements of valley closure. The EA uses >200 mm predicted closure as the threshold for concern and 33 swamps above the threshold are identified in Figures 04, 05 and 06 of Appendix O. The majority are larger swamps.

The Panel considers that the use of >200 mm predicted closure is an unsatisfactory interim measure as already discussed in Chapter 4 of this report. Although the approach was applied in the Metropolitan Coal Project, the Metropolitan PAC Report gave clear warning that further research may see this approach revised.[150]

[147] DoP (2009a), p.87.
[148] EA for Metropolitan Coal Project, Appendix A, Section 3.5.2, p.31.
[149] DoP (2009a), pp.28-31.
[150] DoP (2009a), p.34.

DECCW disputes the use of the >200 mm threshold of predicted closure, preferring to rely on the prediction of compressive strain and of predicted upsidence due to valley closure. DECCW has nominated a threshold closure strain of *2 mm/m predicted incremental compressive strain* which it attributes to the MSEC report that constituted Appendix A of the EA for the Metropolitan Coal Project. It has nominated an upsidence threshold of 30 mm which it attributes to an independent review undertaken in 2005 of subsidence impacts on the Waratah Rivulet[151].

The Panel concurs with the principle of using closure strain as a risk criterion. Closure is a measure of the absolute amount of horizontal displacement across a valley. The impact of this movement is determined by how it is distributed between the two sides of a valley, that is, by the strain[152] arising from this movement. Strain is not uniformly distributed, but changes across the closure profile. This is illustrated by measurements made at Waratah Rivulet[153],[154] Georges River, and a number of other sites which show that peak strain occurs as a spike towards the centre of a valley. The measured strains illustrate that closure strains rather than closure displacements are more relevant to assessing closure impacts.

DECCW's threshold value of *2 mm/m incremental compressive strain* is correctly quoted from the EA for the Metropolitan Coal Project; however, technically it should read *2 mm/m total compressive strain*[155]. As already noted, it is based on MSEC's advice that fracturing of sandstone has generally been observed in the Southern Coalfield once systematic compressive strain has exceeded 2 mm/m. This concurs with the Panel's experience. However, based on the Panel's own inquiries, field inspections and experience, total diversion of surface flow into a subsidence-induced subsurface fracture system requires higher total compressive strains that are very dependent on geological factors such as strata composition, thickness and bedding laminations. Limited measurements suggest a threshold total compressive strain[156] value for total diversion of flow in sandstone environments of the order of 7 mm/m, however the database is too small to be reliable at this point in time. Conventional compressive strain can make a significant contribution to this total compressive strain.

Due to the variable manner in which upsidence can develop and is measured, the Panel shares the concerns of the SCI in using predicted upsidence as a predictive parameter or risk criterion. As already discussed, upsidence measurements are very susceptible to the manner in which the skin of the surface rock fails and to the location of survey stations relative to the resulting movement. DECCW states that impacts have been noted when upsidence has exceeded 30 mm.[157] It needs to be appreciated that this was an estimated value.[158] Nevertheless, on at least one

[151] Galvin (2005).
[152] Strain being the ratio of change in length to original length.
[153] Galvin, 2005.
[154] Mills, 2008.
[155] Appendix A of the EA is inconsistent in describing this value.
[156] Total compressive strain is comprised of both conventional and non-conventional strain components.
[157] DECCW (2009b), p.6.
[158] Galvin (2005).

occasion, impacts resulting in drying out of pools have been recorded at *measured* upsidence of 60 mm.[159]

Based on DECCW's thresholds of 2 mm/m compressive strain, 0.5 mm/m systematic tensile strain and 30 mm upsidence, a much larger number of swamps (78 in total) are included in swamps at risk of impact from non-conventional subsidence.[160] This number reduced to 55 when DECCW applied a 60 mm upsidence threshold. ICHPL responded by stating that:

> *'The assessment of potential impacts on upland swamps (Appendix O of the EA) was undertaken in accordance with the recommendations of the Metropolitan PAC Report (PAC, 2009), which identified three broad mechanisms by which subsidence could cause changes in hydrology'.*[161]

The response is ambiguous. The Metropolitan PAC Panel did recommend a risk assessment approach, being the one that the same Panel is now applying to this assessment of swamps for the BSO Project. It did not recommend that any such assessment was to be based on the three broad mechanisms which it identified when assessing the Metropolitan Coal Project. The Panel notes, however, that if the same information on which DECCW is relying[162] is re-assessed on the basis of closure strain, being a measure that is consistent with mechanism 3 identified by the Metropolitan PAC, there are 55 swamps which are predicted to experience 7.5 mm/m or more closure strain. To these strain values must be added conventional closure strain, which exceeds 2 mm/m at 30 swamps. ICHPL is of the view that *'it is considered more relevant to base the assessment of potential non-conventional subsidence movements on valley closure not closure strain'*[163]. This view is not consistent with that of the Panel.

The Panel notes that some submissions, including one from DECCW, have interpreted the Metropolitan PAC Report as signalling a focus on non-conventional subsidence rather than conventional subsidence. It is important to make it clear that both forms of subsidence can cause impacts and must be explored fully for any proposal. The distance between the top of the fractured zone and the base of the swamps in the Metropolitan Coal Project and the relatively low levels of conventional compressive strain simply meant that conventional subsidence was of less concern to the Panel than non-conventional subsidence in that case.

6.4.2. Step 2 – Features of Upland Swamps in the BSO Study Area

The swamps are identified and mapped in the EA. Limited fauna and flora survey work has been undertaken and issues with this are discussed in Section 6.4.2.1. The topographic and hydrologic characteristics are reported in the EA, but the EA notes that there are limitations in the groundwater model and further work is required. This is discussed in Section 6.4.2.2. Features of special significance are discussed in Section 6.4.2.1 and Section 6.4.3.

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159 Ibid.
160 DECCW (2009b), p.5.
161 ICHPL (2010c), p.12.
162 EA, Appendix O, Attachment OB.
163 ICHPL (2010c), p.12.

6.4.2.1. Flora and Fauna

The flora and fauna surveys are described in Appendix E (Terrestrial Flora Assessment) and Appendix F (Terrestrial Fauna Assessment) of the EA.

In relation to swamps it appears that 27 swamps were subject to some level of flora survey, with the methodology varying from detailed quadrats (eight sites), rapid spot surveys (20 sites), and random meander targeting threatened species (11 sites).[164] The total flora survey sampling effort was stratified approximately in proportion to the extant areas of each vegetation type.[165] There appears to have been no attempt to sample swamps at a greater level of intensity despite their known conservation importance[166] and complexity and their crucial role in catchment hydrology compared to other vegetation associations in the BSO Project Area.

The sampling intensity (all methods) for flora was around 12 % of swamps, although the majority of the sampling did not constitute a full-scale flora survey.

For fauna, Table 3 of Appendix F of the EA shows that 11 swamps were surveyed out of a total 226 in the BSO Project Area. This is less than 5% percent of the total. At seven of the sites systematic surveys were conducted and at four of the sites targeted surveys were conducted for swamp specialist species and threatened species. Examination of Table 3 of Appendix F reveals that three of the systematic surveys and one of the targeted surveys were outside the proposed mining area, with one of these (S14)[167] outside of the BSO Project Area altogether.

As with the flora survey there has been no attempt to stratify the sampling to increase the focus on the upland swamps, which are arguably the highest value conservation habitats in the Project Area. Instead, the sampling has been heavily biased towards the proposed Stage IV Coal Washery Emplacement.

In response to DECCW concerns about the overall survey effort in relation to swamps the Proponent simply re-states the sampling effort undertaken, as set out in the EA, and notes that some:

> *'additional swamp inspections have been conducted following lodgement of the EA. The observations recorded during these site inspections will be provided separately to the Bulli Seam Operations PAC Panel'*.[168]

The Panel makes two observations on this:

(i) the additional inspections are based on the same activity as that reported in the EA and are therefore of little scientific value. ICHPL itself acknowledges these methodological shortcomings; and

(ii) the failure to provide information in the EA means that the government

[164] EA, Appendix E, p.33, Table 10.
[165] EA, Appendix E, p.32.
[166] DoP (2008), pp.17-18; DoP (2009a), p.77.
[167] S14 is over 1500m from the Project Area boundary.
[168] ICHPL (2010c), p.17.

agencies and the public are prevented from assessing the project proposal properly and are unable to give the Panel comprehensive advice.

ICHPL also makes other points on survey intensity in upland swamps in response to DECCW concerns.[169] They are:

- that *'the draft DECCW Upland Swamp Assessment Guidelines are not yet publically [sic] available'*;
- that *'the EA for the Project provides substantially more information on swamps within the Project Area than the information available for the Metropolitan PAC'*; and
- that *'the EA was deemed adequate by DoP [Department of Planning] on 13 October 2009'*.

The Panel notes the following in relation to these quotes:

(i) it is the Proponent's responsibility to undertake the work in preparing the EA to meet the Director General's requirements.[170] In this context the Panel does not accept that the description of the existing environment in this EA is adequate, nor that an adequate risk assessment is possible based on the survey work undertaken;

(ii) the Panel acknowledges that there is more information on subsidence effects and impacts for swamps than was initially available to the Metropolitan PAC Panel. However, the survey effort in upland swamps in the BSO Project Area falls so far short of the requirement for assessment of risk that any comparisons are meaningless; and

(iii) the EA was not deemed by the Department of Planning to be 'adequate'. It was deemed to be adequate for exhibition which is a fundamentally different thing. The adequacy review is an important threshold step in the environmental assessment process, but it is not designed to identify or correct every defect in the Proponent's proposal – particularly for something as large and complex as the BSO Project Proposal.

The Department of Planning cannot be expected to have assessed the EA to the same standard as will occur in the public assessment and submission process (and the possible PAC review process) prior to those processes occurring. If that were the case the legislation could dispense with both the public process and the PAC and simply allow the Department and the Minister to make both the assessment and the decision.

[169] ICHPL (2010c), p.16.
[170] EA, Volume 1, Attachment 1.

In relation to threatened species, the EA states that the swamps in the Project Area provide potential habitat for a range of threatened species.[171] The EA also acknowledges the limitations of the survey work and suggests that additional work will be conducted as part of the Swamp Risk Management Plans.[172]

The manifestly inadequate survey work means that concentrations of threatened species are unlikely to be found and, even if some individuals are found, the extent of any population will remain unclear. In this context it is interesting to note that the threatened Eastern Ground Parrot (*Pezoporus wallicus*) was detected twice during the survey (two individuals at one site and one at another). This species was thought to be regionally extinct until recently.[173] However, two records in the Metropolitan Study Area and these two records from the extremely limited sampling effort in the BSO Project Area swamps indicate a strong likelihood that a nationally significant population may still exist in the region. Until an adequate survey of the swamps in the BSO Project Area is undertaken, no one really knows.

However, the Project Approval sought by ICHPL would allow it to undermine any swamp in the Study Area (i.e. not confined to the Base Case mine layout or the longwall panel width in the EA) subject only to possible mitigation, monitoring and offset measures identified in Upland Swamp Risk Management Plans developed as part of future Extraction Plans.[174] These future plans are not defined in the legislation and do not require public scrutiny.

The Panel concludes that:

- The survey intensity for flora and fauna in the upland swamps is manifestly inadequate to provide the basis for the second step of the risk assessment process (i.e. all swamps in the Project Area are identified, have their vegetation mapped and fauna surveyed …). Furthermore,
- The low survey intensity to date ensures that the existence of concentrations of threatened species associated with upland swamps in the BSO Project Area will remain conjecture, thus avoiding any proper assessment of 'special significance' for swamps at the Project Approval stage. This effectively removes threatened species and upland swamps generally from scrutiny by the public or the PAC as part of the Part 3A process.

6.4.2.2. <u>Groundwater Hydrology of Swamps</u>

Hydrology issues in relation to swamps have been discussed in Chapter 5 and in Section 6.3.2. The key issues for this part of the risk assessment are:

- There is substantial criticism by stakeholders, including SCA, NOW, DECCW, NGOs and independent experts, of the level of information available about potential subsidence-related impacts on swamps.

[171] EA, Appendix O, p.15.
[172] EA, Appendix O, p.32.
[173] DECC (2007).
[174] EA, Vol 1, Section 5, pp.21-24. But see the rejection of mitigation strategies for upland swamps (EA, Appendix O, pp.35-36) and the inadequate offset proposals (EA Appendix O, p.41). This is discussed in more detail in Section 6.4.5.2 below.

- There has been no piezometric monitoring of any swamp in the BSO Study Area. Whilst ICHPL acknowledge this deficiency and recognise the need to acquire this information as part of a swamp monitoring program, the simple fact is that information at this level is required to inform the approval decision, not some subsequent process.

- The conventional wisdom that the upland swamps are perched systems and not in contact with the underlying groundwater systems rests on very little hard evidence. Swamps in the Kangaloon area are reported in the EA as perched but these swamps are situated some 30 km to the south and are relatively small in areal extent. There is a real possibility that the larger swamps of the Woronora Plateau and the high density of swamps have, over the course of time, sustained an elevated water table that is very close to or connected with the base of swamps. Subsidence induced disturbance beneath swamps may have wider implication for regional groundwater flows.

- There is considerable uncertainty as to the possible hydrological consequences for swamps in the BSO Study Area from the fracture height of 385 m based on a 310 m longwall panel width as reported in the EA. ICHPL has sought to distance itself from the possibility of connective cracking from the top of the fractured zone to the mine workings (e.g. see the report by Prof. Hebblewhite[175]), but the Panel is of the view that a real possibility still exists of loss of water from the surface to areas of storage in the upper portion of the fractured zone[176] through pathways created by conventional and non-conventional subsidence impacts.

6.4.3. Step 3 – Significance of Upland Swamps in the BSO Study Area

6.4.3.1. <u>Determining Significance of Upland Swamps Generally</u>

The issues associated with determining significance were canvassed in the SCI report and more recently in the PAC Report on the Metropolitan Coal Project. The latter report sought to provide a comprehensive approach to the issue based on the SCI findings and to apply that approach to the facts of that mining proposal.

Recommendations based on the approach were accepted in-principle in the Approval for the Metropolitan Project issued by the then Minister for Planning, and the approach has subsequently been recognised in the EA for the BSO Project and in Government Agency submissions on the EA. The Metropolitan Project report was also considered judicially in *Rivers SOS v Minister for Planning* [2009] NSWLEC 213 without adverse comment.

The Panel is therefore of the view that the approach adopted in the Metropolitan Project Review is now the accepted standard for assessing significance of swamps in the Southern Coalfield. The key elements of that approach are reproduced below.[177]

'The significance of upland swamps in the context of longwall mining has at

[175] ICHPL (2010e), Attachment 1.
[176] Being either voids created by the subsidence effects or by creating access to existing voids.
[177] DoP (2009a), pp.76-77.

least three dimensions:

> *i) for what purposes(s) the swamps are to be conserved (i.e. catchment protection, habitat protection, presence of EEC or threatened species, etc);*
>
> *ii) whether it is possible to determine what proportion of each type of upland swamp should be conserved across a region; and*
>
> *iii) whether some swamps are of such special significance that they warrant a higher level of protection than swamps generally.*

'Special significance' has its own definition difficulties. It is much easier to recognise at the extremes of the spectrum than in the middle. For example, if the regional population of a relatively sedentary threatened species is found in only one swamp in a Project Area; or a swamp is both unremarkable and one of 20 similar swamps in the Project Area, the position is simple. However, if single sightings of a locally migratory species have occurred in five swamps in a Project Area, then determining whether one of those swamps is of special significance based on the sighting will inevitably involve a substantial degree of subjective analysis.

The current position on availability of information on the conservation significance of upland swamps can be summarised as: qualitative information should be available in relation to conservation purpose, there is probably no reliable information on the proportion of swamps to be conserved, and there should be qualitative information available for 'special significance', but its interpretation will involve a substantial level of subjectivity.

Under the current circumstances the commonsense approach to significance would appear to be:

> *i) to recognise upland swamps generally as habitats of high conservation value that are prima facie worthy of preservation; and then*
>
> *ii) on a case by case basis argue whether individual swamps [or associations of swamps]*[178] *in a Project Area should be afforded 'special significance' status based on specific conservation reasons supported by evidence of substantial size, unusual complexity,*

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[178] Some submissions on the BSO project proposal have interpreted the second limb of the approach to 'special significance' as applying only to individual swamps and not to clusters of swamps. This was not the intent of the Panel as evidenced by the Metropolitan PAC Report at p.78 which refers to 'any individual swamp or group of swamps … as being of special significance' and 'if a swamp or group of swamps has been identified as being of special significance and thus requiring special consideration in a risk assessment framework' and at p.80 where it refers to 'Any swamp or associations of swamps that are of special significance …'. The Panel notes that ICHPL has taken this broader interpretation (EA Vol 1, pp.5-19). However, for the sake of clarity, the words in brackets should become part of the description of the significance assessment process.

> *contiguous habitat, presence of EEC or threatened species, etc.*[179] *In the absence of quantifiable measures and an objective threshold, conclusions about 'special significance' will be subjective. However, the practical effect of this subjectivity will decrease as the threshold is moved toward the top or the bottom of the scale.'*

6.4.3.2. Determining Significance of Upland Swamps in the BSO Study Area

The general proposition that upland swamps are habitats of high conservation value is common ground between the Proponent, government agencies and independent experts. It also reflects the position adopted by the SCI[180] and the Metropolitan PAC Report.

Substantial material was available to the Panel on the issue of the significance of the BSO Study Area swamps. This included the SCI Report, the EA, the submission and presentation by DECCW, the supplementary submission and presentation by DECCW, the supplementary submission by the Proponent in response, submission and supplementary submission by Dr Ann Young, submissions from key NGOs (including National Parks Association, Total Environment Centre and Colong Foundation) other written and oral submissions connected with the public hearings, and oral examinations of various experts.

In its response to DECCW's submission concerning the inadequacy of the significance assessment in the EA,[181] the Proponent appears to be extracting conclusions about significance from the Metropolitan PAC Report that were based on the evidence available in that case and applying these conclusions to a different fact situation without rigorous analysis.[182] As indicated previously, the BSO Review Panel, which is composed of the same Commissioners as the Panel for the Metropolitan Project Review, is of the view that the fact situations in the two project proposals are different. Application of the same principles for assessment of 'special significance' may therefore lead to a very different outcome.

In the Metropolitan PAC Report the Panel noted that when giving evidence to the SCI in 2007, DECC (as it then was) had not included the swamps in the Metropolitan Project Area in its list of four groups of swamps of special conservation significance. The Panel considered this to be an important factor in determining that the swamps in the Metropolitan Study Area did not meet the threshold for 'special significance' status, even though the Panel recognised the high conservation value of these swamps.[183]

The situation in the BSO Study Area is quite different. Over half of the swamps in the BSO Study Area form part of the Maddens Plains cluster of swamps,[184] which was

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[179] Note that this includes scientific importance, archaeological or cultural importance and uniqueness (DoP 2009a, p.42).
[180] DoP (2008), pp.17-18.
[181] DECCW (2009b).
[182] ICHPL (2010c).
[183] DoP (2009a), pp.76-78.
[184] 132 out of 226 (approx 60%).

one of the four groups of swamps identified by DECC to the SCI as being of special conservation significance.

ICHPL has contended that the swamps in the BSO Study Area are typical of swamps across the Woronora Plateau and therefore do not warrant the status of special significance. Any change to this conclusion based on a finding that swamps in the North Cliff and Area 2 mining domains are of 'special significance' status could mean changes are required to the proposed approach to mining these areas.

The Panel's view is that, if substantial weight was attached to DECC's evidence to the SCI by the Metropolitan PAC Panel; and the Metropolitan Study Area swamps were excluded from the status of 'special significance' because they were not included in the four groups of swamps identified by DECC as being of the highest conservation significance; then when a group of swamps is being considered that was included in one of the four groups (i.e. those in the BSO Study Area), the same weight should be attached to the same evidence.

If the Panel does not apply this approach for the same evidence across the whole of the Woronora Plateau, all aggregations of swamps within mining leases would be at risk from damage to some or all of their component swamps based only on the convenience of the mining company in determining the mining layout.

The issues to be considered for 'special significance' status are set out below.

<u>Size</u>

ICHPL's position is that *'the size of the swamps is considered typical of swamps encountered across the Woronora Plateau in the Southern Coalfield'*[185]. ICHPL also notes that the swamps are not *'exceptional in the region from a size perspective'* and therefore no swamps in the BSO Study Area should be considered as being of special significance.

There are several problems with this simplistic approach:

(i) The assessment of special significance for swamps is *'based on <u>specific conservation reasons supported by evidence of substantial size</u>, unusual complexity, contiguous habitat, presence of an EEC or threatened species etc'*.[186] It is not based on an assessment of size alone and the Metropolitan PAC Report makes it clear that the assessment of special significance may involve a combination of values.[187]

(ii) ICHPL has substituted 'exceptional' for the PAC risk assessment expression 'substantial'.[188] The two words have quite different connotations. It is certainly not a requirement that only '<u>exceptional</u>' size should be considered. Rather, the importance of a swamp or group of

[185] EA, Appendix O, pp.18-19.
[186] DoP (2008), p.42; EA, Appendix O, p.18.
[187] DoP (2008), p.42.
[188] EA, Appendix O, p.19.

swamps needs to be assessed and there are sound conservation reasons for including substantial size as a factor in that assessment.

(iii) DECCW has provided[189] a number of reasons why size is an important consideration in determining special significance including:

(a) differential contribution to water balance in a catchment (larger swamps are more likely to transmit a proportionally higher volume of high-quality water into the streams that feed water storages);

(b) larger swamps are likely to contain a wider range of soil profiles and hydrological characteristics than small swamps and therefore contain a greater variety of habitats and plant communities. They are more likely to be inhabited by, or provide refuges for, threatened species; and

(c) large swamps are less exposed to edge effects than small swamps, meaning that they are less vulnerable to some key external threatening processes such as invasion by weeds and microclimate effects.

(iv) In response to a question from the Panel, DECCW mapped the size of all swamps on the Woronora Plateau (996 swamps) to obtain the size for inclusion in the upper 10th percentile. This was found to be 9.3 ha or greater. Of the 226 Woronora Plateau swamps in the BSO Study Area, 27 swamps are greater than 9.3 ha in size and a further three smaller 'sub-swamps'[190] are considered to be part of these larger swamps (i.e. a total of 30 swamps identified in the EA should be included in the top 10 percent based on size).

Use of the Woronora Plateau swamps as a whole to calculate the relevant area for inclusion in the upper 10th percentile is consistent with ICHPL's approach to comparing the BSO Study Area swamps with the rest of the swamps on the Plateau. While the choice of the upper 10 percent cut-off point is necessarily arbitrary, it is considered by the Panel to be reasonable to single out the top 10 percent of a population for a characteristic that clearly has important implications for conservation value.[191]

(v) DECCW also points out that, within the swamps on the Woronora Plateau (and within the BSO Study Area) there are a number of types of swamps and that average size may vary between types. Size as a criterion for assessment of 'special significance' should therefore be considered in both relative and absolute terms.

ICHPL's response[192] to the issues raised about size in the DECCW submission only deals with the water balance issue (and then tangentially). It does not challenge any

[189] DECCW (2009b), pp.8-9.
[190] i.e. Swamp Nos CRE-S7b, WOR-S5c and ILC-S4e.
[191] 90% would be considered a substantial proportion of any population. Selecting the upper 10 percentile means that 90% of the swamps are smaller than those selected.
[192] ICHPL (2010c), pp.17-20.

of the other points on the importance of size from that submission, appearing to rely on the assertion in the EA quoted above.

The Panel notes that even a cursory examination of Figure 22 and of maps in Appendix A[193] indicates that there are some large swamps located in the headwaters of key catchment streams including Woronora River, O'Hares Creek, Iluka Creek, Stokes Creek, Cataract River Tributary 1 and Cataract River Tributary 2.

From the limited survey work undertaken to date in swamps in the BSO Study Area (see Section 6.4.2.1), it is not possible at this point in time to assess relative size against swamp type.

<u>Complexity</u>

ICHPL states that based on the swamps in the BSO Project Area being characteristic of those across the Woronora Plateau, none of the swamps are considered to be of special significance status.[194]

DECCW has responded with a series of points concerning the assessment of complexity.[195] These include the diversity of vegetation types within the swamp (some larger swamps may contain all vegetation types) and the density and variety of plants and species. DECCW notes that the greater the complexity, the greater the likelihood that the swamp can provide habitat for threatened species.

In its response to the DECCW Submission, ICHPL has not commented on the points raised by DECCW concerning complexity[196].

In response to a request from the Panel, DECCW provided further information on swamp complexity as follows:

> *'The most limited community in terms of occurrence and extent is Tea-tree Thicket, map unit 43 on the Woronora Plateau in 'The Native Vegetation of the Woronora, O'Hares and Metropolitan Catchments' (NPWS 2003). This is due to the fact that this community requires permanently wet habitat, while the other swamp associated communities occur along a decreasing moisture gradient outwards towards the edge of a swamp. As a result the presence of Tea-tree Thicket can be used as a reliable surrogate for those diverse swamps that contain patches of all swamp vegetation communities that occur in the region.*
>
> *The scale at which these swamp communities occur can be very fine, with different communities occurring as very small patches, or thin fringing bands in any given swamp. Vegetation mapping derived from aerial photography will not pick up all of these fine scale changes in vegetation and subsequently swamps mapped as containing Tea-Tree Thicket may not show all of the remaining swamp vegetation communities. However, long term monitoring of*

193 See EA, Appendix A, Drawings MSEC 404-203 and MSEC 404-204 for greater detail.
194 EA, Appendix O, p.0-18.
195 DECCW (2010a), pp.5-6.
196 ICHPL (2010c).

plots throughout the study area has shown that the relationship between presence of Tea-Tree Thicket and the other swamp vegetation communities is consistently robust to be used as an indicator of complexity (D. Keith pers. comm.)

13 swamps within the study area are mapped as containing Tea-tree Thicket.'[197]

Contiguous Habitat

ICHPL[198] states that none of the swamps should be considered to be of special significance based on connectivity of swamp habitat since the swamps in the BSO Study Area are typical of swamps on the Woronora Plateau.

This issue has already been partially dealt with in this section. In the Panel's view, the inclusion of a substantial proportion of BSO Study Area swamps in the Maddens Plains Cluster (which was one of only four clusters of Woronora Plateau swamps considered to be of highest conservation value in evidence to the SCI in 2007) is sufficient on its own to defeat the ICHPL argument. However, DECCW makes two further points in its submission[199] that should be noted. They are:

- The Woronora Plateau contains the highest concentration of upland swamps in mainland Australia; and
- The clusters of these swamps provide large areas of contiguous habitat that are critical to the maintenance of swamp specialist species.

Presence of EECs or Threatened Species

Endangered Ecological Communities (EECs) – ICHPL states in the EA that none of the swamp vegetation communities represent EECs currently listed under the NSW *Threatened Species Conservation Act 1995* (TSC Act) or the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

DECCW has submitted[200] that a number of the Woronora Plateau swamps may meet the definition of Temperate Highland Peat Swamps on Sandstone (THPSS), which is an EEC under the EPBC Act.

ICHPL rejected this suggestion with an extensive response.[201] This response is attached in full as Annexure 2. However, it can be summarised for the Panel's purposes as:

- Swamps in the Study Area do not represent THPSS.

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[197] DECCW (2010a), pp.6.
[198] EA, Appendix O, pp.19 and 20
[199] DECCW (2009b), p.10.
[200] DECCW (2009b), pp.10-11.
[201] ICHPL (2010c), pp.20-21.

- The key features from the definitions in the Approved Conservation Advice (DEWHA 2008) are:
  - an altitudinal range of 600-1,100m above sea level;
  - distribution on NSW and Southern Tablelands including the Blue Mountains, Lithgow, Southern Highlands and Bombala regions; and
  - presence of sphagnum bogs.
- All Woronora Plateau swamps are below 450m in altitude.
- No Woronora swamps are included in the description, nor are they within the described geographical boundaries of the EEC.
- Only the wetter swamps on Woronora Plateau develop peat.
- Whilst there are substantial overlaps in vegetation between the Woronora Plateau swamps and the highland swamps in the Blue Mountains, there are some differences.
- If Woronora Plateau swamps are to be included in the THPSS the EEC will need to be re-defined and re-named.

The Panel provided the full text of the ICHPL response on this issue to DECCW for comment. DECCW's comments[202] are set out in full in Annexure 3, but can be summarised as:

- The structure of the vegetation, soil type, peat content, geomorphic, hydrological and climatic characteristics of the Woronora swamps are consistent with the listing;
- A high proportion of the species listed as characteristic of THPSS occur on the Woronora Plateau;
- A number of Woronora swamps are specifically listed as part of the Endangered Ecological Community;
- The listing specifically includes one of the two vegetation types found in the Woronora swamps (FRW p130) as part of the THPSS;
- The other extensive vegetation type within the Woronora swamps is FRW p.129. The differences in floristic composition between FRW p.129 and FRW p.130 are subtle relative to the variation to the variation in floristics across the swamps specifically included in the THPSS listing;
- There are specific examples of swamps in the listing itself that are at altitudes as low as 300m and others are between 300m and 600m. The lower bound of 600m can therefore only be indicative and it is the swamp characteristics rather than an arbitrary elevation range that should determine inclusion in the THPSS;
- Similarly, the listing describes THPSS as occurring on sandstone, but the listing itself contains major examples that are on shales, basalt and metasediments – not sandstone;

[202] DECCW (2010d).

- The range of peat in soils within swamps of the Woronora are indistinguishable from other examples of THPSS in the Blue Mountains. Soils of swamps in both regions include areas with minimal or no peat content on their seasonally dry margins, with peat content up to 60 per cent dry weight (>60 per cent by volume) along the more poorly drained central axis. Thus, one could point to areas of low peat content, but virtually all medium and large-sized swamps on the Woronora have some areas of appreciable peat content, as is the case with examples of the THPSS from other regions. It is therefore difficult to see how swamps on the Woronora Plateau could be excluded from THPSS based on their peat content.

Based on the DECCW response, the Panel is of the view that swamps in the BSO Study Area are more likely than not to be classified ultimately as examples of THPSS and therefore of National Significance.

<u>Threatened Species</u>

ICHPL states in the EA that none of the swamps are considered of special significance status based on the presence of threatened species because all swamps in the Project Area provide potential habitat for a range of threatened flora and fauna species as discussed in Section O4.4.6 of Appendix O of the EA.[203]

The ICHPL response to the DECCW submission on the EA describes some difference between its position and DECCW's position on threatened species based on:

- ICHPL's failure to record some species in surveys;
- Minor differences between threatened species lists provided by DECCW to the Metropolitan PAC Review and the current review; and
- The finding of some DECCW listed species outside swamps during surveys.

The Panel has already commented on survey intensity. However, the crux of the ICHPL argument appears to be that the Metropolitan PAC Report considered the presence of *'two swamps with records of the Eastern Ground Parrot and the swamps containing Pultanaea aristata'* and concluded that there were no swamps that warranted the status of special significance – ergo no swamps in the BSO Study Area warrant this status either.[204]

The Panel has already indicated that it does not accept that the fact situations for swamps are identical in the Metropolitan Study Area and the BSO Study Area and therefore rejects the argument that conclusions (as opposed to methodology) can be transposed from the Metropolitan Study Area to the BSO Study Area. One simple example of the difference between the two Study Areas will suffice. Comparison of the density of the swamps in the Metropolitan Study Area (where swamps are distributed across the whole area) with the density of swamps in those parts of the BSO Study Area where swamps are prevalent (i.e. the eastern and southern parts of

203 ICHPL (2010c), p.20.
204 ICHPL (2010c), pp.24-25.

North Cliff and Area 2) shows 6.5 ha of swamps per km^2 for Metropolitan and 14.7 ha per km^2 for BSO.[205]

Another flaw in the ICHPL argument is that, if all swamps in the BSO Study Area provide potential habitat for a range of threatened flora and fauna species[206] (a position confirmed by DECCW[207]), then the high concentration of swamps in Area 2 and the eastern and southern parts of North Cliff would suggest that these particular swamps are a critical conservation resource for threatened species and should be considered to be of special significance. This is entirely consistent with the status given to 60% of the swamps in this area by DECCW in its evidence to the SCI in 2007.

The significance of the BSO Study Area swamps as habitat for threatened species must be assessed on the basis of rigorously collected data on the BSO Study Area swamps. The work by ICHPL reported in the EA is manifestly inadequate for this purpose.

Scientific Importance

This factor was listed as a consideration for special significance assessment in the Metropolitan PAC Report.[208] The Panel requested information from DECCW on this issue. The response is included in full at Annexure 5 and can be summarised as:

> The southern portion of North Cliff overlaps the Dharawal upland swamp study area. This study area was established in 1983 and is internationally recognised as a critical reference area for wetland research. Approximately half the 60 monitoring sites, one of the two intensive swamp gradsects and three of ten subcatchments in the climate study occur within the southern portion of the North Cliff domain. The established infrastructure and long-term data sets are invaluable resources for ongoing work on upland swamps. This infrastructure and the scientific knowledge base are irreplaceable.
>
> The most important aspect of this long-term study – the study of the climate gradient that extends from west to east – is dependent on maintaining the hydrological integrity of the swamps throughout the study area. If the hydrological integrity of some of the swamps is compromised by mining, then the experimental design becomes confounded and it is impossible to interpret the results as being the results of climate change. If mining were to impact the swamps in this study area it would compromise the scientific value of 25 years of research.

The Panel notes that there is a high likelihood that the hydrologic balance of undermined swamps will be altered to some degree.

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205 Figures supplied by DECCW in response to a request from the Panel. A map showing the areas compared is included as Annexure 4.
206 EA, Appendix O, Section 4.4.6.
207 DECCW (2010a), pp.7-9.
208 DoP (2009a), p.42.

Aboriginal and Cultural Significance

There is no information available to the Panel on the significance to Aboriginal people of swamps in the BSO Study Area. Whilst it is likely that swamps provided an important food source for Aboriginal people (the concentration of flora and fauna is significantly greater in swamps than in the drier areas), no evidence concerning use has been provided to the Panel.

Value as Refuge and Foraging Habitat for Fauna

The Panel noted during field inspections that many species of fauna that would not be described as exclusive swamp dwellers were present in the swamps and around their margins. Often there was a substantial diversity of species present and substantial numbers of individuals. The difference in observed abundance between swamp habitats and the surrounding vegetation associations was stark.

The Panel therefore sought expert opinion from DECCW as to the importance of swamps in the region as refuge and foraging habitat for species that would not be regarded as swamp specialists. DECCW responded that:

> *'Upland swamps support an exceptionally high diversity of flora, with up to 70 plant species being found in a 15 m^2 area of upland swamp in the Southern Coalfields, compared to around 25 plant species per 25 m^2 in surrounding eucalypt forests (Keith and Myerscough 1993). Similarly, the habitats provided by upland swamps are used by a large number of vertebrate and invertebrate species for breeding, shelter and foraging. The dense ground cover and permanent water and soil moisture in swamps provides many species with shelter, refuge and breeding habitat, including many insects, amphibians, reptiles, mammals, birds and fish. Upland swamps are important foraging habitat due to the high diversity of aquatic and flying invertebrates they contain. Many amphibians, reptiles, birds, bats and ground living mammals forage in and above upland swamps, with their high diversity and variety of blossoming shrubs and trees, which provide important nectar and pollen resources for insects and birds, such as honeyeaters. Many migratory species also visit swamps for food and water.*
>
> *South-eastern Australia is characterised by climatic extremes of drought and flood, and frequent, high intensity fire. Swamps act as refugia for many species during dry periods when groundwater keeps swamps relatively moist while the forested habitats around them dry out. The role of swamps as refugia will be increasingly important under the impact of climate change.*[209]*'*

128 species of animals (excluding invertebrates) are known to utilise swamps on the Woronora Plateau for foraging, shelter or breeding (Annexure 6). One of these is listed as endangered and 16 others as vulnerable under the TSC Act.

[209] DECCW (2010a), response to Question 4.

Swamp Contribution to Catchment Hydrology

The issue of swamp contribution to catchment yield is covered in the EA, but from the perspective of total yield only.[210] Again the Panel observes that the hydrologic analyses of swamps and their contribution to catchment yield is manifestly inadequate.

Appendix C of the EA describes runoff modelling which explores the contribution of swamps to stream runoff within O'Hares and Stokes Creek catchments located partly within North Cliff area. The AWBM (Australian Water Balance Model) was used for this purpose and takes into account catchment areas where swamps comprise between 17% and 25% of the total areas. Appendix C states that the swamps are '*relatively low yielding*' as a result of the modelling effort. The purpose of this point and indeed the whole modelling effort, is unclear and the approach is somewhat surprising given the other aspects of swamp contributions to catchment hydrology. The two of greatest significance are the role in maintaining water quality and the role in maintaining baseflow in downstream reaches in times of low rainfall.

Baseflow is a sustained (but diminishing) flow following rainfall event(s) which is especially important in maintaining aquatic and riparian ecosystems and habitat connectivity. The AWBM model fails to quantify baseflows that might reasonably be attributed to swamps, instead providing an estimate of baseflows at downstream gauging stations of 18 to 20% of total flows. Lack of data or supporting analyses precludes sensible understanding of the hydrologic role of swamps by the Panel.

Further, there is no analysis of the contribution of swamps to aspects of stream health in the Study Area and there is no analysis of the risks to any downstream environments posed by potential impacts on swamps.

The Panel also notes the serious criticisms made by the Commission in the Bickham Coal Project PAC Report concerning the Proponent's failure to assess the importance of baseflow to dry weather flows and the observation that in the Australian context, the concepts of average flows (and by implication total flows) were meaningless.[211]

6.4.3.3. Findings and Conclusions

The Panel's findings and conclusions in relation to special significance are that:

(i) ICHPL's position that there are no swamps in the BSO Study Area that are of special significance is simply not tenable on the evidence available;

(ii) there has been insufficient work done to identify all swamps that might warrant classification as being of special significance based on the presence of EECs or Threatened Species;

[210] EA, Appendix O, pp.12-13.
[211] Bickham Coal Project PAC Report at p.13 and pp.23-24.

(iii) on the basis of size, swamps in the Study Area falling within the upper 10th percentile for swamps on the Woronora Plateau should be deemed to be of special significance i.e.

<u>Area 2</u>: CRE-S6b, CRE-S7a, CRE-S8, CT1-S4, CT1-S5, CT1-S6, CT2-S2, CT2-S6 (plus CRE-S7b)

<u>North Cliff</u> : DAC-S7b, DAC-S9, FOG-S1, HSC-S1, ILC-S3, ILC-S4a, ILC-S5e, OHC-S17, OHT-S6a, STC-S12, STC-S13, STC-S18, STC-S24, STC-S26, STC-S28a, STC-S28b, UNT-S1, WOR-S4, WOR-S5a (plus WOR-S5c and ILC-S4e)

(iv) on the basis of complexity, swamps containing the range of vegetation types found in swamps on the Woronora Plateau should be afforded special significance status. There are 13 such swamps within the BSO Study Area, i.e. DAC-S7b, ILC-S3, ILC-S4a, ILC-S4e, OHC-S15, OHC-S17, OHC-S4, STC-S13, STC-S17, STC-S19a, WOR-S4, WOR-S5a, WOR-S5b.

(v) there is a very strong case that all swamps in the eastern and southern parts of North Cliff and in Area 2 should be classified as being of special significance based on:

- scientific importance,
- identification of a large proportion of these swamps as belonging to one of four clusters of swamps of highest conservation value in evidence to the SCI,
- continuity of habitat.

6.4.4. Step 4 – Risks of Impacts and Consequences

The purpose of this step is to identify swamps that are at real risk of negative environmental consequences if they are undermined. This should be done by calculating the predicted subsidence effects from all potential sources for the swamp within a Risk Management Zone (RMZ) drawn around the outside of the swamp and then assessing whether these effects are likely to cause impacts that could lead to environmental consequences. The current understanding on the main mechanisms-pathways by which this could occur was set out in Sections 6.3.1 and 6.3.2 and detailed discussion of the risks they present to swamps is included in Sections 6.4.4.1 to 6.4.4.5.

The EA presents the detailed data for RMZs and the predicted subsidence effects in Appendix O and summarises these in Vol. 1 Section 5, pp.19-21. The predictions are based on the Base Case layout in the EA, which ICHPL indicates may change. Of particular concern in this context is the stated preference of ICHPL to increase the width of the longwalls during the life of the project.[212] This would be expected to increase hydrological impacts at or near the surface and thus potentially increase the

[212] EA, Vol. 1, p.7-33 and p.7-34.

risks to swamps in terms of numbers of swamps impacted and the magnitude of some impacts.

6.4.4.1. Impacts Associated With Tensile Fracturing Of Bedrock

As already noted, MSEC provided advice in the Metropolitan Coal Project that *'Fracturing of sandstone has generally been observed in the Southern Coalfield where the systematic tensile and compressive strains have exceeded 0.5 mm/m and 2 mm/m, respectively'*[213]. ICHPL and DECCW have both adopted a threshold concern value for tensile strain of >0.5 mm/m, although only DECCW has provided a basis for selecting this value, being that noted above. There are 89 swamps in the Project Area that have been predicted to experience tensile strains >0.5 mm/m, with seven predicted to experience between 1.5 to 2.0 mm/m of tensile strain and one in excess of 2 mm/m.[214]

ICHPL argues that tensile strain is not sufficient to cause changes in swamp hydrology without the intervention of some other factor that would allow water to escape from the perched water table. The only possible intervention factor advanced in the EA is that the depth of mining is sufficiently small relative to the width of the proposed Base Case longwall panels to result in the fractured zone above the mine excavations extending up to a height of 385 m, thereby intersecting the fracture zone that develops on the surface above the excavations[215], Figure 5.

DECCW on the other hand take the position that tensile strains above 0.5 mm/m are of concern independent of depth of cover. For this to be the case, tensile strains would have to be able to produce impacts in their own right or in association with factors other than interaction with a fractured zone originating from the mining horizon such as connection to an upsidence zone. The difference in the two positions is significant – there is nearly a four-fold difference between swamps with tensile strains >0.5 mm/m (89) and those with tensile strains >0.5 mm/m and depth of cover <385 m (24).

The prediction in the EA that the fractured zone above a 310 m wide longwall panel can extend to 385 m above the mine workings and, therefore, will intersect the surface fracture zone in portions of North Cliff and Area 2 mining domain, is an outcome of a model developed by MSEC. It is the interaction between these two fracture zones that many stakeholders associate with the opportunity for water to drain from the surface into a deeper fracture network.

MSEC's model has created considerable confusion amongst many stakeholders because it purports to calculate the height of the fractured zone depicted in Figure 5. However, ICHPL responses to questions raised by the Panel indicate that the model is being used to calculate the height to which fracturing may occur rather than the height of the fractured zone[216]. As such, the fracturing that the model is now claimed to

[213] EA for Metropolitan Coal Project, Appendix A, p.88.
[214] EA, Appendix O, Table O-B and Table 9 of this PAC Report.
[215] EA, Appendix O, p.24 – but note that EA Appendix A, p.95 states that *'The main mechanisms that could potentially result in the cracking, buckling and dilation of the strata beneath the swamps are the systematic curvatures and strains and the valley related upsidence and closure movements'*.
[216] ICHPL (2010e).

address is that which may develop in the constrained zone and/or within the surface zone. This latter fracturing is generally believed to comprise open horizontal fractures and parting planes and scattered vertical fractures which, in the case of the BSO Project, are not connected to the mine workings. The horizontal fractures and partings can have a significant capacity to transmit and store water.

Hence, ICHPL rejects the notion that fracturing could form a conduit for water that escapes from the perched water table to enter the mine workings. The Panel accepts that the ICHPL position is the likely situation in the case of the BSO Study Area. ICHPL also asserts that very few swamps would connect to groundwater aquifers from vertical cracking, but the support for this assertion comes from a conceptual groundwater model and not from hard data. ICHPL acknowledges this shortcoming and suggests that piezometric measurements would be required as part of any swamp monitoring program to establish the facts.[217]

The Panel also notes that the EA claims that the SCA's work at Butler's Swamp and Stockyard Creek provides evidence that the perched water table of the swamps and the underlying regional groundwater aquifer are not hydraulically connected.[218] However, the issue is not whether these systems are separated under natural conditions, but what might happen if they are undermined. The examples used as 'evidence' are from bore pumping tests, not mining, and, whilst there may have been depressurisation in the regional aquifer, the other impacts of mining were not present.

There is a further possibility, being that the disturbance in the profile above the mining layout provides access to a pre-existing shallow permeable strata or conduit that is not connected to the mine workings. (There is evidence from some swamps that, following undermining, substantial quantities of surface water flow into a subsurface network without reporting to either the mine workings or downstream gauges.)[219]

6.4.4.2. Impacts Associated With Compressive Fracturing Of Bedrock

The issue has not been addressed in the EA, possibly because it was not referred to specifically as a possible mechanism in the Metropolitan PAC Report. The maximum conventional compressive strain predicted for the Metropolitan Coal Project was 1.7 mm/m and therefore below the MSEC threshold trigger level for compressive fracturing to develop in sandstone environments.

6.4.4.3. Impacts Associated With Vertical Displacement

Subsidence results in a change in the elevation of parts of a swamp or an entire swamp relative to the surrounding landscape, with larger swamps having a higher exposure to this subsidence effect. The spatial relationship between the Base Case longwall panel layout and the distribution of swamps shown in Figure 23 illustrates the potential for differential and absolute changes in the elevation of swamps in the North Cliff and Area 2 mining domains. Figure 24 shows the effect in detail for

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[217] EA, Appendix O, p.12.
[218] EA, Appendix B, p.60.
[219] e.g. East Wolgan Swamp – see ICHPL (2010e), Response to PAC Question 14, pp.19-20.

Swamp DAC-S7b, circled in Figure 23. It can be seen that the elevation of a large section of this swamp has been reduced by around 800 mm and that within this subsided section there are variations in elevation of about 400 mm.

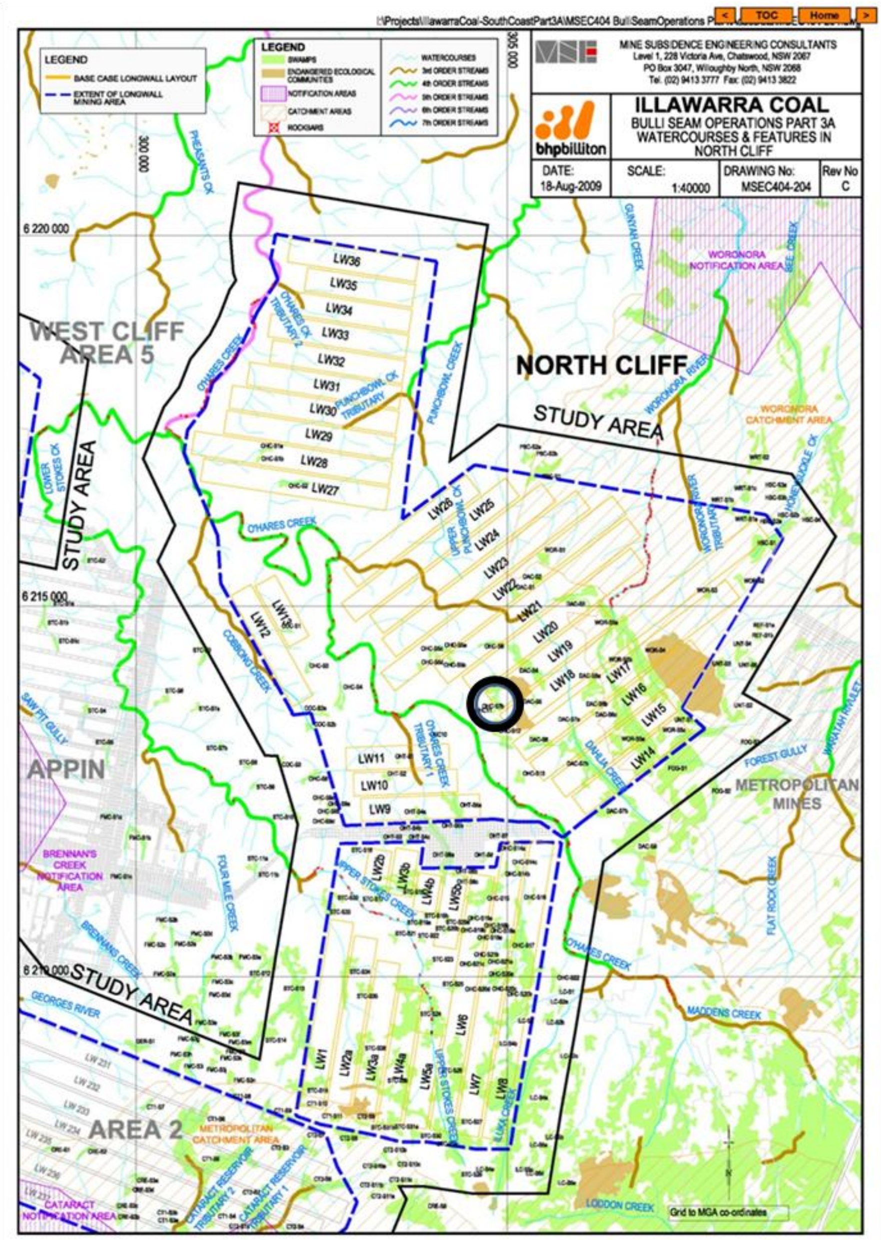

Figure 23: Location of Swamps in BSO Study Area Relative to Base Case Longwall Layout, with Swamp DAC-S7b Circled[220]

[220] Reproduced from EA, Appendix A, Drawing No MSEC401-204.

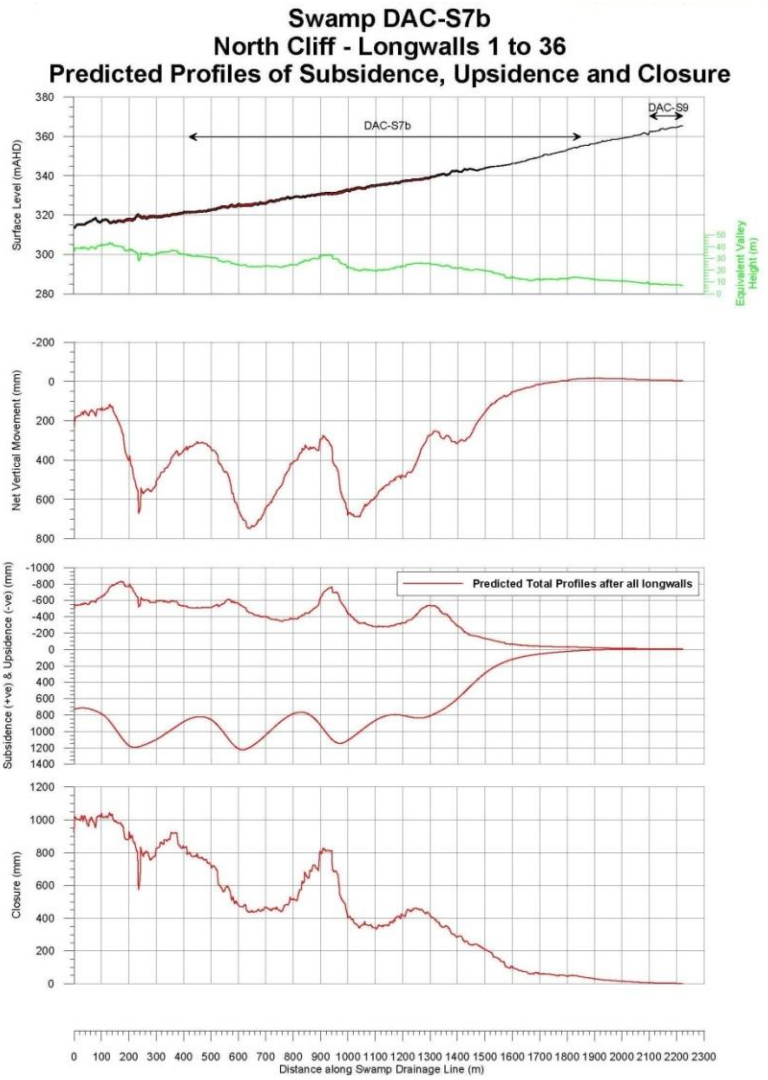

Figure 24: Predicted Net Vertical Displacement, Upsidence and Closure Profiles for Swamp DAC-S7b on Dahlia Creek Showing Change in Elevation of the Swamp[221]

Swamp DAC-S7b is one of the swamps that the Panel has previously concluded should be deemed to be of 'special significance' because of its size (see Section 6.4.3.3). The Panel also notes that the following subsidence predictions are associated with this swamp[222]:

Tensile strain:	1.3 mm/m
Compressive strain	2.1 mm/m
Closure strain	13.5mm/m
Closure	827 mm

These subsidence effects are conducive to increasing the permeability of the surface zone and facilitating groundwater flow from the flanks of the swamp into the

[221] Reproduced from EA, Appendix O, Fig. DAC-S7b-V.
[222] Appendix O, Attachment OB.

subsidence depression in the first instance, and then possibly out of the system through upsidence fracture networks. Hence, the Panel considers that at the very least, this swamp should be classified as at risk of significant negative environmental consequences.

The issue of differential change in elevation and its impacts have not been addressed in the EA, possibly because it was not referred to specifically as a possible mechanism in the Metropolitan PAC Report. However, the Panel considers that it is likely to be of significance in the BSO fact situation and should be addressed. How this can be done on the basis of a flexible mine plan is difficult to contemplate, since the impacts will be site-specific.

6.4.4.4. Impacts Associated With Tilt

In line with the Metropolitan PAC Report, the EA identifies subsidence-induced tilting of swamps as a possible mechanism of impact. Tilting may lead to hydrological change in swamps if it is of sufficient magnitude to:

- Re-concentrate run-off leading to scour and erosion; or
- Alter water distribution in parts of the swamp leading to changes in either swamp health or vegetation composition. In relation to water distribution, impacts can occur from both increases and decreases in water levels in swamps or parts of swamps.

The EA raises the issue of changes in drainage alignment and states that 11 swamps are likely to suffer 'moderate' changes in drainage alignment[223] but concludes that these are unlikely to result in significant negative environmental consequences for these swamps. There is no clear indication as to how this conclusion was reached or on what information it was based.

The EA goes on to describe a method of assessing the vulnerability of swamps to scour and erosion (the 'erosion index').

The analysis of susceptibility to scour relies on an assessment of the magnitude of change in this theoretical erosion risk index, calculated to represent the potential for scour in the swamp if the vegetation is destroyed by fire. While the index is broadly based on a selection of the physical mechanisms at play, predictions based on the absolute value of the index remain speculative. One potential mismatch between the index and reality comes from the reliance on a single '<u>representative</u>' cross section flow geometry for the calculation of boundary shear stress in the swamp. This fails to recognise the fundamental mechanism that scour is most likely to be initiated at an <u>unrepresentatively</u> narrow or steep or erosive section of swamp, before propagating through the swamp by upstream and downstream progressing degradation.

Figure 4 reproduced from Appendix O in the EA shows the computed erosion index for pre-subsidence conditions to be highly variable (from an index value of 0.14 to 14.2) compared to the changes predicted from subsidence. An erosion index of 1.0 implies that scour of the swamp is just occurring.

[223] EA, Appendix A, p.95.

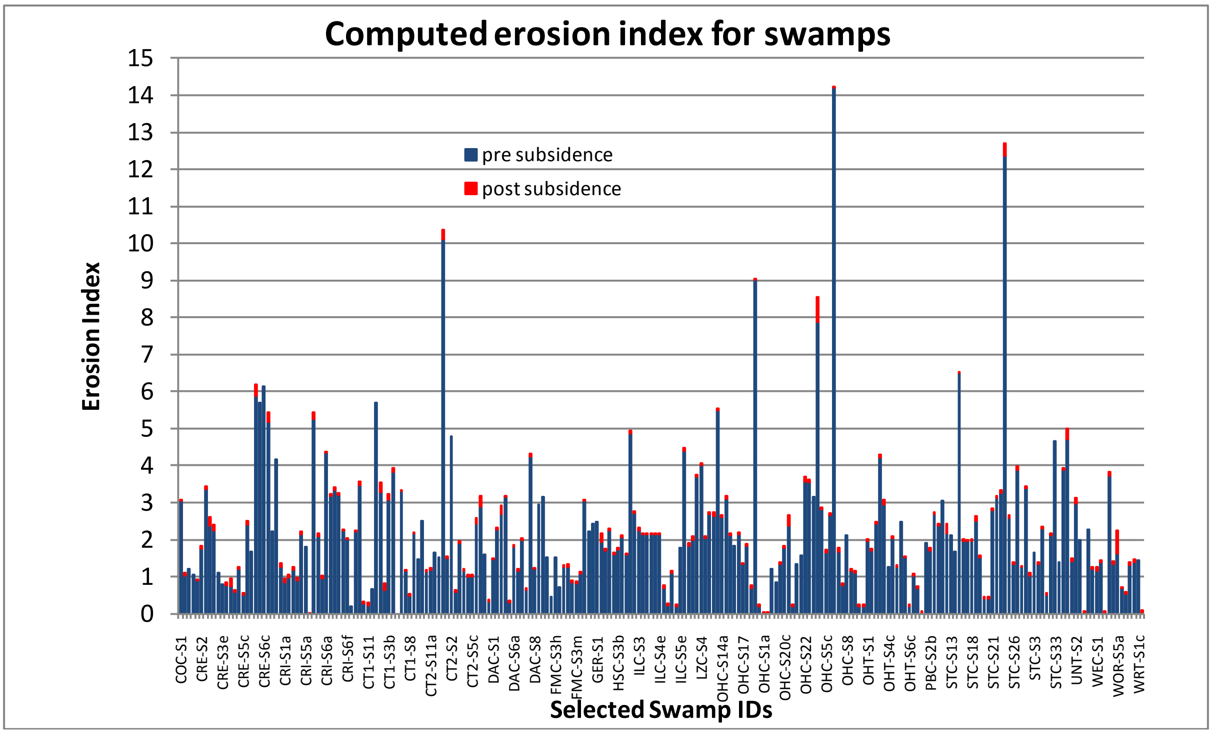

Figure 25: Erosion Index Computed for Swamps for Pre-subsidence and Post-subsidence Conditions.

The risk assessment reported in the EA identifies high susceptibility swamps as those showing an absolute change in the value of the index of greater than 0.2 from pre subsidence to post subsidence conditions. This results in 14 out of 232 swamps being categorised in the EA as susceptible to erosion post-subsidence. In fact, this categorisation resolves simply to identifing any swamp where the change in boundary shear stress as a result of subsidence is greater than 10 N/m^2. No justification is given for the selection of this threshold.

Predicted changes in the erosion index in combination with its absolute value are used to identify 14 swamps as being highly susceptible to erosion. Of these, only eight are carried forward to be classified as swamps at risk of significant negative environmental consequences on the basis that they are also predicted to be subject to valley closure movements of more than 200 mm.

The EA does not explain why erosion potential on its own would not be sufficient to classify swamps as being at risk of significant negative environmental consequences. If the potential for erosion is high, then that fact on its own should be sufficient to create concern.

Since the EA uses analysis of susceptibility to scour as a critically important component in the risk categorisation of swamps in the EA, it is important to note that the thresholds for both the predicted erosion index and the predicted change are not justified in the EA except by reference to 'anecdotal' information from previously undermined areas. In a response to questions from the Panel, ICHPL states that:

> *'the erosion index was intended to be a screening tool to identify swamps that are more likely to be sensitive to erosion as a result of predicted subsidence tilts when compared to other swamps'.*[224]

The Panel has concluded that the erosion index described in the EA may provide an indication of the relative vulnerability of swamps to erosion following subsidence. However its use is not justifiable in an absolute sense to demarcate swamps where risk management procedures are (or are not) required. Furthermore, the approach only considers the possibility of tilt-induced erosion after fire. It does not consider the other components of tilt-induced risk identified in the Metropolitan PAC Report. These other forms of tilt-induced change in hydrology may be more important, with long-term redistribution of water in a swamp causing some parts of the swamp to become wetter and some parts drier, thus favouring some of the six vegetation associations more than others. Changes in water distribution may also increase vulnerability to other hydrological impacts arising from erosion and scouring and may also alter the size of the swamp.

6.4.4.5. Impacts Associated With Non-Conventional Subsidence - Valley Closure

The EA identifies maximum predicted valley closure values for swamps and utilises the threshold of >200 mm predicted closure (using the MSEC prediction methodology discussed in Section 4.2.2.2 for inclusion in the swamp risk assessment. On this basis 33 swamps have been identified as being at risk of negative environmental consequences and of these, only eight are considered to be at risk of significant environmental consequences[225] based on their erosion index parameters.

The assumption in the risk assessment that the erosion index is relevant to assessment of the threat of impact from upsidence is difficult to understand. The two may work in tandem, but they don't have to do so to cause effect, impact and consequences.

Negative environmental consequences could be caused by erosion and drying out of the swamp via the eroded channel, or they could be due to redistribution of water caused by the upsidence, or they could be due to diversion of water away from the swamp via connected pathways exposed by buckling and shearing of the bedrock. Erosion may be a long-term consequence of the latter two, but not the proximate cause of the damage.

The Panel is also concerned that the threshold for assessment of risk is being set at >200 mm predicted closure. As knowledge improves there will undoubtedly be a revision of this figure as a threshold for triggering concern or investigation (there is already evidence of damage occurring to rock bars in streams at lower predicted closures). The Panel is of the view that the more sensible approach as knowledge improves is to develop a prediction methodology that is premised on a correlation between measured closure and measured impacts. Developments in the prediction of

[224] ICHPL (2010b), Response to PAC Question 60, p.50.
[225] EA, Appendix O, p.O-29.

closure, closure strains and upsidence need to be kept under review and adjustments made to swamp risk assessments methodologies and thresholds as required.

It appears intuitive and logical from a mechanistic perspective that valley closure and upsidence mechanisms would operate under swamps in the same way they do under streams, i.e. buckling and bedding shear enhances fracture connectivity in the host bedrock and water is diverted into the fracture network where it is either stored or provided with an escape path away from the swamp. The only potentially significant difference between the streams on Hawkesbury Sandstone and the upland swamps is that the swamps have sediment and organic material above the bedrock which may either seal or partially seal the fracture network. The streams generally have very little sediment, and most of it is sand. Attempts to use sand to seal rock bar fractures on the Waratah Rivulet have been unsuccessful to date.

For swamps there is no solid evidence that self-sealing occurs at all, or is 100 percent effective if it does occur. Evidence of hydrological impact and negative environmental consequences for undermined swamps is emerging and until much more research has been done, it is the Panel's view that self-sealing (sometimes called self-healing) cannot be relied upon to mitigate or manage upsidence-related impacts on swamps.

The Panel also notes when undertaking subsidence impact assessment that some non-conventional subsidence effects, such as vertical displacement and strain, need to be combined with the corresponding conventional effects in order to take full account of subsidence effects. In the case of the BSO Project, non-conventional subsidence alone is predicted to result in 21 swamps being exposed to a closure strain of 9.5 mm/m or above[226]. Six of these swamps have a predicted closure strain of 13.5 mm/m and one has a predicted strain of 20.0 mm/m.

Of the 21 swamps, six overlap with the substantial size criteria discussed in Section 6.4.3.2 (CT1-S5, CT1-S6, CT2-S6, OHT-S6a, STC-S13, STC-S26) and three with the complexity criteria (OHC-S15, STC-S13, STC-S19a). One, STC-S13, overlaps with both of those criteria. The others are: CRI-S5c, CRI-S7, CT1-S2, CT2-S7, DAC-S2, DAC-S3 (maximum closure strain of 20.0 mm/m), DAC-S7b, OHC-S5a, OHC-S6, OHC-S7a, OHT-S5a, STC-S15, and STC-S34. Only four of the 21 swamps are included in the eight swamps that ICHPL considers to be at risk of significant negative environmental consequences.

The Panel notes that none of the three swamps singled out for special attention on the basis of maximum predicted closure strains in the approval for the Metropolitan Project had predicted strains of more than 8.9 mm/m.

6.4.4.6. Findings and Conclusions on Risks of Impacts and Consequences

- The ICHPL criteria for selection of swamps as being at real risk of negative environmental consequences minimises the number of swamps that might be considered to be of greatest concern. The selection of eight swamps considered to be at risk of significant negative environmental consequences is

[226] EA, Appendix O, Attachment OB.

based on assessment of only two of the multiple possible impacts and then by requiring both of these to be present at a high level. The justification for this is not provided and in the Panel's view the ICHPL analysis and conclusion is not sustainable.

- The Panel's view is that, at the present state of knowledge, the following criteria should be applied individually to identify swamps that may be at risk of negative environmental consequences[227]:

  - all swamps subject to systematic tensile strains > 0.5 mm/m.
  - all swamps subject to systematic compressive strains > 2 mm/m.
  - all swamps with depth of cover less than 1.5 times longwall panel width.
  - all swamps subject to tilt (transient or final) > 4 mm/m.
  - all swamps subject to a predicted valley closure of >200 mm.
  - all swamps subject to a 'maximum observed closure strain' >7.0 mm/m.

- All swamps subject to the risk of negative environmental consequences should be individually assessed in terms of their characteristics to determine whether the risk is either unacceptable or acceptable with or without mitigation and/or management measures. This has not been done for flora and fauna, even for the substantially reduced number of swamps that ICHPL identified as being at risk. It has also not been done for hydrology, with no actual piezometric measurements conducted in any swamps in the Study Area.

- Some of the data in Appendix O (Swamp Risk Assessment) of the EA is of value in assessment of risk. However, in the Panel's view, Appendix O simply places pre-existing data and conclusions into the risk assessment framework identified in the Metropolitan PAC Report. The elapsed time between the publication of the Metropolitan PAC Report (June 2009) and the submission of the EA for the BSO Project (31 August 2009) would support this view, as would the manifestly inadequate data on swamp hydrology and flora and fauna in the EA.

  For Appendix O to meet the requirements set out in the Metropolitan PAC Report the predicted impacts should be used to identify all swamps at risk of negative environmental consequences from all subsidence effects. These swamps should then be assessed individually to determine whether the predicted impacts could have a significant effect on (i) hydrology and (ii) flora and fauna in that swamp. This cannot be achieved without the relevant information for hydrology and flora and fauna – which is not provided in the EA.

  It is only once there is a comprehensive understanding of the nature of the risk, its magnitude and its possible consequences that there can be any basis for considering what might be done to avoid, mitigate or manage it.

[227] Note that this is a threshold for investigation – not a conclusion that the swamp will be impacted or suffer consequences.

The possibility noted in the EA that the width of the longwall panels may increase by an unspecified amount makes it impossible to assess the full risk potential for upland swamps in the BSO Study Area. However, any increase in longwall width must logically increase the potential risks to swamps.

6.4.5. Step 5 – Consideration of Acceptability of Negative Environmental Consequences

The requirements are set out in the Metropolitan PAC Report at p.82 and acknowledged in the EA.[228] The relevant extract is set out below.

> *'Negative environmental consequences are considered undesirable for all swamps and*
>
> *a) swamps of special significance will be protected from negative environmental consequences;*
>
> *b) a presumption of protection from significant negative environmental consequences will exist for all other swamps unless the Proponent can demonstrate for an individual swamp that costs of avoidance would be prohibitive and mitigation or remediation options are not reasonable or feasible. Under circumstances where the decision is to allow significant negative environmental consequences to occur and remediation is not feasible offsets may be considered appropriate.'*

6.4.5.1. Swamps of Special Significance

The Panel has already described the ICHPL survey efforts as manifestly inadequate for the purposes of assessing special significance and, on this and other grounds, has concluded that the ICHPL determination that no swamps in the BSO Study Area are of special significance is simply not credible.

The problem is that the substantial gaps in the information make it impossible for the Panel to provide a complete list of swamps warranting a recommendation of special significance status. There appear to be three options:

(i) all swamps in the eastern and southern parts of the North Cliff and Area 2 are classified as being of special significance and are therefore to be protected by a requirement for either nil or negligible impact.

(ii) Classify as being of 'special significance':

  (a) those 30 swamps identified in Section 6.4.3.2 based on inclusion in the upper 10^{th} percentile for size and the 13 identified based on complexity[229], and

  (b) swamps or clusters of swamps identified as important for the conservation of EECs or threatened species based on a comprehensive survey of flora and fauna, including appropriately targeted surveys for threatened species conducted according to DECCW specifications.

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[228] EA, Appendix O, p.3.
[229] Seven of these swamps fall into both categories.

(iii) Refuse approval for mining in the North Cliff or Area 2 domains on the basis that the lack of relevant information on individual swamps in the EA means that no risk assessment relevant to the approval of undermining of swamps in the BSO Study Area has yet been carried out.

The Panel notes that its approach in the Metropolitan Project Review (in-principle approval followed by monitoring of a representative sample of swamps and specific investigation of three swamps) is not appropriate in the case of the BSO Project because the mining parameters are substantially different and the risks to swamps are potentially much greater both in terms of the number of swamps that could suffer negative consequences and the magnitude of those consequences.

The Panel also notes that the lack of data on something as critical to assessment of overall risk to swamps as the determination of special significance means that the public, the government agencies and this Commission have been unable to scrutinise the proposal to the level required to support a positive recommendation for mining as proposed.

6.4.5.2. Significant Negative Environmental Consequences

ICHPL has provided some alternative mine plans to avoid or minimise impacts on the eight swamps it considered to be at risk of significant environmental harm and concluded that the economic loss in terms of foregone coal production was greater than the economic gain from protecting these swamps[230] and therefore impact avoidance was not required.

The economic analysis is based on the results of the Choice Modelling exercise and the Panel has raised concerns about the validity of using results from this study for estimates of environmental value for natural features of high conservation value.[231]

ICHPL examined possible mitigation measures for minimising impacts on these swamps (i.e. narrowing longwalls and widening chain pillars). Again alternative mine plans were produced and conclusions were reached that costs outweighed benefits.[232]

ICHPL also examined possible maintenance responses (i.e. actions taken to repair damage or to control its impact on a swamp). Examples include sealing of cracks in bedrock, use of coir logs and matting to control water distribution, and grouting of rock bars. Unfortunately none of these techniques has a track record in swamp remediation and most of the work that has been done with them is in other environments and is unpublished.

ICHPL define their preferred risk management approach as:

- *'Implementation of maintenance responses (knick point control, water spreading, sealing of bedrock fractures and/or injection grouting) to maintain*

[230] EA, Appendix O, p.34.
[231] This issue is dealt with at length in Chapter 17
[232] EA, Appendix O, pp.35-36.

the physical state and function of a swamp that experiences subsidence impacts.

- *Implementation of the monitoring programme described in Section 07.5 (of the EA) to obtain additional baseline information to further inform the risk of subsidence impacts and environmental consequences.*
- *Implementation of offset measures, described in Table O-5 (of the EA).'*[233]

In relation to these points the Panel notes:

(i) the capacity of the proposed maintenance responses to maintain the physical state and function of a swamp is completely unproven and has been commented upon adversely by most stakeholders;

(ii) implementation of a monitoring program designed to obtain the data that was required to inform the risk assessment does not enable the decision-maker at the approval stage to make an informed decision; and

(iii) there are no offset measures proposed for swamps other than a financial contribution to research that, for most part, should have been undertaken previously to provide an adequate basis to assess ICHPL's proposals.

There are thus no protection measures proposed to prevent damage to upland swamps from subsidence-related impacts, <u>even for the eight swamps identified by ICHPL to be at risk of significant negative environmental consequences</u>. Furthermore, the Panel notes that of these eight: five were included in the Maddens Plains Cluster of swamps identified by DECC as being of the highest conservation value in evidence to the SCI in 2007, two are in the top 10 percent of swamps based on size on the whole Woronora Plateau, one is also included among the 13 most complex swamps identified by DECCW in the BSO Study Area, and <u>NONE</u> have been the subject of targeted surveys for threatened fauna species. ICHPL is in effect seeking approval to seriously damage and possibly destroy these swamps without providing even the most basic information on which such an assessment could be made.

The Panel's assessment is that the proposed approach by ICHPL to swamps is deficient at almost every stage of the risk assessment process and in most stages there are multiple deficiencies.

6.5. PRECAUTIONARY PRINCIPLE IN RELATION TO UPLAND SWAMPS

A number of submissions raised the application of the Precautionary Principle in relation to the potential for serious environmental consequences for upland swamps as a result of the proposed project.[234]

The Panel approached this issue by examining some of the various definitions used for describing the principle, examining the relevant case law and then applying the

[233] EA, Appendix O, p.41.
[234] e.g. Total Environment Centre, Colong Foundation for Wilderness, National Parks Association.

principles from the cases to the facts of the BSO Project as it relates to upland swamps.

There are several definitions of the principle including the one in s.6(2) of the Protection of the Environment Administration Act (1991) NSW which states that:

> *'...if there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation.*
>
> *In the application of the precautionary principle, public and private decisions should be guided by:*
>
> *(i) careful evaluation to avoid, wherever practicable, serious or irreversible damage to the environment, and*
>
> *(ii) an assessment of the risk-weighted consequences of various options'*

This is adopted by s.4(1) of the EP&A Act (1979) and is the definition referred to in the key NSW cases.

The two cases of most relevance are *Telstra Corporation Limited v. Hornsby Shire Council* [2006] NSW LEC 133 (*Telstra*) and *Newcastle and Hunter Valley Speleological Society Inc v. Upper Hunter Shire Council and Stoneco Pty Limited* [2010] NSW LEC 48 (*Stoneco*). Both of these cases were heard before the current Chief Judge of the NSW Land and Environment Court. The first case (*Telstra*) sets out in clear detail the factors to be considered in applying the Precautionary Principle. These are summarised below.

(i) The principle is triggered when two pre-conditions exist:

- a threat of serious or irreversible environmental damage
- scientific uncertainty as to the environmental damage.

(ii) The first pre-condition requires a threat, not actual damage, and that the anticipated damage is serious or irreversible. The threat can be direct or indirect and incremental or cumulative impacts are included.

(iii) The seriousness or irreversibility of environmental damage involves consideration of many factors some of which might include:

(a) spatial scale of the threat;

(b) magnitude of the possible impacts;

(c) perceived value of the threatened environment;

(d) temporal scale (including persistence);

(e) complexity and connectivity of the possible impacts;

(f) manageability of impacts (availability and acceptability of means);

(g) level of public concern and the scientific or other evidentiary basis for that concern; and

(h) reversibility of the impacts including feasibility and cost.

(iv) The second pre-condition is that there be a lack of full scientific certainty. Assessment of the degree of uncertainty includes:

(a) sufficiency of the evidence that there may be serious or irreversible harm caused;

(b) the level and kind of uncertainty;

(c) the potential to reduce uncertainty (what is possible in-principle, economically, and within a reasonable timeframe).

(v) The threshold to be met for uncertainty is less clear, but the formulations appear to require that there be at least a plausible scientific basis for the relationship postulated between cause and effect and that the level of uncertainty be considerable.

(vi) Once both pre-conditions are satisfied, the principle is triggered. The consequences are:

- the burden of proof shifts to the Proponent who must now demonstrate that the threat either does not exist or is negligible;
- unless the Proponent discharges the burden of proof the decision-maker must assume that the threat is a reality rather than uncertain; and
- the preference is to prevent the damage rather than remediate it.

However, the principle does not become the only factor in the decision-making, nor is it given weight beyond the consideration of environmental harm generally. But if the decision-maker approves the proposal the legal position is that they have done so in full knowledge that there will be serious or irreversible environmental harm.

(vii) *Telstra* then went on the deal with the level of precaution required. The simplest formulation is 'the more significant and the more uncertain the threat, the greater the degree of precaution required'. It was also noted that until the consequences of proceeding with the proposal are known, there should be a safety margin retained in favour of the environment.

(viii) One method discussed for achieving an appropriate level of precaution was adaptive management – based on the project being constrained in the area of uncertainty and only allowed to expand as the uncertainty reduced. The key elements include: monitoring of impacts based on agreed indicators; promoting research to reduce key uncertainties; adjustment of the activity based on the results and an efficient and effective compliance system.

(ix) The principle also requires that the measures used to resolve the problem are proportional to the problem itself, i.e. they should not go beyond what is necessary and, where there is a choice between appropriate measures, the least onerous should be pursued. A reasonable balance must be struck between the stringency of the precautionary measures and the seriousness and irreversibility of the potential threat.

(x) The principle does not operate to require prevention at any cost. The potential costs of prevention must be in proportion to the benefits. The case notes the inappropriateness of traditional cost-benefit analysis for this task and suggests that multicriteria analytical tools may be of more use.

In *Stoneco* the Court considered the precautionary principle in relation to a mining proposal (limestone quarry). Applying the principles in *Telstra* the Court found that a threat of serious or irreversible damage existed to the cave dwelling biota potentially present at the site. The uncertainty requirement was met by uncertainty as to the extent of the presence of biota and therefore, the extent of the impact. The presence of the biota and the potential impact mechanism were both scientifically plausible.

The Court went on to apply a step-wise adaptive management approach to managing the threat. In doing so it elaborated on the requirements of an adaptive management approach, i.e.

> *'Adaptive management is a concept which is frequently invoked but less often implemented in practice. Adaptive management is not a "suck it and see", trial and error approach to management, but it is an iterative approach involving explicit testing of the achievement of defined goals. Through feedback to the management process, the management procedures are changed in steps until monitoring shows that the desired outcome is obtained. The monitoring program has to be designed so that there is statistical confidence in the outcome. In adaptive management the goal to be achieved is set, so there is no uncertainty as to the outcome and conditions requiring adaptive management do not lack certainty, but rather they establish a regime which would permit changes, within defined parameters, to the way the outcome is achieved.'*[235]

The principles in these two cases are applied below to the potential impacts of mining on upland swamps in the BSO Study Area. Numbering from the case law analysis above is used for ease of referencing.

(ii) <u>Existence of the threat of serious or irreversible harm</u>.

The existence of the threat of serious or irreversible harm is not contested. The Proponent identifies eight swamps as being at risk of significant negative environmental consequences and a further 47 as being at risk of negative environmental consequences. Other key stakeholders (and this Panel) consider the number in both categories is seriously underestimated by ICHPL.

[235] *Newcastle and Hunter Valley Speleological Society Inc* v. *Upper Hunter Shire Council and Stoneco Pty Limited* [2010] NSW LEC 48.

There is a possibility of cumulative impacts from multiple longwalls damaging an individual swamp, and to flora and fauna from damage to multiple swamps particularly where they are in close proximity.

Note that in *Stoneco* the various attributes associated with the feature were all part of the issue to be considered (i.e. the limestone formation, the hydrology and the biota).

(iii) The seriousness or irreversibility of environmental damage

(a) Spatial scale: Most of the 226 swamps in the BSO Study Area are concentrated in two of the seven mining domains covering an area of approximately $74km^2$. DECCW estimates that more than 10 percent of this area is covered by upland swamps. Examination of the base case mine layout indicates that a high proportion of these swamps would be undermined in whole or in part.

(b) Magnitude of impacts: in the Southern Coalfield, impacts that have occurred in association with mining range from destruction of swamps or parts of swamps through to minor areas of vegetation dieback. In between are a range of impacts from minor changes in distribution of vegetation associations to major changes in distribution of vegetation associations. The environmental consequences for a swamp depend on the hydrological changes caused by the subsidence impacts.

The BSO Project mining parameters coupled with steeply dissected terrain in the eastern half of the Study Area make the threat significantly greater, and the potential impacts significantly greater, than for many other Southern Coalfield mining operations.

At the landscape scale the number of swamps at risk is contested. The Proponent has identified a very small proportion and the other stakeholders (including DECCW) a much higher proportion. In the Panel's view the latter is the credible position.

(c) Perceived value of the threatened environment: Upland swamps are identified as habitats of the very highest conservation value in terms of species diversity and density and protection of threatened species. Overall the swamps in the BSO Study Area were included in one of the four clusters of swamps identified by DECCW as highest conservation value in evidence to the SCI in 2007. They are also regarded by SCA to be critical elements of the Sydney Drinking Water Catchment hydrology.

(d) Temporal scale: environmental damage results from changes in hydrology involving either loss of water or redistribution of water. Loss of water occurs through accelerated flow via altered flow paths, scour and erosion, fracture of controlling rock bars, etc, and from escape into fractured networks in bedrock below the swamp. Redistribution of water in the swamp can also occur in response to both conventional and non-conventional subsidence.

The environmental damage can therefore occur quickly (e.g. if the swamp drains) or over decades (e.g. if the changes in water distribution cause shifts in vegetation composition or increased vulnerability to some other threatening process such as fire or flood). The persistence of most changes would be long-term.

(e) Complex connectivity: the chain of causation from effect through impact to environmental harm is complex in the case of subsidence-induced environmental harm to swamps. There are four stages. Mining causes either conventional or non-conventional subsidence effects. These effects may cause impacts such as vertical fracturing, tilt or valley closure and upsidence. Depending on severity and location these may cause changes in swamp hydrology which in turn may lead to environmental damage to swamps.

The range of possible hydrological changes ensures that it is difficult, if not impossible, to predict the precise outcome in advance from an understanding of the mining parameters and the geological features.

(f) The manageability of possible impacts: The Proponent has put forward some possible approaches to management of a limited number of the possible hydrological changes. To the Panel's knowledge none of these proposed approaches has been used successfully to manage impacts on upland swamps.

(g) The level of public concern and the basis for that concern: there is a high degree of public concern as evidenced by submissions on the EA and to this Review,[236] articles in major metropolitan newspapers on the threat to swamps from this project proposal and the importance of swamps to conservation and catchment health, and television documentaries and news items on the role of swamps and the threat posed to them by mining.

There is sufficient scientific evidence of both the importance of upland swamps and their vulnerability to subsidence-induced impacts to more than satisfy this requirement.

(h) Reversibility of impacts: the environmental consequences are such that they are very difficult to reverse (arguably impossible in any practical sense). It is equally unlikely that the hydrologic changes can be reversed and the collateral damage from attempting to do so using engineering solutions would likely produce their own significant impacts.

In the Panel's opinion the first pre-condition is satisfied, i.e. there is a threat of serious or irreversible harm and that harm is likely to affect a substantial number of swamps in the Project Area.

(iv) and (v) Lack of full scientific certainty

There are clear statements in the report of the SCI and in the Metropolitan PAC Report concerning the lack of scientific knowledge about the relationship between subsidence effect, impact and environmental consequences for swamps. These are repeated in the EA.

Some (but not all) of the pathways by which environmental consequences occur are known at the principle level but as yet there is no quantitative relationship between effect and consequence that could be used predictively.

A limited attempt has been made in the EA to classify swamps in the BSO Study Area according to risk of serious harm using two of the potential impact pathways. The approach has been criticised by other experts as not credible. The Panel shares the concern about credibility of the current attempt, but

236 Including individuals, NGOs, Local Governments and NSW State Agencies (DECCW, SCA, NOW).

recognises that this approach will need to be pursued further with a more comprehensive suite of parameters and better information.

It will take some time to acquire the information to improve current understanding of subsidence impacts and environmental damage to swamps. The Metropolitan PAC Report[237] recommended that a workshop be held between experts from all parties and multiple disciplines to explore a structured approach to further research in this area.

The Panel notes in relation to uncertainty the manifestly inadequate information in the EA concerning the important characteristics of each swamp, including the key information on flora and fauna.

The Panel also notes the considerable increase in uncertainty based on the potential changes to mine layout and longwall panel width.

The Panel is of the opinion that the second pre-condition is met and that there is overwhelming evidence that the precautionary principle is therefore triggered.

(vi) Shift in the Burden of Proof

The Panel is of the view that, based on the information provided in the EA and in response to questions, the Proponent has not provided information that could discharge its obligation to demonstrate that the threat either does not exist or is negligible. In the Panel's view the threat both exists and is substantial.

(vii) The level of precaution required

Since there is both a significant threat and a substantial level of uncertainty the principle requires the application of a significant degree of precaution, with the safety margin falling on the side of the environment.

Both *Telstra* and *Stoneco* discussed adaptive management as a possible way to proceed with a development by limiting the opportunity for impacts, monitoring the results of early work, and then adjusting the project to maintain the required outcomes.

Some elements of the adaptive management approach to upland swamps are evident in the EA. There is a commitment to monitoring and to a contribution to research in the areas of uncertainty. There is also a commitment to some form of remediation, albeit using unproven techniques and limited to a couple of the multiple pathways by which hydrologic changes can cause negative environmental consequences for the swamp.

But the serious omission is any rigorous monitoring, review and management adjustment process as set out in *Stoneco*. What is in the BSO Project proposal falls well short of the basic requirements for an adaptive management program as set out in that case.

(viii) Proportionality of the solution

The BSO Project proposal has been presented as a single project. However, there are seven mining domains within it and only two of these contain large numbers of upland swamps (Area 2 and North Cliff). In the case of North Cliff the swamps are mostly in the eastern and southern portions. The focus

[237] DoP (2009a), p.89.

for any solution should therefore only be on the eastern and southern portions of North Cliff and Area 2.

The two possible solutions proposed in Section **6.7.2** below that would allow mining under swamps are designed to minimise the restrictions on mining whilst providing the required level of protection for the swamps. The first would see a number of swamps classed as being of special significance based on their identified attributes (e.g. size, complexity, contiguous habitat, presence of threatened species and EECs, etc) and therefore warranting negligible impact criteria being applied to them, and the second would see an area containing a substantial proportion of upland swamps protected to the same standard, with less rigorous protection for swamps outside that area unless they met the special significance test. Mining would be allowed under swamps provided the impact criteria could be met.

(ix) Cost of Prevention

The EA uses the results of the economic analysis combined with examination of some alternative mine plans to examine the costs and benefits of avoidance of impact at the eight swamps it considers to be at risk of serious harm and then mitigation of impact at these swamps.

Not surprisingly, the economic costs of avoidance and mitigation are found to exceed the economic benefit of protecting the swamps.

There are multiple problems with this analysis. In Chapter 17 the Panel points out in detail the flaws in the economic study and the dangers of using it to assess values at the domain or sub-domain levels. It should also be obvious that changing mining parameters for a few swamps and assessing costs and benefits on that basis will create a balance in favour of continuing damage. In the Panel's view, the analysis it is not based on sound methodology for determining the economic value that the public would place on upland swamps if they were properly informed about their contribution to conservation and catchment health. Multicriteria analysis, as recommended in *Telstra*[238] has not been used.

6.6. THE POSSIBLE INCREASE IN LONGWALL WIDTH AND ITS POTENTIAL IMPACT ON SWAMPS

If the longwall width increases, the number of swamps experiencing negative environmental consequences and the significance of those consequences is expected to increase. The Panel requested that ICHPL undertake sensitivity testing to determine the change in subsidence effects, impacts and consequences arising from different increments in longwall width.[239] ICHPL declined to do so[240] referring the Panel to Appendix A in the EA (which does not provide the required information). ICHPL went on to state that it expected that the form of any approval for the BSO Project would be the same as used in the Metropolitan Project Approval,[241] i.e. Performance Measures set out in the Approval Conditions with the details concerning mine layout etc in the Extraction Plans which must be consistent with achievement of

[238] *Telstra Corporation Limited v. Hornsby Shire Council* [2006] NSW LEC 133.
[239] BSO PAC Panel Questions to ICHPL, Question 16.
[240] ICHPL (2010e), p.29 and p.31.
[241] ICHPL (2010e), p.30.

the Performance Measures in the Approval and the predictions and commitments in the EA.[242]

There are multiple problems with the ICHPL position. They include:

(i) The approval to undermine upland swamps in the Metropolitan Study Area followed a recommendation from the Metropolitan PAC Panel that was based on its assessment that sufficient information existed for the Panel to be confident that the risks to upland swamps were low overall. The Panel had a firm proposition to consider (the mining parameters were not subject to change) and had the benefit of considering government agency expert advice and independent expert advice on the proposal.

(ii) The potential structure of the Approval was considered by the Panel and was deemed to be appropriate for protecting the upland swamps. The Panel's recommendations included a monitoring program for upland swamps and specific pre-conditions relevant to three swamps that may have been exposed to non-conventional subsidence effects at specific locations.

(iii) The BSO Project situation for upland swamps does not resemble the situation described above. The Panel's assessment is that, even on the Base Case layout and with 310m longwalls, the subsidence-related risks to swamps are greater than the EA predicts, and there is inadequate information to determine the full extent of that risk. The proposition to be assessed is anything but firm, with ICHPL stating that both the location of the longwalls and the longwall panel width are flexible. The Panel's view is that the introduction of wider longwall panels has the capacity to so substantially alter the occurrence and magnitude of subsidence-related risks to upland swamps that it effectively creates a different project proposal – one for which government agencies, special interest groups and the general public have not had the opportunity to provide advice to the Panel or to Government on the fully disclosed risks to upland swamps. It was to try and quantify the increase in subsidence-related risk from wider longwall panels that the Panel requested the information from ICHPL.

(iv) Application of the Precautionary Principle requires that there be strong protective measures for upland swamps set out in any Approval rather than being left to subsequent processes such as Extraction Plans that are not open to public scrutiny. This is even more critical with potential increases in longwall panel width. The options appear to be relatively few:

- ignore the risk and proceed;
- prohibit mining under or adjacent to upland swamps (or a specified sub-set of upland swamps);
- set a negligible or nil impact for all upland swamps (or a specified sub-set of upland swamps).

242 ICHPL (2010e), p.30-31.

(v) The commitment in the EA[243] concerning increases in longwall width states:

'... in the event that the environmental impacts associated with mine subsidence exceed that authorised by the Project Approval, in addition to remediating the impacts, adaptive management techniques would include reducing longwall width, increasing pillar widths or shortening a longwall to reduce subsidence effects at the surface.'

Dissecting this statement in the context of swamps reveals the following:

- it is environmental impacts that must exceed the Project Approval before action is required (not predicted subsidence impacts). But some of the key environmental 'impacts' (presumably equivalent to 'consequences' in SCI and Metropolitan PAC terms[244]) will only become evident over time, i.e. when the mining is complete.
- What ICHPL is seeking in the Project Approval becomes very relevant in this context. ICHPL is in fact seeking to be able to undermine any swamp in the Study Area. ICHPL identifies that 55 swamps (approximately 25 percent of all swamps) are at risk of negative environmental consequences and of these 8 are at risk of significant negative environmental consequences.[245] However, ICHPL claims that it would be inefficient to avoid undermining any of these swamps and would also be inefficient to use the adaptive management techniques of narrower longwalls, wider pillars and setbacks to protect them.[246]
- Remediation of the impacts is only required if the predicted environmental 'impacts' from the wider longwall panels exceed the predictions in the EA. There are two issues with this in relation to swamps:
  - The predictions are for 25% of swamps to suffer negative environmental consequences. However, these would not appear to be candidates for any remedial action under the terms proposed.
  - In any event, there are no guaranteed remediation techniques for the majority of likely impacts in relation to swamps. ICHPL have suggested possible techniques for a limited range of impacts, but these are all unproven.

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243 EA, Vol 1, Section 7.6.2, p.34.

244 If this is not the meaning, the commitment as a whole is meaningless. In Appendix O, ICHPL is careful to use the concepts of effect, impact and consequence as set out in the SCI and Metropolitan PAC Reports.

245 Note the Panel's conclusion that the ICHPL estimates are significantly lower than the likely number of swamps to be impacted.

246 EA, Appendix O, 7.3.1 and 7.3.2. Note that this position is reinforced in the ICHPL answer to Question 59 from the PAC (ICHPL (2010b), Q59 at p.50) where the possibility of using pre-mining stabilisation measures is determined by the 'status of the swamp'. This refers to swamps of 'special significance' status and ICHPL claims that there are none of these in the BSO Study Area.

- Adaptive management to bring the environmental impacts back within the EA predictions is a meaningless commitment for swamps because the main adaptive management techniques to prevent further risk of harm (and mentioned in the quote above) are specifically rejected in the EA in the case of swamps – even for those swamps identified by ICHPL to be at risk of significant negative environmental consequences. The ICHPL risk management measures for swamps are set out in the EA.[247] They include some monitoring and research, use of management and remediation techniques (all of which are unproven) directed at a limited range of possible impacts, and offsets (which are trivial commitments and not consistent with offsetting damage to upland swamps).

  It should also be noted in this context that there is no adaptive management plan in the EA in relation to swamps that would satisfy the test laid out in *Stoneco*.[248]

The Panel is of the view that the commitments are of low value in relation to swamps. It would be possible for ICHPL to increase longwall panel width and undermine swamps potentially causing substantial damage without triggering a response that would stop the damage or prevent its further occurrence.

6.7. UPLAND SWAMPS - FINDINGS AND RECOMMENDATIONS

6.7.1. Findings

(i) Extrapolation of conclusions from the Metropolitan PAC Report to assessment of the BSO Project Proposal is only valid where robust information exists to demonstrate that the characteristics of the two areas are sufficiently comparable to make such extrapolation appropriate. The Panel is of the view that the differences in the mine parameters and key characteristics affecting subsidence impacts make extrapolation of conclusions related to subsidence impacts unsound without further research and assessment.

However, the Panel considers that the methodologies for assessment of risk for subsidence-induced impacts reported in the Metropolitan PAC Report[249] are generally appropriate to the review of the BSO Project Proposal.

(ii) The mining parameters in the BSO Study Area indicate a much higher level of risk for upland swamps generally than was evident in the Metropolitan Project Review.

(iii) Since the Metropolitan Project Report was published, information has been emerging to suggest that a number of upland swamps in the

[247] EA, Appendix O, 7.4, p.41
[248] *Newcastle and Hunter Valley Speleological Society Inc v. Upper Hunter Shire Council and Stoneco Pty Limited* [2010] NSW LEC 48 (*Stoneco*)
[249] The Metropolitan PAC Report refined and applied to a mining proposal the principles set out in the SCI report.

Southern Coalfield are being impacted by subsidence-induced changes to hydrology.

(iv) The risk assessment in the EA is considered to be inadequate. The reasons are set out in 6.4.3.3 above. The key findings are that there are a substantial number of swamps that should be classified as swamps of 'special significance' (possibly extending to all swamps in the eastern and southern parts of the North Cliff and Appin Area 2) that the restrictive criteria used by ICHPL for classification of swamps at risk of significant negative environmental consequences is flawed, and that a much higher number of swamps than is estimated in the EA are likely to be at risk of both negative environmental consequences and significant negative environmental consequences.

(v) The proposals in the EA for managing risk to swamps are not considered acceptable by the Panel. Avoidance of impact is ruled out, as are mitigation measures - even for swamps the EA identifies as being at risk of significant negative environmental consequences. The management measures proposed are unproven and, even if they could be successfully implemented, only cover a very narrow spectrum of the potential hydrologic impacts to swamps. The proposed offsets are meaningless in terms of negative environmental consequences for swamps.

The Panel is also of the view that the Choice Modelling has not been used appropriately for assessing the value the community would place on upland swamps in the Study Area.

(vi) There are no protection measures proposed to prevent damage to upland swamps from subsidence-related impacts and ICHPL are seeking approval to undermine all upland swamps in the Study Area. The Part 3A Approval would effectively 'turn off' the NSW statutory protections for both EECs and threatened species, but the basic survey work to assess either presence or viability of any threatened species in the Study Area swamps has not been done. The Panel has described the work undertaken by ICHPL on fauna survey as manifestly inadequate. The Panel is of the view that this issue is of critical importance and that resolution cannot be deferred to a subsequent process.

(vii) The Precautionary Principle would appear to be squarely applicable to the proposed undermining of upland swamps in the BSO Study Area.

(viii) The predictions for subsidence-related impacts are based on 310m wide longwall panels. If longwall panel widths increase there is a substantial, but unquantified, risk of increase in the number of swamps likely to suffer negative environmental consequences and for these consequences to become much more significant. ICHPL has declined to provide the basic information required for the Panel to consider the magnitude of the increased risk and, combined with the pre-existing lack of adequate data on the characteristics of individual swamps, the Panel considers that the risks must be categorised as unacceptable unless the swamps are protected by a nil or negligible impact requirement.

6.7.2. Recommendations

The Panel recommends that one of the following three options be implemented in relation to protection of upland swamps in the Study Area:

(i) Mining not be approved for the area marked A on Figure 26;

(ii) Upland swamps in the area marked A on Figure 26 be protected by requiring as part of any Approval, a performance criterion of negligible subsidence-related impact. This means that:

<u>- before mining can occur under or adjacent to an upland swamp in Area A:</u>

(a) a Swamp Risk Management Plan (SRMP) must be developed as part of the Extraction Plan. This SRMP must demonstrate to the satisfaction of the Director-General of Planning that, for the proposed mining arrangement, subsidence predictions for conventional and non-conventional subsidence are within limits that will ensure the hydrology of the swamp will not be affected such that there is no potential for change in the size or functioning of the swamp, including potential changes in species composition or distribution within the swamp. This means that water will not drain from the swamp or part of the swamp as a result of any mining-induced subsidence, nor will water be re-distributed within a swamp or part of a swamp as a result of any mining-induced subsidence to an extent where such potential changes could occur;

(b) a monitoring program is designed and implemented that will provide both a platform for understanding the hydrology of swamps and advanced warning of any potential exceedances of the subsidence predictions, detect any actual exceedances of subsidence predictions and detect any impacts on the hydrology of the swamp and underlying hard rock strata. Especially important is the need to characterise the relationship between swamps and their role in recharging the regional groundwater systems; and

(c) an adaptive management plan is in place that meets the tests laid down in *Stoneco*[250] and is linked to the monitoring program in such a way that early detection will enable the mining operations to be adjusted so that the subsidence predictions are not exceeded and subsidence impacts creating a risk of negative environmental consequences do not occur.

The proposed performance criteria should be backed by sanctions sufficient to deter non-compliance.

[250] *Newcastle and Hunter Valley Speleological Society Inc v. Upper Hunter Shire Council and Stoneco Pty Limited* [2010] NSW LEC 48 (*Stoneco*).

- before mining can occur under or adjacent to any upland swamp in other areas:

(d) a comprehensive description of their characteristics is compiled including adequate information on EECs and threatened species (to standards set by DECCW);

(e) a rigorous assessment (to the satisfaction of DECCW) has been conducted as to whether the swamp contains an EEC or contains or is part of the habitat of a significant population of threatened species, or is of special significance for some other reason. If found to be of special significance the swamp is to be protected by the same negligible impact criteria, monitoring requirements and adaptive management requirements as swamps in Area A;

(f) for swamps not meeting the significance levels in (b) an Upland Swamp Risk Management Plan has been approved by the Director-General of Planning with such plan to include *inter alia* an assessment of the subsidence-related risks, a monitoring plan, a mitigation strategy if required and, as a last resort, remediation strategies where avoidance or mitigation of impacts are not feasible; and

(g) an offset strategy has been developed that has been agreed with DECCW for circumstances where significant negative environmental consequences occur in upland swamps.

(iii) Mining be approved in the area marked A on Figure 26, but with a negligible impact requirement for the swamps listed below plus any other swamps in Area A found to contain EECs or threatened species after comprehensive survey and which are considered by DECCW[251] to meet the test of special significance based on the conservation significance of those findings either alone or in combination with other values. The swamps identified currently are:

CRE-S6b, CRE-S7a, CRE-S8 (plus CRE-S7b)
CT1-S4, CT1-S5, CT1-S6
CT2-S2, CT2-S6
DAC-S7b, DAC-S9
FOG-S1
HSC-S1
ILC-S3, ILC-S4a, ILC-S5e (plus ILC-S4e)
OHC-S4, OHC-S15, OHC-S17
OHT-S6a
STC-S12, STC-S13, STC-S17, STC-S18, STC-19a, STC-S24, STC-S26, STC-S28a, STC-S28b
UNT-S1
WOR-S4, WOR-S5a, WOR-S56 (plus WOR-S5c)

[251] The Panel is of the view that the work by ICHPL to date on this issue does not provide a sufficient level of confidence that swamps of special significance would be identified correctly if ICHPL alone is responsible for the recommended work. The Panel considers that in this instance the conservation authority should act as 'certifier'.

Any swamps of special significance should have the same monitoring requirements and adaptive management requirements as those specified in (i) (b) and (i) (c) above.

For any upland swamp in Area A that does not meet the Special Significance test, the requirements in (d), (f) and (g) of (ii) above should apply, and for all upland swamps outside Area A, the requirements in (d), (e), (f) and (g) of (ii) above should apply.

The differences between (ii) and (iii) are probably relatively small in terms of impact on the mining operation, but (ii) would be much simpler to administer.

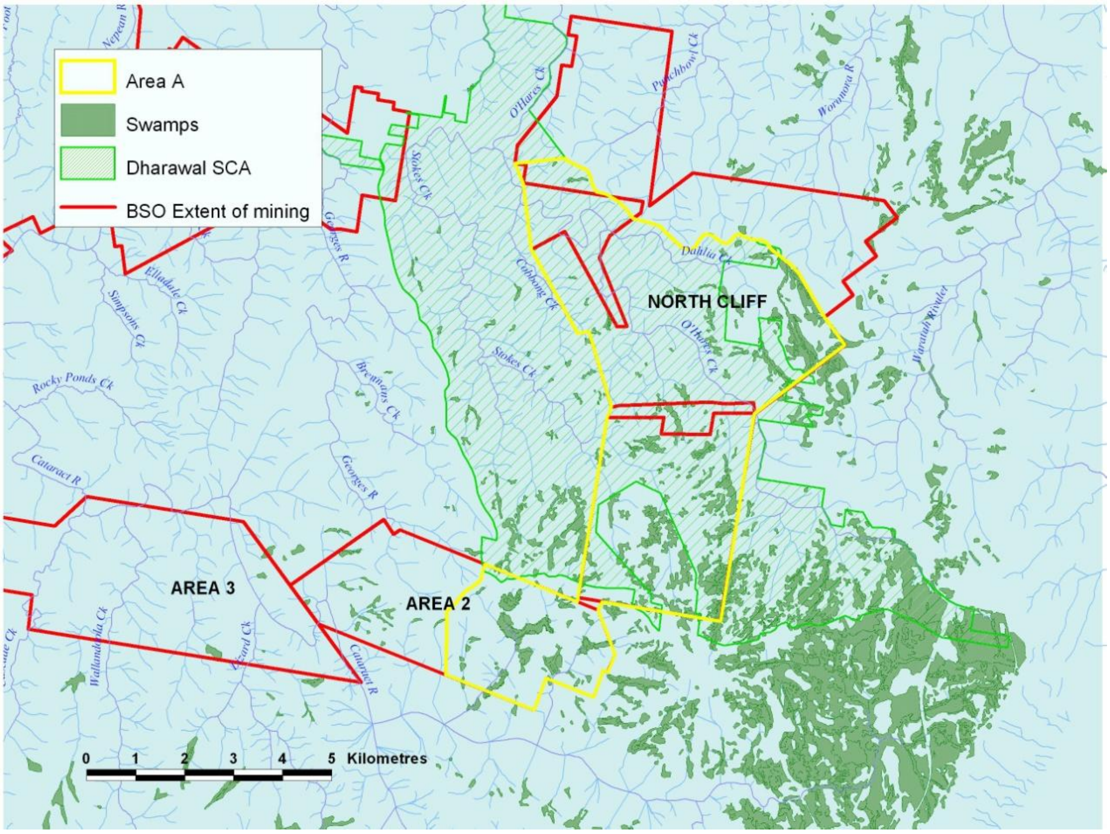

Figure 26: Boundaries Defining Area A

7.0 SURFACE WATER AND AQUATIC ECOLOGY

7.1. INTRODUCTION

A defining natural feature of the Study Area is its system of creeks and rivers and their importance for Sydney's water supply system. This system ranges from shallow, unconfined creeks with clay bed and banks and poor water quality to remote gorges with waterfalls, cascades, boulder fields and pools in an undisturbed setting. The impact of mining and the consequences for the condition of the waterways is a key issue addressed in the EA, in public submissions and in this section of the report.

7.1.1. Approach to Assessment

The Panel has relied on material from the EA, from public and agency submissions and from responses to requests for additional information. This material has been supplemented with the Panel's field inspections, knowledge and experience to:

- identify the range of values served by the river system;
- describe the magnitude, density and extent of the consequences of the project on river system values; and
- assess the acceptability of the consequences taking account of mitigation strategies.

The Panel makes two observations that distinguish key differences between the approach taken by the Panel and the approach taken in the EA.

1. The Panel does not subscribe to streams being represented as a series of discrete features in the landscape. Streams form a connected linear network. Many stream values depend on the recognition of the stream system as a continuum with the value of any segment heavily dependent on what happens up and downstream and in higher and lower order components of the system. Pools behind rockbars may be visually dominant features but other stream morphologies including boulder fields and pools behind other channel constrictions are also vital components of the linear system. At the same time, in the deeply incised gorge landforms that predominate in the sandstone geology, the 'conventional' and 'non-conventional' impacts of mining compound along the valley systems.

   Protecting the values of streams from impacts that are broad in scale will rarely require intervention only at a series of discrete locations – it is more likely to require some form of intervention or control throughout the interconnected linear network. This is at odds with the focus of the EA on remediation 'at controlling rock bars' as the pervasive objective in its preferred risk management options.

2. In the remote areas of sandstone gorges to the east and south of the Study Area, the Panel's assessment finds that much of the value of the stream network is closely associated with its natural characteristics and its pristine setting. Values relying on 'naturalness' have two distinguishing traits:

   i. Even small impacts can have major consequences for naturalness values. The response is non linear with a major threshold at very low levels of impact. Any activity (including remediation activities) that interferes with the natural hydrological, physical or biological processes in the stream system, immediately leads to loss of naturalness values and that loss can propagate up and downstream. This seems not to have been recognised in the EA where preventative risk management options rely on specification of valley closure constraints at controlling rock bars but not elsewhere in the stream system.

ii. Even with appropriate remediation, recovery of naturalness values has a long hysteresis and may in fact be irreversible. The EA's reliance on remediation as a primary risk management option does not recognise this trait.

The Panel makes the further observation that for rivers and streams, unlike impacts and consequences for some other natural features (swamps for example), the existence of links from impacts to consequences is broadly accepted by the Proponent. Agency and public submissions indicate a level of accord with at least the nature of the impacts and consequences[252]. Where differences emerge is in assessing the magnitude, density and extent of the consequences, and in the significance of the consequence to the values of the system. This has focussed the Panel's efforts toward resolving differences in this part of the assessment as reported below.

7.2. RIVERS AND STREAMS IN THE STUDY AREA

An overview of the rivers and streams shows two river catchments – the Nepean River catchment and the Georges River catchment – draining the Study Area northwards. The Nepean River (known as Hawkesbury-Nepean River further downstream) is the larger. Its tributary, the Cataract River, flows north-west through the Study Area, downstream of Cataract Dam. A small part of the north east corner of the Study Area drains to the Woronora Reservoir via the Woronora River.

Characteristics of rivers and streams in the Study Area vary across the catchments – principally dictated by geology. Stream condition (or 'stream health') is heavily influenced by catchment land use which is also geology dependent. Figure 27 illustrates the (simplified) geology of the region superimposed on the stream network. Areas of Ashfield Shale (part of the Wianamatta Shale Group) are strongly correlated with areas that have been cleared and developed – mainly for agriculture and urban use. Areas shown as Hawkesbury Sandstone are largely undeveloped. Topography and rainfall also reflect geology with areas of highest elevation and highest rainfall in the south and east of the Study Area.

Four broad categories of stream result from this general classification and have been used by the Panel to guide the assessment that follows, namely:

1. Within the Study Area, streams in the north west in the **Ashfield Shale** zone typically flow through developed agricultural land. This is the group of streams that flow north and west from the proposed mining Area 7, Area 8 and Area 9. They are unconfined creeks with clay bed and banks. They show limited variety in their physical form apart from occasional eroding bends and farm dams. Riparian vegetation is limited or absent. Water quality is generally poor[253].

2. In contrast, rivers and creeks in the **Hawkesbury Sandstone** to the south and east of the Study Area are heavily confined streams or gorges often flowing in protected water supply catchment, declared conservation zones or otherwise largely undisturbed

[252] The issue of catchment yield is an exception to this accord. See discussion in later sections.
[253] EA, Appendix C.

areas. They are typically steep, exhibiting a range of physical form reflecting their bedrock controlled confinement including boulder fields, rock shelves and rock bars, pools, waterfalls and cascades. In their upper reaches, the smaller tributaries emerge from their gorges and are associated with a range of swamp types. Runoff is high with persistent base flow. Water quality data in undisturbed areas is sparse but with some exceptions water quality appears good.

3. Between these two extremes are a number of streams that drain catchments of **mixed geology** where the drainage network has dissected the Ashfield Shale and cut down into the underlying Hawkesbury Sandstone. This includes the northward, southward and westward flowing tributaries of the Nepean River in the west of the Study Area. These creeks and rivers exhibit many of the physical features of the sandstone gorges to the east (rock bars, waterfalls, pools, etc) but water quality, hydrology and vegetation may be influenced by developed areas of Ashfield Shale origin adjacent to the gorge or upstream in the catchment.

4. As a special case, the **Nepean and Cataract Rivers** represent the region's major streams. They are deeply incised into the Hawkesbury sandstone but have areas of shale in their catchments. Their size and their dominant character within the landscape justify a separate category.

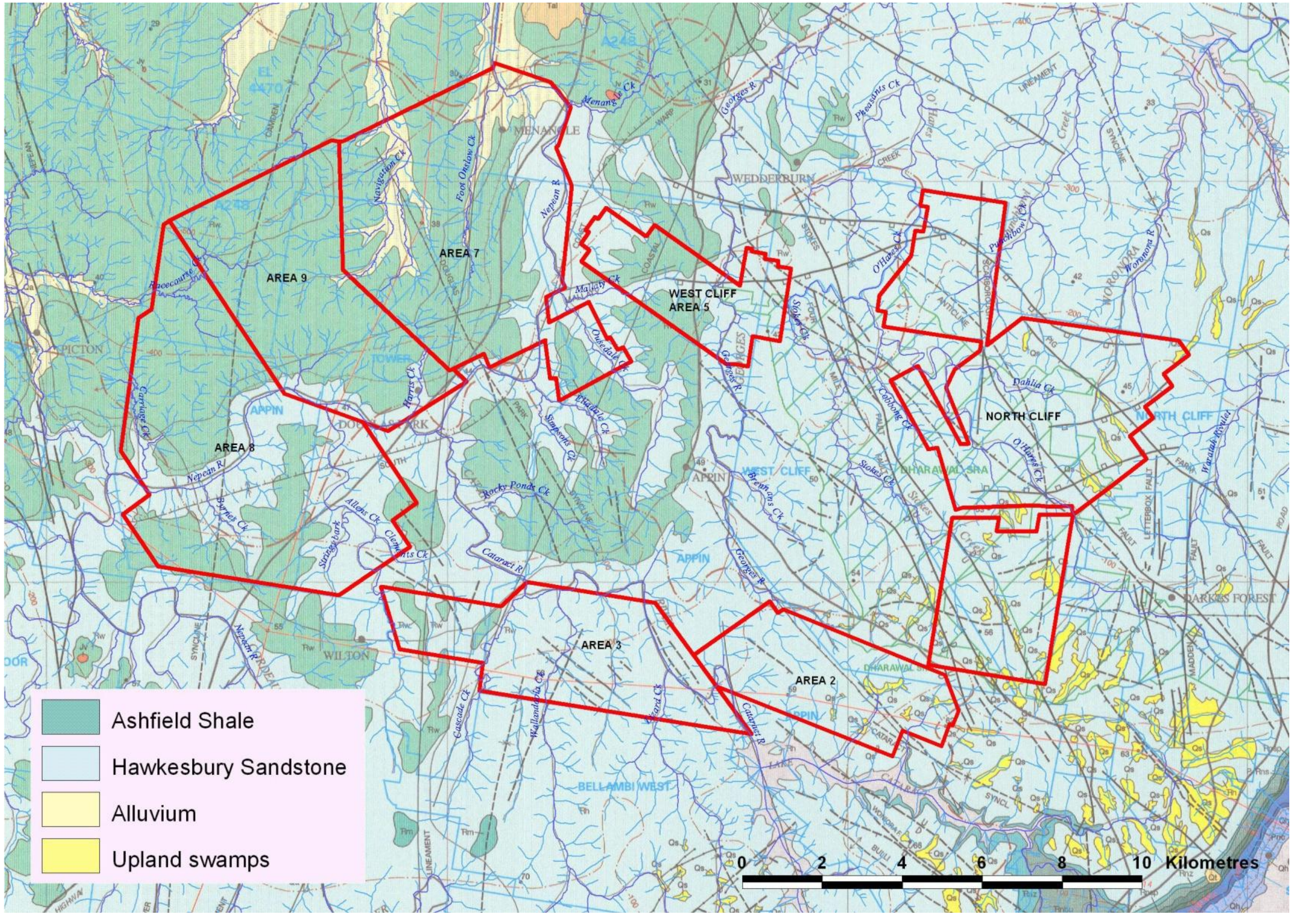

Figure 27: Stream Network Overlaying Simplified Geology

7.3. ASSESSING RISKS TO WATERCOURSES FROM MINING IN THE STUDY AREA

The SCI Report[254] and the Metropolitan PAC Report[255] describe a process that leads to an assessment of the acceptability of mining risks to the values of natural features. At its simplest, an application of this process to rivers and streams in the BSO Operations Study Area requires:

- Identification of the value and significance[256] of rivers and streams in the Study Area.
- An assessment of the impact of the Project on the value of rivers and streams in terms of likelihood and consequences of impact, including the effect of mitigation and remediation measures.
- An assessment of the acceptability of the outcome.

The EA goes some way toward this process but falls short in crucial areas.

Appendix C and Appendix P of the EA provide detailed descriptions of streams and their attributes. The detailed stream surveys that have mapped, catalogued and photographed streams and stream attributes throughout the Study Area, together with the other information presented in the 'stream matrix' (Attachment PB) provide an exemplary data base.

Appendix P goes on to acknowledge the range of use and non use values of the waterways: water supply, ecological significance, conservation value, community value and recreational value are all recognised. However little progress is made in the EA toward interpreting the catalogue of raw data to provide any link to the significance of an individual stream or a collective of streams in a catchment. Furthermore, only a subset of the values appear to be carried forward for assessment of the acceptability of impacts. The difficulty of these steps is acknowledged by the Panel and it is not suggested that any deterministic process can be called upon to deliver incontestable outcomes. However, without an assignment of values to streams or groups of streams, and without consistent appreciation of all the values in the system, it becomes impossible to make an holistic assessment of the risks to those values from mining.

As a result, description of project-related risks to stream values in the EA is narrow, focused almost entirely on catchment yield, maintenance of in-stream pools and protection of water quality. This narrow focus represents a limited appreciation of the risks to the values of rivers and streams from mining in the Study Area, particularly in the sandstone gorge areas to the east and south, and renders incomplete any judgement of acceptability that relies only on this assessment.

[254] DoP (2008).
[255] DoP (2009a).
[256] Assessment of 'significance', including 'special significance', is discussed in Chapter 6.

7.4. STREAM VALUES

7.4.1. Attributes

Stream classification and condition assessment schemes combine a number of attributes to characterise a watercourse.

- **Hydrology**: the flow regime in the river or creek. The magnitude, frequency and duration of flows are discriminating characteristics that influence the physical form, water quality, vegetation and aquatic life of the waterway. They dictate its usefulness for water supply. The hydrology of a catchment depends on its size, topography, climate, geology, vegetation and land use and is heavily impacted by any water resource development.
- **Physical form**: the size, shape and slope of the waterway and its in-stream features: pools, runs, bars, waterfalls, meanders, riffles, in-channel wood, and composition of the bed. Physical form is dictated by the geologic, tectonic and climatic history of the catchment including any anthropogenic intervention. Physical form is the result of long term geomorphic processes and is an obvious physical discriminator between streams.
- **Vegetation**: both riparian and in-stream vegetation. Includes grasses, sedges, shrubs and trees in and adjacent to the channel. Vegetation contributes to aquatic and terrestrial life by its influence on habitat, nutrient cycling, water quality and temperature. Vegetation associations are readily impacted by clearing, grazing and invasion of exotic species.
- **Quality of water**: the physical and chemical properties of the water flowing in the waterway. Includes turbidity, temperature, nutrients and other natural and introduced chemicals and contaminants.
- **Aquatic life**: the plant and animal organisms that live in the waterway. Includes macroinvertebrates algae and fish. The diversity and abundance of aquatic life depends on hydrology, physical form, vegetation and water quality.

7.4.2. Values

These attributes, singly or jointly give rise to, or support the values that society ascribes to a waterway. In the Study Area these values can be categorised as:

- **Hydrologic value:** includes the importance to catchment yield, particularly its significance to water supply. This is a 'use value' in economic terms. Water quality and permanence of flow are also important and contribute to amenity and ecological values. Aspects of ecosystem services including flood retardation and filtering of contaminants may also be classified as hydrological values.
- **Ecological value**: including contribution to biodiversity at regional, local and biotope scales and more specifically, conservation of threatened species of terrestrial and aquatic fauna and flora. These are passive and non-use values.
- **Environmental quality**: Society values the existence of areas preserved for their environmental quality or rarity; a non use value. Environmental quality is often closely related to naturalness.
- **Amenity value**: visual amenity and recreational opportunities afforded by the waterway are use values.

7.4.3. Describing Changes to Values

There are methods to quantify the change in values (in economic terms) as a consequence of the BSO Project. Some have been applied in the EA to compare the costs and benefits of project alternatives. The methods of economic evaluation reported in the EA (particularly the Choice Modelling) can provide a guide to the significance of changes to the values of streams in the Study Area as a whole, but the scale and resolution of the analysis precludes discrimination between streams or even groups of streams across the Study Area, even with the extensive data set presented in the EA. In the absence of such a practical, objective method of quantifying changes in values in individual streams or groups of streams in the Study Area, a qualitative assessment will need to take account of:

- **Scale**: the scale of the waterway as represented by its Strahler stream order and its catchment area.
- **Community value**: assessing the relativity of the values that society ascribes to waterways.
- **Regional significance**: the importance of a particular attribute in the context of any specially designated areas and the broader setting of the region.

These three measures together with the list of values noted in the previous section accord with suggestions from the Metropolitan PAC Report[257] that the following traits should be considered in characterising the significance of impacts on streams:

- Importance to catchment yield;
- Significance to water supply;
- Scale of the watercourse;
- Permanence of flow;
- Water quality;
- Ecological importance;
- Environmental quality (pristine, modified, severely modified);
- Visual amenity (eg cascades runs, pools etc);
- Community value (value the community attributes to protection);
- Regional significance.

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[257] DoP (2009a), Section 7.4.

7.5. VALUES OF RIVERS AND STREAMS IN THE STUDY AREA

As a first step toward assessing project related changes to stream values, this section reports on the Panel's assessment of the values attributable to streams in the Study Area[258] in their current condition.

Appendix P of the EA, following the suggestions in the Metropolitan PAC Report, has used the list of measures and values noted in Section 7.4 to contribute to the characterisation of a selection of streams within the Study Area. The selection is based on streams that are named on the NSW 1:25,000 map series or are classified as third order and above (presumably also on the basis of those streams identified on this same 1:25,000 map series). The results are given in the 'Stream Matrix' presented as Attachment PB of Appendix P of the EA.

While the stream matrix tabulates detailed information on each of the stream traits already noted, there is no attempt in the EA to interpret this information to provide a description of absolute or relative significance for each stream.

For this report, Table 11 lists a subset of attributes sourced from Attachment PB of the EA. The attributes have been rearranged and re-grouped to facilitate their interpretation in line with the measures of value and significance described above.

The Table presents the streams in order of catchment area. Catchment area is a measure of the scale of the watercourse and acts as a surrogate for mean annual flow and channel size. Where the EA has identified separate reaches of the same stream, these are re-grouped in the Table. Also, neighbouring streams of similar characteristics with similar catchments have been grouped to avoid repetition.

Table 11 includes a set of comments on the value and significance of each group of watercourses. The comments are a compendium of information interpreted from the Table, from elsewhere in the EA, the GIS and photographic data provided in support of the EA and from Panel members' own observations and knowledge. The comments provide the Panel's interpretation of the stream related values and the significance of the values that apply to each group of streams.

[258] Note that the list of streams considered here is based on the stream attributes presented in the EA. It is therefore restricted to streams that are named on the NSW 1:25,000 map series or are classified as third order and above. Smaller or unnamed streams may also be important contributors to values. In particular, groups of smaller streams may combine to provide significance or may contribute to or protect the values of swamps or of larger waterways downstream. This issue is considered in more detail later in this report.

Table 11: Stream Attributes Grouped to Assist Interpretation of Stream Values

STREAM NAME	SCALE			HYDROLOGIC VALUE					ECOLOGICAL IMPORTANCE				ENVIRONMENTAL QUALITY					AMENITY VALUE			SETTING		
						Water Supply: % of catchment					Threatened Species Recorded												
	Stream Catchment (km2)	Maximum Stream Order	Stream length within 600 m of Mining Area (km)	Flow / Flow Regime	Importance to Yield	Woronora Dam	Cataract Dam	Broughtons Pass Weir	Fauna (F), Flora(FL) and Aquatic (A) Survey Sites	EECs Present in Riparian Zone	Records within Strams	Records Adjacent to Streams in Riparian or Gully Habitats	Disturbance	Previously Subsided	Km already affected	Geomorphic Type	Average Gradient (m/km)	Visual Amenity/Key Features (e.g. riffles, pools, etc.)	Public Accessibility	Geological Formation	Relevant DECC	SCA Special Area	Land Zoning
Nepean R Reach 1		7	8.9	P	H	-	-	-	A	-	MP (HR), SHD (HR)	-	SM		-	V1,FP1,B1,DF4	<1	B, P, R, RB, W	Y	HS	-	-	I, R
Nepean R Reach 2	225	7	19	P	H	-	-	-	A, F	REF, SST	MP (HR)	GFF (PS), PO (PS)	SM	Y	1.0	V1,FP1,B1,DF4	<1	P, RB	Y	HS	-	-	NU, OS, R, SU
Nepean R Reach 3	234	7	3.6	P	H	-	-	-	A, F	REF, SST	MP (HR)	-	SM		-	V1,FP2,B1,DF4	<1	P	Y	HS	-	-	NU, R, SU
	The major river in the Study Area. Crucial component of water supply system locally and for Sydney. Considered an iconic waterway and an important ecological and community asset (Appendix P of the EA page P-14). Water Quality shows elevated metals and nutrients. Threatened species recorded in or adjacent include Macquarie Perch, Sydney Hawk Dragonfly, Grey headed Flying Fox and the Powerful Owl. A dominant feature of the landscape. Significant because of its scale, hydrologic, ecological and amenity value, and iconic community status.																						
Cataract River	220	6	15	P	H	-	-	100	A, FL, F	-	LFM (PS), MP (PS,HR)	LE (PS), RCT (PS)	SM	Y	4.8	V1,FP1,B1,DF1/DF2	18	B, P, RB, W	Y	HS	-	M	WC
	Large tributary to the Nepean River. Important to Sydney water supply because of Cataract Dam and Broughtons Pass Weir. Water quality shows elevated nutrients and elevated levels of aluminium, zinc and iron. Threatened species have been recorded. Lower reaches in developed land and previously undermined. Upper reaches, steep, confined sandstone gorge in SCA Special Area and largely undisturbed. Large in-stream pools, boulder fields, cascades and waterfalls dominate physical form and visual amenity. Significant because of its scale, hydrologic, ecological and amenity value and iconic community status.																						
O'Hares Creek	47	4	17	P	M	-	-	-	A, FL, F	-	-	LE (PS), PoA (PS), EPP (PS)	M		-	V1,FP1,B1,DF1/DF3	7.5	B, P, R, RB, RS, SB, W	Y	HS	DSCA	O	WC
	Major tributary of Georges River. Threatened species recorded. Some limited land clearing and development in upper catchment otherwise undisturbed. Part of SCA Special Area, Dharawal State Conservation Area, Dharawal Nature Reserve and Holsworthy Military Area. Zoned as Water Catchment. Limited sampling suggests some high metal concentrations. Confined sandstone gorge. Pools, rock shelves, rock bars, boulder fields, cascades and waterfalls dominate physical form and visual amenity. Dense concentration of swamps in unnamed southern tributaries and Iluka Creek. Significant because of scale, permanent flow, connectivity with swamps, hydrologic and ecological value, environmental quality and recognised conservation status.																						
Wallandoola Creek	32	4	4.0	P	M	-	-	15	-	-	-	-	P	Y	4.0	V1,FP1,B1,DF1/DF3/DF6 (u/s)	13	B, P, RS, RB	N	HS	-	M	WC
	Large tributary of Cataract River. Permanent flow contributes to water supply via Broughtons Pass Weir. Some previous subsidence in upper catchment otherwise undisturbed. Limited data suggests excellent water quality. Part of SCA Special Area. Zoned as Water Catchment. . Steep, confined sandstone gorge with pools, narrow elongated rockbars, rock shelves, cascades, waterfalls and boulder fields. Significant because of scale, hydrologic value, and the environmental quality of its physical form and pristine setting.																						

Streams have been ordered by catchment area (representing scale of the stream) except where reaches of the same stream or similar streams are grouped.
Acronyms and abbreviations are listed in Appendix PC of the EA and summarised on the following pages. Some attributes have been summarised – original data can be seen in Appendix PB of the EA
Description of stream values is a compendium of information from the Table, the EA, the GIS data provided in support of the EA and from PAC members' own observations and knowledge.
Water quality issues are noted in the comments. Details of water quality observations are in Appendix C of the EA but were not included in Appendix P.

Table 11 (cont): Stream Attributes Grouped to Assist Interpretation of Stream Values

STREAM NAME	SCALE			HYDROLOGIC VALUE					ECOLOGICAL IMPORTANCE				ENVIRONMENTAL QUALITY					AMENITY VALUE			SETTING		
						Water Supply: % of catchment					Threatened Species Recorded												
	Stream Catchment (km2)	Maximum Stream Order	Stream length within 600 m of Mining Area (km)	Flow / Flow Regime	Importance to Yield	Woronora Dam	Cataract Dam	Broughtons Pass Weir	Fauna (F), Flora(FL) and Aquatic (A) Survey Sites	EECs Present in Riparian Zone	Records within Strams	Records Adjacent to Streams in Riparian or Gully Habitats	Disturbance	Previously Subsided	Km already affected	Geomorphic Type	Average Gradient (m/km)	Visual Amenity/Key Features (e.g. riffles, pools, etc.)	Public Accessibility	Geological Formation	Relevant DECC	SCA Special Area	Land Zoning
Stokes Creek Reach 1	28	4	4.2	P	M	-	-	-	F	-	-	-	M	Y	3.3	V1,FP1,B1,DF1	9	B, I, P, R, RB, RS	Y	HS	DSCA	O	WC
Stokes Creek Reach 2	11	2	3.4	I-E	M	-	-	-	A, FL	-	-	-	M		-	V1,FP1,B1,DF1/DF3	16	B, I, P, R, RB, RS, W	Y	HS	DSCA (part)	O	WC
Stokes Creek Reach 3	2.2	1	1.8	I-E	L	-	-	-	A	-	-	-	M		-	V2,FP1,B1,DF1	41	B, P, RB, RS, SB, V	Y	HS	DSCA (part)	O	WC
	Large tributary of O'Hares Creek. Permanent flow except in upper reaches. Some subsidence effects already experienced in lower catchment; upper catchment largely undisturbed. Part of SCA Special Area and Dharawal State Conservation Area. Zoned as Water Catchment. Limited data suggests good water quality except for elevated Aluminium and Zinc. Steep, confined sandstone gorge with pools, rockbars, rock shelves, cascades, waterfalls and boulder fields and a dense collections of swamps in and adjacent to the waterway in the upper catchment. Significant because of scale and hydrologic value and (in the upper catchment) the environmental quality of a largely pristine sandstone gorge with dense concentration of swamps.																						
Georges R Reach 2	27	4	5.9	P	M	-	-	-	A, FL, F	SST	MP (HR)	EBB (PS), GFF (PS), K (PS)	SM	Y	7.1	V2,FP2,B1,DF1/DF3	11	B, I, P, R, RB	Y	HS	-	-	NU, OS, R
Georges R Reach 1	5.1	3	1.0	P	M	-	-	-	F	-	-	EBB (PS)	M	Y	7.1	V1,FP1,B1,DF3/DF1	36	B, P, RB	Y	HS	-	-	R
	Major river. Already undermined downstream of Study Area and includes urban, agricultural and industrial land uses. Receives discharge from coal waste disposal area via Brennans Creek. Variable water quality influenced by runoff from Brennans Creek emplacement and other mining and agriculture includes elevated salinity, pH, nutrients and metals. Threatened species have been recorded. Steep, confined sandstone gorge with large pools. Significant because of scale, physical form and amenity value to local community.																						
Lizard Creek	21	5	5.6	P	M	-	-	10	A	-	-	-	P	Y	9.0	V1,FP1,B1,DF1/DF3/DF6(u/s)	46	B, P, R, RB, RS, W	N	HS	-	M	WC
	Large tributary of Cataract River. Permanent flow contributes to water supply via Broughtons Pass Weir. Limited data suggests good water quality. Previous subsidence upstream of Study Area shows impacts on creek, otherwise catchment undisturbed. Part of SCA Special Area. Zoned as Water Catchment. Very steep, confined sandstone gorge with pools, narrow elongated rockbars, rock shelves, cascades, waterfalls and boulder fields. Significant because of scale, hydrologic value and the environmental quality of its physical form and largely pristine setting.																						

Table 11 (cont): Stream Attributes Grouped to Assist Interpretation of Stream Values

STREAM NAME	SCALE			HYDROLOGIC VALUE					ECOLOGICAL IMPORTANCE				ENVIRONMENTAL QUALITY					AMENITY VALUE			SETTING		
						Water Supply: % of catchment					Threatened Species Recorded												
	Stream Catchment (km2)	Maximum Stream Order	Stream length within 600 m of Mining Area (km)	Flow / Flow Regime	Importance to Yield	Woronora Dam	Cataract Dam	Broughtons Pass Weir	Fauna (F), Flora(FL) and Aquatic (A) Survey Sites	EECs Present in Riparian Zone	Records within Strams	Records Adjacent to Streams in Riparian or Gully Habitats	Disturbance	Previously Subsided	Km already affected	Geomorphic Type	Average Gradient (m/km)	Visual Amenity/Key Features (e.g. riffles, pools, etc.)	Public Accessibility	Geological Formation	Relevant DECC	SCA Special Area	Land Zoning
Navigation Creek	15	4	6.0	P/I-E	H	-	-	-	-	REF	-	-	SM		-	V2/V3,FP3,B2/B3, DF4/DF5	31	N/D	Y	WG	-	-	AL, R, RL
Trib to Navigation Creek 1	2.3	3	3.6	I-E	L	-	-	-	-	-	-	-	SM		-	V3,FP3,B2/B3,DF 5	28	N/D	Y	WG	-	-	AL, RL
Trib to Navigation Creek 2	2.2	3	0.9	I-E	L	-	-	-	-	-	-	-	SM		-	V2/V3,FP3,B2,DF 5	62	N/D	Y	WG	-	-	RL
Trib to Navigation Creek 3	0.7	3	0.3	I-E	L	-	-	-	-	-	-	-	SM		-	V2,FP3,B2/B3,DF 5	83	N/D	Y	WG	-	-	AL
Trib to Navigation Creek 4	1.1	3	1.1	I-E	L	-	-	-	-	REF	-	-	SM		-	V3,FP3,B2/B3,DF 5	60	N/D	Y	WG	-	-	AL, R
Trib to Navigation Creek 5	1.0	3	1.6	I-E	L	-	-	-	F	-	-	-	SM		-	V3,FP3,B2/B3,DF 5	41	N/D	Y	WG	-	-	AL, R
Matahill Creek	3.7	3	2.7	I-E	L	-	-	-	-	REF	-	-	SM		-	V2,FP2,B2/B3,DF 4	75	N/D	Y	WG	-	-	R
Foot Onslow Creek	5.6	3	5.6	P/I-E	H	-	-	-	A	REF	-	-	SM		-	V2/V3,FP3,B2/B3, DF4/DF5	17	N/D	Y	WG	-	-	R
	Drains a cleared section of the Nepean River catchment used mainly for grazing livestock. Steep streams in clay and alluvium flowing across Wianamatta Shale. Limited riparian vegetation includes examples of endangered River-flat Eucalyptus Forest. No water quality data reported. In current state, low ecological and visual values, low environmental quality. Hydrological value limited to local stock and domestic supplies and drainage.																						
Dahlia Creek Reach 1	14	3	2.9	I-E	M	-	-	-	A	-	-	-	P		-	V1,FP1,B1,DF1/DF3/DF6	21	B, P, R, RB, RS	Y	HS	DSCA	O	WC
Dahlia Creek Reach 2	2.8	2	3.6	I-E	L	-	-	-	A	-	-	-	P		-	V2,FP2,B1/B2,DF 1/D5	22	B, P, R, RB, RS, W	Y	HS	DSCA	O	WC
	Major tributary of O'Hares Creek. Classified as intermittent-ephemeral on basis of 1:25,000 mapping. Very limited data suggests excellent water quality. No threatened species recorded but likely to be present. Small patch of cleared and developed land in upper catchment: otherwise undisturbed. Part of SCA Special Area, Dharawal State Conservation Area and undisturbed parts of Holsworthy Military Area. Zoned as Water Catchment. Confined, smaller scale sandstone gorge. Pools, rock shelves, rock bars, boulder fields, cascades and waterfalls dominate physical form and visual amenity. Significant because of hydrologic and ecological value, quality of the pristine environment and location within areas of recognised conservation status.																						

Table 11 (cont): Stream Attributes Grouped to Assist Interpretation of Stream Values

STREAM NAME	SCALE			HYDROLOGIC VALUE					ECOLOGICAL IMPORTANCE				ENVIRONMENTAL QUALITY					AMENITY VALUE			SETTING		
						Water Supply: % of catchment					Threatened Species Recorded												
	Stream Catchment (km2)	Maximum Stream Order	Stream length within 600 m of Mining Area (km)	Flow / Flow Regime	Importance to Yield	Woronora Dam	Cataract Dam	Broughtons Pass Weir	Fauna (F), Flora(FL) and Aquatic (A) Survey Sites	EECs Present in Riparian Zone	Records within Strams	Records Adjacent to Streams in Riparian or Gully Habitats	Disturbance	Previously Subsided	Km already affected	Geomorphic Type	Average Gradient (m/km)	Visual Amenity/Key Features (e.g. riffles, pools, etc.)	Public Accessibility	Geological Formation	Relevant DECC	SCA Special Area	Land Zoning
Racecourse Creek	11	4	4.6	I-E	H	-	-	-	A	CPW,REF, SDR	-	-	SM		-	V2,FP2,B2/B3,DF4/DF5	25	N/D	Y	WG	-	-	AL
Trib to Racecourse Creek 1	2.0	3	2.3	I-E	L	-	-	-	-	-	-	-	SM		-	V1/V2,FP1/FP2,B2/B3,DF4/DF5	21	N/D	Y	WG	-	-	AL
Trib to Racecourse Creek 2	0.7	3	0.2	I-E	L	-	-	-	-	-	-	-	SM		-	V2,FP2,B2/B3,DF4/DF5	95	N/D	Y	WG	-	-	AL
Apps Gully	1.1	3	1.6	I-E	L	-	-	-	-	CPW, SDR	-	-	M		-	V1,FP1,B1,DF1	47	N/D	Y	WG	-	-	AL, RL
	These creeks drain a cleared section of the Nepean River catchment used mainly for grazing livestock and some semi urban development. They are steep streams in clay and alluvium flowing across Wianamatta Shale. Piecemeal riparian vegetation includes examples of endangered ecological communities. No water quality data reported. Proximate to urban communities in Picton but in current state exhibits low ecological and visual values and low environmental quality. Hydrological value limited to local stock and domestic supplies and drainage.																						
Cascade Creek	11.0	3	5.1	P/I-E	M	-	-	5	A, FL, F	SST	-	-	P		-	V1,FP1,B1,DF1/DF3	40	B, P, RB, W	N	HS	-	M	WC
	Tributary of Cataract River. Contributes directly to Broughtons Pass Weir. Classified as intermittent-ephemeral on basis of 1:25,000 mapping. Creek line is largely undisturbed but part of ridge to the west is cleared for agriculture. Limited data suggests good water quality apart from high zinc and very high iron. Part of SCA Special Area. Zoned as Water Catchment. Steep, confined sandstone gorge with pools, narrow elongated rockbars, cascades and waterfalls. Significance is hydrologic value, and the environmental quality of its physical form and pristine setting.																						
Allens Creek	10	4	6.8	P/I-E	L	-	-	-	F	-	-	BCH (PS), GFF (PS)	M		-	V2,FP2,B1,DF1/DF3	14	B, P, R, RB, SB, V	Y	HS	-	-	R
Clements Creek	1.3	3	1.5	I-E	L	-	-	-	A	-	-	-	M		-	V1,FP1,B1,DF1/DF3	29	B, P, RB, S	Y	HS	-	-	R
Stringybark Creek	4.0	3	2.4	I-E	L	-	-	-	F	-	-	-	M		-	V1/V2,FP2,B1,DF1/DF3	31	B, P, RB, SB, V	Y	HS	-	-	R
Byrnes Creek	3.9	3	1.6	I-E	L	-	-	-	-	SST	-	-	M		-	V1/V2,FP1,B1,DF3/DF1	42	B, P, RB, S	Y	WG/HS	-	-	R
	These tributaries to Nepean River dissect a plateau of Wianamatta Shale in the south west of the Study Area. Classified as intermittent-ephemeral on basis of 1:25,000 mapping. Creeks are incised through shale into underlying sandstone. Plateau areas are developed for agriculture and residential use (and Appin West pit top) but incised creek lines remain largely uncleared. Water quality in Allens Creek is poor and shows high levels of metals, Arsenic and Cyanide. Riparian vegetation is substantially intact except weeds have encroached. Creeks and environs provide habitat refuge in otherwise developed landscape. Threatened species (Black-chinned Honeyeater, Grey-headed Flying Fox) have been recorded. Endangered ecological communities are present in the riparian zone. Creek beds in sandstone comprise' rockbars and boulder-fields controlling numerous pools. Ecological significance is as a vegetation remnant and habitat refuge in an otherwise developed landscape. Environmental quality and visual amenity are enhanced by the physical form of the stream and its setting in an otherwise developed landscape. At the same time, environmental quality is constrained by adjacent development. Hydrologically the creek and the riparian zone act to retard flow peaks and to filter particulates, organic matter and other contaminants from agricultural, urban and industrial runoff into the Nepean River. Proximity to development may highlight community interest.																						

Table 11 (cont): Stream Attributes Grouped to Assist Interpretation of Stream Values

STREAM NAME	SCALE			HYDROLOGIC VALUE					ECOLOGICAL IMPORTANCE				ENVIRONMENTAL QUALITY					AMENITY VALUE			SETTING		
	Stream Catchment (km2)	Maximum Stream Order	Stream length within 600 m of Mining Area (km)	Flow / Flow Regime	Importance to Yield	Water Supply: % of catchment – Woronora Dam	Water Supply: % of catchment – Cataract Dam	Water Supply: % of catchment – Broughtons Pass Weir	Fauna (F), Flora(FL) and Aquatic (A) Survey Sites	EECs Present in Riparian Zone	Threatened Species Recorded – Records within Strams	Threatened Species Recorded – Records Adjacent to Streams in Riparian or Gully Habitats	Disturbance	Previously Subsided	Km already affected	Geomorphic Type	Average Gradient (m/km)	Visual Amenity/Key Features (e.g. riffles, pools, etc.)	Public Accessibility	Geological Formation	Relevant DECC	SCA Special Area	Land Zoning
Woronora River	8.0	2	2.5	P	H	11	-	-	FL	-	-	PuA (PS), GFF (PS)	P		-	V1,FP1,B1,DF1/DF3	45	B, P, RB, RS, SB	N	HS	-	W	SEP, WC
Trib to Woronora R	4.8	3	0.6	I-E	M	6	-	-	F	-	-	-	P		-	V1,FP1,B1,DF1/DF3	20	N/D	N	HS	-	W	SEP
	Approximately 4 km of the upper Woronora River is within the Study Area adjacent to Dahlia Creek to the west and Waratah Rivulet to the east. Woronora River contributes to Sydney's water supply via Woronora Reservoir. Limited sampling suggests very good water quality with occasional spikes of high total iron. Threatened species have been recorded. The river and its upper catchment are undisturbed and part of an SCA Special Area. Confined sandstone gorge: pools, rock shelves, rock bars and boulder fields dominate physical form. Swamps flank the lower order sections of the river and its tributaries. Significant because of hydrologic value, and the environmental quality of its physical form and pristine setting.																						
Elladale Creek	7.7	3	1.5	I-E	L	-	-	-	A	SST	-	-	M	Y	3.3	V1,FP1,B1,DF1/DF3	42	B, P, RB, S	Y	HS	-	-	R
Ousedale Creek	5.1	4	2.7	I-E	L	-	-	-	F	REF, SST	-	-	M	Y	5.1	V2,FP2,B1/B2,DF1/DF3	35	B, P, R, RB, RS	Y	HS	-	-	R, SU
Mallaty Creek	3.3	3	2.0	I-E	L	-	-	-	-	SST	-	-	M	Y	0.2	V2,FP2,B2,DF1/DF3	33	B, P, R, RB, RS	Y	WG/HS	-	-	NU, R, SU
Simpsons Creek	3.9	3	0.8	I-E	L	-	-	-	A	SST	-	-	M	Y	2.2	V1,FP1,B1,DF1/DF4	64	B, P, RB	Y	HS	-	-	R
	These are eastern tributaries to Nepean River. Upper reaches flow on Wianamatta shale but some reaches closer to the Nepean River are incised into sandstone. Surrounding areas are developed for agricultural, industrial and residential use. Classified as intermittent-ephemeral on basis of 1:25,000 mapping. Poor water quality with high levels ofnutrients and metals. In some reaches riparian vegetation is substantially intact except weeds have encroached and width of remnant riparian vegetation is variable. Endangered ecological communities are present in the riparian zone. Creek beds in sandstone comprise ' rockbars and boulder-fields with pools. Elsewhere valley ids shallow and bed and bank material is clay or alluvium. Photos show poor water quality. Ecological significance is as a vegetation remnant and habitat refuge in an otherwise developed landscape. Environmental quality is constrained by adjacent development. Hydrologically the creek and the riparian zone act to retard flow peaks and to filter particulates, organic matter and other contaminants.																						
Punchbowl Creek	6.1	3	1.8	P/I-E	M	-	-	-	-	-	-	-	P		-	V1,FP1,B1,DF1/DF3	55	B, P, RB, RS, SB	Y	HS	-	-	WC
Trib to Punchbowl Ck	4.5	3	0.6	I-E	H?	-	-	-	-	-	-	-	P		-	V1,FP1,B1,DF1	61	N/D	Y	HS	-	-	WC
	Tributaries of the Georges River. Adjacent to Woronora River. The creeks and catchments are undisturbed and part of the Holsworthy Military Area. Confined sandstone gorges: pools, rock shelves, rock bars and boulder fields dominate physical form. Significance from the environmental quality of physical form and pristine setting.																						

Table 11 (cont): Stream Attributes Grouped to Assist Interpretation of Stream Values

STREAM NAME	SCALE			HYDROLOGIC VALUE					ECOLOGICAL IMPORTANCE				ENVIRONMENTAL QUALITY					AMENITY VALUE			SETTING		
	Stream Catchment (km2)	Maximum Stream Order	Stream length within 600 m of Mining Area (km)	Flow / Flow Regime	Importance to Yield	Water Supply: % of catchment – Woronora Dam	Water Supply: % of catchment – Cataract Dam	Water Supply: % of catchment – Broughtons Pass Weir	Fauna (F), Flora(FL) and Aquatic (A) Survey Sites	EECs Present in Riparian Zone	Threatened Species Recorded – Records within Streams	Threatened Species Recorded – Records Adjacent to Streams in Riparian or Gully Habitats	Disturbance	Previously Subsided	Km already affected	Geomorphic Type	Average Gradient (m/km)	Visual Amenity/Key Features (e.g. riffles, pools, etc.)	Public Accessibility	Geological Formation	Relevant DECC	SCA Special Area	Land Zoning
Carriage Creek	5.8	4	3.3	I-E	L	-	-	-	A	SST	-	-	SM		-	V2,FP2,B1/B2,DF 1/DF4	40	B, P, RB, RS, SB, V	Y	WG/ HS	-	-	AL, I, R, SU
Trib to Carriage Ck 1	1.7	3	0.7	I-E	L	-	-	-	-	SST	-	-	SM		-	V2,FP2,B1/B3,DF 1/DF5	25	N/D	Y	WG	-	-	I, R, SU
Trib to Carriage Ck 2	0.5	3	0.6	I-E	L	-	-	-	-	-	-	-	SM		-	V2,FP2,B1/B3,DF 1/DF5	40	N/D	Y	WG	-	-	AL, R
Trib to Nepean R 1	2.7	3	1.4	I-E	L	-	-	-	-	SST	-	-	M		-	V2,FP2,B1/B3,DF 1	57	N/D	Y	WG/ HS	-	-	R
Trib to Nepean R 2	0.9	3	0.2	I-E	L	-	-	-	-	-	-	-	M		-	V1,FP2,B1/B3,DF 1/DF5	50	N/D	Y	WG/ HS	-	-	R
Harris Creek	1.7	3	2.9	I-E	L	-	-	-	-	-	-	-	M		-	V2,FP2,B1/B2,DF 1/DF4	18	B, P, RB, S, V	Y	WG/ HS	-	-	R, Res, SU
	These are northern tributaries to Nepean River. Upper reaches flow on Wianamatta shale but some reaches closer to the Nepean River are incised into sandstone. Water quality in Harris Creek shows low DO and elevated levels of nutrients, aluminium, copper and zinc. Surrounding areas are developed for agricultural, industrial and residential use. Classified as intermittent-ephemeral on basis of 1:25,000 mapping. In some reaches riparian vegetation is substantially intact except weeds have encroached and width of remnant riparian vegetation is variable. Endangered ecological communities are present in the riparian zone. Creek beds in sandstone comprise ' rockbars and boulder-fields with pools. Elsewhere valley is shallow and bed and bank material is clay or alluvium. Ecological significance is as a vegetation remnant and habitat refuge in an otherwise developed landscape. Environmental quality is constrained by adjacent development. Hydrologically the creek and the riparian zone act to retard flow peaks and to filter particulates, organic matter and other contaminants.																						
Trib to Cataract Reservoir 2	4.2	3	2.3	I-E	L	-	3	-	A	-	-	-	P		-	V2,FP2,B1,DF6/D F1	36	B, P, RB, RS	N	HS	-	M	WC
Trib to Cataract Reservoir 1	2.7	3	1.2	I-E	L	-	2	-	F	-	-	GFF (PS)	P		-	V2,FP2,B1,DF1/D F3/DF6	50	B, P, R, RB, RS, W	N	HS	-	M	WC
	These creeks contribute flow directly into Cataract Reservoir. Threatened species have been recorded. Catchment and creeks undisturbed and in SCA Special Area. Zoned as Water Catchment. Sandstone gorge but less confined than other examples in region. Pools, rock shelves, rock bars, boulder fields and waterfalls dominate physical form but discontinuous floodplains and adjacent swamps are also present. Dense concentration of swamps along the drainage lines of the upper catchments. Significant because of hydrologic and ecological values and the environmental quality of its pristine setting and the physical form associated with the less confined valley including dense associations of flanking and in-stream swamps.																						
Wallandoola East Creek	4.0	3	2.6	I-E	L	-	-	2	A, FL	-	-	-	P	Y	1.2	V1,FP1,B1,DF1/D F3	43	N/D	N	HS	-	M	WC
	Small tributary of Cataract River. Contributes to water supply via Broughtons Pass Weir. Undisturbed catchment. Part of SCA Special Area. Zoned as Water Catchment. Steep, confined sandstone gorge expected to exhibit pools, rockbars, rock shelves, cascades, waterfalls and boulder fields. Significant because of hydrologic value, and the environmental quality of its physical form and pristine setting.																						

Table 11 (cont): Stream Attributes Grouped to Assist Interpretation of Stream Values

STREAM NAME	SCALE			HYDROLOGIC VALUE					ECOLOGICAL IMPORTANCE				ENVIRONMENTAL QUALITY					AMENITY VALUE			SETTING		
	Stream Catchment (km2)	Maximum Stream Order	Stream length within 600 m of Mining Area (km)	Flow / Flow Regime	Importance to Yield	Water Supply: % of catchment – Woronora Dam	Water Supply: % of catchment – Cataract Dam	Water Supply: % of catchment – Broughtons Pass Weir	Fauna (F), Flora(FL) and Aquatic (A) Survey Sites	EECs Present in Riparian Zone	Threatened Species Recorded – Records within Streams	Threatened Species Recorded – Records Adjacent to Streams in Riparian or Gully Habitats	Disturbance	Previously Subsided	Km already affected	Geomorphic Type	Average Gradient (m/km)	Visual Amenity/Key Features (e.g. riffles, pools, etc.)	Public Accessibility	Geological Formation	Relevant DECC	SCA Special Area	Land Zoning
Cobbong Creek	3.5	3	2.9	I-E	L	-	-	-	-	-	-	RCT (PS)	P		-	V1,FP1,B1,DF3	46	N/D	Y	HS	DSCA	O	WC
Trib to O'Hares Ck 1	2.5	3	1.0	I-E	L	-	-	-	-	-	-	-	P		-	V1,FP1,B1,DF1	40	B, P, RB, S	Y	HS	DSCA	O	WC
Trib to O'Hares Ck 2	1.4	3	0.4	I-E	L	-	-	-	-	-	-	-	P		-	V1,FP1,B1,DF1	75	N/D	Y	HS	DSCA	O	WC
	Tributaries of O'Hares Creek. Classified as intermittent-ephemeral on basis of 1:25,000 mapping. Threatened species recorded in Cobbong Creek. Undisturbed catchment. Part of SCA Special Area, Dharawal State Conservation Area. Zoned as Water Catchment. Confined, smaller scale sandstone gorges. Pools, rock bars, boulder fields and waterfalls dominate physical form and visual amenity. Significant because of hydrologic and ecological value, environmental quality associated with the physical form and the pristine setting and location within areas of recognised conservation status.																						
Trib to Cataract R 2	1.8	3	0.1	I-E	L	-	-	1	-	SST	-	-	M	Y	0.9	V2,FP1,B1,DF1/DF3	33	N/D	N	HS	-	M	WC
Trib to Cataract R 1	1.5	3	0.3	I-E	L	-	-	1	-	-	-	-	P	Y	0.5	V1,FP1,B1,DF1/DF3	43	N/D	N	HS	-	M	WC
	Small tributaries to Cataract River. Listed as 3rd order streams but features not mapped in EA. Tributary 2 is in cleared land probably similar in characteristics to Elladale Creek. Tributary 1 has an undisturbed catchment with upland swamps, probably similar in characteristics to Cataract Reservoir tributary 1 and 2.																						

Source: Attachment PB of Appendix P of the EA.

Legend: B = Boulderfield. I = Island. P = Pool. R = Riffle. RB = Rockbar. RS = Rockshelf. S = Sediment. SB = Sandbar. V = Vegetated Drainage Line. W = Waterfall. N/D = Not determined. Valley Type: V1 = Confined. V2 = Partially Confined. V3 = Alluvial. Floodplain Development: FP1 = No floodplains. FP2 = Irregular floodplain and floodplain pockets less than 25% of stream fringed by floodplains. FP3 = Moderate floodplain development – between 25% and 75% of stream fringed by floodplains. FP4 = High floodplain development – greater than 75% of stream fringed by floodplains. Bed Materials and Mobility: B1 = Bedrock comprising rock outcrop or boulderfield beds with no or minimal/infrequent mobile sediments in some sections. B2 = Sand bed comprising cohesionless sandy sediments. B3 = Cohesive bed comprising silty, sandy bed materials with significant cohesion and/or organic materials. Dominant Physical Features: DF1 = Pools and rockbars and chutes. DF2 = Cascades and waterfalls. DF3 = Boulderfields. DF4 = Pools and riffles in alluvial/mobile streams. DF5 = Uniform streams with no or insignificant pool development. DF6 = Swamps and/or chain of ponds wide shallow streams with significant in-stream vegetation and persistent swamps or wide shallow pools with ill defined channels.

7.6. SIGNIFICANCE OF THE VALUES

The comments in Table 11 provide the Panel's preliminary interpretation of the data and give a description of the stream related values and the significance of the values for each group of streams. This is a useful start but it is the change in value as a consequence of mining-induced impacts that is the important consideration for acceptability. The approach described in Section 7.3 indicates one exception to this. If a natural feature achieves '*special significance'* status then its value is elevated to the point where it automatically receives special consideration for protection that would ensure negligible change in its values from the impacts of mining.

The EA does not assign special significance to any of the rivers or creeks in the Study Area although it does make the suggestion that[259]:

> *'Based on the Metropolitan PAC Report's description of special significance, the authorities may consider the Nepean River as a stream that warrants special significance status.'*

The Panel has addressed the question: are there other rivers and streams in the Study Area that cross the special significance threshold either for individual values or in consideration of the sum of several values? The comments in Table 11 suggest a number of possible candidates. The candidates comprise the rivers and creeks that flow in the largely undisturbed confined sandstone gorges mainly in the south and east of the Study Area and all in the Hawkesbury Sandstone or major streams classification of Section 7.1 and Figure 27.

7.6.1. Assessment of Significance by SCA

In responding to the Panel's questions, the SCA has provided the following rationale for rating the value of watercourses within its area of control:

'Cataract River (from the Cataract Dam wall to the full supply level of Broughtons Pass Weir)

.... *is of 'special significance'*[260] *for the following reasons:*

- *This section of river is a key component of the Sydney water supply system as it is used to transfer raw drinking water from Cataract Dam to Broughtons Pass weir;*
- *This section of the river is largely in pristine condition – due in part to its classification as a Schedule 1 Special Area where public access is prohibited unless prior approval from the SCA has been obtained;*
- *While the flow in this section of the river is significantly affected by releases from Cataract Dam, the SCA releases a minimum of 1.3 ML/d for environmental purposes and it is important that this flow is protected and reserved for the purpose for which it is released. From July 2010 the environmental flow releases from the dam will be dependent upon inflows to the dam (80th percentile transparent flows and 20 percent*

[259] EA, Appendix P, p.P-14.

[260] *'special significance'* being as defined in the Metropolitan PAC Report, DoP (2009a).

translucent flows) – and consequently the minimum release from the dam is expected, on average, to be greater than the current minimum release; and

- *A significant waterfall – known as the Appin Falls – is located on this section of the river. Within the Project area Appin Falls is the largest waterfall, the top of the falls is the largest rockbar and the pool at the base of the falls is understood to be the deepest of any pool. It is also understood that the Appin Falls is the largest falls on the entire Woronora plateau.*

Other features/values of the Cataract River are:

- *the river is a 6th order stream;*
- *the catchment is very large - 220 square kilometres;*
- *the river flow is permanent;*
- *the high importance to catchment yield;*
- *the very high significance to water supply;*
- *the water quality is very good;*
- *the presence of 2 threatened species;*
- *the presence of a large number of rockbars and pools; and*
- *the relatively shallow depth of cover'*[261].

The SCA has also listed rationale for seeking high levels of protection for other watercourses as follows:

Lizard Creek, Wallandoola Creek and Cascade Creek (for their full length) –

"Negligible" environmental consequences................because:

- *'they are all at least 3rd order streams – Lizard Creek is a 5th order stream;*
- *the collective catchment is large – 64 square kilometres;*
- *the flow in each watercourse is permanent and/or there is permanent water;*
- *the moderate importance to catchment yield;*
- *the high significance to water supply;*
- *the water quality is very good;*
- *they drain to the section of the Cataract River which flows to Broughtons Pass Weir and therefore there is minimal buffering opportunity before water reaches a critical water supply off take; the presence of a large number of rockbars and pools; and*
- *they are all largely pristine'.*

Cataract River Tributary 1 and Wallandoola East Creek (for their full length) -

[261] SCA (2010), p.7.

..........“negligible” environmental consequences............ because

- *they are 3rd order streams;*
- *the water quality is very good;*
- *they drain to the section of the Cataract River which flows to Broughtons Pass Weir and therefore there is minimal buffering opportunity before water reaches a critical water supply off take; the presence of a large number of rockbars and pools; and*
- *they are pristine.*

Cataract Reservoir Tributary 1 and Cataract Reservoir Tributary 2 (3rd order sections)

..........“negligible” environmental consequences............ because

- *they are 3rd order streams;*
- *the flow in each watercourse is permanent and/or there is permanent water;*
- *the water quality is very good;*
- *they drain direct to Cataract Reservoir;*
- *the quality and quantity of water flowing from these watercourses is predicted to decline as a result of mining and this will have a direct impact on stored waters;*
- *there is strong nexus with swamps;*
- *the presence of a large number of rockbars and pools; and*
- *they are pristine.*

Woronora River (tributary downstream of the crossing of Fire Trail 14 and adjacent to the northern end of Longwall 19 – and 3rd order tributary downstream of Longwall 18)

- “Negligible” environmental consequences............ because

- *the flow in the Woronora River is permanent;*
- *there is strong nexus with swamps for Woronora River;*
- *the high to moderate importance to catchment yield;*
- *their moderate significance to water supply;*
- *the water quality is very good;*
- *the presence of a large number of rockbars and pools;*
- *the presence of 2 threatened species; and*
- *they are pristine.’*[262]

[262] SCA (2010), pp.8-9.

7.6.2. Significance of Hydrologic Values and Amenity Values

'Use values' refer to functions provided by stream systems, such as water supply, ecosystem services and visual amenity and recreational opportunity.

7.6.2.1. <u>Water supply</u>

All those streams located within Special Areas declared under the *Sydney Water Catchment Management Act* are significant for their water supply function. Those that are 3rd order and above have been noted in Table 11 and in the extracts of the SCA response to include:

- Cataract River
- O'Hares Creek
- Stokes Creek
- Dahlia Creek
- Cobbong Creek and Tributaries 1 & 2 to O'Hares Creek
- Woronora River and tributaries
- Cascade Creek
- Wallandoola Creek
- Wallandoola East Creek
- Lizard Creek
- Cataract Reservoir Tributaries 1 & 2

In its response to the Panel's questions, the SCA explained:

> *'The Special Areas are declared for their value in protecting the quality of the raw water used to provide drinking water to Sydney and for their ecological integrity. The Special Areas are a critical barrier in a multi-barrier approach to protecting water quality. They act as a filtration system for water entering water storages by reducing nutrients, sediments and other substances that can affect water quality. The greater the ecological integrity of the Special Areas, the more effective their role as a barrier.'*[263]

The Panel agrees with the SCA proposition that the Cataract River from the Cataract Dam wall to the full supply level of Broughtons Pass Weir meets the criteria for 'special significance' status. The Panel concludes that the water supply function of the other streams in the preceding also warrants *prima facie* a level of protection that underwrites the capacity of these watercourses to continue to provide that function.

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[263] SCA (2010), p.7.

7.6.2.2. Amenity Value

Other 'use values' include recreation and visual amenity. The Panel has concluded that these values contribute to the iconic status of the Nepean River and support the proponent's suggestion of special significance status for that stream. The Panel has concluded that amenity values are currently limited by lack of access to the SCA Special Areas and other more remote parts of the Study Area, and that amenity value does not therefore support special significance status in other streams at this time.

7.6.3. Significance of Ecologic Values and Environmental Quality

Ecological values and Environmental quality are 'non-use' values that recognise the contribution that a stream makes to biodiversity and ecological integrity. Non-use values include the more abstract notions of existence value and option value.

7.6.3.1. Naturalness

Non-use values rely heavily on the concept of the condition or the 'health' of the stream. High ecological value or high environmental quality requires good stream condition. There are numerous approaches to assessing overall waterway condition in use in Australia[264]. Relevant examples include:

- Sustainable Rivers Audit (Murray Darling Basin Authority)
- State of Rivers (Queensland, NSW)
- Pressure Biota Habitat Approach (NSW)
- Index of Stream Condition (Victoria)
- National State of the Environment Reporting (Commonwealth)
- Assessment of River Condition (Commonwealth)

As stated in the Metropolitan PAC Report:

> *'These approaches use different techniques but all are designed to allow a relative ranking of waterway condition on the basis of assessments of environmental themes broadly: hydrology, physical form, water quality and condition of riparian vegetation; and by measuring populations of key aquatic communities such as fish and macroinvertebrates'.* [265]

In assessing condition and devising a relative condition ranking, each of the above approaches either implicitly or explicitly uses a naturalness template as a desirable reference point. This is also the case for more rigorous assessment techniques such as AUSRIVAS[266]. The inevitable conclusion is that in Australia, ecological and environmental quality values of streams remain closely linked to templates of naturalness.

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[264] CRC (2001).
[265] DoP (2009a).
[266] http://ausrivas.canberra.edu.au/index.html

Description, data and mapping (summarised in Table 11) identifies a number of creeks within the Study Area that would score highly against a naturalness template at least for observational attributes such as physical form and vegetation. Those that are 3rd order and above include:

- O'Hares Creek
- Stokes Creek
- Dahlia Creek
- Cobbong Creek and Tribs 1 & 2 to O'Hares Creek
- Woronora River and tributaries
- Punchbowl Creek and tribs
- Cascade Creek
- Wallandoola Creek
- Wallandoola East Creek
- Lizard Creek
- Cataract Reservoir tributaries 1&2
- Upper Georges River

Of these, O'Hares Creek and its tributaries including Stokes and Dahlia Creeks are also within the Dharawal State Conservation Area.

There are small areas of disturbance in most catchments including roads and some limited activity associated with mining. There is also a small section of cleared land in the headwaters of O'Hares Creek. None of these is likely to have a noticeable effect that would detract from naturalness values in the waterways.

The naturalness value of Lizard Creek is diminished by the effects of previous mining upstream in its catchment. In the Cascade Creek catchment, some areas of the ridge to the west have been cleared for agriculture and water quality measurements suggest Cascade Creek may be less than pristine.

The conclusion is that at least O'Hares Creek, Stokes Creek, Dahlia Creek, Cobbong Creek, Tributaries 1 & 2 to O'Hares Creek, Woronora River and tributaries, Punchbowl Creek and tributaries, Wallandoola Creek, Wallandoola East Creek and Cataract Reservoir Tributaries 1 & 2 would rank very highly in any assessment of condition that is referenced to naturalness and therefore in assessments of ecological value and environmental quality.

Assessment of special significance status depends on how important and how rare this condition is in a regional and national context. To gauge that, the Panel has referred to the national assessment of the condition of streams[267] which indicates in Table 12 that naturalness is a rarity in Australian rivers. Using an index of aquatic biota (ARC_B) approximately one third of the river length assessed in Australia is classified as impaired with almost a quarter having lost at least 20 percent of the different kinds of aquatic invertebrates

[267] Norris et al (2001).

that would be expected to occur under natural conditions. An index of environmental features (ARC_E) shows that over 85 percent of the river length assessed is significantly modified from the original condition. Nineteen percent of the river length assessed is classed as substantially modified. With only 3% of rivers classified as 'largely unmodified', New South Wales has the greatest percentage of modified river.

More specifically in the Hawkesbury Nepean Catchment, a 2005 audit of the Sydney drinking water catchment[268] identified a decline in ecosystem health in the catchment above the drinking water storages since the 2003 Audit[269]. The 2005 Audit found that generally above the dams:

- water quality has the potential to affect ecosystem health
- number and diversity of macroinvertebrates is low
- native fish species diversity is poor and there is a high proportion of exotic fish above water supply dams.

Table 12: Assessment of River Condition[270]

The Assessment of River Condition in the area assessed.

Scale	ARC_E				ARC_B			
	Largely Unmodified	Moderately Modified	Substantially Modified	Severely Modified	Reference	Significantly Impaired	Severely Impaired	Extremely Impaired
National 209,118 km	14%	66%	19%	<0.1%	69%	23%	6%	2%
Qld. 72,425 km	13%	71%	16	0%	80%	17%	2%	0.1%
NSW 59,533 km	3%	68%	29%	0%	51%	34%	13%	3%
ACT 270 km	16%	71%	13%	0%	64%	29%	7%	0%
Vic. 15,750 km	20%	59%	20%	0%	77%	20%	3%	0.4%
Tas. 5,586 km	37%	59%	4	0%	76%	20%	3%	2%
S.A. 9,668 km	4%	61%	35%	0%	83%	12%	1%	4%
W.A. 25,395 km	7%	78%	14%	0.1%	64%	29%	6%	0.5%
N.T. 20,491 km	66%	34%	0%	0%	88%	10%	2%	0%

The Panel therefore concludes that the condition of O'Hares Creek, Stokes Creek, Dahlia Creek, Cobbong Creek, Tributaries 1 & 2 to O'Hares Creek, Woronora River and tributaries, Punchbowl Creek and tributaries, Wallandoola Creek, Wallandoola East Creek and Cataract Reservoir tributaries 1 & 2 is both important and rare. On its own, the irreversibility of any change in values that is based on naturalness makes these creeks strong candidates for special significance status.

268 DEC (2005).
269 www.environment.nsw.gov.au/resources/sdwcfullreport.pdf
270 Reproduced from Norris et al (2001).

7.6.4. First and Second Order Streams

A significant issue arising from the above discussions about water supply and naturalness is that on the basis that scale is a contributing factor to significance, only streams larger than third order have been chosen for application of risk assessment procedures in the EA. In reality, the condition of third order streams cannot be divorced from the condition of their first and second order tributaries or for that matter, the condition of the swamps that supply their base flow. It follows that if any third order or larger stream qualifies for special protection or special significance status on these grounds, then assessment of all of its tributaries is required to determine whether subsidence-induced impacts could compromise the protection status of the stream itself.

First and second order streams also provide the connectivity between upland swamps and the larger streams. The upland swamps provide baseflow to these lower order connecting streams and that maintains both continuity of flow and water of the highest quality. If the larger stream is considered significant, and water quality is one of the important values, then it makes no sense whatsoever to compromise both the flow pathway and the quality of the water emanating from the swamp by allowing subsidence-induced damage to these connecting sections of lower order streams. The value of the swamp-stream connection is emphasised around the dense concentrations of swamps in the headwaters of Dahlia Creek, O'Hares Creek and tributaries, Stokes Creek, Cataract Reservoir Tributaries 1 and 2, and Woronora River and its tributaries.

7.6.5. Threatened Species and EECs

Although the Panel has concerns over the inadequacy of survey intensities for fauna and flora[271], nevertheless threatened species and endangered ecological communities (EECs) were still recorded adjacent to waterways in the Study Area. There are listed in Table 13 and Table 14. A report of a species or EEC can be cross-referenced to a particular creek by reference to Table 11. These records add weight to the proposition that the creeks have high ecological value.

7.6.6. Special Significance Status

The Panel has assessed qualitatively the considerations reported above, Table 15. A 'tick' in Table 15 indicates a consideration assessed as carrying weight for that stream. While not implying that each of the considerations in Table 15 is of comparable importance, the Panel has reached the view that a number of streams in the sandstone gorge classification warrant special significance status. These streams are shown shaded in the Table. In reaching this view, the Panel has had regard to the Proponent's reasoning regarding the iconic nature of the Nepean River. It has also accepted the SCA propositions regarding the values of the Cataract River between Cataract Dam and Broughtons Pass weir. The Panel has given weight to the arguments that the high ecological and amenity values of the sandstone gorge creeks rely on their naturalness and are irreversible, and has included all of the streams that ranked highly by that criteria except Punchbowl Creek and tributaries and upper Georges River, where the Panel found no other persuasive supporting arguments.

[271] Chapters 6 and 8

Table 13: Threatened Species Recorded in or Adjacent to Streams

Threatened Species Recorded	**Streams where Threatened Species have been Recorded**
Sydney Hawk Dragonfly Macquarie Perch Large-footed Myotis *Leucopogon exolasius* *Pomaderris adnata* *Pultenaea aristata* Black-chinned Honeyeater Eastern Bentwing-bat Eastern Pygmy Possum Grey-headed Flying Fox Koala Powerful Owl Red Crowned Toadlet	Nepean River Cataract River O'Hares Creek Georges River Allens Creek Woronora River Tributary to Cataract Reservoir 2 Cobbong Creek

Table 14: Endangered Ecological Communities Recorded in the Riparian Zone

EECs Recorded	**Streams where EECs have been Recorded**
Cumberland Plain Woodland (TSC Act) River-flat Eucalypt Forest on Coastal Floodplains (TSC Act) Eastern Sydney Dry Rainforest in the Sydney Basin Bioregion (TSCAct) Sandstone/Shale Transition Forest (TSC Act and EPBC Act)	Nepean River Georges River Navigation Creek Matahill Creek Foot Onslow Creek Racecourse Creek Apps Gully Cascade Creek Byrnes Creek Elladale Creek Ousedale Creek Mallaty Creek Simpsons Creek Carriage Creek and tributaries Tributary to Cataract Reservoir 2

The following sections of this Chapter describe the potential impacts and consequences for these streams from the mining proposal and outline the Panel's views on the acceptability of these potential consequences.

Table 15: Summary of Considerations from Section 7.6

(Shaded rows represent streams that the Panel assesses as achieving special significance status.)

	Consideration						
	Proponent's suggestion	**SCA recommendation**	**Naturalness template**	**SCA Special Area**	**Dharawal Conservation Area**	**Connectivity with swamp complexes**	**Threatened Species and EEC**
Nepean River	√						√
Cataract River (dam to Broughtons Pass Weir)		√		√			√
O'Hares Creek			√	√	√	√	√
Stokes Creek			√	√	√	√	
Dahlia Creek			√	√	√	√	
Cobbong Creek			√	√	√		
Tributaries 1 & 2 to O'Hares Creek			√	√	√	√	
Woronora River and tributaries			√	√		√	√
Punchbowl Creekand Tributaries			√				
Cascade Creek				√			√
Wallandoola Creek			√	√			
Wallandoola East Creek			√	√			
Lizard Creek				√			
Cataract Reservoir tributaries 1&2			√	√		√	√
Upper Georges River			√				√

7.7. EXPECTED IMPACTS AND CONSEQUENCES

This section addresses in general terms how the proposed mining will affect the stream values discussed above. The next section assigns the *impacts* and *consequences*[272] to individual groups of streams to discuss the significance and the acceptability of the consequences in each case.

The *impacts* and *consequences* of longwall mining on rivers and streams have been discussed previously in EA for the Metropolitan Coal Project, the SCI Report and the Metropolitan PAC Report. The EA for the BSO Project addresses these issues in considerable detail in Appendix A, Appendix C and Appendix P. Submissions to the PAC have added further description and opinion. Across all these sources there is general agreement about the nature and even the magnitude of impact, and some reasonable agreement about at least the nature of consequences. Disparity in opinion grows around the magnitude, density and extent of the consequences, the relationship of consequences to values, and the capacity for the consequences to be effectively mitigated or remediated.

As described in the EA and earlier in this report, conventional subsidence manifests at the surface as relatively shallow and spatially variable fractures resulting from tensile and compressive strains. Along valley floors, experience demonstrates that non conventional subsidence has the potential to generate more intense impacts with a much greater potential for fracture connectivity and diversion of surface flow to the underlying strata.

It is broadly accepted in the EA and in public and agency submissions that when longwalls mine beneath waterways in the Southern Coalfield, the potential consequences for watercourses can include:

- visible fracturing of bedrock within the bed of the watercourse;
- physical dislocation of slabs of rock from the bed and subsequent transport and breakdown of these slabs into finer material;
- loss of water from pools;
- loss of low flows from the bed of the watercourse generally;
- increased concentrations of dissolved metals leading to:
    - iron staining on rock;
    - iron flocs and algal growth, and discoloration and opacity of water in pools and downstream.

Data banks for some subsidence processes have grown to the extent that analysis can provide useful empirical tools for predicting subsidence effects and impacts. However, no such process-understanding or detailed data bank exists to allow quantitative prediction of the magnitude, density or extent of *consequences* along a particular waterway. In part, this is because the consequences are changes to values, some of which remain intractable to quantification. Instead, acknowledging the imprecise nature of the predictive tools that are available, the best indicator of the magnitude, density and extent of consequences relies on a qualitative extrapolation of experience and observation from geologically and topographically similar areas that have been subject to similar mining impacts. The proponent and public and agency submissions have relied on this approach in describing the

[272] As per the definition of these terms noted in Chapter 4.

consequences of subsidence. The Panel too has had regard to examples of the magnitude, density and extent of consequences from neighbouring areas to guide its assessment.

The following consequences have the most significant potential to impact on the values of waterways in the Study Area.

- Draining of pools
- Loss of surface flows throughout the bed of the stream
- Loss of catchment yield and baseflows
- Iron staining, opacity and water quality deterioration

7.7.1. Draining of Rock Pools

Draining of rock pools results from cracking of a controlling rock bar or uplift and fracturing in the valley floor leading to the development of other sub-surface flow paths away from the pool. Loss of pools is described in Appendix A[273] and Appendix C[274] the EA and in public and Agency submissions. The Panel notes that despite the emphasis in the EA on loss of pools by cracking of controlling rock bars, in fact the mechanism need not be so specific. Any new flow path away from a pool can lead to loss of water from the pool and this applies equally to pools formed behind rock bars, riffles, boulder fields or any other channel feature.

Examples of pools where water levels have been affected by mining subsidence have been inspected by the Panel and further examples are reported for Waratah Rivulet[275] and the Georges River[276]. Several other examples are referenced in the SCI Report and in a variety of literature [277,278,279]. As an example in a neighbouring catchment, Figure 28 illustrates a pool in Waratah Rivulet where water levels have been impacted by subsidence-induced cracking.

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[273] EA, Appendix A, Section 5.2.3.2.
[274] EA, Appendix C, Section 5.4.
[275] EA for the Metropolitan Coal Project.
[276] EA for Bulli Seam Operations Project.
[277] Kay et al (2006).
[278] TEC (2007).
[279] Jankowski et al (2008).

Figure 28: Pool Water Level on Waratah Rivulet Impacted by Subsidence-Induced Fracturing

Partial or complete loss of water from pools results in loss of stream values including ecological values, environmental quality and visual amenity. The loss in value occurs through changes in the wetting regime of the pool boundaries: rock and sediment forming its bed and banks and in-stream wood; change in aquatic and fringing habitats and changes in riparian and in-stream vegetation. The proponent acknowledges this to some extent by proposing management measures that provide for grouting at all controlling rock bars where diversion of flow occurs[280]. There is general acceptance that loss of water from pools will have important consequences for stream values and so the existence of this consequence is not further argued here although it is important to note that only 47% of pools mapped in streams of third order and above are controlled by rock bars[281].

An attempt is made in the EA to assess the likely magnitude, density and extent of pool loss by simulating the behavior of pools under various assumptions of pool size, leakage rates and catchment inflow characteristics[282]. The results are presented as comparative spells analyses for periods where the pools are dry with and without the impact of the BSO Project. While this is conceptually useful in understanding the range of behaviour mechanisms that may occur, it fails to contribute meaningfully to an assessment of the consequences of the BSO Project. This is because the scale of the project relative to the resolution of the analysis

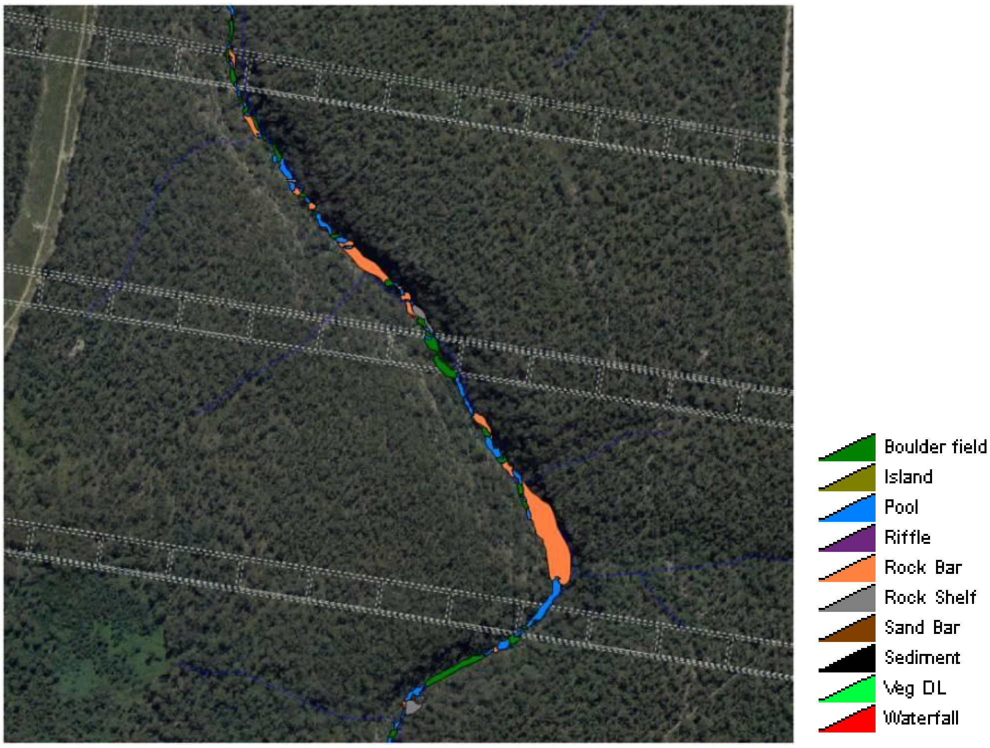
[280] EA, Appendix P, Table P-5.
[281] ICHPL (2010b). Response to Question No. 52.
[282] EA, Appendix C, Section 5.4.1.

means that the assumptions remain uncorrelated with the characteristics of specific waterways and catchments and the expected impacts. The results therefore remain generic.

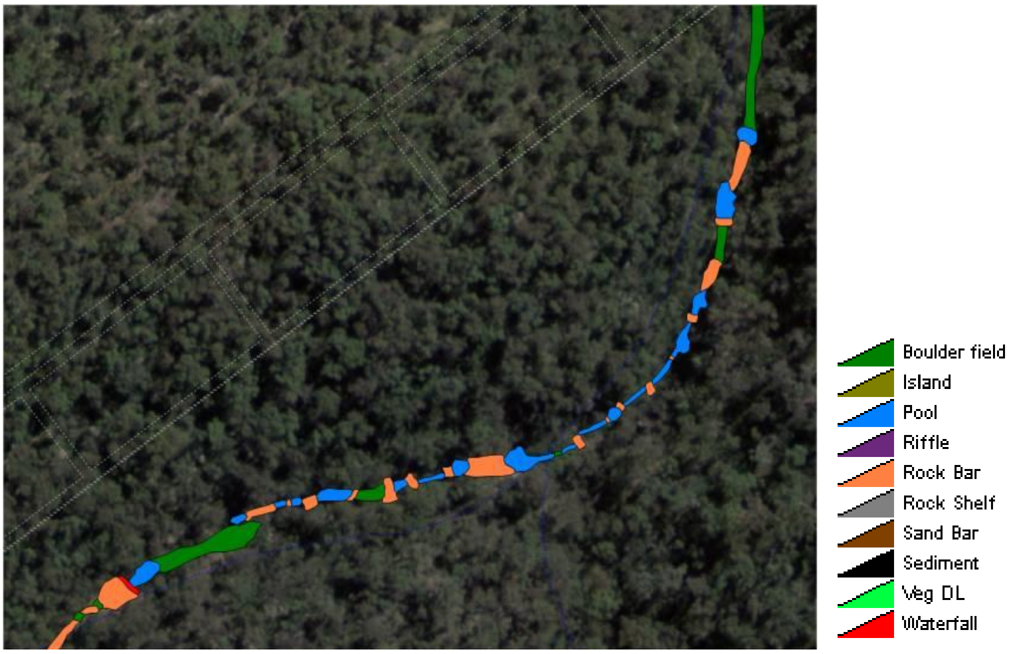
The magnitude, density and extent of consequences to pool related values remain unknown. However the magnitude of impacts elsewhere, with similar mine parameters, suggests extreme caution is warranted. In the absence of other prediction models, the density and extent of pool morphology in the Study Area must remain an important indicator of the likely density and extent of consequences. Table 11 has already described the dominance of pools in creek morphology in large parts of the Study Area. Figure 29 shows an example of the complexity and the density of the pool morphology in the sandstone areas to the south and east of the Study Area, and the importance of rock bars, rock shelves and boulder fields in controlling the physical form of the waterways.

The Proponent proposes remediation through grouting of rock bars to restore stream values associated with pools[283]. The Panel considers that this technique can possibly be applied to the remediation of selected values at specific locations. However, it remains unconvinced about its wholesale application as a primary approach to protecting stream-related values in the long term, particularly where the works themselves may have adverse consequences for some of the values that the approach is intended to recover. This reservation is further reported in Section 7.8.

[283] The Panel notes that only 47% of mapped pools are controlled by rock bars and remediation techniques have not been demonstrated adequately for the other pool controlling features such as boulder fields.



(a) Wallandoola Creek near Cataract River



(b) Upper Woronora River

Figure 29: Examples of Complexity and Density of Pool Morphology in East and South of Study Area[284]

[284] Source: Derived from GIS information provided to PAC.

7.7.2. Loss of Surface Flows Stream Bed

7.7.2.1. Magnitude of Sub-surface Flow

Cracking of the valley floor means that water is potentially lost from the stream to the new subsurface fracture network, not only at pools but along an entire length of impacted stream. This can leave reaches of stream channel dry, or with reduced flows in all stream types including boulder fields, rock shelves, rock bars, cascades and waterfalls.

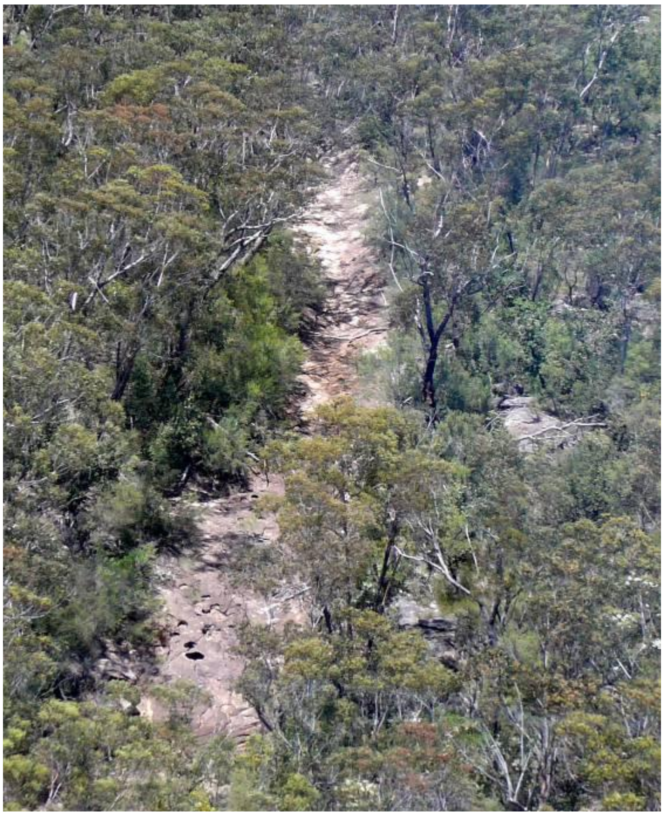


Figure 30: Apparent Mining-Induced Loss of Flow in Lizard Creek

Mining-induced diversions with complete loss of flow over many hundreds of metres of stream have been observed by the Panel in Lizard Creek and over shorter distances in Waratah Rivulet and other channels. Figure 30 is an example of a section of Lizard Creek that has been subsided and was dry on both occasions that Panel members have undertaken aerial inspection (2009 and 2010), despite obvious flow upstream and downstream.

The magnitude of this consequence will depend largely on the hydraulic capacity of the new subsurface fracture network compared to the flow characteristics of the waterway. In the pool analysis presented in the EA[285], the scenarios considered a hydraulic capacity of the fracture network of 0.05 ML/d in shale and 0.12 ML/d in sandstone for areas subject to *small* subsidence effects, increasing to 0.5 ML/d in areas with *moderate* subsidence effects and up to 1.5 ML/d in areas subject to *large* subsidence effects. Small, moderate and large are not

[285] Appendix C Section 5.4.1

defined in terms of subsidence parameters but the Panel considers that subsurface flows of 1.5 ML/d or more are possible following subsidence. The Panel notes, for example, that flow monitoring data suggested that up to 1 ML/day was being diverted (post mining) via the subsurface fracture network in some sections of the Georges River prior to remediation initiatives[286].

7.7.2.2. Significance of Loss of Surface Flows

Diversion of flow of this magnitude away from surface flows and into the subsurface fracture network is significant in terms of local stream flow in all but the largest rivers. This is demonstrated by reference to standardised flow duration curves for stream gauging stations on Stokes Creeks (GS 213204) and Woronora River (GS 2132101) as presented in the EA[287]. (These stations were selected here because their catchment areas of 30 km^2 and 12.4 km^2 respectively, are most relevant to impacted catchments.) Table 16 shows the proportion of time that flow is currently less than 0.5 Ml/d for catchments of 5, 10 and 20 km^2, based on data from the two stations. This therefore provides a rough indication of the proportion of time that a stream would become dry if subsidence resulted in diversion of 0.5 Ml/d into a sub-surface fracture network.

This is a similar type of impact to that shown for Waratah Rivulet in the Metropolitan PAC Report, where it was noted that:

> *'….in planning for water resources developments or water sharing plans or in environmental flows assessments … an increase of this magnitude in the frequency of zero flow periods would not be acceptable'.*[288]

Table 16: Indication of % Time a Creek would be Dry if Sub-surface Flow was 0.5 ML/d

For catchments of 5 to 20 km^2 based on gauging data from two stations.

Catchment Area (km^2)	**Approximate % of Time Flow < 0.5ML/d**	
	Based on Data for Stokes Ck at Dam Site GS 213204	Based on Data for Woronora River u/s Dam GS 2132101
5	50%	60%
10	30%	45%
20	20%	30%

7.7.2.3. Significance of Water Loss from Non-pool Stream Morphologies

[286] EA, Appendix C, p.162.
[287] EA, Appendix C, Figures 89 and 92
[288] DoP (2009a), p.58, Figure 18.

The Panel is concerned that whilst loss of water from pools receives particular attention in the EA and elsewhere because of its immediate visual impact, loss of flow in other sections of the streams will also be important and may have equal or even more pervasive consequences for environmental quality and ecological values. As part of its deliberations on this issue, the Panel inspected reaches of stream channels consisting of boulder fields, riffles, rock shelves, and vegetated and unvegetated sand and sediments. The Panel also reviewed a range of local and international literature[289,290,291,292.]dealing with environmental flow assessments and with impacts of changes in flow regime resulting from storage and consumptive use.

These documents make it clear that deviation from natural flow regimes has consequences for ecological and environmental quality values in all stream morphologies. Reductions in surface flows that lead to the drying of a perennial stream or to increased durations of zero flow in an intermittent stream are shown to have highly undesirable consequences throughout the whole length of affected stream – not just pools controlled by rock bars. The otherwise natural flow regime in many of the streams in the Study Area increases the importance of the current regime and the significance of any changes

The Panel notes that alteration of natural flow regimes of rivers and streams is recognised as a key threatening process under the Threatened Species Conservation Act, the Environmental Protection and Biodiversity Conservation Act and Fisheries Management Acts. Alteration of habitat following subsidence due to longwall mining is also specifically listed as a key threatening process in Schedule 3 of the Threatened Species Conservation Act 1995, largely as a result of potential effects on aquatic and semi aquatic species through flow regime and water quality consequences.

It is apparent that the range of stream morphologies along a waterway provides a range of biotopes, each contributing to an integral habitat characteristic and diversity for the reach. Boulder fields in particular offer important habitat opportunity because of the high wetted areas of rock and vegetation surfaces, the complexity of micro-hydraulic patterns and the cover and food and litter input from the vegetation which flourishes as part of the hydraulic regime. They are also sensitive to changes in hydrology, with any reduction in low to moderate flows having an immediate and substantial impact on water levels within the boulder field because of the steep stage discharge relation that will exist within the myriad of complex flow paths.

Boulder fields are the dominant morphology in some reaches of creek. Figure 31 is an example in the lower reaches of Harris Creek where boulder fields predominate.

Given this range of pointers, it might be expected that an environmental assessment would be explicit in exploring the link between hydrologic change and risks to ecological values at a scale that recognized not only pools, but the range of biotopes associated with the dominant stream morphologies. Despite extensive material addressing stream related consequences and risks in (at least) Appendices A, C, D and P of the EA, the Panel was unable to find convincing links from subsidence impacts and their hydrologic consequences to an assessment of the risks of changes to the ecological values of stream biotopes associated with the range of stream morphologies that will be impacted throughout the Study Area.

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[289] Poff et al (2010)
[290] VDNRE (2002)
[291] Arthingtom et al (1998).
[292] ARMCANZ (1996).

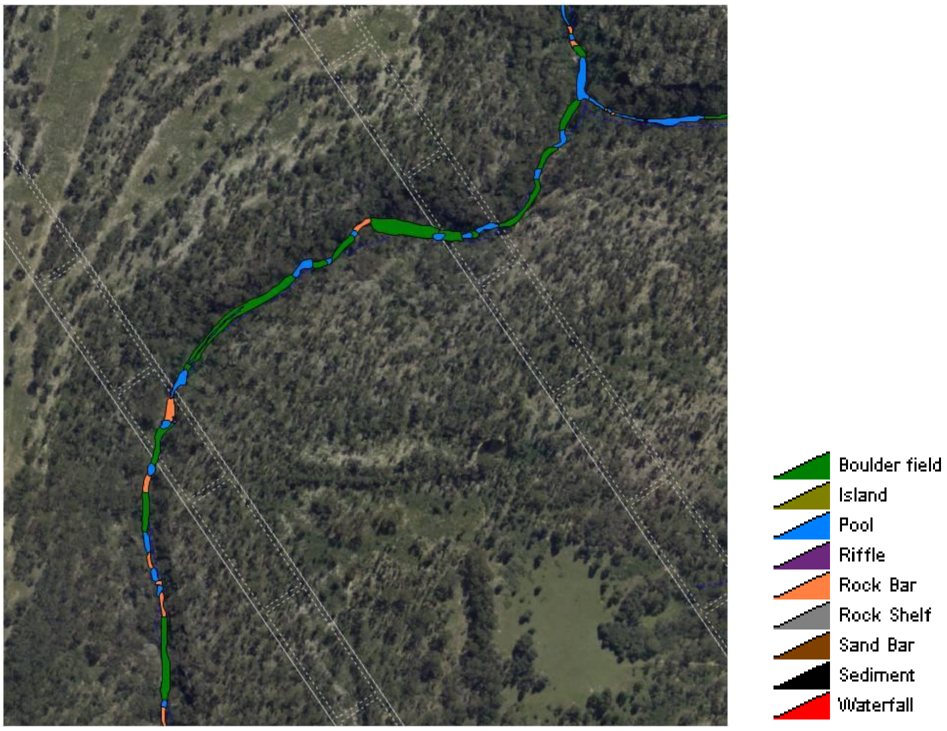

Figure 31: Lower End of Harris Creek Showing Dominance of Boulder Fields[293]

7.7.2.4. Consequences for Environmental Quality

Environmental quality is a more abstract value that is also threatened when changes in the surface flow regime affects the integrity of natural flora and fauna systems. The irreversible consequences of changes to 'naturalness' values have already been discussed in Section 7.6.3.1.

7.7.2.5. EA Risk Management Proposal

Despite scant recognition of threat to ecological and environmental quality values, remediation of the stream bed between rock bars is proposed[294] as part of the BSO Project but only

> *'…where remediation measures are considered technically feasible (e.g. where there was pre-miming flow and the substrate is suitable for grouting)'.*

The EA does little to convince that remediation by grouting is a serious strategy anywhere other than at specific rock bars. Despite some additional material presented by the Proponent in the response to Panel questions, the Panel remains unconvinced about the wholesale application of remediation as a primary approach to protecting stream related values (see Section 0), and in any case the commitment in the EA (Table P-5) is so heavily conditioned as to be ineffectual.

[293] Source: Derived from GIS information provided to PAC.
[294] EA, Appendix P, Table P-5

7.7.3. Loss of Catchment Yield and Baseflows

Some parts of the Study Area contribute to the SCA water supply system (see Section 7.6.2.1) and to rivers where flows are managed for licensed extractions (e.g. Cataract River, Georges River, Nepean River).

In their submissions, DECCW and SCA have highlighted the possibility that water may be permanently lost to streams in the Study Area as a consequence of mine induced subsidence. SCA presents a series of arguments that suggest this is a realistic concern. DECCW's concern is principally around potential loss of baseflow contributions from swamps and reduction in the downstream baseflow that sustains licensed extractions during low flow periods. The EA addresses these issues with a series of arguments, but they are based on limited data and modelling.

Despite some minor variations, the situation on this issue has essentially not progressed since the Metropolitan PAC Report , being at the time:

> *'The Panel is of the view that analyses based on standard flow measurement techniques at discrete points on Waratah Rivulet are not capable of providing reliable guidance on the likelihood or otherwise of water loss from the catchment of Woronora Dam, nor is this guidance provided by the hydrologic modelling that has been reported to date. However the local and regional groundwater conditions, coupled with the mine parameters, would suggest that the likelihood of water being lost from the surface water system as a consequence of mining, and then by passing Woronora Reservoir, is very low'*[295].

The Metropolitan PAC Report therefore relied on predictions of groundwater behavior to limit its concern over potential loss of catchment yield. In the BSO Study Area, the Panel has less confidence about predicted groundwater flow mechanisms because of the larger and more diverse area involved, the lack of data to support modelling and the increased longwall panel width. The Panel is therefore of the view that the issue of possible loss of catchment yield is not resolved, and warrants further investigation.

7.7.4. Iron Staining and Downstream Water Quality

An example of iron staining, discolouration and opacity in Lizard Creek, downstream of longwall mining panels, is shown in Figure 32. As previously noted, iron staining results from water-rock geochemical interactions. Stream water migrating along new sub surface fracture pathways may dissolve iron bearing minerals like siderite, hematite and marcasite which are known to be present in the Hawkesbury Sandstone. When this water emerges back to the surface, iron precipitates in the form of oxy-hydroxides leaving characteristic orange and red staining.

[295] DoP (2009a), p.50.

Figure 32: Iron Staining, Discolouration and Opacity of Water Downstream of Subsided Area, Lizard Creek

The Panel members have observed iron staining frequently during their field and aerial inspections associated with the BSO Project and with previous Inquiries. On a number of occasions, the attention of the Panel members has been drawn to what is purported to be examples of natural iron staining. The Panel accepts that iron staining can have natural causes, however it has yet to be presented with information that confirms these examples were natural. The scale, location and, in some instances, the intensity of the iron staining that Panel members have observed prompted the Panel to map the sites of these observations together with sites that it could interpret from the stream photo base provided by ICHPL.

The outcomes, which need to be validated by 'ground truthing', are shown in Figure 33. The Panel has concluded that there appears to be a strong correlation between past mining activities and iron staining. Some of the iron staining shown in Figure 33 correlates with mine workings not shown on the Figure. An overview suggests these are generally 3rd order and higher streams and include Wallandoola Creek (upper reaches), Lizard Creek, Stokes Creek, Waratah Rivulet, parts of Ousedale Creek and Elladale Creek. Most of the stain areas are in proximity to historical mining operations, are in Hawkesbury Sandstone terrain, and are associated with incised valleys. Isolated stain occurrences located in the upper reaches of O'Hares Creek and Woronora River are remote from existing mining, but may still be associated with far field movements of the rock strata.

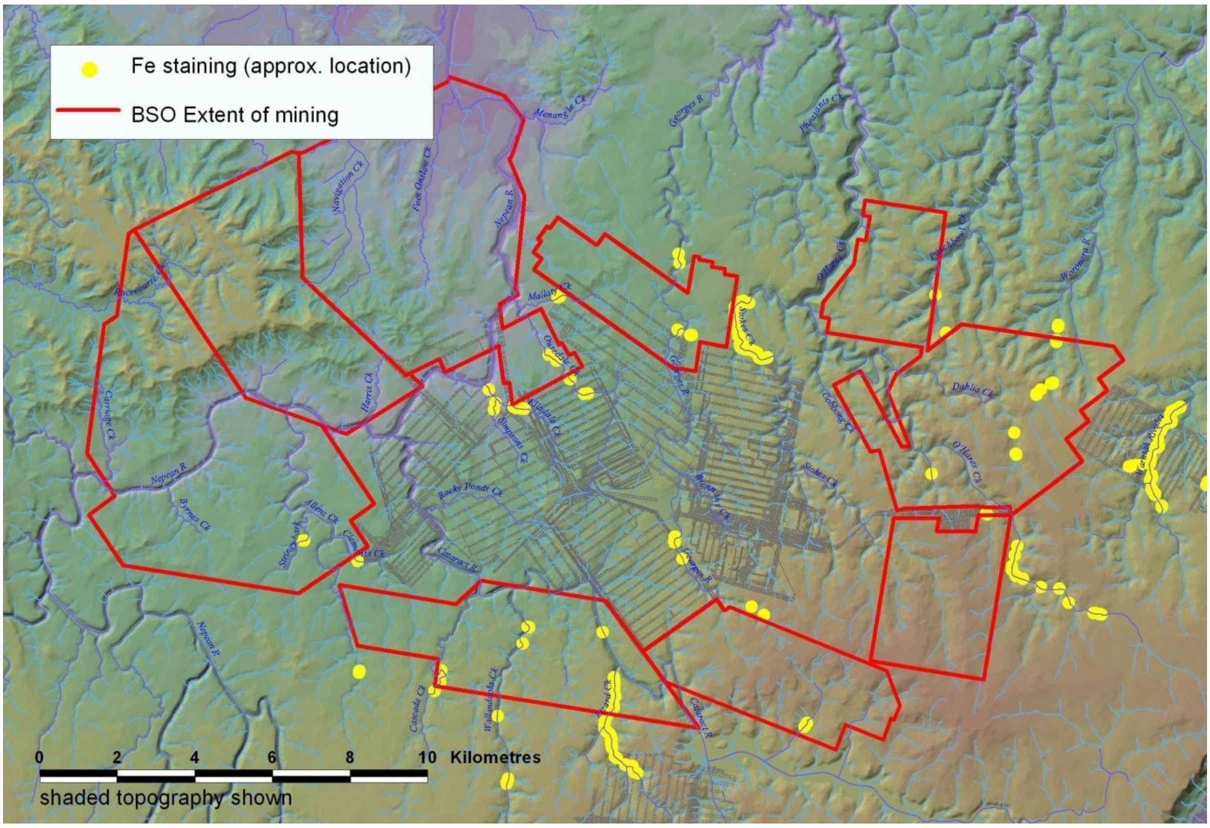

Figure 33: Approximate Distribution of Iron Staining as Mapped by the Panel[296]

During periods of low or intermittent stream flow, the presence of iron oxidising bacteria often results in the growth of bacterial mats on submerged litter and plants. Figure 32 and Figure 34 show examples of iron staining on Lizard Creek and Stokes Creek, respectively, both sites being downstream of past longwall panels extracted more than a decade ago.

Panel members have also noted water to be discoloured and opaque for considerable distances downstream of mine workings, but not upstream. The Panel inquired into this when assessing the Metropolitan Coal Project and was advised the dissolution of marcasite or iron oxy-hydroxides can lead to green opacity of water and algal blooms in rock pools accompanied by dissolved oxygen and related eco-toxic impacts[297].

In response to Panel questions regarding the BSO Project, SCA has advised that manganese dissolution and precipitation accompanies iron dissolution and that:

> *'During rainfall events, acidic rain water and surface run-off re-mobilises iron and manganese oxides and hydroxides, eroding them from the streambed and dissolving them from floating mats and returning these metals again to the aquatic system to cause further pollution downstream (Figures 4 and 5). During high water stages when turbulent flow prevails, iron mats are washed from pools and meanders where they have been immobile during low flow conditions, resulting in further contamination as they are dissolved in acidic conditions.*

[296] Mapping needs to be confirmed by ground truthing.
[297] DoP (2009a), p.60.

Experimental studies in the Waratah Rivulet showed that rainwater is able to completely remove iron/manganese precipitates (Figure 6) increasing their concentration during and after rainfall event. The dissolved phases of iron and manganese are transported into Woronora storage causing significant increasing loading of these metals'[298].

Figure 34: Example of Bacterial Mat and Discoloration of Pooled Water, Stokes Creek

The frequent occurrence of staining and the spatial relationship to historical mining leads the Panel to conclude that iron staining and impaired water quality are inevitable outcomes of the proposed mine plan.

The Panel also considers there is a possibility of iron staining within stream beds in areas dominated by Ashfield Shale. However the generally more subdued topography associated with drainages in shale terrain suggests the extent and intensity of subterranean cracking along stream channels is likely to be lower than for sandstone terrain and as such, diverted flows and iron staining may be less common.

The EA predicts that iron staining will occur as a result of subsidence in many creeks throughout the Study Area. The Panel considers there is strong evidence that growth of bacterial mats, opacity and the deterioration in water quality accompany iron staining and that these impacts may persist for long periods. The EA makes no attempt to assess the likely consequences of iron staining, bacterial mats, opacity or deterioration in water quality on stream related values. The Panel is of the view that the consequences of iron staining, opacity, bacterial mats and deterioration of water quality has potentially significant consequences for hydrologic values (water quality), ecological values, environmental quality and amenity value as further described in Section 7.9.

[298] SCA (2010), p.17, response to Question No. 6.

7.8. REMEDIATION

The EA indicates in Appendices A, C and P that the general nature of the impacts and consequences described above is acknowledged by the Proponent. In response, it is proposed in the EA[299] that adverse consequences be limited by a set of management measures that in essence are intended to:

- Minimise damage by avoiding mining under or close to some selected streams; and/or
- Implement measures to remediate damage that does occur.

Remediation is proposed as a key management measure for all 3rd order and above streams in the Study Area except the Nepean River (reaches 2 and 3). The management measures are described as:

- Implementation of stream remediation measures (i.e. grouting) on stream reaches of third order and above at controlling rockbars to return stream flow to pre-mining characteristics.
- Implementation of stream remediation measures on stream reaches of third order and above in stream reaches between controlling rockbars, where remediation measures are technically feasible (e.g. where there was pre-mining flow and the substrate is suitable for grouting).

In the Panel's view, reliance on these remediation proposals to protect the values of streams throughout the Study Area reveals a key difference between the Proponent's and the Panel's assessments of the values associated with the sandstone gorge sections of the stream systems and the way that the consequences will impact on these values. Based on its assessment of the likely importance and extent of consequences, the Panel cannot recommend the proposed extensive reliance on remediation as a wholesale and primary measure to protect stream related values. There are several considerations that have led the Panel to this assessment, including:

- To be effective at restoring the range of stream values that have been discussed above, remediation would have to be intense and extensive.
- The values to be protected in the sandstone gorge parts of the Study Area are strongly associated with naturalness. Remediation proposals conflict with naturalness values.
- Remediation is proposed *at controlling rockbars* and *between controlling rockbars …where feasible*. The *where feasible* condition is so open ended as to be ineffectual.
- If remediation is not applied successfully between rockbars as well as at rockbars, the range of stream values cannot be restored.
- The proposed remediation measures are an extension of grouting techniques that have been trialed at some specific locations as a means of restoring pools behind rockbars. While the Panel acknowledges some success at sealing subsurface fractures at specific rockbars, the universal applicability of this technique to restore flow throughout entire lengths of streams is speculative at best.
- Even where some success has been demonstrated at restoring pools behind specific rockbars, the longevity of the technique has been questioned in submissions and remains unproven.

[299] EA, Appendix P, Table P-5.

- The remediation proposal has a focus on restoration of pools behind rockbars. Table 17 demonstrates that for some important streams, more pools form behind boulder fields than form behind rock bars[300]. The feasibility of restoring pools behind boulder fields is unproven.
- Remediation proposals have developed from efforts to restore pools behind rockbars – principally in response to concerns about the importance of pools for visual amenity and ecological values. The effectiveness of remediation proposals for dealing with other consequences to other values is doubtful.
- Some ecological values depend on continuity within the stream. Even short lengths of unremediated stream may cause loss of ecological value.
- Timing of implementation of remediation measures is not specified. Where multiple longwalls affect a length of creek remediation, measures may have to wait until impacts from multiple longwalls are complete, or remediation measures may have to be repeated.
- The NSW Minerals Council has submitted that remediation in areas of difficult access may cause more harm than the subsidence impacts themselves.[301] Much of the terrain under discussion would be classed as being difficult to access.
- Monitoring programs proposed in the EA will not reveal the need for, or effectiveness of, remediation for all values.

[300] ICHPL (2010b). Response to Panel Question No. 52.
[301] NSW Minerals Council submission to SCI.

Table 17: Proportion of Pools Formed Behind Rockbars and Boulder Fields

Breakdown of Pool Types for Mapped Streams

Mapped Stream	Number of Mapped Pools	Pools Upstream of Boulder Fields (%)	Pools Upstream of Rockbars (%)	Pools Upstream of Other Obstructions (%)
Nepean River	17	94	6	0
Carriage Creek	2	100	0	0
Allens Creek	29	66	24	10
Clements Creek	15	93	0	7
Stringybark Creek	3	33	33	33
Harris Creek	3	33	67	0
Elladale Creek	5	60	40	0
Simpsons Creek	0	0	0	0
Ousedale Creek	14	78	22	0
Mallaty Creek	0	0	0	0
Byrnes Creek	1	0	100	0
Cataract River	43	54	46	0
Lizard Creek	8	50	37.5	12.5
Cascade Creek	16	75	25	0
Wallandoola Creek	8	50	50	0
Cataract Reservoir Tributary 1	7	29	57	14
Cataract Reservoir Tributary 2	6	17	83	0
Georges River	24	33	62	5
Stokes Creek	34	20	65	15
O'Hares Creek	89	46	50	2
O'Hares Creek Tributary 1	0	0	0	0
Dahlia Creek	21	10	86	4
Punchbowl Creek	11	9	91	0
Woronora River	3	33	67	0

Note: There is by necessity some subjectivity in distinguishing individual pools.

7.9. Assessing the Significance of Consequences

Based on the evidence of consequences in neighbouring areas, and on the importance of hydrologic, ecologic, environmental quality and amenity values in the Study Area, particularly the sandstone gorges, the Panel assess that the consequences of the Project will be widespread and significant.

The EA describes the consequences of subsidence for individual streams throughout the Study Area[302]. The Panel generally concurs with this description of consequences.

Appendix P of the EA present a risk assessment and risk management plans for the streams. The Panel considers that these sections do not succeed in linking the consequences of mining to the attributes listed in the stream matrix (Attachment PB). The risk assessment considers a selection of consequences but fails to assess their significance in terms of risks to stream values. Therefore it leads to risk management plans that are disconnected from the stream characterisation and its detailed database.

To form a view of the significance of the consequences of mining on stream values, the Panel has reconsidered the consequences of mining on streams using the detailed descriptions of consequences from Section 7.7 and the four geologically based categories proposed in Section 7.1 further subdivided in the following sub-sections.

7.9.1. Streams Flowing Predominantly in Ashfield Shale

Stream name	Mining Domain	Description and values (from Table 11)
Navigation Creek and tributaries	7	Drains a cleared section of the Nepean River catchment used mainly for grazing livestock. Steep streams in clay and alluvium flowing across Wianamatta Shale. Limited riparian vegetation includes examples of endangered River-flat Eucalyptus Forest. In current state, low ecological and visual values, low environmental quality. Hydrological value limited to local stock and domestic supplies and drainage
Matahill Creek	7	
Foot Onslow Creek	7	
Racecourse Creek and tributaries	8, 9	These creeks drain a cleared section of the Nepean River catchment used mainly for grazing livestock and some semi urban development. They are steep streams in clay and alluvium flowing across Wianamatta Shale. Piecemeal riparian vegetation includes examples of endangered ecological communities. Proximate to urban communities in Picton but in current state exhibit low ecological and visual values and low environmental quality. Hydrological value limited to local stock and domestic supplies and drainage.
Apps Gully Creek	9	

<u>Proponent's proposal</u>

The EA comments generally about impacts in shale areas as follows.

[302] EA, Appendix C, Section 6.

‘The streams in alluvial valleys in Wianamatta Group shale areas are typically formed in relatively shallow open valleys. The nature of the substrates in these areas generally allow the sediments to be subject to subsidence movements without creating the interconnected dilation type of cracking that occurs in the Hawkesbury Sandstone terrains (MSEC, 2009)’[303]. The Panel accepts this assessment of impact. The EA goes on to claim past experience as substantiating the claim that consequences in these streams will be localised and minor.

‘Past experience indicates that subsidence impacts on streams formed in the Wianamatta Group shale terrain typically include: localised and relatively isolated cracking of bed sediments; creation of transient and permanent pools in subsidence depressions; and/or alteration to existing pools and small scale bed and bank scour due to local increases in bed and bank slope’[304].

Furthermore the EA claims that any consequences that do occur will be short lived.

‘The predominance of clay rich (cohesive) bed sediments in these watercourses means that subsidence induced cracks are more likely to self-seal over time when compared to streams bedded in the Hawkesbury Sandstone. As a result, there is unlikely to be any significant diversion of flow, with any localised diversion being of a temporary nature’[305].

These comments are reinforced when dealing with specific creeks[306].

Risk management proposals for these streams in the EA are for:

‘… remediation measures (i.e. grouting) … at controlling rockbars ….’

and:

‘… remediation measures in stream reaches between controlling rockbars, where remediation measures are technically feasible ….’[307]

Panel’s Assessment

While it is an intuitive proposition, scant evidence has been presented (both in the EA and in response to a subsequent PAC question) in support of the claims that past experience suggests limited and short lived consequences for streams in shale. But the Panel considers that a risk assessment in this zone does not need to rely on that premise alone. The Panel is satisfied that the proposed risk management measures are sufficient to prevent loss of creek values in this zone, mainly because hydrological, ecological, environmental quality and amenity values are currently very low and none of the consequences will impact irreversibly on these residual values. The Panel therefore accepts that mining can occur beneath these streams with low consequences for their values.

[303] EA, Appendix C, p.139, Section 5.2.
[304] EA, Appendix C, p.139, Section 5.2.
[305] EA, Appendix P, p.P-19.
[306] EA, Volume 1, p.5-76 and Appendix C, p.176, Section 6.2.2 and Section 6.3.2
[307] EA, Appendix P, Table P-5.

7.9.2. Large Streams Incised in Hawkesbury Sandstone

(Catchment area > 200 km^2)

Stream name	Mining Domain	Description and values (from Table 11)
Nepean River	7,8,9	The major river in the Study Area. Crucial component of water supply system locally and for Sydney. Considered an iconic waterway and an important ecological and community asset (Appendix P of the EA page P-14). Threatened species recorded in or adjacent include Macquarie Perch, Sydney Hawk Dragonfly, Grey headed Flying Fox and the Powerful Owl. A dominant feature of the landscape. Significant because of its scale, hydrologic, ecological and amenity value, and iconic community status.
Cataract River	2,3	A major river in the Study Area. Crucial component of water supply system locally and for Sydney. Considered an iconic waterway and an important ecological and community asset (Appendix P of the EA page P-14). Threatened species recorded in or adjacent include Macquarie Perch, Sydney Hawk Dragonfly, Grey headed Flying Fox and the Powerful Owl. A dominant feature of the landscape. Significant because of its scale, hydrologic, ecological and amenity value, and iconic community status.

Proponent's proposal

The EA recognises the potential for impact on the Nepean and Cataract River. ICHPL has proposed risk management measures that minimise the impact and reduce the accompanying adverse consequences. In fact the EA has even suggested that '*the authorities may consider the Nepean River as a stream that warrants special significance status* '[308].

Two different criteria have been applied across these river reaches. For the Nepean River Reaches 2 and 3 the criteria only allow localised impacts on stream water quality and strata gas release. The stream is not to be directly undermined and minimum setbacks from the stream and cliff lines are to be applied.

For the Cataract River and the Nepean River Reach 1, the criteria allow:

Minor fracturing of controlling rockbars, with negligible diversion of water from associated pools. Potential for fracturing of stream bed and consequent stream flow diversion in stream reaches between controlling rockbars. Localised impacts on stream water quality. Strata gas release[309].
This is to be achieved by:

Longwall layout design to achieve a maximum predicted closure of 200 mm at controlling rockbars. Implementation of stream remediation measures … where subsidence results in the diversion of stream flow in stream reaches between controlling rockbars, and where the stream features are such that the remediation measures are considered technically feasible[310].

[308] EA, Appendix P, p.P-14.
[309] EA, Appendix P, p.P-34, Table P-5.
[310] EA, Appendix P, p.P-34, Table P-5.

Panel's assessment

By the standards of the EA this is a high level of protection but the Panel remains dissatisfied with this approach on three grounds:

- Firstly, the Panel assesses these two rivers as exhibiting highly significant hydrologic, ecological and amenity value, and iconic community status. The Panel proposes that they both achieve 'special significance status'. The Panel considers that any diminution of these values by those mining-induced impacts that could lead to fracturing of rockbars or fracturing of the river bed between rock bars is unacceptable.
- Secondly, the Panel is not satisfied that stream values are protected by a focus on limiting fracturing only at rock bars but allowing fracturing elsewhere in the valley floor. It is noted that there is no requirement that prevents these streams being undermined in some future re-arrangement of the mine plan (though none is proposed in the current layout).
- Thirdly, the Panel does not support reliance on remediation after damage as a primary management measure.

The Panel recommends that a negligible impact criterion be applied to these rivers throughout their length.[311] Negligible impact as it applies to rivers and streams is defined below.

The Project Approval issued by the Minister for Planning for the Metropolitan Coal Project defines 'negligible' as 'small and unimportant, such as to be not worth considering'. Applied to streams for that project this was interpreted to mean 'no diversion of flows, no change in natural drainage behaviour of pools, minimal iron staining, and minimal gas releases'.[312]

'Negligible impact' for rivers and streams requires that the hydrologic, ecologic, environmental quality and amenity values ascribed to the rivers and streams are not perceptibly altered (i.e. 'small and unimportant, such as to be not worth considering'). In reviewing the BSO Project Proposal it has become obvious that a significant negative consequence of undermining on rivers and streams is the frequent occurrence of a marked deterioration in water quality evidenced by a persistent milky green discolouration that may extend for a substantial distance downstream of the undermined area (see Section 7.7.4).

The Panel considers that, on the basis of the evidence now available, the interpretation of negligible impact for rivers and streams would be deficient if it did not include a requirement for maintenance of water quality in the river or stream at its pre-mining standard.

The Panel therefore recommends that the definition of 'negligible impact' for rivers and streams should be:

> *'no diversion of flows, no change in the natural drainage behaviour of pools, minimal iron staining, minimal gas releases and continued maintenance of water quality at its pre-mining standard'.*

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[311] The Panel is of the view that conditions that require protection for a stream to a 'negligible impact' standard for a proportion (or percentage) of its length are unlikely to prevent deterioration of water quality over substantial reaches of the stream and are equally unlikely to be enforceable against the mine operator.

[312] DoP (2009b), Schedule 3, p.5.

For rivers and streams classed as having 'special significance' status and therefore likely to have a 'negligible impact' criterion imposed it will be necessary to assess whether their tributaries and feeder streams are likely to be impacted by subsidence to the extent that water quality in the protected stream itself may be compromised.

7.9.3. North Cliff Streams Flowing Exclusively in Hawkesbury Sandstone

Stream name	Mining Domain	Description and values (fromTable 11)
O'Hares Creek	North Cliff	Major tributary of Georges River. Threatened species have been recorded. Some limited land clearing and development in upper catchment otherwise undisturbed. Part of SCA Special Area, Dharawal State Conservation Area, Dharawal Nature Reserve and Holsworthy Military Area. Zoned as Water Catchment. Confined sandstone gorge. Pools, rock shelves, rock bars, boulder fields, cascades and waterfalls dominate physical form and visual amenity. Dense concentration of swamps in unnamed southern tributaries and Iluka Creek. Significant because of scale, swamps, hydrologic and ecological value, environmental quality and recognised conservation status.
Stokes Creek	North Cliff	Large tributary of O'Hares Creek. Permanent flow except in upper reaches. Some subsidence effects already experienced in lower catchment; upper catchment largely undisturbed. Part of SCA Special Area and Dharawal State Conservation Area. Zoned as Water Catchment. Steep, confined sandstone gorge with pools, rockbars, rock shelves, cascades, waterfalls and boulder fields and a dense collections of swamps in and adjacent to the waterway in the upper catchment. Significant because of scale and hydrologic value and (in the upper catchment) the environmental quality of a largely pristine sandstone gorge with dense concentration of swamps.
Dahlia Creek	North Cliff	Major tributary of O'Hares Creek. Classified as intermittent-ephemeral on basis of 1:25,000 mapping. No threatened species recorded but likely to be present. Small patch of cleared and developed land in upper catchment: otherwise undisturbed. Part of SCA Special Area, Dharawal State Conservation Area and undisturbed parts of Holsworthy Military Area. Zoned as Water Catchment. Confined, smaller scale sandstone gorge. Pools, rock shelves, rock bars, boulder fields, cascades and waterfalls dominate physical form and visual amenity. Significant because of hydrologic and ecological value, quality of the pristine environment and location within areas of recognised conservation status.
Cobbong Creek and Tributaries 1 & 2 to O'Hares Creek	North Cliff	Tributaries of O'Hares Creek. Classified as intermittent-ephemeral on basis of 1:25,000 mapping. Threatened species recorded in Cobbong Creek. Undisturbed catchment. Part of SCA Special Area, Dharawal State Conservation Area. Zoned as Water Catchment. Confined, smaller scale sandstone gorges. Pools, rock bars, boulder fields and waterfalls dominate physical form and visual amenity. Significant because of hydrologic and ecological value, environmental quality associated with the physical form and the pristine setting and location within areas of recognised conservation status.
Woronora River and tributaries	North Cliff	Approximately 4 km of the upper Woronora River is within the Study Area adjacent to Dahlia Creek to the west and Waratah Rivulet to the east. Woronora River contributes to Sydney's water supply via Woronora Reservoir. Threatened species have been recorded. The river and its upper catchment are undisturbed and part of an SCA Special Area. Confined sandstone gorge: pools, rock shelves, rock bars and boulder fields dominate physical form. Swamps flank the lower order sections of the river and its tributaries. Significant because of hydrologic value, and the environmental quality of its physical form and pristine setting.
Punchbowl Creek and tributaries	North Cliff	Tributaries of the Georges River. Adjacent to Woronora River. The creeks and catchments are undisturbed and part of the Holsworthy Military Area. Confined sandstone gorges: pools, rock shelves, rock bars and boulder fields dominate physical form. Significance from the environmental quality of physical form and pristine setting.

Proponent's proposal

The EA proposes that O'Hare's Creek and the lower reaches of Stokes Creek be afforded the same level of protection as Cataract River and Nepean River Reach 1. The criteria allow:

'Minor fracturing of controlling rockbars, with negligible diversion of water from associated pools. Potential for fracturing of stream bed and consequent stream flow diversion in stream reaches between controlling rockbars. Localised impacts on stream water quality. Strata gas release'.
This is to be achieved by:

'Longwall layout design to achieve a maximum predicted closure of 200 mm at controlling rockbars. Implementation of stream remediation measures … where subsidence results in the diversion of stream flow in stream reaches between controlling rockbars, and where the stream features are such that the remediation measures are considered technically feasible'.
Undermining is not prohibited by this proposal although none is proposed in the current mine layout.

For all the other creeks listed, no control on the extent of impact is proposed, and management of consequences relies on subsequent remediation of rockbars, and remediation of other reaches *where technically feasible*.

Panel's assessment

This grouping includes all the sandstone gorges in the east of the Study Area and the largely undisturbed areas that are currently managed as part of the Holsworthy Military Area, Dharawal State Conservation Area, Dharawal Nature Reserve and SCA Special Area. It includes part of the Woronora Reservoir catchment. Streams are mainly steep, confined sandstone gorges with pools, rockbars, rock shelves, cascades, waterfalls and boulder fields. In their upper catchments, as they emerge on to the plateau, there are dense collections of swamps in and adjacent to the waterway.

The Panel assesses high hydrologic and ecological value to all the rivers and creeks in this zone associated with the environmental quality of the largely pristine environment including iconic sandstone gorges and the proximity of areas of recognised conservation status. In addition, Stokes and O'Hares Creeks and tributaries are associated with a dense array of swamps and Woronora River contributes to Sydney's water supply via Woronora Reservoir.

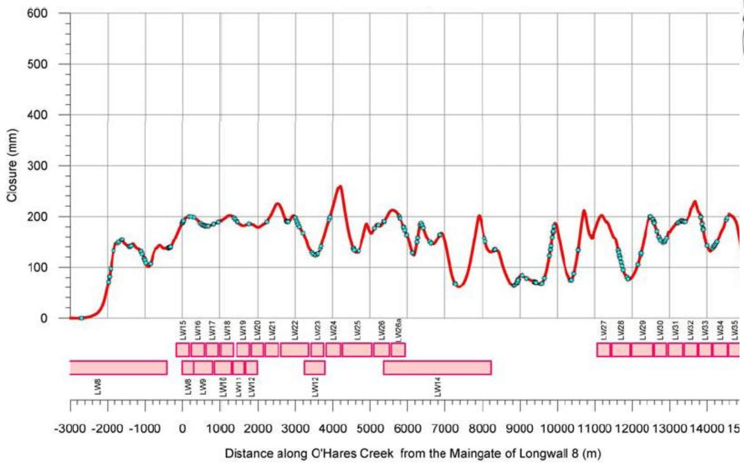
The Panel finds that the expected impacts and consequences of mining beneath these streams are at odds with these values and that many of the values are not protected or restored by the remediation strategies that are proposed. The following considerations have guided the Panel in reaching this finding.

- The EA attempts no explicit link between the special values of the rivers and creeks in this zone and the consequences of mining. It focuses only on a limited set of consequences: water levels in pools, catchment yield and water quality in reaching its management recommendations. The impact of mining on the broader values of creeks in this zone remains unexplored and unremediated.

- The condition of the rivers and creeks in this zone is integral to a broader set of values that are associated with the pristine nature of the area, its vast array of swamps and the integrity and range of aquatic, semi-aquatic and terrestrial biotopes.
- Many of the values of rivers in this zone rely on its pristine nature. These values will exhibit a threshold response to change. For example aesthetic values associated with the pristine nature of the streams are immediately lost if iron staining of the type observed elsewhere (e.g. in Lizard Creek) occurs. The value of the creeks and their surrounds as undisturbed habitat is immediately reduced as the result of externally induced hydrologic change.
- Some creeks in this zone are predicted to be subject to extreme valley closure movements (e.g. up to 1500mm closure in Dahlia Creek[313]). In the absence of any better predictive methodology, the impact on valley floors and creek beds must be projected as considerable and the consequences must be projected to be at least as severe as those observed elsewhere in the region.
- Stream values do not just rely on the existence of pools. The feasibility of restoring surface flow in other channel types is unproven and the Panel remains sceptical of success. Continuous application of remediation works over long lengths of stream conflicts with the natural values of the system.
- In this zone, remediation measures cannot be accomplished without loss of values that depend on naturalness, especially where predicted impacts are high.
- The EA assesses variable levels of protection as appropriate to different creeks in this zone, even where, by the Panel's assessment, values appear similar. For example, Figure 35 compares predicted closure for O'Hares Creek, Dahlia Creek and Stokes Creek. The predicted closure figures have been copied from Appendix C of the EA and adjusted and placed on the page to align vertical scales. Photos have been added to allow a quick visual comparison. While these three streams represent different sizes of channel, the Panel cannot accept that allowing such different levels of impact is defensible for otherwise similar streams.
- Despite their importance for hydrologic and ecologic connectivity, no protection or remediation is proposed for 1st and 2nd order streams in this zone. The importance of these low order streams for protecting the water quality of baseflows from swamps is not recognised.
- Predicted closure criteria are only applied at rockbars. No predicted closure criteria are applied for lengths of stream where rockbars are not observed. Values of other stream morphologies are therefore not protected and rely on remediation for reinstatement.
- The SCA in its submissions remains firmly opposed to underground mining in its special areas on the grounds of potential loss of water quality and potential loss of catchment yield.

In Section 7.6 the Panel has proposed that all these streams with the exception of Punchbowl Creek be afforded special significance status. The Panel's assessment of the significance of consequences supports this proposition.

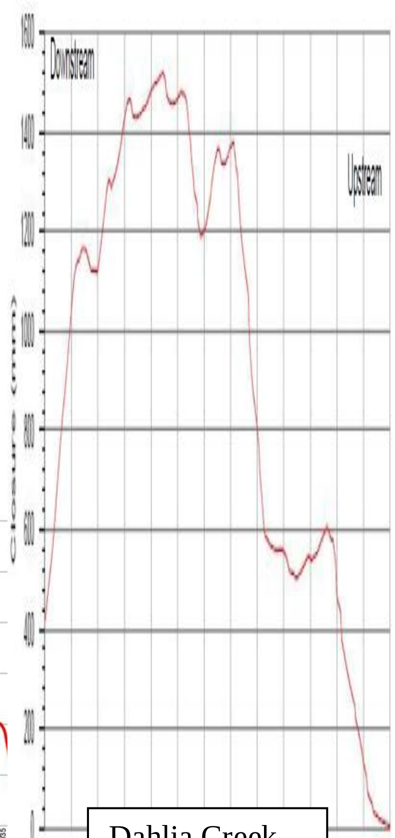
[313] EA, Appendix C, p.206, Figure 154.



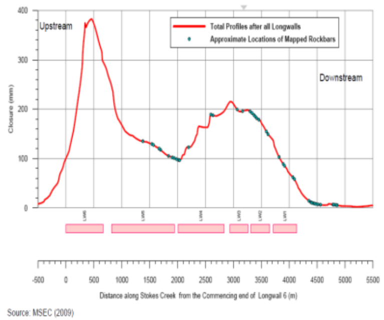
Source: MSEC (2009)

O'Hares Creek

Taken from Appendix C of the EA and adjusted (approximately) to align scale for comparison. Photos from Appendix C and Project GIS superimposed



Dahlia Creek



Stokes Creek

Figure 35: Predicted Valley Closure Movements along O'Hares Creek, Dahlia Creek and Stokes Creek

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7.9.4. Cataract Tributaries Flowing Exclusively in Hawkesbury Sandstone

Stream name	Mining Domain	Description and values (from Table 11)
Cascade Creek	3	Tributary of Cataract River. Contributes directly to Broughtons Pass Weir. Classified as intermittent-ephemeral on basis of 1:25,000 mapping. Creek line is largely undisturbed but part of ridge to the west is cleared for agriculture. Part of SCA Special Area. Zoned as Water Catchment. Steep, confined sandstone gorge with pools, narrow elongated rockbars, cascades and waterfalls. Significance is hydrologic value, and the environmental quality of its physical form and pristine setting.
Wallandoola Creek	3	Large tributary of Cataract River. Permanent flow contributes to water supply via Broughtons Pass Weir. Some previous subsidence in upper catchment otherwise undisturbed. Part of SCA Special Area. Zoned as Water Catchment. Steep, confined sandstone gorge with pools, narrow elongated rockbars, rock shelves, cascades, waterfalls and boulder fields. Significant because of scale, hydrologic value, and the environmental quality of its physical form and pristine setting.
Wallandoola East Creek	3	Small tributary of Cataract River. Contributes to water supply via Broughtons Pass Weir. Undisturbed catchment. Part of SCA Special Area. Zoned as Water Catchment. Steep, confined sandstone gorge expected to exhibit pools, rockbars, rock shelves, cascades, waterfalls and boulder fields. Significant because of hydrologic value, and the environmental quality of its physical form and pristine setting.
Lizard Creek	3	Large tributary of Cataract River. Permanent flow contributes to water supply via Broughtons Pass Weir. Previous subsidence upstream of Study Area shows noticeable impacts on creek, otherwise catchment undisturbed. Part of SCA Special Area. Zoned as Water Catchment. Very steep, confined sandstone gorge with pools, narrow elongated rockbars, rock shelves, cascades, waterfalls and boulder fields. Significant because of scale, hydrologic value and the environmental quality of its physical form and largely pristine setting.
Cataract Reservoir Tributaries 1 & 2	2	These creeks contribute flow directly into Cataract Reservoir. Threatened species have been recorded. Catchment and creeks undisturbed and in SCA Special Area. Zoned as Water Catchment. Sandstone gorge but less confined than other examples in region. Pools, rock shelves, rock bars, boulder fields and waterfalls dominate physical form but discontinuous floodplains and adjacent swamps are also present. Dense concentration of swamps along the drainage lines of the upper catchments. Significant because of hydrologic and ecological values and the environmental quality of its pristine setting and the physical form associated with the less confined valley including dense associations of flanking and in-stream swamps.

Proponent’s proposal

The EA proposes that Lizard Creek be afforded the same level of protection as Cataract River and Nepean River Reach 1. The Proponent’s criteria would allow:

‘Minor fracturing of controlling rockbars, with negligible diversion of water from associated pools. Potential for fracturing of stream bed and consequent stream flow diversion in stream reaches between controlling rockbars. Localised impacts on stream water quality. Strata gas release’.

This is to be achieved by:

'Longwall layout design to achieve a maximum predicted closure of 200 mm at controlling rockbars. Implementation of stream remediation measures … where subsidence results in the diversion of stream flow in stream reaches between controlling rockbars, and where the stream features are such that the remediation measures are considered technically feasible'.
Undermining is not prohibited by this proposal although none is proposed in the current mine layout.

For all the other creeks listed, no control on the extent of impact is proposed, and management of consequences relies on subsequent remediation of rockbars, and remediation of other reaches *where technically feasible*.

Panel's assessment

This grouping includes all the sandstone gorges in the south east of the Study Area and the largely undisturbed areas that are currently managed as part of SCA Special Areas. It includes part of the Cataract Reservoir catchment. Streams are mainly steep, confined sandstone gorges with pools, rockbars, rock shelves, cascades, waterfalls and boulder fields. In the eastern part of the zone, in the upper catchments, there are dense collections of swamps in and adjacent to the waterway.

The Panel assesses high hydrologic and ecological value to all the rivers and creeks in this zone associated with the environmental quality of the largely pristine environment including iconic sandstone gorges and the proximity of areas of recognised conservation status. In addition, Cataract Reservoir Tributaries 1 and 2 are associated with a dense array of swamps and all creeks contribute directly to water supply either via Cataract Reservoir or Broughtons Pass weir.

The Panel finds that the expected impacts and consequences of mining beneath these streams are at odds with these values and that many of the values are not protected or restored by the remediation strategies that are proposed. In reaching this finding, the Panel has relied on similar considerations to those reported in the previous section.

In Section 7.6 the Panel has proposed that all these streams with the exception of Cataract Creek and Lizard Creek be afforded special significance status. The Panel's assessment of the significance of consequences supports this proposition. Furthermore, despite not achieving special significance status because of previous impacts, Cataract Creek and Lizard Creek exhibit highly significant values and the consequences of further impact makes them worthy of protection.

7.9.5. Georges River Flowing Exclusively in Hawkesbury Sandstone

Stream name	Mining Domain	Description and values (from Table 11)
Georges River	2,5	Major river. Already undermined downstream of Study Area and includes urban, agricultural and industrial land uses. Receives discharge from coal waste disposal area via Brennans Creek. Threatened species have been recorded. Steep, confined sandstone gorge with large pools. Significant because of scale, physical form and amenity value to local community.

Proponent's proposal

The EA recognises the potential for impact on two sections of the Georges River and has proposed risk management measures that minimise the impact and reduce the accompanying adverse consequences.

Two different criteria have been applied across the two river reaches. For the lower Georges River, the criteria allow:

'Minor fracturing of controlling rockbars, with negligible diversion of water from associated pools. Potential for fracturing of stream bed and consequent stream flow diversion in stream reaches between controlling rockbars. Localised impacts on stream water quality. Strata gas release'.
This is to be achieved by:

'Longwall layout design to achieve a maximum predicted closure of 200 mm at controlling rockbars. Implementation of stream remediation measures … where subsidence results in the diversion of stream flow in stream reaches between controlling rockbars, and where the stream features are such that the remediation measures are considered technically feasible.'
For the upper Georges River, the river is not to be directly undermined where it is classified as third order but there is no 'performance' criteria applied i.e. cracking of rockbars may occur. Remediation is proposed at rock bars and between rock bars where feasible.

Panel's Assessment

By the standards of the EA this is a high level of protection, but the Panel seeks more stringent criteria for both segments of the Georges River.

For the lower Georges River, the Panel considers that any diminution of values by mining-induced impacts that could lead to fracturing of rockbars or fracturing of the river bed between rock bars is unacceptable. The Panel recommends negligible impact criteria be applied to this section of river. The Panel is not satisfied that stream values are protected by a focus on limiting fracturing only at rock bars but allowing fracturing elsewhere in the valley floor.

The Panel does not support reliance on remediation after damage as a primary management measure.

For the upper Georges River, the longwall layout as proposed is unlikely to impact on the third order section of the river and the issue becomes the impact of mining on the that part of the Georges River (and its tributaries) which are not protected because they are classified as first or second order streams. The Panel notes that these sections of stream are not without value but the absence of significant swamps or direct water supply implications or other implications means that they have not been proposed for special significance status.

7.9.6. Streams with Mixed Geology

Stream name	Mining Domain	Description and values (from Table 11)
Carriage Creek and tributaries	8	These are northern tributaries to Nepean River. Upper reaches flow on Wianamatta shale but some reaches closer to the Nepean River are incised into sandstone. Surrounding areas are developed for agricultural, industrial and residential use. Classified as intermittent-ephemeral on basis of 1:25,000 mapping. In some reaches riparian vegetation is substantially intact except weeds have encroached and width of remnant riparian vegetation is variable. Endangered ecological communities are present in the riparian zone. Creek beds in sandstone comprise ' rockbars and boulder-fields with pools. Elsewhere valley is shallow and bed and bank material is clay or alluvium. Ecological significance is as a vegetation remnant and habitat refuge in an otherwise developed landscape. Environmental quality is constrained by adjacent development. Hydrologically the creek and the riparian zone act to retard flow peaks and to filter particulates, organic matter and other contaminants.
Trib to Nepean River 1 & 2	9	
Harris Creek	7, 9	
Elladale Creek	5	These are eastern tributaries to Nepean River. Upper reaches flow on Wianamatta shale but some reaches closer to the Nepean River are incised into sandstone. Surrounding areas are developed for agricultural, industrial and residential use. Classified as intermittent-ephemeral on basis of 1:25,000 mapping. In some reaches riparian vegetation is substantially intact except weeds have encroached and width of remnant riparian vegetation is variable. Endangered ecological communities are present in the riparian zone. Creek beds in sandstone comprise ' rockbars and boulder-fields with pools. Elsewhere valley ids shallow and bed and bank material is clay or alluvium. Photos show poor water quality. Ecological significance is as a vegetation remnant and habitat refuge in an otherwise developed landscape. Environmental quality is constrained by adjacent development. Hydrologically the creek and the riparian zone act to retard flow peaks and to filter particulates, organic matter and other contaminants.
Ousedale Creek	5	
Mallaty Creek	5	
Simpsons Creek	5	
Allens Creek	8	These tributaries to Nepean River dissect a plateau of Wianamatta Shale in the south west of the Study Area. Classified as intermittent-ephemeral on basis of 1:25,000 mapping. Creeks are incised through shale into underlying sandstone. Plateau areas are developed for agriculture and residential use (and Appin West pit top) but incised creek lines remain largely uncleared. Riparian vegetation is substantially intact except weeds have encroached. Creeks and environs provide habitat refuge in otherwise developed landscape. Threatened species (Black-chinned Honeyeater, Grey-headed Flying Fox) have been recorded adjacent to stream. Endangered ecological communities are present in the riparian zone. Creek beds in sandstone comprise ' rockbars and boulder-fields controlling numerous pools. Ecological significance is as a vegetation remnant and habitat refuge in an otherwise developed landscape. Environmental quality and visual amenity are enhanced by the physical form of the stream and its setting in an otherwise developed landscape. At the same time, environmental quality is constrained by adjacent development. Hydrologically the creek and the riparian zone act to retard flow peaks and to filter particulates, organic matter and other contaminants from agricultural, urban and industrial runoff into the Nepean River. Proximity to development may highlight community interest.
Clements Creek	8	
Stringybark Creek	8	
Byrnes Creek	8	

Proponent's proposal

No control is proposed on the extent of impact that is allowed in these creeks and management of consequences relies on subsequent remediation of rockbars, and remediation of other reaches where technically feasible.

The proponent suggests that the presence of clays in the catchments and the creek beds will prevent long term loss of water through subsurface cracking by blocking flow paths.

Panel's assessment

These creek systems are a complex of characteristics associated with both their shale and sandstone geology. They are not without value. Creeks and environs provide refuge in an otherwise developed landscape including for some threatened species and endangered ecological communities. Ecologically significance is as a vegetation remnant and habitat refuge (including for some threatened species). Environmental quality and visual amenity are enhanced by the physical form of the stream and its setting in an otherwise developed landscape. At the same time, environmental quality is constrained by adjacent development. Hydrologically, the creek and the riparian zone act to retard flow peaks and to filter particulates, organic matter and other contaminants from agricultural, urban and industrial runoff into the Nepean River.

The Panel recognises that the impacts of subsidence present some risks to these values. Furthermore, proximity to development may highlight community interest in any loss of values that does occur.

Overall however the Panel assesses a level of resilience in these values that will limit the magnitude of consequences. This is largely because the characteristics of the values that are exhibited by these creeks do not rely on naturalness. Development in and adjacent to the streams has already led to changes in ecological and aesthetic values and in environmental quality. In general, changes induced by mining will generate incremental consequences on top of the existing changes rather than representing the first major departure from naturalness (as is often the case in the undisturbed sandstone gorges to the east and south).

Many of the residual values are expected to be resilient to further change. For instance, the impact of mining should have negligible consequence for the ability of the creeks to filter particulates, organic matter and other contaminants or to retard flood peaks. Other values are potentially at some risk. For example, aquatic habitat values may be decreased if some water follows subsurface pathways but aquatic habitat values are already diminished and the valley will continue to provide vegetation remnants and a habitat refuge. The Panel has observed that consequences such as iron staining, bacterial mats and deteriorating water quality appear to be less prevalent in areas of this geology. This will limit impacts on amenity values.

7.10. FINDINGS AND RECOMMENDATIONS

7.10.1. Findings

1. The Panel finds that stream values depend on the recognition of the stream system as a continuum with the value of any segment heavily dependent on upstream and downstream conditions and in higher and lower order components of the system. Pools behind rockbars may be visually dominant features but other stream morphologies including boulder fields and pools behind other channel constrictions are also vital components of the linear system.

2. In the remote areas of sandstone gorges to the east and south of the Study Area, the Panel finds that the value of the stream network is closely associated with its natural characteristics and its pristine setting. The Panel finds that in these zones even small impacts can have major consequences for naturalness values and may be irreversible.

3. In the Study Area, stream condition is heavily influenced by geology and catchment land use. The Panel finds that a classification of streams based on underlying geology is a useful basis for differentiating the magnitude, density and extent of consequences.

4. The Panel finds that the catalogue of data presented in Appendix P of the EA and in the accompanying GIS provides an excellent database. However these data are not used in the EA to describe the range of stream values or the relative significance of changes in those values following mining. The EA presents no holistic assessment of the risks to stream values or justification for the selection of streams for proposed management measures.

5. The Panel finds that the exclusion of first and second order streams from consideration of consequences ignores the vital role that these streams play in the interconnectivity of the system. In particular they are important in protecting the continuity of flow and the quality of water conveyed between the upland swamps and the larger streams.

6. The loss of surface flow to sub surface fracture networks can result in dry periods for otherwise perennial streams and increased periods of zero flow in intermittent streams. The Panel finds that the likely magnitude of this impact would exceed standards generally accepted for allowable impacts on the flow regime in assessment of water resources development projects.

7. The frequent occurrence of iron staining and the spatial relationship to historical mining leads the Panel to conclude that iron staining and impaired water quality are inevitable outcomes of the proposed mine plan.

8. The Panel concludes that the remediation strategies proposed in the EA should not be relied on as a wholesale and primary measure to protect stream related values.

7.10.2. Recommendations

1. The Panel recommends that the following streams be afforded 'special significance status' throughout their length within the Project Area:

   - Nepean River
   - Cataract River (dam to Broughtons Pass Weir)
   - O'Hares Creek
   - Stokes Creek
   - Dahlia Creek
   - Cobbong Creek
   - Tributaries 1 & 2 to O'Hares Creek
   - Woronora River and tributaries
   - Wallandoola Creek
   - Wallandoola East Creek
   - Cataract Reservoir Tributaries 1 & 2

2. The Panel recommends that all streams afforded special significance status plus Lizard and Cascade Creeks and the Georges River in West Cliff Area 5 be protected by requiring, as part of any Approval, a performance criterion of negligible subsidence-related impact as defined in 7.9.2 above ie

   > *'no diversion of flows, no change in the natural drainage behaviour of pools, minimal iron staining, minimal gas releases and continued maintenance of water quality at its pre-mining standard'.*

3. The Panel recommends that mining be permitted under the remaining streams listed in the EA subject to the stream impact minimization criteria and the management measures proposed in the EA.

7.11. AQUATIC ECOLOGY

7.11.1. Introduction

Appendix D of the EA addresses aquatic ecology. It includes catchment-based descriptions of the streams in the Project Area, a description of the many previous studies on various aspects of aquatic ecology in the area, a description of the aquatic macrophytes, macroinvertebrates and fish in the catchment streams plus general information on catchment water quality, a description of the study sites and what was found, and an assessment of the potential risks to aquatic ecosystems from the BSO Project Proposal. However, the descriptions are very general in nature and contain very little site-specific information.

7.11.2. Survey Intensity

Despite the substantial size of the Study Area, and the number of streams in it - and substantial variation in their characteristics - only 28 locations (56 sites) were sampled as part of this study. The explanation offered in the EA is that this study was simply to augment information gained from previous studies.[314]

DECCW has criticised the survey scope and intensity as being inadequate for the purpose of assessing the potential threats to aquatic systems from the Project Proposal[315] and particularly in relation to threatened species. ICHPL did not respond to these criticisms in its response to DECCW submissions apart from noting that Adams Emerald Dragonfly had not been located in the Project Area in previous surveys but, nevertheless, a risk assessment had been completed for it.[316] In relation to survey adequacy the Panel is of the same view as DECCW and, if aquatic ecology became the turning point in whether to approve the Project or not, would advise that there was insufficient information on which to base an informed decision.

However, since the subsidence-induced impacts on aquatic ecology are largely (but not exclusively) dependent on impacts to streams and swamps, the Panel is of the view that the appropriate focus for decision-making should be on those features. The one exception to this would be if there was a site-specific concentration of a threatened species where specific action may be required beyond that already being considered for the respective streams and swamps.

7.11.3. Assessment of Potential Impacts on Aquatic Systems

Assessment of potential impacts of the mining proposal on aquatic habitats is stated to be based on the subsidence, groundwater, surface water and flora studies reported in the EA.[317] Very strong caveats are applied to the aquatic ecology risk assessment:

> *'Consequently this assessment relies on the coverage, rigour and predictive capacity of these studies and the models therein ... the predictions presented*

[314] EA, Appendix D, p.49
[315] DECCW (2009b), p.23
[316] ICHPL (2010c), pp.27-29
[317] EA, Appendix D, p.122

... are contingent on the actual surface water and subsidence effects being equal to or less than those predicted.'[318]

As noted in Chapter 8 on Terrestrial Ecology the problem with a suite of interconnecting caveats is that if one of the supporting pillars is not able to withstand scrutiny, then the proposition itself is on shaky ground. The problem here is that the Panel has expressed concerns with the groundwater model presented in the EA and with the adequacy of the flora survey. The Panel is also concerned that the focus of the surface water studies does not allow an adequate assessment of important impacts relevant to aquatic ecology.

The description in the EA of subsidence impacts on aquatic habitats[319] is limited. However, it does mention that the impacts occur across the spectrum from permanent watercourses to ephemeral streams and notes the substantial variation across the Project Area with a focus on the difference from west to east.

The description of potential subsidence impacts on whole stream and catchment systems is even more limited. An example from Appin Area 3 is:

'Potential impacts of the Project on Wallandoola Creek, Cascade Creeks, the un-named tributary of the Cataract River, Clements Creek and Third Point Creek include fracturing and localised flow diversion (including reduced water level and drying during dry weather at some pools), iron staining and transient spikes in water quality parameters such as iron in areas where flows emerge from subsidence induced fractures fractures [sic] and strata gas emissions for a period of time.'[320]

One important aspect that receives little coverage is the impact on ephemeral and intermittent streams (e.g. these are not mentioned in relation to impacts in Area 2 and Area 3 and North Cliff[321]). These streams provide habitat for a range of aquatic and semi-aquatic species and are vulnerable to subsidence impacts in terms of redirected flows and water quality. In terms of water quality, the likelihood is that impacts in these ephemeral and intermittent streams will be long-lasting rather than transient (as is suggested in the EA) given that the flows are either small or infrequent and the leaching from the fractures will therefore occur much more slowly. There are no proposals in the EA to avoid, mitigate or remediate impacts on these lower order streams.

Alteration of natural flow regimes of rivers and streams is recognised as a key threatening process under the NSW *Threatened Species Conservation Act 1995* (TSC Act), Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and NSW Fisheries Management Act (FM Act). Subsidence-impacts are recognised in the EA as a potential source of changes in flow regimes that may cause localised significant negative consequences for aquatic or riparian species, but their potential for negative consequences is considered low overall. There is no

[318] EA, Appendix D, p.131
[319] EA, Appendix D, pp.122-123
[320] EA, Appendix D, pp.129
[321] EA, Appendix D, pp.128-130

information in the EA that links the risk of site-specific subsidence predictions to an assessment of risk for aquatic species at those sites.

Decrease in water quality as a consequence of subsidence is also mentioned as a risk to aquatic systems, although the water quality changes are described as 'localised and transient'.[322] This does not accord with the Panel's observations of subsidence-induced water quality changes which can extend a substantial distance downstream of the impacted area and be persistent for a long period (e.g. iron staining and turbidity). Interestingly turbidity is not mentioned, although it is a common occurrence downstream of mining and it is a known threat to macroinvertebrates and some riparian fauna.

Alteration in flow regimes can lead to drying out of some reaches and pools and change the nature of some smaller streams from permanent to intermittent or, in extreme cases, ephemeral. Given that ICHPL consider that most 2nd order and above streams would be perennial or intermittent[323], and there are many kilometres of such streams, this must be considered a significant threat, particularly if an impact coincides with a population of threatened species or an area of habitat suitable for a threatened species.

The EA assessment is that the risk is not significant. However, DECCW points out[324] that, of the 118 km of measured streams, approximately 65 km are predicted to experience valley closure >200 mm and that, whilst ICHPL may indicate a preparedness to remediate some rock bars to restore pool function, this potential impact cannot be considered insignificant. In addition the Panel notes that the ICHPL commitment to remediate carries a 'where practicable' tag, remediation is not yet a proven long term proposition for restoring function and, in any event, more than half the pools shown in Table 2 of the ICHPL response to the PAC Questions[325] are controlled by boulder fields (175) and not by rock bars (169).

In relation to boulder fields, although they appear to have a rich macroinvertebrate fauna and a significant riparian zone fauna[326], they do not appear to have been sampled as part of the survey work, nor are the risks to their aquatic ecology considered in the EA.

7.11.4. Threatened Species

Four threatened species listed under the TSC, FM and/or EPBC Acts possibly occur within the BSO Project Area or its immediate surrounds, namely Macquarie Perch (*Macquaria australasica*), Sydney Hawk Dragonfly (*Austrocordulia leonardi*), Adams Emerald Dragonfly (*Archaeophya adamsi*) and the Giant Dragonfly (*Petalura gigantea*). Of these, only the Macquarie Perch was found in the survey for the BSO Project Proposal.[327] The EA provides an aquatic ecology impact assessment for each of these species.[328]

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[322] EA, Appendix D, pp.131
[323] ICHPL Response to PAC Questions, No 51, p.37
[324] DECCW, Second Submission on the EA, 16/12/09, p.24
[325] ICHPL Response to PAC Questions, No 52, p.38
[326] Panel direct observation
[327] EA, Appendix D, p.155
[328] EA, Appendix D, p.155-168

7.11.4.1. Macquarie Perch

This species is listed as endangered under both the FM Act and the EPBC Act.

The EA records a viable population of this species in the Project Area. The core population is in the Cataract River between Cataract Dam and Broughtons Pass Weir, but specimens have also been found in the Nepean River downstream of Pheasants Nest Weir and also in the Georges River near the Punchbowl Creek confluence. No specimens were found in O'Hares Creek or Stokes Creek despite the apparently suitable habitat.

The EA notes that the proposed mining operations will have some water quality impacts on the Cataract River between Cataract Dam and Broughtons Pass Weir, but that they will not have any impact on the lifecycle of Macquarie Perch, principally it seems because this stretch of river is flushed regularly with water being transferred from the dam to the Sydney supply.[329]

Similarly with the Nepean River, some water quality impacts are anticipated, but the EA claims that regular flushing of the system should ensure that any impacts are transient in the relevant habitat area.[330]

Shallow riffles with gravel or rocky bottoms are important spawning sites for Macquarie Perch. Water quality impacts could potentially affect this stage of the lifecycle, although again the EA minimises the risk.[331]

DECCW makes the point that the survey effort for this species was inadequate and so it is simply not possible to know whether there are other populations in the BSO Study Area and, if so, what the potential impacts of the Project would be on these populations.[332] The Panel agrees that the information provided is not adequate for the purposes of a comprehensive risk assessment on a species that is listed as endangered under both NSW and Commonwealth statutes.

7.11.4.2. Sydney Hawk Dragonfly

This species is listed as endangered under the FM Act and is only known from four locations. Whilst it was not found in the current survey, the known locations are proximate to the Project Area and it may exist in areas of suitable habitat within the Project Area. The survey effort was insufficient to settle the question. Most of the lifecycle is spent in the larval form in deep riverine pools. The adults are only present for a few weeks.

Anything that disturbs flow, temperature or water levels will impact the habitat of this species. Any decrease in water quality is also a potential threat to larval stages. Without a comprehensive targeted survey for this species across all suitable habitats it is not possible to match populations with predicted subsidence impacts at any occupied sites.

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[329] EA, Appendix D, p.156
[330] EA, Appendix D, p.155
[331] EA, Appendix D, p.156-158
[332] DECCW (2009b), p.29

7.11.4.3. Adams Emerald Dragonfly

This species is listed as endangered under the FM Act. Only five adults of this species have ever been collected. Most of the lifecycle is spent in the larval stages (up to seven years). Larval stages are known to inhabit small streams with gravel or sandy bottoms in narrow, shaded riffle zones with moss and rich riparian vegetation.[333] It was not located in the Study Area during the current studies.

The EA notes the main threats to this species include impacts on riparian vegetation, water quality and siltation.[334] To this list should be added alterations to flow. The EA also notes that natural disasters could threaten the species 'given that local extinctions could affect the survival of the species as a whole'.[335]

The long period spent in the larval stage and the nature of the habitat requirements make this species particularly vulnerable to subsidence-induced impacts on streams and riparian systems.[336] The EA notes that significant areas of potential habitat are likely to be impacted, although some areas would not be subject to impacts.[337] No assessment is made of potential changes to either the Base Case mine layout or the longwall panel width.

The EA concludes that the species is unlikely to exist in the Project Area and that, even if it did, the potential impacts on streams are unlikely to threaten survival of a population. This is based on a number of assertions including the potential for re-colonising areas that have dried out once water returns, and the ability of the adult stage to fly.[338] The credibility of these assertions for a species that has an aquatic life cycle of up to seven years and with an adult flying stage lasting only a few months is highly questionable.

It is also worth noting that DECCW quotes the acknowledged expert on this species as advising that there is no reason to consider that the species would not exist in the Project Area.[339]

Overall, the Panel considers that the survey intensity is inadequate for this species and that it is not possible to rule out its occurrence in the Project Area. The Panel takes the view that the impact assessment in the EA is not credible in relation to this species and, because of the species' particular habitat requirements and lifestyle characteristics, it would be highly vulnerable to mining-induced subsidence impacts on streams.

7.11.4.4. Giant Dragonfly

The Giant Dragonfly is listed as endangered under the TSC. It is a swamp specialist species with a very long life-cycle. Larval stages can take 10-30 years, but adults are

[333] EA, Appendix D, p.163
[334] EA, Appendix D, p.163
[335] EA, Appendix D, p.163
[336] DECCW (2009b), p.28
[337] EA, Appendix D, p.163
[338] EA, Appendix D, p.163
[339] DECCW (2009b), p.29

short-lived and survive for only one summer. Larvae live in long-chambered burrows and avoid open water.[340]

The EA states that the species was not found in the surveys for this study, but it is equally clear that there were no attempts to target it in either the terrestrial fauna surveys or the aquatic ecology surveys. The species is not included in the list in Appendix F of the EA of threatened species possibly occurring within the Project Area[341], although this omission is strongly criticised by DECCW, who assert that the species is likely to occur in areas of suitable habitat within the Project Area.[342]

The species is stated to be vulnerable to subsidence-induced impacts on swamps, but the risk of adverse effects on any population is considered 'unlikely'.[343] However, the assessment is based on the conclusion in the EA that only eight of the 226 swamps in the Project Area would be at risk of significant negative environmental consequences and that measures to mitigate and manage negative consequences in these swamps would be implemented by ICHPL.[344] However, the Panel notes that ICHPL has expressly rejected mitigation measures for these swamps.[345]

The Panel concludes that:

- The ICHPL estimates of the consequences of any subsidence impacts on swamps for this species are not considered credible. The Panel's findings are that a much larger number of swamps will be impacted and that a larger number of swamps will be significantly impacted. If wider longwall panels are used, it is very likely that the magnitude of the impacts will increase;

- The habitat requirements and lifecycle characteristics would make this species highly vulnerable to changes in swamp hydrology; and

- The lack of information on occurrence in the Study Area rests squarely with the proponent, since surveys that might have located it were not conducted. If there are localised populations and that location is subject to subsidence-induced impact then the consequences for the localised population could be disastrous.

7.11.5. Findings and Recommendations

(i) The survey intensity is inadequate for the purposes of assessing subsidence-related risks to aquatic systems and the assessments provided are very general.

(ii) The surveys are also considered inadequate for the four threatened species identified as potentially occurring in the Project Area. In this context it should be noted that no attempt was made to locate the Giant Dragonfly and that the surveys for the Adams Emerald Dragonfly and

[340] EA, Appendix D, p.166
[341] EA, Appendix F, Table 1, pp.8-9
[342] DECCW, Response to PAC Questions, Part 1, 05/02/10, Item 9. (See also Y.3.3 above)
[343] EA, Appendix D, p.166
[344] EA, Appendix D, p.166
[345] See Chapter X.6 and EA, Appendix O, 7.3.1 and 7.3.2

the Sydney Hawk Dragonfly covered only small sections of possible habitat.

(iii) The Panel is strongly of the view that the basic information on which to base the threshold decision for approval must be provided up front so that the Panel and the Government can consider public and agency comment on the fully disclosed risks of the project prior to agreeing in principle to proceed to a subsequent staged detailed assessment and implementation process.

(iv) Given the position in (ii) the Panel considers that the basic requirements for assessment of risk to these species have not been met and that, unless the conditions in (v) below are met, no recommendation for Project Approval can therefore be made.

(v) The only alternative that the Panel considers viable is for there to be a substantial level of protection given in any Approval to the potential habitats for the threatened species, including negligible impact criteria for the relevant swamps and streams. This could reasonably be achieved if the Panel's recommendations in Chapter 17 are accepted.

8.0 TERRESTRIAL ECOLOGY

8.1. INTRODUCTION

The EA contains information on flora and fauna in the Project Area, primarily in Appendices E (Terrestrial Flora Assessment) and F (Terrestrial Fauna Assessment). Flora and Fauna are also discussed in other places including, *inter alia*, the risk assessment approach (Appendix N). A substantial number of written submissions, including those from government agencies, raised concerns about the adequacy of the survey work, the risk assessment and proposed levels of protection for flora and fauna. Strong concerns were also expressed by special interest groups and individuals in oral submissions at the Public Hearings.

There are two significant issues for the Panel arising from the material:

- whether there are risks of significant impacts on native species, habitats or ecological communities from the mining proposal; and
- whether there are risks that trigger action under legislation, in particular the *Environment Protection and Biodiversity Conservation Act* 1999 (Cth) (EPBC Act) or the *Threatened Species Conservation Act* 1995 (NSW) (TSC Act).

In line with treatment in the EA, Terrestrial Ecology is divided in this Chapter into Flora and Fauna sections. Habitat protection is considered under Flora.

8.2. FLORA

8.2.1. Introduction

For convenience, consideration of potential impacts on flora is divided into three main areas:

1. all areas within the Project Area other than upland swamps and the proposed Stage IV Coal Washery Emplacement;
2. upland swamps (dealt with separately, see Chapter 6);
3. proposed Stage IV Coal Washery Emplacement (dealt with separately in Chapter 13).

Only 1 is dealt with in this Chapter.

There were strongly held views expressed in written submissions and in oral evidence, by some government agencies, conservation groups and members of the public concerning the value of the habitats in the Project Area and that there should be a no-risk approach adopted to damage from mining, particularly for those habitats considered to be of high conservation value such as incised valleys and their streams and upland swamps.

Part of the concern was based on the view that the eastern portion of the Project Area (i.e. North Cliff and Appin Areas 2 and 3) lies largely within the SCA Special Areas and that this should afford a very high level of protection from threats other than those associated with water supply infrastructure and operations. The argument is that the primary purpose for the Special Areas is water supply and this is dependent on maintaining the integrity of the ecosystems in these areas.

Similarly DECCW has identified previously that listing of swamps in the Woronora Plateau under the TSC and EPBC Acts has not been pursued to date because the swamps were considered to be adequately protected by being located in the Special Areas or in conservation reserves.[346] A case is made for listing under these Acts based on the key listing criteria.

In addition to the SCA Special Areas there were many very strong representations made about the threat posed by the BSO Project to the conservation values of the Dharawal State Conservation Area (SCA).

The substantial overlap between the Special Areas, Dharawal SCA and the eastern and southern mining domains is shown in Figure 36.

8.2.2. Survey effort

The sampling intensity across the whole Project Area is shown in Figure 37. There are no sampling sites in large parts of the Project Area and there are intense concentrations of sites in some areas. Some of the latter are located outside the proposed mining area.

The strategy for selection of sampling sites in the survey (stratification) was designed to sample the known vegetation types and also to target threatened species.[347] In relation to EECs, the seven known EECs were each subject to one or more sampling techniques in a minimum of one sampling site. It is not clear how targeted attempts were made to locate and sample the six additional EECs listed as possibly present in the Project Area.[348]

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[346] DECC Supplementary Submission to the Metropolitan PAC Review, p.6.

[347] EA, Appendix E, p.31.

[348] Although the EA mentions survey effort for all 13 EECs and Table 10 lists the survey effort stratified by communities which includes the 7 known EECs, there is no information on the other 6 possibly occurring EECs.

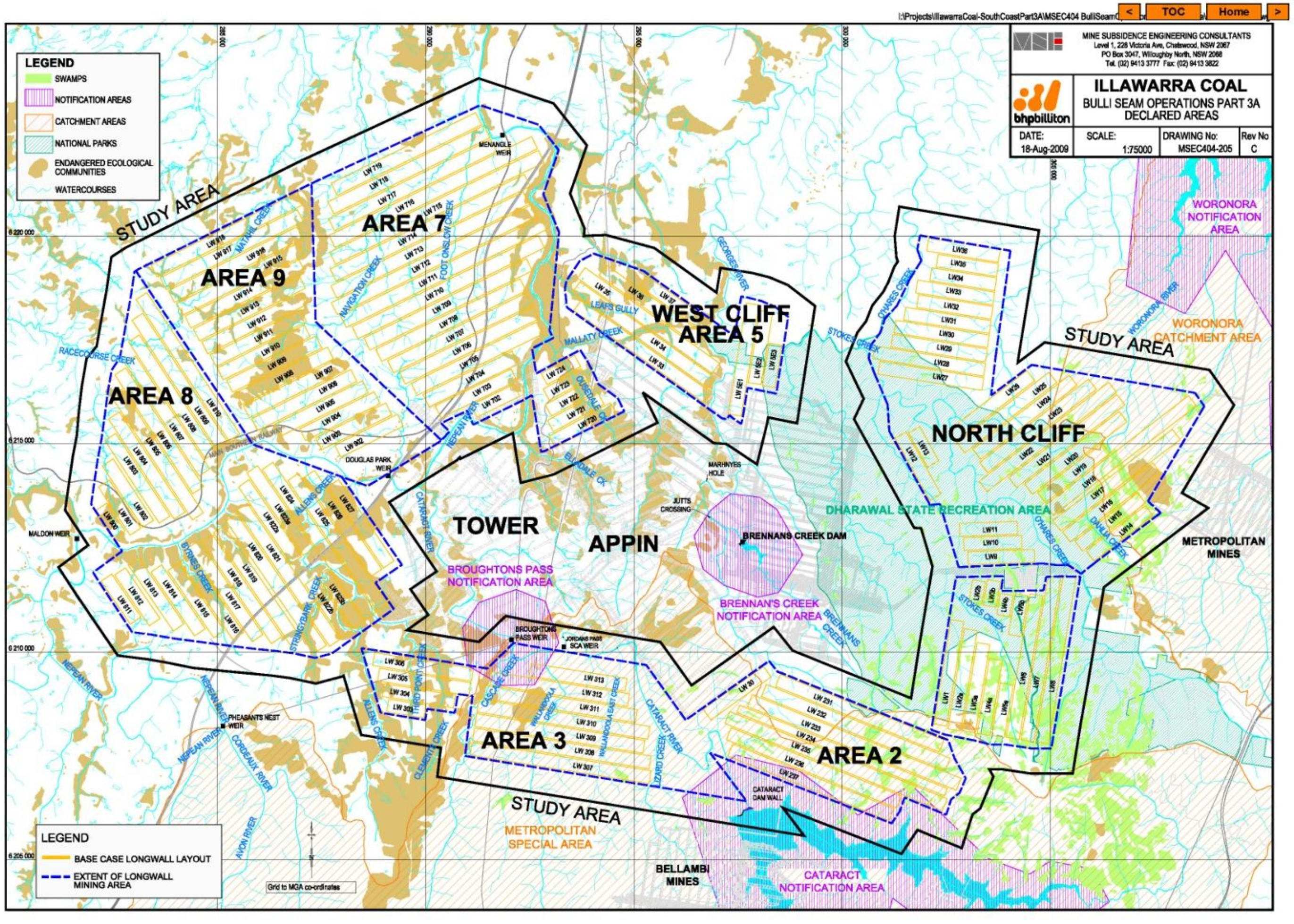

Figure 36: Spatial Relationship between the Special Areas (Catchment Areas), Dharawal SCA and the BSO Mining Domains

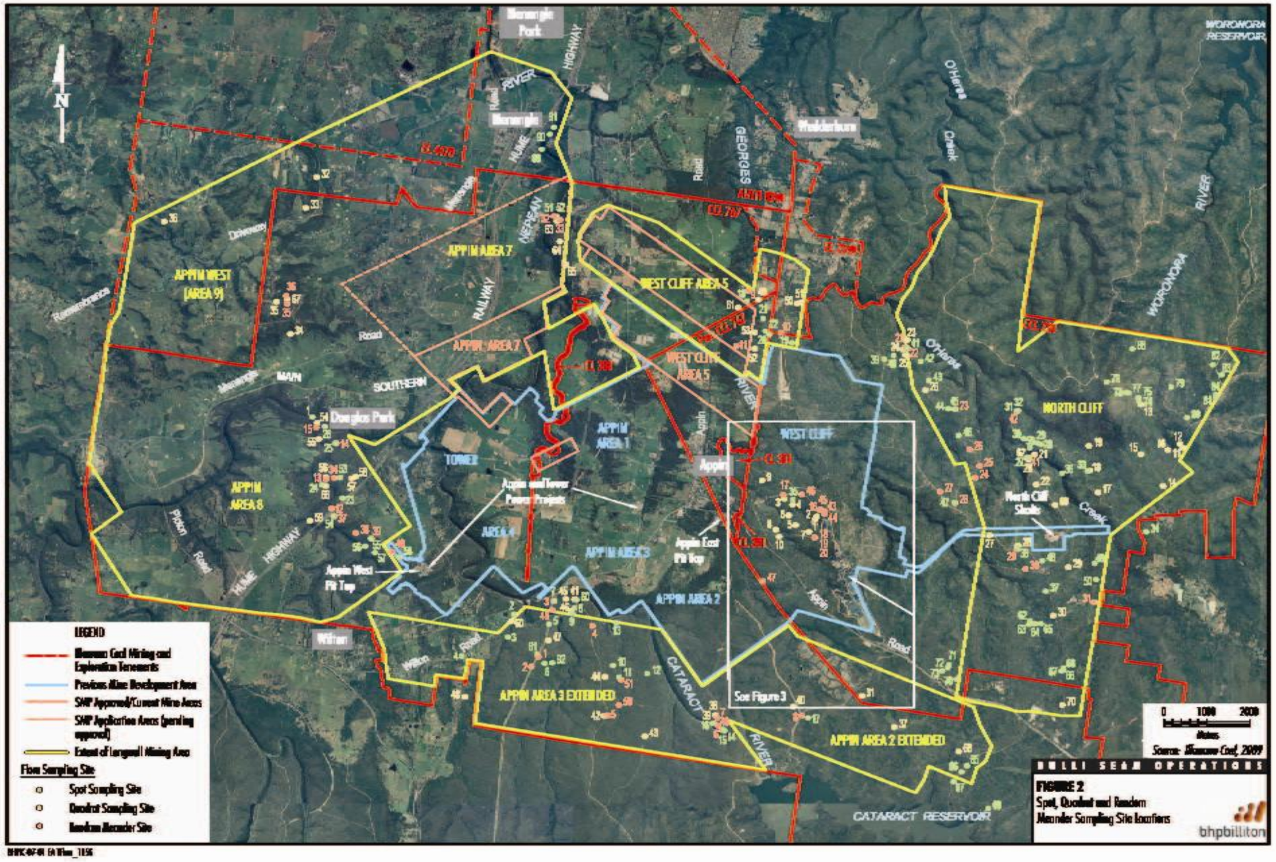

Figure 37: Sampling Site Locations Across the BSO Project Area

No attempt appears to have been made to stratify survey effort based on either the conservation importance of the habitat type or the vulnerability to the effects of underground mining. In the Panel's view a satisfactory approach to the survey task would have required three layers of stratification to ensure that the information relevant to assessment of risk to flora from underground mining was available. The problem is particularly acute in the case of upland swamps, where the sampling intensity was less than 12 percent of swamps - yet these are arguably the highest conservation value habitats and the most vulnerable to the effects of subsidence.

To provide advice and recommendations to Government to approve a mining proposal the Panel must be confident that:

(i) it has had the benefit of public and government agency input on the fully disclosed risks to the natural features; and

(ii) the threats to the natural features can be sufficiently identified and assessed so that the performance standards recommended can be translated into effective approval conditions that will guide (and control where necessary) the subsequent detailed assessment and conditioning for the extraction of coal from one or a group of longwall panels.

Deciding whether there is sufficient information is not context free. The Panel is trying to reconcile the nature and magnitude of the potential risk with the significance and vulnerability of the natural feature. It follows that the amount of information required concerning the natural feature will vary with the identified risk parameters. If the risk parameters indicate a very low likelihood of damage to a natural feature (and the mechanisms are sufficiently understood to predict reliably that any damage that did occur would be insignificant), then not a lot of information is needed about the natural feature itself in order to decide that the proposed activity could be approved subject to any conditions designed to ensure that both the risk and any damage remained within predictions. In these circumstances the key information needed for the natural feature is that it exists, identifies its important characteristics and identifies any particular vulnerabilities that this kind of feature may have in relation to the proposed activity. But if there is uncertainty about the nature or extent of the risk, then we need to know substantially more about the significant natural features in the Project Area in order to assess whether approval to undermine them, with or without conditions, should be recommended. Two examples of this kind of reasoning are set out below, one from the EA itself and one from the Metropolitan PAC Report.

(i) The EA deals with the threat of clearing of native vegetation for surface facilities (other than the Stage 4 Coal Wash Emplacement) by stating that a maximum of 37 ha will be cleared, that EECs and threatened species will be avoided wherever practicable (with two identified exceptions) and that detailed surveys and assessments will be carried out before decisions are made about precise location of the surface facility. The Panel clearly has sufficient information to be confident that, provided the commitments are met, this is unlikely to be a significant threat to EECs or threatened species in the Project Area.

(ii) Similarly, in the Metropolitan PAC Report, the Panel was able to conclude in relation to subsidence-related impacts on habitats other than upland swamps:

'Whilst there may be isolated instances or areas where consequences occur, the likelihood of these consequences being on a scale sufficient to threaten a habitat type in the Project Area is extremely remote. The main reason the Panel can arrive at these conclusions is that the parameters for this particular mine are such that predicted subsidence impacts over a large part of the area are low.

The Panel considers that the likely impact on individual protected flora and fauna species will generally follow the same pattern as the likely impact on habitats. The only caveat to this is where a species may be rare and its occurrence confined to one or a few units of the habitat type within the Project Area. Negative environmental consequences for the habitat unit (of itself not significant in terms of overall security of the habitat type) could then produce a negative species outcome that was highly significant.

Nothing of substance was presented to the Panel to suggest that any individual species other than those already on statutory schedules would be at risk from the mining proposal, although it is clear that some individual members of a species may suffer consequences from localised impacts.'[349]

The Panel then went on to recommend that mining be allowed subject to some further investigations to be completed to the satisfaction of the Director-General of the Department of Planning, with any subsequent requirements to be included in the relevant Extraction Plan.

Clearing and catastrophic fire aside, the greatest risk to habitats in the Project Area (including EECs) derives from subsidence-induced impacts on the hydrology of these habitats. The evaluation in Appendix E of the EA suggests that these impacts will not be significant. But the propositions in this evaluation contain carefully worded caveats. The implication is that if the caveats don't stand up to scrutiny, neither does the proposition they are associated with. Some of these caveats are set out below along with the Panel's assessment of them.

At p87: *'this evaluation draws heavily on the potential subsidence impacts ..., potential groundwater impacts ... and the potential surface water impacts'* (i.e. all as described by the various ICHPL consultants).

- The Panel notes that there are serious criticisms of the groundwater impact predictions and also concerns about the surface water predictions. The subsidence predictions are based on the Base Case mine layout and a 310 m longwall width. Both of these are said in the EA to be subject to change by ICHPL. Consequently these predictions may not be relevant to assessment of impact on flora from mining in the Project Area.

[349] DoP (2009a), p.91.

at p.91: *'As provided in Appendix O of the EA, eight of the 226 swamps (i.e. 3.5%) may be subject to significant negative consequences.* Given this *[emphasis added], it is considered unlikely that flora species associated with upland swamps would be impacted by the Project to the extent that the viability of any flora population would be put at risk.'*

- The predictions for swamps are expressly contingent on only eight of 226 swamps being at risk of significant negative environmental consequences. Other commentators and the Panel do not accept this analysis of the number of swamps at this level of risk as plausible at the currently proposed mine parameters. Any increase in longwall panel width would place even more swamps into this category.

at p.93: '*The depth of cover in areas of gently undulating lands is typically greater than 480m (MSEC 2009). Were cracking to occur it would be too small a magnitude to influence the hydrological processes in these areas …'*

- The depth of cover is only one part of the conventional subsidence equation. While it may be reasonable to assume that 400 m cover would be sufficient to minimise surface cracking with a 310 m longwall, a longwall panel width of 400 m plus could be a very different story (e.g. based on the MSEC model in the EA, a longwall panel width of 380m will result in fracturing progressing through to the surface at a depth of 480m).

at p.100: *'Therefore the predictions presented below are contingent on the actual surface water and subsidence effects being equal to or less than those predicted.'*

- There is nothing robust about a conclusion that is so strongly caveated, particularly when the Panel has grave doubts that the surface water and subsidence effects will be contained within EA predictions. The conclusions about predicted outcomes for flora from the BSO Project proposal must therefore be treated with great caution.

From the foregoing material it is clear that:

(i) the probability is that the subsidence-related impacts on flora will not be as benign as those predicted for the Metropolitan Project Proposal with its maximum 163 m longwalls and substantial depth of cover; and

(ii) the subsidence predictions themselves cannot be relied upon, since key parameters underpinning them are stated in the EA to be subject to change by ICHPL.

The consequence of these findings is that the characteristics of the individual natural features[350] become critically important to assessing whether the natural features should be protected and, if so, what constraints may need to be applied at the approval stage to provide protection from an uncertain but possibly significant threat. In this context the statement in the EA governing survey effort for flora is of concern:

[350] Note that the SCI includes flora and fauna in the category of 'significant natural features' in the Southern Coalfield (p.22) and also notes the importance of protecting the EECs and threatened species.

'As is common with all vegetation surveys conducted over relatively large areas it was not feasible, nor considered necessary, to visit and describe the existing native vegetation in all parts of the study area. Rather the survey was designed to broadly sample the vegetation diversity in representative parts of the study area in order to confirm and extend previous work. The vegetation classification and mapping from previous detailed studies of the area (outlined in the literature review above) enabled the development of a survey strategy that incorporated all known vegetation types across the study area. It also enabled threatened species searches to be targeted in the areas most likely to support them.'[351]

In the Panel's view the sampling intensity for flora must be sufficient to identify and describe the key habitats (including all EECs that are present) and any threatened species or aggregations of threatened species that are present. It is only when the extent of the EECs and threatened species is properly mapped and described that any consideration of the possible environmental consequences can begin using the approaches recommended in the SCI and refined in the Metropolitan PAC Report.

The fact that the area is large and that substantial effort would be required to survey it is irrelevant. If the proponent is seeking approval to undermine this same large area (and that approval would 'turn off' the relevant environment protection legislation) then the words 'large' and 'not feasible' should be applied to the mining proposal as well as to the flora survey requirements.

8.2.3. Threatened Species and EECs

Threatened species and EECs recorded in the Project Area and immediate surrounds from previous research and survey work are comprehensively described in Appendix E. There are 18 threatened species recorded[352] and seven EECs[353]. As noted in Section 8.2.2 above each of the seven EECs was specifically sampled at a minimum of one site in this survey and survey effort was directed at a further six EECs that may be present in the area. The 18 threatened species were also the subject of targetted survey in this study. Forty-two days of field work were used to survey the 226 km^2 of the Project Area. Only six of the 18 threatened species were found and none of the six 'possible' EECs.

The EA states that, in relation to threatened species, the survey was designed to find threatened species *in the areas most likely to support them* [emphasis added]. However, if only one third of the threatened species *known* from the Project Area and immediate surrounds are found in the survey, questions must arise concerning the adequacy of the survey for the purposes of considering approval.

At this stage there is obviously incomplete information on the precise locations and extent of threatened species and the probability exists that more threatened species are present in the Project Area, as well as more individuals and localised populations of threatened species. The locations and extent of threatened species are relevant to any

[351] EA, Appendix E, p.31.
[352] EA, Appendix E, Table 8.
[353] EA, Appendix E, Table 7.

decision to approve mining in an area. They are not issues that can be deferred to some later process that lacks public scrutiny.

The EA attempts to circumvent this problem by assuming that all threatened species known from the area are actually present and then proceeds to assess risk to each in a general way, but based on the risk predictions contained in the EA. There is no attempt to identify the locations and extent of threatened species to a level that would allow consideration of the potential for subsidence-related impacts at those locations.

The locations where the six threatened species already known to occur in the Project Area were found in this survey are shown in Figure 13 of Appendix E. The locations where the additional 12 threatened species were found previously in the Project Area or immediate surrounds are not indicated on Figure 13. For these 12 the only clue as to location is the general habitat description in the EA.

The EA records healthy populations of all six species that were located.[354] The fact that the other 12 were not found indicates one or more of the following:

- that the survey intensity was inadequate
- that the threatened species are rare
- that the threatened species are in isolated pockets of their preferred habitat.

All three of these possibilities raise concerns, with the latter two of particular concern since they indicate potentially significant vulnerability for at least some threatened species in the Project Area.

As noted above, from previous work and this study seven EECs are known to exist and six more may exist in the Project Area.[355] Whilst the surveys were designed to target all 13 EECs, only seven are recorded within the Project Area in Figures 4-9. The Panel notes that it is not readily apparent from the EA what level of effort went into locating the other six. The accuracy of the mapping of the seven EECs in Figures 5-9 is also difficult to judge given the multiple sources from which it appears to have been derived and the lack of ground-truthing evident.[356]

The Panel appreciates that for a large scale flora survey it may be reasonable to proceed in the manner identified in the EA (i.e. a mixture of previous studies and confirmatory field survey). But if the purpose of that survey is to be part of a risk assessment for underground mining where subsidence-related impacts may occur, then the survey must be suitable for that purpose.

[354] Note that the single occurrence of *Pomanderris adnata* is not included in the six mentioned here since it was not previously recorded from the area.
[355] EA, Appendix E, pp.28-29.
[356] Areas of EECs are identified in Figures 5-9 for which no sampling survey sites are identified in Figure 2. A few of many examples of EECs mapped with no corresponding survey sites are:
Figure 6 - near the southern boundary of North cliff a large area of S143a
Figure 7 – the north-western part of Appin Area 9 shows two areas of p38 with no corresponding site, and for the western part of Area 8 there are areas of p28, p514 and p2 without corresponding sites.

The level of survey effort required is determined in part by the magnitude of the predicted subsidence impacts and the level of certainty about those predictions. If predicted subsidence impacts potentially create a risk of environmental consequences and/or the level of risk is uncertain then a higher level of information is required about the characteristics of the flora and its possible vulnerability to subsidence-induced impacts within the possible range of those impacts. This information allows the decision-maker to assess whether the natural feature (in this case the flora) or parts of it (e.g. EECs or threatened species) warrant special concern or precaution at the approval stage.[357]

In the opinion of the Panel there is substantial uncertainty about the magnitude of the subsidence-related impacts, particularly in areas where the depth of cover is approaching the predicted height of fracturing (i.e. 385 m) for 310 m longwalls. The survey intensity provides insufficient information to compensate for this level of uncertainty in assessment of risk.

8.2.4. Flora – Other Matters

Apart from the issues considered above, the EA canvasses a wide range of possible impacts on native vegetation (e.g. fire, introduced species, disease, clearing, etc). In the Panel's view these have been dealt with adequately.

8.2.5. Flora – Findings and Recommendations

The Panel's findings and recommendations in relation to flora[358] are:

1. The survey design has not addressed the need to sample high conservation value habitats at an appropriate intensity and the description of swamp vegetation does not provide the site-specific information required for the assessment of risk to upland swamps as described in the swamp risk assessment methodology.

2. The survey work for threatened species is inadequate to support an assessment of risk from potential subsidence-related impacts of mining in the BSO Project Area based on nominal longwall panel widths of 310 m and the Base Case mine layout. There is no site-specific information on the two-thirds of the threatened species known from the area that were not found in the BSO surveys.

3. The possibility of increased longwall panel width has not been factored into the assessment of possible subsidence-related impacts on habitats or particular species or associations, particularly threatened species and EECs.

[357] This raises an issue concerning the timing of studies for underground mining EAs. Logically the results of subsidence predictions and groundwater studies are required before the likely risks to some habitats (e.g. swamps) and terrestrial flora and fauna can be estimated. Design of the surveys (particularly intensity and stratification) for flora and fauna can then be targetted properly to address risk. It becomes a problem if a survey based on predicted low or no risk is undertaken and risk is subsequently found to exist.

[358] As discussed in this Chapter. Most of the issues with flora related to swamps and the proposed Stage IV Coal Washery Emplacement are dealt with elsewhere.

4. Where the depth of cover is 400 m or less or where valley closure predictions exceed 200 mm[359] comprehensive flora surveys should be conducted to specifications provided by DECCW with a view to identifying EECs or threatened species and, where these are found, assessing population viability and risk from subsidence-related impacts of mining. If significant EECs or populations of threatened species are found, measures to protect those EECs and/or threatened species should be developed prior to any mining commencing.

[359] This is based on 310m longwalls. If that increases these estimates need to be revised.

8.3. FAUNA

8.3.1. Introduction

As with flora, the consideration of potential impacts on fauna is divided into:

1. all areas within the Project Area other than upland swamps and the proposed Stage IV Coal Washery Emplacement;

2. upland swamps (dealt with separately, see Chapter 6); and

3. Coal Washery Emplacement (dealt with separately, see Chapter 12).

Only 1 will be dealt with here.

The broad issues raised in submissions and at the Public Hearings about habitats of high conservation value are outlined in Section 8.2.1 above. They apply to fauna as well as flora.

The principal differences in the submissions between the flora and fauna components are a much greater level of concern with the adequacy of the fauna survey and a higher level of focus on threatened species.

8.3.2. Survey Intensity

The survey is based on a random stratified sampling process covering all major habitat types across the Project Area.[360] The distribution of sampling sites is mapped in Figure 2 of Appendix F.[361]

Examination of the distribution of the total fauna survey effort shows that it is heavily biased away from the proposed mining area (approximately 56 out of 107 sites) and of these 56 sites, approximately 33 are within 1 km of the boundary of the surface lease for the proposed Stage 4 Coal Wash Emplacement.[362] Figure 3 covers the Emplacement and surrounds in more detail and shows that, of the 30.15 km^2 (approximately) included in that Figure, two large areas amounting to approximately 9 km^2 and 1.65 km^2 have no survey sites in them, meaning that the 33 survey sites are located in 19.5 km^2. Over 30 percent of the total fauna survey sites are therefore located on less than 9 percent of the Project Area (and all of this 30 percent are outside the mining area!).

DECCW made the following comments in relation to fauna survey:

> *'The project area of the Bulli Seam Operations is very large, covering approximately 220 km sq. For the proponent to adequately identify and describe the natural values of the project area a substantial environmental assessment is required. A wide variety of habitats occur within the project*

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[360] EA, Appendix F, p.15.
[361] EA, Appendix F, Figure 2.
[362] Using Figure 2 Appendix F of the EA and counting sites that appear to be outside the proposed mining areas.

area, ranging from highly modified woodlands and forests of the Cumberland Plain in the west to the relatively intact sandstone landscape of the Woronora Plateau in the east. However, the presence of high quality habitats for threatened species is not uniformly distributed across the project area. The clusters of upland swamps in the south-eastern portion of the project area are well documented as highly significant habitats for a large number of State and Nationally listed threatened species of flora and fauna.

Similarly the potential impacts of the proposal are not expected to be uniform across the habitats in the study area. 'Alteration of habitat following subsidence due to longwall mining' is recognised as a Key Threatening Process under the NSW Threatened Species Conservation Act 1995 (TSC Act) due to the fact that it has been recognised as causing habitat alteration, such as causing cracks beneath a stream, swamp or other water body. This can lead to a temporary or permanent loss of water flows and could cause permanent changes to swamps and riparian community structure and composition. Species and ecological communities that depend on aquatic and semi-aquatic habitats are particularly susceptible to the impacts of subsidence.

In light of the above, ***DECCW considers that there is a significant flaw in the design of the fauna survey in particular****. Instead of targeting the greatest effort toward those habitats of the highest ecological significance where populations of highly threatened habitat specialist species are most likely to occur and the impacts of the proposal are likely to be greatest, the consultant chose to spread the effort across the entire project area.'*[363]

DECCW went on to use upland swamps as an example where survey effort was substantially below that required, leading to the conclusion that 'the proponent … is unable to draw valid conclusions about the likely significance of the impact of the proposal'.[364] The Panel concurs with the views expressed by DECCW concerning the inadequacy of the fauna survey. The implications of this will be discussed after the issue of threatened species is considered below.

8.3.3. Threatened Species

The survey techniques and survey design are set out in the EA.[365] Of the 47 threatened species listed in Table 1[366] as possibly occurring in the Project Area (a list refined from the literature and previous research and survey results based on known distribution and occurrence of likely habitat) only 17 were found in the survey (i.e. 36 percent)[367] In many cases only one individual was located at one site. Nine of the 47 threatened species in Table 1 are classified as endangered under the NSW Threatened Species Conservation Act, but only two of the nine were located in the survey. Only the locations of species found in this survey are shown in Figures 4 and 5 of Appendix F.

[363] DECCW (2010a), Item 9.
[364] Ibid.
[365] EA, Appendix F.
[366] EA, Appendix F, pp.8-10.
[367] EA, Appendix F, Table 7, pp.38-39.

The information on threatened species is not sufficient to identify the locations at which threatened species have been found in previous surveys. With the low survey intensity in this study unidentified populations of threatened species are almost certain to exist in the Project Area, but their locations are unknown. One of the identified key threatening processes for many threatened species is subsidence-induced impacts from longwall mining and this is locality-specific. Given the obvious weaknesses in the threatened species survey, unless these subsidence impacts are deemed to be negligible across the whole Project Area, the accurate assessment of risk to threatened species is impossible.[368]

Three examples of the problem with survey intensity will suffice:

<u>Littlejohn's Tree Frog</u> (*Litoria littlejohni*)

This species is listed as vulnerable under the NSW TSC Act and vulnerable under the Commonwealth's EPBC Act. Littlejohn's Tree Frog appears to be restricted to sandstone woodland and heath communities at mid to high altitude. It occurs in relatively undisturbed forested areas with infrequent natural fires and unpolluted, non-turbid water and is considered to be particularly sensitive to habitat changes.

Littlejohn's Tree Frog is known from only a very few locations in New South Wales and at these locations the number of individuals is likely to be very small, with most populations containing four or fewer calling males (Lemckert 2005). Three individuals of this species were observed opportunistically during the surveys for the EA in the North Cliff Area.[369]. The rarity of the species and its apparent location-specific populations mean that assessment of risk requires that the locations of the populations are known so that location-specific impacts can be assessed and a determination made as to whether precautionary action is required at the approval stage.

However, the EA[370] takes an overview approach to the environmental consequences that might arise from subsidence impacts and concludes that, although there may be local impacts, the BSO Project would have little impact on the population of this species overall. The assessment of local impacts is based largely on the surface water studies for the BSO Project and, in the Panel's view, significantly underestimates the impact of subsidence on stream water quality (particularly turbidity) which is a critical issue for this species. The EA[371] notes that the likely locations for populations of this species are in the south-east of North Cliff and the eastern portion of Appin Area 2.

Since subsidence-based impacts are location-specific (i.e. they need a longwall, plus subsidence effects) and there is no location-specific information about populations that would assist the Panel to make precise recommendations for protection of this threatened species, the Panel appears to have three broad options open:

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[368] This conclusion is based on the full argument set out in 8.2.2 above in relation to the same issue for flora threatened species.
[369] DECCW (2009a).
[370] EA Appendix F, Section 6.2.1, pp.77-79.
[371] EA Appendix F, p.77.

1. accept the general proposition in the EA and not worry about localised populations (but without any idea of the significance of these populations);

2. reject the general proposition and recommend no mining be approved in the areas of potential habitat (i.e. south-eastern part of North Cliff and the eastern part of Appin Area 2); or

3. reject the general proposition and set performance outcomes requiring no impact on the threatened species or its habitat. In the case of Littlejohn's Tree Frog a negligible impact requirement on all streams in the relevant areas would probably suffice to protect both the habitat and the frog.

Of these, the first is not effective and the last two are blunt, but effective, instruments.

Red-Crowned Toadlet (*Pseudophyrne australis*)

This species is listed as vulnerable under the NSW TSC Act and is known only from Triassic sandstones of the Sydney Basin. Its preferred habitat is permanently moist soaks or areas of dense ground vegetation or litter along or near headwater stream beds. These are the non-perennial first or second order drainage systems that are adjacent to ridges, are ephemeral in nature, and commonly called 'feeder-creeks'. Such watercourses are dry or reduced to scattered shallow pools or ponds for much of the year, and have sustained flow for only a few weeks following thunderstorms. Under natural conditions these feeder creeks have high water quality and low nutrient loads. Red-crowned Toadlets have not been recorded breeding in permanently flowing streams or waters that are even mildly polluted or with a ph outside the range 5.5 to 6.5.

Red-crowned Toadlets are quite a localised species that appear to be largely restricted to the immediate vicinity of suitable breeding habitat, so recruitment and re-colonisation of areas of vacant habitat is likely to be low. Due to this tendency for discrete populations to concentrate at particular sites, a relatively small localised disturbance may have a significant impact on a population if it occurs on a favoured breeding or refuge site. The Woronora Plateau is considered to be a core area for this species.[372]

As with Littlejohn's Tree Frog the EA takes an overview approach and concludes that there is unlikely to be any impact on this species. The primary basis for this is the surface water study assessment of subsidence-related impacts on streams. However, the elements missing from the analysis are the potential impacts of subsidence on water quality in these ephemeral streams and the localised nature of the populations making them vulnerable to location-specific impacts.

In contrast to the information for Littlejohn's Tree Frog, the EA does not indicate any particular habitat locations, relying on the general preferred habitat description to guide the decision-maker. The Panel is faced with accepting the proposition in the EA and ignoring the conservation needs of this threatened species, or rejecting the proposition and working out what to do next given that the EA is unhelpful in terms of possible alternatives. Whilst a prohibition on mining in all habitats that meet the

[372] DECCW Response to Questions from PAC, Part 1, 5.2.10, Item 10.

preferred habitat description would undoubtedly solve the conservation problem, it is again a very blunt instrument.

Eastern Ground Parrot (*Pezoporus wallicus*)

This species is listed as vulnerable under the Threatened Species Act, with only three isolated populations known in NSW. It was thought to be regionally extinct until recently re-discovered in the Metropolitan Project Area. There were also two sightings (three individuals) in surveys for the current project proposal. It is primarily a swamp specialist species, although it also occurs on dense heathlands.

The main threats to this species relate to habitat loss either from fire or from subsidence-induced impacts on swamps (which may in turn increase the risk of fire). The EA dismisses the risk from subsidence based on the material presented in Appendix O indicating that only 'a few swamps' would be subject to significant impacts and also dismisses the risk from fire on the basis that the project would not increase the risk of fire.[373]

The manifestly inadequate survey work for this threatened species (less than five percent of swamps were sampled) means that the Panel has no idea of the population size or viability. However, the fact that it has now been the subject of two sighting in the Metropolitan Project Area and two in the BSO Project Area suggests that there is a viable and highly significant population present in this area. For the BSO Project Area this means that the area of interest is the eastern and southern parts of North Cliff and Appin Area 2.

The Panel clearly does not accept that the subsidence-related impacts to swamps have been adequately assessed and is of the opinion that far greater numbers of swamps may be at risk of negative environmental consequences and serious negative environmental consequences than are indicated in the EA. Moreover, if the longwall width increases the number of swamps in the significant negative environmental consequences category will almost certainly increase markedly. Under these circumstances the Panel is left with little choice other than to recommend that swamps in the eastern and southern parts of North Cliff and Appin Area 2 should either not be undermined or should have a nil or negligible impact requirement placed over them.

There are many other threatened species of fauna that possibly occur in the Project Area. However, the Panel's task is not to spend considerable time and effort undertaking the work that it considers should have been done in the EA. The above three examples indicate the location-specific nature of many threatened fauna species populations and, unless there are no possible risks to the populations of any threatened fauna species from mining-induced subsidence impacts, much more information is required about the populations before approval to proceed with mining could be recommended.

Two specific issues with the survey for threatened species raised with the Panel and not covered above are the failure to include the Cumberland Plain Land Snail

[373] EA Appendix F, pp.108-109

(*Meridolu, corneovirens*) in targetted surveys[374] and the failure to include the endangered Giant Dragonfly (*Petalura gigantea*) in the list of possible threatened species in Table 1 or to include it in the targetted surveys.

In relation to the latter DECCW notes:

> *'The species occurs in upland swamps and DECCW considers that records from surveys associated with the Dendrobium coal mine (DoP 2008b) and records from swamps within Penrose State Forest and Wingecarribee Swamp (NPWS Atlas of NSW Wildlife) clearly flag the likely presence of this species in suitable habitat in the project area. Surveys for adults should be carried out from early December until late January and not during windy, cold (below 16 degree Celsius), wet or misty weather.'*[375]

In the broader context, the Panel examined the figures in the EA that map the distribution of survey sites against the distribution of species found in the survey for this study (Figs. 2 and 3 respectively).[376] Of the 17 species found in the survey, nine were found within North Cliff and Appin Area 2 and an additional one (the Eastern Ground Parrot) was sighted in between these two areas and in close proximity to them.[377] Of the eight species not found in these areas in the survey, three were birds and two were bats.

In terms of survey intensity in these areas, North Cliff had less than 20 sites (and only five in the southern areas), Appin Area 2 had less than 10 sites and Appin Area 3 had less than five sites. Given this low survey intensity, the discovery of so many threatened species is remarkable.

8.3.4. Fauna – Findings and Recommendations

The Panel's findings and recommendations in relation to fauna[378] are:

1. The survey intensity is inadequate for the purposes of assessment of risk to fauna in the Project Area generally and manifestly inadequate in relation to fauna that utilise swamp habitats.

2. It is clear that the eastern and southern parts of North Cliff and Appin Area 2 contain a high concentration of threatened fauna species and that a comprehensive survey would probably yield an even higher number of species.[379] The survey work to date does not allow any assessment of the size of the populations of threatened species or their viability.

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[374] See EA Appendix F p.15. But note that this species was assumed to exist and therefore included in the risk assessment.
[375] DECCW Response to PAC Questions, Part 1, 5/2/10, Item 9
[376] EA Appendix F
[377] In this context note that there were no survey sites in either North Cliff or Area 2 in proximity to the sightings.
[378] As discussed in this Chapter. The issues with fauna related to swamps are dealt with in Chapter 6 and the proposed Stage IV Coal Washery Emplacement are dealt with in Chapter 13.
[379] The Panel notes that the EA also records the greatest diversity and abundance of fauna generally in the southern and eastern portions of the Project Area.

3. In broad terms, most threatened fauna species would be protected by a requirement for nil or negligible impact for swamps and streams in an area since this would ensure protection of other important habitats such as cliff lines and overhangs. It is recommended that such an approach be adopted for protection of threatened species in the eastern and southern parts of North Cliff and in Appin Area 2.

4. Given the lack of survey effort (i.e. zero) in the whole of the northern part of North Cliff it is recommended that comprehensive surveys be conducted in that area (and also the unsurveyed area in the northern part of the eastern part of North Cliff) to determine whether threatened species are present and, if so, what actions might need to be taken to protect any significant populations should mining be allowed to occur in these areas. Survey design and execution should be supervised by DECCW to ensure that the required standard is achieved and the surveys and required management plans should be required well in advance of any proposed mining. The Panel notes that there are very few swamps in the northern part of North Cliff and only a small cluster in the northern part of eastern North Cliff. The subsidence-related impacts of relevance in these areas will therefore primarily relate to streams.

In relation to management plans, the full suite of avoidance, mitigation and management approaches should be considered and, if adaptive management is an option, it should meet the test laid out in *Stoneco*.[380]

1. In relation to Appin Area 3, the same approach needs to be adopted as for the northern part of North Cliff. The survey work in Appin Area 3 was inadequate and the Panel is far from satisfied that further threatened species do not occur in this area.

2. For the western domains (Area 7, Area 8 and Area 9 and West Cliff Area 5) further targeted surveys for threatened species should be undertaken based on advice from DECCW. These surveys are designed to locate threatened species and provide sufficient information to allow assessment of any actions required to protect significant populations of threatened species from the potential impacts of the mining proposal.

Given that a Part 3A approval can 'turn off' the relevant statutory protection for threatened species,[381] if mining is to occur in these western domains the Approval conditions will need to be sufficiently robust to ensure that the surveys and assessments are done to DECCW standards and that before mining proceeds the necessary management actions are in place to protect any significant populations of threatened species from mining impacts

[380] *Newcastle and Hunter Valley Speleological Society Inc v. Upper Hunter Shire Council and Stoneco Pty Limited* [2010] NSW LEC 48

[381] And noting that the Panel does not accept that the risk assessments and management approaches in the EA are adequate.

9.0 CLIFFS AND STEEP SLOPES

9.1. SCOPE

The EA has defined a cliff and a steep slope as:

- Cliff - *a continuous rockface having a minimum height of 10 metres and a minimum slope of 2 to 1, i.e. having a minimum angle to the horizontal of 63º* [382].

- Steep slope - *an area of land having a gradient between 1 in 3 (33% or 18.3º) and 2 in 1 (200% or 63.4º)*[383].

It is the Panel's understanding that there is no unique or universally agreed definition for a *cliff* and for a *slope* and that the above definitions are based on the limits of identification associated with NSW Land and Property Management Authority surface contours and with aerial laser scans. These plans are based on a contour interval of 2 m. The criteria for identifying cliffs and steep slopes have been chosen for practical convenience and it is possible that some cliffs of less than 10 m in height may be worthy of consideration. The Panel considers the approach adopted to be reasonable for the purposes and scale of the EA except, as discussed later in this section, for cliffs located within watercourses.

Figure 38 shows the location of cliffs and steep slopes within the Study Area. Appendix A (Subsidence Predictions and Impacts Assessments) is premised on there being 634 cliffs in the Study Area whilst Appendix R (Major Cliff Line Risk Assessment) reports that *a total of 611 major cliff lines have been identified within the study area*. No basis is given in the EA for distinguishing between these two numbers.

The Base Case layout mine plan shows that, with the exception of a few isolated locations, longwall mining directly beneath cliffs is confined to the flanks of Wallandoola Creek and Cascade Creek in Area 3 and Allens Creek in Area 8, Figure 38. Other cliffs within the BSO Study Area are located along Cataract River, Nepean River, Elladale Creek, Ousedale Creek, Lizard Creek, Clements Creek, Stonequarry Creek, O'Hares Creek, Cobbong Creek, and Punchbowl Creek. Of the 634 cliffs identified in Appendix A, 456 are more than 200 m from a proposed longwall panel.

Steep slopes occur predominantly along the valley flanks of these and other watercourses, and on the sides of ridges of the Razorback Range.

No cliffs have been identified as being of 'special' significance as defined in the Metropolitan PAC Report[384].

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[382] EA, Appendix A, p.80.
[383] EA, Appendix A, p.88.
[384] DoP (2009a).

9.2. BASIS FOR ASSESSMENT

Subsidence effects, impacts and consequences associated with cliffs are very susceptible to changes in mine layout, particularly changes in longwall direction, longwall panel width and the width of buffer zones between longwall panels and cliffs. Although the EA for the BSO Project emphasizes that the Base Case layout may change over the life of the Project, the assessment of cliffs in both Appendix A and Appendix R has been based solely on the Base Case layout. Appendix R states that:

> *'The EA Base case Longwalls would not mine directly beneath the majority of cliff lines within the study area. This includes cliffs located along the Nepean River, Harris Creek, Cataract River, O'Hares Creek and Cobbong Creek.'*[385]

The subsidence assessment presented in Appendix A is premised on a similar basis:

> *'The longwalls will not mine directly beneath the majority of cliffs within the Study Area. This includes cliffs located along the Nepean River, Harris Creek, Cataract River, O'Hares Creek and Cobbong Creek.'*[386].

As neither statement rules out changes to the Base Case layout in the future, the Panel is faced with two options in framing its recommendations, namely:

1. They can be tied to the Base Case layout on which the EA is based, such that a change in the Base Case layout would require the Proponent to seek a new approval; or

2. They can be framed such that they apply to any and all future mining layouts.

In order to assess the potential impacts and consequences that are likely to result from any future changes in the Base Case layout, the Panel requested ICHPL to undertake sensitivity analysis based on a range of longwall panel widths. ICHPL declined to do this, preferring instead for the Panel to assess the Project and set Performance Criteria on the basis of information presented for the Base Case layout, with ICHPL accepting the risk that this approach could impact on its capacity to modify the mine layout in the future[387].

[385] EA, Appendix R, p.R-8.
[386] EA, Appendix A, p.83. and a similar commitment in the Major Cliff Line Risk Assessment - EA, Appendix R, p.R-8
[387] ICHPL (2010e), response to Question 16.

9.3. CLIFFS

9.3.1. Cliffs Located Outside of Longwall Footprint

Section 5.3.2 of Appendix A is titled *Cliffs Located Above Solid Coal*. It would be more appropriate to title this section *Cliffs not Located Above Longwall Panels* as it includes cliffs located above bord and pillar workings (development roadways or first workings). It records that the highest predicted systematic (conventional) subsidence parameters for the Base Case layout occur in the North Cliff domain[388]. Following the request of the Panel for all curvature values to also be expressed in terms of strain, these values are:

- Tilt - 3.2 mm/m
- Hogging curvature 0.03 km^{-1}, or 0.5 mm/m of tensile strain
- Sagging curvature 0.02 km^{-1}, or 0.3 mm/m of compressive strain

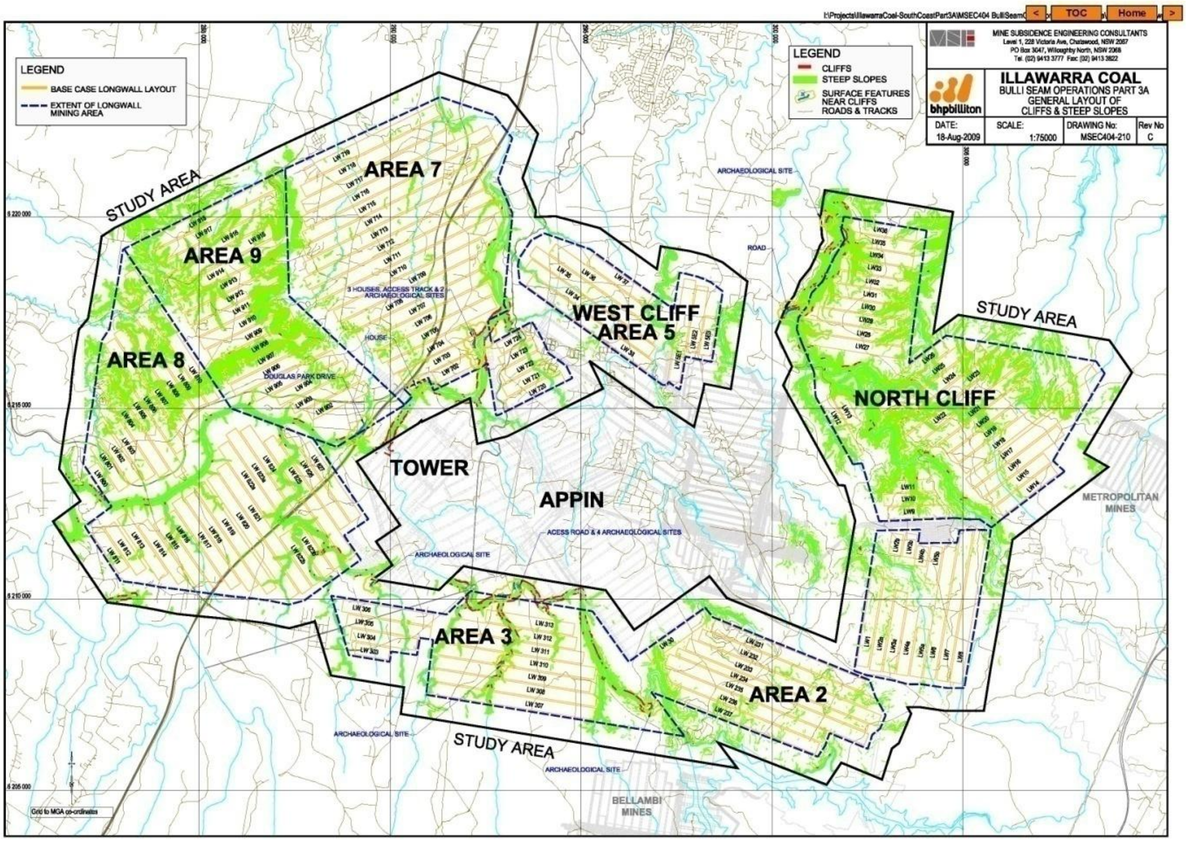

Figure 38: Distribution of Cliffs and Steep Slopes within the Study Area

The EA does not discuss the significance of these values or draw conclusions from them specific to cliffs. Rather, it reports that the average tensile and compressive

388 EA, Appendix A, p.83, Table 5.12

strains measured over 1405 survey bays above solid coal in the Southern Coalfield were both less than 0.2 mm/m, and that except for a compressive strain of 5.9 mm/m recorded at a geological fault, peak systematic tensile and compressive strains have not exceeded 1.3 mm/m. The Panel considers that the average strain values (tensile and compressive) are of little practical use for assessing cliffs in the EA because:

1. They are within the order of accuracy of survey techniques[389].

2. Many of the measured strains are more than double the average value of 0.2mm/m[390].

3. Impacts and impact consequences on surface features are determined by maximum (peak) strains, not average strains.

In order to assign some significance to the values of predicted systematic tensile and compressive strain in the EA and ICHPL's responses to the Panel's questions, the Panel once again has had to rely on advice in the EA for the Metropolitan Coal Project that *'Fracturing of sandstone has generally been observed in the Southern Coalfield where the systematic tensile and compressive strains have exceeded 0.5 mm/m and 2 mm/m, respectively'*[391]. Based on this advice, the Panel concludes that when the strains are uniformly distributed, cracking of cliffs due to systematic strains is unlikely. However, as noted later, systematic strains may not always be uniformly distributed.

Tilt is another potential cause of cliff instability. Appendix A concludes that *the predicted maximum tilts at cliffs that are located above solid coal within the Study Area are very small in comparison to the existing slopes of the cliff faces and are unlikely, therefore, to result in toppling type failures.....In the majority of cases, it is predicted that mining will tilt the cliffs back into the slope, reducing the overturning moments*[392]. The Panel concurs.

Appendix A goes on to state that it is possible that *if ground curvatures or strains are of sufficient magnitude, sections of rock could fracture along existing bedding planes or joints and become unstable, resulting in sliding or toppling type failures along the cliffs*[393]. The Panel also concurs with this conclusion, even though the maximum strain values predicted over solid coal are low (0.5 mm/m tensile, 0.3 mm/m compressive). This is because they are expressed as if they were uniformly distributed when, in reality, once a tensile crack develops in a rock, future movement is likely to concentrate at that crack. The lower the value of uniformly distributed strain, the smaller the width of any concentrated crack and hence, the lower the likelihood that the stability of a cliff may be adversely affected.

Cliffs located over solid coal may also be subjected to valley related movements arising from the extraction of nearby longwall panels. Closure movements tend to be bodily movements of the valley sides, with maximum compressive strain and upsidence usually occurring in the base of the valley. However, stress can be induced

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389 EA, Appendix A, p.83.
390 EA, Appendix A, P.17, Figure 3.6.
391 EA for Metropolitan Coal Project, Appendix A, p.88.
392 EA, Appendix A, Page 83
393EA, Appendix A, page 83

in the valley sides where differential closure movements occur around a bend in the valley. Appendix A reports that approximately 65% of cliffs within the Study Area are located along relatively straight sections of the valleys. The Panel concludes from this that the remaining 35% of cliffs, classified as *concave* or *convex*[394], are associated with bends in valleys and therefore may be exposed to an additional risk of instability from differential closure movement.

Having presented predictions of subsidence effects at cliffs, the EA contains no analysis of their significance in regards to potential impacts. Instead, it goes on to conclude that:

> *'It is extremely difficult to assess the likelihood of cliff instabilities based upon predicted ground movements. The likelihood of a cliff becoming unstable is dependent on a number of factors which are difficult to fully quantify. These include jointing, inclusions, weaknesses within the rockmass and water pressure and seepage from behind the rockface. Even if these factors could be determined, it would still be difficult to quantify the extent to which these factors may influence the stability of a cliff naturally or when exposed to mine subsidence movements. It is therefore possible that cliff instabilities may occur during mining that may be attributable to either natural causes, mine subsidence or both'*[395].

On this basis, the EA relies on three case studies from Appin Colliery and Tower Colliery to assess the likelihood of cliff instability over solid coal. The first is based on Appin Longwalls 301 and 302, which were 260 m wide and separated by a single row of 40 m wide chain pillars at a depth of 500 m. These panels approached to within 50 m of cliffs along the Cataract River. It is reported that there were no cliff instabilities observed but there were five minor rock falls or disturbances which occurred during mining, of which three are considered likely to have occurred due to a significant rainfall event and natural instability of the cliff/overhang. The Panel questions whether, as a result of mining, the cliff faces may have become more susceptible to impact from natural events. The EA concludes that as a result of the mining, the length of cliff line disturbed by mining these two panels was less than 1%.

The second and third case studies involve two 320 m wide longwall panels (Longwalls 701 and 702) at Appin Colliery and three longwall panels (Longwalls 18 to 20) of unspecified width at the adjacent Tower Colliery (but not more than 250 m wide). The two Appin longwalls approached to within 75 m of the cliffs whilst Tower Longwall 20 mined directly beneath some cliffs. It is stated that *'no cliff instabilities were recorded'*.

Hence, the EA concludes that:

> *'Based on the history of mining at Appin and Tower Collieries, it is possible that isolated rock falls could occur (over 'solid' coal) as a result of extraction of the longwalls. It is not expected, however, that any large cliff instabilities would occur as a result of the extraction of the longwalls'*[396].

[394] EA, Appendix A, p.82, Table 5.15
[395] EA, Appendix A, p.84.
[396] EA, Appendix A, p.85.

However, in some domains of the Study Area mining is proposed at shallower depths of cover than that on which these conclusions are premised. Hence, subsidence impacts may be greater. The Panel notes that the Base Case layout depicted in Figure 38 is amenable to varying the distance between most longwall panels and those cliffs that it is currently proposed not to undermine. The Panel agrees but is also mindful of the implications that a change in the Base Plan layout might hold for this management measure.

When dealing with cliffs, neither Appendix A nor Appendix R address setback distances from cliffs. However, the *Preferred Risk Management Options* for streams[397] incorporate this as a management measure for mining in the vicinity of reaches 2 and 3 of the Nepean River, the offset distance being *'50 m from the top of mapped cliff* lines'. A 50 m offset has also been applied to steep slopes along the river. These offsets have been tabulated in Appendix A in Section 5.2.4 *Longwall Design for Selected Streams* that precedes the sections dealing with cliffs and steep slopes.

The EA provides no basis for the offset distance being set at 50 m. It has only been applied to the Nepean River, apparently on the basis that *'Based on the Metropolitan PAC Report's description of special significance, the authorities may consider the Nepean River as a stream that warrants special significance status'*[398]. Based on the discussion of mining parameters earlier in this section, the Panel assumes that the offset is intended to achieve a Performance Criteria of *'possible isolated rock falls but no large cliff instabilities'.*

The EA and some submissions make reference to cliffs that run along Douglas Park Drive. The nature of these cliffs and the fact that they overhang the road in some places results in them presenting a serious risk to public safety and public convenience if they were to become unstable. However, they are some 700 m away from the nearest longwall panel shown on the Base Case layout and so would not normally be of concern. The EA does not mention whether the cliffs might have already been affected by previous mining in the area or whether the concerns arise purely from far-field effects associated with future longwall mining. However, in response to public submissions, ICHPL advised that:

> *'An intensive monitoring and survey program was implemented in the Nepean River gorge at Douglas Park bridges during the mining of Longwalls 16 and 17. This included specific monitoring of the cliffs adjacent to Douglas Park Drive. No cliff instability was identified resulting from mining at these cliff locations'*[399].

By reference to Drawing No: MSEC404-211[400], it appears to the Panel that Longwall 16 passed within about 700 m of the cliffs whilst Longwall 17 terminated about 500 m short of them. The EA has not addressed cumulative impacts of this and future mining on the cliffs. Nevertheless, based on the information contained in the EA, it

[397] EA, Volume 1, p.5-11, Table 5-2 and EA, Appendix p, P.P-5, Table P-5.
[398] EA, Volume 1, p.5-8.
[399] ICHPL (2010d), p.24, response item number 20.
[400] EA, Appendix A.

would seem very unlikely that the cliffs on Douglas Park Drive would be adversely impacted by the mining layout shown in the Base Case layout. However, the Panel is conscious that this may not be the situation if the location, orientation and/or width of the longwall panels in the Base Case layout are changed. The Panel is also conscious of the potentially major consequences if these cliffs became unstable.

The EA proposes that the risks presented to members of the public by instability of these cliffs and other cliffs on private land can be addressed through Management Plans developed in consultation with stakeholders. The EA contains insufficient information on the Management Plans for the Panel to comment on the feasibility of this proposal. In any event, the Panel is of the view that the Performance Criteria should be set in any Approval conditions (e.g. 'no increase in risk to the public from mining-induced instability in cliff lines') and the detailed mechanism for ensuring that such criteria are achieved is then a matter for consideration when approving Extraction Plans.

9.3.2. Cliffs Located Inside of Longwall Footprint

The EA reports that the longwalls will mine directly beneath some cliffs along Wallandoola Creek and Cascade Creek in Area 3, Figure 38. It fails to identify and analyze a further 10 cliffs in the upper reaches and 2 in the lower reaches of Allens Creek in Area 8 that are also proposed to be directly undermined[401].

The prediction of systematic subsidence effects and impacts on cliffs above longwall panels closely mirrors that for cliffs over 'solid' ground and similar limitations are associated with it. Average measured tensile and compressive strains based on 1008 monitoring sites located over goaf areas in the Southern Coalfield are presented in Appendix A of the EA. The highest compressive strain of 16.6 mm/m was associated with a fault plane on which the highest strains were also recorded over solid coal. All other recorded strains were less than 5 mm/m. Appendix A reports that those cliffs that will be directly undermined along Wallandoola Creek and Cascade Creek may experience the maximum predicted subsidence movements for Area 3, being[402]:

- Tilt – 7.5 mm/m
- Hogging curvature 0.11 km^{-1}, or 1.7 mm/m of tensile strain
- Sagging curvature 0.19 km^{-1}, or 2.9 mm/m of compressive strain

The Panel concludes on the basis of the EA for the Metropolitan Coal Project that these strains are of sufficient magnitude to cause cracking of cliffs even when such strains are uniformly distributed.

Appendix A repeats the statement that: *'It is extremely difficult to assess the likelihood of cliff instabilities based upon predicted ground movements'*. It presents two case studies of longwall mining beneath cliff faces as a basis for assessing

[401] See EA, Appendix A, Drawing No: MSEC404-213. These cliffs are numbered in the range AA8 0405 to AA8 0660.
[402] EA, Appendix A, p.20, Table 4.2, and ICHPL (2010b).

likelihood of cliff instabilities over longwall goaves. One relates to Longwalls 1 to 17 at Tower Colliery and the other to Longwalls 14 to 19 at Tahmoor Colliery. The Tower Colliery longwalls ranged from 110 to 210 m in width, with 35 to 50 m wide chain pillars, and were extracted in a depth range of 400 to 540 m. It is reported that *'there were a total of 10 cliff instabilities recorded along the Cataract and Nepean Rivers, as a result of the extraction of Tower Longwalls 1 to 17*. These falls affected *approximately 4% of the total length of cliffline'.*

Longwall panels at Tahmoor Colliery were 240 m wide, with 37 m wide chain pillars, and extracted in a depth range of 380 to 390 m. It is reported that *'no cliff instabilities were observed during the mining period'.* The term 'cliff instability' has not been defined. The Panel is not aware of cliff instabilities that may have developed (at Tahmoor Colliery) since the completion of mining.

The EA concludes that:

- *'Based on the case study history of mining at Tower and Tahmoor Collieries, there is a moderate to likely probability that rock falls and cliff instabilities will occur somewhere along clifflines which are directly mined beneath, including those along Wallandoola Creek and Cascade Creek.*

- *Any impacts on the cliffs, resulting from the extraction of the longwalls, are expected to affect 3% to 5% of the total length of cliffs that are directly mined beneath. It is extremely difficult to accurately predict which cliffs will experience impacts. As a general rule, however, cliffs at greater risk of impact are those with large overhangs and cliffs located along concave sections of the creeks'*[403].

The Panel notes in respect of these conclusions that:

1. The likelihood associated with the words *moderate to likely* has not been quantified.

2. The widths of the longwall panels in the Base Case layout for the BSO Project are in the order of 30% to 200% wider than those in the case studies. The EA gives no consideration to how this may affect the accuracy of the impact prediction of 3% to 5% of total length of cliff lines that is apparently premised on the case studies of narrower longwall panels. The Panel has not been provided with any information regarding the extent to which this impact prediction may change with changes in the Base Case layout.

3. The conclusions do not provide any indication of the continuous length of cliff line segments that may be impacted by instability.

A number of submissions to the PAC raised cliff instabilities at Dendrobium Colliery as a point of reference in expressing concerns relating to the prediction, extent and monitoring of cliff stability. ICHPL responded to these submissions, stating that:

> *'Rock falls consisted of fallen boulders and rock fragments rather than cliff collapses. This reflects the higher depths of cover in the Southern Coalfield*

[403] EA, Appendix A, p.87.

when compared to some other mining areas where large cliff collapses have been recorded.

…………..

The total number of observed rock falls along the entire Area 1 cliff line is 20, with 16 of 20 rock fall impacts classified as minor (often no more than single boulders) in accordance with the trigger levels defined in the Subsidence Environmental Management Plan, and the remaining 4 of 20 rock fall impacts classified as moderate.

....

The total length of the affected cliff line in Area 1 is 2,961 m. Based on this and the total length of rock fall disturbance of 294 m, it is estimated that 10% of the total length of cliff line has been affected by rock falls'.[404]

The Panel undertook an aerial inspection of cliff lines above Dendrobium Colliery to better understand the issues. It agrees that the majority of cliff instabilities could be aptly described as rock falls. However, it is the Panel's opinion that at least two constitute 'cliff falls', as evidenced in Figure 39.

Figure 39: Falls of Ground over Dendrobium Colliery that the Panel Considers Constitute Cliff Falls.

[404] ICHPL (2010d)

The Panel has taken into consideration the findings of the SCI that:

> *'The SCI Panel inspected valley sides at a number of sites which have been affected by subsidence, including Waratah Rivulet, Upper and Lower Cataract River, Nepean River and Bargo River. It was the opinion of the Panel that whilst a number of relatively small cliff and overhang collapses were observed, these were relatively isolated incidents, albeit significant in the immediate vicinity of such falls.........*
>
> *However, it was the general observation of the Panel that the cliff lines and valley sides in many of the areas inspected were remarkably robust, when considering the amount of valley closure that has occurred in places (eg Nepean Gorge valley closure in excess of 460 mm).*
>
> *There is little to no evidence that vegetation or fauna habitats have been significantly altered as a result of cliff falls associated with subsidence..... However, there is potential for large cracks at the surface to act as temporary pitfalls for small ground fauna such as reptiles or small mammals'*[405].

However in the case of the BSO Project, systematic and non-systematic subsidence effects associated with the Base Case layout are likely to be greater because the longwall panels are substantially wider. Therefore, there is potential for greater subsidence impacts at similar depths of mining to those where the SCI made its observations. Cascade Creek and Wallandoola Creek are immediately upstream of the sites where the SCI Panel made its observations and depth of mining is similar[406]. Allens Creek is also in the same area. Predicted closure exceeds 1200 mm over an extensive length of Wallandoola Creek and is up to 330 mm over sections of Cascade Creek[407]. It ranges from around 400 mm to 1000 mm over the cliff affected sections of Allens Creek[408] not considered in the EA. Hence, the predicted closure along Wallandoola Creek and sections of Allens Creek is more than double that which the SCI reported was measured in the Nepean Gorge.

The Panel concludes that the EA presents an inadequate discussion of the potential impacts of the Base Case layout on cliffs located above goaves, these being confined to Area 3 and Area 8[409]. It is of the view that the total length of cliff line that could be impacted by cliff instability for the Base Case layout may be considerably greater than 3 to 5% and that such impacts will include cliff falls, as opposed to rock falls. Furthermore, the consequences of these impacts may be higher than conveyed by the figure of 3 to 5%, or any other such figure that is based on overall length of cliff line, especially if cliff instability is concentrated in particular segments, such as bends in a valley. Any increase in longwall panel width is likely to result in a significant increase in the level of impact that, on the basis of the information presented in the EA, is indeterminate at this point is time.

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405 DoP (2008), p.72.
406 EA, Appendix A, Drawing No: MSEC404-104.
407 EA, Appendix A, Figures 200-22 and 200-23.
408 EA, Appendix A, Fig. 200-06.
409 There may be some minor exceptions, with one cliff being shown over longwall workings on Dahlia Creek for example, EA, Appendix A, Drawing No: MSEC404-210.

The Panel recognizes that the Base Case layout is amenable to increasing the width of the buffer zone between Cascade Creek and the longwall panels, hence reducing both closure along Cascade Creek and exposure of one aboriginal heritage site of high significance (52-2-1282) to subsidence impacts.

This is not the case for Wallandoola Creek and Allens Creek. The Panel considers that there is an increased potential for cliff instability, including cliff falls, along these watercourses. The EA does not contain the information required for the Panel to be able to base its assessment on a consideration of the physical, cultural and environmental attributes of cliffs along the two creeks and the likely consequences of instabilities on these attributes.[410] Based on its field observations, the Panel formed the opinion that specific cliff lines and the cliff lines as a collective system along Wallandoola Creek may constitute significant natural features. This opinion is not inconsistent with the outcomes of limited analysis that the Panel has undertaken of the data for Wallandoola Creek, which indicates that there are seven cliff lines longer than 100m, all seven are at least 30 m high, and two have Aboriginal sites associated with them.

9.3.3. Cliffs of Special Significance

The Metropolitan PAC Report introduced the concept of identifying natural features of *special significance* as a component of risk assessment, whereby:

> *'Special Significance Status is based on an assessment of a natural feature that determines the feature to be so special that it warrants a level of consideration (and possibly protection) well beyond that accorded to others of its kind. It may be based on a rigorous assessment of scientific importance, uniqueness, meeting a statutory threshold or some other identifiable value or combination of values'*[411].

Appendix R of the EA for the BSO Project has considered this aspect and concluded that:

> *'Based on cliff line characteristics described in Attachment RA (such as length, height, shape, ………..,) no individual cliff lines in the Project area are considered to be sufficiently unique or different as to require identification of 'special significance' and thus requiring special significance in a risk assessment framework.*
>
> *…………*
>
> *No cliff line of special significance status, when compared to the characteristics of other cliff lines in the study area, has been identified'*[412].

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410 As noted later in this section of the Panel's report, Appendix R presents very worthwhile tabulations of a range of dimensions and attributes relating to cliffs in the Study Area. However, much of the information has not been analysed in the EA.
411 DoP (2009a).
412 EA, Appendix R, p.7.

The Panel has the following concerns in this regard:

1. It appears that the EA does not give consideration to cliffs that constitute waterfalls. The Panel saw a number of medium to large waterfalls during its aerial inspection of the Study Area, including Appin Falls on the Cataract River upstream of Broughtons Pass Weir. The SCA has advised the Panel that:

   > *'Within the Project area Appin Falls is the largest waterfall, the top of the falls is the largest rockbar and the pool at the base of the falls is understood to be the deepest of any pool (on the Cataract River). It is also understood that the Appin Falls is the largest falls on the entire Woronora Plateau'*[413].

   The only reference in the EA to the physical characteristics of Appin Falls is in Appendix D (Aquatic Ecology), which notes that the falls are ~30m high and therefore a major barrier to the migration of fish.

   The Panel also inspected a waterfall on Lizard Creek, just upstream from its confluence with the Cataract River and within the BSO Study Area. This waterfall is not identified in the EA. It has been identified in ICHPL's responses to the Panel's questions[414] as being represented by cliffs A3_0530 and A3_0540 on Drawing No: MSEC404-213[415]. This drawing shows the two cliffs to be disconnected and on opposite sides of Lizard Creek. The Risk Management Zone Plan for these cliffs depicts them in a similar manner and shows them to be less than 10 m high[416]. However, in the Major Cliff Line Matrix, they are recorded as being 20 m and 30 m high, respectively.

[413] SCA (2010).
[414] ICHPL (2010b), Response to Question 57, p.45.
[415] EA, Appendix A.
[416] EA, Appendix R, Cliff RMZ Plan 28.

Figure 40: Waterfall on Lizard Creek.

Against this background, the Panel considers that the cliff face which constitutes Appin Falls and the cliff face that constitutes the large waterfall on Lizard Creek warrant classification as being of *special significance* and that there may be other waterfalls in the Study Area that also warrant this classification. In coming to the conclusion concerning Lizard Creek the Panel considered the existing iron staining, but was of the view that the significance of the fall was still sufficient to put it into the special significance category.

2. Based on the many field inspections undertaken by various Panel members in the Southern Coalfield during the course of this and other reviews, the Panel is of the view that cliffs which function as waterfalls have additional attributes that increase their value and that these attributes may have been overlooked when assessment is based on the definition of a cliff which has been used in the EA[417]. The Panel considers that this definition warrants revision to include structures that comprise waterfalls greater than a certain height, the threshold height being no greater than 5m and perhaps as low as 3m.

3. Figure 41 shows the frequency distributions for cliff length and cliff height. Of note is that in this very large Study Area, there are only 10 cliffs longer than 200 m and 9 cliffs that are 40 m or more high. Five cliffs have both attributes. Furthermore, only one of these is longer than 400 m and only two are higher than 60 m. The Panel questions why these characteristics do not justify the classification of *special significance*. The Panel considers that this

[417] EA, Appendix A, p.80, Section 5.3.

matter warranted more detailed discussion in the EA and recommends, therefore, that:

i. The 14 cliffs that are longer than 200 m and/or equal to or higher than 40 m be afforded special significance status, and

ii. No mining be permitted that could risk damage to these cliffs beyond that described as ‘negligible environmental consequences’ later in this chapter.

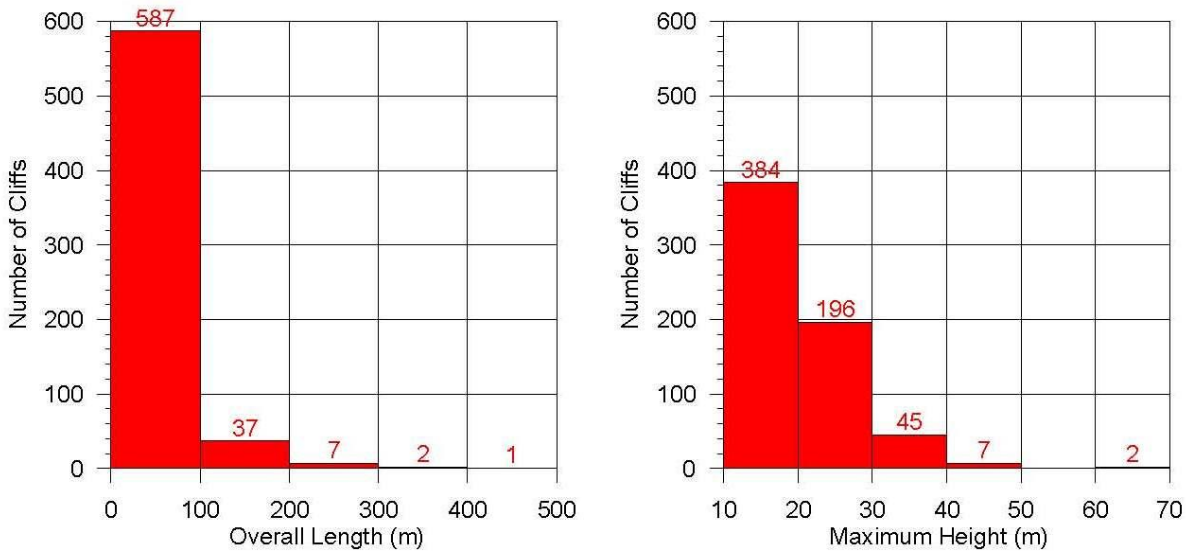

Figure 41: Frequency Distribution of the Length and Height of Cliffs[418]

The Panel also notes that waterfalls in the Southern Coalfield are generally located on the axes of valleys and, hence, cliffs comprising waterfalls are prone to much higher valley closure strains than cliffs located on the flanks of valleys. Therefore, the impacts reported in the EA for cliffs both outside and inside of the footprint of longwall panels may have been significantly underestimated for cliffs that constitute waterfalls.

9.3.4. Major Cliff Line Risk Assessment

Attachment RA comprises a suite of matrices that capture a wide range of characteristics of the cliff lines. This is very useful information on which to base a risk assessment. However, little use has been made of it. Rather, the text that comprises the various steps in the reported risk assessment is a repetition of that contained in Appendix A.

The concept of risk assessment as put forward by the SCI and advanced in the Metropolitan PAC Report was intended to be consistent with the relevant Australian Standards and guidelines, with the various definitions contained in both the SCI report

[418] EA, Appendix A, p.82, Figure 5.14.

and the Metropolitan PAC Report being based on these standards and guidelines[419]. The risk assessment pertaining to cliffs that is presented in Appendix R does not reflect these standards.

9.3.5. Conclusions and Recommendations

The Panel concludes that:

1. The definition of a cliff is reasonable for the purposes and scale of the EA, except for cliffs located within watercourses.

2. Cliffs which function as waterfalls have additional attributes that increase their value.

3. The impacts reported in the EA for cliffs both outside and inside of the footprint of longwall panels may have been significantly underestimated for cliffs that constitute waterfalls.

4. Although curvatures and strains have been presented in the EA, these are of only limited value because the EA does not directly relate these values to predicted impacts and consequences.

5. Conclusions drawn from the case studies of subsidence impacts presented in the EA may have underestimated impacts associated with the wider longwall faces and shallower depths of mining proposed in the EA.

6. The EA presents an inadequate discussion of potential impacts of longwall mining on cliffs located above goaves which, for the Base Plan layout, are confined to Area 3 and Area 8.

7. The proposed longwall layout is amenable to increasing the width of the buffer zone between Cascade Creek and the longwall panels, hence reducing both closure along Cascade Creek and exposure of one aboriginal heritage site of high significance (52-2-1282) to subsidence impacts.

8. There is an increased potential for cliff instability, including cliff falls, along Wallandoola Creek. The total length of cliff line that could be impacted may be considerably greater than the predicted 3 to 5% and include cliff falls, as opposed to rock falls. The consequences of these impacts may be higher than conveyed by the figure of 3 to 5% if cliff instability is concentrated in particular segments, such as at bends in the valley.

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[419] *Australian/New Zealand Standard 4360 - 2004: Risk Management* (superseded in November 2009 by *International Standard ISO 31000: Risk Management – Principles and Practice*) provides a framework for adopting an integrated and comprehensive approach to managing risk. In the case of the NSW mining industry, this standard is supported by:

- Mining Design Guideline MDG1010 – Risk Management Handbook, 1997. (www.dpi.nsw.gov.au/minerals/safety)
- Mining Design Guideline MDG1014 – Guide to Reviewing a Risk Assessment of Mine Equipment and Operations, 1997. (www.dpi.nsw.gov.au/minerals/safety)

9. There is insufficient site specific information in the EA relating to matters such as cliff height, cliff length, overhangs and associations with Aboriginal heritage for the Panel to be able to assess the physical, cultural and environmental attributes of cliffs along Wallandoola Creek and the likely consequences of instabilities on these attributes.

10. The Major Cliff Line Risk Assessment (Appendix R) contains a range of useful information for undertaking risk assessment. Nevertheless, Appendix R does not constitute an adequate risk assessment of mine subsidence implications for cliffs in the Study Area.

11. There are a number of cliffs which warrant consideration as being of *special significance*, including:

    i. The 14 cliffs in the Study Area that are longer than 200 m and/or 40 m or more in height.

    ii. Appin Falls.

    iii. The waterfall on Lizard Creek associated with cliffs A3_0530 and A3_0540.

The Panel recommends that

1. A hierarchy of mining-induced consequences on cliffs be established as follows:

    i. *nil* environmental consequences – where nil has the meaning of *none whatsoever*.

    ii. *negligible* environmental consequences - where *negligible* has the meaning ascribed in the Metropolitan Coal Project Approval of *small and unimportant so as not to be worth considering*[420]. Occasional displacement of boulders, hairline fracturing and isolated dislodgement of slabs from overhangs that in total do not impact on more than 0.5% of the total length of a cliffline are indicative of the scale of impacts falling within this category.

    iii. *minor* environmental consequences – where *minor* has the meaning of relatively *small in quantity, size and degree.* Isolated rock falls of less than 30 m^3 that do not impact on aboriginal heritage, EECs, public safety and the like; which affect less than 5% of the total length of cliffs and associated overhangs; and which affect less than 10% of any 100 m interval of cliff line are indicative of the scale of impacts falling within this category.

2. Cliffs in the Study Area having the following attributes be afforded *special significance* status:

[420] DoP (2009b), p.1.

i. Cliffs longer than 200 m.

ii. Cliffs higher than 40 m.

iii. Cliffs higher than 5 m that constitute waterfalls.

3. Approval be based on a Performance Criterion of *negligible* environmental consequences for all cliffs which have:

   i. Special significance status, or which

   ii. Flank or are within streams that have been described in this report as warranting special significance status[421].

4. Approval be based on a Performance Criterion of *minor* environmental consequences for all other cliffs in the Study Area.

5. Approval be based on a Performance Criterion that includes a requirement that no additional risk be created for the public from mining-induced cliff instability. Therefore, no Extraction Plan should be approved that could create any additional risk from cliff instability to the public, including users of Douglas Park Drive, until all potential sources of the increased risk have been investigated to the satisfaction of the Director-General of the Department of Planning and the proposals in the Extraction Plan for avoidance, mitigation or management of any such risks ensure that users of Douglas Park Drive are not exposed to additional danger.

6. The Major Cliff Line Risk Assessment (Appendix R of the EA) should not be relied upon in the environmental assessment process.

[421] This recommendation recognises that cliffs are a component of the landscape that contributes to stream being classified as being of *special significance.*

9.4. STEEP SLOPES

9.4.1. Assessment

The EA categorizes steep slopes as:

- Slopes on the sides of valleys, and
- Slopes on the sides of ridges.

In respect of slopes on the sides of valleys, Appendix A notes that the proposed longwalls will not mine directly beneath the majority of steep slopes in the Study Area. It briefly reviews mining history in the Southern Coalfield and concludes that no large scale slope failures have been observed along steep valley slopes in the Southern Coalfield, even where longwalls have mined directly beneath them Potential impacts are described before concluding that few structures or roads are located along the sides of valleys within the Study Area. In light of experience in the Southern Coalfield, the Panel considers this assessment to be reasonable.

Appendix A states that steep slopes on the sides of ridges are predominantly found in Area 8 and Area 9 on the Razorback Range and that these slopes are formed in the Wianamatta Shales, which comprise small rock fragments. It then states that:

> *'There is limited experience of longwall mining beneath steep slopes in Wianamatta Shales. While longwalls at Appin and West Cliff Collieries have directly mined beneath Wianamatta Shale slopes, the grades have been substantially less than those found on the Razorback Range'*[422].

This is followed by the statement that:

> *'While any impacts to steep slopes are likely to consist of surface cracking, there remains a low probability of large-scale slope slippage. Localised natural slope slippage has been observed along the Razorback Range and it is therefore possible that further localised slope failures along the Razorback Range may occur during mining that may be attributable to either natural causes, mine subsidence or both'*[423].

The Panel observed a number of previous land slips during its inspections of the area. It questions the basis for concluding that there is likely to be a low probability of large scale slope slippage (landslide).

A consideration of the mechanics of landslide indicates that there is considerable potential for mining induced subsidence to increase the likelihood of land slippage in Wianamatta Shale environments. The resistance to land slippage reduces with decreased cohesion (bonding), increased strata pore water pressure, decreased friction along potential sliding planes, and increased slope of the land mass. Subsidence induced slopes, strains and fracturing have the potential to reduce cohesion and friction within the landmass, to increase water ingress and hence pore water pressure,

[422] Appendix A, page 90
[423] ibid

and to increase the slope of the land mass. Wianamatta Shale environments have a higher exposure to these impacts because the material is laminated, weak, friable and prone to disintegrate to soil. Landslips over unmined areas in the region to date suggest that some slopes are already in a meta-stable state[424]. Hence, only a small amount of subsidence may be required to cause these slopes to become unstable.

Appendix A goes on to report that:

> *'The most significant road is Remembrance Driveway, where small debris has been observed on the pavement following wet weather. One section of the road traverses a defined ridgeline with steep slopes on either side of it. This section of road is located above Areas 8 and 9 and it is possible that longwalls will mine beneath it even though the longwalls shown in the Base Case layout do not'*[425].

This provides further evidence that some slopes are likely to already be in a meta-stable state. Given that the mine layout may change in the future, the Panel is not in a position to base its assessment on a consideration of the most likely or worse case impacts, particularly in respect of Remembrance Drive.

The Panel is aware that whilst slope stability is a well established element of geotechnical engineering, there is a considerable degree of uncertainty associated with design procedures and the determination of material properties to input into these procedures. It notes that the measures proposed for managing land slippage in the EA include *site investigation and landslide risk assessment of structures near slopes by a qualified geotechnical engineer.*

9.4.2. Conclusions and Recommendations

The Panel concludes that:

1. The assessment of stability of slopes on the sides of valleys is considered reasonable in light of experience in these environments in the Southern Coalfield.

2. The assessment of stability of slopes on the sides of ridges has not been founded on geotechnical engineering principles and is inadequate.

3. The need remains to quantify subjective terms such as *moderate, likely, unlikely* as applied to the prediction of subsidence effects and impacts.

The Panel recommends that:

1. The Performance Criteria in any Project Approval should include a requirement that, where any slopes are present that might be impacted by a proposed mining layout: all infrastructure not owned by the leaseholder remains in a safe, serviceable or repairable condition unless otherwise agreed

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424 A geomechanics term for situations that are on the brink of becoming unstable.
425 Appendix A, page 90

by the infrastructure owner; no significant environmental harm is caused and risks to public safety are not increased.

2. Where any slopes are present that might be impacted by a proposed mining layout, no Extraction Plan should be approved until:

   i. any risks associated with increased instability have been assessed to the satisfaction of the Director-General of the Department of Planning by a geotechnical engineer who is a recognised specialist in land slippage and utilising methodologies consistent with the Australian Standards, and

   ii. where such risks are present that the proposed avoidance, mitigation or management measures are capable of ensuring the Performance Criteria in the Approval are met.

10.0 ABORIGINAL HERITAGE

10.1. SCOPE

The assessment of Aboriginal heritage is focused on the seven proposed longwall mining domains and the West Cliff Stage 4 Coal Wash Emplacement, none of which have previously been the subject of an Aboriginal cultural assessment. To assist with referencing and discussing the context of particular areas or sites, the Aboriginal Cultural Heritage Assessment (Appendix G) has classified the seven mining domains into four regional mining domains, being:

- North domain – comprising West Cliff Area 5 and Appin Area 7
- East domain – North Cliff
- West domain – Appin Area 8 and Appin Area 9
- South domain – Appin Area 2 and 3 Extended

Over 630 Aboriginal heritage sites have been identified to date in these four domains.

10.2. PROCESS

Appendix G reports that the preparation of the Aboriginal Cultural Heritage Assessment involved:

1. Conducting searches of the relevant heritage registers to identify previously recorded sites in the areas of interest.

2. Conducting background research to recognise any identifiable trends in site distribution and location, and to accurately quantify the cultural heritage resources present.

3. Consulting with Aboriginal stakeholders in the area regarding the cultural values of the study area.

4. Conducting site inspections of previously recorded sites, focusing on sites determined to be of high and moderate significance, collecting baseline information and gauging the veracity of site records and the conditions of the sites present.

5. Providing representatives of the Aboriginal community the opportunity to inspect the study area and any Aboriginal sites of particular significance or interest.

6. Conducting surveys to locate and record sites in areas deemed to be archaeologically sensitive but which have been previously subject to less intensive survey.

7. Identifying and assessing identified sites in compliance with DECC guidelines.

8. Conducting an archaeological significance assessment for all sites within the study area.

9. Presenting the views of Aboriginal communities in regard to cultural significance of the area and Aboriginal sites and places.

10. Describing potential impacts to all identified Aboriginal sites within the study area.

11. Making recommendations to minimize, mitigate and/or manage potential impacts to cultural heritage values within the study area.

The Panel notes that risk assessment was not included as one of these activities but that it has been addressed subsequently in the Aboriginal Heritage Site Risk Assessment (Appendix Q). Based on the content of the EA and the number and nature of submissions, the Panel is satisfied that activities 1 to 7 were undertaken diligently and to an adequate standard.

The consultation process as reported in Appendix G involved a range of government agencies, local councils, and individuals and associations representing Aboriginal interests. The manner in which it was administered appears consistent with the activities associated with preparing an Aboriginal Cultural Heritage Assessment Nevertheless, as noted later, the Panel is not convinced that stakeholders fully appreciated that a Part 3A Approval would extinguish protection for Aboriginal heritage provided under other legislation, or that Aboriginal concerns regarding the Stage 4 Coal Wash Emplacement were adequately addressed.

Appendix G provides a description of the environmental background to the Study Area for the purpose of giving context to the cultural heritage assessment. This is also supported by a section on ethnohistory and a review of local archaeological and cultural heritage studies.

Subsequent to the EA being placed on public display, only one Aboriginal interest group made a submission to the Panel. This submission expressed discontent with aspects of the field inspections, such that the interest group was not involved in them. The submission had merit but the Panel does not consider the matters it canvassed have serious implications for the outcomes of the Aboriginal Cultural Heritage Assessment at this stage in the approval process. Should the project proceed, the opportunity exists to consider the matters raised in the submission when preparing Extraction Plans.

Appendix G reports that the Wadi Wadi Coomaditchie Aboriginal Corporation, Woronora Plateau Gundungara and the Wulungulu Elders Council, via the Northern Illawarra Aboriginal Collective and the Illawarra Local Aboriginal Land Council made the following similar comments:

> *'We don't wish to be used by Biosis, BHP Billiton to obtain S87's or S90's. We object to this and don't wish to be blamed for Biosis, BHP Billiton operations or reports.*
>
> *The Illawarra Local Aboriginal Council objects to Section 90, Rights to Damage or Destroy being granted as longwall mining continues to impact on our waterways and damage Aboriginal sites.'*[426]

ICHPL responded that:

[426] EA, Appendix G, p.17.

> *'Approvals under Part 6 of the NSW National Parks and Wildlife Act 1974 will not be sought for the Project, as it is being assessed under Part 3A of the EP&A Act.'*[427]

The Panel considers it unlikely that the various stakeholders fully appreciated the significance of ICHPL's response, this being that Part 3A approval extinguishes the need for ICHPL to obtain approval to destroy sites of Aboriginal heritage. The Panel is also of the view that had the response been couched directly in these terms it would have prompted additional submissions from stakeholders.

ICHPL's response goes on to state that:

> *'….an AHP will be developed in consultation with the Aboriginal community, and this will include a protocol for the involvement of the Aboriginal community.'*[428]

The response provides no insight into the content of an Aboriginal Heritage Plan (AHP) and its associated protocol. Again, it does not make the reader aware that the existence of an AHP and protocol would not necessarily protect Aboriginal heritage sites from destruction in areas where a Part 3A approval has been granted. The Panel is mindful that all significant Aboriginal heritage sites may not have been identified to date, a point emphasized in the dissenting submission to the Panel previously noted and by DECCW[429]. Furthermore, the Panel is mindful that during the 30+ year period that protection for Aboriginal heritage may be turned off by a Part 3A approval, there could be significant developments in detecting and interpreting Aboriginal sites and significant shifts in understanding Aboriginal values.

Activities 8 and 9 of the Aboriginal Cultural Heritage Assessment were concerned with conducting an archaeological significance assessment for all sites within the study area and presenting the views of the Aboriginal communities in regard to cultural significance of the area and of Aboriginal sites and places. The EA notes that cultural heritage managers and government agencies in Australia have adopted heritage assessment criteria as outlined in the Australia International Council on Monuments and Sites (ICOMOS) Burra Charter. Significance values include:

- Historical (evolution and association)
- Aesthetic (scenic/architectural qualities, creative accomplishment)
- Social (contemporary, community esteem)
- Scientific (archaeological, industrial educational, research potential, scientific significance values)

Appendix G reports that the cultural and archaeological significance of Aboriginal and historic sites and places has been assessed on the basis of the significance of these ICOMOS significance values and on formal criteria and guidelines developed by government agencies for assessing heritage. Of primary interest to the EA are guidelines prepared by the Commonwealth Department of the Environment, Water Heritage and the Arts (DEWHA) and the Heritage Branch of the NSW Department of Planning. The EA also acknowledges

[427] EA, Appendix G, p.17.
[428] EA, Appendix G, p.17.
[429] DECCW (2010a), p.15.

DECC[430] Guidelines which specify the importance of considering cultural landscapes when determining and assessing Aboriginal heritage values. The EA notes that:

> *'The principle behind a cultural landscape is that "the significance of individual features is derived from their inter-relatedness within the cultural landscape". This means that sites or places cannot be 'assessed in isolation' but must be considered as parts of the wider cultural landscape. Hence the site or place will possibly have values derived from its association with other sites and places.'*[431]

The EA goes on to note that:

> *'Although other values may be considered – such as educational or tourism – the two principal values that are likely to be addressed in a consideration of Aboriginal sites and places are the cultural/social significance to Aboriginal people and the archaeological or scientific significance to archaeologists.*
>
> *……..*
>
> *The determinations of archaeological and cultural significance for sites and places should then be expressed as 'statements of significance' that preface a concise discussion of the contributing factors to Aboriginal cultural heritage significance.'*[432]

Appendix G notes that *archaeological significance* is also called *scientific significance* and that whilst various criteria have been advanced over the years, most of them fall under the heading of 'archaeological research potential'. The EA then presents a tabulation of the archaeological significance for 632 sites identified in the project area, with the significance assessment reported to be based on *Part 1 of the DECC Guidelines for Aboriginal Heritage Impact Assessment (DECC 2006)*. However, there is no information as to which stakeholders were involved in undertaking the assessment and the validity of the ranking outcomes therefore remains questionable.

The EA considers that social, historic and aesthetic values relate to community or cultural significance and that these aspects of heritage assessment can only be determined through consultative processes with one or more Aboriginal communities. It notes that cultural and social values can be complex and rich and attract differing values. The EA presents the statements and comments of cultural significance made by registered Aboriginal stakeholders during field studies, both in regard to individual sites and in general. The Panel acknowledges advice from some members of the Aboriginal community that all sites are culturally significant, especially when considered as a collection of sites. A tabulation is presented of 8 sites *deemed* to be of particular cultural significance identified from these statements and comments. It is unclear from the EA whether it was ICHPL that *deemed* the sites as such or whether this was a consensus outcome from the Aboriginal communities involved in the process.

[430] Since restructured as the Department of Environment, Climate Change and Water (DECCW).
[431] EA, Appendix G, p.24.
[432] Ibid.

10.3. SITE IDENTIFICATION

Appendix G reports that the search of the AHIMS database returned 611 archaeological and cultural sites in the study area, of which 23 were found to be duplicate entries. The Aboriginal heritage survey and site inspection recorded 44 new sites, giving a total of 632 known sites within the Study Area, Table 18.

Table 18: Number and Types of Aboriginal Heritage Sites within the Project Area[433]

Site Type	Number of Sites	% of Total Sites
Potential Archaeological Deposit	78	12%
Sandstone Platform with Grinding Groove/Engraving	173	28%
Sandstone Shelter with Art/Grinding Groove/ Engraving/Deposit	240	38%
Sandstone Shelter with Deposit only	33	5%
Scarred Tree	8	1%
Stone Artifact(s)	100	16%
TOTAL	**632**	**100%**

Classification of the archaeological significance of these sites is summarized in Table 19.

433 Source: EA, Appendix G, p.32, Table 2.

Table 19: Summary of Archaeological Significance for all Sites[434]

Archaeological Significance	Number of Sites	% of Total Sites
High	14	2%
Moderate	65	10%
Low	448	71%
N/A – Limited information available	27	4%
PAD	78	13%
TOTAL	**632**	**100%**

Appendix Q (Aboriginal Heritage Site Risk Assessment) reports a revised total of 623 sites, noting that 7 sites referenced in Appendix G were found later to be outside the 600m boundary of the Study Area and 2 sites were found to be duplicate entries. However, an additional three sites were identified between studies arising out of a change in the boundary of the Study Area *'due to minor changes in the longwall layout'.*

Table 9 of Appendix G purports to list sites of *'high'* and *'moderate'* archaeological significance and *'particular'* cultural significance. There are 76 sites, which does not tally with the 79 listed in Table 7 of Appendix G. Attachment QA of Appendix Q lists all 623 sites. The Panel notes that the Aboriginal Heritage Sites at the West Cliff Coal Wash Emplacement, one of which is the most archaeologically and culturally significant site in the whole Project Area, are not included in either tabulation. This may account for the discrepancy in recorded site numbers in the tabulations. The sites affected by the West Cliff Coal Wash Emplacement have not been addressed in the Risk Assessment presented in Appendix Q.

10.4. RISK ASSESSMENT

10.4.1. Terminology

The terminology relating to risk in Appendices G and Q is not used in a consistent manner and both it and the risk assessment process presented in the two appendices do not always conform with that defined in *Australian/New Zealand Standard 4360: Risk Management*[435] and in the reports of the Southern Coalfield Inquiry (SCI)[436] and the Planning Assessment Commission (PAC) for the Metropolitan Coal Project (MCP)[437].

Risk is an expression of the effect of uncertainty on the achievement of objectives. The level of risk is determined by considering the likelihood of an event occurring and the magnitude of the consequences should it occur.

For the purpose of this review, an 'event' is defined as a mining-induced impact on an Aboriginal heritage site. The concept of a Risk Management Zone (RMZ) is premised on determining the level of risk present within the zone, deciding if this level of risk is

[434] Source: EA, Appendix G, p.84, Table 7.

[435] Recently superseded by *ISO 31000*:2009 *Risk Management – Principles and Guidelines*

[436] DoP (2008)

[437] DoP (2009)

acceptable, implementing controls to reduce the level of risk to an acceptable level if need be, assessing the residual risk and having contingency plans in case an unacceptable level of risk still arises. The level of risk may be reduced by reducing either or both the likelihood of an impact occurring and the consequences should an impact occur.

10.4.2. Risk Assessment for Aboriginal Heritage Sites

Appendix G addresses Activity 10 of the Aboriginal Cultural Heritage Assessment. It reports that to date, 103 Aboriginal sites subjected to mining-induced subsidence effects have been systematically monitored and reported. These take in a range of site types, landscape types and subsidence parameters. It is reported that *'impacts'* attributed to mining were recorded at 11% (11) of the 103 sites. Only one archaeological feature was *'impacted'*, this being the fracturing of an art panel. Appendix Q reports the number of sites monitored to date to be 153, with 11 sites recording *'consequences'*, this now representing 7% of monitored sites.

The Panel notes that:

1. The statistics, at least for the 103 sites reported in Appendix G, were based on monitoring programs that have generally only included those sites identified as being at higher risk of impact.

2. The western and northern domains, which comprise large areas of pasture and hills with relatively deep soils, are comparatively less archaeologically rich compared to the eastern and southern domains and less sensitive to subsidence movements.

3. As a result of stream impact minimization commitments contained in the EA, many of the 632 Aboriginal heritage sites within the Study Area are located outside of the footprint of longwall panels shown in the Base Case Layout. Subject to these commitments remaining in place, a change in the Base Case Layout is likely to have a minimal effect on the number of Aboriginal heritage sites impacted, although the level of impact may change.

Hence, statistics relating to the probability of impacting on Aboriginal heritage sites may over-estimate the likelihood of impacts when applied across the entire Study Area. However, in the case of significant Aboriginal heritage sites, the Panel does not consider it acceptable to base impact predictions on a blanket probability (such as 11% or 7%). Rather, each site must be assessed in its own right. The EA presents a method for undertaking this assessment, viz:

> *'The method described by Biosis Research (2007b) simply considers risk factors as being present or not, and 'sums' these to produce an overall risk category (described above). The more risk factors exhibited by a site then the greater the determined risk category. In particular, the following reasoning has been used to formulate the risk assessments for the site of high and moderate archaeological significance, where sites are considered to be at risk if:*
>
> - *the shelter is >50m*^{3}
> - *the shelter has existing water seepage*
> - *the site is located near the valley bottom, or*

- *the shelter is a block-fall type shelter'*[438]

The Panel has three concerns with this approach:

1. All the factors are weighted equally. There is no discrimination between the relative contribution of each factor to increasing the likelihood of a site being impacted by subsidence.

2. The level of so-called *risk* associated with each factor is fixed whereas there is likely to be a sliding scale of likelihood of impact associated with some factors, for example, the volume of a shelter.

3. The criterion related to shelter volume may be sensitive to mining geometry, in particular longwall panel width which may increase substantially over the projected life of the BSO Project.

Appendices G and Q do not provide information on the scoring system associated with the methodology and its correlation to the qualitative descriptions of likelihood that have apparently been derived from it. Immediately after the methodology is presented, Appendix G goes on to discuss 'risk of impact' and to tabulate this parameter for all sites of 'moderate' or 'high' archaeological significance[439]. It states:

> *'The highest category for risk of impact is 'moderate'; this recognises the difficulty in making precise statements of impact, and to incorporate the results of previous monitoring programs – described in detail above - that show generally impacts to sites are rare (occurring in approximately 11% of monitored cases which have focused on sites with higher risk of impact) and that when impacts have been recorded they have been relatively minor (rarely impacting art surfaces for example). Hence the category 'moderate' means impacts are possible but likely to occur in less than 10% of cases.'*[440]

Appendix Q contains extensive tabulations of the four risk factors described by Biosis Research[441] plus depth of mining which the EA notes that MSEC has also identified as a risk factor, but it does not provide any insight into how this worthwhile information was processed to produce a likelihood rating. Appendix Q confuses the situation further in that the methodology of Biosis Research for assessing the likelihood of impact is discussed under the heading of 'consequence', with the description and criteria now modified and expressed in terms of consequence, not impact, viz:

> *'The highest category generally achieved by the risk of impact assessment is "moderate". This recognises the results of previous monitoring that indicate consequences to sites are rare (occurring in approximately 7% of monitored cases which have focused on sites with higher risk of impact) and that when consequences have been recorded they have been relatively minor (rarely impacting art surfaces for example).'*[442]

[438] Appendix G, page 91

[439] Site 52-2-0496 either does not belong in this tabulation or has been assigned an incorrect level of archaeological significance.

[440] EA, Appendix G, p.92.

[441] Biosis Research (2007).

[442] EA, Appendix Q, p.Q-8.

Against this background, the following additional concerns arise:

- The impact risk assessment presented in Appendix G only addresses one half of the risk assessment equation, namely the assessment of the likelihood of an impact occurring. It does not address the consequences of the event.

- The classification of likelihood is generic and qualitative. *'Moderate'* has been designated the highest likelihood category and assigned a probability of occurrence of less than 10%. This probability has no regard for the site specific characteristics of a site, which could result in a much higher probability of impact. The three other likelihood categories are defined in qualitative terms, namely, *low* (impacts are unlikely), *very low* (impacts are highly unlikely) and *negligible* (impacts are highly unlikely and would likely be indistinguishable from the natural background environment and natural deterioration processes). Unless these descriptions are linked to a scoring system or experience base, they are open to interpretation, depending on the experience, culture and risk profile of those using the information. The definition of *negligible* is confounded further by being a mix of the likelihood of impact and the consequences of the impact.

Due to the limited consideration given to consequences associated with subsidence impacts, Appendix Q cannot be considered to present the outcomes of a risk assessment. However, in the case of the Aboriginal Heritage sites recorded in Table 9 of Appendix G, it might reasonably be assumed that the consequence of an impact will to some considerable extent be proportional to the archaeological significance of the impacted site. This being the case, Table 9 might provide an approximate basis for determining risk to significant archaeological sites.

Although Table 9 of Appendix Q is labeled and described as a risk impact assessment for sites of *archaeological significance and particular cultural significance,* it only rates the sites in terms of their archaeological significance. Hence, the risk assessment needs to be repeated for cultural heritage sites of particular significance.

Appendix Q reports that 18 sites were assessed in Appendix G as having either high archaeological significance or particular cultural significance. It then goes on to report that one of these sites, being 854, *is considered to be more archaeologically significant than all other sites in the study area*. DECCW also singled out this site, stating:

> *'the most archaeologically significant site within the study area (52-2-0854) has been identified in North Cliff, within the Woronora catchment. This site has been assessed as having high significance on the basis of its features (rock shelter with art, deposit and grinding grooves) and art motifs'.*[443]

Appendix G reports that Ngunawi Heritage Aboriginal Corporation advised that they wished to inspect this site but it could not be found[444]. Given that ICHPL and DECCW are apparently in agreement that this is a particularly significant site and that Aboriginal stakeholders have a particular interest in the site, the Panel considers that this site warranted a higher significance than the other 17 sites.

[443] DECCW (2010c), Response to PAC question 6, p.5.
[444] Section 6.3.2 and Table 6

10.5. PROPOSED STAGE 4 EMPLACEMENT

There are a number of Aboriginal Heritage Sites in the vicinity of the proposed Stage 4 Emplacement. One of the sites, namely 52-2-3505, is the only site in the entire BSO Project to be classified as being of both high archaeological significance and particular cultural significance. The Panel notes with concern that none of the sites were included in the Aboriginal Heritage Site Risk Assessment (Appendix Q).

Appendix G introduces the Stage 4 Emplacement Area by stating that:

> *'The proposed Stage 4 Coal Wash Emplacement area has the potential to impact sites either through burial of the sites under the Coal Wash Emplacement, through direct impact by associated works supporting the Stage 4 Coal Wash Emplacement area, ……, or through secondary impacts.*
>
> *The design of the Stage 4 Coal Wash Emplacement has resulted in avoidance of the primary impact of burial by the emplacement to three sites, including the only highly significant (both culturally and archaeologically) site (52-2-3505, West Cliff 2) identified in the area.*
>
> *Table 10 summaries the risk impact for the sites from Stage 4 Coal Wash Emplacement'*[445].

Table 10. Risk impact assessment for sites near the proposed West Cliff Stage 4 Coal Wash Emplacement

Site Number	Site Name	Site Type	Archaeological Significance	Impact
52-2-1373	Brennans Creek 7	Sandstone Shelter with Art / Grinding Groove / Engraving / Deposit	Moderate	Likely (burial)
52-2-2228/3617	D10	Sandstone Shelter with Deposit only	Low	Likely (burial)
52-2-3504	West Cliff 1	Sandstone Shelter with Art / Grinding Groove / Engraving / Deposit	Moderate	Possible (dust)
52-2-3505	West Cliff 2	Sandstone Shelter with Art / Grinding Groove / Engraving / Deposit	High	Possible (dust)
52-2-3506	West Cliff 3	Potential Archaeological Deposit	PAD	Likely (burial)
52-2-3508	West Cliff 5	Stone Artefact(s)	Low	Possible (existing road)
52-2-3533/3616	D11	Sandstone Shelter with Deposit Only	Moderate	Likely (burial)

The Panel turned to the input of Aboriginal stakeholders as reported in the EA to try to gauge the significance of the predicted impacts of the Stage 4 Coal Wash Emplacement on Aboriginal heritage sites. The EA reports that the Cubbitch Barta Native Claimants Aboriginal Corporation expressed the following view:

> *'I note that included in the recommendations, No. 4. mentions Stage 4 emplacement, and I do not believe that this can be included in the Same AHP, as the Bulli Seam Operations. The stage 3 emplacement area, was a huge project, and I believe that*

[445] EA, Appendix G, p.97.

Stage 4 should not get lost within the larger operational project for the mining of the Bulli Seam'[446].

In response to a range of other comments from Aboriginal stakeholders, ICHPL has stated that:

> *'The proposed Stage 4 Coal Wash Emplacement area footprint has been specifically designed to minimise impact to sites through site avoidance.'*

These statements took on added significance following the submission from DECCW that:

> *'The DECCW considers that the Stage 4 wash reject Emplacement proposals will have a significant impact to a number of Aboriginal Cultural Heritage (ACH) sites both directly and as a result of the emplacement and indirectly as a result of dust.*
>
> *Previous consultation with the proponent and DECCW during the Stage 3 proposal resulted in the footprint of the Stage 3 coal wash reject emplacement being altered to avoid impacting a number of these sites however DECCW notes that these are now proposed to be impacted by the Stage 4 emplacement.*
>
> *In particular some of these sites have significant cultural and archaeological value as they represent the best examples of their site type being rock shelters with art and evidence of Aboriginal occupation. In this regard the DECCW recommends that impacts must be avoided on sites 52-2-3505, 52-2-2228/3617, 52-2-1373, 52-2-*3533*/3613. The DECCW also recommends further consultation with DoP and the proponent on this matter'.* [447]

The assessment of Aboriginal heritage in the EA makes no mention that the Aboriginal heritage sites to be impacted by the Stage 4 Emplacement had already been a focal point in the Stage 3 Emplacement approval process and, furthermore, the Stage 3 Emplacement Plan had apparently been altered in order to protect some of these sites.

The Panel looked to ICHPL's response[448] to the DECCW submission for clarification on the issue. However, ICHPL's response did not go to the issue and was decidedly unhelpful, simply reproducing the (above) extract from the EA that gave rise to the issue.

The Panel notes that three of the four sites for which DECCW has recommended impacts be avoided, are classified in the EA as '*likely*' to be buried. The EA provides no indication of likelihood associated with the classification '*likely*'. However, the Panel interprets the words *has the potential to impact sites* to imply that there are measures available to avoid impact if need be. If this is not the case and burial is inevitable, then given the other already noted in this section, the Panel seriously doubts the transparency of the EA.

Site 52-2-3505 in the Stage 4 Emplacement Area has been identified in Appendix G as being the only site in the BSO Project Area to be of both high archaeological significance and particular cultural significance. The Panel considers that:

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[446] EA, Appendix G, p.12.
[447] DECCW (2009a), p.13.
[448] ICHPL (2010a).

1. The combination of archaeological and cultural values for this site warrant that significance ratings take into account the wider cultural landscape.

2. The combination of these significance values and the fact that this is the only site in a very large area to have both high archaeological and cultural values warrants the significance of this site to be elevated to *'very high'* to distinguish it from all other sites.

3. For the same reasons, the site should be afforded the classification of *special significance* (noting that the risk assessment process which should lead to this type of conclusion was not undertaken for sites in the vicinity of the Stage 4 Emplacement).

4. Any approval for Stage 4 Emplacement Area needs to give consideration to how Stage 4 may impact on values of Site 52-2-3505 that derive from its association with other sites and places.

10.6. ABORIGINAL HERITAGE MANAGEMENT PLAN

The Aboriginal Cultural Heritage Assessment incorporates a proposed Management Plan for Aboriginal heritage. The most comprehensive submission in regards to Aboriginal heritage was from DECCW which submitted that:

> *'The assessment of archaeological significance of the sites has been carried out in accordance with the Australia International Council on Monuments and Sites (ICOMOS) Burra Charter guidelines, DECCW's ACH Standards & Guidelines Kit (National Parks & Wildlife Service, 1997, draft) and DoP's Draft Guidelines for ACH Impact Assessment and Community Consultation (2005) and is considered to be adequate, as is the community consultation. The assessment of cultural significance has also been carried out in accordance with the above guidelines…*
> *…*
> *DECCW notes the management recommendations in the ACH Assessment and supports these recommendations. Further, it is noted that the majority of the Aboriginal community responses also indicate support for these management recommendations'*[449].

In response to this submission, ICHPL has stated that:

> *'As described in Section 5.10.3 of the EA:*
>
> *An Aboriginal Heritage Plan (AHP) would be developed for the Project in consultation with the Aboriginal community and the DECC. The AHP would be active throughout the life of the Project and would incorporate the outcomes of monitoring, survey and fieldwork, analysis and consultation…The AHP would detail the statutory requirements to be met throughout the life of the Project regarding the management of Aboriginal heritage and include the mitigation measures described in the sub-sections below'*[450].

[449] DECCW (2009a), p.15.
[450] ICHPL (2010a).

The Panel concludes that, on paper, the Aboriginal Heritage Management Plan proposed in the EA is adequate and amenable to continuous improvement as further information and experience is gained in regards to mining impacts on Aboriginal heritage sites. However, in practice this Plan may need to place a higher focus on the management of Aboriginal heritage sites in the Coal Wash Emplacement Area.

10.7. CONCLUSIONS

The Panel concludes that:

1. On the basis of documentation presented in the EA, the preparation of the Aboriginal Cultural Heritage Assessment (ACHA) is premised on adequate communications and input from Aboriginal communities and other stakeholders. However, the Panel is not convinced that stakeholders fully appreciated that a Part 3A Approval would extinguish protection for Aboriginal heritage provided under other legislation, or that Aboriginal concerns regarding the Stage 4 Coal Wash Emplacement were adequately addressed.

2. The ACHA has identified and documented Aboriginal heritage sites in a diligent manner, albeit that it is likely some sites have not been identified.

3. A valuable database of information has been complied on which to base risk assessment. Nevertheless, the risk assessment of Aboriginal Heritage Sites does not conform with risk assessment standards, and the outcomes of the process are incomplete.

4. The methodology proposed in the EA for assessing the propensity of an aboriginal heritage site to subsidence induced impacts is rudimentary and has a number of shortcomings.

5. Aboriginal heritage sites in the vicinity of the Coal Wash Emplacement area should have been included in the risk assessment.

6. Impacts on Aboriginal heritage associated with the Stage 4 Coal Wash Emplacement have not been adequately assessed in the EA.

7. Aboriginal heritage sites 52-2-0854 and 52-2-3505 warrant classification as being of *special significance*.

The Panel recommends that

1. A hierarchy of mining-induced consequences on Aboriginal cultural heritage sites be established as follows:

    i. *nil* consequences – where nil has the meaning of *none whatsoever*.

    ii. *negligible* consequences - where *negligible* has the meaning ascribed in the Metropolitan Coal Project Approval of *small and unimportant so as not to be worth considering*[451]. Hairline fracturing and isolated dislodgement of smalls pieces of ground surface or overhangs that in total do not affect more than 5%

[451] DoP (2009b), p.1.

of an Aboriginal site and do not affect at all the physical condition of any item of Aboriginal heritage or any cultural value, are indicative of the scale of impacts falling within this category.

iii. *minor* consequences – where *minor* has the meaning of relatively *small in quantity, size and degree.* Isolated open cracking and rock falls of less than 2 m^3 that do not affect the physical condition of any item of Aboriginal heritage or any aboriginal cultural value, are indicative of the scale of impacts falling within this category.

2. The following Aboriginal heritage sites be afforded *special significance* status:

   i. 52-2-0854

   ii. 52-2-3505

3. Any approval should be based on a Performance Criteria of *negligible* environmental consequences for all Aboriginal heritage sites which have *special significance* status.

4. The Stage 4 Coal Wash Emplacement should not proceed until such time as the continued protection of significant sites that were specifically protected as part of the Stage 3 Coal Wash Emplacement approval process is resolved to the satisfaction of the Director General of Planning after:

   i. completion of an adequate Aboriginal Heritage assessment;

   ii. consultation with Department of Climate Change and Water (DECCW);

   iii. consultation with the relevant Aboriginal communities.

5. Before secondary extraction can commence under the Approval, the Director-General of the Department of Planning should:

   i. commission work to determine an appropriate standard for protection of Aboriginal heritage sites that are not classified as being of special significance;

   ii. include in that work appropriate research on how any such standards could be monitored and enforced; and

   iii. ensure that the requirements are included in Extraction Plans.

6. One option considered by the Panel was achievement of minor environmental consequences at 90% of such sites, but the Panel's view is that this issue would benefit from further work before a conclusion is reached.

7. Approval be based on the Aboriginal Cultural Heritage Plan being externally audited every three years for the duration of the project by a suitably qualified person appointed by the Department of Planning in consultation with the DECCW and relevant Aboriginal communities. The audit is to include a focus on:

8. The need to classify or reclassify any current or new sites as being of *special significance,* taking in consideration new and evolving knowledge of Aboriginal history and culture.

9. Verification that the performance standards set under point 5 above have been met.

11.0 BUILT ENVIRONMENT

11.1. SCOPE

The Study Area covers more than 220 km^2, is within 60 km of a capital city (Sydney) and a number of regional cities (including Wollongong, Campbelltown, Liverpool, and Penrith), is adjacent to the population growth centre of Macarthur, and straddles the main transport and services corridor connecting Sydney with Canberra and Melbourne. It encapsulates towns and villages, elements of the water catchment and supply system for the Sydney Metropolitan Area, a national highway, a national railway line, national gas supply pipelines, national telecommunication networks, industrial complexes, farms, recreational areas, air strips, and all the services that support such infrastructure (water, sewerage, gas, electricity, communication systems, survey control stations etc). As such, it contains a vast number and range of built structures, reflected in the fact that 60% of the main text of the Subsidence Assessment (Appendix A) is taken up with identifying the major categories of infrastructure, the principal structures within each category, and predictions of subsidence effects and impact for these structures. These categories, some of which encapsulate many hundreds and, in some cases, thousands of structures (e.g. 1294 houses, 4356 rural buildings) or kilometers of hardware (e.g. water supply lines, optical cables) are:

1. Public Utilities

    i. Main Southern Railway, incorporating elements such as stations, culverts, cuttings, viaducts and embankments.

    ii. Maldon-Dombarton Railway

    iii. Hume Highway, incorporating elements such as pavement, drainage and bridges.

    iv. Local roads

    v. Sydney Water Infrastructure

    vi. Macarthur Water Supply

    vii. Sydney Catchment Authority Infrastructure

    viii. Gas Infrastructure

    ix. Electricity Infrastructure

    x. Telecommunications Infrastructure

    xi. Mobile Phone sites

    xii. Air Strips

    xiii. Survey Control Marks

2. Public Amenities

i. Hospitals
ii. Places of Worship
iii. Schools
iv. Shopping Centres
v. Community Centres
vi. Office Buildings
vii. Swimming Pools
viii. Bowling Greens
ix. Ovals or Cricket Grounds
x. Racecourses
xi. Golf Courses and Tennis Courts

3. Farms and Farm Facilities
    i. Agricultural Utilisation
    ii. Farm Buildings and Sheds
    iii. Gas and Fuel Storages
    iv. Poultry Sheds
    v. Irrigation Systems
    vi. Fences
    vii. Farm Dams
    viii. Wells and Bores
4. Industrial, Commercial and Business Establishments
    i. Cement Works
    ii. Flour Mills
    iii. Gas or Fuel Storage
5. Non-Aboriginal Heritage
6. Residential Buildings

Table 20 summarizes the distribution of the major categories of infrastructure on a mining domain basis. The total amount of existing infrastructure in these mining domains is vast and the Panel considers that it is simply not feasible for the EA or for the Panel to assess each and every item at this stage of the planning process. The Panel concurs in general with the approach adopted in the EA, which is effectively:

- Identifying the maximum subsidence effects predicted within each mining domain.
- Cataloguing items of built infrastructure into the classifications noted above.
- Assessing subsidence effects, impacts and consequences for these items on a class basis (as opposed to an individual basis) within each mining domain.
- Basing this assessment on the maximum subsidence effects predicted for the Base Case layout in each mining domain so as to cater for any future changes in the direction or location of longwall panels (but not changes in longwall panel width).
- Identifying those items of infrastructure within each class for which subsidence may present an elevated risk and providing a more detailed assessment of risk to that item.

The assessment of the Built Environment in the EA has not been premised on a formal risk assessment and so the Panel has had to base its recommendations on its own assessment of risk derived from information in the EA, the submissions, site inspections and responses to the Panel's questions. In considering the implications of the BSO Project on existing infrastructure, the Panel has given consideration to likely changes in the value of the infrastructure over the proposed 30 years of project life. Issues such as the integrity of water supply systems and their potentially increased significance as Sydney's population grows, and changes to rural infrastructure or obsolescence in the communications network over the project life, have been considered. Additionally, the Panel turned its mind to the type, scale and location of likely infrastructure in the future.

Table 20: Summary of Major Infrastructure in the Study Area

Mining domain	**Area 2**	**Area 3**	**Area 7**	**Area 8**	**Area 9**	**West Cliff Area 5**	**North Cliff**
Highways	1	2	1 (Hume)	1 (Hume)	1 (Hume)	1	1
Major Roads	-	2	4	4	4	2	-
Main Southern Railway	-	-	✓	✓	✓	-	-
Buildings	Many	Many	Many, including Menangle Township	Many including Douglas Park Township	Many	Many including Wedderburn Township	Very few
Farm Dams & Tanks	Very Few - Localised	Many	Many	Many	Many	Many	Very Few
Bores	0	2	36	9	9	1	0
SCA Infrastructure		-Upper Canal & Aqueducts -Cataract Tunnel -Nepean Tunnel -Broughtons Pass Weir -Cataract Dam Wall -Jordans Pass Weir					
Other Water Infrastructure		Menangle Weir			Douglas Park Weir		
Tele-communications	Copper	Copper Optical	Copper Optical	Copper Optical	Copper	Copper Optical	Copper Optical
Power lines	11 kV	330 kV 11 kV	330 kV 66 kV 11 kV	66 kV 11 kV	66 kV 11 kV	330 kV 66 kV 11 kV	66 kV
Gas Pipelines	-	3	Marginal (3)			3	
Survey Control Marks	✓	✓	✓	✓	✓	✓	✓

11.2. SUBSIDENCE MANAGEMENT FOR BUILT INFRASTRUCTURE

11.2.1. Operational Aspects

The Panel acknowledges a history of experience in undermining built environment in NSW over a period of more than 150 years, and even longer experience in Britain and Europe. The Panel is also aware that there are precedents in NSW for undermining all the categories of infrastructure proposed to be undermined by the BSO Project whilst still maintaining the affected structures in a *safe, serviceable and repairable* condition[452]. Many of these precedents exist in areas already undermined by Appin Colliery (now called Appin East), Tower Colliery (now called Appin West) and West Cliff Colliery. They include the Cataract Tunnel, the Upper Canal, Simpsons Creek Aqueduct, Appin Township, high pressure gas pipelines, and arterial roads.

Although it may be technically feasible to subject structures to subsidence effects whilst maintaining them in a safe, serviceable and repairable state, the Panel is conscious of the risk posed if there are inadequacies in the subsidence management processes and plans that underpin Extraction Plans. A robust subsidence management system is also important in addressing the implications associated with future changes in the mine layout on which this assessment is based. Therefore, the Panel reviewed the current processes for managing subsidence in order to provide it with a basis for evaluating the EA. The statutory components of these processes have already been summarised in Chapter 3.

The capacity of infrastructure to tolerate subsidence effects whilst remaining in a safe and serviceable state is determined primarily by the flexibility of the structures and the sensitivity of gradient reliant services (such as, gutters, sewerage and drainage) to changes in slope and tilt. Structures need to be either sufficiently rigid such that they are able to move as a single body, or they need to be sufficiently flexible that they can tolerate the differential movements associated with subsidence. This could include a facility for adjustment as subsidence movements are occurring so the structure remains within designated tolerance levels.

The rate at which subsidence movements develop reduces with increasing depth. Table 21 records currently known peak and average rates for vertical displacement, closure and upsidence based on case studies at depths of more than 400 m in the Southern Coalfield. The rates are quite slow and thus provide opportunity for periodic adjustment to infrastructure during the subsidence process. A similar situation appears to exist in the case of anomalies (unexpected, non-systematic movements such as sometimes associated with faults). The EA reports that the largest known case of anomalous movement in the Southern Coalfield occurred above Appin Longwall 408[453]. The rate of differential movement across the known fault at the time that it could first be detected was less than 0.5 mm/d. Subsequently, as mining progressed, this increased to about 4 mm/day (28 mm/week).

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[452] *Safe* means no danger to users; *Serviceable* means available for its intended use*; Repairable* means damaged components can be repaired economically. (DoP, 2009b).
[453] EA. Appendix A, p.101.

Table 21: Typical Rates for Subsidence Development in the Southern Coalfield for Depths Greater than 400 m

Parameter	Peak Rate	Average Rate
Vertical displacement	39 mm/d	20 mm/d
Closure	14 mm/d	5 mm/d
Upsidence	8 mm/d	3 mm/d

Critical items of infrastructure recently undermined or soon to be undermined in the Southern Coalfield are Cataract Tunnel and the Upper Canal (progressively undermined by Appin Colliery since 1997), the Main Southern Railway (recently undermined by Tahmoor Colliery) and the Hume Highway (about to be undermined by Appin Colliery). The Panel inspected the Upper Canal and Simpsons Creek Aqueduct, Figure 42, which were undermined in 2009 by Longwall 409 at Appin Colliery. The aqueduct was subjected to more than 750mm of vertical displacement and over 200 mm of valley closure. Figure 43 to Figure 45 illustrate some of the mitigation measures applied to this infrastructure. Some measures, such as raising the walls of the canal to compensate for vertical displacement, were a once off prior to the commencement of mining whilst others, such as jacking and realignment of the aqueduct, Figure 45, were undertaken periodically during mining.

The Panel also inspected gas pipelines undermined by Longwalls 32 and 33 at West Cliff Colliery, Figure 46. Prior to mining, the pipelines were uncovered, trenches were widened and flexible joints installed at some locations to decouple the pipelines from the ground in order to accommodate vertical displacement, systematic strain and closure. Some other subsidence mitigation measures inspected by the Panel were a high voltage transmission tower that had been retrofitted with a rigid cruciform foundation, Figure 47, and sliding switch blades inserted into the Main Southern Railway and supported with real time monitoring, Figure 48.

Figure 42: Simpsons Creek Aqueduct

Figure 43: Increase in Height of Walls of Upper Canal to Mitigate Vertical Displacement

Figure 44: Rubber Bellows Fitted into Simpsons Creek Aqueduct to Mitigate Valley Closure

Figure 45: Jacking and Packing of Simpsons Creek Aqueduct to Accommodate Upsidence

Figure 46: Decoupling of Pressurised Gas Pipelines and Water Main from Ground Movements, Mallaty Creek

Figure 47: A High Voltage Transmission Tower above West Cliff Colliery Retrofitted with a Rigid Cruciform Foundation to Mitigate Differential Subsidence Movements[454]

[454] Photograph sourced from field inspection notes provided by ICHPL.

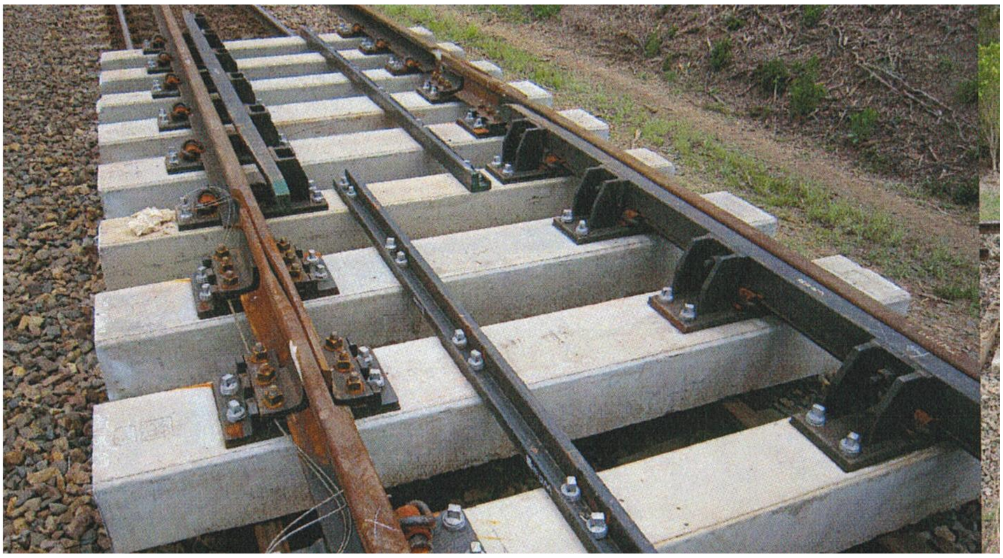

Figure 48: Switch Points and Real Time Monitoring Installed in the Main Southern Rail Line above Longwall 703 at Appin Colliery to Manage Mining Induced Strain in the Rails[455]

Figure 42 to Figure 48 illustrate a few of the engineering measures already adopted in the Southern Coalfield to mitigate subsidence related risks. However, their effectiveness is still highly dependent on the robustness of the subsidence risk management system of which they are an element.

11.2.2. Leading Practice

Leading practice in NSW for effectively managing subsidence impacts and consequences is based on a risk management approach that mirrors *Australian/New Zealand Standard 4360 - 2004: Risk Management*, superseded in November 2009 by *International Standard ISO 31000: Risk Management – Principles and Practice.* This Standard provides a framework for adopting an integrated and comprehensive approach to managing risk associated with both threats and opportunities.

Examples of leading practice in managing subsidence risk in NSW are mostly associated with mining in the vicinity of critical items of infrastructure. The Panel acknowledges that such robust management plans may not be required for all infrastructure that falls within the zone of influence of mining. However, because the BSO Project has the potential to impact on critical infrastructure and on areas of high infrastructure density, the Panel has undertaken a review of leading practice in managing subsidence to aid in formulating its recommendations to government.

11.2.3. Process Implementation

The basic steps in managing any type of risk are:

1. Identify the threats that can cause an unwanted event and devise controls that reduce the likelihood of the event occurring to some designated (acceptable) level.

[455] Photograph sourced from field inspection notes provided by ICHPL.

2. Prepare contingency plans for reducing the consequences of the event to some designated (acceptable) level if the event were still to occur.

A so-called *Bowtie Diagram* is one means of illustrating this process, Figure 49. Trigger Action Response Plans (TARPs) find extensive use in managing the threats (left side of diagram) so that they do not result in an adverse event. A TARP is a plan designed to prevent a threat from escalating by identifying potential precursors, or triggers, assigning a hierarchy of alarms or trigger levels to each potential precursor, and specifying responses for each trigger level. Contingency plans find application (right side of diagram) for managing each consequence arising out of the adverse event. Both TARPs and Contingency Plans should be subjected to risk assessment in developing a robust risk management plan.

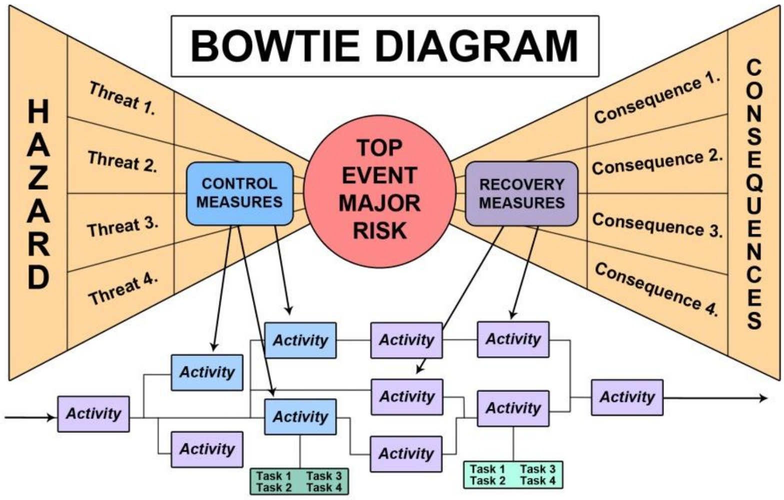

Figure 49: A Bowtie Diagram Showing the Process for Minimising both the Likelihood of a Hazard Developing into an Unwanted Event and the Consequences Associated with the Event

The basic steps in the process for managing subsidence of infrastructure are those provided to the Panel by Illawarra Coal,[456] namely:

1. Identify structures
2. Consult infrastructure owners
3. Undertake engineering assessment
4. Subject engineering assessment to independent review
5. Establish project governance framework
6. Develop appropriate management responses
7. Project manage the required responses.

[456] ICHPL (2010e).

These steps are developed into a risk management plan through a process of stakeholder consultation, risk assessment[457] and independent review. There is no 'one size fit all' approach or model.

In the case of the recent undermining of the Upper Canal and Simpsons Creek Aqueduct, the process led to the development of an Asset Protection Plan (APP) that addressed subsidence predictions, engineering assessments, preventative and remedial measures, risk assessments and heritage values. Monitoring procedures, TARPs and contingency plans underpinned a master agreement.

This plan was supported by a governance structure that provided for:

1. A Steering Committee comprising the principal stakeholders;

2. A Technical Review Panel comprising three independent experts;

3. A Technical Committee comprising technical services personnel and consultants employed by the principal stakeholders;

4. A Construction Committee comprising stakeholder representatives and contractors engaged to undertake and oversee mitigation, contingency and remediation measures.

5. Successful implementation of the management plan was dependent on two factors, namely:

6. The timely monitoring of the structures and the implementation of appropriate responses to the monitoring outcomes, and

7. Timely and effective communications in accordance with a pre-determined chain of command.

Accordingly, protocols were developed for both of these.

The monitoring data review process is shown in Figure 51. Figure 50 shows that this element of risk management was structured into the governance process in a manner that simultaneously informed both the infrastructure owner and the technical personnel overseeing the project.

[457] Risk Assessment - *The overall process of risk identification, risk analysis and risk evaluation*: ISO 31000

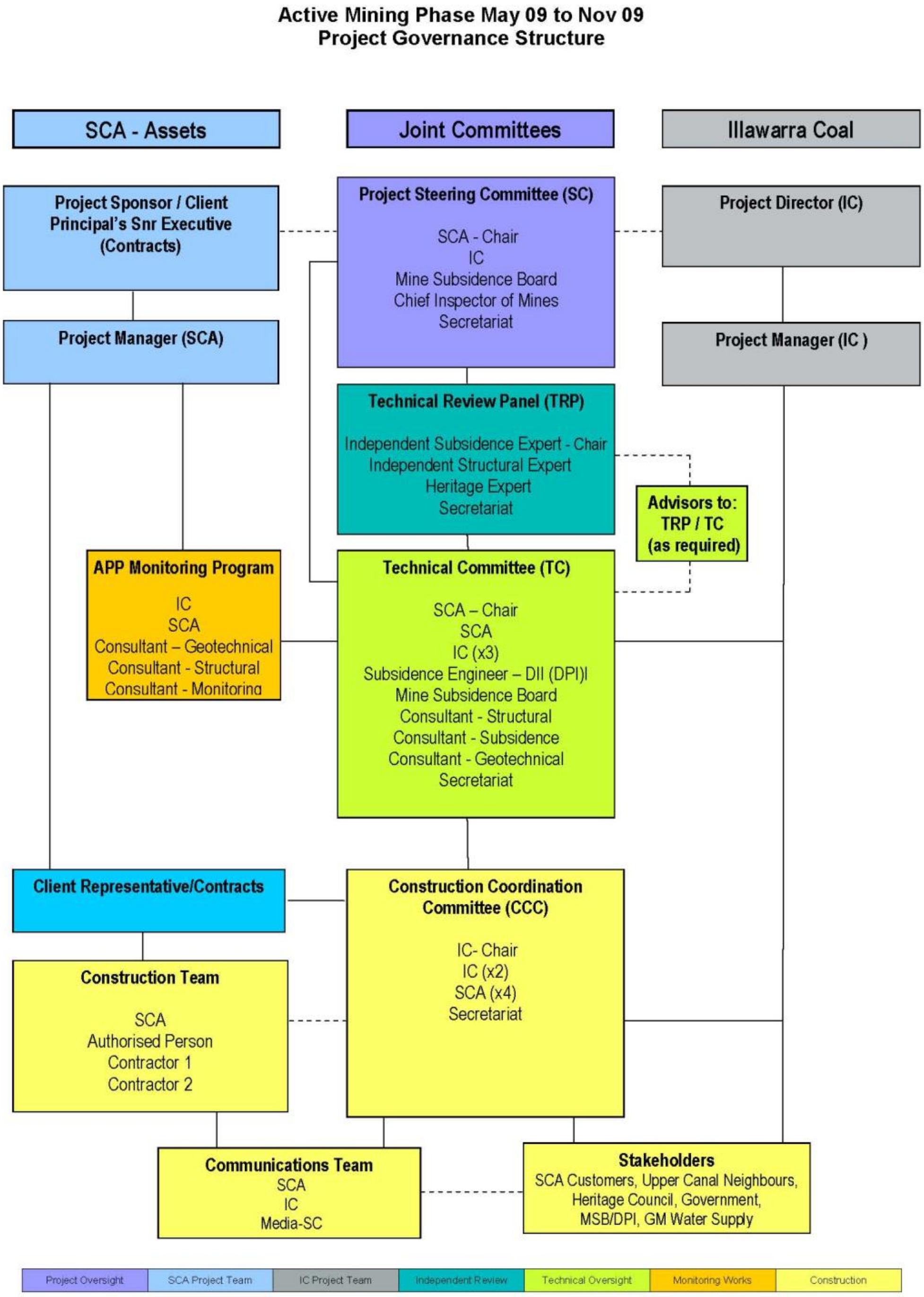

Figure 50: Governance Structure for the Undermining of Simpsons Creek Aqueduct and the Upper Canal

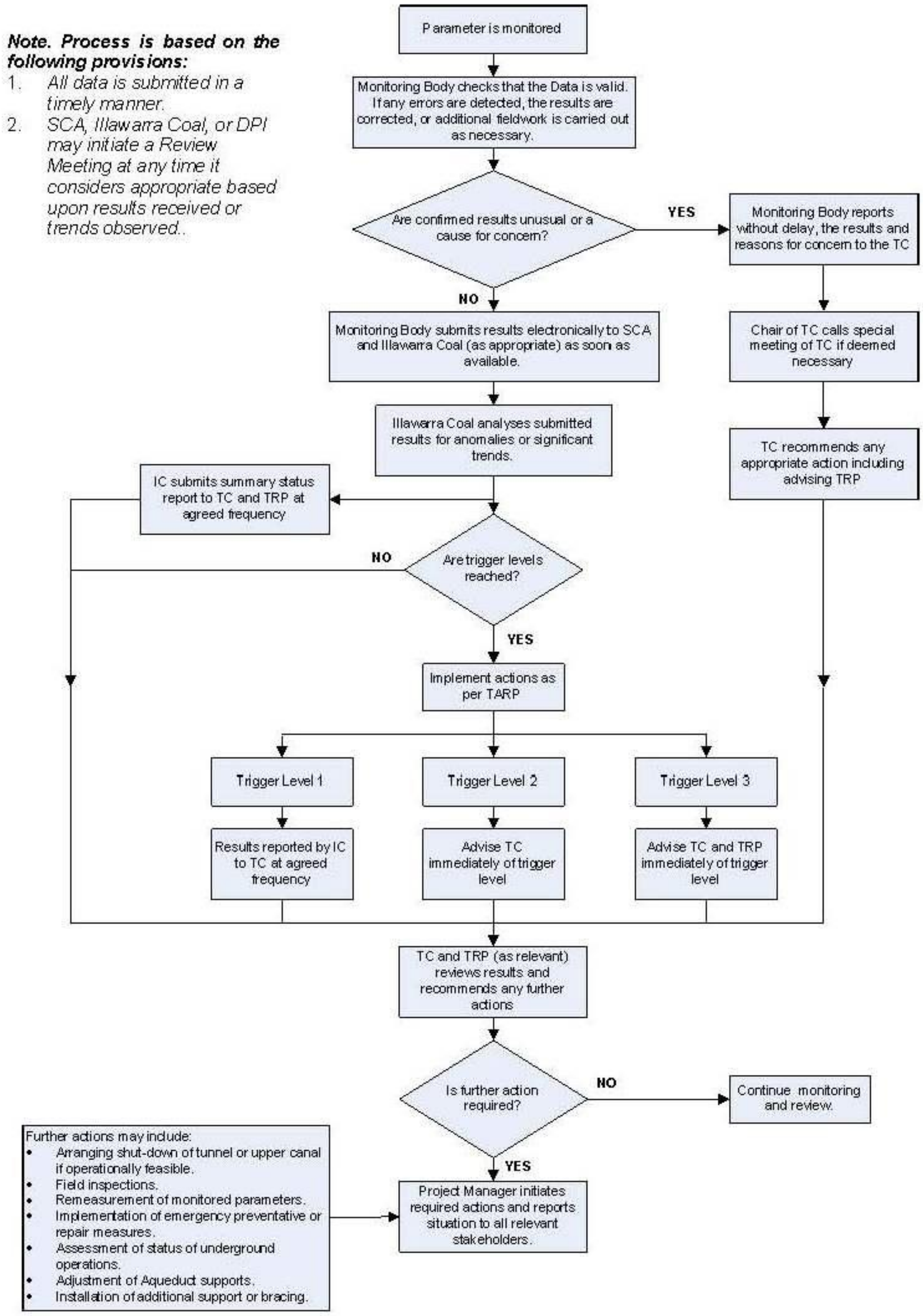

Figure 51: Monitoring Data Review Process for Managing Risk Arising from Subsidence Movements during Undermining of Simpsons Creek Aqueduct and the Upper Canal

11.3. FRAMING RECOMMENDED APPROVAL CONDITIONS

The words *leaseholder* and *mining company* and *mine operator* and other variants are used in an interchangeable manner throughout the Panel's report on Built Infrastructure when referring to entities responsible for conducting the coal mining operations. This is adequate for the Panel's purpose. However, the Department of Planning will need to ensure that the correct legal entity is required to assume responsibility for actions/costs in relation to any conditions of approval where this may be relevant.

A number of the Panel's recommendations are framed in term of the infrastructure owner having the *prima facie* right to determine what is *safe, serviceable and repairable* for their purposes. *Safe* means no danger to users; *Serviceable* means available for its intended use*; Repairable* means damaged components can be repaired economically[458]. This condition recognises: the critical importance of some of the infrastructure to the State; the fact that the appropriate knowledge and expertise regarding the design and serviceability of the infrastructure is most likely to reside with the infrastructure owner; and the fact that the accountability for maintaining the infrastructure in a safe, serviceable and repairable state resides with the infrastructure owner.

11.4. MAIN SOUTHERN RAILWAY

11.4.1. Scope

An 18.2 km stretch of the Main Southern Railway overlies Area 7, Area 8 and Area 9. The railway line is a dual track consisting of 60 kg rail on concrete sleepers. Speed limits on both tracks range between 95 km/hr and 115 km/hr for normal services and between 105 km/hr to 140 km/hr for XPT services. There is one track junction in this section and a second will be required if and when the Maldon-Dombarton Railway is completed. Major and minor structures associated with the railway include stations, viaduct, bridges, culverts, cuttings, embankments, level crossings, and signalling and telecommunications equipment.

Appendix A in the EA presents subsidence parameters calculated along the length of the railway for the Base Case mine layout. It notes however, that these parameters could vary if the Base Case layout is changed and that it is possible that any point along the railway could experience subsidence movements that are similar to the maximum regional predicted total subsidence movements for Areas 7, 8 and 9. These movements are all higher than those predicted for the current mine layout and are recorded in Table 22. The Panel notes that this analysis of changes to the Base Case layout did not include the implications of a change in longwall panel width.

Table 22: Maximum Predicted Subsidence Parameters for Areas 7, 8 and 9 for Base Case Longwall Panel Width

Parameter	Prediction	Mining Domain
Total vertical displacement	1600 mm	Area 7
Total tilt	8.0 mm/m	Area 7
Total systematic tensile strain	1.4 mm/m	Area 7
Total systematic compressive strain	2.3 mm/m	Area 7

458458 (DoP, 2009b).

Maximum predicted non-systematic movements occur in Area 9 and are:

- Closure: 300 mm
- Upsidence: 430 mm

A number of geological structures intersect the railway. Appendix A notes the experience over Longwall 408 at Appin Colliery in this regard, where the maximum rate of differential movement was 28 mm per week[459].

11.4.2. Subsidence Effects, Impacts and Consequences

It is reported that at the time of preparing Appendix A, Longwall 25 at Tahmoor Colliery had been successfully extracted directly beneath the Main Southern Railway. However, the Panel is uncertain what weight to place on the successful outcome at Tahmoor because the EA provides no subsidence parameters as a point of reference.

The EA notes that a Rail Technical Committee has been formed to coordinate the development of the risk management strategies for undermining the Main Southern Railway by Longwall 703 at Appin Colliery (which is already approved and working to a SMP). This Committee includes representatives from Australian Rail and Track Corporation (ARTC), Illawarra Coal Holdings (ICHPL), the leaseholder (Tahmoor Colliery, owned by Xstrata), the DII, the MSB and specialist consultants in the fields of railway track engineering, geotechnical engineering, structural engineering, track signalling, mine subsidence, risk assessment and project management. As such, the project appears to have been based on a similar risk management approach to that for the undermining of the Upper Canal and Simpsons Creek Aqueduct noted in Section 11.2.2.

Appendix A provides a suite of predictions and profiles of subsidence effects and then reviews how these may impact a railway. The review forms the basis for the following conclusions in the EA:

1. The maximum allowable deviations specified in the ARTC standards are almost an order of magnitude greater than the predicted systematic subsidence movements. However, Appendix A also notes that the subsidence predictions are based on survey pegs that are nominally 20 m apart (that is, averaged over a 20 m interval) whilst the track geometry measurements are based on a shorter interval. A number of factors are presented which are claimed to give confidence in the applicability of the predicted subsidence movements.

2. Mine subsidence could result in changes in track geometry that exceed ARTC Standards due to:

    i. Substantial non-systematic movements (e.g. faulting causing a step in the ground). The EA compares the maximum rate of differential movement of 28 mm per week for the fault above Appin Longwall 408, with ARTC standards of maximum allowable deviations in track geometry of between 35 mm and 43 mm for the first speed limit and 46 mm to 75 mm before trains

[459] EA, Appendix A, p.104.

must be stopped. It reports that the Rail Technical Committee has developed procedures to manage the potential risk to track geometry and summarises these before concluding that:

'With an appropriate management plan in place, it is considered that potential impacts to track geometry can be managed for any orientation of longwalls within the Extents of the Longwall Mining Area, even if actual subsidence movements are greater than the predictions or substantial non-systematic movements occur'[460].

ii. The track becoming unstable as a result of rail stress or loss of support.

A change in temperature causes a rail track to expand or contact which in turn induces stress in the track that can cause it to buckle in compression or to crack in tension. Railway engineers use change in the 'stress free temperature' as a measure of the stress induced in a rail. If 100% of the predicted ground strains are transferred to the rail track, it is reported that the impact is equivalent to a change in stress free temperature of 100°C. By comparison, a change in stress free temperature of approximately 14°C is sufficient to warrant immediate preventative action on a track with concrete sleepers. Therefore the Rail Technical Committee has introduced a combination of rail expansion switches and zero toe load clips which permit sections of rail to slide past each other so as to dissipate mining and temperature related rail stress. This mitigation measure has previously been trialed in the Hunter Valley and utilized at Tahmoor Colliery in the Southern Coalfield. The Panel inspected a switch point that had been installed in the Main Southern Railway above Appin Longwall 703, Figure 48. It was complemented with real time monitoring and a range of management measures detailed in the EA[461].

The EA draws a similar conclusion to that noted earlier, viz:

'With an appropriate management plan in place, it is considered that potential impacts to rail stress track geometry can be managed for any orientation of longwalls within the Extents of the Longwall Mining Area, even if actual subsidence movements are greater than the predictions or substantial non-systematic movements occur'[462].

The EA goes on to review major structures associated with the affected section of railway before drawing a similar conclusion to that noted above in each case. This conclusion has been prefaced in a number of instances with a statement that the Rail Technical Committee will consider mitigation measures before each structure experiences subsidence movement. It also discusses likely subsidence impacts on embankments. The Panel notes that these embankments are constructed in Wianamatta Shale and that some are relatively high and steep (e.g. that shown in Figure 6.11 of Appendix A). It appears to the Panel that the risk management measures for these slopes may not be as detailed and not aligned to those proposed elsewhere in the EA for steep slopes in Wianamatta Shale environments. If so, this is a concern given the severe consequences that might be associated with failure of a railway embankment.

The PAC did not receive any detailed submissions specific to the undermining of the Main Southern Railway. However, the DII used it as an example in bringing the Panel's attention

[460] EA, Appendix A, p.104.
[461] EA, Appendix A, p.106.
[462] EA, Appendix A, p.106.

to the number of *'potential high-impact subsidence issues'* associated with the BSO Project[463]. The Panel has a general awareness of the involvement of officers of the DII in plans to undermine the railway in the near future by Longwall 703 at Appin Colliery. Because subsidence effects are incremental at depth, a number of longwall panels will need to be extracted before the railway is subject to maximum subsidence effects. Hence, this will provide an opportunity to assess subsidence impacts incrementally.

11.4.3. Conclusions with Respect to the Main Southern Railway

The Panel concludes in respect of mine layouts for the longwall panel widths associated with the Base Case mine layout that:

1. The nature of subsidence impacts and consequences on the Main Southern Railway is a matter for specialist advice that does not reside within the PAC.

2. However, it appears to be technically feasible to undermine the Main Southern Railway in the manner proposed without adversely affecting public safety and the serviceability of the rail system.

3. The risk associated with a subsidence induced mishap could be extremely high unless appropriate controls are in place.

4. Effective risk management will be highly dependent on the composition and competence of the Rail Technical Committee and the Risk Management structure within which the Committee operates.

The Panel recommends that Performance Criteria in any Project Approval should include the following requirements:

1. Mining is not to impact on the safe operation of the Main Southern Railway. (This condition is not intended to exclude the application of temporary controls such as speed restrictions in order to achieve this performance outcome.)

2. Mining is not to impact on the serviceability of the Main Southern Railway. (This condition is not intended to exclude the closure of one or both tracks to permit mitigation and remediation works to be undertaken to a planned schedule agreed with the owner of the infrastructure. However, it is intended to limit unplanned outages to durations of no more than several hours, unless contingency planning provides for longer outages with the agreement of the infrastructure owner.)

3. The infrastructure owner has the *prima facie* right to determine what is *safe, serviceable and repairable* for their purposes, with any dispute with the leaseholder being referred to a neutral arbiter selected by the Department of Planning and funded by the leaseholder.

4. The leaseholder is to guarantee funding to undertake all risk assessment activities and all mitigation and remediate measures to return the Main Southern Railway to its pre-mining state as soon as practical after the completion of mining and to remediate any residual mining related impacts that may subsequently develop. This includes all the direct and indirect costs of the infrastructure owner in participating in this risk

[463] DII (2009b).

management process. (Given the incremental nature of subsidence development, a number of remediation campaigns may be required.)

5. All activities related to undermining the Main Southern Railway are to be structured within a risk management framework that is consistent with *ISO 31000 Risk Management*.

6. The risk management system for undermining the Main Southern Railway is to be:

    i. Audited externally for compliance with ISO 31000 prior to lodgment of associated Extraction Plans, with the auditor/s to be selected by the Department of Planning in consultation with the infrastructure owner, and the audit report to accompany the Extraction Plan application.

    ii. Audited externally for compliance with ISO 31000 on an annual basis for the duration that the plan is invoked, with the auditor/s to be selected by the Department of Planning in consultation with the infrastructure owner.

    iii. Reviewed externally for effectiveness on an annual basis for the duration that the plan is invoked, with the reviewer to be selected by the Department of Planning in consultation with the infrastructure owner.

7. No Extraction Plan should be approved that could create any additional risk to the public from undermining of the Main Southern Railway, until all potential sources of the increased risk have been investigated to the satisfaction of the Director-General of the Department of Planning and the proposals in the Extraction Plan for avoidance, mitigation or control of any such risks ensure that users of the Main Southern Railway are not exposed to additional danger.

11.5. HUME HIGHWAY

11.5.1. Scope

The Hume Highway is a dual carriageway highway constructed with an asphaltic pavement on a slag road base and stabilized crushed sandstone sub-base. It carries in excess of 20 million tonnes of road freight per annum and current traffic volumes are in excess of 37,000 vehicles per day. Mining in Area 7, Area 8 and Area 9 has the potential to affect 13.4 km of the highway, although predicted subsidence effects for the Base Case longwall panel widths in Area 9 are very small. There are a number of highway structures within or near the Study Area, the major ones comprising bridges, a subway, an interchange and a rest area[464]. There are also a number of smaller structures including culverts, cuttings, embankments, emergency phone systems and road signage.

The EA presents subsidence parameters calculated along the length of the highway for the Base Case mine layout. It notes, however, that these could vary if the Base Case layout is changed and that it is possible that any point along the highway could experience subsidence movements that are close to or similar to the maximum regional predicted total subsidence movements for Area 7 and Area 8 (for the Base Case longwall panel widths). These maximum regional movements are all higher than those predicted for the current mine layout and occur in Area 7. Hence, they are the same as those already recorded in Table 22.

Maximum predicted non-systematic movements occur across a small watercourse in Area 8 and at the Moolgun Creek Bridges over Allens Creek, Table 23. Appendix A also reports that a study of geological structures at seam level identified a number of structures that may intersect the highway and could potentially induce anomalous movements.

Table 23: Predicted Maximum Closures and Upsidence along the Hume Highway in the Study Area for the Base Case Longwall Panel Widths

Location	Predicted Closure	Predicted Upsidence
Watercourse – Area 8	200 mm	350 mm
Moolgun Creek Bridges – Allens Creek	610 mm	270 mm

There is extensive experience throughout the world of undermining secondary and tertiary roads. There is much less experience in undermining highways, although highways have been undermined and subsided in both the Wollongong and Newcastle regions. The Hume Highway is distinguished from these past experiences by its construction method, traffic volume and scale, both laterally and longitudinally. The considerable width of the highway corridor and the distance over which it will be directly undermined, increase the exposure of the highway to subsidence impacts. The Panel is not aware of any precedent for mining in the vicinity of so many major bridge structures that are prone to valley closure and upsidence. Both the large number of structures (which increases the likelihood of one being adversely impacted) and the severe consequences associated with a critical structure becoming

[464] EA, Appendix A, p.117.

unserviceable (e.g. a Hume Highway bridge), elevate the risk associated with mining in the vicinity of these structures.

11.5.2. Subsidence Effects, Impacts and Consequences

The primary components of the Hume Highway that may be impacted by subsidence are the pavement, drainage systems, bridges, overpasses and underpasses. Appendix A of the EA reports that a Technical Committee has already been established to develop an infrastructure risk management plan to safely manage impacts to pavements. This committee has identified that there is potential risk that mine subsidence may result in the development of steps in roadway pavement due to the presence of the stiff bound sandstone layer and that stepping failures have occurred as a result of mine subsidence on two occasions on the F6 Freeway. Step failures present a serious risk to cyclists and to traffic travelling at high speed.

The EA states that it has been identified that the potential impact of mine subsidence on the pavement can be substantially reduced by dissipating pavement strain through cutting slots in the pavement. These are to be installed prior to the development of subsidence movements, with a contingency for the development of additional slots during mining should monitoring detect an unexpected build up of strains that may result in stepping. It is stated that these unexpected strains may be due to non-systematic movements.

Longwalls 703 and 704 at Appin Colliery have already been approved through the SMP process to undermine the Hume Highway. Some of the mitigation works undertaken for this project were pointed out to the Panel during one of its field inspections. They include slots cut into the pavement and real time monitoring of movement utilising fibre optical cable embedded in the pavement. As the full impacts are not likely to be experienced until several adjacent longwall panels have been extracted, the Panel is not in a position to rely on past experience to assess likely impacts. However, monitoring will need to be vigilant and response plans robust in order to control risks that may be associated with stepping failures.

Appendix A identifies a range of bridge, overpass and underpass structures along the affected area of the Hume Highway and discusses mitigation and remediation measures for these. The Panel has selectively summarised the content of the EA in this regard, Table 5. It is apparent that the identification and control of mitigation and remediation measures is in its infancy. The EA consistently proposes that the process for mining near or under these structures will involve monitoring, TARPs, and reporting and communication plans. The Panel has taken into consideration the precedent for managing subsidence impacts on the Twin Bridges at Douglas Park associated with longwall mining at Tower Colliery some 10 years ago[465]. It has also placed weight on the RTA submissions.

[465] EA, Appendix A, p.124.

Table 24: Selective Summary of Information Pertaining to Bridges, Overpasses and Underpasses in Appendix A of the EA

Structure	Domain	Offset			Mitigation & Remediation
		Over LW	deg °	m	
Twin Bridges - Menangle	Area 7	No	35	370	-Limited capacity for differential movement -ICHPL and RTA to study potential for modifications to bridge bearings -Adjust mine plan to increase offset -Monitoring and realign bridge
Twin Bridges – Douglas Park	Area 9	No	-	1000	-Mitigation measures previously undertaken -Technical Committee has undertaken detailed studies -Realign bridge
Moolgun Bridges	Area 8	No	35	300	-Limited capacity for differential movement without modifications to bearings and provision for realignment -ICHPL and RTA to study potential management and mitigation measures including modifications to bridge bearings
Twin Bridges – Pheasants Nest	Beyond Area 8	No	-	1000	-ICHPL and RTA to study potential for management and mitigation measures
Moreton Park Road Bridge	Area 7	Yes	-	-	-Limited capacity to accommodate differential movement -ICHPL and RTA to study potential for management and mitigation measures -Adjust mine plan to increase offset
Moreton Park Road Bridge (South)	Area 9	No	-	210	-Technical Committee has undertaken detailed studies -Additional footings already installed -Provision to provide additional support
Douglas Park Drive Bridge	Area 8	No	-	350	-ICHPL and RTA to study potential for management and mitigation measures
Access Bridge to Private Property	Area 8	Yes	-	-	-ICHPL and RTA to study potential for management and mitigation measures
Picton Road Bridge and Interchange	Area 8	-	-	>400	-ICHPL and RTA to study potential for management and mitigation measures
Subway	Area 8	Yes	-	-	-ICHPL and RTA to study potential for management and mitigation measures

The EA reports that:

> *'ICHPL and the Roads and Traffic Authority of NSW (RTA) are jointly developing detailed risk management strategies for effectively managing potential mine subsidence impacts to the Hume Highway due to the mining of Longwalls 701 to 704 at Appin Colliery.*
>
> *The management structure established through an agreed Terms of Reference comprises:*
>
> - *a Steering Committee chaired by the RTA, with senior representatives from the RTA, ICHPL, the Mine Subsidence Board (MSB), and*
> - *a Technical Committee chaired by the RTA and reporting to the Steering Committee, with representatives from the RTA, ICHPL, MSB, DII, selected specialists as required from the fields of geotechnical engineering, pavements, bridges, traffic management, mine subsidence, risk assessment, modelling and project management.*
>
> *Works by the Technical Committee include:*
>
> - *Identification of all potential mechanisms for impacts to the highway,*
> - *Identification of geological structures in the surface geology that may respond in a non-systematic manner as a result of mine subsidence,*
> - *Undertaking a risk management approach, where all identified risks are assessed and risk control measures are implemented,*
> - *Improving the current knowledge base by undertaking trials, and*
> - *Development of management measures that include mitigation and preventive works, monitoring plans, triggered response plans, traffic plans and communication plans.*
>
> *An assessment of potential impacts and development of risk management measures will be undertaken jointly by the RTA and ICHPL through the Technical Committee. The Committee will review the performance of the management measures following the mining of each longwall'.*[466]

In its submission to the DoP, the Roads and Traffic Authority states:

> *'The Proposal has the potential to impact on a number of highly significant State Classified Roads which are maintained by the RTA. These roads are the Hume Highway (HW2), Picton Road (MR95/MR612) and Appin Road (MR177). The RTA considers that the proponent must ensure that the Proposal does not in any way compromise functionality of these roads, the infrastructure itself or road safety.'*[467]

[466] EA, Appendix A, p.121.
[467] RTA (2009).

The Panel has noted the word *'compromise'* and concluded from the discussions that follow that it has the meaning of *serviceability*.

ICHPL responded that:

> *'The Road Technical Committee would develop management measures to ensure the safe operation of the highway during mining and would review the performance of the management measures following the mining of each longwall.'*[468]

The RTA also stated:

> *'The RTA understand that the proponent would be required to prepare a Built Features Management Plan (BFMP) to manage, and where necessary ameliorate, the impacts of the Proposal on any third parties including the RTA. The RTA has significant concerns that the BFMP only requires the proponent to consult with the RTA. Notwithstanding this, the RTA expects that the following would be undertaken:*
>
> *- Prior to the commencement of mining activities the proponent shall be required to enter into a Deed of Agreement with the RTA, indemnifying the RTA from consequences of mining, and undertaking to pay any costs for monitoring, mitigation or remediation not funded by the Mine Subsidence Board (MSB)....*
>
> *- Formation of a Steering Committee with executive representation from relevant stakeholders including the proponent, the RTA, the MSB, Department of Primary Industries and if appropriate, the Department of Planning.*
> *- Formation of a Technical Working Party with representation as for the steering committee, to develop recommendations for monitoring, mitigation, remediation and management measures. The body would provide technical input to the Steering Committee.*
> *- Undertaking a formal risk assessment for the potential impacts on State Classified Roads and infrastructure, including any far field effects, with consideration of the risks to:*
>
> - *RTA infrastructure............*
> - *Functionality of the aforementioned State Classified Roads – need for traffic management or speed reduction during mining.*
> - *Road Safety and risk to life from subsidence impacts on the aforementioned State Classified Roads.'*[469]

ICHPL responded to selected paragraphs stating that ICHPL agrees with the formation of a Steering Committee and a Technical Working Party and has worked under the same regime successfully with the RTA in the past.[470]

RTA goes on to state that it:

> *'........... will not accept any subsidence from mining directly affecting any bridges on any of the above State roads.'*[471]

[468] ICHPL (2010a).
[469] RTA (2009).
[470] ICHPL (2010a).

The Panel is unsure whether the use of the word *'directly'* is an RTA reference to subsidence *effects* or to subsidence *impacts*. ICHPL (2010a) has responded that:

> *'ICHPL commits to maintaining all bridges in a safe, serviceable and repairable condition throughout the mining period. Management plans would be developed for each bridge on State roads in consultation with the RTA.'*

The Panel notes that the term *'mining period'* is open to interpretation. It recommends that any approval conditions which rely upon this commitment define the term to mean *'until the structure (of interest) is beyond the field of influence of any mining undertaken by the leaseholder'*.

The RTA also states that:

> *…the RTA considers that any future mining that has the potential to impact on the Hume Highway (or other State roads) must be subject to an assessment of the findings from the Area 7 experience and review.*

ICHPL agrees with this RTA requirement, stating that future Extraction Plans for mining in the vicinity of State roads would be informed by the current mining of Longwalls 703 and 704 and repeating the commitment contained in the EA that the Technical Committee will review the performance of the management measures following the mining of each longwall[472]. During the course of informal discussions during this assessment process, the Panel received a number of reports that the risk management structure currently invoked to manage any impacts and consequences arising from undermining the Hume Highway with Longwall 403 was effective.

The Panel notes that the RTA also submitted that if it is not satisfied that the impacts of the mining will be appropriately managed, the RTA will not provide Section 138 concurrence/consent under the Road Act 1993 for works under a State Classified Road. Section 138 of the Roads Act 1993 states that *'a person must not erect a structure or carry out a work in, on or over a public road, or dig up or disturb the surface of a public road etc.'* The Panel sought advice on this issue and has been informed that under s.75V of the EP & A Act, as long as it is necessary for an approved project, the RTA cannot refuse to give a consent under section 138 of the Roads Act 1993. to *..(b) dig up or disturb the surface of a public road*. This situation will therefore need to be addressed in the Approval Conditions given the significance of the potential disruption if any of the main road thoroughfares are disturbed.

There is potential for the BSO Project to also impact on pavement drainage, highway cuttings, embankments, highway rest areas and communication and signage. The Panel accepts as reasonable the EA assertions in relation to these structures that, with appropriate risk management plans in place, the potential impacts should be able to be managed for any orientation of longwalls within the Extents of Longwall Mining Areas, even if actual subsidence movements are greater than the predictions or substantial non-systematic movements were to occur.

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[471] RTA (2009).
[472] ICHPL (2010a).

11.5.3. Conclusions with Respect to the Hume Highway

The Panel concludes that:

1. The nature of subsidence impacts and consequences on the Hume Highway is a matter for specialist advice that does not reside within the PAC.

2. Nevertheless, it may be feasible from a technical perspective to undermine the Hume Highway in the manner proposed without adversely affecting public safety and the serviceability of the highway.

3. There is an increased level of risk when mining in the vicinity of bridges associated with the Hume Highway. This because some of the bridges span deep gorges, some have not been designed to tolerate the predicted levels of subsidence, and a reduction in or total loss of serviceability of a bridge could have very serious consequences for community and the economy.

4. Effective risk management will be highly dependent on the composition and competence of the Technical Committee and the Risk Management structure in which the Committee operates.

5. There is a need for a robust Extraction Plan process to manage subsidence impacts and for extreme caution when mining in the vicinity of critical infrastructure and infrastructure that might present a risk to public safety if it were to be impacted adversely.

The Panel recommends that Performance Criteria in any Project Approval should include the following requirements:

1. Mining is not to impact on the safe operation of the Hume Highway. (This condition is not intended to exclude the application of temporary controls such as speed restrictions in order to achieve this performance outcome.)

2. Mining is not to impact of the serviceability of the Hume Highway. (This condition is not intended to exclude the closure of one of the dual carriageways from time to time to permit mitigation and remediation works to be undertaken. However, it is intended to exclude simultaneous closure of both carriageways for other than isolated periods restricted to several minutes duration. Alternative traffic flow arrangements, such as contra-flow, are to be in place prior to undermining any section of highway that may need to be closed for more than several minutes.)

3. The infrastructure owner has the *prima facie* right to determine what is *safe, serviceable and repairable* for their purposes, with any dispute with the leaseholder being referred to a neutral arbiter selected by the Department of Planning and funded by the leaseholder.

4. The leaseholder is to guarantee funding to undertake all risk assessment activities and all mitigation and remediate measures to return the Hume Highway to its pre-mining state as soon as practical after the completion of mining and to remediate any residual mining related impacts that may subsequently develop. This includes all the direct and indirect costs of the infrastructure owner in participating in this risk management

process. (Given the incremental nature of subsidence development, a number of remediation campaigns may be required.)

5. All activities related to undermining the Hume Highway are to be structured within a risk management framework that is consistent with *ISO 31000 Risk Management*.

6. The risk management system for undermining the Hume Highway is to be:

    i. Audited externally for compliance with ISO 31000 prior to lodgment of associated Extraction Plans, with the auditor/s to be selected by the Department of Planning in consultation with the infrastructure owner, and the audit report to accompany the Extraction Plan application.

    ii. Audited externally for compliance with ISO 31000 on an annual basis for the duration that the plan is invoked, with the auditor/s to be selected by the Department of Planning in consultation with the infrastructure owner.

    iii. Reviewed externally for effectiveness on an annual basis for the duration that the plan is invoked, with the reviewer to be selected by the Department of Planning in consultation with the infrastructure owner.

7. No Extraction Plan should be approved that could create any additional risk to the public from undermining of the Hume Highway until all potential sources of the increased risk have been investigated to the satisfaction of the Director-General of the Department of Planning and the proposals in the Extraction Plan for avoidance, mitigation or control of any such risks ensure that users of the Hume Highway are not exposed to additional danger.

Furthermore, given the significance of the potential disruption if any of the main road thoroughfares are disrupted, the effect of any approval under s.75V of the EP & A Act on the RTA's powers to exercise control over mining impacts on state roads under Section 138 of the Road Act 1993 will need to be addressed in the Approval Conditions[473].

[473] Assuming that the advice to the Panel on this matter is correct.

11.6. Roads

Table 25, prepared from information in the EA, summarises the major roads and bridges within the Study Area and the maximum predicted systematic subsidence parameters for each mining domain for the Base Case layout. It reveals that 49.2 km of major roads and two bridges are located directly above the proposed longwall panels. A range of other structures are associated with these roads including level crossings, culverts, cuttings, embankments, road signage and street furniture. With the exception of two roads managed by the RTA, the roads are managed by local councils.

Table 25: Summary of Major Roads and Bridges within the Study Area and Predicted Maximum Subsidence Effects for Each Mining Domain for Base Case Longwall Panel Widths

Domain	Roads above Longwall Panels		Bridges			Maximum Subsidence Prediction for Domain			
	Number	km	Above B & P	Above LW	Offset	Vert Disp (mm)	Tilt (mm/m)	Tensile Strain (mm/m)	Comp Strain (mm/m)
Area 2 & North Cliff	1	3.5	0	0	0	1400	11	2.4	5.3
Area 3	2	3.9	1	0	0	1250	7.5	1.7	2.9
West Cliff Area 5	1	2.2	0	0	0	1300	7.0	1.4	2.1
Area 7	3	17.1	2	2	0	1600	8.0	1.4	2.3
Area 8	3	9.8	1	0	3	1200	6.5	1.2	2.0
Area 9	4	12.7	2	0	0	1600	6.5	1.1	1.7
TOTAL		**49.2 km**	**6**	**2**	**3**				

The EA provides profiles of subsidence and tilt along the major roads in each domain from which it is concluded that the predicted maximum systematic vertical displacements range between 700 mm and 1600 mm and tilts range between 4 mm/m and 7 mm/m.[474] It reports that a number of local roads have been undermined by previous longwalls in the Southern Coalfield and that the impacts on these roads did not present a public safety risk; they were remediated using normal road maintenance. This largely concurs with the Panel's experience. However, the Panel has observed that some tension cracks and compression humps beyond roadway corridors could have implications for the safety of motor bike riders were they to develop on a road surface. It is expected that given the slow rate at which subsidence develops, this hazard could be managed effectively by robust monitoring and contingency plans. The Panel is also conscious that past experience may not be applicable to roads associated with steep slopes in the Razorback Range. All these subsidence effects are likely to be magnified as longwall panel width is increased.

Campbelltown City Council expressed concern at the public hearing regarding subsidence effects on the Menangle Road bridge. ICHPL responded that:

> *'ICHPL has committed to avoid mining directly beneath the Nepean River and hence beneath this bridge…….. As a component of the Extraction Plan process ICHPL*

[474] EA, Appendix A, p.145.

would, in consultation with Campbelltown City Council, Wollondilly Shire Council, Roads and Traffic Authority (RTA) and Industry and Investment NSW (I&I NSW), study the potential for impacts on the bridge and develop management measures to ensure that the bridge remains safe and serviceable throughout the mining period'.[475]

The Panel notes from reference to Drawing No: MSEC404-301 that the longwall layout shown for the Base Case is amenable to increasing the offset to this bridge through the Extraction Plan approval process.

The EA presents a range of initiatives for managing subsidence of local bridges. These involve management plans developed in consultation with local councils. It also proposes the use of management plans for controlling potential impacts on culverts, cuttings and embankments. The Panel is satisfied on the basis of past experience that subsidence impacts on these structures can be controlled in a manner that maintains them in a safe and serviceable state. Once again, however, this is highly dependent on the rigor of the Extraction Plan and the associated risk management processes. The Panel is also conscious of the potential cost impost on rate payers and the (limited) technical resources of local councils to assess mining plans and subsidence outcomes.

11.6.1. Conclusions with Respect to Roads

The Panel recommends that Performance Criteria in any Project Approval should include the following requirements:

1. Mining is not to impact on the safe use of roads in the Study Area.

2. Mining is not to impact on the serviceability of roads in the Study Area. (This condition is not intended to exclude the application of temporary controls such as speed restrictions in order to achieve this performance outcome.)

3. The leaseholder is to guarantee funding to undertake all risk assessment activities and all mitigation and remediation measures to return roads to their pre-mining state as soon as practicable after the completion of mining and to remediate any residual mining related impacts that may subsequently develop. This includes all the direct and indirect costs of the infrastructure owner in participating in this risk management process. (Given the incremental nature of subsidence development, a number of remediation campaigns may be required.)

4. All activities related to undermining road networks are to be structured within a risk management framework that is consistent with *ISO 31000 Risk Management*.

5. No Extraction Plan should be approved that could create any additional risk to the public from undermining of the roads within the Study Area until all potential sources of the increased risk have been investigated to the satisfaction of the Director-General of the Department of Planning and the proposals in the Extraction Plan for avoidance, mitigation or control of any such risks ensure that users of the roads are not exposed to additional danger.

[475] ICHPL (2010d).

11.7. FIRE TRAILS

There are numerous fire trails in the Study Area, many of which fall under the control of the SCA. The Panel notes the submission of SCA that:

> *'Based on past experience, the assessment, monitoring and management measures proposed with regards to impacts on SCA fire trails and four wheel drive tracks and Cataract Dam access road in the EA are considered appropriate'.*[476]

Some Panel members have observed impacts such as wide cracks at the top of steep slopes and fracturing of concrete causeways over active mining areas in similar conditions at other locations in the Southern Coalfield. However, during the course of its field investigations for the BSO Project, the Panel travelled on many fire trails that had been subsided by previous ICHPL mining operations adjacent to the Study Area and did not observe any residual impacts and consequences. It places weight on this observation and the advice of SCA whose personnel travel the fire trails on a frequent basis.

The Panel recommends any Project Approval should include the following requirement:

No Extraction Plan should be approved that could create any additional risk to the users of fire trails from undermining of the roads within the Study Area until all potential sources of the increased risk have been investigated to the satisfaction of the Director-General of the Department of Planning and the proposals in the Extraction Plan for avoidance, mitigation or management of any such risks ensure that users of the fire trails are not exposed to additional danger.

[476] SCA (2009).

11.8. SCA INFRASTRUCTURE

11.8.1. Scope

Table 26, prepared from information in the EA, summarises the location and predicted maximum incremental subsidence effects at SCA infrastructure if mining proceeds in accordance with the Base Case. It is proposed to longwall directly beneath parts of the Nepean Tunnel and the Upper Canal. The Nepean Tunnel/Cataract Tunnel/Upper Canal form part of a gravity water supply system for Sydney that was completed in 1888. The tunnels were mined by hand and not supported. The Nepean Tunnel transfers water from Pheasants Nest Weir to Broughtons Pass Weir. The Cataract Tunnel transfers water from Broughtons Pass Weir to the Upper Canal from where it flows to Prospect Reservoir. Other SCA infrastructure within the area of influence of the proposed mining operations includes Cataract Dam, four weirs and two fish ladders under construction. The Panel has not given consideration to the fish ladders, noting that they have been designed to Mine Subsidence Board specifications.

The Cataract Dam, the Nepean Tunnel, the Upper Canal and its associated tunnels and aqueducts, and Broughtons Pass Weir are state heritage listed, thereby increasing the consequences of some impacts. In addition to its original function of transferring water from the local dams in the Southern Coalfield to Prospect Reservoir, the Upper Canal system is now one of two routes for water transfer from the Shoalhaven system, further increasing the potential consequence of subsidence impacts.

The Cataract Dam, Broughtons Pass Weir and Brennans Creek Dam are all prescribed dams (with prescribed Notification Areas) as listed in Schedule 1 of the *Dams Safety Act 1978* Prior to the commencement of mining within a Notification Area, the leaseholder must obtain the consent of the Minister Administering the *Mining Act 1992*. A Dams Safety Committee (DSC) established under the *Dams Safety Act* advises the Minister administering the *Mining Act* on the extent and type of mining to be permitted, and on any special conditions which should apply. Hence, there are effectively three different approval authorities (DoP, DII and DSC) with respect to prescribed dams. This being the case, it appears somewhat superfluous to the Panel, for the EA and the Panel to be concerned with the design and assessment of mine layouts within Notification Areas when a third authority, not involved in the assessment process, ultimately determines the mining method and mine layout.

Figure 52 shows the extent of the Notification Areas around Cataract Dam, Broughtons Pass Weir and Brennans Creek Dam. In the case of Cataract Dam and Broughtons Pass Weir, the Extent of Longwall Mining for the Base Case mine layout intrudes into these areas. The EA advises that ICHPL has consulted with the DSC during the preparation of the EA and that the final mine layout would conform to the requirements of the DSC, including appropriate set back distances from the Cataract Reservoir dam wall and the Broughtons Pass Weir to maintain the structural integrity of the dam wall and weir. Nevertheless, the EA presents analysis of subsidence effects, impacts and consequences within the Notification Areas to support the Base Case mine layout and, therefore, the Panel has assessed these.

Table 26: Summary of Location and Predicted Maximum Incremental Subsidence for SCA Infrastructure[477]

Structure	**Location**				**Maximum Incremental Subsidence**					
	Directly over L/W Panels	**Within Extent of L/W Area**	**Within Study Area but Outside Extent of L/W Area**	**Outside Study Area**	**Vert. Disp. (mm)**	**Tilt (mm/m)**	**Tensile Strain (mm/m)**	**Comp Strain (mm/m)**	**Closure (mm)**	**Upsidence (mm)**
Cataract Tunnel	-	-	Short section adjacent to Area 3	(Extends well outside)	<20	<0.2	<0.2	<0.2	-	-
Nepean Tunnel	Area 3 2 L/W	-	-	-	1250	7.5	1.7	2.9	-	-
Upper Canal – Open sections	Area 7 2 L/W	-	-	(Extends outside)	960	4	1.8	1.2	-	-
Upper Canal – Ousedale aqueduct	Area 7	-	-	-	1600	8	1.4	2.3	300	210
Upper Canal – Other tunnels & aqueducts	-	-	-	-	-	-	-	-	<25	<20
Broughtons Pass Weir	-	-	Adjacent to Area 3	-	<20	<0.2	<0.2	<0.2	50	50
Jordans Pass Weir	-	-	Area 3	-	-	-	-	-	60	100
Menangle Weir	-	Area 7	-	-	30	<0.2	<0.2	<0.2	50	60
Douglas Pass Weir	-	-	Area 9	-	-	-	-	-	80	110
Maldon Weir	-	-	-	Adjacent to Area 8	-	-	-	-	20	20
Cataract Dam Wall	-	-	Adjacent to Area 2	-	<20	<0.01	<0.2	<0.2	<20	<20

[477] Some of this data has inconsistencies as noted in the PAC report and should not be relied upon.

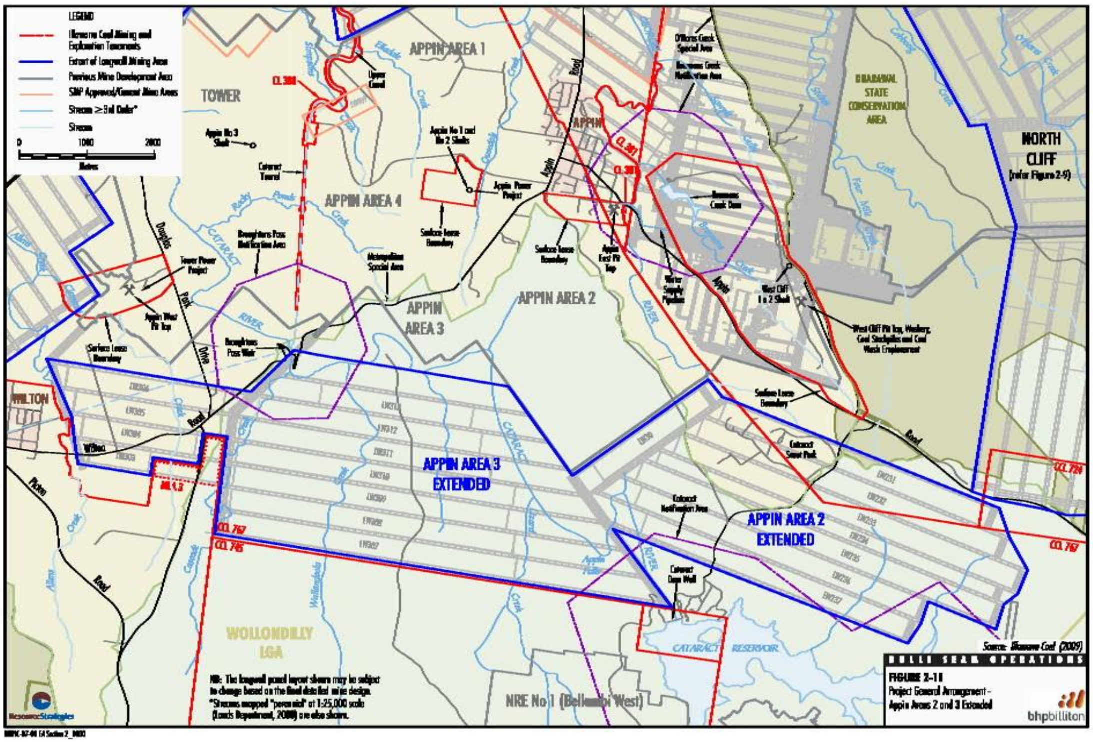

Figure 52: Extent of Notification Area (Purple Lines) around Cataract Dam, Broughtons Pass Weir and Brennans Creek Dam as Prescribed in Schedule 1 of the Dam Safety Act, 1978.

The SCA made two written submissions and an oral submission to the PAC and conducted the Panel on one field inspection. SCA reports[478] that it has adopted terminology and definitions in the SCI report for *'subsidence effects, subsidence impacts* and *subsidence consequences'*[479] and, likewise, in the Metropolitan PAC Report for *'negligible'*[480] and for *safe, serviceable and repairable'*[481]. The Panel notes that the SCI definitions for effects, impact and consequences were developed for natural features and refined in the Metropolitan PAC Report to also encapsulate the built environment. The Panel has worked to the Metropolitan Coal Project definitions when evaluating SCA submissions.

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478 SCA (2009).
479 The term *effect* describes subsidence itself;
Any physical change to the fabric of the ground, its surface, or man-made features is described as an *impact;*
The environmental *consequence* is used to describe any change in the amenity or function of a feature that arises from an impact. (DoP, 2008).
480 *Negligible – small and unimportant, such as to be not worth considering.*
481 *Safe* means no danger to users; *Serviceable* means available for its intended use*; Repairable* means damaged components can be repaired economically. (DoP, 2009b).

11.8.2. Subsidence Effects, Impacts and Consequences

Cataract Tunnel

The Nepean Tunnel/Cataract Tunnel/Upper Canal form part of a gravity water supply system that was completed in 1888. The tunnels were mined by hand and are not supported. Cataract Tunnel is between about 15 m and 72 m below the surface and has been undermined by Longwall Panels 401 to 408 at Appin Colliery (see Figure 53). Maximum subsidence of around 1200 mm occurred above Longwall 405. Prior to mining, a number of rock falls had occurred in the tunnel and these were removed and stabilized when the tunnel was supported as a subsidence mitigation measure. The tunnel was also affected by the two shear faults previously noted in this report to trend over Longwall 408.

Longwall Panel 409 recently successfully undermined the Upper Canal and Simpsons Creek Aqueduct (see Figure 42 to Figure 45 and Figure 53), resulting in around 750 mm of vertical displacement at Simpsons Creek Aqueduct. There were no unplanned outages of the water supply system but it had to be shut down a number of times outside of normal scheduled periods in order to permit mitigation works to proceed.

The subsidence predictions for the Cataract Tunnel contained in the EA have been reported as *maximum* values. In fact, they are *incremental* values attributed only to the BSO Project rather than cumulative values that capture all movements from previous mining operations in the vicinity of the tunnel. Their significance should be assessed in light of the nature and magnitude of mining induced movement that the tunnel has already experienced. In this instance, however, the incremental changes are too small to permit a meaningful assessment and so no serious implications arise out of this deficiency.

SCA has advised the PAC that:

'The SCA is generally satisfied that the Project's likely impacts on the Cataract Tunnel would be "negligible" and it would remain "safe and serviceable":'[482]

The Panel concurs in respect of the Base Case layout. However, there is insufficient information in the EA to enable an assessment of the potential impacts and consequences associated with any increase in longwall panel width.

The Panel recommends that any Project Approval should require that the Extraction Plan includes provision for the Cataract Tunnel to be monitored on a periodic basis to confirm that mining activities in the Study Area are not impacting on the safe and serviceable state of the tunnel.

The Panel recommends that Performance Criteria in any Project Approval should include the following requirements:

1. Future mining operations in the Study Area are not to impact on the safe and serviceable condition of the Cataract Tunnel. This condition is not intended to exclude planned outages of the tunnel for mitigation and remediation purposes or unplanned outages of a limited duration in order to undertake mitigation or remedial

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[482] SCA (2009)

works related to mine subsidence impacts in order to maintain the tunnel in a safe and serviceable state.

2. The infrastructure owner has the *prima facie* right to determine what is *safe, serviceable and repairable* for their purposes, with any dispute with the leaseholder being referred to a neutral arbiter selected by the Department of Planning and funded by the leaseholder.

3. The leaseholder is to guarantee funding to undertake all risk management activities and all mitigation and remediation activities associated with protecting the Cataract Tunnel from impacts due to mining operations in the Study Area so that it can be maintained in a safe and serviceable condition. This includes all the direct and indirect costs of the infrastructure owner in participating in this risk management process.

<u>Nepean Tunnel</u>

The EA provides no information on the physical state of the Nepean Tunnel. It reports that the predicted vertical displacement profile could result in parts of the tunnel becoming a siphon which could affect serviceability of the structure. Furthermore, curvatures and ground strains could also result in instabilities in the roof and walls resulting in spalling or rock falls. It goes on to state that the observed movements along the Cataract Tunnel were similar to those predicted along the Nepean Tunnel before concluding that:

It is expected, therefore, the potential impacts on the Nepean Tunnel can be managed by the implementation of suitable management strategies, as were undertaken for the Cataract Tunnel. These management strategies should be developed by ICHPL in consultation with SCA.

On the face of it, this conclusion appears reasonable to the Panel. However, SCA has advised that the Nepean Tunnel is a critical component of the water supply system to the Macarthur Area and that:

'A recent assessment has shown that the tunnel is in a poorer state generally than the previously undermined Cataract Tunnel. The SCA is not satisfied that the Project's likely overall impacts on the Nepean Tunnel would be "negligible" or that the tunnel would remain safe and serviceable'. [483]

[483] SAC (2009).

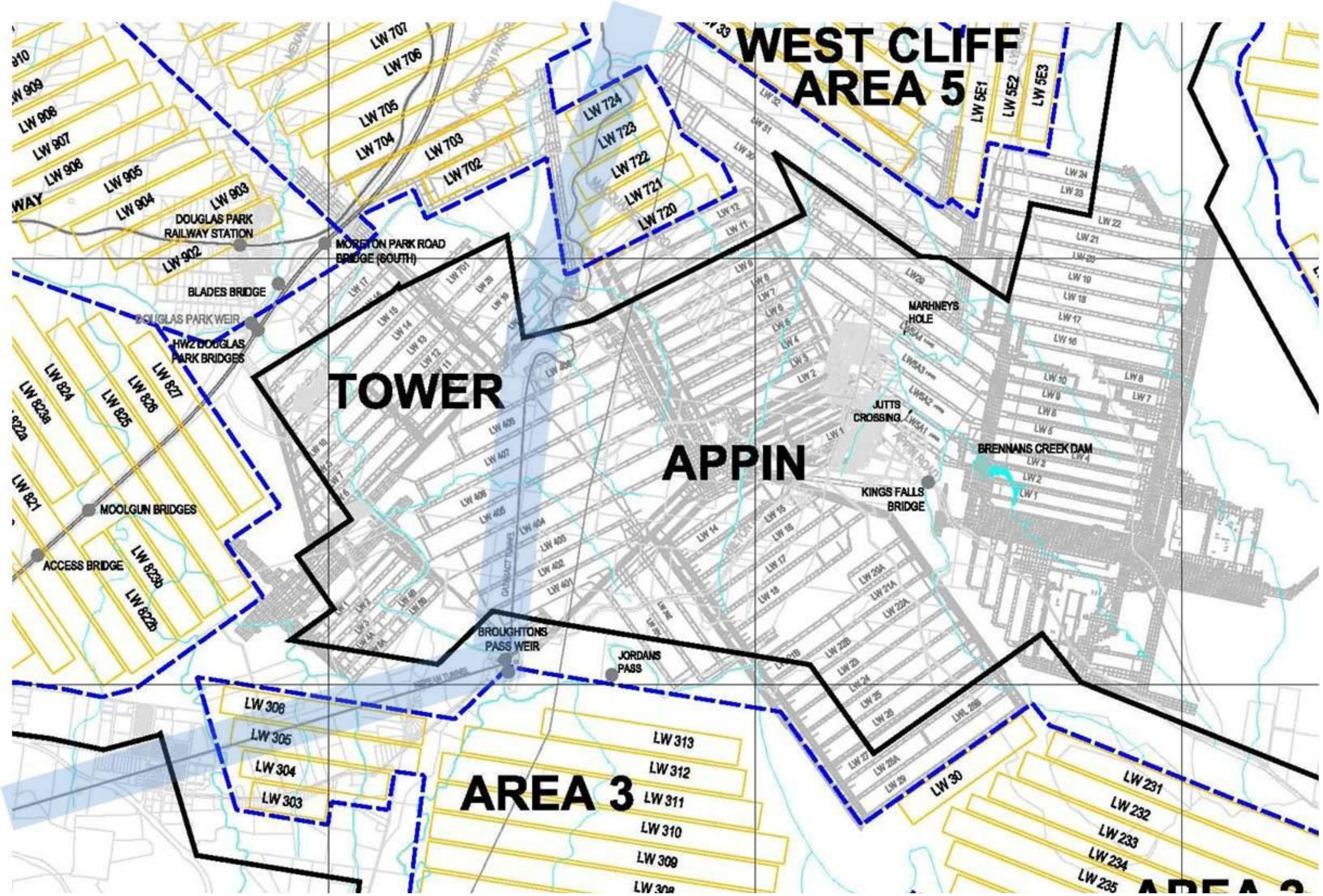

Figure 53: Location of Cataract Tunnel and Upper Canal with Respect to Previous Longwall Mining, and Nepean Tunnel and Upper Canal with Respect to Proposed Mining (Blue Corridor).

SCA has advised[484] that the tunnel is relatively fragile and that effects of mining on the tunnel could include:

- Short term outages associated with monitoring, testing, maintenance and repairs. Outages of less than a week can generally be managed, particularly if scheduled in advance and the downstream users can be notified.
- Outages lasting from one week to one month in duration associated with major failure of the tunnel requiring significant repair or to implement preventative or remedial works.
- Catastrophic failure of the Nepean Tunnel. This would render Avon, Nepean and Cordeaux dams isolated from the supply with significant impact on the capacity of the system to supply Sydney.
- The Panel notes a similarity between these scenarios and consequences and those originally pertaining to the undermining of Cataract Tunnel. It appears that the two situations differ more in terms of the likelihood of tunnel instability rather than consequences. The EA does not contain information on which to base an assessment of likelihood.

ICHPL has responded that:

> *'ICHPL commits to maintaining SCA infrastructure in a safe and serviceable condition'.*[485]

The Panel is unaware of any reason why the risk associated with undermining the Nepean Tunnel could not be quantified and controlled by a similar management process to that adopted for undermining the Upper Canal and Simpsons Creek Aqueduct (remembering that 'no mining' is one type of control to manage the risk).

The Panel recommends that Performance Criteria in any Project Approval should include the following requirements:

1. The Nepean Tunnel is to remain in a safe and serviceable condition if undermined. This condition is not intended to exclude planned outages of the tunnel for mitigation and remediation purposes or unplanned outages of a limited duration in order to undertake additional mitigation or remedial works.

2. The infrastructure owner has the *prima facie* right to determine what is *safe, serviceable and repairable* for their purposes, with any dispute with the leaseholder being referred to a neutral arbiter selected by the Department of Planning and funded by the leaseholder.

3. The leaseholder is to guarantee funding to undertake all risk management activities and all mitigation and remediation activities associated with maintaining the Nepean Tunnel in a safe and serviceable condition if it is undermined and to remediate any residual mining related impacts that may subsequently develop. This includes all the direct and indirect costs of the infrastructure owner in participating in this risk

[484] SCA (2010).
[485] ICHPL (2009).

management process. (Given the incremental nature of subsidence development, a number of remediation campaigns may be required.)

4. All activities related to undermining the Nepean Tunnel are to be structured within a risk management framework that is consistent with *ISO 31000 Risk Management*.

5. The risk management system for undermining the Nepean Tunnel is to be:

   i. Audited externally for compliance with ISO 31000 prior to lodgment of associated Extraction Plans, with the auditor/s to be selected by the Department of Planning in consultation with the infrastructure owner, and the audit report to accompany the Extraction Plan application.

   ii. Audited externally for compliance with ISO 31000 on an annual basis for the duration that the plan is invoked, with the auditor/s to be selected by the Department of Planning in consultation with the infrastructure owner.

   iii. Reviewed externally for effectiveness on an annual basis for the duration that the plan is invoked, with the reviewer to be selected by the Department of Planning in consultation with the infrastructure owner.

6. No Extraction Plan should be approved that could create any additional risk to the State's water supply system from undermining of the Nepean Tunnel until all potential sources of the increased risk have been investigated to the satisfaction of the Director-General of the Department of Planning and the proposals in the Extraction Plan for avoidance, mitigation or control of any such risks ensure that the functionality of the State's water supply system is not put in jeopardy.

<u>Upper Canal – excluding the Cataract and Nepean Tunnels</u>

This section of the Upper Canal consists of open canal sections that include Ousedale Creek Aqueduct, Elladale Creek Aqueduct, Mallaty Creek Aqueduct, Devines Tunnel 1 and Devines Tunnel 2. The EA advises that the open sections of the Upper Canal have a minimum freeboard of 500 mm and, without mitigation measures in place, the maximum predicted vertical displacement of 960 mm (Table 26) is likely to result in the canal overflowing. Furthermore, the canal is constructed from sandstone blocks and it is possible that ground movements could result in spalling or fracturing of the blocks or collapse of the walls. If fracturing were of sufficient magnitude, it could result in increased leakage from the canal or collapse of the canal walls.

The EA states that:

- *'Management strategies have been developed for the extraction of Longwall 409 beneath the open section of the Upper Canal in Area 4. The predicted systematic subsidence movements along the canal, resulting from the extraction of the longwalls, are similar to those predicted for Appin Longwall 409.*
- *It is recommended that ICHPL develop management strategies for the open section of the Upper Canal, in consultation with the SCA, so that the potential impacts on the canal resulting from the longwalls can be managed. The necessary management strategies are expected to be similar to those developed for Appin Longwall 409,*

which included the development of preventive and remedial measures and a detailed monitoring and Trigger Action Response Plan'.[486]

SCA has advised that it is not satisfied that the Project's likely overall impacts on the open section of the Upper Canal above and adjacent to longwalls 720 to 724 would be "negligible" and that it would remain "safe and serviceable", which is SCA's stated performance criteria[487]. ICHPL has replied that ICHPL commits to maintaining SCA infrastructure in a safe and serviceable condition.[488]

SCA also advises that it is investigating the long term management of the Upper Canal with options of refurbishment and replacement being considered. It may be that scope exists for longwall mining to be phased with refurbishment or emplacement works undertaken by the SCA to address the SCA's concerns. ICHPL acknowledges this statement and contains a commitment to work with the SCA to explore this potential.

SCA has advised the Panel that:

- *'The Upper Canal is an aging and fragile asset and is easily damaged. Sections of the Upper Canal have already been affected by previous mining operations resulting in outages and remedial works.*
- *Outages of less than a week in duration can generally be managed through an increase in volume from Warragamba Pipelines, particularly if scheduled in advance'*[489].

The EA identifies that wrought iron aqueducts span Mallaty Creek, Ousedale Creek, Leafs Gully and Nepean Creek and two concrete aqueducts span small tributaries upstream and downstream of Devines Tunnel No. 1. It reports that mitigation works have already been undertaken for the wrought iron aqueducts but that Ousedale Creek Aqueduct may require additional mitigation works to accommodate the BSO Project. It concludes that ICHPL expects that all aqueducts can be maintained in a safe and serviceable condition.

SCA reports that:

- *'The effect of subsidence on the Ousedale Creek aqueduct could be more serious than that experienced at Simpsons Creek aqueduct due to mining of longwall 409. This is particularly due to the fact that Ousedale Aqueduct is significantly different in nature than Simpsons Creek Aqueduct being very much longer and not in a straight alignment vertically. Notwithstanding that protective works have already been implemented on Ousedale aqueduct due to earlier Westcliff Area 5 longwalls, the SCA is not satisfied that the Project's likely overall impacts on Ousedale aqueduct due to the direct undermining of Appin Areas & longwalls would be "negligible" or that it would remain "safe and serviceable".*
- For the other aqueducts, it *is satisfied that the Project's likely overall impacts on the aqueducts would be "negligible" and they would remain "safe and serviceable".'*[490]

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[486] EA, Appendix A, p.241.
[487] SCA (2009).
[488] ICHPL (2010a), p.2 of section dealing with responses to the SCA.
[489] SCA (2010).
[490] SCA (2009).

Table 26 of this PAC report points to a significant discrepancy between the predicted maximum incremental subsidence parameters for open sections of the Upper Canal System and those for Ousedale Creek Aqueduct. For example, the open sections of the Upper Canal System are predicted to subside 960 mm and be subjected to 1.2 mm/m compressive strain whilst the aqueduct is predicted to subside 1600 mm and be subjected to a maximum compressive strain of 2.3 mm/m. These discrepancies appear to arise because the subsidence predictions in the EA for the open canal sections were premised on the maximum predicted movements along the path of the Upper Canal System in the Base Case layout whilst those for Ousedale Creek Aqueduct are based on advice in the EA[491] that the aqueduct could be subjected to the maximum predicted systematic subsidence parameters in the Area 7 mining domain[492].

If the latter approach is correct, then the Panel questions why it should not have also been applied to the open canal sections. The Panel cannot resolve this discrepancy although it considers it most likely that subsidence effects at the Ousedale Creek Aqueduct have been overestimated rather than subsidence effects on the open canal sections having been underestimated.

The EA predicts that Devines Tunnels No. 1 and No. 2 will not experience any significant systematic subsidence but may be subjected to very small far-field horizontal mass movements. Therefore the tunnels are unlikely to be significantly impacted. The SCA is also generally satisfied that the Project's likely impacts to these tunnels would be "negligible" and they would remain "safe and serviceable" (SCA, 2009).

The Panel recommends that Performance Criteria in any Project Approval should include the following requirements:

1. The Upper Canal System is to remain in a safe and serviceable condition if undermined. This condition is not intended to exclude planned outages of the tunnel for mitigation and remediation purposes or unplanned outages of a limited duration in order to undertake additional mitigation or remedial works.

2. The infrastructure owner has the *prima facie* right to determine what is *safe, serviceable and repairable* for their purposes, with any dispute with the leaseholder being referred to a neutral arbiter selected by the Department of Planning and funded by the leaseholder.

3. The leaseholder is to guarantee funding to undertake all risk management activities and all mitigation and remediation activities associated with maintaining the Upper Canal System in a safe and serviceable condition if it is undermined and to remediate any residual mining related impacts that may subsequently develop. This includes all the direct and indirect costs of the infrastructure owner in participating in this risk management process. (Given the incremental nature of subsidence development, a number of remediation campaigns may be required.)

4. All activities related to undermining the Upper Canal System are to be structured within a risk management framework that is consistent with *ISO 31000 Risk Management*.

[491] Appendix A, page 167 of the EA.
[492] As provided in Section 4.1 of the EA.

5. The risk management system for undermining the Upper Canal System is to be:

    i. Audited externally for compliance with ISO 31000 prior to lodgment of associated Extraction Plans, with the auditor/s to be selected by the Department of Planning in consultation with the infrastructure owner, and the audit report to accompany the Extraction Plan application.

    ii. Audited externally for compliance with ISO 31000 on an annual basis for the duration that the plan is invoked, with the auditor/s to be selected by the Department of Planning in consultation with the infrastructure owner.

    iii. Reviewed externally for effectiveness on an annual basis for the duration that the plan is invoked, with the reviewer to be selected by the Department of Planning in consultation with the infrastructure owner.

6. No Extraction Plan should be approved that could create any additional risk to the State's water supply system or the public from undermining of the Upper Canal System until all potential sources of the increased risk have been investigated to the satisfaction of the Director General of the Department of Planning and the proposals in the Extraction Plan for avoidance, mitigation or control of any such risks ensure that the functionality of the State's water supply system and public safety are not put in jeopardy.

Broughtons Pass Weir

Subsidence values for Broughtons Pass Weir have been reported as *maximum* values when, in fact, they are *incremental* values due only to the BSO Project and not cumulative values that include all movements from previous mining operations in the vicinity of the weir. Hence, the incremental values for vertical displacement, tilt, tensile strain and compressive strain are small and so might be dismissed as 'insignificant'. The Panel has the following concerns with this reporting approach:

1. Closure and upsidence sufficient to cause fracturing and leakage of the weir has already occurred as a result of extracting Longwalls 401 and 402 at Appin Colliery, even though these longwalls are no closer than 400 m to the weir, Figure 53. The assessment of the subsidence implications of the BSO Project on Broughtons Pass Weir fails both to consider the magnitude of previous closure and upsidence, and to base the assessment of impacts and consequences on cumulative closure and upsidence. SCA reports that:

    'The weir has been significantly damaged (cracked and uplifted on one side) by previous mining'[493].

2. Broughtons Pass Weir is the site where mining induced fracturing has been recorded furthest from a longwall panel in NSW. Hence, this site may be particularly prone to incremental subsidence movements.

3. Irrespective of previous closure and upsidence, the predicted incremental increases in both these parameters of 50 mm may be sufficient in their own right to impact

[493] SCA (2009).

adversely on the weir, especially if the site characteristics make it prone to impact. It is known that 60 mm of upsidence can be sufficient to cause fracturing of a rockbar and diversion of surface flow into a subsurface fracture network at Waratah Rivulet.[494]

The Panel recognises the conservative approach taken in the EA to predicting closure and upsidence. Nevertheless, it has concerns that the BSO Project could cause further negative impacts at the weir.

SCA submits that:

> *'This weir is the most critical piece of infrastructure involved with the sole supply of water to the Macarthur Area'*[495].

SCA has advised the Panel that the effects of mining on Broughtons Pass Weir could result in:

- *'short term outages associated with testing, maintenance and minor repair. Outages of less than a day can be managed if planned in advance allowing Macarthur WFP [water filtration plant] to prepare the system. Outages of longer than one day may see Macarthur WFP drain Broughton Pass and restrict supply. With prior planning and filling of system storage Macarthur WFP may be able to manage up to a week without supply from Broughton Pass, depending on the time of the year.*
- *outages lasting from one week to one month in duration. These outages would be associated with major failure of the weir requiring significant repair or with the implementation of preventative or remedial works.*
- *catastrophic failure of Broughton Pass. This would mean a significant reduction in supply to the Macarthur WFP and ultimately a failure of supply to the zones which rely solely on that facility.*
- *supply from the metropolitan system into the Upper Canal being compromised'*[496].

SCA reports that the SCA is not satisfied that the Project's overall likely impacts on Broughtons Pass Weir would be "negligible" or that it would remain "safe and serviceable"[497]. Based on its consideration of the likelihood of impacts and the potential consequences of impacts, and in the absence of a risk assessment, the Panel also holds this view.

The Panel recommends that Performance Criteria in any Project Approval should include the following requirements:

1. Mining in the Study Area is to result in *nil* incremental impacts on the structure, stability and functionality of Broughtons Pass Weir whilst ever the weir remains in service.

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[494] Galvin (2005).
[495] SCA (2009).
[496] SCA (2010).
[497] SCA (2009).

2. The leaseholder is to guarantee funding to undertake all activities associated with monitoring Broughtons Pass Weir to verify that this Performance Criteria is being satisfied.

Other Weirs

The EA has identified that the Maldon, Douglas Park, Jordans Pass and Menangle Weirs could be impacted by closure and upsidence associated with the BSO Project. The weirs are located on the Nepean and Cataract Rivers. In all cases, upsidence may exceed subsidence (vertical displacement), resulting in predicted net uplift of the weirs of between 20 mm and 80 mm. The EA presents an assessment of the consequences of net uplift and concludes that the predicted net uplift at the weirs due to mining is less than the typical seasonal changes in water level. It also reports that the predicted changes in water level are smaller than those experienced along the Nepean and Cataract River due to past mining activities. These conclusions have not been challenged in submissions and appear to be plausible to the Panel.

The Maldon Weir is located 740 m from the Extent of Longwall Mining zone defined in the EA and both closure and upsidence are predicted to be less than 20 mm, Table 26. The Panel concludes that any subsidence impacts and consequences are likely to be minimal and readily controlled by an appropriate management plan.

The Menangle Weir is remote from previous mining. The SCA has advised the Panel that reports that the weir is not used by the SCA for water supply but is accessed by others for pumping purposes[498]. The Panel concurs with the assessment by SCA that the predicted subsidence and upsidence at this weir could cause minor cracking of the weir , that the Project's likely impacts on the wall of the weir would be minor, and that it would remain 'safe and serviceable'. The consequences of these impacts do not appear to be as high as for the other weirs of interest given that it is not used for water supply purposes.

The Panel has concerns regarding the prediction of closure and upsidence effects, impacts and consequences for Douglas Park Weir and for Jordans Pass Weir. Predicted closure and upsidence at Douglas Park Weir is 80 mm and 110 mm, respectively. Similarly, predicted closure and upsidence at Jordans Pass Weir is 60 mm and 100 mm, respectively. As noted previously, this level of movement has been known to cause fracturing and subsurface diversion of flow. However, the Panel notes that both weirs have already been subjected to closure and upsidence. The Douglas Park Weir for example, is immediately upstream of the Douglas Park Twin Bridges which were subjected to closure sufficient to require substantial post mining mitigation and remediation measures. Appendix A states that:

> *'It is proposed that the Base Case longwalls in Area 3 will be extracted at a similar distance from Jordans Pass Weir as the previously extracted Appin Longwalls 301 and 302. Similarly, it is proposed that the Base Case longwalls in Area 9 will be extracted at a similar distance from the Douglas Park Weir as the previously extracted Tower Longwalls 16 and 17. There were no reported adverse impacts on these weirs during the mining of these previously extracted longwalls'.*[499]

Given that the proposed mining will approach within a similar distance to Douglas Park and Jordans Pass weirs as previous mining and is predicted to result in closure of 60 mm to

[498] SCA (2009).
[499] EA, Appendix A, p.170.

80 mm and upsidence of 100 mm to 110 mm, the question arises as whether the weirs have not already been subjected to similar closure and upsidence values. If so, then the cumulative values of closure and upsidence could result in more significant impacts and consequences than predicted in the EA. These are also likely to be greater if longwall panel width is increased.

SCA reports that the predicted subsidence and upsidence at Jordans Pass Weir could cause minor cracking of the weir and this may compromise its role as a gauging station[500]. The SCA is satisfied that *the Project's likely overall impacts on the wall of the weir could be minor and it would remain "safe, serviceable and repairable".* It has set "safe, serviceable and repairable" as a performance goal for Douglas Park Weir but has not provided an assessment of whether this outcome is likely to be achieved with the proposed mine layout. It appears to the Panel that the SCA's assessment did not consider the implications of any increase in longwall panel width over the life of the project.

The Panel recommends that Performance Criteria in any Project Approval should include the following requirements:

1. The Maldon, Douglas Park, Jordans Pass and Menangle Weirs are to remain in a safe and serviceable condition if impacted by mining operations in the Study Area. This condition is not intended to exclude mitigation and remediation measures to maintain the weirs in this condition.

2. The infrastructure owner has the *prima facie* right to determine what is *safe, serviceable and repairable* for their purposes, with any dispute with the leaseholder being referred to a neutral arbiter selected by the Department of Planning and funded by the leaseholder.

3. The leaseholder is to guarantee funding to undertake all risk management activities and all mitigation and remediation activities associated with maintaining the Maldon, Douglas Park, Jordans Pass and Menangle Weirs in a safe and serviceable condition if they are impacted by mining in the Study Area and to remediate any residual mining related impacts that may subsequently develop. This includes all the direct and indirect costs of the infrastructure owner in participating in this risk management process. (Given the incremental nature of subsidence development, a number of remediation campaigns may be required.)

4. All activities related to maintaining the Maldon, Douglas Park, Jordans Pass and Menangle Weirs in a safe and serviceable state are to be structured within a risk management framework that is consistent with *ISO 31000 Risk Management*.

5. The risk management system for managing mining impacts on the Maldon, Douglas Park, Jordans Pass and Menangle Weirs Upper Canal System is to be:

    i. Audited externally for compliance with ISO 31000 prior to lodgment of associated Extraction Plans, with the auditor/s to be selected by the Department of Planning in consultation with the infrastructure owner, and the audit report to accompany the Extraction Plan application.

[500] SCA (2009).

ii. Audited externally for compliance with ISO 31000 on an annual basis for the duration that the plan is invoked, with the auditor/s to be selected by the Department of Planning in consultation with the infrastructure owner.

iii. Reviewed externally for effectiveness on an annual basis for the duration that the plan is invoked, with the reviewer to be selected by the Department of Planning in consultation with the infrastructure owner.

6. No Extraction Plan should be approved until the risks associated with mining in the Study Area in vicinity of the Maldon, Douglas Park, Jordans Pass and Menangle Weirs have been investigated to the satisfaction of the Director-General of the Department of Planning and the proposals in the Extraction Plan for the management of any risks are consistent with maintaining each weir in a safe, serviceable and repairable condition.

Cataract Dam

The Cataract Dam wall is located approximately 150 m from the Extent of Longwall Mining for Area 3. The longwall panels in the Base Case layout in Area 3 are located at a minimum distance of approximately one kilometre from the dam wall. The associated predicted subsidence movements recorded in the EA are negligible, Table 26. Once again, however, the values are reported as *maximum* values when, in fact, they are *incremental* values due only to the BSO Project and not cumulative values that include all movements from previous mining operations in the vicinity of the dam wall. Furthermore, they do not account for increased subsidence effects should longwall panel width be increased in the future. The EA reports that longwalls previously extracted at South Bulli Colliery are within 800 m of the dam wall and longwalls at Bellambi Mine are within 950 m. The EA does not acknowledge that other mining has been undertaken at similar distances from the dam wall.

Monitoring of the wall of Cataract Dam as reported by Reed (1998) provided one of the first indications of far-field behaviour in the Southern Coalfield[501]. In 2000, Reed reported horizontal movements of the dam wall of the order of 20 mm due to coal mining[502]. Unfortunately, far-field horizontal movements appear to have also affected the survey reference station used to compute these movements. Based on back-analysis of a range of survey data, it now appears that the Cataract Dam wall moved about 30 mm in the direction 217° (azimuth) from 1986 to 1992 as a result of longwall mining more than 800 m away[503]. Furthermore, mining triggered horizontal movements extending up to 1.5 to 1.7 km from the edge of a total extraction goaf in the vicinity of Cataract Dam.

Although the dam wall may have moved, the movements to date have apparently been en-masse, with the result that the dam wall has not been impacted structurally by differential displacements. Nevertheless, movement of such a critical structure warrants very careful consideration, particularly in regards to cumulative movement. The EA makes no reference to the magnitude of horizontal movement of the dam wall to date. Rather, it states that:

[501] Reed (1998).
[502] Reed, (2000).
[503] Reed, (2001).

It is likely, therefore, that the dam wall would experience far-field horizontal movements similar to those experienced during the extraction of the previous longwalls at South Bulli and Bellambi Mine[504].

This being the case, based on the measurements of Reed (2001), the proposed mining might result in the dam wall moving horizontally another 30 mm, to total 60 mm. There is limited discussion in the EA concerning risk to the dam wall. It appears from the submission of SCA and the EA that both the SCA and ICHPL are relying on the risks being controlled through intervention of the Dams Safety Committee at some future date. The SCA has submitted:

> *Assessment of potential impacts.............The SCA notes that the Dams Safety Committee will be involved in a detailed assessment of the potential impact on the dam. The SCA supports this process to more accurately understand potential impacts and to determine appropriate management responses*[505].
>
> ....
>
> *Risk-based management strategies developed in consultation with and to the satisfaction of SCA and Dams Safety Committee should include risk assessment on the impact of mining, detailed structural analysis of the dam wall, remediation plan, contingency plan, Trigger Action Response Plan (TARP), and monitoring plan*[506].

This position is effectively consistent with the EA which states that:

> *The potential impacts on the Cataract Dam could be managed by the implementation of suitable management strategies including:*
>
> - *structural analyses of the dam wall to determine the existing stresses within the structure and the allowable differential movements which could result from mining;*
> - *the use of conventional ground monitoring with a Trigger Action Response Plan; and*
> - *The formation of a Technical Committee comprising ICHPL, the Dams Safety Committee, the Sydney Catchment Authority and the subsidence engineer, to regularly review the movements during the mining period*[507].

The Cataract Dam is a critical item of infrastructure.

The Panel recommends that Performance Criteria in any Project Approval should include the following requirements:

1. Mining in the Study Area is to result in a *nil* impact outcome for the dam wall of Cataract Reservoir.

[504] EA, Appendix A, p.171.
[505] SCA (2009), p.5.
[506] SCA (2009), p.15.
[507] EA, Appendix A, p.171.

2. The leaseholder is to guarantee funding to undertake all activities associated with monitoring the dam wall of Cataract Reservoir to verify that this Performance Criteria is being satisfied.

3. All activities related to ensuring a *nil* impact outcome for the dam wall of Cataract Reservoir are to be structured within a risk management framework that is consistent with *ISO 31000 Risk Management*.

4. The risk management system for ensuring a *nil* impact outcome for the dam wall of Cataract Reservoir is to be:

    i. Audited externally for compliance with ISO 31000 prior to lodgment of associated Extraction Plans, with the auditor/s to be selected by the Department of Planning in consultation with the infrastructure owner, and the audit report to accompany the Extraction Plan application.

    ii. Audited externally for compliance with ISO 31000 on an annual basis for the duration that the plan is invoked, with the auditor/s to be selected by the Department of Planning in consultation with the infrastructure owner.

    iii. Reviewed externally for effectiveness on an annual basis for the duration that the plan is invoked, with the reviewer to be selected by the Department of Planning in consultation with the infrastructure owner.

5. No Extraction Plan should be approved until the Director-General of the Department of Planning is satisfied that the proposals in the Extraction Plan for the management of risk are consistent with achieving a *nil* impact outcome for the dam wall of Cataract Reservoir.

11.9. RESIDENTIAL HOUSES

11.9.1. Scope

The Study Area falls within three Local Government Areas (LGAs), namely Wollondilly Shire Council, Campbelltown City Council and Wollongong City Council, with the majority being in the Wollondilly LGA. Residential development is effectively confined to the western half of the Study Area, most of which falls within one of four declared Mine Subsidence Districts shown in Figure 54.

At the time of compiling the EA, a total of 1294 houses had been identified in the Study Area, of which 1007 were located in Area 7, Area 8 and Area 9, Table 27. These areas include part or all of the townships of Menangle, Douglas Park and Wilton, Figure 54. Of the 62 houses not located in a Mine Subsidence District, 50 are located in the town of Wedderburn in Westcliff Area 5. Most of these houses are located at the northern end of the proposed Longwalls SE1 to SE3. The EA does not identify how many of the houses within declared Mine Subsidence Districts were constructed prior to these areas being declared.

Table 27: Distribution of Houses within the Study Area

Domain	Number of Houses		
	Within Study Area	**Directly above Extent of Longwall Area**	**Not Within Mine Subsidence District**
Area 2	4	2	2
Area 3	196	81	6
West Cliff Area 5	83	43	50
Area 7	349	334	0
Area 8	227	69	0
Area 9	431	399	0
North Cliff	4	0	4
TOTAL	**1294**	**928**	**62**

The Panel has given consideration to potential future residential development within the Study Area over the life of the project, scheduled to be 30 years based on the Base Case layout and projected annual rates of production. This life could be shortened if portions of the Base Case layout were not mined, whilst technological advances might result in increased rates of production leading to early exhaustion of reserves.

The Metropolitan Strategy is a broad framework to promote and manage the growth of Sydney. The strategy comprises a number of Subregional Strategies, one of which is the South West Subregion draft strategy covering Liverpool, Campbelltown, Camden and Wollondilly LGAs. The EA reports that[508]:

[508] EA, Volume 1, p.7-2, Section 7.2.

- A number of landholders approached the DoP to have Macarthur South, a rural area located largely within this Subregion and the Study Area, Figure 55, included in the Metropolitan Strategy.
- the Macarthur South Regional Environmental Study was prepared in 1991 and concluded that development of the area, apart from a small part of Mount Gilead, should be deferred due to the high cost of infrastructure required and until water quality, air quality and coal mining issues could be satisfactorily resolved.
- In 2009, the NSW Government decided to cease and defer further investigations of Macarthur South as a land release area due to factors including the infrastructure cost of servicing the area, the economic value of coal and agricultural resources in the area and the status of land supply in the south-west.

The Panel has formed the view that it is more likely than not that portions of the Study Area will be released for development during the next 30 years. If this view is supported by DoP then, for reasons noted later in this section, there may be mutual benefits to ICHPL, community and government in strategically sequencing extraction of mining domains to facilitate this development.

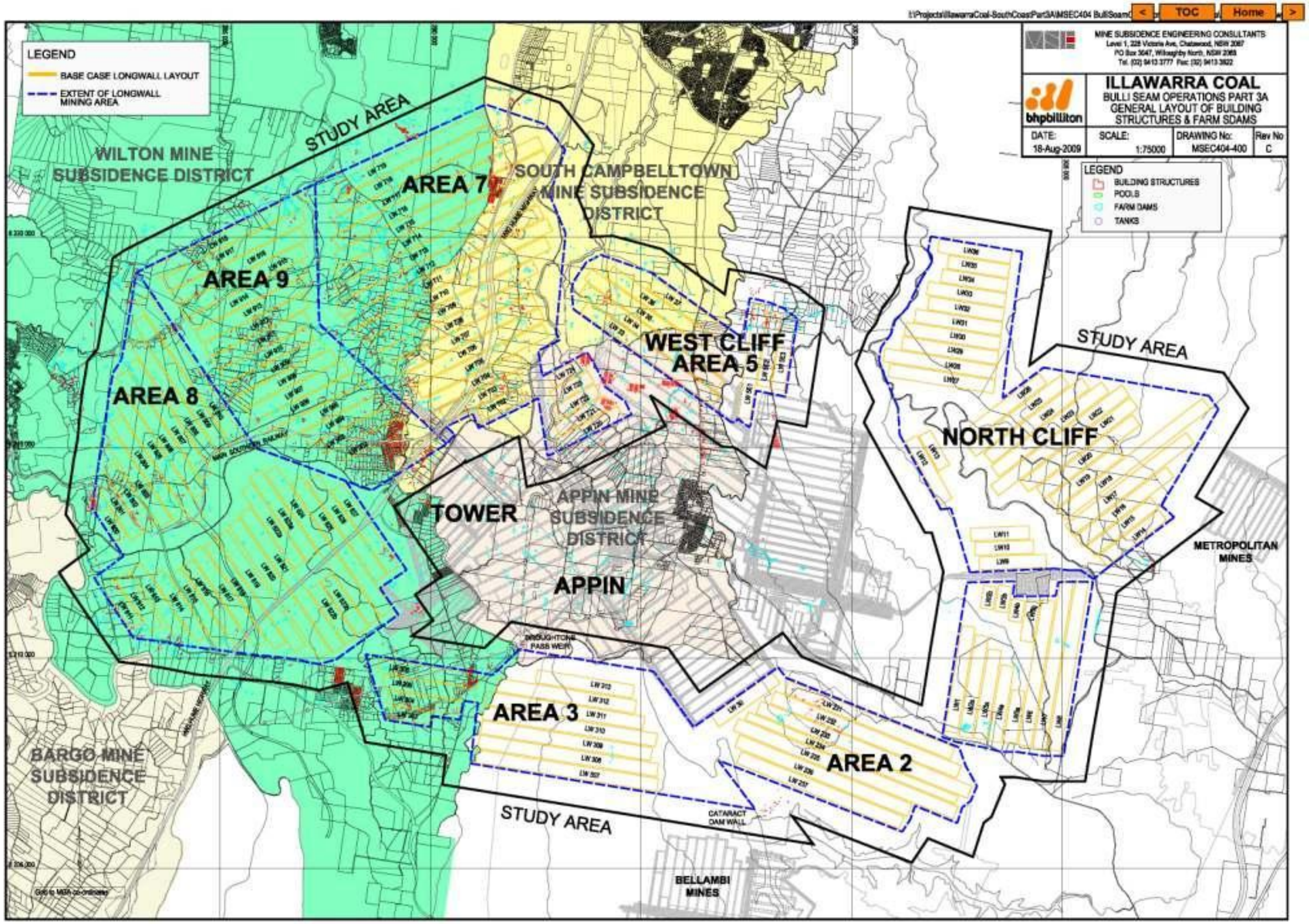

Figure 54: Mine Subsidence Districts and Location of Houses in Study Area

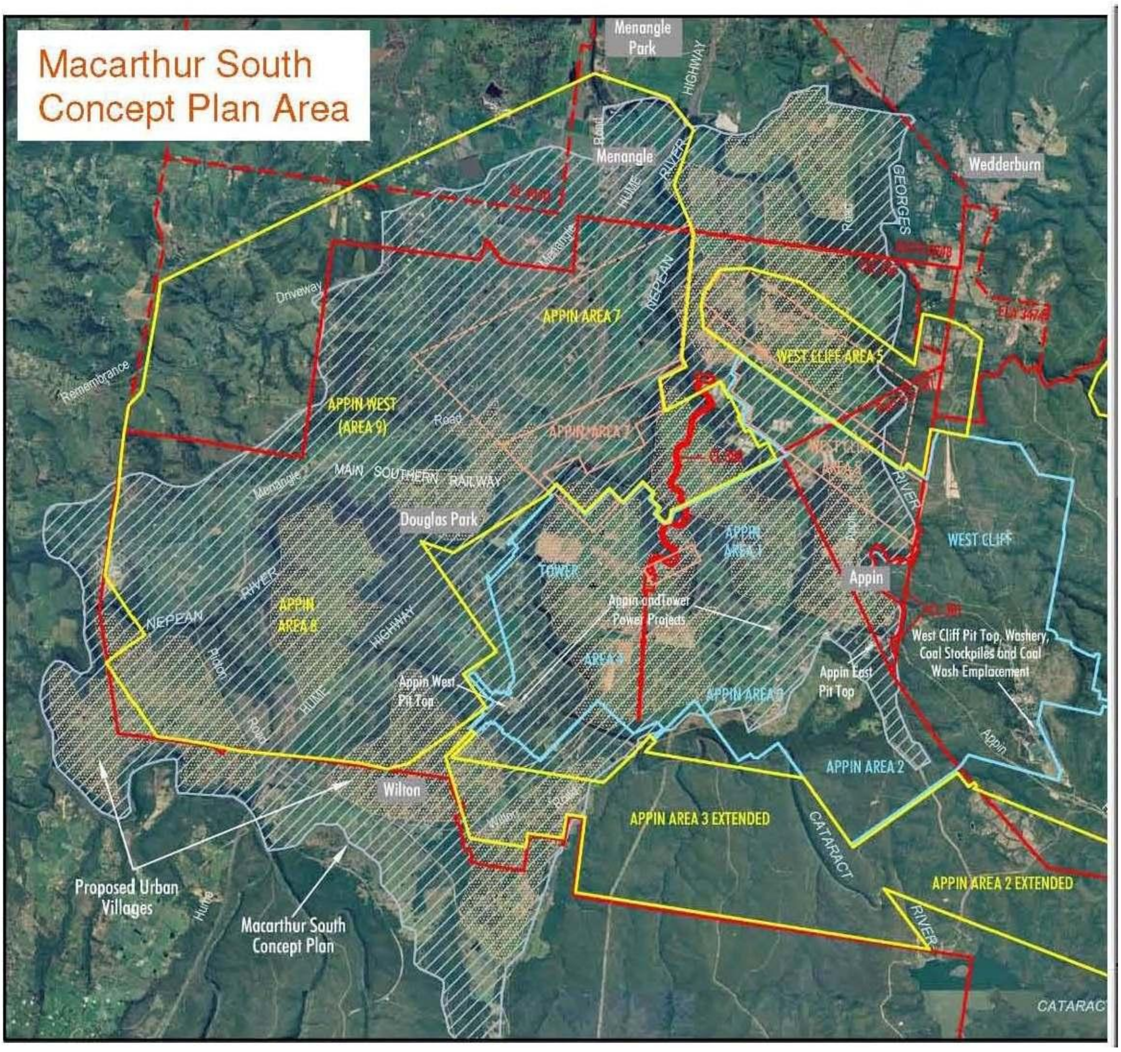

Figure 55: Location of Proposed Macarthur South Development Area

11.9.2. Subsidence Effects, Impacts and Consequences

Australian Standard *AS2870-1996 Residential Slabs and Footings* defines five impact categories of structural damage to buildings on the basis of crack width. This classification system supported by a similar system for tilt has been used extensively in NSW in predicting the impacts of systematic subsidence on residential structures. In March 2009, Mine Subsidence Engineering Consultants (MSEC) reported on research into subsidence impact assessment on buildings that MSEC had been undertaking on behalf of the Australian Coal Association Research Program (ACARP)[509]. This research was based on 1037 houses and civil structures affected by subsidence over the workings of Tahmoor Colliery, which lies to the south west of the Study Area. It produced an alternative impact classification system which has been used for the prediction of subsidence impacts on houses in the BSO Project Study Area. The Panel reviewed the system in light of the lack of experience with its use.

[509] ACARP (2009).

A comparison between predicted impacts based on the existing classification system and observed impacts at Tahmoor Colliery undertaken as part of the research, revealed that in 96% of cases, actual impacts were less than or equal to predicted. The EA states that based on this outcome, it is considered that this method for impact assessment was generally conservative even though it did not take non-systematic movements into account[510]. However, when compared on a house by house basis, a number of predictions were substantially exceeded in a small proportion of cases. The majority, if not all, of these excessive exceedances were attributable to non-systematic subsidence movements.

The research concluded in respect of the existing classification system based on crack width that:

- A benefit of using crack width as the main measure of impact is that it provides a clear objective measure by which to classify impact. However,
- Experience has shown that crack width provides a poor measure of overall impact and extent of repair to a structure.
- This method of impact classification may be useful for assessing impact to newly built structures in a non-systematic environment but further improvement and clarification is recommended before it can be effectively applied to houses impacted by mine subsidence.
- By focusing on crack width, the Australian Standard impact classification table appears to be classifying impacts from a structural stability perspective. It recommended that a revised impact classification system be developed that was more closely aligned with all aspects of a building, including its finishes and services. Residents who are affected by impacts are concerned as much about impacts to internal lining, finishes and services as they are about cracks to their external walls and a revised impact classification system needs to reflect this.

The revised classification system developed by MSEC is shown in Table 28. Degree of impact is expressed in terms of 'repair category'. Appendix A of the EA compares predictions based on this classification system with that based on AS2870-1996 and concludes that it produces more reliable outcomes for the circumstances pertaining to Tahmoor Colliery. The Panel concurs.

The ACARP research examined a range of factors that influence the degree of impact or repair category associated with a given level of systematic subsidence. These factors included construction type, structure size, position of structure relative to longwall footprint, ground tilt, ground strain and ground curvature. This analysis was used to establish probabilities of impact based on a range in ground curvature and construction type[511]. However, these probabilities still do not take account of impacts arising from non-systematic subsidence and MSEC concludes that further research is required in this area. This deficiency is addressed in Appendix A of the EA by producing a correlation between curvature (broken into three ranges) and probability of impact for structures above Tahmoor Colliery that does not distinguish between the

[510] EA, Appendix C of Appendix A.
[511] EA, Appendix C of Appendix A, p.286, Table C.5.

type of construction. That correlation has been reproduced inTable 29 in terms of *radius of curvature*[512] for the purpose of this report.

Table 28: Revised Impact Classification System Adopted in the EA[513]

Table 5-10
Residential Dwellings Repair Categories

Repair Category	Extent of Repair
Nil	No repairs required.
R0 Adjustment	One or more of the following, where the damage does not require the removal or replacement of any external or internal claddings or linings: • door, window or gate jams or swings; or • movement of cornices; or • movement at external or internal expansion joints.
R1 Very Minor Repair	One or more of the following, where the damage can be repaired by filling, patching or painting without the removal or replacement of any external or internal brickwork, claddings or linings: • cracks in brick mortar only, or isolated cracked, broken, or loose bricks in the external facade; or • cracks or movement less than 5 mm in width in any external or internal wall claddings, linings, or finish; or • isolated cracked, loose, or drummy floor or wall tiles; or • minor repairs to any services or gutters.
R2 Minor Repair	One or more of the following, where the damage affects a small proportion of external or internal claddings or linings, but does not affect the integrity of external brickwork or structural elements: • continuous cracking in bricks less than 5 mm in width in one or more locations in the total external facade; or • slippage along the damp proof course of 2 to 5 mm anywhere in the total external facade; or • cracks or movement greater than or equal to 5 mm in width in any external or internal wall claddings, linings, finish; or • several cracked, loose or drummy floor or wall tiles; or • replacement of any services.
R3 Substantial Repair	One or more of the following, where the damage requires the removal or replacement of a large proportion of external or internal claddings or linings, or affects the integrity of the external brickwork or structural elements: • continuous cracking in bricks of 5 to 15 mm in width in one or more locations in the total external façade; or • slippage along the damp proof course of 5 to 15 mm anywhere in the total external facade; or • loss of bearing to isolated walls, piers, columns, or other load-bearing elements; or • loss of stability of building elements.
R4 Extensive Repair	One or more of the following, where the damage requires the removal or replacement of a large proportion of external brickwork, or the replacement or repair of structural elements: • continuous cracking in bricks greater than 15 mm in width in one or more locations in the total external facade; or • slippage along the damp proof course of 15 mm or greater anywhere in the total external facade; or • re-levelling of building; or • loss of stability of several structural elements.
R5 Re-build	Extensive damage to house that requires it to be re-built as the cost of repair is greater than the cost of replacement.

Source: Appendix A.

[512] *Radius of curvature* is the inverse of *curvature*. A curvature of 5 km, for example, equates to a radius of curvature of 1/5 = 0.2 km^{-1}.
[513] EA, Appendix C of Appendix A, p.282, Table C.4.

Table 29: Observed Frequency of Impacts for all Buildings over Tahmoor Colliery[514]

Curvature, R^{-1} (km^{-1})	Repair Category			
	No Claim or R0	**R1 or R2**	**R3 or R4**	**R5**
<0.02	94%	4%	1%	0%
0.02 to 0.07	86%	9%	4%	0.7%
0.07 to 0.2	76%	17%	7%	0%

In applying the research outcomes to the BSO Project, predictions of subsidence, tilt, curvature and strains have been made at the centre (centroid) and each corner (vertex) of each structure in the Study Area as well as at eight equally spaced points radially placed around each centroid and vertex at a distance of 20 m. In the case of a rectangular shaped structure, predictions have been made at a minimum of 45 points within and around the structure. The maximum predicted subsidence parameters have been extracted from these predictions during and after each longwall, and have been used to assess the likely impacts. The Panel considers this to be a pragmatic and conservative approach to account for spatial variation in subsidence parameters in this manner.

An analysis has also been undertaken in the EA of the sensitivity of subsidence predictions (at houses) to changes in the location and orientation of longwall panels in the Base Case layout. This was done by shifting the Base Case longwall layout in 50 m increments to the north, south, east and west as well as reorientating it at various angles. It was found that whilst the predicted movements for each house increased or decreased, the overall levels of movement at the houses across the Study Area did not change significantly. The Panel considers this to be a reasonable approach given the scale of the project and the current stage of the planning and approvals process. It notes once again, however, that no sensitivity analysis has been undertaken of impacts arising from an increase in longwall panel width.

The EA has based the impact assessment for houses within the BSO Study Area on the correlation between curvature and impacts for 1257 houses and civil structures affected by longwall mining at Tahmoor Colliery as at May 2008. It concludes that 85 to 90 % of the houses within the Study Area are predicted to experience hogging and sagging curvatures no greater than 0.05 km^{-1} and that the predicted maximum curvatures at the houses within the Study Area will be similar to those predicted to have occurred at Tahmoor Colliery.

The Panel has compared these two sets of curves, Figure 56, and concurs with this conclusion in respect of sagging curvature but has reservations in respect of hogging curvature. The proportion of houses that are predicted to experience hogging curvature of between 0 and 0.025 km^{-1} is significantly different, being 62 % for

[514] Modified from Table C.6 of Appendix C of Appendix A of the EA by converting radius of curvature to curvature.

Tahmoor Colliery and 48 % for the BSO Project. The Panel places significance on this because the ACARP research being relied upon for the impact assessment in the EA identified 0 to 0.02 km^{-1} as a curvature range for assessing subsidence impacts on structures at Tahmoor Colliery, Table 29.

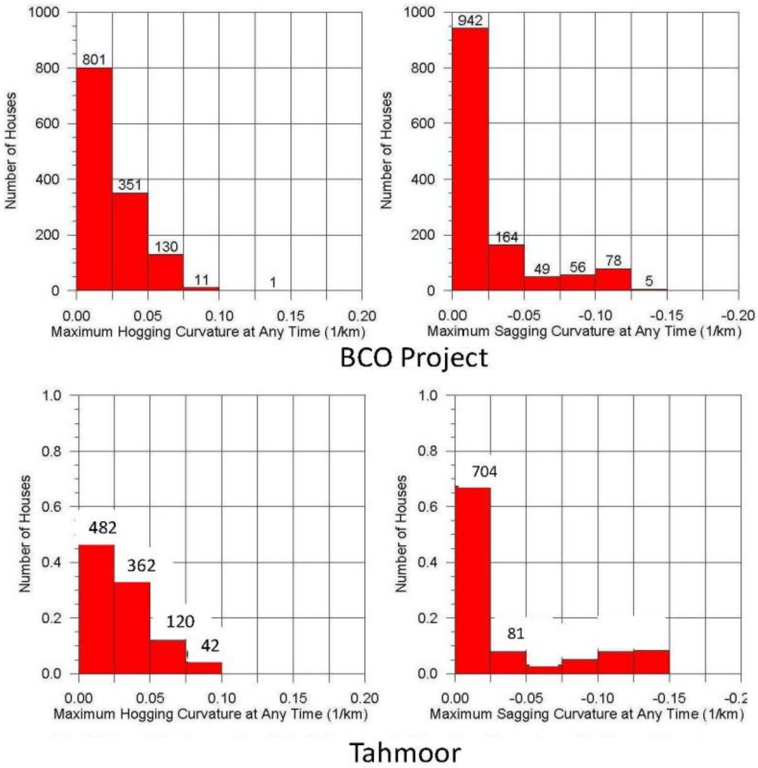

Figure 56: Comparison between Curvature Predictions for Houses in the Study Area and those in the Reference Area at Tahmoor[515]

Based on the premise that the curvature distributions for Tahmoor Colliery and Appin Colliery are similar, the EA then applies the probabilities for impact outcomes arising from Tahmoor Colliery mining operations to the BSO Project. From a subsidence engineering perspective, this is a sensible approach because differences in mining parameters between the two operations (such as longwall panel width and mining height) are factored into the curvature predictions. However, the validity and accuracy of the approach is also dependent on the surface structures having similar characteristics in respect of factors such as Mine Subsidence Board design requirements, construction type, plan area, height, density, topography, and location relative to longwall footprints. These factors are not addressed explicitly in the EA, although it is noted that two contributory reasons for why the distribution of impacts for the higher impact categories is higher for the Study Area than for Tahmoor Colliery may be:

515 Adapted from Figure 11.5 and Figure 11.6 of Appendix C of Appendix A of the EA, pp.247-248.

- The conservative assumption that all the houses in the Study Area are of masonry construction with strip footings.

- The distribution of size of structure is slightly greater than at Tahmoor due to the higher proportion of rural houses.

The EA acknowledges that the chance of impacts may be greater for houses located on steep slopes, such as those near the Razorback Range. It also concludes from past experience that residents will not be exposed to 'immediate and sudden' safety hazards as a result of mine subsidence movements.

Based on the Tahmoor Colliery experience, impacts have been predicted for houses in the BSO Study Area, Table 30. It is predicted that 85 % of houses will experience nil or negligible impacts whilst 0.4% or five houses, will be impacted to an extent that they will require rebuilding. Given this prediction and the fact that a number of houses had to be rebuilt at Tahmoor, the Panel is somewhat perplexed that the EA concludes that:

> *'....all houses within the Study Area are expected to remain safe, serviceable and repairable throughout the mining period, provided that they are in sound structural condition prior to mining'*[516].

Furthermore, the predictions regarding the percentage of houses impacted are not based on any consideration of increases in longwall panel width that may occur over the life of the project. Such increases can be expected to result in an increase in both the number of houses impacted and the severity of the impacts.

Table 30: Predicted Distribution of Impacts for all Houses in the Study Area

Group	Repair Category			
	No Claim or R0	**R1 or R2**	**R3 or R4**	**R5**
Houses directly above goaf (total of 730)	580 (79 %)	93 (13 %)	52 (7 %)	5 (0.7 %)
Houses directly above solid coal (total of 564)	524 (93 %)	33 (6 %)	7 (1 %)	0 (0 %)
All houses (total of 1294)	**1104 (85 %)**	**126 (10 %)**	**59 (5 %)**	**5 (0.4 %)**

516 EA, Appendix A, p.250.

11.9.3. Submissions

Wollondilly Shire Council requested information as to when the boundaries of declared Mine Subsidence Districts will be adjusted to include Wedderburn[517]. The Council also raised the issue of compensation to land owners whose properties were not previously within a declared Mine Subsidence District. During the public hearings, Mr David Mouat expressed a number of concerns regarding the BSO Project including the impact on the structural integrity of houses and a severe reduction in market values of Wedderburn properties even if repairs are carried out[518].

Wollondilly Shire Council also requested that the State Government review the process for funding the Mine Subsidence Board, with the aim of providing a proportional nexus between the costs of compensation and the particular mining operation directly responsible for the subsidence[519]. The Council also expressed concern on behalf of rate payers regarding inadequate compensation for mine subsidence damage, conditions attached to this compensation, and to everyday inconvenience associated with mitigating and remediating mine subsidence damage[520]. It, along with a number of residents, expressed annoyance and frustration at the time that had to elapse for subsidence to be complete before repairs were undertaken by the MSB. Given the incremental manner in which subsidence develops, property owners may have to wait several years for a series of longwall panels to be extracted before subsidence stabilized. The Council drew the Panel's attention to the concerns of the Tahmoor Colliery Community Consultative Committee (TCCC) regarding subsidence impacts on houses[521]. In June 2009, the TCCC expressed a number of concerns to the MSB regarding compensation to residents affected by subsidence impacts. The MSB advised, amongst other things, that:

> *'The Mine Subsidence Compensation Act provides a scheme of compensation where surface improvements are damaged by mine subsidence resulting from the extraction of coal. There is no provision for additional payments. 'Inconvenience and anxiety' is outside the scope of normal insurance/compensation provisions'*[522].

The Panel notes, however, that in this instance the insurance policy is not one taken out by the owner of the surface improvement. Furthermore, the owner of the surface improvement has no control over the risk to which the improvement is exposed. Both of these factors distinguish the insurance scheme from that of other insurances. The Panel also notes that the claim for compensation for 'inconvenience and suffering' is more aligned to a third party claim for 'pain and suffering'. This view is not inconsistent with the MSB's offer in its letter to the TCCC to *'arrange counselling if a claimant is experiencing difficulties in dealing with mine subsidence issues'.*

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517 WSC (2010a).
518 Mouat (2010).
519 WSC (2010a).
520 WSC (2010b).
521 WSC (2010b).
522 Attachment to WSC (2010c).

The Panel considers that there is merit in the arguments placed before it, in particular, those relating to duration of impact, increased up-front construction costs to comply with MSB requirements, and home owners having no control over anything in the process. The Panel has formed the view that the current legislative scheme and its manner of administration may need review.

Campbelltown City Council expressed concern in the public hearing that the EA did not adequately address potential impacts in the Menangle Park Urban Release Area. ICHPL responded that currently only three houses are located north of the Nepean River within 600 metres of the extent of longwall mining, the predicted probability of impact at these houses is less than 6 %, and the probability of an impact requiring rebuild is less than 0.1 %.[523]

11.9.4. Conclusions with Respect to Residences

The Panel concludes that:

- There is already in place a well established mechanism supported by legislation and administered by the Mine Subsidence Board for managing the impacts on mining on residential structures.

- This mechanism is effective in not exposing residents to personal harm arising from mine subsidence and in maintaining and restoring structures to a condition equal to or better than their pre-mining state at no financial cost to owners.

- However, this mechanism does not compensate owners for annoyance, anxiety or inconvenience associated with structures being damaged by mine subsidence, which is compounded in the BSO Study Area by the extended period of time (in some cases 3 or more years) that remediation and restoration activities are deferred until mine subsidence movements stabilize. In many instances, owners of structures in declared Mine Subsidence Districts have already incurred a cost burden at the time of construction to mitigate against subsidence impacts.

- Therefore, the current legislative scheme and its manner of administration may need review to enhance its operation, especially in circumstances where subsidence develops incrementally over several years.

- The commitment by ICHPL that *all houses within the Study Area are expected to remain safe, serviceable and repairable,* is unrealistic in light of experience to date. A small number of structures are likely to be damaged to the extent that they will need to be demolished and reconstructed.

- The number of structures impacted by mining and the degree of impact is likely to be greater than predicted in the EA if longwall panel width is increased.

[523] ICHPL (2010d).

- It is more likely than not that portions of the Study Area will be released for development during the next 30 years and, therefore, there may be mutual benefits to ICHPL, community and government to strategically sequence extraction of mining domains to facilitate this development.

11.10. SERVICES INFRASTRUCTURE

11.10.1. Sydney Water Infrastructure

Sydney Water owns and maintains a number of water pipelines within the Study Area which supply the townships of Wilton in Area 3, Menangle in Area 7, Maldon in Area 8, Douglas Park in Area 9 and Appin in Area 5. It currently has proposals to install a Sewerage Pumping Station at Appin and a pressurised pipeline to Campbelltown. These developments are to be designed to accommodate subsidence and will have to be approved by the MSB. There are no other sewage treatment plants within the Study Area.

Appendix A tabulates the size and types of pipes in each mining domain which the Panel has tallied to be a total of 38.8 km of pipeline of which 21.1 km is directly above the extent of the longwall mining area, Table 31. Appendix A records that there is some 7.4 km of pipeline in Area 9 but then gives no consideration to this mining domain in the analysis that follows. The Panel notes from its own assessment (see Table 31) that the predicted maximum subsidence parameters for Area 9 fall at the lower end of the range for the affected mining domains and has therefore assumed that the conclusions drawn for the other mining domains are also valid for Area 9.

Table 31: Summary of Sydney Water Pipelines within the Study Area and Predicted Maximum Subsidence Effects

Mining Domain	Total Length of Pipeline		Maximum Subsidence Prediction					
	Within Study Area (km)	Directly above Longwall Mining Area (km)	Vertical Disp (mm)	Tilt (mm/m)	Tensile Strain (mm/m)	Comp Strain (mm/m)	Closure (mm)	Upsidence (mm)
Area 2	0	0	1350	11	2.4	5.3	-	-
Area 3	13 2	4.8	1250	7.5	1.7	2.9	180	175
West Cliff Area 5	3.1	1.9	1300	7.0	1.4	2.1	-	-
Area 7	8.7	6.7	1600	8.0	1.4	2.3	75	65
Area 8	6.4	0.8	1200	6.5	1.2	2.0	95	120
Area 9	7.4	6.9	1600	6.5	1.1	1.7	-	-
North Cliff	0	0	1400	8.5	1.5	2.9	-	-
TOTAL	**38.8**	**21.1**						

The EA discusses previously observed movements and impacts over longwall panels at Appin, Westcliff and Tahmoor Collieries. In the case of existing mines associated with the BSO Project, impacts have been confined to one creek crossing. The EA concludes that:

- *The predicted systematic movements are of a similar order of magnitude to those predicted and observed along pipelines previously undermined by longwall panels in the Southern Coalfield.*
- *Based on this experience, it is expected that some minor leakages of the water pipelines could occur, as a result of the extraction of the longwalls, however, the incidence of impacts is expected to be low. Impacts are more likely to occur in the locations of non-systematic movements, and at creek crossings due to valley related movements.*
- *Any impacts are expected to be of a minor nature which could easily be remediated.*
- *With an appropriate management plan in place, it is considered that the potential impacts on Sydney (Water) pipelines can be managed for any orientation of longwalls within the Extents of the Longwall Mining Areas, even if actual subsidence movements are greater than predictions*[524].

The Panel concurs with these conclusions but in so doing, re-emphasises the need for robust management plans that include provision for effective contingencies for responding to impacted pipelines.

11.10.2. Macarthur Water Supply System

Part of the Macarthur Water Supply System, which is owned by United Utilities Australia lies within Area 3 and West Cliff Area 5. The system treats and supplies water from the Cataract River (at Broughtons Pass) to Campbelltown and surrounding townships including Wilton and Appin.

A 1200 mm diameter untreated and a 1500 mm untreated water main lie within Area 3 just outside the extent of the longwall mining areas. The EA provides no information as to whether these water mains were designed to Mine Subsidence Board requirements. A 1200 mm diameter treated water gravity main designed and constructed in 1994 to the Mine Subsidence Board's design requirements passes through West Cliff Area 5.

The EA states that the predicted subsidence movements at the pipelines in Area 3 are very small and are, therefore, unlikely to result in any significant impacts on the two water mains. Based on the information presented in the EA, this conclusion appears reasonable to the Panel although it is noted that the EA does not provide an assessment of non-systematic subsidence movements on these pipelines.

The 1200 mm diameter pipeline has already been subjected to 760 mm subsidence, 195 mm of valley closure and 70 mm of upsidence at Mallaty Creek as a result of been under-mined by longwall panels at Westcliff Colliery. The EA summarises the mitigation measures associated with this mining, some of which are shown in Figure

[524] Appendix A, page 158

46. The pipeline will be subjected to additional subsidence effects at Mallaty Creek and to subsidence effects at other creek sites when subsequent longwalls within the Study Area are extracted.

The EA concludes that:

> *'With an appropriate management plan in place, it is considered that the potential impacts on the 1200 mm pipeline can be managed for any orientation of longwalls within the Extents of the Longwall Mining Areas, even if actual subsidence movements are greater than predictions'*[525].

Based on field inspections of the Mallaty Creek site and outcomes to date, the Panel concurs with this conclusion but, once again, with the proviso that management plans must be robust and include effective contingencies.

11.10.3. Gas Infrastructure

Three high pressure gas pipelines traverse the Study Area in Area 3, Area 5 and Area 7, these being the Eastern Gas Pipeline, the AGN Pipeline and an Ethane Pipeline. There is also a gas distribution network which services the properties in the northern part of Area 7. The Panel has calculated a total of 26.6 km of pipeline within the Study Area, of which 10.4 km is directly above the extent of the longwall mining area, Table 32.

Table 32: Summary of Gas Pipeline Infrastructure within the Study Area and Predicted Maximum Subsidence Effects

Mining Domain	**Total Length of Pipeline**		**Maximum Subsidence Prediction**					
	Within Study Area (km)	**Directly above Longwall Mining Area (km)**	**Vertical Disp (mm)**	**Tilt (mm/m)**	**Tensile Strain (mm/m)**	**Comp Strain (mm/m)**	**Closure (mm)**	**Upsidence (mm)**
Area 3	11.3	2.9	1250	7.5	1.7	2.9	80	70
West Cliff Area 5	9	5.7	1300	7.0	1.4	2.1	700	475
Area 7	6.3	1.8	1600	8.0	1.4	2.3	320	180
TOTAL	**26.6**	**10.4**						

The Eastern Gas Pipeline (EGP) is owned and operated by Jemena and was constructed in 2000. The pipeline is a fully welded steel pipeline, 450 mm in diameter, laid below ground with a minimum cover of 600 mm. It was designed to accommodate subsidence and was approved by the Mine Subsidence Board.

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[525] Appendix A, page 162

The AGN Pipeline, which is also owned and operated by Jemena, was completed prior to 1976 and forms part of the Sydney Region Trunk Distribution System. The pipeline is a fully welded steel pipeline, 864 mm in diameter, which is laid below ground with a minimum cover of 800 mm. The pipeline was built without Mine Subsidence Board approval within the Appin Mine Subsidence District which is located south of Mallaty Creek. The pipeline, however, was built prior to the declaration of the South Campbelltown Mine Subsidence District, which is located north of Mallaty Creek, and the northern section is consequently covered by the Mine Subsidence Compensation Act.

The Ethane Pipeline is owned and operated by Gorodok. It is a fully welded steel pipeline, 203 mm in diameter, which is laid below ground with a minimum cover of 800 mm. It is a high pressure main with a wall thickness of 8 mm and operates at pressures up to 15 MPa. The pipeline was designed to AS2885, constructed under the Pipeline Authority Act, and is licensed by the Department of Energy. However, it is not approved by the Mine Subsidence Board.

The gas distribution network comprises buried pipelines ranging in diameter between 90 mm and 450 mm.

The EA discusses movements and impacts previously observed over longwall panels at Appin and Westcliff Collieries. In one case in Area 2 at Appin Colliery, the pipelines have been subjected to 20 mm upsidence and 305 mm closure. In another case over Area 4 at Appin Colliery, the pipelines have been subsided 1000 mm and been subjected to 195 mm of closure and 135 mm of upsidence. A third case is that shown in Figure 46 at Mallaty Creek. The EA reviews the management strategies adopted in these three cases and concludes that:

> *At the time of this report, West Cliff Longwall 33 had been successfully mined beneath these gas pipelines. The majority of the upsidence and closure movements at Mallaty Creek, the largest crossing, are considered to have occurred, with only small additional movements predicted for the future longwalls. It is expected, therefore, that the gas pipelines will continue to be successfully managed at West Cliff Colliery for the future longwalls, as the valley depths of Leafs Gully and Nepean Creek are smaller than the valley depth at Mallaty Creek. It is also expected, that the mine subsidence movements in Area 3 can be managed using similar strategies as those previously adopted in Areas 2, 4 and 5.*
>
> *With an appropriate management plan in place, it is considered that potential impacts to the gas pipelines can be managed for any orientation of longwalls within the Extents of the Longwall Mining Areas, even if actual subsidence movements are greater than the predictions*[526].

The key issues are public safety and security of gas supply.

The Panel recommends that Performance Criteria in any Project Approval should include the following requirements:

[526] EA, Appendix A, p.174.

1. Mining activities in the BSO Study Area are not to jeopardize public safety or security of gas supply.

2. Mining is not to impact on gas reticulation systems and devices such that they cannot be maintained in a *safe, serviceable and repairable* condition.

3. The infrastructure owner has the *prima facie* right to determine what is *safe, serviceable and repairable* for their purposes, with any dispute with the leaseholder[527] being referred to a neutral arbiter selected by the Department of Planning and funded by the leaseholder.[528]

4. The leaseholder is to guarantee funding to undertake all risk management activities and all mitigation and remediation activities associated with maintaining in a safe, serviceable and repairable condition, all gas reticulation systems that are impacted by mining operations. This includes all the direct and indirect costs of the infrastructure owner in participating in this risk management process. (Given the incremental nature of subsidence development, a number of remediation campaigns may be required.)

5. All activities related to maintaining security of gas supply and gas reticulation systems in a safe, serviceable and repairable condition are to be structured within a risk management framework that is consistent with *ISO 31000 Risk Management*.

6. The risk management system for mining in the vicinity of gas reticulation systems is to be:

   i. Audited externally for compliance with ISO 31000 prior to lodgment of associated Extraction Plans, with the auditor/s to be selected by the Department of Planning in consultation with the infrastructure owner, and the audit report to accompany the Extraction Plan application.

   ii. Audited externally for compliance with ISO 31000 on an annual basis for the duration that the plan is invoked, with the auditor/s to be selected by the Department of Planning in consultation with the infrastructure owner.

   iii. Reviewed externally for effectiveness on an annual basis for the duration that the plan is invoked, with the reviewer to be selected by the Department of Planning in consultation with the infrastructure owner.

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[527] The words *leaseholder* and *mining company* and *mine operator* and other variants are used throughout the Panel's report in an interchangeable manner when referring to entities responsible for conducting the coal mining operations. This is adequate for the Panel's purpose. However, the Department of Planning will need to ensure that the correct legal entity is required to assume responsibility for actions/costs in relation to any conditions of approval where this may be relevant.

[528] This condition recognises: the critical importance of the infrastructure to the State; the fact that the appropriate knowledge and expertise regarding the design and serviceability of the infrastructure is most likely to reside with the infrastructure owner; and the fact that the accountability for maintaining the infrastructure in a safe, serviceable and repairable state resides with the infrastructure owner.

7. No Extraction Plan should be approved that could create any additional risk to the State's gas supply system from mining activities until all potential sources of the increased risk have been investigated to the satisfaction of the Director-General of the Department of Planning and the proposals in the Extraction Plan for avoidance, mitigation or control of any such risks ensure that the functionality of the State's gas supply system is not put in jeopardy.

In setting this outcome, the Panel recognizes that mining is already occurring within the Study Area under the SMP approval process and that due to the small number of longwall panels involved, there may be no need to specify approval based on the BSO Project assessment process for existing gas supply infrastructure.

11.10.4. Gas Trunk Receiving Station

There is a gas trunk receiving station within the Study Area at Wilton in Area 3. Based on the very limited information contained in the EA regarding this infrastructure, the Panel considers it to comprise a component of the gas reticulation systems in the Study Area and, therefore, subject to the Performance Criteria already noted in relation to gas supply systems.

11.10.5. Electrical Reticulation

Integral Energy owns and maintains a number of 66 kV, 11 kV and low voltage powerlines within the Study Area. All of the conductors within the distribution network consist of overhead cables supported by some 4000 power poles within the Study Area, of which 2900 are located within the extent of the longwall mining area.

TransGrid owns and maintains a 330 kV transmission line which crosses Areas 3, 5 and 7. Of the 9.5 km of transmission line within the Study Area, 6.2 km is directly above the extent of the longwall mining area.

The 66 kV, 11 kV and low voltage powerlines are expected to experience the full range of predicted systematic subsidence movements. The cables are not affected by ground curvatures and strains, as they are supported by the poles above ground level. However the cables can be affected by changes in the bay lengths where the distances between the poles at the height of the cables changes as a result of induced differential subsidence, horizontal ground movements and lateral movements. The stabilities of the poles can also be affected by the tilting of the poles and the changes in the catenary profiles of the cables.

The EA summarises a range of experiences in undermining powerlines in the Southern Coalfield and concludes that there have been only very minor impacts on powerlines. Some remedial measures have been required. These have included adjustments to cable catenaries, pole tilts and to consumer cables which connect between the power poles and houses.

The cables along the 330 kV line are supported by towers as opposed to poles. The cables can be affected by changes in distance between towers resulting from mining induced differential vertical displacement, horizontal ground movements and lateral movements at the top of the towers due to tilting of the towers. The stability of the towers can be affected by the mining inducted tilts and ground strain at the location of each tower, and by changes in the catenary profiles of the cables.

Based on a tower height of 50 m, the maximum predicted systematic tilt and predicted systematic horizontal movement results in a maximum predicted horizontal movement of 500 mm at the tops of the towers. This may lead to small changes in the catenary profile of the aerial cables which in turn, can result in differential horizontal loads on the towers. This may necessitate roller sheaves on some towers to accommodate the predicted horizontal movements.

The EA reports that previous experience of mining beneath transmission towers in the Southern Coalfield indicates that the transmission towers can typically accommodate ground strains associated with a depth of mining greater than 400 m, as is the case within the Project Area. In some cases, cruciform bases may be required to isolate the transmission towers from ground curvatures and strains, Figure 47.

The Panel is aware that there is an extensive international experience base in undermining transmission lines without jeopardizing public safety and security of power supply and that it is undertaken routinely, especially at the depths of mining associated with the Study Area. So-called ‘tension’ towers present the greatest obstacle. These are towers located at points where the transmission lines change direction, thereby subjecting the towers to lateral forces which, if sufficiently high, can cause a tower to topple. The EA notes that there are three tension towers located directly above the Extent of Longwall Mining Areas and provides the predicted maximum subsidence parameters for these. It recommends that these movements be provided to TransGrid so that a detailed structural analysis can be undertaken.

The key issues are public safety and security of power supply.

The Panel recommends that Performance Criteria in any Project Approval should include the following requirements:

1. Mining activities in the BSO Study Area are not to jeopardize public safety or security of power supply.

2. Mining is not to impact on electrical reticulation systems and devices such that they cannot be maintained in a safe, serviceable and repairable condition.

3. The infrastructure owner has the prima facie right to determine what is safe, serviceable and repairable for their purposes, with any dispute with the leaseholder being referred to a neutral arbiter selected by the Department of Planning and funded by the leaseholder.

4. The leaseholder is to guarantee funding to undertake all risk management activities and all mitigation and remediation activities associated with maintaining in a safe, serviceable and repairable condition, all electrical reticulation systems that are impacted by mining operations. This includes all the direct and indirect costs of the infrastructure owner in participating in this risk management process. (Given the incremental nature of subsidence development, a number of remediation campaigns may be required.)

5. All activities related to maintaining security of power supply and electrical reticulation systems in a safe, serviceable and repairable condition are to be structured within a risk management framework that is consistent with ISO 31000 Risk Management.

6. The risk management system for mining in the vicinity of electrical reticulation systems is to be:

   i. Audited externally for compliance with ISO 31000 prior to lodgment of associated Extraction Plans, with the auditor/s to be selected by the Department of Planning in consultation with the infrastructure owner, and the audit report to accompany the Extraction Plan application.

   ii. Audited externally for compliance with ISO 31000 on an annual basis for the duration that the plan is invoked, with the auditor/s to be selected by the Department of Planning in consultation with the infrastructure owner.

   iii. Reviewed externally for effectiveness on an annual basis for the duration that the plan is invoked, with the reviewer to be selected by the Department of Planning in consultation with the infrastructure owner.

7. No Extraction Plan should be approved that could create any additional risk to the State's electrical power supply system from mining activities until all potential sources of the increased risk have been investigated to the satisfaction of the Director-General of the Department of Planning and the proposals in the Extraction Plan for avoidance, mitigation or control of any such risks ensure that the functionality of the State's electrical power supply system is not put in jeopardy.

There are three substations within the Study Area. The EA states that it will be necessary for ICHPL, in consultation with Integral Energy and the Mine Subsidence Board, to develop a subsidence management strategy for these substations in liaison with Integral Energy before mining occurs. The Panel considers these substations to comprise components of an electrical reticulation system and therefore to be subject to the Performance Criteria already noted.

11.10.6. Telecommunications

The telecommunications infrastructure in the Study Area comprises aerial and underground copper cables and buried optical cables. A total of 264 km of copper cabling and 61.6 km of optical cable fibre already exist in the study area, Table 33.

Table 33: Summary of Telecommunications Infrastructure within the Study Area

Domain	Total Length of Copper Cables		Total Length of Optical Fibre Cables	
	Within Study Area (km)	Directly above Extent of Longwall Mining Area (km)	Within Study Area (km)	Directly above Extent of Longwall Mining Area (km)
Area 2	-	-	0	0
Area 3	-	-	5.7	3.4
West Cliff Area 5	-	-	1.9	1.0
Area 7	-	-	38.8	35.8
Area 8	-	-	12.3	6.5
Area 9	-	-	18.1	14.9
North Cliff	-	-	0	0
TOTAL	**369 km**	**264 km**	**77 km**	**61.6 km**

The EA discusses movements and impacts previously observed over longwall panels at Appin, Westcliff and Tahmoor Collieries in respect of both buried and aerial copper cables. It concludes that there have been only minor impacts on the aerial copper communications cables. Impacts on buried cables are not specifically addressed although the case studies presented in the EA all report *no significant impacts*[529]. The Panel is aware that many hundreds of kilometres of copper telecommunications have been undermined both nationally and internationally with only minor or nil impacts. The likelihood of unacceptable impact is very low in the case of the BSO Project because of the considerable depth of mining.

The EA also presents a number of case studies on undermining optical fibre cable in the Southern Coalfield, the Newcastle Coalfield and the Hunter Coalfield. An impact was only recorded for one of these case studies, being South Bulga Colliery which the Panel is aware was mined at a much shallower depth than that associated with the BSO Project. The EA recommends that:

> *.. existing management plans be reviewed, where already established, and additional management plans developed elsewhere, so that the optical cables can be maintained in serviceable conditions throughout the mining period*[530]

However, the Panel is aware of the concerns of DII in its oral and written submission (DII, 2009b) regarding the consequential losses arising from the failure of a major telecommunications cable linking Sydney with Melbourne and Canberra. The EA does not identify the type of information transmitted by the optical cables, redundancy and contingencies for transmitting this information, nor the potential consequences should its function be adversely impacted by mining. It appears to the Panel, on the basis of the limited information available, that the failure of a telecommunications cable may be a low to moderate likelihood event that has high potential consequences.

[529] Appendix A, page 183
[530] Appendix A, page 185

Hence, a high level of risk may be associated with such an event. In this particular case, the level of risk is likely to change with time as current telecommunication systems become obsolete and new systems are either wireless or designed and located to avoid exposure to mining impacts. New technologies will need to be considered as part of the Extraction Plan approval process.

The Panel recommends that Performance Criteria in any Project Approval should include the following requirements:

1. Mining activities in the BSO Study Area are not to cause an interruption to state and national cable based telecommunication systems. This condition is not intended to exclude contingencies that involve temporarily switching to an alternative communications system or corridor in the event of a loss of serviceability, provided that there is no loss of communications.

2. Mining activities in the BSO Study Area are not to result in a loss of local cable based telecommunications systems. This does not preclude the provision of alternative local communication systems (mobile phones, VHF radio) for brief periods whilst the normal telecommunication system is restored.

1. Mining is not to impact on cable telecommunication systems and devices such that they cannot be maintained in a *safe, serviceable and repairable* condition.

2. The infrastructure owner has the *prima facie* right to determine what is *safe, serviceable and repairable* for their purposes, with any dispute with the leaseholder being referred to a neutral arbiter selected by the Department of Planning and funded by the leaseholder.

3. The leaseholder is to guarantee funding to undertake all risk management activities and all mitigation and remediation activities associated with maintaining in a safe, serviceable and repairable condition, all cable telecommunication systems that are impacted by mining operations. This includes all the direct and indirect costs of the infrastructure owner in participating in this risk management process. (Given the incremental nature of subsidence development, a number of remediation campaigns may be required.)

4. All activities related to maintaining security of telecommunication and telecommunication systems in a safe, serviceable and repairable condition are to be structured within a risk management framework that is consistent with *ISO 31000 Risk Management*.

5. The risk management system for mining in the vicinity of cable telecommunication systems is to be:

   i. Audited externally for compliance with ISO 31000 prior to lodgment of associated Extraction Plans, with the auditor/s to be selected by the Department of Planning in consultation with the infrastructure owner, and the audit report to accompany the Extraction Plan application.

ii. Audited externally for compliance with ISO 31000 on an annual basis for the duration that the plan is invoked, with the auditor/s to be selected by the Department of Planning in consultation with the infrastructure owner.

iii. Reviewed externally for effectiveness on an annual basis for the duration that the plan is invoked, with the reviewer to be selected by the Department of Planning in consultation with the infrastructure owner.

6. No Extraction Plan should be approved that could create any additional risk to the State's cable telecommunications systems from mining activities until all potential sources of the increased risk have been investigated to the satisfaction of the Director-General of the Department of Planning and the proposals in the Extraction Plan for avoidance, mitigation or control of any such risks ensure that the functionality of the State's telecommunication systems.

11.10.7. Mobile Phone Towers

The Panel recommends that mobile phone towers be subject to the same Performance Criteria as apply to the cable telecommunication system.

11.10.8. Air Strips

There are two air strips within the Study Area. The Sydney Sky Divers Centre is located adjacent to the Hume Highway in Area 8 and includes an 800 m long, compacted earth air strip. It is directly above the proposed longwalls and may experience the maximum predicted subsidence movements for Area 8. The EA identifies the main risks associated with mining beneath an air strip to be the formation of cracks and humps in the compacted earth. It assesses that potential impacts can be managed in consultation with Sydney Sky Divers by means of an appropriate management plan.

The EA has not given consideration to the impact of wider longwall panels in the air strip. Nevertheless, given the rate at which subsidence movements develop, the Panel considers that the management approach proposed in the EA is plausible. Consideration should be given to applying similar approval conditions to those that are applied to local roads.

The second air strip is Wedderburn Air Strip located within Area 5 and managed by the NSW Sport Aircraft Club. The strip is more than 970 m long and consists of a sealed asphaltic pavement. The EA reports that the air strip experienced mine subsidence movements during the extraction of West Cliff Longwalls 20 to 24 but provides no information as to the nature and magnitude of these movements. It notes that the closest distance of the longwalls (Extent of Longwall Mining) in the Base Case layout is more than 400 m and beyond the limit of vertical subsidence. On this basis, there does not appear to be a need to recommend approval conditions.

11.10.9. Survey Control Marks

There are numerous survey control marks in the Study Area and they are subject to the full range of subsidence outcomes. It is not uncommon to undermine survey control marks and to relocate them or to reinstate them at their original location once ground movements have stabilized.

The Panel recommends that approval conditions include a requirement to relocate and/or reinstate survey control marks to a standard determined by the NSW Land and Property Management Authority within an agreed timeframe.

11.11. FARMS AND FARM FACILITIES

There are a number of farming enterprises in the Study Area. The Panel is aware that there is an extensive international experience base relating to the undermining of farms and farm facilities that can be utilized for preparing Extraction Plans. Therefore, only select points are noted in this section.

- Elizabeth Macarthur Agricultural Institute – Almost all structures are located outside of the longwalls in the Base Case layout. The closest longwall is approximately 80 m from the nearest structure. The site is discussed in more detail in Section 11.13 – Heritage.
- Wineries – The Panel is of the view that, with one exception, the issues are adequately and accurately discussed in the EA. The Panel does not accept that at the depth of mining in the Study Area, *surface impacts are typically orders of magnitude lower than in the Hunter Valley*[531]. The term *orders of magnitude* implies some 10 to 100 fold or more decrease in impacts, which is considered to be a gross over-estimation. The Panel recommends that this description not be taken literally.
- Agriculture – The Panel is of the view that the issues are adequately and accurately discussed in the EA.
- Horse Studs - The Panel is of the view that the issues are adequately and accurately discussed in the EA.
- Farm Buildings and Sheds – There are 4356 structures reported in the Study Area. Case studies of 354 undermined rural structures revealed that 7 experienced impacts. This low figure is attributed in the EA to the structures being generally small in size and of light-weight construction. The EA gives a commitment that *'any impacts on rural structures that occur as the result of the extraction of the longwalls are expected to be remediated using well established building techniques'*[532]. This commitment is open to interpretation. Presumably, it is intended to mean that any impacts *will be able to be* remediated. A further question arises as to whether this commitment extends to structures that may have been constructed in a declared mine subsidence district without MSB approval.
- Tanks - The Panel is of the view that the issues are adequately and accurately discussed in the EA.
- Gas and Fuel Storages - The Panel is of the view that the issues are adequately and accurately discussed in the EA.

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[531] Appendix A, page 203

[532] EA, Appendix A, p.206.

- Poultry Sheds - The Panel is of the view that the issues are adequately and accurately discussed in the EA.
- Farm Dams – The EA states that the predicted subsidence parameters for farm dams within the Study Area are a similar order of magnitude as those predicted at farm dams which have been mined directly beneath by previously extracted longwalls in the Southern Coalfield and that based on this experience, *it is considered that mining of the longwalls is unlikely to result in impacts to a significant number of dams within the Study Area. It is possible that some cracking or leakage of water may occur in the farm dam walls which are subjected to higher strains, though any cracking or leakages could be readily identified and remediated as required*[533]. The EA goes on to state that ICHPL will develop Management Plans in consultation with landowners to address the management of impacts on farm dams. Such plans are well established for farm dams in subsidence engineering.
- Wells and Bores – Mr John Peart, President of *Wedderburn Against Mining (WAM)* expressed concern on behalf of WAM about, amongst other things, the loss of water supply from tanks, dams and bores. Wedderburn relies on these sources of water as it is not connected to a town supply. WAM does not believe that the MSB will reinstate the local water supply within hours of damage, especially when Wedderburn is threatened by bush fire.

  The EA acknowledges the potential for blockage of bores from mining induced movements and for groundwater depressurisation and that impacts may include:

  > *'temporary lowering of the piezometric surface'*. It states that *ICHPL has developed a number of management plans for groundwater bores which have been previously mined beneath in the Southern Coalfield'* and recommends that *'these existing management plans be reviewed, where already established, and additional management plans developed elsewhere such that the potential impacts on the groundwater can be managed throughout the mining period'*[534].

  However, the EA provides no details of these management plans and so the Panel cannot make an assessment of their appropriateness or effectiveness.

  The Panel is conscious that water level reduction in bores may be time dependent, in which case mining operations may be defunct before the impacts are fully developed.

11.12. INDUSTRIAL, COMMERCIAL AND BUSINESS

11.12.1. Maldon Cement Works

The cement works contains a number of structures and items of plant that are sensitive to differential ground movements. The more sensitive structures are located some 60 to 100 m outside of the footprints of Longwalls 800 and 801 in Area 8. The elements of a management strategy are identified in the EA, none of which propose increasing

533 EA, Appendix A, p.211.
534 EA, Appendix A, p.212.

the offset distance between the start of the longwall panels and the infrastructure. The Base Plan layout is amenable to this mitigation measure.

The Panel recommends that any form of mining within 600 m of the footprint of the Maldon Cement Works not be approved until such time as the risk to the structures that comprise the complex have been assessed and arrangements put in place for avoidance, mitigation and/or control of the risks and these arrangements are detailed in the relevant instruments that would permit mining to proceed.

11.12.2. Allied Mills Flour Mill

This mill is reported to have been designed to Mine Subsidence Board requirements. Nevertheless, the EA states that the building structures and silos would appear to be reasonably sensitive to differential subsidence movements and the serviceability of these items needs to be considered before the mine plan is finalised. The Panel does not have adequate information to be able to reconcile these two positions.

The Panel recommends that any form of mining within 600 m of the footprint of the Allied Mills Flour Mill not be approved until such time as the risk to the structures that comprise the complex have been assessed and arrangements put in place for avoidance, mitigation and/or control of the risks and these arrangements are detailed in the relevant instruments that would permit mining to proceed.

11.12.3. Douglas Park Petrol Station

The EA reports that there is limited history of undermining petrol stations. The Panel notes that the two case studies presented in the EA were associated with significantly less vertical displacement than that which the Douglas Park petrol station is predicted to experience for the Base Case layout. The Panel has insufficient information to assess the situation.

The Panel recommends that any form of mining within 600 m of the footprint of the Douglas Park Petrol Station not be approved until such time as the risk to the structures that comprise the complex have been assessed and arrangements put in place for avoidance, mitigation and/or control of the risks and these arrangements are detailed in the relevant instruments that would permit mining to proceed.

11.13. NON-ABORIGINAL HERITAGE

11.13.1. Scope

A total of 47 structures of non-Aboriginal heritage significance have been identified within the Study Area. These include:

- Menangle Railway Bridge and Viaduct
- Menangle Railway Station
- Menangle Weir
- Nepean Tunnel and Upper Canal
- Cataract Dam and Broughtons Pass Weir
- Maldon Suspension Bridge
- Elizabeth Macarthur Agricultural Institute
- Menangle Conservation Area, which includes a number of buildings including two churches, a store and 10 residences
- A monument and milepost

The Menangle Conservation Area and some surrounding structures have been recommended for State Heritage Listing by Wollondilly Shire Council.

11.13.2. Subsidence Effects, Impacts and Consequences

Predictions of subsidence effects and impacts in the EA for those structures located beyond or near the Extent of the Longwall Mining Area are site specific based on the Base Case layout. For structures located directly above longwall panels, these predictions have been based on the maximum predicted movements within the mining domain, in order to account for any change in longwall orientation or location in the future. The Panel supports this concept and recognizes that not all structures above longwall panels will actually experience the maximum predicted movements for the Base Case longwall panel width. However, no provision has been made in the assessment for increased subsidence effects if longwall panel width is increased in the future.

The probabilistic method of assessment developed from the ACARP research conducted at Tahmoor Colliery[535] has been applied to buildings of heritage significance. This methodology has been applied in a more sophisticated manner that applied to assessing impacts on residences in the Study Area (as discussed in Section 11.9), in that it distinguishes between different construction materials and techniques, Table 34.

These are:

- Brick or brick-veneer houses with slab on ground
- Brick or brick-veneer houses with strip footing

[535] As described in Appendix C of Appendix A.

- Timber-framed houses with flexible external linings of any foundation type

Table 34: Probabilities of Impact based on Curvature and Construction Type based on the Revised Method of Impact Classification[536]

Curvature, R^{-1} (km^{-1})	Repair Category			
	No Repair or R0	**R1 or R2**	**R3 or R4**	**R5**
Brick or brick-veneer houses with Slab on Ground				
<0.02	90 ~ 95 %	3 ~ 10 %	1 %	< 0.1 %
0.02 to 0.07	80 ~ 85 %	12 ~ 17 %	2 ~ 5 %	< 0.5 %
0.07 to 0.2	70 ~ 75 %	17 ~ 22 %	5 ~ 8 %	< 0.5 %
Brick or brick-veneer houses with Strip Footing				
<0.02	90 ~ 95 %	3 ~ 10 %	1 %	< 0.1 %
0.02 to 0.07	80 ~ 85 %	7 ~ 12 %	2 ~ 7 %	< 0.5 %
0.07 to 0.2	70 ~ 75 %	15 ~ 20 %	7 ~ 12 %	< 0.5 %
Timber-framed houses with flexible external linings of any foundation type				
<0.02	90 ~ 95 %	3 ~ 10 %	1 %	< 0.1 %
0.02 to 0.07	85 ~ 90 %	7 ~ 13 %	1 ~ 3 %	< 0.5 %
0.07 to 0.2	80 ~ 85 %	10 ~ 15 %	3 ~ 5 %	< 0.5 %

The Panel is aware from its site inspections and information in the EA that many of the houses of heritage status can be classified into one of these construction categories. However, it notes that some structures do not fit these categories, including three of the more significant structures, being:

- St James Anglican Church, Menangle
- St Mary's Tower, Douglas Park, and
- Wilton Park Stables, Wilton

Appendix H states that:

> *In the case that heritage cannot feasibly (economically or technically) be maintained using engineering mitigation measures for items of state and/or national; significance, adjustment to the mine plan would be considered to achieve the same. Informing that decision would be the management context and condition of the place, and the likelihood of long term conservation being achieved*[537].

[536] Modified from Table C.5 of Appendix C of Appendix A of the EA by converting radius of curvature to curvature. Curvature = 1/radius of curvature
[537] EA, Appendix H, p.43.

The Panel notes that EA only commits to 'considering' making adjustments to the mine plan in order to maintain heritage value and does not identify the decision makers in the above process.

Appendix H goes on to state that:

> *In the case that it is not feasible (either economically or technically) to implement management or mitigation measures to maintain the heritage values of a state and/or national heritage significance item, adjustment to the mine plan would be considered to achieve the same........The items where this level of management may particularly need to be considered as a component of the EP process are:*
>
> - *St James Anglican Church, Menangle*
> - *St Mary's Tower, Douglas Park, and*
> - *Wilton Park Stables, Wilton*
>
> *While they are of lesser heritage significance, the Camden Park Estate Creamery, Gilbulla (Anglican Conference Centre) and St Patrick's Catholic Church (of regional, local/regional and local significance respectively) are also larger multistorey brick buildings. Subject to the outcomes of the detailed subsidence and structural assessments, these items may also require more detailed consideration of the potential implementation of mitigation or management measures during the EP process, due to their actual size and construction*[538]*.*

The Panel notes once again that the EA only commits ICHPL to *considering* these courses of actions. It does not categorically commit to maintaining the heritage values of the structures of interest.

Appendix A acknowledges that in the case of the larger masonry type structures, the method of assessment has been based in observations of impacts to houses and not to larger and more rigid structures such as churches. It reports that if impacts occurred to the masonry walls of the larger heritage structures, the opportunities to repair the heritage fabric would be limited.

The Panel notes that this and other conclusions concerning heritage structures in Appendices A and H do not give specific consideration to the impact of non-systematic or anomalous subsidence behaviour. Rather, Appendix A only acknowledges that *'it is possible that the heritage items could experience non-systematic movements'*[539]. Subsidence impacts on houses are discussed further on in Appendix A, where it is reported that:

> *The majority, if not all, of the houses that experienced Category 3, 4 or 5 impacts (at Tahmoor Colliery) are considered to have experienced substantial non-systematic movements*[540]*.*

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[538] EA, Appendix H, p45.
[539] EA, Appendix A, p.224.
[540] EA, Appendix A, p.276.

> and
>
> *While additional statistical information is now available, there remains limited knowledge at this point in time to accurately predicted the locations for non-systematic movement. Substantial gains are still to be had in this area.*
>
> *In the meantime, therefore, a probabilistic method of impact has been developed. The method combines the potential for impacts from both systematic and non-systematic subsidence movement*[541].

Based on consideration of subsidence impacts on houses in the region, the Panel considers that there is an unacceptably high risk (comprised of probability and consequence) that an anomaly in the vicinity of a heritage structure of masonry construction could result in a significant loss of heritage value, which may extend to demolition.

11.13.3. Performance Criteria

The Panel is not qualified to assess Heritage value and in any case, could not do so in the timeframe available. The EA reports that in July 2009, ICHPL consulted with the Heritage Branch of DoP with respect to management of non-Aboriginal heritage items in the vicinity of the Project. The EA states that it is anticipated that the Heritage Branch will provide additional formal feedback on the Non-Aboriginal Heritage Assessment (Appendix H) following public exhibition of the EA[542]. The Panel also sought advice from the Heritage Branch and was advised that:

> *'The Heritage Branch is unable to provide detailed comments in the time frame required regarding what would essentially be a wide range of repair techniques to a number of different structure and fabric types where the impacts of the project are not yet fully appreciated. It is suggested that this should have formed part of the Non-Aboriginal Heritage Study already commissioned for this project and now should be the subject of a separate study to be commissioned in the immediate future'.*

Hence, the Panel has had to rely on the descriptions of heritage structures and their values provided in the EA, supported by site inspections to develop points of reference for advising on Performance Criteria. The Panel formed the following views from this process:

- A considerable number of the heritage items are of single storey weatherboard construction and, therefore, are likely to have a high tolerance to subsidence and to be amenable to repair in a manner sympathetic with their heritage values.

- A number of structures are of masonry construction, some of two storey construction. A number of these have an architectural brickwork finish which

[541] EA, Appendix A, p.284
[542] EA, Volume 1, p.3-1.

contributes significantly to their heritage value. In most of these cases, the EA reports that:

> *'If impacts occur to the masonry walls, the opportunities to repair the heritage fabric .....are limited as the bricks are exposed and will be difficult to match'*[543]

- Some structures are large functioning engineering constructions and in instances, such as for Cataract and Nepean Tunnels, are hidden from sight. Some have already been subjected to subsidence impacts, for example, Cataract Tunnel, the Upper Canal and Broughtons Pass Weir.

- There are a number of heritage listed structures that are in a state of disrepair and are unlikely to have their heritage value diminished further by being subjected to subsidence.

St James Anglican Church, Menangle was considered by the Panel to be one of the most significant heritage structures in the Study Area. The EA provides a tabulation of *Preliminary Recommendations to Maintain Heritage Values* which for St James Anglican Church proposes *Minimise damage to external brickwork to cracks in a small number of bricks only and any continuous cracking to be limited to the mortar only*[544].

The Panel inspected this structure and noted that the external brickwork is a strong architectural feature in its own right and is also an internal architectural feature of this building, Figure 57: Figure 58: The heritage value of this structure is particularly at risk by damage to its brickwork, particularly since *the opportunities to repair the heritage fabric of the Church are limited as the bricks are exposed and will be difficult to match*[545]. Based on the consideration of the heritage value of this church in its own right, in the setting of the Menangle Conservation Area, and in a regional setting, the Panel was of a view that the church warrants a Performance Criteria of *nil* impact.

At the other extreme is the Camden Park Rotolactor. It is in a very poor state of disrepair and restoration in any event would impact significantly on its original structural fabric.

The Panel recommends that any approval be based on:

10. A Performance Criteria of *nil* impact on the heritage value of the following sites, where *nil* means *no mining induced change of any description in heritage value*. In the case of sites which may have already been impacted by past mining operations, e.g. Broughton's Pass Weir, *nil* impact has the meaning of *no additional mining induced change of any description*. These sites are:

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[543] This applies to St James Church and St Patrick's Church in Menangle, for instance – EA, Appendix A, pp228-229.
[544] EA, Appendix H, p.37, Table 4-4.
[545] EA, Appendix A, p.228.

i. Cataract Dam Wall.

ii. Broughtons Pass Weir.

iii. St James Church, Menangle.

iv. St Mary's Tower, Douglas Park.

11. A requirement that no Extraction Plan is to be approved unless:

i. A survey has been undertaken of all non-Aboriginal heritage sites within an area defined by a 600 m wide boundary around the mining area to which the Extraction Plan relates;

ii. The heritage value of each site within this boundary has been determined by appropriately qualified persons in consultation with the Heritage Branch;

iii. Measures necessary to preserve the heritage value of all heritage sites of significance are incorporated into a Heritage Management Plan as an element of the associated Extraction Plan including incorporation of effective adaptive management provisions for responding to unpredicted anomalous and non-conventional subsidence effects.

iv. The Heritage Management Plan has been peer reviewed by a person appointed by the Department of Planning and the Director-General of the Department of Planning is satisfied that the predicted impacts of the proposed mining operations will not have an adverse effect on the heritage values of any significant heritage sites;

Figure 57: External architectural appearance of St James Anglican Church, Menangle

Figure 58: Internal architectural appearance of St James Anglican Church, Menangle

11.14. OTHER INFRASTRUCTURE

11.14.1. Existing Infrastructure

The EA lists a range of other existing infrastructure in the Study Area which the Panel considers does not warrant detailed assessment because either there is an extensive experience base of successfully undermining these types of structures, or such structures can be replaced without too much inconvenience or cost, or structures are amenable to site specific assessment as part of any Extraction Plan process (which may lead to offsets at that time). Structures falling into one of these categories are:

- Swimming pools – where there is a history of 18% of pools being impacted, mainly by tilt (slope) and many to the extent that they had to be replaced.
- Tennis Courts
- On-site waste water systems
- Paths and pavements
- Fences
- Tanks
- Farm dams
- Places of worship – excluding those that are state heritage listed. It is recommended that approval conditions require these structures to remain safe, serviceable and repairable, unless agreement is reached with the property administrators for alternative facilities to be provided.
- Schools - It is recommended that approval conditions require these structures to remain safe, serviceable and repairable.
- Community Centres and Child Care Centres - It is recommended that approval conditions require these structures to remain safe, serviceable and repairable, unless alternative facilities are provided.
- Sports grounds and game facilities
- Cataract Scout Park

11.14.2. Future Built Infrastructure

Although the BSO Project has a projected life of 30+ years, the EA does not address mining impacts on infrastructure that may be built in the Study Area during the project life. In declared Mine Subsidence Districts, which cover the majority of the western mining domains for the BSO Project, new structures will be required to conform to MSB design requirements. However, given the life of the project and the open-ended nature of the mine design, in particular longwall panel width, it remains problematic as to how appropriate the current MSB requirements may be in the long term. The only reference to these requirements in the EA relates to the fishways on the Douglas Park Weir and the Menangle Weir, where the MSB's minimum design parameters are reported to be[546]:

[546] EA, Appendix A, p.170.

Vertical Displacement:	1200 mm
Tilt:	6 mm/m
Strains:[547]	2.5 mm/m
Radius of curvature:	10 km
Curvature:	0.10 km^{-1}

As reference to Table 4.1 of Appendix A[548] shows, a higher maximum tilt than the MSB value of 6 mm/m is predicted in all mining domains for the Base Case layout, whilst the MSB value for vertical displacement is equal to that predicted in Area 8 and less than that predicted in all other mining domains. The MSB strain values lie in the middle of the range for compressive strain and at the upper end for predicted tensile strains. The predicted values need to be increased by up to 50% if longwall panel width is increased to 500 m, as recorded in Chapter 4. Hence, the construction of new structures in accordance with current MSB requirements may not be adequate in all circumstances for ensuring that they remain safe, serviceable and repairable when located within the zone of influence of mining. New structures may also be located within the BSO Study Area but outside of declared Mine Subsidence Districts.

At this point in time, these are hypothetical issues. Suffice to state that the Panel is of the view that the risk management processes outlined in this report in respect of existing infrastructure will be applicable to assessing mining impacts on infrastructure constructed in the Study Area during the life of the BSO Project.

In the interim, it is recommended that:

1. The MSB review its design requirements for new structures in the Study Area in light of the subsidence predictions contained in the EA.

2. Consideration is given to locating new surface infrastructure in areas that have already been undermined or are unlikely to be undermined.

11.15. REGIONAL STABILITY

The BSO Study Area covers a very large area and if it were to be extracted to the extent proposed in the Base Plan layout it could, along with the existing Appin, Tower, West Cliff, Darkes Forest, Coalcliff, Bulli and Bellambi West[549] Colliery workings that adjoin it, contribute to a significant rearrangement of the regional stress field around these workings. This has the potential to trigger seismic events.

It is well established that the extraction of extensive areas of tabular[550] metalliferous deposits can cause an increase in the number and magnitude of seismic events. There is a range of evidence which indicates that similar behaviour is associated with underground coal mining[551], including in Australia. Klose (2007) has presented a number of examples where mining may have caused a change in the groundwater regime that then resulted in disturbance of the in-situ stress field in the upper crust,

547 Tensile or compressive not distinguished.
548 EA, Appendix A, p.19.
549 Also known as NRE No. 1 Colliery and South Bulli Colliery.
550 Seam type deposits
551 e.g. Galvin (2003), Klose (2007)

triggering seismic events. Klose puts this mechanism forward as the possible cause of the 1925 and 1989 Newcastle earthquakes.

There have been a number of moderately large seismic events in the Southern Coalfield over the past two decades, one of which tripped the main ventilation fan at Appin Colliery, causing the mine to be evacuated. Whilst there is no evidence to suggest that mining contributed to these events, there is evidence that seismic events can be initiated as a result of mining extensive areas using high aerial extraction methods such as longwall mining.

Seismicity, therefore, is a factor that needs to be considered when assessing the stability of key and/or sensitive items of infrastructure such as in this instance, the dam wall of Cataract Reservoir, the Hume Highway bridges over the Nepean River Gorge, and Broughtons Pass Weir. The EA for the BSO Project has not given any consideration to mining induced seismicity and its implications for the stability of natural and man-made structures and the safety of the general public who utilize these features.

The Panel recommends that:

1. Conducting of seismic monitoring on a regional basis, analysis of outcomes and correlation with mining operations should be a requirement of all Extraction Plans for the BSO Project.

2. This information is reported to the Department of Planning on an annual basis.

3. Seismic monitoring data and analysis is externally reviewed every 3 years by a suitably qualified person nominated by the Department of Planning.

4. Any identified associations or trends between the seismic data and mining activities should constitute a trigger that requires:

    v. mine planning to be reviewed internally by the leaseholder and externally by a person nominated by the Department of Planning, and

    vi. a risk assessment to be undertaken of the potential impacts and consequences of seismicity for man-made features and natural features associated with the BSO Project.

12.0 MINE SURFACE INFRASTRUCTURE

Mine surface infrastructure principally comprises the West Cliff Colliery pit top including the coal washery, coal wash emplacement and Brennans Creek Dam, Appin East pit top, Appin West pit top, Appin No. 1 and No. 2 Shafts, Appin No.3 shaft, North Cliff Shafts and remote service sites utilising boreholes[552].

[552] The EA also makes reference to the site of the defunct Bulli Shafts.

The Panel notes that with the exception of surface goaf gas drainage boreholes, ventilation shafts, and West Cliff pit top and coal emplacement facility, the other facilities will function in the future in much the same manner as is currently the case and generally under existing approvals. Proposed activities include upgrading of certain infrastructure e.g. pipelines, water treatment and disposal plants and ventilation shafts.

The proposed Stage 4 Coal Wash Emplacement is assessed in Chapter 13 of this report. That aside, the EA lacks clarity as to exactly what other items of future surface infrastructure the Part 3A Application is intended to encompass. Therefore, the Panel's conclusions are confined to goaf gas drainage boreholes and modifications to existing ventilation shafts.

12.1. GOAF GAS DRAINAGE BOREHOLES

Goaf gas drainage is currently conducted by drilling surface to goaf drainage bores to extract the methane gas which is then flared or vented at surface. In order to undertake such activity, it has been necessary at existing gas drainage locations for ICHPL to conduct appropriate environmental assessments including air, noise, visual and vegetation surveys.

ICHPL has obtained a separate Part 3A Approval for the West Cliff Colliery Surface Gas Drainage Project and has separately lodged a Part 3A Application for the Appin Mine Area 7 Goaf Gas Drainage project. However the EA for the BSO Project notes that:

> '*if required, the installation of surface goaf gas drainage boreholes and associated surface infrastructure would be subject to preparation of supplementary specialist environmental assessment studies. These studies and any associated management measures would be detailed in a Surface Goaf Gas Drainage Management Plan*'[553].

It is unclear from this statement whether this implies that future gas drainage associated with the BSO Project Application would be the subject of separate Part 3A applications or whether future approvals would be sought via a 'Surface Goaf Gas Drainage Management Plan' under the current Part 3A. However a later statement provides some clarity:

> '*The above assessment and approval approach would not be applied for any surface goaf gas drainage proposals in the Dharawal State Conservation Area. Such a proposal in the Dharawal State Conservation Area would be subject to a separate Part 3A assessment and approval process*'[554].

Neither the Panel nor the public have had an opportunity to scrutinise and comment on the future gas drainage proposals. The proposition appears to be that, apart from any gas drainage that might be required for Dharawal State Conservation Area any surface gas drainage activities for the BSO Project that were not already covered or

[553] EA, Volume 1, Section 2, p.31.
[554] EA, Volume 1, Section 2, p.32.

proposed to be covered by Part 3A approvals would be dealt with via a non-public process based on Management Plans.

The Panel does not understand why it is necessary for the West Cliff Surface Gas Drainage Project, the Appin Area 7 Surface Gas Drainage Project and any gas drainage that occurs in Dharawal SCA to be dealt with transparently by way of a Part 3A application but not any other surface activities associated with gas drainage. There may well be a logical explanation, but the EA sheds no light on what it might be.[555]

In view of the lack of information available, the Panel recommends:

1. That the government consider the implications of including surface goaf gas drainage facilities in an approval where there has been no opportunity for the public to comment on the details of any proposals and there are potential impacts of construction and operation of the facilities on both public and private land.

12.2. VENTILATION SHAFTS

The EA notes that existing ventilation shafts may be modified over the course of the project life. Specifically it is noted that '*North Cliff No.3 and No.4 ventilation shafts would be recommissioned as upcast and/or downcast ventilation shafts prior to commencement of longwall operations within the North Cliff domain*'[556]. Here it is noted that certain shafts may also be switched from upcast to downcast or be upgraded to higher rates of airflow. The EA further notes that '*Approval of upgrades/changes to existing ventilation shafts described above is being sought as part of the Project*'

No information offering any detail with respect to any upgrades or changes to existing ventilation shafts, nor any information relating to the environmental effects of any upgrades, has been supplied in the EA. In the absence of such information, the Panel is unable to provide advice as to whether the government should include them within any Approval. The Panel notes that neither the public nor the government agencies have had an opportunity to understand and scrutinise these issues.

13.0 WEST CLIFF COAL WASH EMPLACEMENT AREA

13.1. DESCRIPTION

The West Cliff coal preparation plant is integral to the operations of ICHPL in the BSO Project Area. West Cliff Colliery Run of Mine (ROM) coal is delivered directly to this plant, whilst ROM coal from Appin West and Appin East Mines is trucked to the plant from Appin East pit top. Product coal produced from the washery is stockpiled for transportation by truck to Wollongong and Port Kembla.

The washing process generates a coal reject fraction, referred to in the EA as *coal wash*, which is a result of the presence of carbonaceous shales, mudstones and minor

[555] EA, Volume 1, pp.31-32.
[556] EA, Volume 1, Section 2, p.33.

sandstones in the ROM coal. The coal wash comprises three waste types - coarse materials, finer materials and sludge, all of which are emplaced contiguously in designated areas at the West Cliff facility. Coal wash from the washery at Dendrobium Mine (to the south of the BSO Project Area) is also transported by road to West Cliff Colliery for emplacement. The existing coal wash emplacement area is located within Brennans Creek catchment (a tributary of the Georges River) and has been approved in three stages to date, namely:

1. **Stage 1**: Commenced in 1976 and was completed in 2001. This area of 21 ha contains 4.6 Mt of coal wash and is currently undergoing top soiling and revegetation.

2. **Stage 2**: Covers an area of about 29 ha and has a design capacity of 17 Mt. Emplacement in this area followed on from Stage 1 but the area is nearly exhausted and rehabilitation has commenced.

3. **Stage 3**: Covers an area of about 66 ha and has a design capacity of 33.5 Mt. Emplacement in this area will follow closure of Stage 2. The area is planned to accept coal wash over the first 10 years of the BSO Project before reaching full capacity.

Approval of a fourth area is sought as part of the BSO Project (see Figure 59). Referred to as **Stage 4**, it has a design capacity of 40 Mt and would occupy 76 ha, which would have to be stripped of vegetation and soil.

Long term alternatives to expansion of the Stage 4 emplacement area include surface emplacement at another location and/or underground emplacement subject to feasibility trials and value analyses. However ICHPL note that the West Cliff area provides '*the most viable coal wash management option*[557]' because it is located within the existing West Cliff Colliery lease, is close to the washery and is logistically feasible for the emplacement of Dendrobium coal wash. The proponent also notes that the Stage 4 area is more confined than previous areas in so far as Brennans Creek (tributary) is more steeply incised in this area, thereby facilitating increased emplacement volume per unit area relative to earlier emplacements.

[557] EA, Volume 1, Section 2: Project description, p.36.

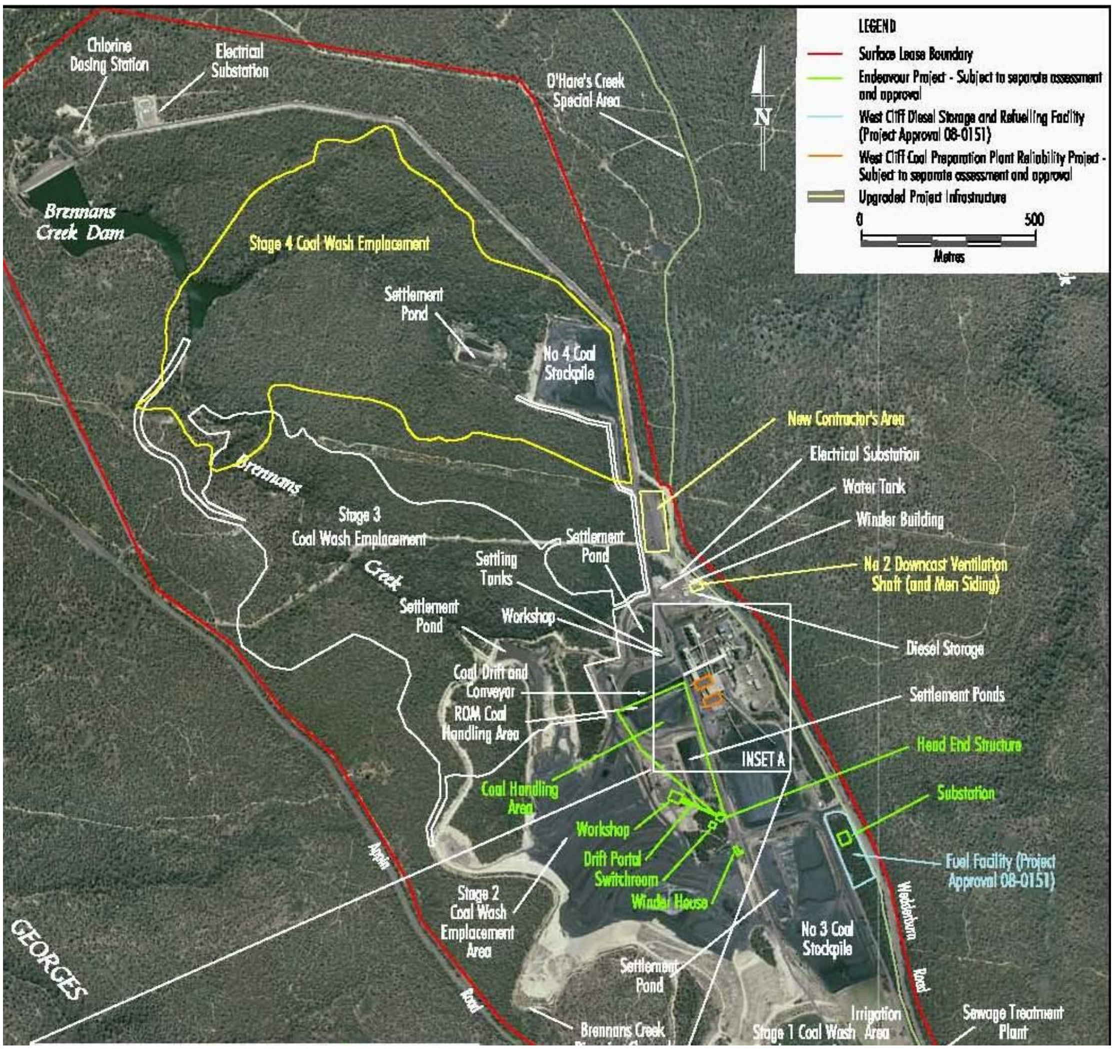

Figure 59: Westcliff Emplacement Area[558]

Each approved emplacement stage has been designed with storm water runoff diversion and management systems, retention ponds and an under drainage system incorporating a trunk line situated down the valley axis, and numerous collector lines. The under drainage leachate quality typically exhibits a pH value in the range 7.0 to 8.0 and an electrical conductivity in the range 2400 to 3000 uS/cm[559]. This conductivity range reflects conditions for Stages 1 and 2 with emplacement now having occurred over some 30 years of operation (Stage 3 emplacement has not commenced). The under drainage reports to Brennans Creek Dam where it is stored and discharged via discharge points LDP1 and LDP10 licensed by DECCW.

[558] Reproduced from Figure 6 of Appendix A of the EA)
[559] ICHPL Response to Panel Question No. 29

13.1.1. Issues Raised in Submissions

The main issues raised in submissions to the Panel regarding the Stage 4 Coal Wash Emplacement relate primarily to ongoing destruction of flora and fauna habitat (including threatened species), and water quality impairment in Brennans Creek and the Georges River.

DECCW stated that the bushland area of Stage 4 contains '*relatively pristine intact vegetation and has both unique biodiversity and Aboriginal Cultural Heritage values*[560]'.... Of particular concern are the potential impacts on the Hairy Geebung (*Persoonia hirsuta*), the Southern Brown Bandicoot (*Isoodon obesulus*) and the Broad Headed Snake (*Hoplocephalus bungaroides)*. For these and other reasons, DECCW does not support approval of the Stage 4 Emplacement Area, noting that other strategies including underground emplacement should be actively pursued, especially since Stage 3 provides a window of ten years to prepare and invoke an alternative strategy.

In respect of water management issues and discharges from Brennans Creek Dam, DECCW believes that future investigations should '*focus more widely on the impact of flow and water quality on the upper Georges River*' and that investigations '*should build upon current PRP's*[561]' (Pollution Reduction Programs). This is especially significant if the increased discharges from the dam predicted by ICHPL are realised. DECCW also notes that impacts on downstream river flows and water quality have been poorly addressed in the EA. Other issues raised include dust emissions, storm water runoff and leachate generation.

DECCW acknowledge that while Stages 1 and 2 emplacements have been well managed and Stage 3 has been approved, a lower impact alternative to Stage 4 is preferred. DECCW recommend Stage 4 approval should be deferred until substantive investigations (to be conducted by ICHPL) discount any other viable alternative including underground disposal, alternative surface facilities, and/or beneficial use of the coal wash.

Wollondilly Shire Council submitted that there should be a focus on alternatives for storage of the coal wash, with studies to determine the feasibility of underground storage being recommended as part of any Conditions of Approval.

13.1.2. Inspections by the Panel

The Panel inspected sections of Stages 1 to 4 in order to gain an appreciation of the scale and importance of issues raised in submissions. Stage 1 emplacement was found to be well advanced in rehabilitation while Stage 2 was noted to be relatively immature where rehabilitation had been undertaken. Capping materials (Stage 2 area) appeared to be generally sandy and suggested rainfall would easily infiltrate to the deeper emplaced materials. Density and type of vegetation appeared to be quite variable. In active parts of Stage 2 area where emplacement was current, the coal wash was observed to be generally coarse material comprised largely of carbonaceous shale and other stony material, laid directly upon Hawkesbury Sandstone bedrock.

[560] DECCW (2009a), p.14.
[561] DECCW (2009a), p.19.

The Brennans Creek diversion drain, under drainage inspection ports and retention dams were also inspected. Some areas were undergoing stripping and preparation for emplacement while other areas (Stage 3 and Stage 4) generally presented as virgin bushland with a typically thin sandy soil over sandstone bedrock. Brennans Creek dam was also inspected.

Subsequent to inspections, a number of questions were put to ICHPL by the Panel in relation to flora and fauna habitat and survey, and site water management in the long term. In addition, the Panel sought further advice from DECCW with respect to flora, fauna and dam discharge water quality issues.

13.1.3. Clearance of Natural Habitat

The proposed Stage 4 Coal Wash Emplacement will result in clearance of 76 ha of pristine native bushland and have a direct impact on one endangered plant species (*Persoonia hirsuta*) and possible impacts on up to eleven threatened species of fauna including the endangered Broad Headed Snake (*Hoplocephalus bungaroides*) and Southern Brown Bandicoot (*Isoodon obesulus*).

The Panel considers that that clearance of pristine native vegetation for a Stage 4 Emplacement Area is an undesirable outcome of coal wash emplacement. However the Panel also notes that past decisions and approvals have repeatedly endorsed this approach which has resulted in the consumption of more than 40% of Brennans Creek catchment for the purpose of coal washing and emplacement of coal wash waste (including Stage 3). In the Panel's view the general undesirability of the facility should not interfere with the logical progression to completion and, unless there are outstanding new issues to be considered, the development should be allowed to continue subject to minimising the impacts on conservation outcomes and the environment. In this context the Panel's view is that two of the three endangered species qualify as 'outstanding new issues', as does the proposed increase in risk to the population of the third threatened species (*Persoonia hirsuta*). They are considered individually below.

(i) Hairy Geebung *(Persoonia hirsuta*)

P. hirsuta is classified as an endangered plant species under both the TSC and EPBC Acts and rarely occurs in populations of more than 20 individuals. The Coal Washery Emplacement contains the core population in the BSO Project Area, with two smaller groupings outside this and some other scattered individuals.[562] Stages 3 and 4 will see 31% of the total of 88 known plants destroyed (20 individuals in Stage 3 and a further seven in Stage 4). An area of approximately 24 ha will be left between Stage 3 and Stage 4 areas that contains the remaining 61 plants of the core population, but this is bounded by facilities or roads on all sides.

Survey work for the assessment of risk to *P. hirsuta* has been thorough and the relevant questions have been asked in the EA.[563] The problems lie in the answers - in

[562] EA, Appendix E, Figure 14.
[563] EA, Appendix E, pp.153-156.

that there is insufficient information available on this plant or related species to be confident that the core population can survive construction and operation of the emplacement. Questions remain concerning pollination of the remnant of the core population and seed dispersal from that core.

The Panel requested a substantial amount of additional information from ICHPL in a series of questions[564] aimed at exploring the adequacy of the conservation area between Stages 3 and 4, the potential impacts of isolation on pollination, and the potential impacts of facility operations on the population.

ICHPL provided comprehensive responses to the questions,[565] but acknowledged that the information was not capable of providing complete assurance that the remnant population would survive. However, ICHPL considered that the situation was far from hopeless and there were reasonable prospects that, provided the various management strategies were implemented, the population could survive through to the rehabilitation stages of the adjoining areas.

The Panel considers that the issue is finely balanced and that there will be little prospect of success unless the various commitments are kept. Even then there are no guarantees that this core population can survive. If Stage 4 is to be approved, the most critical action required for protection of *P. hirsuta* is to move the less definite management measures[566] in the EA into formal requirements that are enforceable and monitored.

(ii) Broad-Headed Snake *(Hoplocephalus bungaroides*)

This snake is classified as endangered under the TSC Act and vulnerable under the EPBC Act. It has been found within the Stage 3 area previously, although not in the current surveys for Stage 4. Some specimens were found in other parts of the BSO Project Area in the current surveys.[567]

The snake is rare and sightings are infrequent. It tends to be widely dispersed in areas of suitable habitat and the habitat requirements are complex and have considerable seasonal variation.

There is an elaborate management plan included in the EA that is similar to the one established in the Approval for the Stage 3 Emplacement Area. DECCW clearly views this plan as of little value as a conservation approach for the species. The Panel agrees with DECCW. The measures are unlikely to make any difference to the population of Broad-Headed Snakes in the area given the nature of the habitat destruction and the nature of the snake.

(iii) Southern Brown Bandicoot (*Isoodon obesulus*)

This species is classified as endangered under both the TSC and EPBC Acts. It is considered to be very rare and, prior to the discovery in the BSO Project Area, had not

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[564] PAC Questions to ICHPL, Nos 40-43.
[565] ICHPL (2010b), pp.26-28.
[566] EA, Appendix E, p.156.
[567] EA, Appendix F, p.38.

been seen in the region for at least 10 years despite targeted survey.[568] The discovery of a live male on the proposed Stage 4 area and a skull in the nearby Metropolitan Special Area indicates the existence of a remnant population. The EA also records the presence of this species based on diggings, however DECCW refutes this on the basis that differentiation between the *Isoodon obesulus* and the common Long-nosed Bandicoot (*Perameles nasuta*) on the basis of diggings is unreliable.

DECCW put a strong case in submissions on the EA and to the Panel suggesting that the conservation status of this species is so significant that no approval should be given for clearing in what is obviously an area of suitable and utilised habitat.[569]

Given the conservation significance of this species the Panel asked ICHPL further questions and suggested that more field data may be required.[570] The additional questions covered the capacity of rehabilitated areas and areas in different stages of disturbance to support this species, the evidence for translocation as a viable strategy, the need for more intensive study of the proposed Stage 4 area to assess population viability, and the accuracy of identification based on diggings.

ICHPL responded with a substantial increase in survey intensity targeted at the Southern Brown Bandicoot in the Stage 4 area.[571] No further specimens were recorded, despite the areas being targeted containing diggings that were considered typical. ICHPL suggest that the evidence indicates that, while the proposed Stage 4 area contains suitable habitat for this species, it is not the stronghold for a localised population. The surrounding areas also contain suitable habitat and there appears to be a substantial under-utilisation of available habitat by this species overall. On the basis of the available evidence the Panel's view is that the clearing of the Stage 4 area is unlikely to eliminate a viable population of Southern Brown Bandicoots.

ICHPL's responses to the questions concerning translocation and utilisation of regenerating habitat were far less convincing. In the Panel's view these so-called management strategies will be ineffectual. The reality is that very large areas are being cleared completely and the individuals in those areas will either die or move into an area of habitat nearby where they may or may not survive (and, depending on the social structure of the species, if they do survive they may do so by displacing existing residents).

The commitments in the EA concerning management are referred to in the ICHPL response, but examination of these commitments[572] indicates that they are either in the 'to be developed' or 'will be given consideration to' categories. If the Stage 4 proposal is to be approved and these management strategies are to form part of it, then there will need to be a substantial tightening of the commitments so that there is an

[568] DECCW (2009a), p.7.
[569] DECCW (2009a) pp.6-7.
[570] PAC Questions to ICHPL, Question 39, pp.44-48.
[571] ICHPL (2010b), response to Question No 45, p.29.
[572] EA, Vol. 1, Sections 5.9.3 and 5.9.4.

enforceable requirement for them to be implemented, not some discretionary option for ICHPL.[573]

The issue of identification of the Southern Brown Bandicoot from diggings was not resolved. ICHPL maintain that it is possible to do so in some circumstances and DECCW maintains that it isn't. This does raise another question and that is, if the additional targeted surveys focussed on areas where diggings were 'identified' by ICHPL, if Southern Brown Bandicoots were not found, what was found by the techniques used? The Panel did not obtain the full results of the additional surveys, but the Department of Planning should seek to obtain these results in order to satisfy itself that the results don't raise any new issues that should be considered in providing advice on the proposal or recommending approval conditions.

13.1.4. Rehabilitation

Apart from threatened species, after its inspection of the existing emplacement areas the Panel was also concerned about the quality of rehabilitation and the implications of that for any potential approval for Stage 4.

The EA provides some commitments concerning the rehabilitation process.[574] However, the wording of these commitments is imprecise and there are significant differences between the wording in Volume 1 and in Appendix E in terms of species and sources of plants for the rehabilitated areas.

The Panel pursued this issue with ICHPL with a series of formal questions.[575] The answers to these questions reveal that there are no pre- and post-clearing flora surveys for Stages 1 and 2, that species other than endemic species have been sown (approximately 30%), and that habitat matching with species sown has clearly not been effectively implemented.

The Panel is of the view that if Stage 4 is to be approved, the requirements for rehabilitation need to be specified in sufficient detail and with sufficient precision to ensure that ICHPL is required to maximise the opportunity for natural regeneration (i.e. early restoration of topsoil from the site), only use endemic species and in appropriate habitat mixes, and maximise retention of suitable habitat features for fauna.

13.1.5. Current Discharges of Waste Water

West Cliff emplacement area waste water is a mixed water comprising underground mine water, washery supernatant (process water), rainfall and runoff. Site water management systems direct any surplus waste water to Brennans Creek Dam where it is stored and discharged in accordance with DECCW licence conditions.

[573] The Panel notes that this is a more general issue than commitments for management of the Southern Brown Bandicoot. Many commitments in the EA are either discretionary, or worded in such a way that the commitment would be difficult to enforce.
[574] EA, Vol 1, Section 5.8.3, pp.10-12 and EA, Appendix E, p.103.
[575] PAC Questions to ICHPL, Questions Nos 35-39.

Current licencing limits pH to the range 6.5 to 9.0, Total Suspended Solids (TSS) to 50 mg/l and oil and grease to 10 mg/l. There are no limits imposed on salinity or discharge volume. However, DECCW has noted concern at the high pH and salinity levels of the discharges. These concerns are addressed through the attachment of Pollution Reduction Programs (PRP) to the West Cliff Colliery discharge licence. PRP-1 was designed to '*characterise chemical constituents*' while PRP's 4, 6 and 9 were to '*examine impacts on downstream ecosystems*'.

Results of the PRP studies to date have indicated the typical discharge salinity is alkaline (attributed to the presence of bicarbonates) with '*relatively low levels of metals*[576]'. Future water quality and flow objectives will be specified following the completion of studies with respect to PRP-10 which is aimed at developing '*locally based water quality trigger values for the Upper Georges River in accordance with section 2.2.1.4 of the ANZECC 2000 Guidelines*'[577].

Dam discharge rates and timings are managed by ICHPL. The current discharge regime aims to minimise the salinity of discharges by continuously releasing water in order to provide freeboard for containment of rainfall runoff and subsequent dilution. This strategy has apparently reduced the salinity of discharged waters from 2500-3500 uS/cm to less than 2000 uS/cm[578] although it is not immediately evident from information supplied by ICHPL[3].

While it is desirable to reduce the salinity of discharges to natural background levels, it is acknowledged that future flows in Brennans Creek (and downstream Georges River) are unlikely to replicate the flow regime that prevailed prior to development of the West Cliff pit top and emplacement areas. Reasons for this are provided by DECCW and include:

1. The regime prior to development was probably ephemeral or intermittent;

2. Groundwater seepage to underground operations is pumped to the washery and ultimately reports to Brennans Creek Dam. This together with rainfall contributions results in a need for a sustained discharge of 0.7 to 1.5 ML/day into Brennans Creek.

River flow objectives set by DECCW for the Georges River also include *'protection of natural flows, rates of change in water levels, and natural flow variability'*.

13.1.6. Hydrological Impacts

The Stage 4 Coal Wash Emplacement will consume an un-named 2nd order tributary of Brennans Creek just upstream of Brennans Creek Dam and will abut the Stage 3 emplacement at the most northerly (downstream) point of Stage 3.

The Panel considers the hydrological impacts of Stage 4 will include:

576 DECCW Response to Panel Questions Attachment 1, Page 9
577 DECCW Response to Panel Questions Attachment 1, page 7
578 DECCW Response to Panel Questions Attachment 1, page 7

1. Increased area of coal wash leading to increased infiltration of rainfall through the emplaced materials. This will invariably lead to greater mixing and flush through of washery water, and greater interaction between rainfall and coal wash via dissolution of minerals in the coal wash. These processes are likely to result in increased volume and increased salinity of underflow reporting to the dam;

2. Loss of otherwise pristine catchment runoff from Stage 4 area which currently acts to dilute the stored waters in Brennans Creek Dam;

3. Physical displacement of 15% of dam water storage by emplaced coal wash in the Stage 4 area leading to a reduction in the open water dam storage from 311 to 267 ML. This reduction is likely to result in a reduced capacity for dilution of stored waters and an increase in the rate of continuous discharge from the dam if freeboard is to be maintained (see Figure 59 for outline of Stage 4).

The Panel also notes there is some potential for pore pressures to build within the coal wash emplacements in the course of time. These pressures may drive movement of coal wash water beneath Brennans Creek Dam (as groundwater) into downstream areas. The Panel observed that no groundwater monitoring had been installed as part of Stages 1 and 2 nor had any monitoring plan been provided in the EA. These along with other groundwater related issues were raised in questions put to ICHPL. In response, ICHPL indicated that while piezometer installations are planned as part of the Stage 3 emplacement, none have been installed in earlier Stages. Based on the information provided, the Panel is satisfied that piezometers are planned and will be installed in Stage 3 area in due course. However no piezometers are specifically proposed downstream of Brennans Creek Dam.

The Panel considers that the cumulative consequences of the above noted processes are likely to result in increased salinity in the Georges River under the current emplacement and discharge management plan (continuous discharge to maintain freeboard). The extent to which these consequences are realised will depend upon future underground mine water that reports to the West Cliff pit top, and climatic conditions which will impact upon surface water management systems and govern the amount of rainwater infiltrating through the emplacement areas.

13.1.7. Stage 4 Panel Findings

Stage 4 provides long term storage capacity for the BSO Project. The Panel agrees with ICHPL that Stage 4 emplacement provides the most viable long term solution for management of the coal wash waste at this time. This view is based on the following considerations:

1. No other surface emplacements areas in the region have been advanced as an appropriate or viable alternative to Stage 4;

2. Any other area would presumably require transportation of the coal wash by road and management of coal wash at a scale similar to that already in place at

the West Cliff pit top. This would further exacerbate regional traffic management problems associated with the Project Proposal;

3. ICHPL have committed to exploring the viability of underground emplacement;

4. Ongoing environmental impacts and consequences of the West Cliff facility that would invoke the greatest regional concern relate largely to water quality issues in Brennans Creek and the Georges River. Water quality issues are governed in turn by DECCW licence constraints which can be adjusted periodically to enforce improved water quality outcomes;

5. ICHPL are bound in the long term by rehabilitation and decommissioning in accordance with DECCW requirements, and management of discharges in compliance with DECCW licensing.

However the Panel is of the view that underground disposal options for the coal wash should be aggressively pursued. There are two reasons for this. The first is that it may be possible to limit the impacts associated with the later stages of the Stage 4 facility and the second is that if production of coal washery waste exceeds expectations then some reserve capability may be available. The proposed timetable by ICHPL for a pilot scale research and development trial needs to be adhered to in a statement of commitments.

13.1.8. Recommendations

The Panel recommends:

1. That any Approval for the Stage 4 Coal Wash Emplacement should specify in sufficient detail and with sufficient precision the measures necessary for:

    i. maximising the opportunity for natural regeneration (i.e. by early use of topsoil from the site),

    ii. only using endemic species and in appropriate habitat mixes, and

    iii. maximising retention of suitable habitat features for fauna.

2. That ICHPL continues to pursue options for the underground disposal of coal wash, including adherence to the proposed pilot scale research and development trial.

3. That no Extraction Plan be approved until:

    i. The management measures proposed in the EA for the protection of P. hirsuta become formal requirements of the Extraction Plan that are enforceable and monitored;

    ii. A management plan for the conservation of the Broad-Headed Snake is developed in consultation with and to the satisfaction of DECCW;

iii. A management plan for the conservation of the Southern Brown Bandicoot is developed in consultation with and to the satisfaction of DECCW.

iv. Piezometers are installed both in the coal wash in Stages 1 and 2, and in future emplacement areas in accordance with the Stage 3 emplacement management plan and design criteria579; and

v. Piezometers are installed in the Hawkesbury Sandstone downstream of Brennans Creek Dam in sufficient number so as to be able to define groundwater flow directions, magnitudes and groundwater qualities.

4. That future Pollution Reduction Programs address the improvement in discharge water quality with a goal of less than 1000 uS/cm within 10 years.

[579] Cardno Forbes Rigby, 2007

14.0 ROADS AND TRAFFIC

14.1. INTRODUCTION

Appendix K of the EA is a Road Transport Assessment of the proposal undertaken by Traffix traffic and transport planners. The Assessment was undertaken to address the DGEARs (Director General's Environmental Assessment Requirements) which included a 'detailed assessment of potential impacts of the Project on safety and performance of the road network' and the road transport related issues identified in the Proponent's Environmental Risk Assessment.

The study includes an assessment of existing and predicted traffic volumes associated with, and independent of, the proposal to ascertain the impacts of the proposal on the efficiency of the road network, ability of the road network to accommodate the additional freight load and road safety.

Whilst the RTA's (Roads and Traffic Authority) submission to the Department prior to exhibition included several comments for consideration, it did not undertake a detailed assessment of the information provided and was thus unable to comment on whether there were any significant issues that were not adequately addressed. Wollondilly Council provided detailed comment regarding the traffic impacts of the proposal and the assumptions made in assessing these impacts, however given the significant increase in heavy vehicle movement generated by the proposal, there were surprisingly few public submissions that raised this issue.

The Panel's assessment of traffic issues has been undertaken based on the information provided in the EA, the Submissions made to the Department and the Panel, and Proponent's Response to Submissions. The Panel understands that there has been ongoing dialogue between the RTA and the Proponent, however the Panel has not been privy to this correspondence.

14.2. TRAFFIC IMPACTS OF THE PROPOSAL

The potential traffic impacts of the project are associated primarily with the haulage of coal to PKCT (Port Kembla Coal Terminal) and Bluescope Steel works of 7.5 Mtpa and 4 Mtpa respectively. Under the proposal coal deliveries to Corrimal and Coalcliff Coke Works would be up to 0.2 Mtpa and delivery of coal to Dendrobium Washery would be up to 0.5 Mtpa. Peak Project delivery would not be more than 9.4 Mtpa. Traffic impacts of a lesser extent can also be attributed to additional workforce traffic and additional operational deliveries.

For the purposes of the traffic assessment the Proponent has assumed that on average 65% of road haulage occurs during the day (7:00am to 6:00pm) and 35% during the night (6:00pm to 7:00am) with an average truck load of 36.5 t per truck.

There are three key periods of the project in relation to traffic impacts are:

- 2011 - which will include existing operations plus construction traffic;

- 2013 - worst case operational period which may involve a shift of significant components of workforce from the West Cliff pit top to the Appin west pit top, combining maximum project operational traffic , longwall machine relocation /upgrade traffic and growth in background traffic;
- 2019 - combining project operational traffic and growth in background traffic.

From Table 35, it is evident that in order to accommodate the planned increase in coal production there would be a significant increase in daily truck movements, particularly to and from PKCT.

Table 35: Additional Traffic Movements by Vehicle Type Generated by ICHPL (per Weekday)

Site	Road and Location	Courier/Deliveries		Coal Product Transport	Employee/ Contractors	Total ICHPL Vehicle Movements		
		Light	Heavy	Heavy	Light	Light	Heavy	Total
To/From PKCT								
1	Bulli-Appin Road, Appin near Kings Fall Bridge	46	- 1	462	356	402	463	865
2	Appin Road north of Princes Highway	88	5	617	95	182	615	797
3	Mount Ousley Road at Mount Pleasant	32	2	626	-101	- 69	628	559
4	F6 Southern Freeway north of Princes Highway Interchange at West Wollongong	32	2	635	-101	- 69	637	568
5	F6 Southern Freeway south of Princes Highway near Footbridge	- 42	2	635	-101	- 69	637	568
6	Masters Road at Mount St. Thomas	- 42	-4	635	0	0	635	635
7	Springhill Road at Coniston	0	0	698	0	0	698	698
To/From BlueScope Steelworks and DCPP								
8	Springhill Road north of Five Islands Road	0	0	290	0	0	290	290
Route to/from Corimal								
-	Northern Distributor, Towradgi, south of Towradgi Road	0	0	8	0	0	8	8
Route to/from Coalcliff								
-	F6 Freeway (North)	10	2	8	15	25	10	35
10	Lawrence Hargrave Drive east of Old Princes Highway	0	0	8	0	0	8	8
Local Roads								
12	Princes Highway at Bulli Pass	46	2	0	181	227	2	229
13	Princes Highway north of Bellambi Lane, Russell Vale	46	2	0	181	227	2	229
14	Narellan – Appin Road north of Appin township, south of Brian Road	14	1	0	60	74	1	75
15	Remembrance Driveway	7	3	0	15	22	3	25

Site	Road and Location	Courier/Deliveries		Coal Product Transport	Employee/ Contractors	Total ICHPL Vehicle Movements		
		Light	Heavy	Heavy	Light	Light	Heavy	Total
	north of Finns Road							
16	Menangle Road at Nepean River Bridge	7	3	0	15	22	3	25
17	Remembrance Driveway 0.5 km north of Regreme Road	7	3	0	15	22	3	25
18	Menangle Road east of Picton-Oakdale Road	7	3	0	15	22	3	25
19	Picton Road at Nepean River Bridge	21	7	0	45	66	7	73
20	Remembrance Driveway 0.8 km south of Tahmoor Post Office	7	3	0	15	22	3	25
21	Picton Road west of Mount Keira Road	14.5	12	0	402	416	12	428
22	Wilton Road at Clements Creek	21	7	0	45	66	7	73

Additional vehicle movements by type generated by ICHPL vehicle movements, adapted from: Total Future ICHPL Vehicle Movements (per Weekday) from Bulli Seam Operations Response to Submissions'' dated April 2010 and Table 10, Appendix K of the EA 'Existing and future average weekday traffic with existing operations (veh/day)'.

Table 35 was produced by comparing the Proponent's estimated 'Future ICHPL Vehicle Movements per Weekday' table on Page 6-3 of their Response to Agency Submissions dated April 2010, and Table 10 'Estimated recent average weekday Appin/West Cliff traffic movements on haulage routes and local roads' in Appendix K of the EA.

The Proponent's 'Response to Agency Submissions' was provided after exhibition of the proposal which raises questions as to the public's ability to understand the traffic impacts of the proposal during the exhibition period.

It should also be noted that Table 35 represents vehicle movements per weekday. Given the Proponent has indicated that road haulage operations would occur 24 hours a day, 7 days a week, it is unclear if the additional vehicle movements generated on weekends need to be accounted for.

14.3. ROAD NETWORK

The traffic study indicates that generally background growth in traffic numbers independent of the project will be the main contributor to future traffic levels in the majority of locations on haulage routes. However at Bulli-Appin Road near Kings Fall Bridge and Appin Road north of the Princes Highway the project's contribution to traffic will increase by 7.7% to 19.1% and by 4.1% to 22.2% respectively by 2013. Whilst these figures indicate that the background growth in vehicle movements will in general have a greater impact on the road network than the proposal, no detail regarding the percentage of overall traffic movements attributed solely to heavy vehicles associated with the proposal has been provided. The Panel is of the view that given the impact of heavy vehicles on road capacity, particularly those that are loaded, a proper assessment of this issue cannot be made without this information.

14.4. INTERSECTION PERFORMANCE

Using SIDRA (Signalised and Unsignalised Intersection and Research Aid), the traffic study indicates that there will be an increase in delays at critical intersections utilised by the project, however these delays are the result of growth in vehicle movements independent of the project. In 2019, it is predicated that the majority of modelled intersections relied on by the proposal will continue operate at a satisfactory level during morning and afternoon peak periods.

The three exceptions to this are the morning and afternoon peak hours at the Appin Road/West Cliff pit top access, the Picton Road/Almond Street intersection and the Mount Ousley Road and F6 Southern Freeway which would all experience unacceptable delays. It is noted that the Proponent provided suggested improvements that will be required at these intersections to provide sufficient capacity. However with the exception of the Appin Road/West Cliff pit top access it suggests the RTA undertake these works due to the existing rates of congestion at these intersections and its relatively low contribution of traffic to them.

The Panel is of the view that without knowing the split between heavy and light vehicles it is difficult to assess the impact of the proposal on intersection performance. Further, whilst the Proponent advised that the calculations of intersection performance using the SIDRA analysis recognises the larger size and likely waiting time of heavy vehicles at intersections, at the time of writing this report, the RTA advised the Panel that the SIDRA analysis used by the Proponent was still under review and they had also requested further information including network diagrams and traffic distribution rates from the Proponent.

Additionally, without confirmation from the RTA, the Panel is unable to conclude that they plan to undertake the intersection upgrades as suggested.

Wollondilly Shire Council also expressed concern that the peak hour turning count surveys used to ascertain the existing operation level of key intersections were undertaken on Easter Thursday and therefore were not likely to be representative of typical weekday traffic movements (particularly the afternoon peak). The Panel believes that Council's concerns have merit and should be investigated to determine if traffic count data has been affected.

14.5. ROAD SAFETY

A safety audit of road of haulage routes used by the ICHPL haulage contractor from January 2003 to December 2007 indicated that 19% of accidents were heavy vehicle accidents, 36% were 'injury crashes' and the remaining 64% involved the tow-away of one or more vehicles.

As indicated in the Proponent's Report when compared with the estimated percentage of project movements per weekday, the proposal results in minimal additional vehicle traffic in accident areas, however again the Panel is unable to ascertain the percentage increase in heavy vehicles in these areas attributed to the proposal and as such the potential road safety impacts of the proposal are unable to be appreciated or accurately assessed.

14.6. RECOMMENDATIONS

The Panel is of the view that whilst some improvements are planned for the coal haulage routes, which occurs primarily on arterial and other RTA controlled roads, there is insufficient information regarding heavy vehicle movements associated with the proposal to comprehensively assess the traffic impacts of the proposal, particularly given that at this time the RTA are still not satisfied with the level of detail provided by the Proponent.

The Panel recommends that any approval for the project contain a requirement that the issues listed below are resolved to the satisfaction of the Director-General of Planning prior to any increase in coal production being permitted.

i. The Proponent clarify if the number of additional traffic movements generated by the proposal require recalculation to accommodate weekend operations of the proposal;

ii. The Proponent provide the Department with the figures regarding the percentages of heavy and light vehicles (included loaded and unloaded) attributed to the proposal at key locations on haulage routes and at key intersections;

iii. The RTA verify the Proponent's SIDRA analysis;

iv. The RTA undertake a thorough assessment of the proposal including its cumulative impact and any supplementary information provided by the Proponent;

v. The RTA review the impact of undertaking peak hour turning count surveys on Easter Thursday.

15.0 ISSUES RAISED IN SUBMISSIONS

15.1. INTRODUCTION

In excess of 70 submissions were referred to the Panel for its information by the DoP. In keeping with its ToR the Panel invited submissions from government agencies and the Public through notices in local newspapers. These notices also offered the opportunity for verbal presentations to be made to the Panel at public hearings held on 17 and 18 February 2010. Letters were also sent to all parties who made submissions to the DoP advising them of the public hearings and inviting them to make submissions.

A total of 23 verbal submissions were made to the Panel at the hearings, comprising 2 from Local Governments, 11 from special interest groups, 9 from individuals and 1 from a mining company.

Six written submissions not supported by verbal presentations were also received by the Panel. These submissions comprised 1 from a Government Agency, 1 from a special interest group and 4 from individuals.

A summary of all submissions received by the Commission is at Annexure 7 to this report.

The Director General's Assessment Report for the Project will include a summary of the submissions received by the Department in response to the exhibition. However, a list of all issues raised in these submissions and a summary of each agency submission received by the Department is also at Annexure 7.

The issues raised in submissions to the PAC and the DoP related to:

- The size and proposed timeframe of the project
- Impact on Special Areas (Dharawal, Metropolitan and Woronora)
- Subsidence impacts including on:
    - Aboriginal and European heritage
    - Public and private infrastructure
    - Wedderburn
    - Cliff lines
    - Water systems
- Groundwater systems
- Surface water
- Swamps including ecological and water issues
- The economics of the proposal
- The cumulative impacts of the proposal
- Effectiveness of proposed remediation techniques
- Accuracy of data
- Coal reject emplacement
- Climate change
- Site management including mine water
- Traffic

- Noise
- Air and dust
- Social amenity
- Subsidence Management Plans and Extraction Plans
- The peer review process
- The Part 3A process itself

The main issues of the proposal are dealt with in previous chapters, however the Commission considers that the following issues raised in submissions require comment and/or have a direct bearing on its recommendations. Other issues appear in the Submissions Summary at Annexure 7 of this Report. Roads and traffic impacts of the proposal were raised by Wollondilly Council and are dealt with as main issues in Chapter 14 of the Report.

15.2. DHARAWAL STATE CONSERVATION AREA

Strong concerns for the protection of Dharawal SCA were raised by special interest groups, government agencies and individuals in both written and oral submissions.

ICHPL responded[580] to some of those concerns by offering rebuttal on some technical points (e.g. about the EEC status of the BSO Project Area swamps[581] and Ramsar listing status) and by pointing out that under Part 3A the various SEPPs are not relevant, that the Memorandum of Understanding (MOU) entered into in 1998[582] had no statutory or legal requirements with respect to mining in Dharawal SCA, and that the Project 'would not have a significant impact on the use of the Dharawal State Conservation Area or Dharawal Nature Reserve'.[583]

Dharawal SCA was gazetted in 1996 and the negotiations concerning establishment extended for some years prior to that. It is therefore worth considering what sorts of mining impacts on the conservation values and natural features of the Dharawal SCA might have been contemplated at that time.

The first thing to note is that, for those mines operating longwalls, the longwalls were much narrower than the proposed BSO Project longwalls. In 1996 there was no longwall panel in NSW that exceeded 250m in width and conventional subsidence-related impacts were generally not envisaged to be significant for natural features.

Non-conventional subsidence was also not a well recognised phenomenon in 1996. The Cataract River was not impacted until 1994[584], and these impacts were not predicted in the mining application submitted prior to 1993.[585] The same is true for impacts on the Bargo River in 2002, although the impacts at Waratah Rivulet in 2004 were predicted (and approved by the then Department of Mineral Resources (DMR))

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[580] ICHPL (2010d) pp.3 and 4
[581] Discussed at length in Chapter 6
[582] The MOU between the then National Parks and Wildlife Service (NPWS), Department of Mineral Resources and BHP Steel (AIS) Pty Ltd concerning mining activities in Dharawal SCA, dated February 1998.
[583] ICHPL (2010d) p.4
[584] DoP (2008), p.1.
[585] SCI (2008), p.82.

in the 2002 mining application. Very little work had been done on valley closure and upsidence prior to 1997-1998.

The bottom line is that no one involved in the negotiations to establish Dharawal as a State Conservation Area could have contemplated the significance of the damage to natural features that a modern longwall mining operation is capable of inflicting – particularly one with a Base Case longwall panel width of 310m and a clear intention to increase that width. In fact, in the early 1990s, the most serious threat to natural features was anticipated to be any essential surface facilities that could not be located outside the Dharawal SCA.

The Panel agrees with ICHPL that the MOU signed in 1998 is of little relevance to the present position. However, the legislation itself is not silent on the principles that govern activities within the SCA. Section 30G(2) of the *National Parks and Wildlife Act* 1974 (NPW Act) states:

> *'(c) provision for undertaking of uses permitted under other provisions of this Act in such areas (including uses permitted by Section 47J) having regard to the conservation of the natural and cultural values of the state conservation area.'*

This means that, whilst mining is an allowable activity, it must occur within a framework that does not compromise the conservation of natural and cultural values in the SCA.

The EA does not address the issue of 'conservation of natural and cultural values' in relation to the Dharawal SCA. The statement in the EA[586] is 'would not have a significant impact on the use of the Dharawal State Conservation Area or the Dharawal Nature Reserve' and reference is made to predictions concerning impacts on natural features and Aboriginal cultural heritage in sections 5.3-5.10 of Volume 1 of the EA.

The question is whether the subsidence-related impacts that could occur as a result of the BSO Project Proposal are compatible with the conservation and cultural values. ICHPL's position is that, based on the assessments in the EA, the Project is compatible with the use of the Dharawal SCA. However, the Panel has pointed out in multiple places in this report that the ICHPL predictions of the amount and/or magnitude of impacts and consequences do not withstand robust scrutiny and that the risks of negative environmental consequences and significant negative environmental consequences are much higher than the EA would suggest.

The Panel's opinion is that the kind of physical damage seen in Waratah Rivulet and some other undermined streams in the Southern Coalfield and the consequential water diversion (drainage of pools, etc) and water quality impacts – iron staining, turbidity and algal blooms – are not compatible with maintenance of conservation values. Add to this the risk of significant harm to cliffs, riparian systems, upland swamps,

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[586] EA, Volume 1, Section 7, p.7, but also repeated in ICHPL's response to submitters mentioned earlier.

threatened species and EECs, long-term scientific research studies, and Aboriginal sites and the extent of incompatibility becomes of even greater concern.

The Panel notes that, apart from its conservation and cultural importance, Dharawal SCA will also assume an increasingly important role for recreation opportunities for the rapidly expanding population of Sydney and its southern surrounds.

15.2.1. Recommendation

The Panel therefore recommends that any approval to mine under Dharawal SCA should be conditional upon negligible subsidence-related impacts on streams, swamps and significant Aboriginal sites within the SCA. This is considered crucial for two reasons:

(i) the normal statutory protections that would apply to natural features and Aboriginal sites within a conservation area are 'turned off' by the Part 3A process; and

(ii) the ICHPL proposal includes flexibility to change the location of longwall panels within a mining domain and to change the width of the longwall panels. Both have the capacity to increase the amount and magnitude of negative consequences for natural features, particularly if longwall panels encroach into areas that are not proposed to be undermined in the Base Case or if longwall panel width is increased. Rigid and enforceable performance criteria are therefore essential at the Approval stage.

15.3. PEER REVIEW

The issue of Peer Review has been raised in previous mining proposal reviews and was raised with the Panel conducting the current review at the Public Hearings and also by the Councils (Wollondilly, Campbelltown and Wollongong) at a combined meeting following the Public Hearings. There are three components:

(i) the perceived lack of independence of the peer review process;

(ii) the quality of the peer reviews themselves; and

(iii) the reliance placed upon peer reviews by stakeholders.

15.3.1. Independence of Peer Review

Some stakeholders express concern that the peer reviewer is engaged by the Proponent, paid for by the Proponent and the report is received and distributed by the Proponent. They question the independence of this arrangement. Of principal concern to these stakeholders is that selection of the reviewer and the drafting of the brief are squarely in the hands of the party with most to lose or gain from the content of the report.

15.3.2. Quality of Peer Review

The quality of the peer reviews is highly variable. In the Panel's experience there are more reviews that are problematic than there are reviews that would meet an acceptable professional standard for referee reports for reputable refereed journals or for significant academic theses. There are two aspects to this: key areas of the work that are outside the expertise of the reviewer may not be commented on (in only some cases will the reviewer identify the shortcoming); and the reviews themselves may be so general that they miss key factors that should have been the subject of comment.

15.3.3. Reliance on Peer Review by Stakeholders

The reliance placed on peer reviews by stakeholders is a significant issue. The Panel, with its substantial professional background, takes a very circumspect approach to Proponent-procured peer reviews and will usually rely on its own investigations and inquiries. However, it appears that this is not possible for many stakeholders. Even relatively skilled organisations such as the three Councils mentioned above take the view that, with their own resourcing constraints and professional skill base, they ought to be entitled to rely on a peer review by a reputable practitioner to determine whether to invest their efforts in one particular aspect of a project or another. These stakeholders do not necessarily have the capacity to pick a sound review from an unsound one, nor are they necessarily able to detect when fine craftsmanship in drafting is masking a serious defect in the work being reviewed.

15.3.4. Recommendation

The Panel recommends that the Department look at this issue with a view to determining whether independent selection and briefing of reviewers should be the norm, even if the cost were borne by the Proponent. As it currently stands the system appears to have little credibility.

15.4. ECONOMICS

A number of submissions raised issue with the cost benefit analysis performed as part of the Environmental Assessment. Questions were raised, for instance, regarding the price forecast used, the discount rate applied and most frequently, the application of the Choice Modelling technique to estimate the environmental and social costs.

Much of the criticism of any cost benefit analysis arises because of the complexity of the task the analysis is seeking to address and the expectations placed on its results. The task is complex because it acts to integrate all the information relating to the policy decision being taken where that information is necessarily uncertain. That uncertainty relates to the lack of a perfect understanding of the bio-physical processes involved as well as the social and economic responses to change. Always, predictions about future events are embedded in the analysis and the future is not known with perfect certainty.

Because of this complexity, the best a cost benefit analysis can do is to provide guidance to the decision making process. It should not be regarded as the sole source of the decision outcome and it is important that it is not expected to do so.

The use of Choice Modelling to gain an appreciation of the extent to which the community values environmental damage should be viewed in a similar light. The technique is capable of providing estimates of environmental values in monetary terms that are suited for inclusion in a cost benefit analysis. This allows a better understanding of the trade-offs between environmental costs and mining benefits than otherwise would be the case. If Choice Modelling had not been used in the BSO case, the cost benefit analysis would have consisted of a financial analysis of the proposal's benefits. The decision makers would have been left with the task of deciding if those well quantified financial benefits outweighed the unquantified environmental costs. In past cases, this choice has been informed by the process of 'benefit transfer' whereby the financial benefits were compared against the environmental costs estimated for in monetary terms in a similar policy context. The current EA cost benefit analysis has taken the approach of applying Choice Modelling to gain a direct estimate of the specific costs.

The Panel welcomes this approach and recommends its use in future EAs where environmental consequences are of particular importance in the determination of policy. However, that is not to say there is no room for improvement in applying the technique. While Choice Modelling cannot claim to deliver precise estimates of environmental costs, its application should be refined to deliver more precision. Of particular concern to the Panel in the BSO Project Proposal is the need for the Choice Modelling application to be more targeted at the specifics of the proposal natural features in the Study Area. The estimates generated from a Choice Modelling application are context specific. The description of the environment in question and the impacts of the proposed change are key elements in that context.

The ecological heterogeneity across the BSO Study Area calls for different context descriptions to be used in split samples. The simplest structure this would afford is one involving two different questionnaires: one for the eastern areas and one for the western areas. That would permit more accurate assessment of mining on an area by area basis.

Much of the criticism levelled at the BSO application of the Choice Modelling technique to this project proposal relates to disagreement with the context description used in the EA study questionnaire. In general, submissions claimed that the environmental damage was not accurately portrayed in the questionnaire. In future applications of Choice Modelling it is recommended that the project proponent works with the relevant government agencies – most importantly DECCW – to develop context descriptions that come as close as possible to an agreed picture of the current situation and what would emerge after the proposal's implementation. Where a common position cannot be established, it is recommended that a split sampling approach is adopted whereby alternative context statements are included in two different Choice Modelling questionnaires. This would enable statistical testing for differences in value estimates caused by the differing contexts.

Even with an agreed context statement and split samples to reflect regional heterogeneity, the complexity of the BSO case is unlikely to be capable of capture in a single Choice Modelling application. It is unlikely that a questionnaire could be designed to incorporate the complexities of the subsidence/upsidence impacts of mining as well as the coal wash emplacement impacts on Brennan's Creek and downstream in the Georges River. For instance, when endangered species are at risk, it would be appropriate for a Choice Modelling questionnaire to provide details of their names and status. However, the information burden on respondents would become too great to ensure a statistically adequate response rate.

Again it must be stressed that the task facing the economic analysis, especially when it involves environmental costs and benefits, is complex and hence imprecise. What the analysis can provide is guidance for decision making rather than the decision outcomes. The BSO Project Proposal cost benefit analysis including the Choice Modelling application is useful in that role and a considerable advance on previous practice. The Panel in its recommendations is looking to advance the use of economic analysis in future proposals.

Remediation of the damage caused by mining is advanced in the EA as a means of ensuring that mining activity can proceed. Submissions have raised concerns regarding this practice when dealing with environmental damage. While remediation has been common practice in dealing with the effects of mining on the built environment, there is less experience in dealing with damage to the natural environment. In part, this reflects changing societal preferences for the environment. In the past, the values associated with the continual functioning of infrastructure were readily apparent (e.g. avoiding catastrophic events such as train crashes or water supply failure). Engineering solutions were also well developed and effective. In other words, the costs of remediation were judged to be less than the benefits. However, for environmental damage, the benefits of remediation were deemed to be of little significance because the environment was not highly valued. In addition, remediation works were little understood and remain uncosted.

With environmental damage now being valued by society, remediation is being sought as a means of allowing mining to continue. The question that must be addressed in considering remediation works is whether or not the benefits exceed the costs. On the benefit side of that comparison, doubt exists as to how well current remediation works achieve the goal of ensuring the values provided by the environment continue to be supplied after mining. These doubts are at least two fold: for streams, does the grouting of cracks in rock bars act to 'seal' creek beds through the long term; and, by focusing on the grouting of rock bars and not boulder fields and pools, is the process useful even in the short run for other than amenity values at specific sites? Certainly, remediation of ecological values would require restoration of longitudinal continuity of flow conditions, and remediation of iron staining would require sealing of all new underflow paths – not just those at selected rock bars. Similar concerns apply to the remediation of damage to swamps where environmental damage may be spread over a wider geographical scale and where ecosystems are more fragile and hence more readily damaged by remediation works. On the cost side, there are financial costs associated with remediation but there can also be environmental costs associated with the disturbance to ecosystems during the remediation works. This is a particular issue in areas that were previously pristine.

Given these concerns regarding both the benefits and costs of remediation, the Panel is of the view that remediation of the natural features on the BSO Study Area should not be viewed as a viable mechanism for dealing with the impacts of mining at present. The Panel is also concerned by the EA's use of the expression 'when feasible to do so' in regard to remediation works. Nowhere is the concept of 'feasibility' defined in the Environmental Assessment. Interpretation of the expression is therefore vague. For instance, because the damage to the environment is a cost to society and not directly to the proponent, it could be argued that remediation of environmental damage would never be a financially viable option for the proponent. Decisions regarding environmental remediation require inputs from both the proponent (costs) and society (benefits) and cannot be left to the determination of the proponent alone.

In the absence of remediation as a means of dealing with mining damage, avoidance, mitigation and offsets are remaining alternatives.

Avoidance of environmental damage does not necessarily mean avoidance of mining under and around the natural feature of concern although it clearly may do so. However, it may also mean the use of mining technologies that allow extraction without the associated subsidence and upsidence. Bord and pillar mining methods ensure this but are not financially as lucrative as longwall mining. Future mining technologies may be developed to achieve profitable extraction without environmental damage. As the price of coking coal increases with growing scarcity, the incentives to develop such alternative technologies will increase. Similarly, techniques may be developed that mitigate (but do not completely avoid damage).

Where environmental damage does occur, perhaps in excess of approved levels as an unintended consequence of mining, or intentionally within permitted bounds offsets may present a mechanism to ensure society is not disadvantaged. An offset involves the proponent investing in the supply of an alternative substitute environment to the one that has been affected. This can involve the withdrawal of a similar ecosystem from the threat of damage – perhaps through the purchase of a yet to be developed ecosystem for declaration as a National Park – or the restoration of a similar ecosystem that has already been affected by another form of development – perhaps through habitat restoration works. For instance, damage to the water quality in one part of a catchment maybe offset by protection work that enhances the water quality sourced from another part of the same catchment. Consideration of the use of offsets requires an analysis of the extent of the costs to society of the environmental damage caused, relative to the environmental benefits of the offset and the costs of undertaking the offset. Crucial to this analysis is an understanding of the 'substitutability' of the environmental damage and the offsetting benefit. Where imperfection in substitution occurs, an 'exchange rate' between damage and offset must be set. For instance, the loss of one kilometre of pristine river due to mining may require the restoration of 10 km of already degraded rivers in the same catchment. The determination of the exchange rate requires the consideration of ecological function as well as community preferences.

A relatively high exchange rate is likely if research is offered as an offset. This is because the investment in research required to offset environmental damage would need to recognise the likelihood of research effort yielding results that have an effect on the environment being considered and that an investment in implementing the research results would take place. These are both uncertain events.

15.5. TRAFFIC NOISE

15.5.1. Introduction

The EA for the BSO Project Proposal includes a specialist road traffic noise report prepared by Wilkinson Murray Pty Ltd in accordance with the *Environmental Noise*

Criteria for Road Traffic Noise (ECRTN*)*. The study was carried out to establish the existing noise levels and to predict traffic noise impacts on residential receivers along all road haulage and personnel routes.

The issue of traffic noise was raised with the PAC Panel by DECCW but in relatively few public submissions.

15.5.2. Traffic Noise Impacts of the Proposal

Traffic noise impacts of the proposal would result from:

- The continued road transport of run of mine (ROM) coal from Appin East Pit Top to the West Cliff Washery;
- The continued road transport of ROM coal from Appin East Pit Top and the West Cliff Cliff pit top via the public road network to the Dendrobium Washery at Port Kembla;
- The continued transport of product coal from the West Cliff Washery via the public road network to Bluescope Steelworks, PKCT, Corrimal and Coalcliffe coke works and other customers;
- The movement of personnel to and from work.

The road traffic noise assessment in the EA concluded that the maximum predicted increase in traffic noise levels (relative to the existing noise levels) associated with the proposal is generally below the relevant 2dB(A) criteria for arterial, sub-arterial and collector roads and is considered acceptable. However it also found that the change in road traffic noise associated with the project would exceed the ECRTN 2 dB(A) allowance for Douglas Park Drive and Macarthur Road due to workshift movements.

Given the increase in predicted noise was 2 dB(A) above existing levels along Douglas Park Drive and Macarthur Road due to workshift movements, the Noise Report assessed the actual noise levels attributed to the project rather than just the change at residential receivers along this route. As these increases were attributed to workforce shift movements, the Report provided a consideration of two workforce configurations, being either two or three shifts daily, and calculated the offset distances at which ECTRN criteria would be achieved along these roads for the existing operations and for year 3 and year 10 of the project.

For the three shift option the noise assessment found that the offset distance to meet compliance with the ECRTN traffic noise goals for Douglas Park Drive would increase from 60 m to 105 m and for Macarthur Road from 50m to 60m. For the two shift option the noise assessment found that the offset distance to meet compliance with the ECRTN traffic noise goals for Douglas Park Drive would increase from 65m to 150m and for Macarthur Road 50 m to 65 m.

The actual location of, and predicted noise levels to, residences along this route were provided by the Proponent in their Response to Submissions. These figures indicated that under existing traffic conditions, a total of up to 36 residences would experience traffic noise levels exceeding the ECTRN criteria and under the project up to 57 residences would exceed the ECTRN criteria in the 3 shift option and 65 under the two shift option.

The Proponent provided suggested mitigation measures including encouraging the mine workforce and project construction workforce to car-pool and minimising workforce-related light vehicle movements.

15.5.3. Recommendation

The Panel is aware that these impacts are based on worst case assumptions, traffic noise levels on collector roads commonly exceed ECRTN criterion and that these exceedances would occur for only two to three hours per day. The Panel also agrees that options for the mitigation of this impact such as noise barriers and restricting the use of Douglas Park Drive and Macarthur Road are limited.

However, given the potential number of residences affected and that these exceedances would primarily occur from 11:00pm to 12:00pm for the three shift scenario and from 4:00am to 5:00am for the two shift scenario, both being situations in which the criterion is 55 dB(A), the Panel is of the view that the project has the potential to result in an unsatisfactory outcome for those residences affected.

The Panel recommends that if after 2013 the noise generated by traffic associated with the project persistently exceeds the relevant criteria at any residence on privately owned land then the Proponent should provide appropriate insulation and ventilation for affected houses at the request of the relevant landowners.

The Proponent should commit to a Road Traffic Noise Management Plan that includes provisions to ensure that the road haulage fleet represents best practice in terms of equipment operation.

16.0 ADEQUACY OF INFORMATION REQUIRED FOR ADVICE TO APPROVE A PROJECT

> *' ... as is common with all vegetation surveys conducted over fairly large areas it would not be feasible ... to visit and describe the existing native vegetation in all parts of the study area.'*[587]

The BSO Project Proposal is a very large proposal with many facets. There are potential impacts from the proposal on a wide range of natural features, built infrastructure and community including *inter alia*:

- the Main Southern Railway
- major roads, including the Hume Highway
- over 1200 houses
- commercial premises and major factories
- Sydney's drinking water supply infrastructure
- gas pipelines and electricity supply
- streams and rivers in the Sydney catchments
- upland swamps
- Dharawal State Conservation Area
- threatened species of plants and animals and EECs
- cliff lines
- Aboriginal cultural heritage
- traffic and traffic noise
- air quality
- European cultural heritage assets.

The Panel has had to consider each of these (and other) issues, and the potential benefits of the project, in determining the advice it is required to give under the terms of the Minister's Direction.

The Approval system that is evolving for underground coal mines involves an initial approval to conduct mining operations granted by the Minister which includes an array of conditions. Some of these conditions govern outcomes directly and some describe subsequent activities and actions that are to be included in a range of Management Plans. One of these is an Extraction Plan that must be prepared 'to the satisfaction of the Director-General' (of Planning) prior to the commencement of secondary extraction, which encapsulates longwall mining.

This type of arrangement was endorsed by the SCI[588], utilised in the Metropolitan PAC Report and the Minister's Approval for that project, and supported by the Land and Environment Court in *Rivers SOS Inc v Minister for Planning* [2009] NSWLEC 213 (*Rivers SOS*). As discussed in that case the important features of this

[587] EA, Appendix E, p.31

[588] Although the subsequent process was described at that time as a Subsidence Management Plan (SMP) which was overseen by the Department administering the Mining Act, being the Department of Primary Industries (DPI), since restructured as the Department of Industry and Innovation (DII).

arrangement are that the Minister's Approval must cover approval to mine in the area in which the infrastructure or natural features occur and it must also provide a comprehensive framework for the subsequent Extraction Plan process (including performance criteria, regulatory arrangements for the carrying out of the project, etc).

It follows that there must be adequate information available to the decision-maker to determine that the project can proceed and to provide a framework of conditions, including performance criteria, that will guide and control the subsequent stages such that it cannot be construed that the decision-maker has in fact delegated the approval function itself (whether constructively or otherwise) to those later stages. In *Rivers SOS* it was found that the discretion of the Director-General was controlled by the interlocking network of conditions that constituted the Approval framework.

In the Metropolitan PAC Report, the Panel (which is the same Panel as for the BSO Project Proposal) formed the view that there was adequate information available for it to assess that, subject to some project modifications, the risks of the project were identifiable and manageable and therefore the Project Proposal could be recommended for Approval subject to an array of conditions directed primarily at improved protection of natural features.[589]

The question arising from the BSO Project Proposal is whether there is adequate information available to the Panel to assess the consequences of the proposal – both negative and positive - and provide advice to the effect that in-principle Approval could be given. The matter is made complex because of the wide array of very significant potential consequences, the amount of information on which to base assessment of some of these potential consequences,[590] and the flexibility sought by the proponent to adjust the mine layout, including the longwall panel width,[591] in unspecified terms.

The Panel's considered view is that the following should form the basis for any advice it provides as to whether the threshold for in-principle Approval has been reached:

(i) whether the public process has allowed both the public and government agencies to consider the fully-disclosed risks of negative consequences of the proposed project and provide advice on these to the Department and the Panel;

(ii) whether the Panel's enquiries have been able to provide satisfactory answers to concerns arising from its own examination of the proposal or arising from submissions made to it;

(iii) whether the impacts from the project on built infrastructure and natural features in the Project Area have been characterised sufficiently to allow assessment of both the likely consequences from those impacts and the significance of those consequences. Key issues are:

[589] There was very little built infrastructure likely to be impacted by the Metropolitan Project Proposal.
[590] Conclusions on the adequacy of information appear throughout this report.
[591] Increased longwall panel width can have a significant effect on predicted impacts on both built infrastructure and natural features.

a. whether the individual items of built infrastructure and significant natural features have been identified and their significance assessed;
b. whether the potential impacts to these items of built infrastructure and significant natural features have been quantified;
c. whether the nature and extent of these impacts are predictable and have been predicted;
d. whether the relationships between these impacts and the consequences that derived from them are understood and quantifiable;[592]
e. whether the potential consequences of these impacts have been identified;
f. whether the significance of the potential consequences has been assessed for the items of built infrastructure and natural features.

(iv) whether the relative magnitudes of the positive and negative consequences of the Project Proposal have been assessed by a rigorous process that properly estimates both the proposed mining benefits and the potential costs.

It is clear that the Approval must be capable of controlling the nature and magnitude of the risks of impacts, even though subsequent processes (e.g. Extraction Plans) may fill in some of the detail. However, if 'filling in the detail' extends to obtaining information that was really required to make a sound approval decision in the first place then this could be construed as delegation of the approval function itself.

If the Panel considers there is inadequate information about the characteristics of the built infrastructure or natural features in the Project Area, the potential impacts and consequences of the Project Proposal, and the associated risks and the relative magnitudes of the costs and benefits of the proposal, such that the Panel considers a proper assessment cannot be made to support a recommendation for Approval, then the Panel appears to have only two options available in giving advice, namely:

(i) recommend rejection of the Project Proposal;

(ii) recommend consideration of Approval, but only contingent on performance criteria that are sufficiently robust to ensure that appropriate protection is afforded to the built infrastructure and natural features from the potential adverse impacts of the proposal and that the subsequent processes are properly constrained and controlled such that the performance criteria themselves cannot be altered.

The subsequent processes should be required to demonstrate to a very high level that the Performance Criteria and other conditions in the Approval will be met by the proposed extraction. This may require considerable additional investigation. Some of these information

[592] As indicated in the Metropolitan PAC Report, some of the relationships may be stepped rather than linear and for others the characteristics of the relationships are unknown.

requirements may themselves be laid out in the conditions of approval to guide the Extraction Plan process.

In the case of (ii) the protections should be commensurate with the significance of the item or feature (or potential significance if there is inadequate information on the items or features themselves) and the potential adverse impacts. The case law on this clearly requires that the greater the uncertainty, the higher the level of protection.[593]

The need to properly constrain and control subsequent processes arises because: the Extraction Plan process is not a public process and there is no requirement to consult or receive submissions; changes in the performance criteria could radically alter the impacts of the proposal without the knowledge of the decision-maker; some key statutory protections for natural features and built infrastructure are 'turned off' by the Part 3A Approval; and the performance criteria are an integral part of the governance arrangements for the Approval itself and should only be modified by another statutory process.

Five examples of the fundamental problems with the adequacy of information in the BSO Project Proposal are set out below (i.e. drawn from sections in this report). One example is drawn from the information on costs and benefits of the proposal. The others are drawn from groundwater, threatened species, upland swamps and traffic impacts sections, but there are numerous other examples in these and other sections of this report.

1. <u>Chapter 17</u>
   This heterogeneity (in natural features) is of particular significance to the assessment of the proposal but is not reflected adequately in the cost benefit analysis. This is particularly evident in the treatment of the environmental costs of mining as estimated by the Choice Modelling application. What the Choice Modelling study does is to provide estimates of the costs associated with a set of environmental consequences that are described to the survey respondents. The description provided is generic and does not provide details of specific ecological conditions evident in the different zones. For instance, particular endangered flora and fauna species are not detailed. Nor are specific features of individual streams such as water falls.

2. <u>Chapter 5</u>
   Given the numerous issues and identified problems with respect to groundwater assessments, and the identified abnormalities in the groundwater model, the Panel indicated to ICHPL that the reported studies were considered to be inadequate for assessment purposes. The characteristics and impacts of strata depressurisation, impacts of that depressurisation on shallower groundwater systems and on surface drainages and swamps could not be sensibly assessed from the information provided.

3. <u>Chapter 6</u>

[593] e.g. see *Telstra Corporation Limited v. Hornsby Shire Council* [2006] NSW LEC 133; *Rivers SOS Inc v Minister for Planning* [2009] NSWLEC 213; and *Newcastle and Hunter Valley Speleological Society Inc v. Upper Hunter Shire Council and Stoneco Pty Limited* [2010] NSW LEC 48.

The Panel's conclusions are that the survey intensity for flora and fauna in the upland swamps is manifestly inadequate to provide the basis for the second step of the risk assessment process (i.e. all swamps in the Project Area are identified, have their vegetation mapped and fauna surveyed …). Furthermore, this low survey intensity ensures that the existence of concentrations of threatened species associated with upland swamps in the BSO Project Area will remain conjecture, thus avoiding any proper assessment of 'special significance' for swamps at the Project Approval stage. This effectively removes threatened species and upland swamps generally from scrutiny by the public or the PAC as part of the Part 3A process.

4. <u>Chapter 6</u>
   The predictions for subsidence-related impacts are based on 310m longwalls. If longwall panel widths increase there is a substantial, but unquantified, risk of increases in the number of swamps likely to suffer negative environmental consequences and for these consequences to become much more significant. ICHPL has declined to provide the basic information required for the Panel to consider the magnitude of the increased risk and, combined with the pre-existing lack of adequate data on the characteristics of individual swamps, the Panel considers that the risks must be categorised as unacceptable unless the swamps are protected by a nil or negligible impact requirement.

5. <u>Chapter 14</u>
   In the case of traffic, the data used to ascertain the existing operation level of key intersections was recorded on Easter Thursday and therefore not likely to be representative of typical weekday traffic movements (particularly the afternoon peak). Further, the actual number of heavy vehicles generated by the proposal at key locations was not provided until after exhibition of the proposal meaning members public were unable to make a fully informed assessment or submission in regard to traffic impacts. The lack of adequate information regarding the number of heavy vehicle movements and the percentage of total vehicles attributed to the proposal make it impossible for the Panel to assess the acceptability of the impacts of the proposal on road capacity, intersection performance and safety.

   The Panel also understands that the RTA has requested further information and has not yet verified the key data used to project intersection performance during project operation. Consequently, the conclusions drawn from these data cannot be relied on as a true representation of the future impact of the proposal.

The level of uncertainty indicated by the examples above is substantial. The performance criteria therefore need to be clear and the monitoring and enforcement systems robust to ensure that unwanted impacts do not occur.

The inadequacies identified in the available information also create difficulties for assessment of acceptability of impacts and consequences. The Panel has approached this using a two part process. In the first part, it has carefully considered the significance of specific elements in each category of built infrastructure (e.g. houses, roads) and natural feature (e.g. swamps, streams) and assessed the likely consequences of proposed mining on these elements. This assessment incorporates the level of confidence the Panel has regarding the potential risks of impacts and consequences given the lack of relevant information. The Panel has then assessed the acceptability of these consequences, bearing in mind the (also) uncertain benefits provided to society by the proposed mine.

The second part of the assessment process has involved the Panel examining the question of 'acceptability' of the proposed project at an aggregate level, where all the elements of natural and built environments are incorporated. This requires an evaluation of the overall costs of the proposed project relative to the benefits it would generate for society. Again, with inadequate information being available on both the benefit and cost sides of the equation, uncertainty prevails. Hence the evaluation required the Panel to exercise its judgement across a range of issues. The Panel also used the aggregate assessment process to consider potential reasonable and justifiable compromises to the project as proposed that could provide an adequate (but not necessarily ideal) level of protection across a range of infrastructure assets and/or natural features while still being able to recommend a strongly conditioned Approval.

17.0 THE GEOGRAPHICALLY-BASED ALTERNATIVE

17.1. INTRODUCTION

As indicated in Chapter 16,[594] for many aspects of the potential impacts on significant natural features,[595] there is insufficient information to be able to assess risk to those features, even on the base case proposal in the EA. In each of the Chapters dealing with significant natural features, requirements for protecting these features to the minimum standards the Panel considers acceptable are identified.

Application of these measures uniformly across the Study Area will place substantial restrictions on the mining arrangements as proposed in the EA.[596] While the Panel considers these measures are warranted by the significance of the features and the potential risks of the mining proposal put forward by ICHPL – the Panel has examined an alternative approach that might improve the mining outcome whilst retaining an adequate level of protection for significant natural features overall. This approach is based on defined geographical areas within the Study Area where the significant aggregations of natural features that occur would be protected to a high standard, with some lesser level of restriction to be applied outside those areas.

In broad terms the model would involve approval of mining in the Study Area, but subject to negligible impact criteria for <u>all</u> examples of classes of significant natural features within a defined area or areas (including all upland swamps, all 3rd order streams, all 1st or 2nd order streams with upstream swamps or that are perennial or intermittent, all significant cliff lines, all significant Aboriginal Cultural Heritage sites, all significant EECs and significant populations of threatened species and their habitats). Significant natural features occurring outside these defined areas would be assessed to determine whether they warranted 'special significance' status, in which case negative environmental consequences should be avoided, or, as a last resort be compensated for. Other significant natural features could be dealt with by ensuring that predicted impacts endorsed in the conditions of Approval are met during mining operations.

For this to work, the existing commitments in the EA concerning protection of natural features such as rivers and streams would have to remain intact for areas outside the defined areas. If this were not to be the case the Panel would not recommend the approach.

The Panel considered this approach in two parts. First, based on the findings and recommendations about natural features in each of their specific chapters, was there an area (or areas) in the Study Area where there was a sufficient aggregation of these natural features in pristine or near pristine condition that could form the basis for a

[594] Chapter 16 provides an overview. Details are found in Chapter 6 (Swamps), Chapter 7 (Surface Water) and Chapter 8 (Terrestrial Ecology).
[595] The SCI listed a range of natural features as 'significant natural features' in Section 2.1 of the SCI Report.
[596] The level of restriction could be markedly different with different mining parameters or technologies.

compromise of the kind outlined above? Second, if such an area (or areas) could be identified, what were the economic considerations that should be taken into account and would these support or not support a recommendation to adopt such a model?

17.2. THE POSSIBLE 'DEFINED AREA'

For natural features, the obvious area to examine was the eastern part of the Study Area.

The Panel recognised that selection of an area (or areas) within this eastern part would necessarily involve a deal of subjectivity. But that subjectivity was informed by two things:

- The substantial level of analysis already undertaken on the risks to classes of natural features (e.g. swamps and streams) and individual features within those classes (e.g. streams of special significance and Aboriginal Heritage Sites of special significance) based on the EA, submissions from government agencies, special interest groups and the public, and examination of experts; and

- The Panel's own observations made during aerial and on-ground inspections of the Study Area.

The Panel's initial consideration resulted in a unanimous view that the eastern and southern parts of North Cliff, Appin Area 2 and a substantial part of Appin Area 3 should be considered for inclusion in any 'Defined Area'.

The Panel also requested DECCW to consider the same issue and provide the Panel with its expert advice as to whether there was an area (or areas) in the Study Area that would contain aggregated values for natural features that might form the basis of a compromise 'Defined Area'. That advice was comprehensive and is attached in full as Annexure 8. The advice essentially describes three overlapping 'Defined Areas' (see Figure 60) and provides arguments in support of each.[597]

[597] DECCW (2010c), Question 6, pp.1-5.

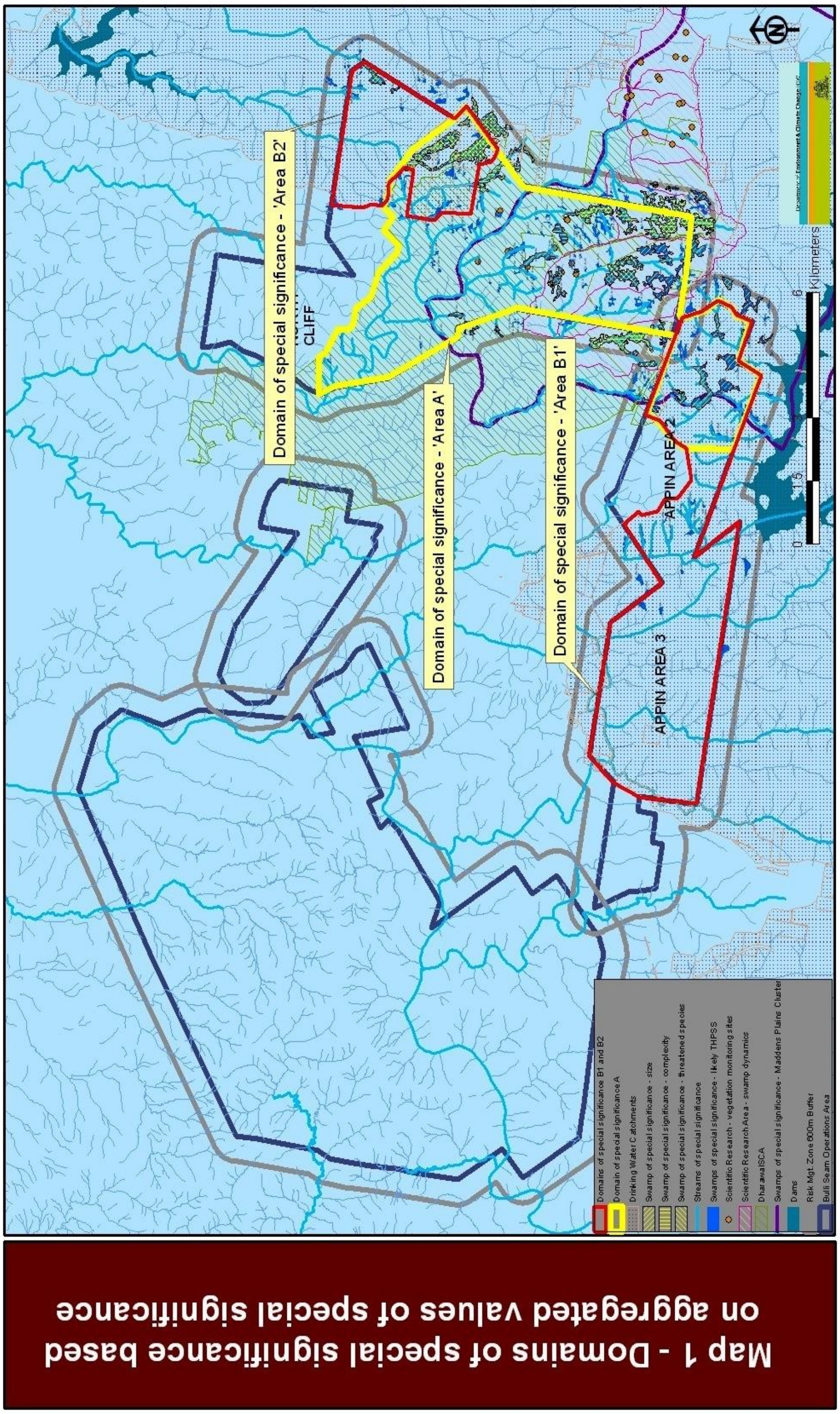

Figure 60: DECCW map of Domains of Special Significance

The Panel is generally in agreement with the DECCW advice, but would suggest that some modifications might provide almost the same level of protection overall without constraining mining operations to the same degree.

The main changes would be:

- eliminate Area B2, but require negligible impact criteria for the Woronora River throughout its length and for any of its tributaries that are connected to upland swamps, and

- negligible impact criteria also to apply to Aboriginal Cultural Heritage site 52-2-0854, which DECCW describes as the most significant site in the Project Area.

The Panel's recommended 'Defined Area' is shown in Figure 61.

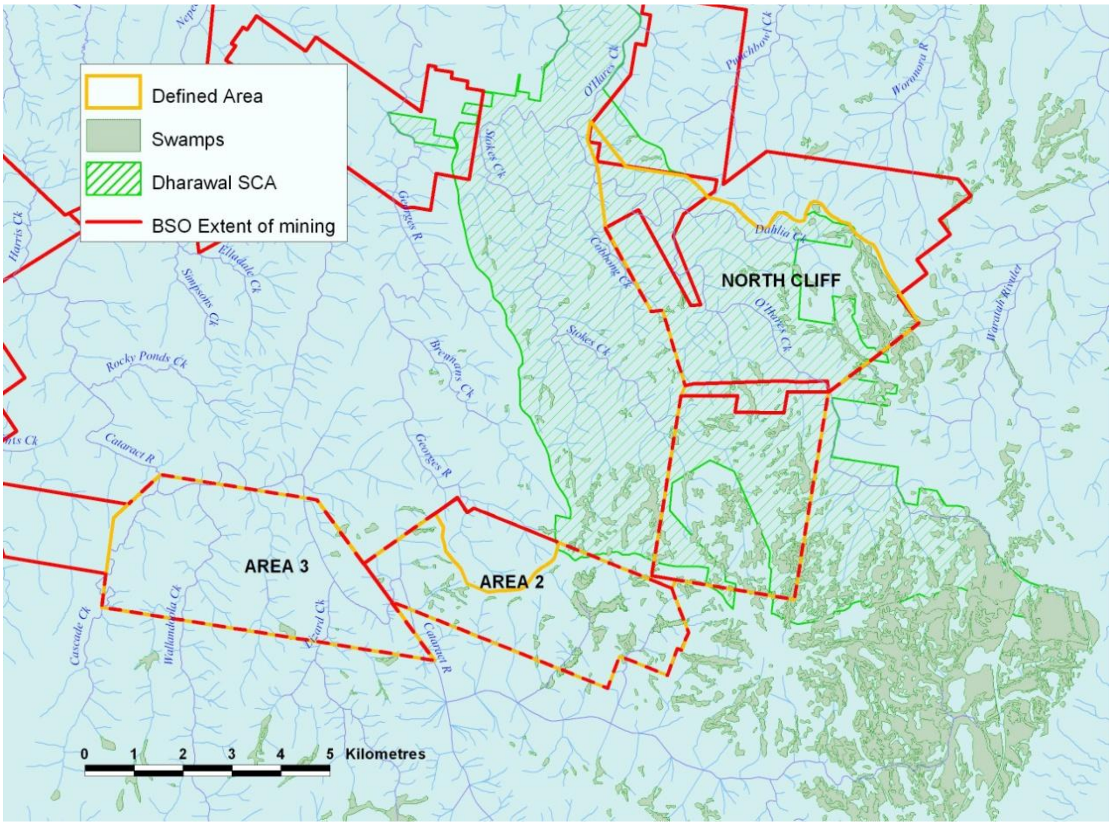

Figure 61: Defined Area Recommended by the PAC

From the perspective of natural features there are positive and negative aspects to this proposition. The negatives include:

- Some areas and features that ought to be protected from the kinds of impacts predicted will not be protected because they are outside the Defined Area. Under the currently accepted risk assessment model their protection to a high standard largely depends on achieving 'special significance' status. As has become evident in the EA, where virtually nothing was designated as being of 'special significance' by ICHPL, this can be a losing proposition for natural features if the decision or the advice is in the hands of the Proponent.

- Some natural features will be better protected than others under a Defined Area approach. For similar overall 'populations' those classes of features which are concentrated within a small area will benefit more than those with a wider distribution. For example, upland swamps are quite concentrated in the southern and eastern parts of North Cliff and Appin Area 2, but Aboriginal Cultural Heritage sites are more evenly spread across the eastern domains even though they are also well represented in the same locations as upland swamps.

- Dharawal State Conservation Area and the Sydney Catchment Authority Special Areas would not be fully protected from significant impacts in at least some parts.

- Most stakeholders who made submissions on the EA and to the PAC would consider the compromise did not provide the level of protection warranted.

On the positive side, the compromise could provide a high standard of protection to the Defined Area which contains the highest concentrations of significant natural features. Substantial parts of Dharawal State Conservation Area and the protected Sydney drinking water catchment areas would be within the proposed Defined Area. On the other hand, there would be less piecemeal restriction on mining outside the Defined Area than would be the case if the individual classes of natural features were afforded the levels of protection the Panel considers appropriate across the whole Study Area.

Mining is also not prohibited in the Defined Area. However, it will be some time before mining can commence in this area and this will give time for consideration of mine arrangement options and mining technologies that might improve extraction prospects without causing unacceptable impacts. Such technologies exist, but are not considered economically feasible in Australia at this time. However, this could change if market conditions changed.

The potential for increased longwall panel width only becomes an issue in the Defined Area model if the Approval conditions do not clearly specify the acceptable level of impacts for any natural features outside the Defined Area that are not of special significance status.[598] If these impacts are specified, a satisfactory early warning monitoring system is in place to detect potential or actual exceedances, and

[598] Impacts will need to be linked to subsidence predictions (all sources) for the purposes of monitoring.

there is an effective and enforceable adaptive management program, then longwall panel width simply becomes an issue for ICHPL to manage in meeting Extraction Plan conditions.

17.3. Economic Considerations for the 'Defined Area' Concept

In the assessment of the Bulli Seam Operations, it is the extent of the changes caused by the proposed mining to the values provided by the significant natural features and built environment that is relevant. Hence, if a feature is highly valuable to society but is unaffected by the mining then it is irrelevant to the assessment. Only if a feature provides significant values to society now or in the future and those values are impacted by the proposal is it relevant to the assessment. An impact must also be considered net of any mitigation, remediation or offset effort. Thus, a mine-affected asset may be remediated so that it is able to generate the same values as it did prior to mining. If so, the relevant cost to society is that associated with the remediation effort. Alternatively, if only a partial remedy is achieved, society's costs include the remediation costs and the reduction in the flow of values the asset is able to produce. Similarly, if changes to an asset are accompanied by the provision of an alternative flow of value through an offset arrangement, then the costs to society from the loss of the original asset's value should be reduced by the benefits achieved from the alternative.

To determine if the net impacts of mining are acceptable to society, the trade-off between the economic wealth created by the BSO Project, summarised in Chapter 3, and the costs of generating that wealth must be considered. These costs include any negative impacts on the natural and built environment. In its simplest and most aggregated form, the trade-off is between the AUD10.31b of mining benefit associated with the complete project as proposed and the costs associated with the environmental changes from mining as well as its impacts on the built environment. The environmental costs are estimated through the application of the Choice Modelling method – see Box 1. The built environment costs are estimated by the costs of remediating the impacts to a 'safe and serviceable' condition via payments made to the Mine Subsidence Board as well as specific anticipated expenditure. This is the essence of the cost benefit analysis featured in the EA. Its findings are that the benefits of mining are greater than its costs: the net present value of the mining proposal is estimated at $7.4b when environmental and infrastructure costs are netted out of the mining surplus. This rises to $8.282b when the social benefits of employment are included. This result is shown to be robust to sensitivities to a wide range of variables that impact on the net present value estimate including the discount rate, price of carbon and the Choice Modelling estimates of natural feature values. In the EA, the most pessimistic estimate of net present value under these sensitivities does not fall below $5b. Furthermore, as detailed earlier, the price of coal on which these net present values are calculated is judged by the Panel to be conservative. Future increases in the price of coal would push these net present value estimates higher.

Box 1: Choice Modelling

In seeking estimates of benefits and costs, economists look to markets as a source of information regarding peoples' preferences for goods and services. Their willingness to pay for marketed products, as revealed through their purchase and sales behaviour is used as a measure of value. However, for environmental benefits and costs where the goods and services are not bought and sold in markets, other sources of information on peoples' preferences and their willingness to pay need to be found. Choice Modelling is one method used to estimate willingness to pay for environmental benefits and costs.

In a Choice Modelling application, respondents to a survey are asked to make choices between a number of alternative future scenarios that involve the non-marketed goods and services being valued. Those alternatives are defined by 'attributes' that describe the scenario outcomes. Examples of environmental good attributes include the number of species present in an area, the suitability of a water body for recreation activities and the area of protected wetlands. The different alternatives between which respondents are asked to choose involve the attributes taking on different levels. Some alternatives have a lot of one attribute but little of another and vice versa. By observing the survey respondents' choices between the scenarios, the choice modeller can investigate the trade-offs they make between the different attributes: How much of one attribute they are willing to give up in order to get more of another. By including a monetary payment as one of the attributes that describe the scenarios, the choices made can be used to infer the amount of money respondents are willing to give up to achieve more of an environmental attribute. This is their willingness to pay for that attribute. It is this monetary estimate of environmental value that is suitable for inclusion in cost benefit analysis.

Previous applications of Choice Modelling in the Australian environmental policy context have included studies commissioned by the Victorian Environmental Assessment Council into the future management of the River Red Gum forests along the River Murray (http://www.veac.vic.gov.au/eefea.htm) and an estimation of the environmental benefits associated with the re-cycling of 'e-waste' carried out for the Environment Protection and Heritage Council

(http://www.ephc.gov.au/sites/default/files/PS_TV_Comp__Willingness_To_Pay_For_EWaste_Recycling_Fin

The Panel is concerned that this broad, aggregated trade-off analysis does not adequately reflect the heterogeneity of impacts across the geographical extent of the Study Area. In general, the western, Wianamatta Shale dominated, zone provides environmental use values associated with rural amenity values, hydrological values associated with water quality improvement and agricultural water storage and some habitat refuge values. In contrast, the eastern, Hawkesbury Sandstone zone provides recreational use values, bushland amenity values, hydrological values associated with water quantity and quality and ecosystem protection non-use values. In between these two areas is an intermediate zone where the streams and rivers have incised through the Wianamatta Shale into the underlying sandstone strata. This zone provides values evident in both the eastern and western zones but to a different extent and in different proportions.

Not only are the existing features of the various zones across the proposal area different, but the impacts of mining are also likely to be different. For instance, undermining the Wianamatta Shale western zone has been demonstrated to cause relatively minor changes to the values supplied by the natural features. However, in the more pristine eastern zone, changes will be more pronounced.

This heterogeneity is of particular significance to the assessment of the proposal but is not reflected adequately in the cost benefit analysis. This is particularly evident in the treatment of the environmental costs of mining as estimated by the Choice Modelling application. What the Choice Modelling study does is to provide estimates of the costs associated with a set of environmental consequences that are described to the survey respondents. The description provided is generic and does not provide details of specific ecological conditions evident in the different zones. For instance, particular endangered flora and fauna species are not detailed. Nor are specific features of individual streams such as waterfalls.

The Choice Modelling study has been carried out in a technically competent fashion, as reflected by the peer review conducted by one of Australia's most respected academics in the field, Prof John Rolfe. However, it has been based on biophysical information regarding the region and the impacts of mining that is generic in nature and insufficiently detailed. The DECCW submission has further criticised the Choice Modelling application in terms of the adequacy of information provided to respondents, particularly with regard to the significance of swamps in the Study Area. The sample of NSW residents who were asked the Choice Modelling questions were provided information based on the proponent's view of the environmental impacts of the project that meant swamps were not included as a choice attribute because the proponent had concluded that there were no swamps of significance in the Study Area. That view is at odds with the findings of this Panel and the submissions from DECCW and a range of other stakeholders including SCA and the NGOs. A key result in the Choice Modelling literature is that the information provided to respondents has an influence on the values so estimated. Put simply, respondents' preferences and values are influenced by what they know of the good in question. If a good is 'downplayed' in a Choice Modelling study, its estimated value will be lower.

The implication is that the Choice Modelling results are problematic in two dimensions. First, they are generic across a wide range of biophysical contexts and so unable to reflect differences across the Study Area. So while changes due to mining are likely to be more environmentally costly in the pristine eastern zone than in the more developed western zone, the estimates of damage costs used in the EA for both areas are based on the generic characteristics described to respondents in the Choice Modelling questionnaire. The Choice Modelling study does not provide sufficiently detailed value estimates to differentiate between natural features of differing value characteristics. Second, the biophysical information on the impacts of mining provided in the Choice Modelling questionnaire was at odds with that provided to the Panel by DECCW, SCA and a range of other stakeholders. This is likely to cause the environmental values estimated in the Choice Modelling application to be lower than had they been estimated on the basis of DECCW information.

Heterogeneity of benefits and costs is also clear from a comparison between areas that have a high concentration of built infrastructure and those that are in a less developed condition. In the case of infrastructure, the costs of mining-induced damage are included in the EA cost benefit analysis on the basis of a cost per tonne of coal produced paid to the Mine Subsidence Board as 'insurance premiums' paid in the event of remediation being required, plus specific costs associated with well-anticipated preventative and remediation costs. This means that in the EA cost benefit analysis, the costs of any mining-induced damage are effectively spread evenly across the Study Area. This is in contrast to the likely actual costs associated with a mining-induced infrastructure failure such as a rail accident or a gas pipeline explosion. Such potential events are concentrated largely in the more developed western areas where the infrastructure assets are located. To account for the possibility of a mining-induced catastrophic failure of infrastructure the cost benefit analysis should include the expected costs of potential incidents as they relate to specifically located infrastructure assets and not the 'diffused' costs of MSB premiums. This involves estimating the costs of the incident outcome multiplied by the probability of its occurrence, noting that while the incident outcome costs are high, particularly when they involve loss of human life, engineering works are proposed to ensure that the probability of occurrence is very low.

Cultural heritage assets are also site specific. This applies to the heritage of both Aboriginal and European people. Aboriginal heritage that remains intact is concentrated in the less developed eastern areas while European culture is more prominent in the rural and semi-rural areas of the west. Even within these broadly defined areas, sites such as churches and clusters of grinding grooves are localised.

Hence in what follows, the economic analysis that underpins the Panel's consideration of acceptability is carried out on a finer geographic scale. The areas of analysis have been selected with recognition of the distribution of significant natural and built capital assets.

This approach seeks to recognise that while the benefits of a tonne of coal extracted from any of the areas are likely to be very similar (with variations due to differential product quality, recoverable fraction and operational cost differences), the impacts of mining on the natural and built environments will not be uniform.

This analysis is necessarily an imprecise exercise. The Panel does not have available to it information on the coal mining net revenues on an area by area basis. Nor does the EA Choice Modelling application provide detailed estimates of the differential values associated with mining-induced environmental damage caused to swamps and streams across the different areas. Similarly, costs associated with infrastructure failures and the probabilities of such occurrences have not been estimated on an item by item basis. Most importantly, the information provided in the Environmental Assessment regarding the impacts and consequences of the proposed mining activity has been demonstrated to be inadequate across a number of dimensions, but specifically in terms of environmental features. The implication is that many of the environmental costs associated with mining are uncertain. This has further implications for the conduct of the cost benefit analysis.

What follows therefore accepts the general magnitudes of the Environmental Assessment's estimates of benefits and costs of the proposal but only as 'averages' across the proposal area. The Choice Modelling derived estimates are therefore accepted as useful indicators of the average costs of environmental harm done to an 'average area' by mining (as depicted by the study's questionnaire). Similarly, the Mine Subsidence Board payments are taken as being 'averaged' across the whole proposal area. Unlike the approach in the EA, the Panel has then overlayed an assessment of how much the environmental and infrastructure costs pertaining to each area are likely to deviate from these averages. Because it is assumed that the mining benefits are by and large similar on an area basis across the proposal area, the analysis becomes primarily an assessment of divergences between the environmental and infrastructure costs and the EA 'averages'.

While assessment of the benefits and costs associated with mining in the separated sub-areas of mining is not possible given the quality of information made available to the Panel, some indicative analysis is insightful to illustrate the logic behind the assessments of ‘appropriateness’ that are made. The information for these illustrative exercises comes from the Environmental Assessment and responses to Panel questions to the proponent. In those questions, the Panel requested information regarding the extent of mining benefit lost and environmental/heritage costs so avoided by standing back from:

1. a set of streams; and
2. a grouping of streams, swamps and aboriginal heritage assets.

This allows an analysis of benefits and costs ‘at the margin’ designed to investigate the change in social well being caused by a deviation from the project as initially proposed. Put simply, it allows for an analysis of the impacts on society caused by approval conditions that may be imposed by the Minister in order to protect those streams and swamps from environmental damage.

In the case of protecting the following streams (Panel Question 49):

a) O’Hares Creek
b) Stokes Creek Reach 1 and 2
c) Cataract River
d) Lizard Creek
e) Georges River Reach 2
f) Nepean River Reach 1

the lost mining production benefit (in present value terms) was reported by the proponent to be $28m. The present value of the associated environmental benefits, calculated using the average value estimated from the Choice Modelling study, was $16m. The proponent concludes that setting aside the coal reserves to protect the streams would leave society worse off by $12m.

In the case of changing the mining plan to protect (Panel Question 68):

1. Wallandoola Creek,
2. Cataract Reservoir Tributary 2 and associated swamps, and
3. the aggregation of upland swamps in the vicinity of Base Case Longwalls 14 to 22,

the Proponent estimates a social loss of $202m.

Both of these social losses have been estimated using the average environmental values. In other words, the value estimates relate to the average environmental features detailed in the Choice Modelling questionnaire: they do not account for any special features of the streams, swamps and artefacts. In the case of the value of swamps, because the Bulli Seam Choice Modelling survey did not include swamps as an environmental attribute of the Study Area, the value estimates were drawn from the Metropolitan Mine proposal Choice Modelling application. The impact of the discrepancy between the proponent's view of the significance of swamps and that of DECCW is illustrated by the reduction in the extent of the social loss associated with the second case when DECCW's definition is used. Rather than $202m, the social loss is $105m.

If the upper bound of the 95% confidence interval for the environmental and heritage values are used in these calculations in an attempt to reflect the special characteristics of the assets involved, the social loss reduces further. Protecting the set of assets in case two is then estimated to cost society $22m.

These two cases serve to illustrate a key point. While the project as proposed is shown by the Environmental Assessment cost benefit analysis to yield a substantial net social benefit, variations to the proposal that are designed to protect key environmental and heritage features impose relatively small social costs. This is particularly the case when the information base of the Environmental Assessment is adjusted to reflect the heterogeneity of features across the project area and DECCW's assessment of the significance of the swamps to be impacted by mining.

Not included in the analysis of these two cases are three further factors that require noting in the formation of an understanding of project 'acceptability'. First, the analyses do not account for aggregations of environmental/heritage features in specific locations across the project area. While the second case involves multiple features being protected from mining damage, the associated benefits are treated in the analysis as simply additive. That does not take into account any interaction effects whereby the benefits of a protected Aboriginal site may be enhanced by its location on a cliff line of special significance that is also protected. Nor is the connectivity between swamps and streams accounted for. Such value interactions were not found to be significant in the Choice Modelling results, but this is to be expected given that the experimental design used as the basis for the Choice Modelling application is not able to support second order effects of the type required to explore interactions. The prospect of value interactions cannot therefore be excluded.

Second, the Environmental Assessment analysis is dismissive of the impacts on recreational usage of the Study Area of the proposed mining activity. It is certainly the case that the environmentally rich eastern areas of the Study Area are currently only lightly used for recreational purposes but growth in south western Sydney's population and increasing pressure on well established nature based recreational sites in the Southern Sydney area (such as Royal National Park) are likely to push demand into the Study Area. This is particularly the case for the Dharawal State Conservation Area. Impacts of mining on Dharawal may have longer term costs for recreational benefits enjoyed by Sydney residents.

Third, the analyses do not take into account the uncertainty surrounding the predicted impacts and consequences of the proposed mining activities. Where such uncertainty exists, option values and quasi option values are associated with the environment and heritage protection benefits of limiting and postponing development. Put simply, people are willing to pay a premium above the values estimated in the Choice Modelling application to protect environmental and heritage assets from development if there is uncertainty associated with future outcomes, especially when those outcomes may be irreversible. This is known as an option value. People are also willing to pay a premium to postpone decisions where the environmental/heritage outcomes are uncertain in order to allow more information on the consequences of development to be collected and analysed. This is known as quasi-option value.

The aggregation effect, the omission of recreational benefits lost together with uncertainty, are likely to cause the environmental value estimates included in the Environmental Assessment and the analyses of marginal costs and benefits of changes to the mine proposal detailed here, to be underestimated. The implication is that it is likely that net social benefits will be achieved by the imposition of selective approval conditions that are designed to protect aggregations of special environmental and heritage features where the biophysical impacts of mining are uncertain. Because of the significance of uncertainty in this proposal, and the resultant importance of option and quasi option values as components of the net social benefit of environmental and heritage protection, postponement of mining operations in some areas to allow for the collection and analysis of further information that will better inform the drafting and assessment of Extraction Plans is also a possible management strategy.

In the following sections, the Study Area is sub-divided into two sub-areas based on the Panel's 'Defined Area' in the east and the rest of the Study Area to the west and north of the Defined Area (Figure 61). These sub-areas are subjected to further analysis of project 'acceptability' in an attempt to recognise the heterogeneity of the Study Area's characteristics.

17.3.1. Western and Northern Sub-Area

The assessment carried out by the Panel indicates that the streams in the western part of this area – noting that the Nepean River will not be undermined - are not without value but will suffer consequences from the proposed mining activity that are not inconsistent with maintenance of their current values. Some streams in the eastern portion of this area have been identified as being of 'special significance' and worthy of protection by negligible impact criteria. Some other streams in the central and eastern parts of the area, e.g. Punchbowl Creek and Allens Creek, will be impacted by mining-induced subsidence, but the impacts on their values have been assessed by the Panel as tolerable within the Base Case layout. There are still some swamps in this sub-area, but they are relatively isolated compared to the majority of swamps in the Defined Area. Overall, the environmental costs associated with mining are therefore deemed to be minimal and on a per unit basis, lower than those estimated (as averages for the project area) in the Choice Modelling application.

Several key elements of infrastructure occur in this sub-area, including housing, the Hume Highway, telecommunication cabling and the main southern railway. The Panel is of the view that undermining these assets will cause little or any loss in the value flows they produce because of the effectiveness of damage prevention and remediation engineering works. The costs of these works are adequately incorporated in the cost benefit analysis of the overall project.

There are European cultural heritage assets present in this area, most of which can be successfully protected and/or remediated during and subsequent to mining. Their protection values are generally not considered to be at risk, but a small number of specially significant heritage assets may require specific protection actions.

With lower than average environmental costs and minor un-remediated damage to infrastructure and cultural heritage assets, the Panel is of the view that the benefits of mining in the western and northern sub-area are sufficient to warrant the costs involved. Hence the Panel considers that the consequences of mining in this sub-area are acceptable subject to limited specific constraints associated with Built Infrastructure, Heritage, and some specified streams of 'special significance' and also possible limited specific constraints associated with EECs and threatened species for which adequate surveys have yet to be conducted.

17.3.2. 'Defined Area' Sub-Area

The assessment carried out by the Panel indicates that the streams in this sub-area are environmentally significant and are expected to experience consequences from the proposed mining activity. There are environmentally significant swamps present in Appin Area 2 and in North Cliff that are also likely to bear consequences from mining. The environmental costs associated with mining are expected to be, on a per unit basis, higher than those estimated (as averages for the project area) in the Choice Modelling application. The full extent of the potential impacts of mining are also considered to be uncertain.

Wallandoola Creek and Wallandoola East Creek in Appin Area 3 flow into the Cataract River above Broughton's Pass Weir. Hence any deterioration in water quality resulting from undermining will feed into Sydney's water supply. Similarly, tributaries in Appin Area 2 flow directly into Cataract Dam. Furthermore, water supply infrastructure assets in this area would be impacted by undermining however, it is the view of the Panel that preventative and remediation work should be effective in preventing loss of values being provided.

Remediation efforts on natural features in the difficult terrain of this area are likely to be themselves damaging to the amenity of the areas and to the ecology, and have unknown capacity to diminish the environmental costs of mining in the medium to long term.

Following the logic developed in the preceding section of this report and the case studies analyses, the Panel has formed the view that the environmental and heritage consequences of mining in the eastern Division as predicted by the Environmental Assessment are unacceptable. The expected benefits of mining in this sub area are expected to be less than the environmental and heritage costs given the current availability of information and the resultant uncertainties. Put another way, the Panel considers that a social net benefit would be generated by conditioning the Project's Approval so that the environmental and heritage assets are protected from damage at least to the levels specified in the recommendations in the Chapters of this report dealing with natural features and cultural heritage. This conditioning does not preclude mining in this sub-area. It does however allow the passage of time in which two possibilities may emerge. First, further information regarding the impacts and consequences of mining on the environment can be collected and analysed. By reducing the uncertainty surrounding the impacts and consequences of mining, and possibly demonstrating that proposed mining will not exceed the Performance Criteria laid down in the Approval conditions, mining may then be able to proceed. Second, technological advances may be made through time that involve the development of alternative mining methods that reduce surface impacts of underground mining. Remediation methods may also be improved.

17.4. FINDINGS AND RECOMMENDATIONS

The Panel advises that, on the basis of its analysis of the available material, there are three options open:

(i) Reject the BSO Project Proposal with a view to encouraging several smaller proposals each containing the required level of information on which to base rigorous assessments;

(ii) Approve the Project subject to the constraints listed at the end of each Chapter for each class of natural features across the Project Area; or

(iii) Approve the Project subject to constraints listed in the geographic area model described above applied to the 'Defined Area' shown in Figure 61.

The Panel recommends:

That Option (iii) be adopted and that the 'Defined Area' shown in Figure 61 be adopted as the minimum area for protection of significant natural features in this option.

18.0 CONCLUSIONS AND RECOMMENDATIONS

18.1. INTRODUCTION

By any standards this is a very substantial and complex project proposal.

The Study Area covers more than 220 km^2, is within 60 km of a capital city (Sydney) and a number of regional cities (including Wollongong, Campbelltown, Liverpool, and Penrith), is adjacent to the population growth centre of Macarthur, and straddles the main transport and services corridor connecting Sydney with Canberra and Melbourne. It encapsulates towns and villages, elements of the water supply system for the Sydney Metropolitan Area, a national highway, a national railway line, national gas supply pipelines, national telecommunication networks, industrial complexes, farms, recreational areas, air strips, and all the services that support such infrastructure (water, sewerage, gas, electricity, communication systems, survey control stations etc). As such, it contains a vast number and range of built structures, including 1294 houses, 4356 rural buildings, kilometers of hardware (e.g. water supply lines, optical cables), major roads and bridges, commercial and retail premises, large factories, etc. The vast majority of this built infrastructure is in the western portion of the Study Area (i.e. West Cliff Area 5 and Appin Areas 7, 8 and 9).

There is also a multitude of significant natural features in the Study Area including 632 identified Aboriginal Heritage sites, 634 cliffs, 226 upland swamps, 47 streams of 3rd order or above (compared with two in the Metropolitan Study Area) and a substantial number of Endangered Ecological Communities (EECs) and threatened species. The majority of the significant natural features are found in the eastern and southern portions of the Study Area (i.e. North Cliff, Appin Area 2 and Appin Area 3) which also overlap substantially with Dharawal State Conservation Area and the Sydney Catchment Authority's (SCA's) Metropolitan Special Area. Substantial parts of this area are in pristine or near-pristine condition and the area is also a significant contributor to drinking water supply for the Greater Sydney Region.

Mining-induced subsidence has the capacity to impact on both built infrastructure and natural features and the impacts can range from negligible to destruction of form and function. The complexities of predicting subsidence effects and impacts, the possible consequences for infrastructure and natural features that may arise from these impacts and the possible management approaches to avoid, mitigate or remediate them, are the subject of a substantial part of this Report. Overall, much more is known about both impacts and their management in relation to built infrastructure than is known about impacts and management for natural features.

The BSO Project Proposal is also seeking to include within any Approval the Stage IV Coal Washery Emplacement and a range of ancillary surface facilities including surface goaf gas drainage facilities and pit-top facilities.

The information supplied with the proposal (the EA), and subsequent information provided by the Proponent either in response to submissions or response to the Panel's questions, is highly variable in terms of coverage and quality. In general terms it is strongest in relation to built infrastructure and weakest in relation to significant natural features.

This weakness in the information base for natural features was recognised by all government agency submissions (including DII, NOW, SCA and DECCW), submissions by the three relevant councils (Wollondilly, Campbelltown and Wollongong), by most Special Interest Groups and by many individuals. The most common position adopted by submitters was that mining should be allowed to proceed in the western areas subject to conditions to protect built infrastructure and some natural features, but that the information base was inadequate to allow mining to be approved in the eastern and southern areas.[599] Many submitters suggested that the Project Application should never have been submitted as a single project given the substantial difference in issues between the western and eastern portions.

The adequacy of the information on which to base an assessment of the Project Proposal and provide advice pursuant to the Minister's direction (Annexure 1) was a

[599] There were two broad sub-groups: those who wanted more work to support a proposal with little or no impact on natural features and those who were totally opposed to mining in these areas.

major concern for the Panel. It is dealt with at length in Chapter 16. Summarised, the Panel's conclusions are that the basis for any advice from the Panel as to whether the threshold for in-principle Approval has been reached should depend on:

(i) whether the public process has allowed both the public and government agencies to consider the fully-disclosed risks of negative consequences of the proposed project;

(ii) whether the Panel's enquiries have been able to provide satisfactory answers to concerns;

(iii) whether the impacts from the project on built infrastructure and natural features in the Project Area have been characterised sufficiently to allow assessment of both the likely consequences from those impacts and the significance of those consequences; and

(iv) whether the relative magnitudes of the positive and negative consequences of the proposed project have been assessed by a rigorous process that properly estimates both the proposed mining benefits and the potential costs.

If the Panel considers there is insufficient information for a proper assessment to be made to support a recommendation for Approval, then the Panel appears to have only two options available in giving advice, namely:

(i) recommend rejection of the Project Proposal;

(ii) recommend consideration of Approval, but only contingent on performance criteria that are sufficiently robust to ensure that appropriate protection is afforded to the built infrastructure and natural features from the potential adverse impacts of the proposal and that the subsequent processes are properly constrained and controlled such that the performance criteria themselves cannot be altered. The case law on this clearly requires that the greater the uncertainty, the higher the level of protection required.[600]

The subsequent processes should be required to demonstrate to a very high level that the performance criteria and other conditions in the Approval will be met by the proposed extraction. This may require considerable additional investigation. Some of these information requirements may themselves be laid out in the conditions of approval to guide the Extraction Plan process.

As noted in Chapter 16 and throughout this Report, the Panel found the information provided by the Proponent to be deficient in many circumstances. Either the information was not available at the time the EA was exhibited (and therefore unable to be scrutinised by the public and other groups including government agencies, e.g.

[600] e.g. see *Telstra Corporation Limited v. Hornsby Shire Council* [2006] NSW LEC 133; *Rivers SOS Inc v Minister for Planning* [2009] NSWLEC 213; and *Newcastle and Hunter Valley Speleological Society Inc v. Upper Hunter Shire Council and Stoneco Pty Limited* [2010] NSW LEC 48.

the 700 additional truck movements per day) or the information was simply inadequate for the purposes of rigorous assessment of the proposal. In the latter context the expressions 'inadequate' and 'manifestly inadequate' appear throughout the report in relation to the information on which the Panel was meant to assess the likely subsidence-related impacts of the proposal on significant natural features, including groundwater.

The information deficiencies are compounded by inclusion in the proposal of a capacity to alter the Base Case mine layout – both in terms of longwall location within the Mining Area and longwall panel width. The Panel has noted the considerable increase in potential subsidence-induced impacts that could arise from the as yet unspecified increases in longwall panel width.

The Panel's view is that the difference between the situation it was faced with in the Metropolitan Coal Project Review and the situation it is faced with now is substantial. In its assessment of the Metropolitan Coal Project Proposal the Panel considered that it had sufficient information to be confident that a recommendation for a conditional Approval could be made and that deferral of some aspects to subsequent processes would still yield a reasonable result.

That is clearly not the position that the Panel considers pertains to the BSO Project Proposal. Information necessary for a proper assessment of the potential subsidence-related impacts and consequences for key features such as groundwater, upland swamps, EECs, threatened species, aquatic ecology, and cliffs and steep slopes is so deficient that it could not be said that the public, government agencies or this Panel were able to assess and comment on the fully disclosed risks posed by the Project Proposal. Whether intentional or not, the result of the information deficiencies in this case could be that the process to date effectively avoids proper scrutiny of the proposal at the approval stage, defers crucial decisions on allowable impacts to processes that occur out of the public domain and closes off judicial review of the merit of decisions.

The Panel is of the view that the deficiencies in the information supporting the Proposal are sufficient to warrant a recommendation of no Approval for the eastern and southern portions of the Study Area. The consequences of allowing the project to proceed in these areas are potentially very significant: the various protections for significant natural features are 'turned off' by the Part 3A process, the timeframe is at least 30 years and the opportunity for third parties to appeal on the merits is extinguished.

However, if the approach outlined above in the second limb of the options the Panel considered it had available to it were adopted, it may be possible to construct an Approval that would cope with the deficiencies in information and still produce an acceptable outcome. It would require setting rigorous performance criteria in the Approval Conditions (essentially outcomes to be met in relation to protection of infrastructure and significant natural features) and ensuring that any subsequent processes were tightly controlled so that the regulator was satisfied that the proposals for extraction of individual longwalls would meet the performance criteria.

Two broad options for proceeding down this path are suggested in this Report. The first is to set the performance criteria for each category of infrastructure or significant natural feature (or individual items or features where this is more appropriate) across the entire Study Area. The suggested criteria are contained within the individual Chapters and the recommendations are set out by Chapter heading in 18.2 below. The main problem with this option is that some key information for assessment of special significance of some significant natural features is not available (some of the work has not been commenced, or undertaken at all) and this may warrant deferral of any Approval until the information is available.

The second is to take a different approach based on known aggregations of significant natural features and provide adequate protection to the aggregation on the basis that this will produce a better overall result for both the mining proposal and the environmental and cultural heritage attributes of the Study Area. This is the Geographically-Based Alternative described in Chapter 17.

What both of these approaches do is allow mining to proceed in the west and north while the Proponent proves that it is capable of meeting the outcomes required in the east and south. The Proponent can demonstrate this capacity in a number of ways, including one or more of:

- showing impacts and consequences for the current proposal are less than those currently predicted and will not exceed the specified outcomes of the Approval;
- altering the proposal to avoid or mitigate any potential exceedances;
- altering technology to limit the impacts and/or consequences;
- improving remediation techniques.

The Panel also notes that, provided the performance criteria set out as outcomes and are rigorous, the longwall panel width is irrelevant. It is the Proponent who must ensure the outcome is met by whatever mining approaches it employs.

The Panel is clearly of the view that the level of impacts proposed in the BSO Project Proposal for some significant natural features are no longer acceptable practice. A simple example will suffice to make the point. In 2002 the then Department of Mineral Resources granted approval to undermine Waratah Rivulet (Woronoa Catchment) <u>knowing</u> the level of damage that would occur. This position was maintained in 2005 despite substantial and obvious damage to this key element of Southern Sydney's water supply. However, by 2007 this was seriously under challenge and in 2009 determined to be not acceptable in the Approval issued for the Metropolitan Coal Project by the then Minister for Planning.

The Panel's assessment is that there are more than 50km of streams in the Study Area with similar stream characteristics to Waratah Rivulet including being 3rd order and above. This 50km excludes the Nepean River and some large first and second order streams (e.g. Woronora River). Some of these are protected by the Proponent in the Base Case mine layout. But others are proposed to be subjected to the same (or worse) subsidence impacts as occurred at Waratah Rivulet. This is despite their being indistinguishable in character from those afforded protection in the Base Case mine layout. The Panel is of the view that it is no longer a viable proposition for mining to cause more than negligible damage to pristine or near-pristine waterways in drinking water catchments or where these waterways are elements of significant conservation areas or significant river systems. As noted in the Metropolitan PAC Report,[601] this level of damage would not be acceptable in any other assessment of water resource use.

The Panel also concludes that there is a problem with allowing the Proponent to assess what is of 'special significance' and what is not. Because attribution of special significance to an item or feature carries with it a requirement for a much higher level of scrutiny and consideration of protection, it is clearly a potentially significant problem for the Proponent since it may require changes to the mining proposal.

The Panel in the Metropolitan PAC Report noted that there was an element of subjectivity in the allocation of special significance status. The point was not lost on the Proponent in this case, who repeated it multiple times in the EA and in responses to submissions and questions. The Proponent's subjective view yielded <u>one</u> (<u>possible</u>) item of special significance in the whole 220 km^2 of the Study Area – the Nepean River. None of the other 46 streams classed as 3rd order and above, none of the 226 upland swamps, none of the 634 cliffs (including Appin Falls) and none of the 632 Aboriginal Heritage Sites in the Study Area succeeded in crossing the Proponent's threshold.

This was in stark contrast to the submissions by government agencies, special interest groups and the public, which identified many such items, usually supported by credible evidence.

The Panel's conclusion is that the Proponent's assessment of 'special significance' is not credible and cannot be relied upon. The Panel's assessments for individual items and classes of features are contained within the relevant Chapters of this report.

Undoubtedly there will be claims that the Panel's recommendations will either jeopardise the Project as a whole or substantially reduce its life and/or profitability.

The Panel's recommendations clearly do not do the first of these: the Project Proposal would be relatively intact in the western and northern areas. As for the eastern and southern areas, the recommendations will only affect the mining proposal to the extent that the mining company is precluded from causing unacceptable damage to significant natural features and some built infrastructure (dams, tunnels, etc). Mining is not prohibited: unacceptable outcomes are prohibited.

The Panel has not had access to commercial-in-confidence information that would allow a detailed assessment of the impact of its recommendation on the financial profitability of the mining operation. It has however attempted to gain an appreciation of the impact of its recommendations on the overall well being of society given the relativities of the benefits and costs involved. The analysis reported in Chapter 17 shows that the benefits of protecting significant natural features in the eastern and

[601] DoP (2009a), p.58

southern areas are likely to be of a similar magnitude to the mining profits that would have to be given up to ensure that protection. So while protection of the significant natural features would involve lower mine profitability, it is likely that society as a whole would gain more from the environmental protection recommended than it would lose in terms of foregone profits.

18.2. CONCLUSIONS AND RECOMMENDATIONS FOR EACH CHAPTER

Some of the recommendations appearing in this section were not formed as formal recommendations in the originating Chapter. Some also have minor wording changes in the interests of consistency. However, the Recommendations in 18.2 are the agreed formal recommendations of the Panel.

18.2.1. Chapter 3 Contextual Matters

Very little information was provided in the EA on the main development workings although these at times are located in areas outside the proposed Extent of Longwall Mining and also located under significant natural features or built infrastructure that the EA indicated were to be subject to minimal or no impact.

The Panel therefore makes the following recommendations:

1. That the outline of the Study Area should constitute the limit of main development workings permitted under any Approval that may flow from this assessment.

2. That main development roadways are the only form of mining that should be permitted within the 600 m zone between the Extent of Longwall Mining and the boundary of the Study Area.

3. That longwall mining and main development roadways are the only forms of mining that should be permitted with the Extent of Longwall Mining under any Approval flowing from this assessment.

4. That the design of all main development roadways within the Study Area should be approved through the Extraction Plan process prior to commencement of such development.

18.2.2. Chapter 4 Subsidence Impacts and Consequences

There is a substantial review of subsidence and subsidence impacts in the context of the Southern Coalfield in this Chapter and a detailed critique of the methodology used in the EA. It is clear that future proposals will need to consider carefully how they approach this issue to avoid the information deficiencies identified with the current proposal.

For water-related systems where subsidence may be an issue, the Panel recommends that the studies outlined in recommendations 5-10 below are completed prior to the consideration of the Extraction Plan. The purpose of these studies is to improve the predictability of impacts so that the approving authority can be confident that any impacts resulting from the proposed Extraction Plan will remain within the

Performance Criteria established in the Approval. For example, if 'negligible impact' on hydrology is designated at the site of a natural feature then the studies will assist in confirming whether the proposed extraction will or will not achieve a 'negligible impact' standard. The recommended studies are:

5. That exploration drilling and core testing be undertaken to establish the mechanical and hydraulic properties of rock strata in proximity to water-dependent systems including swamp systems (Detailed inspections to ascertain lithofacies parameters will promote a more complete understanding of potential failure modes and horizons in the sub strata);

6. That mineralogical assessments of core be undertaken to ascertain presence and distribution of iron bearing minerals that might contribute to water quality impairment if surface water flows are redirected;

7. That sediment profiling in swamp systems be undertaken to characterise type, thickness and sensitivity to differential subsidence;

8. That installation of a regional network of shallow piezometers targeting water dependent systems (especially swamp systems) and underlying rock strata (to at least 30m depth) be undertaken to inform an understanding of the hydrology and climatic implications;

9. That establishment of a network of deep pore pressure monitoring bores be undertaken to assess/quantify the impacts of fracturing within the subsidence zone. The Panel considers it is especially important to target areas where extracted panel widths are similar to the proposed Base Case widths (310m) in order to validate the prediction process;

10. That numerical modelling be utilised to enhance the prediction of subsidence zone fracture distributions, connectivity and potential fracture conduit (groundwater) transmission capacities.

In relation to the technique utilized by MSEC to predict the conventional component of subsidence, the Panel noted that variations in the site conditions across the Study Area may mean that recalibration of the technique is needed as a precursor to preparing Extraction Plans for specific longwalls or groups of longwalls over the course of the project. The Panel therefore recommends:

11. That, as the BSO Study Area is very large and site conditions (such as geology) could vary across the Study Area, the IPM technique be recalibrated periodically as a precursor to preparing Extraction Plans over the course of the project.

The potential for increased subsidence impacts from increased longwall panel width foreshadowed in the Project Application is of significant concern to the Panel. It has not been possible to assess these potentially increased impacts on the information provided. The Panel therefore recommends:

12. That, in any Approval, Performance Criteria designed to protect either significant natural features or items of built infrastructure must be framed such that they are insensitive to any changes in the Base Case mine layout.

Remediation is a frequently proposed strategy in the EA for managing risks of subsidence induced impacts and consequences for significant natural features and built infrastructure. For significant natural features that are water-dependent, the Panel made a number of specific findings and conclusions . These can be summarized as demonstrating that remediation cannot be considered at this time to be an alternative to prevention where the functionality of water-dependent natural features is an objective. At best, remediation is a strategy that may have limited application to a limited range of natural features (i.e. some rock bars), either where Performance Criteria have been exceeded and some attempt to repair is feasible in addition to application of appropriate sanctions, or where the Performance Criteria have not been drafted to allow for some impacts and remediation attempts may be a way of restoring some level of functionality.

Accordingly, the Panel recommends:

13. That at this time neither Approval conditions nor Extraction Plans should rely on remediation as a means of maintaining (or restoring) functionality of water-dependent natural features that are potentially exposed to subsidence-related impacts; and

14. That research should continue to explore remediation techniques with a view to improving their effectiveness, expanding the range of impacts and features to which they may be applied, demonstrating their longevity, and minimising collateral impacts.

18.2.3. Chapter 5 Groundwater Impacts and Consequences

The Panel and submitters identified numerous issues with both the groundwater model presented in the EA and with the amount of site specific data supporting the model and other conclusions concerning potential impacts on groundwater.

Given these numerous issues and identified problems with respect to groundwater assessments, and the identified abnormalities in the groundwater model, the Panel indicated to ICHPL that the reported studies were considered to be inadequate for assessment purposes. The characteristics and impacts of strata depressurisation, impacts of that depressurisation on shallower groundwater systems and on surface drainages and swamps could not be sensibly assessed from the information provided.

As a result the Proponent conducted additional work and presented a revised model. However, substantial questions remained and the Panel concluded that additional studies would be required to ensure that mining proposals contained in Extraction Plans would be able to meet recommended Performance Criteria in an Approval. The following studies are therefore recommended in relation to deep groundwater systems:

15. That further core sampling and hydraulic properties testing (of the core) should be undertaken to validate assumptions with respect to regional continuity of those properties, particularly in the North Cliff area where no hydraulic properties testing has been conducted;

16. That a network of pore pressure monitoring bores and vertical arrays of pore pressure transducers be established to assess/quantify the height of connected and freely drainable fracturing as recommended in Chapter 4. Installations should be targeted above extracted panels with similar dimensions to the proposed Base Case mine layout;

17. That a borehole census should be conducted on all potentially yield (or structurally) affected boreholes, and a long term monitoring program initiated. The census should catalogue bore location, construction parameters, pumping equipment and usage together with any other parameters considered necessary in the event of water supply replacement. Monitoring should include depth to standing water, basic water quality parameters (pH and EC), ionic speciation and any other parameters necessary to characterise the location to the satisfaction of the Director-General of the Department of Planning. Monitoring data should be regularly reviewed and trends in water levels and water qualities assessed using appropriate methodologies to establish the likelihood of sustained long term impacts on yield. The commitment to repair, replace or compensate any landholder suffering partial or complete loss of productive yield must include provision for post mining conditions.

18. That in view of the numerous abnormalities identified in (EA) modelling outcomes, and the marked changes in outcomes reported for the revised groundwater model, a comprehensive independent audit of the revised groundwater model should be undertaken.

In relation to shallow groundwater systems the Panel noted the hydrology of swamps to be especially vulnerable in view of their thin plate-like structure (o.5 to 2.0 m sediment thickness) extending typically over areas of 1 ha or more. Any subsidence induced changes of this magnitude would clearly have the potential to impact upon the hydrology of swamps as would any diversion or loss of water via subsidence induced cracking in the sub-strata. Diversion of flows may in turn have implication for downstream water quality in a similar manner to that observed for surface streams.

For streams the most important issues were drainage of rock pools, diversion and loss of flows over significant sections of streams, iron staining and deterioration in water quality. Both swamps and streams are dealt with at length in Chapters 6 and 7 respectively.

18.2.4. Chapter 6 Swamp Impacts and Consequences

The risks to upland swamps in the Study Area from mining-induced subsidence impacts are a major concern. Swamps are critical components of the catchment hydrology and are major habitats for a wide range of flora and fauna including EECs and threatened species. While there is still some scientific uncertainty about the exact relationship between subsidence effect, subsidence impact and negative environmental consequences for upland swamps, the clear conclusion of the Panel is that if mine subsidence has the potential to impact on near surface formations to an extent that could cause changes in the hydrology of a swamp, then the swamp is at risk of serious negative environmental consequences in whole or in part.

The Panel also carefully considered the applicability of its findings on risks to upland swamps in the Metropolitan Project Study Area to the BSO Project Area and concluded that extrapolation of conclusions from the Metropolitan PAC Report to assessment of the BSO Project Proposal is only valid where robust information exists to demonstrate that the characteristics of the two areas are sufficiently comparable to make such extrapolation appropriate. The Panel is of the view that the differences in the mine parameters and key characteristics affecting subsidence impacts make extrapolation of conclusions related to subsidence impacts unsound.

The Panel concluded that the mining parameters in the BSO Study Area indicate a much higher level of risk for upland swamps generally than was evident in the Metropolitan Project Review and that, since the Metropolitan Project Report was published, information has been emerging to suggest that a number of upland swamps in the Southern Coalfield are being impacted by subsidence-induced changes to hydrology.

The Proponent's risk assessment for subsidence impacts on upland swamps was considered to be inadequate. The detailed reasons are set out in the Chapter. The key findings are that there are a substantial number of swamps that should be classified as swamps of 'special significance' (possibly extending to all swamps in the eastern and southern parts of the North Cliff and Appin Area 2), that the restrictive criteria used by ICHPL for classification of swamps at risk of significant negative environmental consequences is flawed, and that a much higher number of swamps than is estimated in the EA are likely to be at risk of both negative environmental consequences and significant negative environmental consequences.

The proposals in the EA for managing risk to swamps are not considered acceptable by the Panel. Avoidance of impact is ruled out, as are mitigation measures - even for swamps the EA identifies as being at risk of significant negative environmental consequences. The management measures proposed are unproven and, even if they could be successfully implemented, only cover a very narrow spectrum of the potential hydrologic impacts to swamps. The proposed offsets are meaningless in terms of negative environmental consequences for swamps.

There are no protection measures proposed to prevent damage to upland swamps from subsidence-related impacts and ICHPL is seeking approval to undermine all upland swamps in the Study Area. The Part 3A Approval would effectively 'turn off' the NSW statutory protections for both EECs and threatened species, but the basic survey work to assess either presence or viability of any threatened species in the Study Area swamps has not been done. The Panel has described the work undertaken by ICHPL on fauna survey as manifestly inadequate. The Panel is of the view that this issue is of critical importance and that resolution cannot be deferred to a subsequent process. The Panel also concluded that the Precautionary Principle would appear to be squarely applicable to the proposed undermining of upland swamps in the BSO Study Area.

The predictions for subsidence-related impacts are based on 310m wide longwall panels. If longwall panel widths increase there is a substantial, but unquantified, risk of increase in the number of swamps likely to suffer negative environmental consequences and for these consequences to become much more significant. ICHPL has declined to provide the basic information required for the Panel to consider the magnitude of the increased risk and, combined with the pre-existing lack of adequate data on the characteristics of individual swamps, the Panel considers that the risks must be categorised as unacceptable unless the swamps are protected by a nil or negligible impact requirement.

The Panel is also of the view that the Choice Modelling has not been used appropriately for assessing the value the community would place on upland swamps in the Study Area.

The Panel's recommendations in relation to protection of upland swamps from mining – induced subsidence risks are set out below.

19. That one of the following three options be implemented in relation to protection of upland swamps in the Study Area:

(i) Mining not be approved for the area marked A on Figure 26;

(ii) Upland swamps in the area marked A on Figure 26 be protected by requiring as part of any Approval, a performance criterion of negligible subsidence-related impact. This means that:

- before mining can occur under or adjacent to an upland swamp in Area A:

(a) a Swamp Risk Management Plan (SRMP) must be developed as part of the Extraction Plan. This SRMP must demonstrate to the satisfaction of the Director-General of Planning that, for the proposed mining arrangement, subsidence predictions for conventional and non-conventional subsidence are within limits that will ensure the hydrology of the swamp will not be affected such that there is no potential for change in the size or functioning of the swamp, including potential changes in species composition or distribution within the swamp. This means that water will not drain from the swamp or part of the swamp as a result of any mining-induced subsidence, nor will water be re-distributed within a swamp or part of a swamp as a result of any mining-induced subsidence to an extent where such potential changes could occur;

(b) a monitoring program is designed and implemented that will provide both a platform for understanding the hydrology of swamps and advanced warning of any potential exceedances of the subsidence predictions, detect any actual exceedances of subsidence predictions and detect any impacts on the hydrology of the swamp and underlying hard rock strata. Especially important is the need to characterise the relationship between swamps and their role in recharging the regional groundwater systems; and

(c) an adaptive management plan is in place that meets the tests laid down in *Stoneco*[602] and is linked to the monitoring program in such a way that early detection will enable the mining operations to be adjusted so that the subsidence predictions are not exceeded and subsidence impacts creating a risk of negative environmental consequences do not occur.

The proposed performance criteria should be backed by sanctions sufficient to deter non-compliance.

<u>- before mining can occur under or adjacent to any upland swamp in other areas:</u>

(d) a comprehensive description of their characteristics is compiled including adequate information on EECs and threatened species (to standards set by DECCW);

(e) a rigorous assessment (to the satisfaction of DECCW) has been conducted as to whether the swamp contains an EEC or contains or is part of the habitat of a significant population of threatened species, or is of special significance for some other reason. If found to be of special significance the swamp is to be protected by the same negligible impact criteria, monitoring requirements and adaptive management requirements as swamps in Area A;

(f) for swamps not meeting the significance levels in (b) an Upland Swamp Risk Management Plan has been approved by the Director-General of Planning with such plan to include *inter alia* an assessment of the subsidence-related risks, a monitoring plan, a mitigation strategy if required and, as a last resort, remediation strategies where avoidance or mitigation of impacts are not feasible; and

(g) an offset strategy has been developed that has been agreed with DECCW for circumstances where significant negative environmental consequences occur in upland swamps.

(iii) Mining be approved in the area marked A on Figure 26, but with a negligible impact requirement for the swamps listed below plus any other swamps in Area A found to contain EECs or threatened species after comprehensive survey and which are considered by DECCW[603] to meet the test of special significance based on the conservation significance of those findings either alone or in combination with other values. The swamps identified currently are:

CRE-S6b, CRE-S7a, CRE-S8 (plus CRE-S7b)
CT1-S4, CT1-S5, CT1-S6

[602] *Newcastle and Hunter Valley Speleological Society Inc v. Upper Hunter Shire Council and Stoneco Pty Limited* [2010] NSW LEC 48 (*Stoneco*).

[603] The Panel is of the view that the work by ICHPL to date on this issue does not provide a sufficient level of confidence that swamps of special significance would be identified correctly if ICHPL alone is responsible for the recommended work. The Panel considers that in this instance the conservation authority should act as 'certifier'.

CT2-S2, CT2-S6
DAC-S7b, DAC-S9
FOG-S1
HSC-S1
ILC-S3, ILC-S4a, ILC-S5e (plus ILC-S4e)
OHC-S4, OHC-S15, OHC-S17
OHT-S6a
STC-S12, STC-S13, STC-S17, STC-S18, STC-19a, STC-S24, STC-S26, STC-S28a, STC-S28b
UNT-S1
WOR-S4, WOR-S5a, WOR-S56 (plus WOR-S5c)

Any swamps of special significance should have the same monitoring requirements and adaptive management requirements as those specified in (i) (b) and (i) (c) above.

For any upland swamp in Area A that does not meet the Special Significance test, the requirements in (d), (f) and (g) of (ii) above should apply, and for all upland swamps outside Area A, the requirements in (d), (e), (f) and (g) of (ii) above should apply.

The differences between (ii) and (iii) are probably relatively small in terms of impact on the mining operation, but (ii) would be much simpler to administer.

18.2.5. Chapter 7 Surface Water and Aquatic Ecology

Risks posed to surface water and aquatic ecology by mining –induced subsidence were major issues for government agencies, special interest groups, members of the public and this Panel. Streams and Rivers within the Study Area are a critical part of the Sydney drinking water catchment, a source of water for irrigation and other extractive uses. A major ecological resource, and a major recreational resource. Many of the streams in the eastern part of the Study Area are pristine or near-pristine condition making them an exceptionally rare aggregation in NSW.

The Panel’s conclusions in relation to surface waters cover a wide spectrum of issues, including that stream values depend on the recognition of the stream system as a continuum with the value of any segment heavily dependent on upstream and downstream conditions and in higher and lower order components of the system. Pools behind rockbars may be visually dominant features, but other stream morphologies including boulder fields and pools behind other channel constrictions are also vital components of the linear system.

In the remote areas of sandstone gorges to the east and south of the Study Area, the Panel finds that the value of the stream network is closely associated with its natural characteristics and its pristine setting. The Panel finds that in these zones even small impacts can have major consequences for naturalness values and may be irreversible. Stream condition is also heavily influenced by geology and catchment land use. The Panel finds that a classification of streams based on underlying geology is a useful basis for differentiating the magnitude, density and extent of consequences.

The catalogue of data presented in Appendix P of the EA and in the accompanying GIS provides an excellent database. However these data are not used in the EA to describe the range of stream values or the relative significance of changes in those values following mining. The EA presents no holistic assessment of the risks to stream values or justification for the selection of streams for proposed management measures.

The exclusion of first and second order streams from consideration of consequences ignores the vital role that these streams play in the interconnectivity of the system. In particular they are important in protecting the continuity of flow and the quality of water conveyed between the upland swamps and the larger streams. Loss of surface flow to sub surface fracture networks can also result in dry periods for otherwise perennial streams and increased periods of zero flow in intermittent streams. The Panel finds that the likely magnitude of this impact would exceed standards generally accepted for allowable impacts on the flow regime in assessment of water resources development projects.

The frequent occurrence of iron staining and the spatial relationship to historical mining leads the Panel to conclude that iron staining and impaired water quality are inevitable outcomes of the proposed mine plan. The Panel also concludes that the remediation strategies proposed in the EA should not be relied on as a primary measure to protect stream related values.

The Panel's recommendations in relation to surface waters are:

20 That the following streams be afforded 'special significance status' throughout their length within the Project Area:

- Nepean River
- Cataract River (dam to Broughtons Pass Weir)
- O'Hares Creek
- Stokes Creek
- Dahlia Creek
- Cobbong Creek
- Tributaries 1 & 2 to O'Hares Creek
- Woronora River and tributaries
- Wallandoola Creek
- Wallandoola East Creek
- Cataract Reservoir Tributaries 1 & 2

21 That all streams afforded special significance status plus Lizard and Cascade Creeks and the Georges River in West Cliff Area 5 be protected by requiring, as part of any Approval, a performance criterion of negligible subsidence-related impact as defined below ie:

> *'no diversion of flows, no change in the natural drainage behaviour of pools, minimal iron staining, minimal gas releases and continued maintenance of water quality at its pre-mining standard'*.

22 That mining be permitted under the remaining streams listed in the EA subject to the stream impact minimization criteria and the management measures proposed in the EA.

For aquatic ecology the principal concerns relate to inadequate survey effort overall and for threatened species in particular. The Panel found that the level of information and assessment provided was not sufficient for the Panel to conclude that either the government agencies or the public had been given the opportunity to consider the fully disclosed risks of the Project Proposal.

However, the Panel was of the view that this deficiency would be less significant if the Panel's recommendations in relation to protection of streams and swamps were adopted. The Panel therefore recommends as follows:

23 That if the Panel's recommendations in relation to providing adequate protection for streams and swamps are not adopted then an adequate survey for threatened species that may occur in the Study Area or surrounds be conducted to standards agreed between DECCW and DII (Fisheries) before any mining is permitted under streams or swamps in the Study Area.

18.2.6. Chapter 8 Terrestrial Ecology

This Chapter dealt with flora and fauna issues for the Study area generally, with the exception of swamps and the Stage 4 Coal Washery Emplacement which were dealt with in Chapters 6 and 13 respectively.

The principal issues related to survey intensity, but there was also a substantial debate between the Proponent and DECCW about EEC classification that is yet to be resolved.

The Panel's conclusions in relation to flora are that the survey design has not addressed the need to sample high conservation value habitats at an appropriate intensity. The survey work for threatened species is also inadequate to support an assessment of risk from potential subsidence-related impacts of mining in the BSO Study Area based on 310m longwall panel widths and the Base Case mine layout. There is no site-specific information on the two-thirds of the threatened species known from the area that were not found in the BSO surveys.

The possibility of increased longwall panel width has not been factored into the assessment of possible subsidence-related impacts on particular species or associations, particularly threatened species and EECs.

The Panel recommends:

24 That where the depth of cover is 400m or less, or where valley closure predictions exceed 200mm, comprehensive flora surveys should be conducted to specifications provided by DECCW with a view to identifying EECs or threatened species and, where these are found, assessing population viability and risk from subsidence-related impacts of mining. If significant EECs or populations of threatened species are found, measures to protect those EECs

and/or threatened species should be developed prior to any mining commencing. If longwall panel widths increase the depth of cover criterion should be reviewed.

The Panel's conclusions in relation to fauna are that the survey intensity is inadequate for the purposes of assessment of risk to fauna in the Project Area generally and manifestly inadequate in relation to fauna that utilise swamp habitats.

It is clear that the eastern and southern parts of North Cliff and Appin Area 2 contain a high concentration of threatened fauna species and that a comprehensive survey would probably yield an even higher number of species. The survey work to date does not allow any assessment of the size of the populations of threatened species or their viability.

In broad terms, most threatened fauna species would be protected by a requirement for nil or negligible impact for swamps and streams in an area since this would ensure protection of other important habitats such as cliff lines and overhangs. The Panel has suggested such an approach in Chapter 17.

The Panel's recommendations in relation fauna are:

25 That, given the lack of survey effort (i.e. zero) in the whole of the northern part of North Cliff, comprehensive surveys should be conducted in that area (and also the unsurveyed area in the northern part of the eastern part of North Cliff) to determine whether threatened species are present and, if so, what actions might need to be taken to protect any significant populations should mining be allowed to occur in these areas. Survey design and execution should be supervised by DECCW to ensure that the required standard is achieved and the surveys and required management plans should be required well in advance of any proposed mining. In relation to management plans, the full suite of avoidance, mitigation and management approaches should be considered and, if adaptive management is an option, it should meet the test laid out in *Stoneco.*[604]

26 That in relation to Appin Area 3, the same approach needs to be adopted as for the northern part of North Cliff. The survey work in Appin Area 3 was inadequate and the Panel is far from satisfied that further threatened species do not occur in this area.

27 That for the western domains (Appin Areas 7, 8 and 9 and West Cliff) further targeted surveys for threatened species should be undertaken based on advice from DECCW. These surveys are designed to locate threatened species and provide sufficient information to allow assessment of any actions required to protect significant populations of threatened species from the potential impacts of the mining proposal. If mining is to occur in these western domains the Approval conditions will need to be sufficiently robust to ensure that the surveys and assessments are done to DECCW standards and that before

[604] *Newcastle and Hunter Valley Speleological Society Inc v. Upper Hunter Shire Council and Stoneco Pty Limited* [2010] NSW LEC 48

mining proceeds the necessary management actions are in place to protect any significant populations of threatened species from mining impacts.

18.2.7. Chapter 9 Cliffs and Steep Slopes

There is a substantial number of significant cliffs in the Study Area as well as several major waterfalls. Steep slopes are generally confined to the Western parts of the Study Area and include the Razorback Range. There are substantial risks to cliffs and steep slopes from subsidence-induced impacts.

The Panel's conclusions in relation to cliffs are that: The definition of a cliff is reasonable for the purposes and scale of the EA, except for cliffs located within watercourses. Cliffs that function as waterfalls have additional attributes that increase their value. The impacts reported in the EA for cliffs both outside and inside of the footprint of longwall panels may have been significantly underestimated for cliffs that constitute waterfalls.

Although curvatures and strains have been presented in the EA, these are of only limited value because the EA does not directly relate these values to predicted impacts and consequences. Conclusions drawn from the case studies of subsidence impacts presented in the EA may also have underestimated impacts associated with the wider longwall faces and shallower depths of mining proposed in the EA.

The EA presents an inadequate discussion of potential impacts of longwall mining on cliffs located above goaves which, for the Base Plan mine layout, are confined to Area 3 and Area 8.

The proposed longwall layout is amenable to increasing the width of the buffer zone between Cascade Creek and the longwall panels, hence reducing both closure along Cascade Creek and exposure of one Aboriginal heritage site of high significance (52-2-1282) to subsidence impacts.

There is an increased potential for cliff instability, including cliff falls, along Wallandoola Creek. The total length of cliff line that could be impacted may be considerably greater than the predicted 3 to 5% and include cliff falls, as opposed to rock falls. The consequences of these impacts may be higher than conveyed by the figure of 3 to 5% if cliff instability is concentrated in particular segments, such as at bends in the valley. There is insufficient site specific information in the EA relating to matters such as cliff height, cliff length, overhangs and associations with Aboriginal heritage for the Panel to be able to assess the physical, cultural and environmental attributes of cliffs along Wallandoola Creek and the likely consequences of instabilities on these attributes.

The Major Cliff Line Risk Assessment (Appendix R) contains a range of useful information for undertaking risk assessment. Nevertheless, Appendix R does not constitute an adequate risk assessment of mine subsidence implications for cliffs in the Study Area.

There are a number of cliffs which warrant consideration as being of *special significance*, including:

vii. The 14 cliffs in the Study Area that are longer than 200 m and/or 40 m or more in height.

viii. Appin Falls.

ix. The waterfall on Lizard Creek associated with cliffs A3_0530 and A3_0540.

The Panel's recommendations in relation to cliffs are:

28 That a hierarchy of mining-induced consequences on cliffs be established as follows:

i. *nil* environmental consequences – where nil has the meaning of *none whatsoever*.

ii. *negligible* environmental consequences - where *negligible* has the meaning ascribed in the Metropolitan Coal Project Approval of *small and unimportant so as not to be worth considering*[605]. Occasional displacement of boulders, hairline fracturing and isolated dislodgement of slabs from overhangs that in total do not impact on more than 0.5% of the total length of a cliffline are indicative of the scale of impacts falling within this category.

iii. *minor* environmental consequences – where *minor* has the meaning of relatively *small in quantity, size and degree*. Isolated rock falls of less than 30 m^3 that do not impact on aboriginal heritage, EECs, public safety and the like; which affect less than 5% of the total length of cliffs and associated overhangs; and which affect less than 10% of any 100 m interval of cliff line are indicative of the scale of impacts falling within this category.

29 That cliffs in the Study Area having the following attributes be afforded *special significance* status:

i. Cliffs longer than 200 m.

ii. Cliffs higher than 40 m.

iii. Cliffs higher than 5 m that constitute waterfalls.

30 That any approval be based on a Performance Criteria of *negligible* environmental consequences for all cliffs which have:

i. Special significance status, or which

ii. Flank or are within streams that have been described in this report as warranting special significance status.

[605] DoP (2009b), p.1.

31 That any approval be based on a Performance Criteria of *minor* environmental consequences for all other cliffs in the Study Area.

32 That any Approval be based on Performance Criteria that include a requirement that no additional risk be created for the public from mining-induced cliff instability. Therefore, no Extraction Plan should be approved that could create any additional risk from cliff instability to the public, including users of Douglas Park Drive, until all potential sources of the increased risk have been investigated to the satisfaction of the Director-General of the Department of Planning and the proposals in the Extraction Plan for avoidance, mitigation or management of any such risks ensure that users of Douglas Park Drive are not exposed to additional danger.

33 That the Major Cliff Line Risk Assessment (Appendix R of the EA) should not be relied upon in the environmental assessment process.

The Panel's conclusions in relation to steep slopes are that the assessment of stability of slopes on the sides of valleys is considered reasonable in light of experience in these environments in the Southern Coalfield, but the assessment of stability of slopes on the sides of ridges has not been founded on geotechnical engineering principles and is inadequate.

The Panel's recommendations in relation to steep slopes are:

34 That the Performance Criteria in any Project Approval should include a requirement that, where any slopes are present that might be impacted by a proposed mining layout: all infrastructure not owned by the leaseholder remains in a safe, serviceable or repairable condition unless otherwise agreed by the infrastructure owner; no significant environmental harm is caused and risks to public safety are not increased.

35 That, where any slopes are present that might be impacted by a proposed mining layout, no Extraction Plan should be approved until:

i. any risks associated with increased instability have been assessed to the satisfaction of the Director-General of the Department of Planning by a geotechnical engineer who is a recognised specialist in land slippage and utilising methodologies consistent with the Australian Standards, and

ii. where such risks are present that the proposed avoidance, mitigation or management measures are capable of ensuring the Performance Criteria in the Approval are met.

18.2.8. Chapter 10 Aboriginal Heritage

- There are over 600 identified Aboriginal Cultural Heritage Sites in the Study Area. However, the Panel is not convinced that stakeholders fully appreciated that a Part 3A Approval would extinguish protection for Aboriginal heritage provided under other legislation, or that Aboriginal concerns regarding the Stage 4 Coal Wash Emplacement were adequately addressed.

- The Aboriginal Cultural Heritage Assessment has identified and documented Aboriginal heritage sites in a diligent manner, albeit that it is likely some sites have not been identified. While a valuable database of information has been complied on which to base risk assessment, the risk assessment of Aboriginal heritage sites does not conform with risk assessment standards, and the outcomes of the process are incomplete.

- The methodology proposed in the EA for assessing the propensity of an Aboriginal heritage site to subsidence-induced impacts is rudimentary and has a number of shortcomings.

- Aboriginal heritage sites in the vicinity of the Coal Wash Emplacement area should have been included in the risk assessment. Impacts on Aboriginal heritage associated with the Stage 4 Coal Wash Emplacement have not been adequately assessed in the EA.

- Aboriginal heritage sites 52-2-0854 and 52-2-3505 warrant classification as being of *special significance.*

The Panel's recommendations in relation to Aboriginal cultural heritage sites are:

36 That a hierarchy of mining-induced consequences on Aboriginal cultural heritage sites be established as follows:

   i. *nil* consequences – where nil has the meaning of *none whatsoever*.

   ii. *negligible* consequences - where *negligible* has the meaning ascribed in the Metropolitan Coal Project Approval of *small and unimportant so as not to be worth considering*. Hairline fracturing and isolated dislodgement of smalls pieces of ground surface or overhangs that in total do not affect more than 5% of an aboriginal site and do not affect at all the physical condition of any item of aboriginal heritage or any cultural value, are indicative of the scale of impacts falling within this category.

   iii. *minor* consequences – where *minor* has the meaning of relatively *small in quantity, size and degree.* Isolated open cracking and rock falls of less than 2 m^3 that do not affect the physical condition of any item of aboriginal heritage or any aboriginal cultural value, are indicative of the scale of impacts falling within this category.

37 That the following Aboriginal heritage sites be afforded *special significance* status:

   i. 52-2-0854

   ii. 52-2-3505

38 That any approval should be based on a Performance Criteria of *negligible* environmental consequences for all Aboriginal heritage sites which have *special significance* status.

39 The Stage 4 Coal Wash Emplacement should not proceed until such time as the continued protection of significant sites that were specifically protected as part of the Stage 3 Coal Wash Emplacement approval process is resolved to the satisfaction of the Director General of Planning after:

i. completion of an adequate Aboriginal Heritage assessment;

ii. consultation with Department of Climate Change and Water (DECCW);

iii. consultation with the relevant Aboriginal communities.

40 That before secondary extraction can commence under the Approval, the Director-General of the Department of Planning should:

i. commission work to determine an appropriate standard for protection of Aboriginal heritage sites that are not classified as being of special significance;

ii. include in that work appropriate research on how any such standards could be monitored and enforced; and

iii. ensure that the requirements are included in Extraction Plans.

41 That any Approval be based on the Aboriginal Cultural Heritage Plan be externally audited every three years for the duration of the project by a suitably qualified person appointed by the Department of Planning in consultation with the DECCW and relevant Aboriginal communities. The audit is to include a focus on:

i. The need to classify or reclassify any current or new sites as being of *special significance*, taking in consideration new and evolving knowledge of Aboriginal history and culture.

ii. Verification that the performance standards set.

18.2.9. Chapter 11 Built Environment

The built environment is a major issue for the BSO Project Proposal. It occupies over 60% of the main text of the subsidence assessment in the EA and a substantial part of this Report.

The public significance of some of the items of built infrastructure (eg rail lines, major highways, major water supply infrastructure, and electricity, gas and telecommunications supply infrastructure) mean that any potential for subsidence induced impacts must be treated with great care.

However the Panel acknowledges a history of experience in undermining built environment in NSW over a period of more than 150 years, and even longer experience in Britain and Europe. The Panel is also aware that there are precedents in NSW for undermining all the categories of infrastructure proposed to be undermined by the BSO Project whilst still maintaining the affected structures in a *safe*, *serviceable and repairable* condition. Many of these precedents exist in areas already undermined by Appin Colliery (now called Appin East), Tower Colliery (now called Appin West) and West Cliff Colliery. They include the Cataract Tunnel, the Upper Canal, Simpsons Creek Aqueduct, Appin Township, high pressure gas pipelines, and arterial roads. The key to success is a robust subsidence management system based on sound risk management principles.

The conclusions and recommendations for each category of built infrastructure are set out under the category headings (eg Main southern Railway, Hume Highway, etc). Note that unless specified otherwise, the conclusions and recommendations are based on assessment of the possible impacts arising from the Base Case mine layout. Much greater impacts may be associated with increased longwall panel width.

<u>Main Southern Railway</u>

The Panel's conclusions in relation to the Main Southern Railway are that it appears to be technically feasible to undermine the Main Southern Railway in the manner proposed without adversely affecting public safety and the serviceability of the rail system, but the risk associated with a subsidence induced mishap could be extremely high unless appropriate controls are in place.

Effective risk management will be highly dependent on the composition and competence of the Rail Technical Committee and the Risk Management structure within which the Committee operates.

The Panel recommends that Performance Criteria in any Project Approval should include the following requirements:

42 That mining is not to impact on the safe operation of the Main Southern Railway. (This condition is not intended to exclude the application of temporary controls such as speed restrictions in order to achieve this performance outcome.)

43 That mining is not to impact on the serviceability of the Main Southern Railway. (This condition is not intended to exclude the closure of one or both tracks to permit mitigation and remediation works to be undertaken to a planned schedule agreed with the owner of the infrastructure. However, it is intended to limit unplanned outages to durations of no more than several hours, unless contingency planning provides for longer outages with the agreement of the infrastructure owner.)

44 That the infrastructure owner has the *prima facie* right to determine what is *safe, serviceable and repairable* for their purposes, with any dispute with the leaseholder/mine operator being referred to a neutral arbiter selected by the Department of Planning and funded by the leaseholder/mine operator.

45 That the leaseholder/mine operator is to guarantee funding to undertake all risk assessment activities and all mitigation and remediate measures to return the Main Southern Railway to its pre-mining state as soon as practical after the completion of mining and to remediate any residual mining related impacts that may subsequently develop. This includes all the direct and indirect costs

of the infrastructure owner in participating in this risk management process. (Given the incremental nature of subsidence development, a number of remediation campaigns may be required).

46 That all activities related to undermining the Main Southern Railway are to be structured within a risk management framework that is consistent with *ISO 31000 Risk Management*.

47 That the risk management system for undermining the Main Southern Railway is to be:

i. Audited externally for compliance with ISO 31000 prior to lodgment of associated Extraction Plans, with the auditor/s to be selected by the Department of Planning in consultation with the infrastructure owner, and the audit report to accompany the Extraction Plan application.

ii. Audited externally for compliance with ISO 31000 on an annual basis for the duration that the plan is invoked, with the auditor/s to be selected by the Department of Planning in consultation with the infrastructure owner.

iii. Reviewed externally for effectiveness on an annual basis for the duration that the plan is invoked, with the reviewer to be selected by the Department of Planning in consultation with the infrastructure owner.

48 That no Extraction Plan should be approved that could create any additional risk to the public from undermining of the Main Southern Railway, until all potential sources of the increased risk have been investigated to the satisfaction of the Director-General of the Department of Planning and the proposals in the Extraction Plan for avoidance, mitigation or control of any such risks ensure that users of the Main Southern Railway are not exposed to additional danger.

Hume Highway

The Panel's conclusions in relation to the Hume Highway are that it may be feasible from a technical perspective to undermine the Hume Highway in the manner proposed without adversely affecting public safety and the serviceability of the highway. However there is an increased level of risk when mining in the vicinity of bridges associated with the Hume Highway. This because some of the bridges span deep gorges, some have not been designed to tolerate the predicted levels of subsidence, and a reduction in or total loss of serviceability of a bridge could have very serious consequences for community and the economy.

Effective risk management will be highly dependent on the composition and competence of the Technical Committee and the Risk Management structure in which the Committee operates. There is a need for a robust Extraction Plan process to manage subsidence impacts and for extreme caution when mining in the vicinity of critical infrastructure and infrastructure that might present a risk to public safety if it were to be impacted adversely.

The Panel recommends that Performance Criteria in any Project Approval should include the following requirements:

49 That mining is not to impact on the safe operation of the Hume Highway. (This condition is not intended to exclude the application of temporary controls such as speed restrictions in order to achieve this performance outcome.)

50 That Mining is not to impact of the serviceability of the Hume Highway. (This condition is not intended to exclude the closure of one of the dual carriageways from time to time to permit mitigation and remediation works to be undertaken. However, it is intended to exclude simultaneous closure of both carriageways for other than isolated periods restricted to several minutes duration. Alternative traffic flow arrangements, such as contra-flow, are to be in place prior to undermining any section of highway that may need to be closed for more than several minutes.)

51 That infrastructure owner has the *prima facie* right to determine what is *safe, serviceable and repairable* for their purposes, with any dispute with the leaseholder/mine operator being referred to a neutral arbiter selected by the Department of Planning and funded by the leaseholder/mine operator.

52 That the leaseholder/mine operator is to guarantee funding to undertake all risk assessment activities and all mitigation and remediate measures to return the Hume Highway to its pre-mining state as soon as practical after the completion of mining and to remediate any residual mining related impacts that may subsequently develop. This includes all the direct and indirect costs of the infrastructure owner in participating in this risk management process. (Given the incremental nature of subsidence development, a number of remediation campaigns may be required.)

53 That all activities related to undermining the Hume Highway are to be structured within a risk management framework that is consistent with *ISO 31000 Risk Management*.

54 That the risk management system for undermining the Hume Highway is to be:

i. Audited externally for compliance with ISO 31000 prior to lodgment of associated Extraction Plans, with the auditor/s to be selected by the Department of Planning in consultation with the infrastructure owner, and the audit report to accompany the Extraction Plan application.

ii. Audited externally for compliance with ISO 31000 on an annual basis for the duration that the plan is invoked, with the auditor/s to be selected by the Department of Planning in consultation with the infrastructure owner.

iii. Reviewed externally for effectiveness on an annual basis for the duration that the plan is invoked, with the reviewer to be selected by the Department of Planning in consultation with the infrastructure owner.

55 That no Extraction Plan should be approved that could create any additional risk to the public from undermining of the Hume Highway until all potential sources of the increased risk have been investigated to the satisfaction of the Director-General of the Department of Planning and the proposals in the Extraction Plan for avoidance, mitigation or control of any such risks ensure that users of the Hume Highway are not exposed to additional danger.

56 That, given the significance of the disruption if any of the main road thoroughfares, the effect of any approval under S.75V of the EP & A Act on the RTA's powers to exercise control over mining impacts on state roads under Section 138 of the Road Act 1993 will need to be addressed in the Approval Conditions.

<u>Roads</u>

There are major roads and bridges located directly above longwall panels in the Base Case mine layout. Apart from the roads themselves, there are numerous other structures associated with these roads such as culverts, embankments, cuttings etc. In addition to main roads and large buildings, there are numerous minor roads and local bridges that are the responsibility of local councils.

In relation to roads, the Panel concluded that most impacts on road surfaces would be minor and be able to be dealt with as part of normal road maintenance. However, monitoring and contingency plans would still be required. The Panel's main concern was whether the risks of subsidence impacts associated with steep slopes, such as Razorback Range, had been properly accounted for.

The Panel was satisfied that the range of initiatives in the EA for managing subsidence of local bridges and other local road infrastructure in conjunction with local councils was capable of controlling these potential impacts. However success is highly dependent on the rigor of the Extraction Plan and the associated risk management processes. The Panel is also conscious of the potential cost impost on rate-payers and the (limited) technical resources of local councils to assess mining plans and subsidence outcomes.

In relation to roads, the Panel recommends that Performance Criteria in any Project Approval should include the following requirements:

57 That mining is not to impact on the safe use of roads in the Study Area.

58 That mining is not to impact on the serviceability of roads in the Study Area. (This condition is not intended to exclude the application of temporary controls such as speed restrictions in order to achieve this performance outcome.)

59 That the leaseholder/mine operator is to guarantee funding to undertake all risk assessment activities and all mitigation and remediation measures to return roads to their pre-mining state as soon as practicable after the completion of mining and to remediate any residual mining related impacts that may subsequently develop. This includes all the direct and indirect costs of the

infrastructure owner in participating in this risk management process. (Given the incremental nature of subsidence development, a number of remediation campaigns may be required.)

60 That all activities related to undermining road networks are to be structured within a risk management framework that is consistent with *ISO 31000 Risk Management*.

61 That no Extraction Plan should be approved that could create any additional risk to the public from undermining of the roads within the Study Area until all potential sources of the increased risk have been investigated to the satisfaction of the Director-General of the Department of Planning and the proposals in the Extraction Plan for avoidance, mitigation or control of any such risks ensure that users of the roads are not exposed to additional danger.

<u>Fire Trails</u>
There are numerous fire trails in the Study Area, many of which fall under the control of the SCA.

The Panel recommends any Project Approval should include the following requirement for fire trials.

62 That no Extraction Plan should be approved that could create any additional risk to the users of fire trails from undermining of the roads within the Study Area until all potential sources of the increased risk have been investigated to the satisfaction of the Director-General of the Department of Planning and the proposals in the Extraction Plan for avoidance, mitigation or management of any such risks ensure that users of the fire trails are not exposed to additional danger.

<u>Sydney Catchment Authority (SCA) Infrastructure</u>
The SCA has a substantial amount of infrastructure of critical importance to Sydney's drinking water supplies located in, an immediately adjacent to, the BSO Project Study Area. Some major items of this infrastructure eg Cataract Dam, the Nepean Tunnel, the Upper Canal and Broughton's Pass Weir are heritage listed.

Cataract Tunnel
On the Base Case mine layout the Pan concludes that the potential impacts on this tunnel are not likely to make it either unsafe or unserviceable.

The Panel concludes that any Project Approval should require that the Extraction Plan includes provision for the Cataract Tunnel to be monitored on a periodic basis to confirm that mining activities in the Study Area are not impacting on the safe and serviceable state of the tunnel.

The Panel recommends that Performance Criteria in any Project Approval should include the following requirements for the Cataract Tunnel:

63 That future mining operations in the Study Area are not to impact on the safe and serviceable condition of the Cataract Tunnel. This condition is not intended to exclude planned outages of the tunnel for mitigation and remediation purposes or unplanned outages of a limited duration in order to

undertake mitigation or remedial works related to mine subsidence impacts in order to maintain the tunnel in a safe and serviceable state.

64 That infrastructure owner has the *prima facie* right to determine what is *safe, serviceable and repairable* for their purposes, with any dispute with the leaseholder/mine operator being referred to a neutral arbiter selected by the Department of Planning and funded by the leaseholder/mine operator.

65 That the leaseholder/mine operator is to guarantee funding to undertake all risk management activities and all mitigation and remediation activities associated with protecting the Cataract Tunnel from impacts due to mining operations in the Study Area so that it can be maintained in a safe and serviceable condition. This includes all the direct and indirect costs of the infrastructure owner in participating in this risk management process.

Nepean Tunnel

The EA provides no information on the physical state of the Nepean Tunnel. It reports that the predicted vertical displacement profile could result in parts of the tunnel becoming a siphon which could affect serviceability of the structure. Furthermore, curvatures and ground strains could also result in instabilities in the roof and walls resulting in spalling or rock falls.

The SCA and the Proponent are not in agreement about the potential impacts on this tunnel. The SCA has advised that the tunnel is relatively fragile and that effects of mining on the tunnel could include:

- Short term outages associated with monitoring, testing, maintenance and repairs.
- Outages lasting from one week to one month in duration associated with major failure of the tunnel requiring significant repair or to implement preventative or remedial works.
- Catastrophic failure of the Nepean Tunnel. This would render Avon, Nepean and Cordeaux dams isolated from the supply with significant impact on the capacity of the system to supply Sydney Region.

The panel is of the view that the risk should be able to be controlled and quantified by a similar management process to that adopted for previous undermining of the Upper Canal and Simpson's Creek Aqueducts.

The Panel recommends that Performance Criteria in any Project Approval should include the following requirements for the Nepean Tunnel:

66. That the Nepean Tunnel is to remain in a safe and serviceable condition if undermined. This condition is not intended to exclude planned outages of the tunnel for mitigation and remediation purposes or unplanned outages of a limited duration in order to undertake additional mitigation or remedial works.

67. That the infrastructure owner has the *prima facie* right to determine what is *safe, serviceable and repairable* for their purposes, with any dispute with the

leaseholder/mine operator being referred to a neutral arbiter selected by the Department of Planning and funded by the leaseholder/mine operator.

68. That the leaseholder/mine operator is to guarantee funding to undertake all risk management activities and all mitigation and remediation activities associated with maintaining the Nepean Tunnel in a safe and serviceable condition if it is undermined and to remediate any residual mining related impacts that may subsequently develop. This includes all the direct and indirect costs of the infrastructure owner in participating in this risk management process. (Given the incremental nature of subsidence development, a number of remediation campaigns may be required.)

69. That all activities related to undermining the Nepean Tunnel are to be structured within a risk management framework that is consistent with *ISO 31000 Risk Management*.

70. That the risk management system for undermining the Nepean Tunnel is to be:

    i. Audited externally for compliance with ISO 31000 prior to lodgment of associated Extraction Plans, with the auditor/s to be selected by the Department of Planning in consultation with the infrastructure owner, and the audit report to accompany the Extraction Plan application.

    ii. Audited externally for compliance with ISO 31000 on an annual basis for the duration that the plan is invoked, with the auditor/s to be selected by the Department of Planning in consultation with the infrastructure owner.

    iii. Reviewed externally for effectiveness on an annual basis for the duration that the plan is invoked, with the reviewer to be selected by the Department of Planning in consultation with the infrastructure owner.

71 That no Extraction Plan should be approved that could create any additional risk to the State's water supply system from undermining of the Nepean Tunnel until all potential sources of the increased risk have been investigated to the satisfaction of the Director-General of the Department of Planning and the proposals in the Extraction Plan for avoidance, mitigation or control of any such risks ensure that the functionality of the State's water supply system is not put in jeopardy.

Upper Canal – Excluding the Cataract and Nepean Tunnels
The canal is constructed from sandstone blocks and it is possible that subsidence induced ground movements could result in spalling or fracturing of the blocks or collapse of the walls. If fracturing were of sufficient magnitude, it could result in increased leakage from the canal or collapse of the canal walls.

The SCA has advised that it is not satisfied that the Project's likely overall impacts on the open section of the Upper Canal above and adjacent to longwalls 720 to 724 would be "negligible" and that it would remain "safe and serviceable".

The Panel recommends that Performance Criteria in any Project Approval should include the following requirements:

72 That the Upper Canal System is to remain in a safe and serviceable condition if undermined. This condition is not intended to exclude planned outages of the tunnel for mitigation and remediation purposes or unplanned outages of a limited duration in order to undertake additional mitigation or remedial works.

73 That the infrastructure owner has the *prima facie* right to determine what is *safe, serviceable and repairable* for their purposes, with any dispute with the leaseholder/mine operator being referred to a neutral arbiter selected by the Department of Planning and funded by the leaseholder/ mine operator.

74 That the leaseholder/mine operator is to guarantee funding to undertake all risk management activities and all mitigation and remediation activities associated with maintaining the Upper Canal System in a safe and serviceable condition if it is undermined and to remediate any residual mining related impacts that may subsequently develop. This includes all the direct and indirect costs of the infrastructure owner in participating in this risk management process. (Given the incremental nature of subsidence development, a number of remediation campaigns may be required).

75 That all activities related to undermining the Upper Canal System are to be structured within a risk management framework that is consistent with *ISO 31000 Risk Management*.

76 That the risk management system for undermining the Upper Canal System is to be:

a. Audited externally for compliance with ISO 31000 prior to lodgment of associated Extraction Plans, with the auditor/s to be selected by the Department of Planning in consultation with the infrastructure owner, and the audit report to accompany the Extraction Plan application.

b. Audited externally for compliance with ISO 31000 on an annual basis for the duration that the plan is invoked, with the auditor/s to be selected by the Department of Planning in consultation with the infrastructure owner.

c. Reviewed externally for effectiveness on an annual basis for the duration that the plan is invoked, with the reviewer to be selected by the Department of Planning in consultation with the infrastructure owner.

77 That no Extraction Plan should be approved that could create any additional risk to the State's water supply system or the public from undermining of the Upper Canal System until all potential sources of the increased risk have been investigated to the satisfaction of the Director General of the Department of Planning and the proposals in the Extraction Plan for avoidance, mitigation or

control of any such risks ensure that the functionality of the State's water supply system and public safety are not put in jeopardy.

Broughtons Pass Weir

This item of infrastructure is of significant concern. The Panel's conclusions are that closure and upsidence sufficient to cause fracturing and leakage of the weir has already occurred as a result of extracting Longwalls 401 and 402 at Appin Colliery, even though these longwalls are no closer than 400 m to the weir. Assessment of the subsidence implications of the BSO Project on Broughtons Pass Weir fails both to consider the magnitude of previous closure and upsidence, and to base the assessment of impacts and consequences on cumulative closure and upsidence.

Irrespective of previous closure and upsidence, the predicted incremental increases in both these parameters of 50 mm may be sufficient in their own right to impact adversely on the weir, especially if the site characteristics make it prone to impact.

Damage to this weir could have major implications for the supply of water to Macarthur Water Filtration Plant (and to the zones that rely on water from this plant) and would also compromise supply to the Upper Canal. The SCA has indicated that it is not satisfied that the Project's overall likely impacts on Broughtons Pass Weir would be "negligible" or that it would remain "safe and serviceable". Based on its consideration of the likelihood of impacts and the potential consequences of impacts, and in the absence of a risk assessment, the Panel also holds this view.

The Panel recommends that Performance Criteria in any Project Approval should include the following requirements for Broughtons Pass Weir:

78 That mining in the Study Area is to result in *nil* incremental impacts on the structure, stability and functionality of Broughtons Pass Weir whilst the weir remains in service.

79 That the leaseholder/mine operator is to guarantee funding to undertake all activities associated with monitoring Broughtons Pass Weir to verify that this Performance Criterion is being satisfied.

Other Weirs

There are a number of weirs on the Nepean and Cataract Rivers that may be impacted by subsidence. The Base Case mine layout poses greater threats to some of these weirs than others, but the proposed management strategies should be capable of controlling the impacts. The Panel recommends that Performance Criteria in any Project Approval should include the following requirements for weirs other than Broughtons Pass Weir:

80 That the Maldon, Douglas Park, Jordans Pass and Menangle Weirs are to remain in a safe and serviceable condition if impacted by mining operations in the Study Area. This condition is not intended to exclude mitigation and remediation measures to maintain the weirs in this condition.

81 That the infrastructure owner has the *prima facie* right to determine what is *safe, serviceable and repairable* for their purposes, with any dispute with the leaseholder/mine operator being referred to a neutral arbiter selected by the Department of Planning and funded by the leaseholder/mine operator.

82 That the leaseholder/mine operator is to guarantee funding to undertake all risk management activities and all mitigation and remediation activities associated with maintaining the Maldon, Douglas Park, Jordans Pass and Menangle Weirs in a safe and serviceable condition if they are impacted by mining in the Study Area and to remediate any residual mining related impacts that may subsequently develop. This includes all the direct and indirect costs of the infrastructure owner in participating in this risk management process. (Given the incremental nature of subsidence development, a number of remediation campaigns may be required.)

83 That all activities related to maintaining the Maldon, Douglas Park, Jordans Pass and Menangle Weirs in a safe and serviceable state are to be structured within a risk management framework that is consistent with *ISO 31000 Risk Management*.

84 That the risk management system for managing mining impacts on the Maldon, Douglas Park, Jordans Pass and Menangle Weirs Upper Canal System is to be:

  i. Audited externally for compliance with ISO 31000 prior to lodgment of associated Extraction Plans, with the auditor/s to be selected by the Department of Planning in consultation with the infrastructure owner, and the audit report to accompany the Extraction Plan application.

  ii. Audited externally for compliance with ISO 31000 on an annual basis for the duration that the plan is invoked, with the auditor/s to be selected by the Department of Planning in consultation with the infrastructure owner.

  iii. Reviewed externally for effectiveness on an annual basis for the duration that the plan is invoked, with the reviewer to be selected by the Department of Planning in consultation with the infrastructure owner.

85 That no Extraction Plan should be approved until the risks associated with mining in the Study Area in vicinity of the Maldon, Douglas Park, Jordans Pass and Menangle Weirs have been investigated to the satisfaction of the Director General of the Department of Planning and the proposals in the Extraction Plan for the management of any risks are consistent with maintaining each weir in a safe, serviceable and repairable condition.

Cataract Dam

This dam wall has already moved in response to subsidence impacts. The movements to date have apparently been en-masse, with the result that the dam wall has not been impacted structurally by differential displacements. Nevertheless, movement of such a critical structure warrants very careful consideration, particularly in regards to cumulative movement. The EA makes no reference to the magnitude of horizontal movement of the dam wall to date but does acknowledge that further movements are possible. It appears to the Panel that both the SCA and ICHPL are relying on the risks being controlled through intervention of the Dams Safety Committee at some future date.

The Cataract Dam is a critical item of infrastructure and the Panel therefore recommends that Performance Criteria in any Project Approval should include the following requirements:

86 That mining in the Study Area is to result in a *nil* impact outcome for the dam wall of Cataract Reservoir.

87 That the leaseholder/mine operator is to guarantee funding to undertake all activities associated with monitoring the dam wall of Cataract Reservoir to verify that this Performance Criterion is being satisfied.

88 That all activities related to ensuring a *nil* impact outcome for the dam wall of Cataract Reservoir are to be structured within a risk management framework that is consistent with *ISO 31000 Risk Management*.

89 That the risk management system for ensuring a *nil* impact outcome for the dam wall of Cataract Reservoir is to be:

i. Audited externally for compliance with ISO 31000 prior to lodgment of associated Extraction Plans, with the auditor/s to be selected by the Department of Planning in consultation with the infrastructure owner, and the audit report to accompany the Extraction Plan application.

ii. Audited externally for compliance with ISO 31000 on an annual basis for the duration that the plan is invoked, with the auditor/s to be selected by the Department of Planning in consultation with the infrastructure owner.

iii. Reviewed externally for effectiveness on an annual basis for the duration that the plan is invoked, with the reviewer to be selected by the Department of Planning in consultation with the infrastructure owner.

90 That no Extraction Plan should be approved until the Director-General of the Department of Planning is satisfied that the proposals in the Extraction Plan for the management of risk are consistent with achieving a *nil* impact outcome for the dam wall of Cataract Reservoir.

Residential Houses

The Study Area falls within three Local Government Areas (LGAs), namely Wollondilly Shire Council, Campbelltown City Council and Wollongong City Council, with the majority being in the Wollondilly LGA. Residential development is effectively confined to the western half of the Study Area, most of which falls within one of four declared Mine Subsidence Districts. At the time of compiling the EA, a total of 1294 houses had been identified in the Study Area.

The Panel's conclusions are that a well established mechanism supported by legislation and administered by the Mine Subsidence Board already exists for managing the impacts on mining on residential structures. This mechanism is effective in not exposing residents to personal harm arising from mine subsidence and in maintaining and restoring structures to a condition equal to or better than their pre-mining state at no financial cost to owners. However, this mechanism does not compensate owners for annoyance, anxiety or inconvenience associated with structures being damaged by mine subsidence, which is compounded in the BSO Study Area by the extended period of time (in some cases 3 or more years) that remediation and restoration activities are deferred until mine subsidence movements stabilize. In many instances, owners of structures in declared Mine Subsidence Districts have already incurred a cost burden at the time of construction to mitigate against subsidence impacts. The current legislative scheme and its manner of administration may need review to enhance its operation, especially in circumstances where subsidence develops incrementally over several years.

The commitment by ICHPL that all houses within the Study Area are expected to remain safe, serviceable and repairable, is unrealistic in light of experience to date. A small number of structures are likely to be damaged to the extent that they will need to be demolished and reconstructed. In this context the number of structures impacted by mining and the degree of impact is likely to be greater than predicted in the EA if longwall panel width is increased.

It is more likely than not that portions of the Study Area will be released for development during the next 30 years and, therefore, there may be mutual benefits to ICHPL, community and state and local government to strategically sequence extraction of mining domains to facilitate this development.

Water Supply Infrastructure

Sydney Water owns and maintains a number of water pipelines within the Study Area which supply the townships of Wilton in Area 3, Menangle in Area 7, Maldon in Area 8, Douglas Park in Area 9 and Appin in Area 5. It currently has proposals to install a Sewerage Pumping Station at Appin and a pressurised pipeline to Campbelltown.

Part of the Macarthur Water Supply System, which is owned by United Utilities Australia lies within Area 3 and West Cliff Area 5. The system treats and supplies water from the Cataract River (at Broughtons Pass) to Campbelltown and surrounding townships including Wilton and Appin.

A 1200 mm diameter untreated and a 1500 mm untreated water main lie within Area 3 just outside the extent of the longwall mining areas. The EA provides no information as to whether these water mains were designed to Mine Subsidence Board requirements. A 1200 mm diameter treated water gravity main designed and constructed in 1994 to the Mine Subsidence Board’s design requirements passes through West Cliff Area 5.

The Panel’s conclusion is that subsidence impacts on these facilities can be managed using the standard risk management approaches recommended throughout this report.

Gas Infrastructure

Three high pressure gas pipelines traverse the Study Area in Area 3, Area 5 and Area 7, these being the Eastern Gas Pipeline, the AGN Pipeline and an Ethane Pipeline. There is also a gas distribution network which services the properties in the northern part of Area 7. The Panel has calculated a total of 26.6 km of pipeline within the Study Area, of which 10.4 km is directly above the extent of the longwall mining area. A gas trunk receiving station is also located in the study area.

The key issues are public safety and security of gas supply.

The Panel recommends that Performance Criteria in any Project Approval should include the following requirements for gas infrastructure:

91 That mining activities in the BSO Study Area are not to jeopardize public safety or security of gas supply.

92 That mining is not to impact on gas reticulation systems and devices such that they cannot be maintained in a *safe, serviceable and repairable* condition.

93 That the infrastructure owner has the *prima facie* right to determine what is *safe, serviceable and repairable* for their purposes, with any dispute with the leaseholder/mine operator being referred to a neutral arbiter selected by the Department of Planning and funded by the leaseholder/mine operator.

94 That the leaseholder/mine operator is to guarantee funding to undertake all risk management activities and all mitigation and remediation activities associated with maintaining in a safe, serviceable and repairable condition, all gas reticulation systems that are impacted by mining operations. This includes all the direct and indirect costs of the infrastructure owner in participating in this risk management process. (Given the incremental nature of subsidence development, a number of remediation campaigns may be required.)

95 That all activities related to maintaining security of gas supply and gas reticulation systems in a safe, serviceable and repairable condition are to be structured within a risk management framework that is consistent with *ISO 31000 Risk Management*.

96 That the risk management system for mining in the vicinity of gas reticulation systems is to be:

   a. Audited externally for compliance with ISO 31000 prior to lodgment of associated Extraction Plans, with the auditor/s to be selected by the Department of Planning in consultation with the infrastructure owner, and the audit report to accompany the Extraction Plan application.

   b. Audited externally for compliance with ISO 31000 on an annual basis for the duration that the plan is invoked, with the auditor/s to be selected by the Department of Planning in consultation with the infrastructure owner.

   c. Reviewed externally for effectiveness on an annual basis for the duration that the plan is invoked, with the reviewer to be selected by the Department of Planning in consultation with the infrastructure owner.

97 That no Extraction Plan should be approved that could create any additional risk to the State's gas supply system from mining activities until all potential sources of the increased risk have been investigated to the satisfaction of the Director-General of the Department of Planning and the proposals in the Extraction Plan for avoidance, mitigation or control of any such risks ensure that the functionality of the State's gas supply system is not put in jeopardy.

Electrical Reticulation

Integral Energy owns and maintains a number of 66 kV, 11 kV and low voltage powerlines within the Study Area. All of the conductors within the distribution network consist of overhead cables supported by some 4000 power poles within the Study Area, of which 2900 are located within the extent of the longwall mining area. TransGrid owns and maintains a 330 kV transmission line which crosses Areas 3, 5 and 7. Of the 9.5 km of transmission line within the Study Area, 6.2 km is directly above the extent of the longwall mining area. The 66 kV, 11 kV and low voltage powerlines are expected to experience the full range of predicted systematic subsidence movements. There are also substations within the Study Area.

The Panel's conclusion is that there is an extensive international experience base in undermining transmission lines without jeopardizing public safety and security of power supply and that it is undertaken routinely, especially at the depths of mining associated with the Study Area. The key issues are public safety and security of power supply.

The Panel recommends that Performance Criteria in any Project Approval should include the following requirements for electrical reticulation:

98 That mining activities in the BSO Study Area are not to jeopardize public safety or security of power supply.

99 That mining is not to impact on electrical reticulation systems and devices such that they cannot be maintained in a *safe, serviceable and repairable* condition.

100 That the infrastructure owner has the *prima facie* right to determine what is *safe, serviceable and repairable* for their purposes, with any dispute with the leaseholder/mine operator being referred to a neutral arbiter selected by the Department of Planning and funded by the leaseholder/mine operator.

101 That the leaseholder/mine operator is to guarantee funding to undertake all risk management activities and all mitigation and remediation activities associated with maintaining in a safe, serviceable and repairable condition, all electrical reticulation systems that are impacted by mining operations. This includes all the direct and indirect costs of the infrastructure owner in participating in this risk management process. (Given the incremental nature of subsidence development, a number of remediation campaigns may be required.)

102 That all activities related to maintaining security of power supply and electrical reticulation systems in a safe, serviceable and repairable condition

are to be structured within a risk management framework that is consistent with *ISO 31000 Risk Management*.

103 That the risk management system for mining in the vicinity of electrical reticulation systems is to be:

a. Audited externally for compliance with ISO 31000 prior to lodgment of associated Extraction Plans, with the auditor/s to be selected by the Department of Planning in consultation with the infrastructure owner, and the audit report to accompany the Extraction Plan application.

b. Audited externally for compliance with ISO 31000 on an annual basis for the duration that the plan is invoked, with the auditor/s to be selected by the Department of Planning in consultation with the infrastructure owner.

c. Reviewed externally for effectiveness on an annual basis for the duration that the plan is invoked, with the reviewer to be selected by the Department of Planning in consultation with the infrastructure owner.

104 That no extraction should be approved that could create any additional risk to the State's electrical power supply system from mining activities until all potential sources of the increased risk have been investigated to the satisfaction of the Director-General of the Department of Planning and the proposals in the Extraction Plan for avoidance, mitigation or control of any such risks ensure that the functionality of the State's electrical power supply system is not put in jeopardy.

Telecommunications

The telecommunications infrastructure in the Study Area comprises aerial and underground copper cables and buried optical fibre cables. A total of 264 km of copper cabling and 61.6 km of optical fibre cable already exist in the Study Area. There are also mobile phone towers in the Study Area.

The Panel is aware that many hundreds of kilometres of copper telecommunications have been undermined both nationally and internationally with only minor or nil impacts. The likelihood of unacceptable impact is very low in the case of the BSO Project because of the considerable depth of mining. However, it appears to the Panel on the basis of the limited information available, that the failure of an optic fibre telecommunications cable may be a low to moderate likelihood event that has high potential consequences. Hence, a high level of risk may be associated with such an event.

For telecommunications, the Panel recommends that Performance Criteria in any Project Approval should include the following requirements:

105 That mining activities in the BSO study Area are not to cause an interruption to state and national cable based telecommunication systems. This condition is not intended to exclude contingencies that involve temporarily switching to an alternative communications system or corridor in the event of a loss of serviceability, provided that there is no loss of communications.

106 That mining activities in the BSO Study Area are not to result in a loss of local cable based telecommunications systems. This does not preclude the provision of alternative local communication systems (mobile phones, VHF radio) for brief periods whilst the normal telecommunication system is restored.

107 That mining is not to impact on cable telecommunication systems and devices such that they cannot be maintained in a *safe, serviceable and repairable* condition.

108 That the infrastructure owner has the *prima facie* right to determine what is *safe, serviceable and repairable* for their purposes, with any dispute with the leaseholder/mine operator being referred to a neutral arbiter selected by the Department of Planning and funded by the leaseholder/mine operator.

109 That the leaseholder/mine operator is to guarantee funding to undertake all risk management activities and all mitigation and remediation activities associated with maintaining in a safe, serviceable and repairable condition, all cable telecommunication systems that are impacted by mining operations. This includes all the direct and indirect costs of the infrastructure owner in participating in this risk management process. (Given the incremental nature of subsidence development, a number of remediation campaigns may be required.)

110 That all activities related to maintaining security of telecommunication and telecommunication systems in a safe, serviceable and repairable condition are to be structured within a risk management framework that is consistent with *ISO 31000 Risk Management*.

111 That the risk management system for mining in the vicinity of cable telecommunication systems is to be:

a. Audited externally for compliance with ISO 31000 prior to lodgment of associated Extraction Plans, with the auditor/s to be selected by the Department of Planning in consultation with the infrastructure owner, and the audit report to accompany the Extraction Plan application.

b. Audited externally for compliance with ISO 31000 on an annual basis for the duration that the plan is invoked, with the auditor/s to be selected by the Department of Planning in consultation with the infrastructure owner.

c. Reviewed externally for effectiveness on an annual basis for the duration that the plan is invoked, with the reviewer to be selected by the Department of Planning in consultation with the infrastructure owner.

112 That no Extraction Plan should be approved that could create any additional risk to the State's cable telecommunications systems from mining activities until all potential sources of the increased risk have been investigated to the satisfaction of the Director-General of the Department of Planning and the

proposals in the Extraction Plan for avoidance, mitigation or control of any such risks ensure that the functionality of the State's telecommunication systems.

Air Strips

There are two air strips within the Study Area. The Sydney Sky Divers Centre is located adjacent to the Hume Highway in Area 8 and includes an 800 m long, compacted earth air strip. It is directly above the proposed longwalls and may experience the maximum predicted subsidence movements for Area 8 potential impacts can be managed in consultation with Sydney Sky Divers by means of an appropriate management plan.

The second air strip is Wedderburn Air Strip located within Area 5 and managed by the NSW Sport Aircraft Club. The strip is more than 970 m long and consists of a sealed asphaltic pavement. The EA reports that the air strip experienced mine subsidence movements during the extraction of West Cliff Longwalls 20 to 24 but provides no information as to the nature and magnitude of these movements. It notes that the closest distance of the longwalls (Extent of Longwall Mining) in the Base Case layout is more than 400 m and beyond the limit of vertical subsidence. On this basis, there does not appear to be a need to recommend approval conditions.

Survey Control Marks

There are numerous survey control marks in the Study Area and they are subject to the full range of subsidence outcomes.

The Panel recommends:

113That Approval conditions include a requirement to relocate and/or reinstate survey control marks to a standard determined by the NSW Land and Property Management Authority.

Farms and Farm Facilities

There are a number of farming enterprises in the Study Area. The Panel is aware that there is an extensive international experience base relating to the undermining of farms and farm facilities that can be utilized for preparing Extraction Plans. The Panel's conclusion is that most of the relevant issues such as farm buildings, farm dams and livestock facilities are dealt with adequately by commitments in the EA. The one outstanding issue was related to water supply at Wedderburn which is not connected to a town supply and relies on dams, bores and tanks for potable and non-potable water, including the need for water in bushfire events. Any potential to disrupt water supplies in this area will need to be given careful consideration.

Industrial and Commercial Premises

Maldon Cement Works

The Panel's conclusions are that, although the elements of a management strategy are identified in the EA, more work is required.

The Panel recommends:

114 That any form of mining within 600m of the footprint of the Maldron Cement Works not be approved until such time as the risk to the structures that comprise the complex have been assessed and arrangements put in place for avoidance, mitigation and/or control of the risks and these arrangements are detailed in the relevant instruments that would permit mining to proceed.

Allied Mills Flour Mill
This mill is reported to have been designed to Mine Subsidence Board requirements. Nevertheless, the EA states that the building structures and silos would appear to be reasonably sensitive to differential subsidence movements and the serviceability of these items needs to be considered before the mine plan is finalized.

The Panel recommends:

115 That any form of mining within 600 m of the footprint of the Allied Mills Flour Mill not be approved until such time as the risk to the structures that comprise the complex have been assessed and arrangements put in place for avoidance, mitigation and/or control of the risks and these arrangements are detailed in the relevant instruments that would permit mining to proceed.

Douglas Park Petrol Station
The EA reports that there is limited history of undermining petrol stations. The Panel notes that the two case studies presented in the EA were associated with significantly less vertical displacement than that which the Douglas Park petrol station is predicted to experience for the Base Case mine layout. The Panel has insufficient information to assess the situation.

The Panel recommends:

116 That any form of mining within 600 m of the footprint of the Douglas Park Petrol Station not be approved until such time as the risk to the structures that comprise the complex have been assessed and arrangements put in place for avoidance, mitigation and/or control of the risks and these arrangements are detailed in the relevant instruments that would permit mining to proceed.

<u>Non-Aboriginal heritage</u>
A total of 47 structures of non-Aboriginal heritage significance have been identified within the Study Area.

Predictions of subsidence effects and impacts in the EA for those structures located beyond or near the Extent of the Longwall Mining Area are site-specific based on the Base Case mine layout. For structures located directly above longwall panels, these predictions have been based on the maximum predicted movements within the mining domain, in order to account for any change in longwall orientation or location in the future. The Panel supports this concept and recognizes that not all structures above longwall panels will actually experience the maximum predicted movements for the Base Case longwall panel width. However, no provision has been made in the assessment for increased subsidence effects if longwall panel width is increased in the future.

The Panel is not satisfied that the commitments in the EA will result in either proper assessment of the potential impacts of subsidence on the heritage values of significant items of non-Aboriginal heritage, or in maintenance of those heritage values. In this context, some of the masonry structures would appear to be highly vulnerable to subsidence impacts and not repairable to a standard consistent with maintaining heritage values (e.g. St James Anglican Church at Menangle).

The Panel recommends:

117 That a Performance Criterion of *nil* impact on the heritage value of the following sites be imposed in any Approval conditions, where *nil* means *no mining induced change of any description in heritage value*. In the case of sites which may have already been impacted by past mining operations, e.g. Broughton's Pass Weir, *nil* impact has the meaning of *no additional mining induced change of any description.* These sites are:

   a. Cataract Dam Wall.

   b. Broughtons Pass Weir.

   c. St James Church, Menangle.

   d. St Mary's Tower, Douglas Park.

118 That any Approval requires that no Extraction Plan is to be approved unless:

   i. A survey has been undertaken of all non-Aboriginal heritage sites within an area defined by a 600 m wide boundary around the mining area to which the Extraction Plan relates;

   ii. The heritage value of each site within this boundary has been determined by appropriately qualified persons in consultation with the Heritage Branch;

   iii. Measures necessary to preserve the heritage value of all heritage sites of significance are incorporated into a Heritage Management Plan as an element of the associated Extraction Plan including incorporation of effective adaptive management provisions for responding to unpredicted anomalous and non-conventional subsidence effects.

   iv. The Heritage Management Plan has been peer reviewed by a person appointed by the Department of Planning and the Director-General of the Department of Planning is satisfied that the predicted impacts of the proposed mining operations will not have an adverse effect on the heritage values of any significant heritage sites;

<u>Future Built Infrastructure</u>

The EA does not address mining impacts on infrastructure that may be built in the Study Area during the project life. In declared Mine Subsidence Districts, which cover the majority of the western mining domains for the BSO Project, new structures will be required to conform to MSB design requirements.

However, the BSO Project subsidence predictions exceed some current MSB criteria for the Base Case Mine layout and may exceed them substantially if longwall panel width increases. Hence, construction of new structures in accordance with current MSB requirements may not be adequate in all circumstances for ensuring that they remain safe, serviceable and repairable when located within the zone of influence of mining. New structures may also be located within the BSO Study Area, but outside of declared Mine Subsidence Districts.

The Panel therefore recommends:

119 That the MSB review its design requirements for new structures in the Study Area in light of the subsidence predictions contained in the EA and consideration is given to locating new surface infrastructure in areas that have already been undermined.

Regional Stability

The BSO study area covers a very large area and if it were extracted to the extent proposed in the Base Case mine layout it could, along with the existing Appin Tower, West Cliff, Darkes Forest, Coalcliff, Bulli and Belambi West Colliery workings that adjoin it contribute to a significant rearrangement of the regional stress field around these workings. This has the potential to trigger seismic events.

There have been a number of moderately large seismic events in the Southern Coalfield over the past two decades. Whilst there is no evidence to suggest that mining contributed to these events, there is evidence that seismic events can be initiated as a result of mining extensive areas using high aerial extraction methods such as longwall mining.

Seismicity, therefore, is a factor that needs to be considered when assessing the stability of key and/or sensitive items of infrastructure such as in this instance, the dam wall of Cataract Reservoir, the Hume Highway bridges over the Nepean River Gorge, and Broughtons Pass Weir. The EA for the BSO Project has not given any consideration to mining induced seismicity and its implications for the stability of natural and man-made structures and the safety of the general public who utilize these features.

The Panel recommends:

120 That conducting of seismic monitoring on a regional basis, analysis of outcomes and correlation with mining operations should be a requirement of all Extraction Plans for the BSO Project and that this information is reported to the Department of Planning on an annual basis.

121 That seismic monitoring data and analysis is reviewed externally every 3 years by a suitably qualified person nominated by the Department of Planning.

122 That any identified associations or trends between the seismic data and mining activities should constitute a trigger that requires:

a. mine planning to be reviewed internally by the leaseholder/mine operator and externally by a person nominated by the Department of Planning, and

b. a risk assessment to be undertaken of the potential impacts and consequences of seismicity for man-made features and natural features associated with the BSO Project.

18.2.10. Chapter 12 Mine Surface Infrastructure

Mine surface infrastructure principally comprises the West Cliff Colliery pit top including the coal washery, coal wash emplacement and Brennans Creek Dam, Appin East pit top, Appin West pit top, Appin No. 1 and No. 2 Shafts, Appin No.3 shaft, North Cliff Shafts and remote service sites utilising boreholes.

The Panel notes that with the exception of surface goaf gas drainage boreholes, ventilation shafts, and West Cliff pit top and coal emplacement facility, the other facilities will function in the future in much the same manner as is currently the case and generally under existing approvals.

The EA lacks clarity as to exactly what other items of future surface infrastructure the Part 3A Application is intended to encompass. Therefore, the Panel's conclusions are confined to goaf gas drainage boreholes and modifications to existing ventilation shafts. The Coal Washery is dealt with in Chapter 13.

<u>Goaf Gas Drainage</u>
Goaf gas drainage is currently conducted by drilling surface to goaf drainage bores to extract the methane gas which is then flared or vented at surface. In order to undertake such activity, it has been necessary at existing gas drainage locations for ICHPL to conduct appropriate environmental assessments including air, noise, visual and vegetation surveys.

Neither the Panel nor the public have had an opportunity to scrutinise and comment on the future gas drainage proposals. The proposition appears to be that, apart from any gas drainage that might be required for Dharawal State Conservation Area any surface gas drainage activities for the BSO Project that were not already covered or proposed to be covered by Part 3A approvals would be dealt with via a non-public process based on Management Plans.

In view of the lack of information available, the Panel recommends:

2. That the government consider the implications of including surface goaf gas drainage facilities in an Approval where there has been no opportunity for the public to comment on the details of any proposals and there are potential impacts of construction and operation of the facilities on both public and private land.

<u>Ventilation Shafts</u>
The EA notes that existing ventilation shafts may be modified over the course of the project life.

No information offering any detail with respect to any upgrades or changes to existing ventilation shafts, nor any information relating to the environmental effects of any upgrades, has been supplied in the EA. In the absence of such information, the Panel is unable to provide advice as to whether the government should include them within any Approval.

18.2.11. Chapter 13 West Cliff Coal Wash Emplacement

The Stage 4 expansion proposal has caused considerable controversy. The principal objections relate to clearance of pristine native bushland for emplacement waste, impacts to threatened species of flora and fauna, and potential threats to water quality in the George's River. However, neither the Proponent nor the opponents of the proposal have been able to produce a viable alternative at this time.

While the Panel is not enthusiastic about the proposal, it has concluded that the Stage 4 proposal provides the most viable long term solution for washing waste from this Project. This view is based on the following considerations.

a. No other surface emplacements areas in the region have been advanced as an appropriate or viable alternative to Stage 4;

b. Any other area would presumably require transportation of the coal wash by road and management of coal wash at a scale similar to that already in place at the West Cliff pit top. This would further exacerbate regional traffic management problems associated with the Project Proposal;

c. ICHPL have committed to exploring the viability of underground emplacement;

d. Ongoing environmental impacts and consequences of the West Cliff facility that would invoke the greatest regional concern relate largely to water quality issues in Brennans Creek and the Georges River. Water quality issues are governed in turn by DECCW licence constraints which can be adjusted periodically to enforce improved water quality outcomes;

e. ICHPL are bound in the long term by rehabilitation and decommissioning in accordance with DECCW requirements, and management of discharges in compliance with DECCW licensing.

However the Panel is of the view that underground disposal options for the coal wash should be aggressively pursued. There are two reasons for this. The first is that it may be possible to limit the impacts associated with the later stages of the Stage 4 facility and the second is that if production of coal washery waste exceeds expectations then some reserve capability may be available. The proposed timetable by ICHPL for a pilot scale research and development trial needs to be adhered to in a statement of commitments.

The Panel recommends:

124 That any Approval for the Stage 4 Coal Wash Emplacement should specify in sufficient detail and with sufficient precision the measures necessary for:

i. maximising the opportunity for natural regeneration (i.e. by early use of topsoil from the site),

ii. only using endemic species and in appropriate habitat mixes, and

iii. maximising retention of suitable habitat features for fauna.

125 That ICHPL continues to pursue options for the underground disposal of coal wash, including adherence to the proposed pilot scale research and development trial.

126 That no Extraction Plan be approved until:

i. The management measures proposed in the EA for the protection of P. hirsuta become formal requirements of the Extraction Plan that are enforceable and monitored;

ii. A management plan for the conservation of the Broad-Headed Snake is developed in consultation with and to the satisfaction of DECCW;

iii. A management plan for the conservation of the Southern Brown Bandicoot is developed in consultation with and to the satisfaction of DECCW.

iv. Piezometers are installed both in the coal wash in Stages 1 and 2, and in future emplacement areas in accordance with the Stage 3 emplacement management plan and design criteria[606]; and

v. Piezometers are installed in the Hawkesbury Sandstone downstream of Brennans Creek Dam in sufficient number so as to be able to define groundwater flow directions, magnitudes and groundwater qualities.

127 That future Pollution Reduction Programs address the improvement in discharge water quality with a goal of less than 1000 uS/cm within 10 years.

18.2.12. Chapter 14 Roads and Traffic

The Panel was concerned that the EA did not present a clear picture of the potential increase in daily movements of heavy vehicles particularly to and from the Port Kembla Coal Terminal. The extent of this increase varies over the life of the project, but on some roads the increases are between 600 and 700 additional truck movements per weekday. Coal trucks can carry up to 36.5 tonnes per truck.

The Proponent's traffic study suggests that the background growth in traffic will significantly outweigh any contribution from the Proponent's vehicle movements. However the Panel is not convinced that the impact of heavy vehicles has been adequately addressed and that the performance of major intersections will not become an unacceptable hazard. The issues of intersection modifications and traffic volumes are the subject of ongoing negotiation between the RTA and the Proponent.

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[606] Cardno Forbes Rigby, 2007

The Panel is of the view that whilst some improvements are planned for the coal haulage routes, which occur primarily on arterial and other RTA controlled roads, there is insufficient information regarding heavy vehicle movements associated with the proposal to comprehensively assess the traffic impacts of the proposal, particularly given that at this time the RTA are still not satisfied with the level of detail provided by the Proponent.

The Panel recommends:

128 That any approval for the project contain a requirement that the issues listed below are resolved to the satisfaction of the Director-General of Planning prior to any increase in coal production being permitted:

i. The Proponent clarify if the number of additional traffic movements generated by the proposal require recalculation to accommodate weekend operations of the proposal;

ii. The Proponent provide the Department with the figures regarding the percentages of heavy and light vehicles (included loaded and unloaded) attributed to the proposal at key locations on haulage routes and at key intersections;

iii. The RTA verify the Proponent's SIDRA analysis;

iv. The RTA undertake a thorough assessment of the proposal including its cumulative impact and any supplementary information provided by the Proponent;

v. The RTA review the impact of undertaking peak hour turning count surveys on Easter Thursday

18.2.13. Chapter 15 Issues Raised in Submissions

The majority of issues raised in submissions are dealt with in the specific Chapters on significant natural features and built infrastructure. A few that don't fit readily into that framework, but appear to the Panel to require separate comment, are included in Chapter 15.

<u>Dharawal State Conservation Area</u> (SCA)
The potential for the project to cause significant damage to conservation and recreation values of the State Conservation Area was a focus of many submissions Panel's conclusion is that any mining in the SCA should be conducted so as to maintain the conservation and recreational values of the SCA. The current project proposal would not achieve this because of predicted impacts on upland swamps, streams, cliff lines and Aboriginal cultural heritage sites.

The Panel also noted that the 'turning off' of the normal statutory provisions that would protect EECs, threatened species and significant Aboriginal sites in a State Conservation Area required considerable care in the framing Approval conditions to ensure that the values of theses significant natural features are not compromised. The possibility of increases in longwall panel width as a component of future changes in the Base Case mine layout further complicates this issue.

The Panel therefore recommends:

129 That any Approval to mine under Dharawal SCA should be conditional on negligible subsidence related impacts on the significant natural features in the SCA including upland swamps, streams EECs and areas of habitat containing viable populations of threatened species, significant cliff lines and significant Aboriginal cultural heritage sites.

Peer Review

The Panel's conclusion is that there are some problems with the current situation where peer reviews are obtained by the Proponent in support of aspects of the proposal. The key issues are perceived lack of independence, the questionable quality of some reviews and the extent to which special interest groups and individuals appear to rely on such reviews.

The Panel recommends:

130 That the Department of Planning review the use of peer review with the objective of determining whether independent selection, briefing and engagement of the reviewers should be the norm, even if the cost were to be borne by the Proponent.

Economics

Many submissions raised concerns about aspects of the cost-benefit analysis in the EA. The principal concern was whether the Choice Modelling approach used to estimate the environmental costs of the projects had been used appropriately.

The Panel's conclusions are that, while Choice modelling is a suitable technique for estimating such costs, substantial refinements would be required to the work conducted for the BSO EA before the estimates could be relied on to give an accurate estimate of the value society would attribute to the eastern portion (and its sub-portions) of the Study Area.

However, the Panel also noted that economic modelling techniques such as Choice Modelling could be of considerable use in providing advice on acceptability of impacts. But to achieve this, the studies have to be designed recognising the kinds of questions that the Panel will be required to answer. For underground mines these are concerned with the acceptability of subsidence impacts on significant natural features and built infrastructure.

To be useful the design must therefore ensure that three things are satisfied:

(i) the scale at which the studies are conducted must be fine enough to capture information on the values associated with the major classes of significant natural features and built infrastructure;

(ii) if there is significant heterogeneity across the Study Area in terms of the distribution and/or significance of the features or infrastructure then this must be accounted for; and

(iii) the issue of bias (or perceived bias) in design must be eliminated. Survey respondents must have adequate information on the nature of the features or infrastructure likely to be impacted and the potential consequences of those impacts.

The Panel recommends:

131 That future economic studies of environmental values in connection with mining proposals are undertaken at a sufficient level of detail to allow robust comparisons between benefits of mining and benefits of protection of natural features. Critical to this is that the study design provides survey respondents with an adequate description of the environmental attributes in the Study Area and the potential consequences for them of subsidence-induced impacts. Obvious heterogeneity in environmental attributes across the Study Area must also be accounted for.

Traffic Noise

The Panel's conclusions are that there are a substantial number of residences potentially affected by noise exceedances and that these exceedances would primarily occur from 11:00pm to 12:00pm for the three shift scenario and from 4:00am to 5:00am for the two shift scenario, both being situations in which the criterion is 55dB(A). The Panel is of the view that the project has the potential to result in an unsatisfactory outcome for those residences affected.

The Panel recommends:

132 That if after 2013 the noise generated by traffic associated with the project persistently exceeds the relevant criteria at any residence on privately owned land then the Proponent should provide appropriate insulation and ventilation for affected houses at the request of the relevant landowners.

133 That the Proponent should commit to a Road Traffic Noise Management Plan that includes provisions to ensure that the road haulage fleet represents best practice in terms of equipment and operation.

18.2.14. Chapter 16 Adequacy of Information

The Panel's conclusions in relation to adequacy of the information provided by the Proponent to assess the BSO Project Proposal are discussed at length in 18.1 above. In summary, while the information is adequate for assessment of potential subsidence–related impacts on much of the built infrastructure (at least to the point of being able to recommend conditional Approval subject to satisfactory subsequent planning and management processes) that is not the case for many of the significant natural features.

For many of the significant natural features the information necessary for assessment is considered to be either 'inadequate' or 'manifestly inadequate'. The

Panel concludes that any Approval under these circumstances can only proceed where robust performance criteria are in place that provide appropriate protection to the significant natural features from subsidence-related impacts

Accordingly, the Panel recommends:

134 That, where information is deemed to be inadequate for a proper assessment of the subsidence-related impacts on significant natural features or items of built infrastructure, Approval should only be considered where the Performance Criteria are sufficiently robust to ensure that the recommended levels of protection will be achieved by the proposed Extraction Plans for the mining operation.

18.2.15. Chapter 17 Geographically Based Alternative

As indicated in Chapter 16, for many aspects of the potential impacts on significant natural features, there is insufficient information to be able to assess risk to those features, even on the base case proposal in the EA. In each of the Chapters dealing with significant natural features, requirements for protecting these features to the minimum standards the Panel considers acceptable are identified.

Application of these measures uniformly across the Study Area will place substantial restrictions on the mining arrangements as proposed in the EA. While the Panel considers these measures are warranted by the significance of the features and the potential risks of the mining proposal put forward by ICHPL – the Panel has examined an alternative approach that might improve the mining outcome whilst retaining an adequate level of protection for significant natural features overall. This approach is based on defined geographical areas within the Study Area (Defined Areas) where the significant aggregations of natural features that occur would be protected to a high standard, with some lesser level of restriction to be applied outside those areas.

The Panel has concluded that the eastern and southern parts of North Cliff, Appin Area 2 and a substantial part of Appin Area 3 warrant inclusion in such a Defined Area. The Defined Area is shown on Figure 61 in Chapter 17.

The Panel has carefully considered the economic aspects of this proposed compromise and concluded that the environmental and heritage consequences of mining in the eastern Division as predicted by the Environmental Assessment are unacceptable. The expected benefits of mining in this sub area are expected to be less than the environmental and heritage costs given the current availability of information and the resultant uncertainties. Put another way, the Panel considers that a social net benefit would be generated by conditioning the project's approval so that the environmental and heritage assets are protected from damage at least to the levels specified in the recommendations in Chapters 5 to 10 of this report dealing with natural features and Aboriginal cultural heritage.

This conditioning does not preclude mining in this sub-area. It does however allow the passage of time in which two possibilities may emerge. First, further information regarding the impacts and consequences of mining on the environment can be collected and analysed. By reducing the uncertainty surrounding the impacts and consequences of mining, and possibly demonstrating that proposed mining will not exceed the Performance Criteria laid down in the Approval conditions, mining may then be able to proceed. Second, technological advances may be made through time that involve the development of alternative mining methods that reduce surface impacts of underground mining. Remediation methods may also be improved.

The Panel advises that, on the basis of its analysis of the available material, there are sounds reasons to support the 'Defined Area' concept as set out in Chapter 17 and shown in Figure 61.

The Panel therefore recommends:

135 That the 'Defined Area' concept as set out in Chapter 17 of this Report be adopted in the context of any Approval for the BSO Project Proposal.

136 That the Defined Area shown in Figure 61 of this Report be adopted as the minimum such area to which the standard of negligible subsidence-related impact be applied for significant natural features within the BSO Project Study Area.

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ANNEXURES

ANNEXURE 1

Terms of Reference

ANNEXURE 2

ICHPL Response to DECCW

ANNEXURE 3

DECCW Response to ICHPL

ANNEXURE 4

DECCW map showing comparison of areas

ANNEXURE 5

PAC Request for Additional Information

ANNEXURE 6

Species List

ANNEXURE 7

Summary of Submissions

ANNEXURE 8
DECCW Response to PAC Question 6