Centennial Coal



Springvale Subsidence Management Plan Longwalls 411 to 418

Environmental Management Plan

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1.0 Introduction

1.1 Current and Proposed Operations

Springvale Colliery received planning approval in 1992. Longwall mining commenced in 1995 following the sinking of the ventilation shafts and underground development.

Springvale Colliery has completed extraction of 15 longwall blocks between 1995 to present. Extraction of Longwall 416 commenced on the 24 September 2013 and is a continuation of a series of north – south oriented longwalls that are planned to be extracted progressing towards the east of the mining lease 1326 under the Newnes Plateau.

Assessment of the impact of subsidence as a result of mining longwalls 416 to 418 is the focus of this environmental management plan. Carne West Swamp and Sunnyside East Swamp are Newnes Plateau Shrub Swamps which overlie longwalls 416 to 418.

Springvale's mitigation strategy to reduce potential impacts to sensitive surface features involves modifications to mine design including the adoption of a reduced longwall panel void width design with increased chain pillar width for longwalls 416 to 418 that are situated over the Newnes Plateau. These changes were implemented for the development of 416 Panel in 2011, and will reduce subsidence and subsidence related impacts on the surface.

1.2 Scope

The plan has been updated to manage the impacts of mining longwalls 416 and 418. The plan addresses the Subsidence Management Plan Longwall 411 to 418 variation approval requirements dated 8 August 2013 (refer to correspondence in Appendix 3).

The Newnes Plateau Shrub Swamp Management Plan (NPSS MP) has been modified. It now references the Temperate Highland Peat Swamps on Sandstone Monitoring and Management Plan (THPSS MMP) developed for the Federal Government under approval EPBC2011/5949, with certain exclusions (e.g. Newnes Plateau Hanging Swamps). The trigger levels, data analysis methodology and reporting for groundwater, surface water and shrub swamps is consistent with the THPSS MMP developed for the Federal Government under approval EPBC2011/5949.

It should be noted that although Federal Government approval EPBC2011/5949 does not apply to Longwall 418, application for approval for the extraction of Longwall 418 has been made to to the Federal Government under the Springvale Mine Extension Project.

Table 1 EMP Report Structure

	EMP Approval conditions	Section
	The EMP revision should address all requirements of conditions 7, 8, 9, 15 and 18 of the SMP approval for longwalls 411 to 418. The revised EMP must address subsidence impacts on surface and groundwater, flora and fauna, swamps, archaeological sites and any other significant environmental features that may be effected by subsidence resulting from the proposed longwall extraction. Furthermore the revised EMP must include: ▪ A detailed monitoring program ▪ Trigger levels for subsidence impacts that require actions and responses ▪ The procedures that would be followed in the event that the monitoring indicates an exceedance of trigger levels ▪ Measures to mitigate, remediate and / or compensate any identified impacts ▪ A protocol for the notification of identified exceedances of the trigger levels and ▪ A contingency plan	3,7,Appendix 4, NPSS MP
7.	The leaseholder shall develop and implement a program to ensure ongoing baseline data collection, investigation, assessment and regular reviews with stakeholders. A review schedule shall be developed in consultation with these stakeholders. The program and review schedule shall be submitted to the Director Environmental Sustainability within four months of this approval. The leaseholder shall undertake further reviews if such reviews are requested by the Director Environmental Sustainability or the Principal Subsidence Engineer.	3
8	The required ongoing baseline data collection, investigation, assessment and reviews shall aim to identify appropriate management measures to mitigate and or remediate subsidence impacts. The leaseholder shall ensure that management reviews are conducted in consultation with the relevant stakeholders, prior to subsidence of any important surface features or as otherwise determined in the said review schedule as condition 7.	3
9	The leaseholder shall regularly seek advice and or feedback from the relevant stakeholders with regard to the adequacy, quality and effectiveness of the implemented management processes and the need for any appropriate management measures, early response actions or emergency procedures to ensure adequate management of any potential subsidence impacts due to longwall mining.	3
11	End of Panel Report. The leaseholder shall prepare an end of panel report to encompass all environmental and subsidence monitoring, including a comparison of actual impacts with predicted subsidence impacts. This report shall be submitted to the Director, Environmental Sustainability within three months of extraction being completed for each longwall panel.	3
15	Newnes Plateau Shrub Swamps – the leaseholder shall develop a Newnes plateau shrub swamp management plan in consultation with the department of environment and conservation. The commencement of the extraction of longwall 412 shall not be permitted unless the said plan is approved by the director environmental sustainability.	NPSS MP
18	The leaseholder shall implement a management plan to ensure adequate management of any impacts associated with surface cracking, erosion, soil slumping and land degradation caused by subsidence due to longwall mining and or activities associated with subsidence monitoring or other management plans in the application area. The management plan shall be developed within of this approval and implemented to the satisfaction of the NSW State Forests and Sydney Catchment Authorities.	8, Appendix 4

2.0 Existing Approvals

Springvale Mine's Development Consent DA 11/92 was approved by the then Minister for Planning on the 17 July 1992, pursuant to Section 101 of the EP&A Act, permitting the construction and operation of an underground coal mine, and associated CPP and overland conveyor system at Springvale Mine. Three modifications to Development Consent DA 11/92 have been approved since 1992, along with the granting of two approvals through Lithgow City Council, all of which are summarised in Table 2.

Springvale Mine operates under Environment Protection Licence (EPL) 3607. Springvale Mine additionally holds Mining Leases, a Coal Lease, Mining Purposes Lease, Exploration Licences, Subsidence Management Plan approval, Groundwater Licences, Occupation Permits, Section 95 Certificates, a Dangerous Goods Licences and a Radiation Licence.

Tables 2 and 3 contain lists of the current consents, leases and licences relevant to Springvale Mine.

Table 2 Springvale Mine Development Consents

Ref No.	Description	Authority	Date	Expiry
DA 11/92	Original development consent under Section 101 of EP&A Act permitting the construction and operation of an underground coal mine, overland conveyor and CPP.	Department of Planning (now DP&I)	27 Jul 1992	28 Sept 2014
DA 11/92 (MOD 1)	Modification to the original development consent under Section 102 of the EP&A Act to allow the following: ▪ Modifications to the pit top layout; Modifications to storm water controls; New mine entry point; Relocation of mine ventilation shafts ▪ Extension of existing road to access shafts ▪ Use of the existing Western Main Colliery CPP; and ▪ Relocation of existing conveyor route to the Western Main CPP.	Department of Planning (now DP&I)	29 Jun 1993	28 Sept 2014
Modification to Development Consent DA11/92	Modification to the original development consent under Section 102 of the EP&A Act for the replacement of Attachment A (the land description) with Attachment 1 (Schedule of Lands and Tenements).	Department of Planning (now DP&I)	11 Apr 2004	28 Sept 2014
EPBC 2011/5949	Mining of Longwalls 415, 416 and 417 at Springvale Mine, NSW	Commonwealth Department of Sustainability, Environment, Water, Populations and Communities	14 Mar 2012	19 Mar 2032
DA 326/02	Application under Section 81(1)(a) of the EP&A Act for the construction and operation of a coal conveyor from Castlereagh Highway to Wallerawang Power Station.	Lithgow City Council	20 Sept 2002	20 Sept 2007 (if not commenced)
DA 461/02	Application under Section 81(1)(a) of the EP&A Act for the construction and operation of a Ventilation Shaft 3 facility on the Newnes Plateau.	Lithgow City Council	23 Jan 2003	23 Jan 2008 (if not commenced)

DA 461/02 S96 Modification 002/12	Upgrade of Ventilation Shaft 3 facility	Lithgow City Council	30 May 2012	N/A
Modification to Development Consent DA11/92	Construction and Operation of a dewatering facility (Section 75 W Modification). Bore 8.	Department of Planning & Infrastructure	8/3/2013	30/09/2015
Modification to Development Consent DA11/92	Extension of Mining Operations until 30 September 2015. Increase in annual production output (4.5Mt) and site personnel	Department of Planning & Infrastructure	5/12/2013	30/09/2015
Springvale Extension Project EIS	Extension of Mining Operations beyond September 2015	Department of Planning & Infrastructure	pending	

Table 3 **Springvale Mine Mining Authorities**

Reference	Title	Issue Date	Expiry Date	Area (Ha)
Springvale				
CL 377	Coal Lease 377	24 Feb 1992	9 Apr 2025	1,105
A 460	Authorisation 460	07 Jul 1992	6 Jun 2015	1,105
ML 1303	Mining Lease 1303	15 Dec 1992	14 Dec 2013	713
ML 1323	Mining Lease 1323	3 Aug 1993	3 Aug 2014	30.24
ML 1326	Mining Lease 1326	28 Sept 1993	18 Aug 2024	2,157
EL 6974	Exploration Licence 6974	13 Dec 2007	13 Dec 2012	4,385
ML 1537	Mining Lease 1537	16 Jun 2003	25 Jun 2024	4.13
ML 1588	Mining Lease 1588	19 Oct 2006	19 Oct 2027	975.5
ML 1670	Mining Lease 1670	17 Feb 2012	17 Feb 2033	0.3
Springvale Coal Services				
CCL 733	Consolidated Coal Lease 733	23 May 1990	3 July 2027	723.5
ML 204	Mining Lease 204	27 May 1910	27 May 2012	10.12
ML 564	Mining Lease 564	2 May 1922	2 May 2023	19.75
PLL 133	Private Lands Lease 133	10 Aug 1922	10 Aug 2024	16.51
ML 1319	Mining Lease 1319	5 July 1993	5 July 2014	5.71
ML 1352	Mining Lease 1352	23 Jun 1994	23 Jun 2015	8.2 in 2 parts
ML 1448	Mining Lease 1448	31 May 1999	31 May 2020	95.16
CL 361	Coal Lease 361	17 Jul 1990	16 July 2032	14.26
CL 394	Coal Lease 394	27 May 1992	27 May 2013	17.0
MPL 314	Mining Purposes Lease 314	3 Aug 1993	2 Aug 2014	96.4 in 2 parts

3.0 Plan Administration

3.1 Responsibility

The mine manager shall ensure sufficient resources are available to implement the requirements of this EMP. The environmental coordinator shall implement the monitoring and reporting requirements.

3.2 Consultation

Centennial Springvale is committed to a policy of regular liaison with the local community and strives to maintain positive relationships with stakeholders.

SMP reporting to the local community and relevant agencies regarding progress and environmental management performance will be achieved via the following communication and reporting mechanisms.

3.2.1 Community Consultation Committee

In accordance with the CCC Guidelines, the membership of the CCC will be comprised of an independent chair and appropriate representation from Centennial Springvale, Lithgow City Council and the general community in the area of the mine. The CCC will meet at least twice per year.

3.2.2 Subsidence Management Status Report (SMSR)

The compliance status of the SMP EMP will be reported in SMSR reports forwarded to government agencies, regulators and community groups.

3.2.3 End of Panel Report

An end of panel report will be prepared detailing the results of actions carried out under the EMP. The report shall include details on:

- A holistic assessment of overall swamp health
- A listing of trigger levels exceeded
- Actions taken in response to trigger level exceedances
- A review of the need for a response strategy for any exceedances

3.3 Review

The SMP EMP and NPSS MP are linked to the Commonwealth Approved THPSS MMP. Therefore to maintain consistency between the documents the SMP EMP and NPSS MMP will be updated after variations to theTHPSS MMP have been approved.

3.4 Complaints

The Environment and Community Coordinator is responsible for ensuring that all complaints are appropriately investigated, actioned and that information is fed back to the complainant, unless requested to the contrary.

3.5 Incidents

The reporting of incidents will be conducted as soon as practicable after Centennial Springvale becomes aware of the incident. Within five days of the date of the incident, Centennial Springvale will provide the relevant agencies with a written report on the incident.

4.0 Subsidence Predictions

4.1 Predicted subsidence for Longwalls 416 to 418

LWs 416 to 418 are located beneath the Newnes State Forest in the 3.25 m thick Lithgow Seam.

LWs 416 and 417 have cover depths of 360m to 410m and panel void widths of 261m. LW 416 and 417 will have a sub-critical panel width/cover depth ratio range of 0.72 to 0.63). The final maximum subsidence above these panels is predicted to range from 0.92m to 1.10m or 28% to 34% of the mining height of 3.25m.

LW 418 has a depth of cover of 350m to 420m. LW 418 will have a sub-critical panel width/cover depth ratio range of 0.75 to 0.62. The final maximum subsidence above this panel is predicted to range from 0.90 m to 1.05m or 28% to 32% of the mining height of 3.25m.

The reduction in longwall width and increase in chain pillars in mining areas below shrub swamps such as Sunnyside East and Carne West is an impact management strategy proposed for Springvale. Changes to the design of LW 415 were not feasible as development and mining of this longwall block had already commenced.

The critical change to the mining layout at Springvale is expected to result in a reduction in subsidence effects and hence potential impact on shrub swamps. The predicted subsidence effects above LWs 416 to 418 longwall panels presented in this study also assume that similar longwall panel geometries will be extracted further to the east of LW418.

4.2 Observed subsidence during the mining of Longwalls

Measured final subsidence above the four previous 315m wide panels (LWs 410 to 414) has ranged from 1.12m to 1.42m or 34% to 44% of the extraction height. The measured final subsidence above the first ten panels (LWs 1, 401 to 409) with an average width of 261m ranged from 0.73 m to 1.14m, or 27% to 39% of the extraction heights. This illustrates the actual measured reduction in subsidence at Springvale by using narrower longwall extraction widths.

Mining commenced at Springvale in 1992. Since this time 16 longwall panels have been mined. Details of the mining proposed in the approved SMP area for LWs 416 to 418 are summarised below, and the location of the longwall panels in the approved area are shown in Table 6. The term approved mining used in this EMP refers to mining approved in the Springvale Subsidence Management Plan (SMP).

5.0 Newnes Plateau Shrub Swamps

5.1 Shrub Swamps

The Springvale longwall mining operations are located beneath the Newnes State Forest situated to the north east of Lithgow, NSW. The Newnes State Forest (comprising the Newnes Plateau) is an economically, environmentally and socially significant area. Managed by Forests NSW for harvesting of native and introduced timbers, this area is ecologically significant due to the presence of the Newnes Plateau Shrub Swamps (NPSS), an Endangered Ecological Community (EEC) listed under the Threatened Species Conservation Act 1995.

Springvale has committed to undertaking seasonal flora monitoring as underground mining is considered a key threatening process to the NPSS. The primary objective of the monitoring program is to determine whether mining activities impact the health, species composition, and extent of the NPSS. Carne West Swamp and Sunnyside East Swamp are Newnes Plateau Shrub Swamps which overlie longwalls 416 to 418.

A rapid assessment of the existing condition of shrub swamps Carne West and Sunnyside East is detailed below. The condition score uses a rating system of 1 to 4 with 1 being the lowest rating (bad condition) and 4 being the highest rating (good condition). A condition score of 1 indicates a severe impact has occurred on a swamp system whereas a rating of 4 shows that the swamp is largely unaffected.

5.1.1 Sunnyside East Shrub Swamp

Status: Potential impact due mining Longwalls 416, 418.

Mapped swamp type (DEC 2006): Shrub Swamp (MU 50).

Rapid Assessment Program (RAP) location(s): This swamp was assessed from two locations.

- RAP 1 (238604, 6302993)
- RAP 2 (239187, 6303655)

Vegetation: The vegetation of this swamp, its position in the landscape and the presence of peat was consistent with mapping of this swamp as MU 50. The ground layer and shrub layer was simplified in the upper part of the swamp (RAP 1) with the ground layer being dominated by Gleichenia dicarpa (Plate 1). The shrub layer was dominated by Leptospermum grandifolium and Baeckea linifolia and some trees grew on the margins (and arguably within the swamp). Lower down in the catchment the swamp currently has greater diversity and structural complexity in the ground and shrub layers with additional species such as Leptospermum obovatum and Grevillea acanthifolia present and being indicative of a generally moist swamp environment.

Range of natural variability: Fire has caused some variability in successional state across this swamp. At RAP 1 (Plate 1) the shrub layer has been impacted by fire with shrubs surviving or unburnt in some areas but with shrubs burnt (and possibly killed) in other areas. This variability may decline over time as the upper swamp regenerates (the peat layer appeared to be substantially undamaged by the fire). The adjacent forest type to the swamp appeared to change from that recorded adjacent to RAP1 (with a dominance of Eucalyptus oreades) to a dry sclerophyllous woodland adjacent to RAP 2. These different adjacent vegetations would have some influence on the species composition at the different locations in the swamp.

Biological processes: The upper swamp (in the south) is generally dry and channelized, whilst the northern part (lower swamp) is likely to be permanently wet. The hydrological model for Sunnyside East (Aurecon 2011) indicates that the swamp is fed by shallow groundwater whilst a relatively high water table in the surrounding hills would maintain a generally continuous flow. However, it has been predicted that this flow may decline in drought. This hydrological model is reflected in the wetter conditions downstream in the swamp. Notably, however, plant species that predominate in continuously wet systems (e.g. Gymnoschoenus sphaerocephalus; Xyris juncea) are not a dominant components of the swamp as they are in wetter swamps to the east. Despite this, the wetter conditions downs stream would support higher rates of decay, may reduce fire impacts and provide an ecologically more stable system than upstream.

Condition: Sunnyside East was assessed using the methodology of CES (2010) as having a condition score of 3 at RAP 1 and 4 at RAP 2.

Plate 1. Sunnyside East Shrub Swamp RAP 1


Plate 2. Sunnyside East Shrub Swamp RAP 2

Threats: There is potential for alteration to fire regimes, mining activities and some actions / changes that could result from forestry (including localised erosion and flow alterations) to impact upon Sunnyside Swamp.

5.1.2 Carne West Shrub Swamp

Mapped swamp type (DEC 2006): Shrub Swamp (MU 50)

Status: Potential impact due to mining longwalls 417 and 418.

RAP location(s): This swamp was assessed from two locations.

- RAP 1 (239016, 6302504)
- RAP 2 (238903, 6302175)

Vegetation: The vegetation of this swamp, its position in the landscape and the presence of peat was consistent with the mapping of this swamp as MU 50 at RAP 1, but not so at RAP 2. The vegetation at RAP 1 was a species diverse and very high quality and structurally complex Shrub Swamp. Dominant species include Leptospermum obovatum, Leptospermum grandifolium and Grevillea acanthifolium in the shrub layer with Gleichenia dicarpa, Gahnia sieberiana and Empodisma minus being ground layer dominants. At RAP 2 the vegetation was very different floristically. The shrub layer was floristically simple (it included Leptospermum myrtifolium, Leptospermum grandifolium and Baeckea linifolia whilst the shrub layer included Epacris microphylla, Poa sieberiana and Lepyrodia scariosa as dominants). Trees of Eucalyptus pauciflora also occurred on the edge of this swamp at RAP 2.

Range of natural variability: The dominance of Leptospermum myrtifolium and the presence of Eucalyptus pauciflora and Poa sieberiana is consistent with MU 52 in DEC (2006) and the mapped vegetation for this polygon is considered to be a gradation across these vegetation types. Hence this mapped wetland grades from MU 52 (upslope) to MU 50 down slope. The upper part of this polygon connects to a mapped hanging swamp (MU 51 - see hanging swamp descriptions below).

Biological processes: Carne West Swamp is generally lower than Sunnyside West Swamp (see above) but connected to the same groundwater aquifer (Aurecon 2011). Thus flow monitoring points located in the lower parts of this swamp have measured flow when flow had ceased in Sunnyside West Swamp during drought conditions. This is consistent with the predominance of hydrophilic plant species and shrubs species that prefer very moist conditions at RAP 1. Upslope (at RAP 2) the plant species present are consistent with a swamp system which experiences more prolonged dry periods. Shrubs such as Leptospermum myrtilloides are generally found in upslope depressions / swamps and favoured by a longer dry period within the wetting – drying cycle. The upslope part of Carne West Swamp is also less species diverse and would also be more fire prone than the moist down slope locations.

Threats: The drier upslope parts of this swamp may be somewhat dependant on shallow groundwater or surface flows. Forestry has known impacts on water yields (Cornish & Vertessy 2001; Eamus & Froend 2006; Eamus, Froend, Loomes, Hose & Murray 2006; MacKay 2006; Webb 2010) and the upper catchment of Carne West Swamp has and continues to be part of an active logging program. This could potentially alter the hydrology of the upper swamp. A range of other threats exist for Carne West Swamp including erosion associated with recreational activities (unsealed trails / tracks), altered fire regimes and mining related impacts (including potential subsidence related impacts and surface impacts).

Condition: Carne West Swamp was assessed using the methodology of CES (2010) as having a condition score of 4 at RAP 1 and 3 at RAP 2 (reflecting the presence of bare patches in the swamp, some potential for continued erosion and possible forestry impacts).

Plate 3. Carne West Shrub Swamp RAP 1

Plate 4. Carne West Shrub Swamp RAP 2

6.0 Archaeological Sites

A survey was conducted in December 2004 by Environmental Resource Management Australia Pty Ltd. The following information, relating to potential heritage sites and artifacts was provided from this survey and report.

Occasional individual artifacts may occur undetected within the Springvale project study areas (SMP application area). Despite the non-detection of such sites due to vegetation cover, no further effort is warranted to identify or assess such sites.

No Aboriginal heritage sites with the potential to be impacted by longwall mining were found in the Springvale Colliery's proposed mine extensions, and analysis of the landforms observed during site survey suggests that it is unlikely such sites would be present.

Additionally there are two known aboriginal heritage sites within the proximity of, though not located within, the application area. These sites are located over the Springvale Colliery main headings adjacent to the outbye end of Longwall LW 410. The sites are rock shelters located in the upper catchment of Marrangaroo Creek approximately 600 metres from the #3 Shaft site (Appendix 2).

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7.0 Monitoring Program

7.1 Environmental Monitoring Strategy

The environmental monitoring strategy includes monitoring of the following parameters:

- Flora
- Fauna
- Groundwater and surface water
- Sensitive surface features
- Newnes Plateau weather
- Mine Infrastructure

The rationale of the monitoring program is detailed below.

Measure baseline information
Establish background data for the surface above the mining area.

Monitor the effects of mining
Continue monitoring of identified parameters at key positions relating to the longwall position. Monitoring is to be carried out at sites potentially impacted by longwall mining activities and these sites are referred to as impact sites. The selection of these sites is determined by mining activities .

Monitoring sites are also located away from the effects of mining activities. These sites are referred to as reference sites. Reference sites are monitored at the same frequency as impact sites. Reference sites are used as a comparative reference when determining whether any changes at impact sites are natural or whether changes are the result of mining activities.

Regularly assess and interpret monitoring data
Monitoring data is analysed to identify any variations from predictions or unexpected anomalies. Data from both impact and reference sites will be collected and monitored at regular intervals as described in the individual sections below. The analysis of data will include comparing pre-mining and post mining data from impact sites with data from reference sites. Data from reference sites will be compared to pre-mining data at impact sites in order to establish relationships between pre-mining impact sites and reference sites. Using an analysis and comparison with reference site data will also provide an additional cross check on data from impact sites pre and post mining.

Re-assess any impacts and determine consequences
Where variations are greater than predictions made in the SMP, additional assessment/investigation of impacts will be undertaken to determine any environmental consequences. This will be carried out by consultants and Springvale personnel as required.

Identify and implement remedial actions
Additional assessments may indicate a requirement for remedial action. Specialist consultant and stakeholder consultation will be an integral part of determining and implementing appropriate remedial actions.

Refine Monitoring Techniques
Monitoring technology and design will be regularly reviewed to take into account new developments in the science of environmental monitoring and reported research in the field.

7.2 Subsidence

Modelling predictions for the approved subsidence lines are detailed in Appendix 1 and approved subsidence lines are depicted in Appendix 2.

Condition 10 of the Springvale SMP approval requires the establishment of the Subsidence Monitoring and Reporting Program. This document details the schedule for subsidence monitoring at the colliery. The most recent Subsidence Monitoring and Reporting Program for LW416 - LW418 was approved on the 9th December 2011.

Data Analysis Methodology
Empirical models will be used to estimate worst case subsidence effects based on differences between observed and predicted smooth subsidence profiles. It is not practical or reasonable to compare continuous, smooth profile predictions of subsidence, tilt and strain to measured subsidence effect profiles that may include effects of discontinuous strata behaviour such as valley up-sidence and cracking.

Smooth profile predictions of subsidence, tilt and strain will be used to provide systematic predictions relative to the proposed mining layout, but do not include discontinuous strata behaviour effects. The predictions provided to-date have therefore included a field calibration factor for estimating worst case values for a given mining geometry.

Table 4 **Subsidence monitoring management measures**

Trigger type	Response to trigger	Possible cause of trigger	Management measures
Determine whether exceedence of subsidence modelling prediction **is due to a data error**			
Data error	• Check data • Check methodology • Check survey marks • Check calculations	• Misreading • Data handing error • Survey marker damage • Calculation error	• Amend any erroneous data • Review data handling processes and improve if possible • Repair survey marker if necessary • No need to report to DRE if data error
	Exceedence of the subsidence modelling prediction within 200 metres of a shub swamp		
Anomalous subsidence trigger exceeded > 15% once	• Determine extent and magnitude of anomalous subsidence • Determine likely reasons for anomalous subsidence • Determine the potential impacts of the anomalous subsidence on the THPSS	• Undetected data error • Previously unidentified structural discontinuity in the overburden • Other unexpected geological or topographical conditions • Inadequate prediction model	• Inspect site for visual impact • Assess the need for additional survey or wait for next scheduled survey • Report on trigger level exceedence to DRE within 10 working days
Anomalous subsidence trigger exceeded > 15% twice at same location on consecutive surveys.		• Previously unidentified structural discontinuity in the overburden • Other unexpected geological or topographical conditions • Inadequate prediction model	• Inspect site for visual impact • Assess the need for additional survey • Review prediction model and input assumptions. • Notify stakeholders of exceedence • Report on trigger level exceedence to DRE within 10 working days

7.3 Shrub Swamps

7.3.1 Monitoring Sites

Flora monitoring sites within the SMP area are detailed in Table 7 with plans in Appendix 2.

Shrub swamps Carne West and Sunnyside East overly longwalls 416 to 418.

Research over the last three and half years by the Centre for Mined Land Rehabilitation at the University of Queensland has led to the development of five monitoring parameters for use in detecting the above impacts in Newnes Plateau Shrub Swamp communities. These parameters will be used in this EMP and include:

- Reduction in the number of native swamp species present
- Reduction in the condition of key species (qualitative scores 1-5)
- Expansion of non-live ground cover (including bare ground and dead plant material)
- Recruitment of non-swamp species (presently eucalypts)
- Establishment of non-native weeds.

7.3.2 Monitoring Method

At least one quadrat will be located at each of the impact and reference sites.

Transects will be assessed within each quadrat. The starting points of these transects will be positioned randomly along a predetermined edge of the fixed monitoring quadrat. This means that while transect orientation will be fixed at each monitoring time, the start location along the plot axis will be randomised to minimise the impact of monitoring activities.

Quantitative sampling will be conducted using the point intercept method, scoring all vegetation between ground and sky that intercept a vertical line from the point on the ground. The data collected at each point will include species identification condition score of species present and presence/absence of non-live ground cover.

Additionally, along each transect 50cm x 50cm quadrats will be scored at 1 metre intervals for the presence/absence of eucalypt species and weed species. This will provide a total of approximately 80 quantitative measurements of weed and eucalypt presence/absence per monitoring plot. This methodology is described in detail in Erskine and Fletcher (2011). The condition score ratings are set out in Table 5.

Table 5 **Condition Score definitions**

1	Severe damage/dieback
2	Many dead stems
3	Some dead branches present
4	Minor damage
5	Healthy

7.3.3 Monitoring Frequency

Monitoring of flora will be undertaken for a period of 3 years post-mining. The parameters will be measured seasonally during this period. The monitoring program for particular sites will be adaptive should there be a requirement for additional monitoring.

7.3.4 Data Analysis

Data collected since 2003 has been analysed using a range of statistical techniques (see Denny 2011 and Erskine and Fletcher 2011). However, in this plan the strong trend lines found in the range of measured values and the time taken for these values to respond to disturbance and return to pre-disturbance values are used as trigger values for detecting potential impact. This means that simple easily understood numerical values that are clear and precise are used for each of the five trigger levels used in this plan.

Table 6 **Summary of flora monitoring data analysis techniques**

Performance indicator	Parameter measured	Data Analysis and Trigger Methodology
Change in species assemblage	Change in diversity of native species	A change in the number of species as detailed in the THPSS MMP.
	Recruitment of eucalypt species	An increase in eucalypts as detailed in the THPSS MMP.
Change in condition	Condition of key species	A decline in condition score as detailed in the THPSS MMP.
	Non-live ground cover	An increase of bare ground as detailed in the THPSS MMP.
	Non-native weeds	An increase in non-native weed species as detailed in the THPSS MMP.

Table 7 **Details of the flora monitoring and reference sites**

	Monitoring site name	Swamp	Easting (GDA94)	Northing	Description
Impact Sites	WC01	Carne West Swamp	239461	6303219	Permanently wet, groundwater fed swamp. Dominated by Gymnoschoenus sphaerocephalus, Lepidosperma limicola, Leptospermum grandifolium, Gleichenia dicarpa, Xyris gracilis ssp. gracilis and Baeckea linifolia.
	WC02	Carne West Swamp	239461	6303321	Permanently wet, groundwater fed swamp. Dominated by Gymnoschoenus sphaerocephalus, Lepidosperma limicola, Leptospermum grandifolium, Gleichenia dicarpa, Xyris gracilis ssp. gracilis and Baeckea linifolia.
	WC03	Carne West Swamp	239195	6302908	Permanently wet, groundwater fed swamp. Dominated by Gymnoschoenus sphaerocephalus, Lepidosperma limicola, Leptospermum grandifolium, Gleichenia dicarpa, Xyris gracilis ssp. gracilis and Baeckea linifolia.
	WC04	Carne West Swamp	239157	6302773	Permanently wet, groundwater fed swamp. Dominated by Gymnoschoenus sphaerocephalus, Lepidosperma limicola, Leptospermum grandifolium, Gleichenia dicarpa, Xyris gracilis ssp. gracilis and Baeckea linifolia.
	SSE01	Sunnyside East	239022	6303531	Southern half is generally dry and channelized. Northern half likely permanently wet. Dominant species include Gleichenia dicarpa, Leptospermum grandifolium, Baumea rubiginosa and Gahnia sieberiana
Reference sites	TG01	Twin Gully	236565	6308755	Permanently wet, groundwater fed swamp. Dominant species include Baeckea linifolia, Grevillea acanthifolia, Gleichenia dicarpa and Sphagnum cristatum.
	TG02	Twin Gully	236439	6308765	Permanently wet, groundwater fed swamp. Dominant species include Baeckea linifolia, Grevillea acanthifolia, Gleichenia dicarpa and Sphagnum cristatum.
	TRI01	Tristar	236565	6308755	Permanently wet, groundwater fed swamp. Dominated by Baeckea linifolia, Gleichenia dicarpa, Grevillea acanthifolia, Lepidosperma limicola, Leptospermum grandifolium
	TRI02	Tristar	236439	6308765	Permanently wet, groundwater fed swamp. Dominated by Baeckea linifolia, Gleichenia dicarpa, Grevillea acanthifolia, Lepidosperma limicola, Leptospermum grandifolium
	LGG01	Lower Gang Gang Swamp	240148	6303040	Permanently wet, groundwater fed swamp, with channelized flows. Dominated by Leptospermum grandifolium, Lepidosperma limicola, Boronia deanei and Gleichenia dicarpa
	UGE01	Upper Gang Gang East Swamp	239928	6301878	Ephemeral, likely rainfall fed. Dominated by Gleichenia dicarpa, Leptospermum grandifolium, Lepidosperma limicola, Gymnoschoenus sphaerocephalus and Xyris gracilis ssp. gracilis.
	BS01	Barrier Swamp	242111	6303738	Permanently wet, groundwater fed swamp. Dominated by Gleichenia dicarpa, Leptospermum grandifolium, Lepidosperma limicola, Gymnoschoenus sphaerocephalus and Xyris gracilis ssp. gracilis.
	CCS01	Carne Central Swamp	241196	6302578	Ephemeral, likely rainfall fed. Dominated by Lepidosperma limicola, Empodisma minus, Callistemon pityoides, Grevillea acanthifolia.

7.4 Groundwater

The groundwater monitoring program has been implemented on the Newnes Plateau to detect mining related impacts on groundwater levels and groundwater chemistry.

The monitoring programs include the following main aspects:

- Groundwater levels are monitored in impacted and reference shrub swamps
- Swamp surface flows are measured using a combination of a v-notch weir and pool depth monitors.
- The groundwater levels in the upper aquifer zone in the overburden is measured in piezometers that are installed on the ridges between the swamps.
- A basic weather station provides climatic data on the plateau.

7.4.1 Shrub Swamp Piezometers

Groundwater levels are monitored in impact and reference shrub swamp sites within the SMP area and are detailed in Table 8 and illustrated on plans in Appendix 2.

Groundwater levels are measured at three hourly intervals by automatic water level logging instruments installed in the boreholes. The groundwater level data are downloaded at two-monthly intervals. This involves visiting each piezometer to remove the instrument from the borehole and download the data with a lap top computer.

Chemical analysis is carried out for analytes that will indicate mining-induced changes in the swamp systems. The main possible impact on groundwater quality from mining is the potential for oxidation of fresh rock surfaces in subsidence-induced cracks that may form in the rock under the base of a swamp. The parameters that are monitored as indicators of any mining-related impacts and the justification for their use are ph, electrical conductivity and iron.

Table 8 Swamps – Groundwater Monitoring

	Site name	Easting (GDA94)	Northing	Location
Impact sites	SSE1	238668	6303143	LW416/417
	SSE2	238831	6303352	LW 417
	SSE3	239064	6303558	LW 418
	CW1	239352	6303196	LW 419
	CW2	239382	6303247	LW 419
	CW3	238977	6302179	LW 417
	CW4	239070	6302377	LW 417
Reference Site	CC1	241193	6302693	LW 418
	MS1	238860	6299169	LW 418
	TS1	237559	6307289	Angus Place
	TG1	236438	6308766	Angus Place

7.4.2 Aquifer Piezometers

Monitoring sites of deep and shallow aquifer pieozometers are detailed in table 9 and illustrated in Appendix 2.

Aquifer piezometers are installed in open boreholes drilled from ridge tops and are designed to intersect the aquifer that feeds the swamps. Some piezometers have been installed in exploration bores that have been grouted up to the aquifer base. A length of 50 mm class 12 UPVC casing is inserted into the bore. The bottom six to nine metres of the casing is slotted and enclosed in filter sock to permit groundwater movement into the casing and to exclude other material that may cause blockages. The annulus around the casing is filled with sand and the collar enclosed in concrete or bentonite to prevent water ingress from surface runoff.

Automatic water level logging instruments are installed and groundwater levels are measured at three hourly intervals by automatic water level logging instruments. The groundwater level data are downloaded at two-monthly intervals using a lap top computer.

Table 9 **Aquifer Groundwater Monitoring**

	Site name	Easting (GDA94)	Northing	Location	GW depth
Impact sites	RSS	238072	6303500	Over LW 415	✓
	SPR1101	238484	6303627	Over LW 416	✓
	RCW/ SPR1104	239746	6303184	Over LW 420	✓
	SPR1107	239739	6302330	Over LW 420	✓
	SPR1109	239186	6303314	Over LW 418	✓
	SPR1110	238699	6302635	Over LW 416 / 417	✓
Reference Site	SPR1108	239840	6301075	South of LW 420 Over LW427	✓
	SPR1111	240404	6303692	Nth of LW 422	✓
	SPR1113	240625	6302160	Over LW 423	✓
	AP5PR	236523	6308535	NE of Angus Place Mine	✓

7.4.3 Groundwater Level Data Analysis

The methodology for developing groundwater level triggers to determine whether anomalous impacts have occurred is based on statistical analysis and the development of percentile based triggers. Statistical techniques have been applied to baseline data as shown in Appendix E,THPSS MMP. This methodology has been used due to the absence of a universally accepted methodology for development of groundwater impact triggers.

Short-term significant changes in groundwater level are considered to occur at the 95 percentile level. However, exceedence of this level, by definition, will occur five percent of the time under natural conditions. This has led to the development of long term triggers that complement the short term triggers. Any mining-induced changes in groundwater levels will be inferred based on a set of trigger values for the groundwater depths in swamp piezometers and the groundwater elevations at ridge top aquifer piezometers installed beneath the ridges between swamps.

A single-sided trigger will be used to check if the swamps are losing water in an anomalous manner. A double-sided trigger for water elevation in deeper aquifer piezometers (at 5 and 95 percentiles) will be used to check if the water table is dropping anomalously due to deep drainage or alternatively is being built up anomalously from an overlying or adjacent water source.

The percentile groundwater depths will be determined using the data set collected up to the end of the pre-mining period. The recorded groundwater depths and elevations during the mining of LW416 to LW418 are to be seven-day moving averages to account for occasional short-term spikes due to electronic noise, false readings, or disturbance during data downloads and water quality sampling.

Long term impacts will be determined by comparing the groundwater levels in each piezometer over the active longwall panel with groundwater levels in reference piezometers and other impact piezometers that are not affected by the current mining.

The trigger levels are based on the monitoring record from 1 January 2005 up to 31 December 2011 at the swamp piezometers and up to 30 April 2012 for aquifer piezometers. The location of groundwater monitoring sites is shown in Appendix 2.

7.4.3 Groundwater Quality Data Analysis

Triggers for groundwater quality have been developed using data collected from reference sites as set out in Appendix E THPSS MMP. This data has been assessed using the ANZECC (2000) Water Quality Guidelines for the Protection of Aquatic Life (95% species protection levels) to calculate the triggers. Groundwater quality triggers were developed using the ANZECC (2000) guidelines procedure for setting local guidelines when the water quality does not meet the default ANZECC (2000) guideline values because of local conditions. The 80th percentile value of background water quality is used as the local water quality value in the case where the background concentrations are higher than the ANZECC (2000) guidelines. The default is used if the 80th percentile is lower than the default trigger value. This approach has been used to develop the water quality triggers for groundwater.

The ANZECC (2000) guidelines provide an approach to deriving low-risk trigger values in slightly to moderately disturbed environments. The 20th and 80th percentiles of background water quality parameters should be used that may cause impacts at both high or low values. This approach has been used to derive the water quality ranges for pH.

7.5 Surface Water

7.5.1 Flow Rate Monitoring

Flow rate monitoring using flow meters has been adopted due to the difficulty in establishing stream flow weirs. Flow readings are taken at the downstream end of the Carne West Swamp and Marrangaroo Upstream site using a Pygmy flow meter. The flow velocity in the watercourse is measured and read directly from the flow meter as the number of revolutions of the propeller for a fixed period of time. This is converted to a velocity using a conversion formula. The flow volume in ML/day is calculated by multiplying the flow velocity by the estimated cross sectional area of the flow.

7.5.2 Pool Water Level

Water pool level monitoring will be used in combination with flow rate monitoring in order to monitor stream flow. Pool water level monitoring has been recently introduced to assist with calculating flows in combination with flow meter monitoring. A twelve month data set of flow metering and pool level data will be collected and assessed for accuracy prior to developing triggers. The water level in the pool at the downstream end of Carne West Swamp is measured at three hourly intervals by an automatic water level logging instrument installed in the base of the pool. The water level data are downloaded at two-monthly intervals. This involves visiting the pool site to remove the instrument from the pool and download the data to a hand held computer.

7.5.3 Water Quality

Surface water quality is measured in both Sunnyside East and Carne West Swamps. The Carne West water monitoring site is the same as the flow monitoring site which was established in 2005, and the Sunnyside East site was established in 2010. Sampling of the surface water is carried out fortnightly. The main parameters that are monitored to detect these impacts include ph, electrical conductivity, iron, manages, total suspended solids.

The same parameters will be measured in Marrangaroo Creek Upstream which will be used as a reference site for surface water quality. This site has been selected as water quality in Marrangaroo Creek Upstream is similar to Sunnyside East and Carne West.

Table 10 **Details of Surface Water Monitoring Sites**

Impact sites	**Carne West**	239808	6303782	Nth end of Carne West Swamp
	CWP	239816	6303814	Nth end of Carne West Swamp
	SS3 D/S	239363	6303908	Nth end of Sunnyside East Swamp
Reference site	**Marangaroo Creek Upstream**	236633	6301063	Marangaroo Creek upstream

7.5.4 Data Analysis Methodology

Surface water quality triggers have been developed using the ANZECC (2000) water quality guidelines for protection of aquatic life (95% species protection levels). These have been applied to the surface water monitoring data shown in Appendix F, THPSS MMP. Minor and major variation / impacts will be assessed by using the ANZECC protocols of comparing the pre-mining 80th and 95th percentile baseline with the 50th percentile of the post-mining data and allowing for the effects of short-term spikes due to rainfall runoff events.

The guidelines require 24 measurements to set the baseline 80th and 95th percentiles, so that accurate trigger values can be set to activate appropriate corrective actions.
Sufficient pre-mining data was available for individual trigger levels to be set for each piezometer prior to the area being undermined.

Minor and major changes will be determined statistically. Minor changes do not require any management or corrective actions, but provide an early warning of potential permanent changes in the water chemistry. Major changes indicate the need for management or corrective actions.

7.6 Fauna

Centennial Coal has carried out fauna monitoring on the Newnes Plateau for 8 years. Fauna monitoring will continue to be carried out into the future as part of general research efforts on the plateau. There are statistical methods that can be used to determine changes in faunal distributions and numbers in given areas. However, it is difficult to relate any changes directly to any impacts that may occur due to mining activities. This is particularly difficult given the inherent mobility of fauna species, the difficulty that is often experienced in finding individual species at any one location in time and the diversity of land use on the Newnes Plateau.

No triggers will therefore be proposed in this EMP due to the difficulties in developing direct relationships between mining and faunal behaviour.

Centennial Coal will continue to work towards developing meaningful mining related faunal triggers. The data that has been collected in the past and into the future will provide a comprehensive baseline data set.

7.6.1 Monitoring Methods

The faunal surveys will sample a range of faunal groups with a specific emphasis on threatened/endangered species (listed under the TSC Act 1995 and the EPBC Act 1999) Targeted searches will be carried out for threatened species during spring.

Data from the surveys is analysed to show:

- Species counts
- Habitat Characteristics
- Species Diversity
- Species richness

Monitoring will be carried out by way of manually setting traps and/or inspections. Trapped animals will be released within 24 hours of being trapped. Species identified will be recorded and the data analysed. Inspections will be carried out by a qualified, experienced and recognised fauna consultant.

7.6.2 Data Analysis and Reporting

If threatened species are located then dedicated monitoring for each species will be conducted during subsequent surveys.

Any loss of threatened or endangered species will be investigated and reported against the contingency plan.

7.7 Surface Features

Visual and photographic inspections of sensitive surface features may include rock formations, drainage lines, fire trails, waterholes, rock beds within the watercourses.

There are two aspects regarding the potential impacts on drainage lines. These include change of flow characteristics and the impact on rockbars, particularly within swamps.

The inspections will identify any impacts. This may include new water ponding, change in flows, changes to vegetation, changes in flow route and rock bar disturbance, cracking or upsidence. If this occurs, a field inspection will be carried out by a geotechnical expert and Springvale staff. The objective of this investigation will be to determine any adverse consequences to the flows within the drainage line and any adverse consequences to stream banks.

7.7.1 Monitoring Sites

Photographic inspections of sensitive features above the longwall shall be undertaken within 4 months (where practicable) prior to mining. The purpose of this inspection is to gain a baseline record of the surface before underground mining takes place and to record the condition of sensitive surface features. The sensitive surface features will be inspected post mining for any visible impacts.

7.7.2 Monitoring Methods

Where sensitive surface features are located, photographic monitoring sites will be established (with GPS location) and inspections will be carried out pre and post mining of the subject longwalls.

7.7.3 Data Analysis

Climatic data, subsidence and groundwater monitoring data will be used to assist in the analysis of the results where necessary.

A report will be generated from the data with results summarised into the SMSR. An annual summary will be prepared for the AEMR.

Any irregular movements will be investigated and reported in accordance with the contingency plan.

7.8 Mine Infrastructure - Powerlines and Pipelines

7.8.1 Layout of Monitoring Sites

The mine infrastructure will be monitored through regular inspections. All powerlines will be designed to allow for the predicted subsidence, tilts and strains.

The pipelines transporting water to the Wallerawang Power Station from dewatering boreholes have been installed such that any impacts from mine subsidence shall be negligible.

Controls which have been or are being installed include:

- The use of a fully welded, appropriately rated poly pipeline with the ability to withstand the predicted strains;
- Burying of the pipeline to prevent damage by fire or machinery

8.0 Management Measures and Remediation

The Trigger Action Response Plan details the process how exceedances are investigated (refer to charts 1-2).

8.1.1 Contingency Plan

Note that subsidence trigger exceedances shall be reported inline with the contingency plan only when they are within 200 meters of a shrub swamp. Other subsidence exceedance's will be detailed in the quarterly subsidence management status reports and end of panel reports.

In the event the trigger levels are considered to have been exceeded, Springvale will implement the contingency plan (chart 3) to manage any unpredicted impacts and their consequences.

Chart 1 – Trigger Action Response Plan Overview

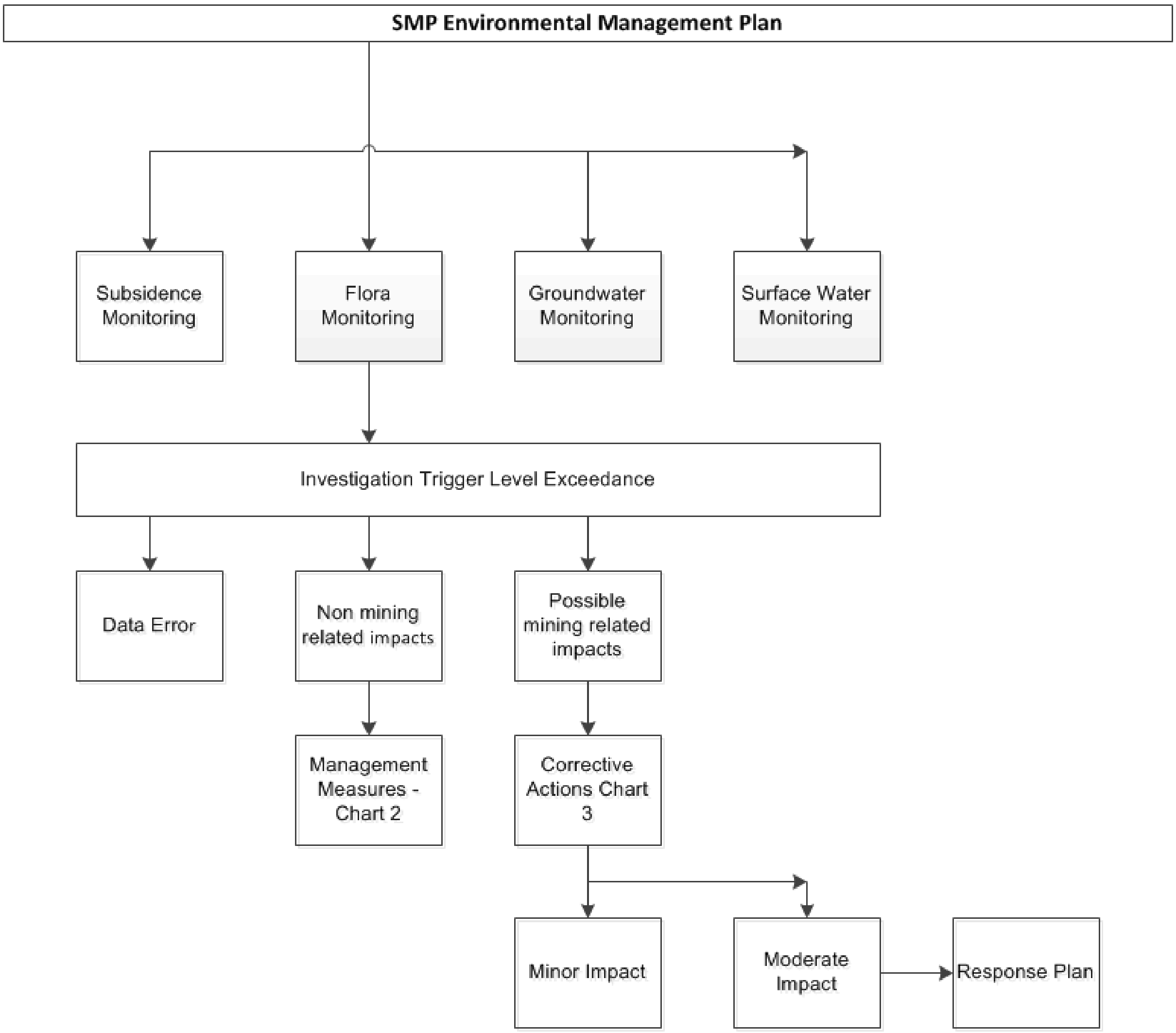


Chart 2 Trigger Action Response Plan

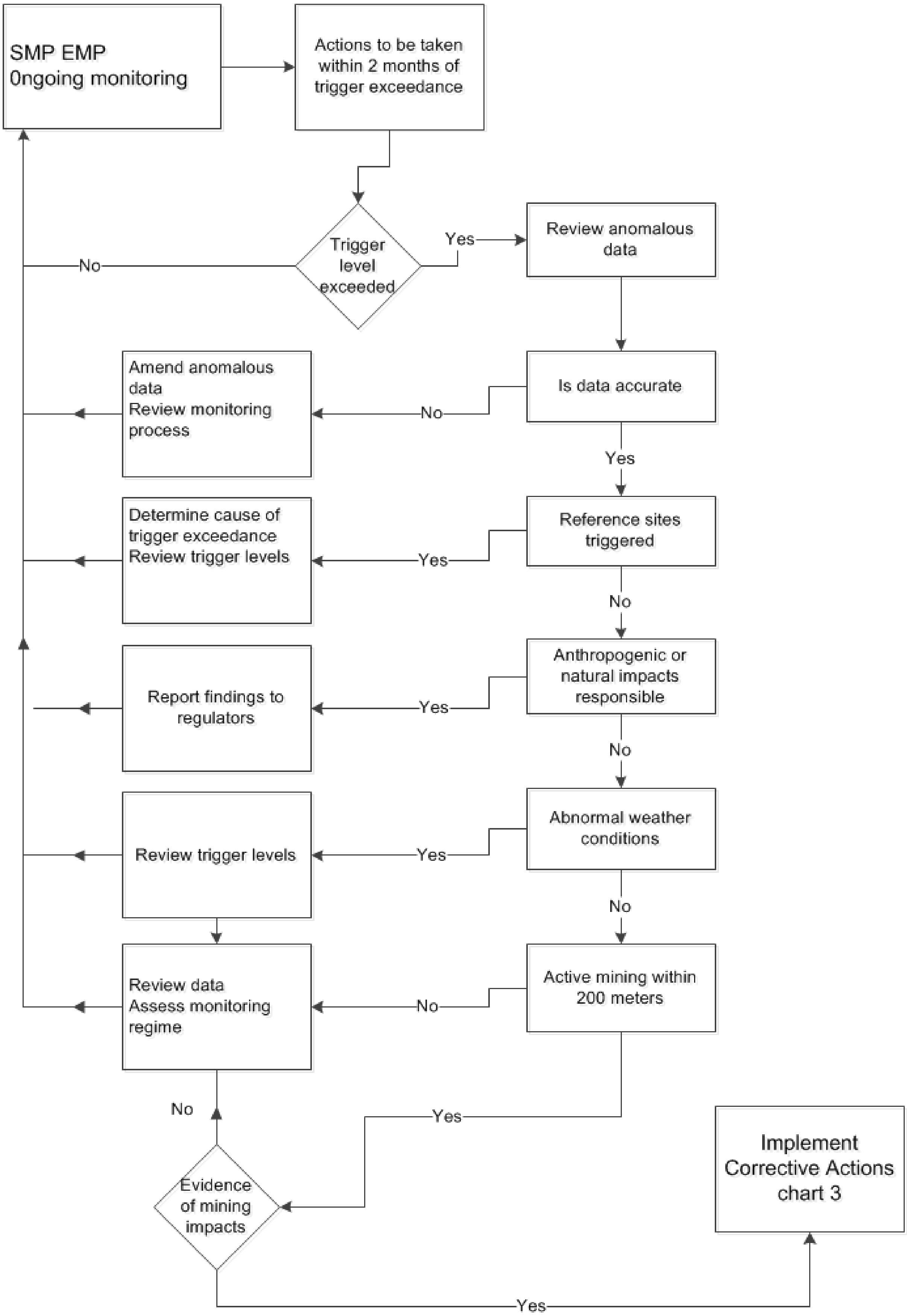
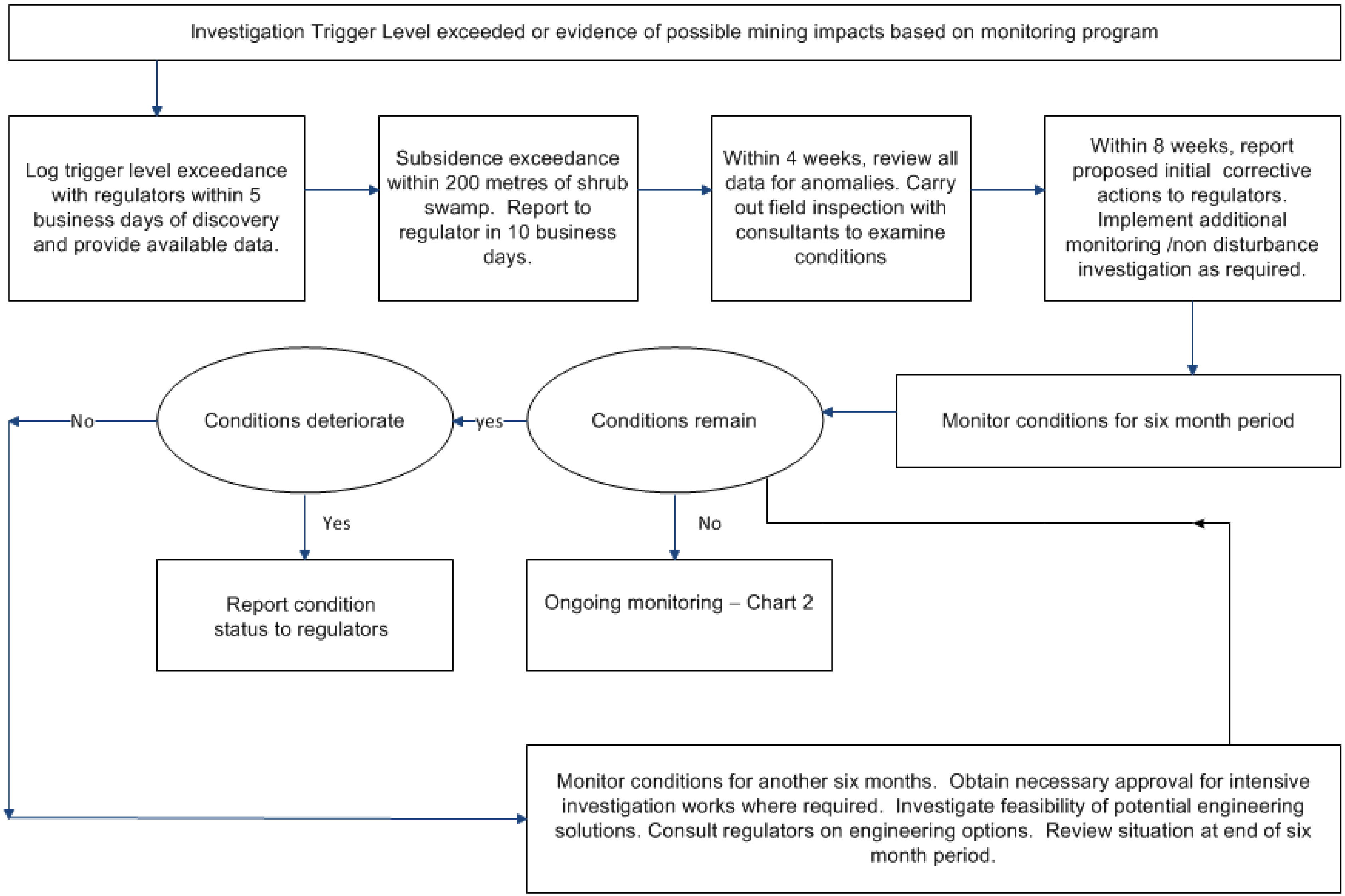


Chart 3 -Trigger Action Response Plan



8.2 Remediation Strategies

8.2.1 Fire Trails

It is anticipated that most cracks will self-repair due to natural processes. Where natural processes have not completely filled each crack, ripping or grading to infill the crack will be undertaken where necessary.

8.2.2 Soft Engineering Solutions

This technique involves damming or packing channelised areas of swamp, to prevent the ongoing dewatering of swamp substrates, and to retain water and eroding swamp substrates within the swamp system. It involves detaining both surface and subsurface water flows through the use of gradient stabilization and other bed control structures in channelised areas. This aids to establish water detention systems to store surface water flows, and prevent the ongoing erosion and dewatering of swamp substrates. It also provides the benefits of the retained surface water flows integrating with groundwater instead of passing through the system rapidly, taking with it eroded swamp substrates. Appendix 4 contains the soft engineering manual prepared by the Blue Mountains City Council. Section 3 of the manual provides case studies using soft engineering techniques.

Figure(s) 1 & 2 illustrate the before and after results from the use of coir logs at Braeside Swamp. Prior to the management intervention the swamp was dominated by exotic grasses. Approximately six months later the increased water-logging has created a trajectory of change promoting the re-colonisation of indigenous sedges and the natural die-back of exotic grasses.

A section 95 Application to the Office of Environment and Heritage is required prior to the implementation of soft engineering solutions within shrub swamps on the Newnes Plateau.

Figure 1 Braeside Swamp condition during installation of coir logs.

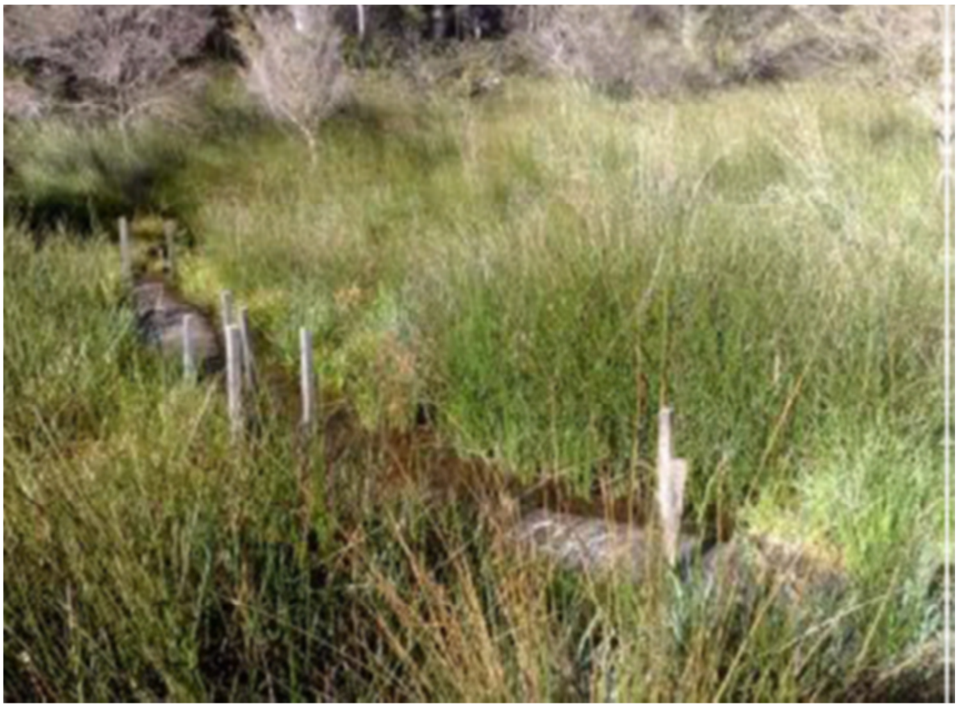


Figure 2 Braeside Swamp condition six months after installation of coir logs.

8.2.3 Hard Engineering Solutions

Grouting of rock formations has been occurring since the 1800's (Heidarzadeh et al (2007)), the technology has evolved since this time. It can be used in a range of different applications. Grouting is utilised to either stabilise rock formations or to manage the flow of groundwater and has been implemented successfully for decades in underground coal mines in Australia and overseas.

This technology has been recently adapted to seal mine subsidence related surface and sub-surface cracking in rock bars in the southern coalfields of NSW.

"Injection grouting" is the process of injecting grout using pre-drilled holes into a cracked rock bar or swamp substrate. Grouting involves injecting a permanent low permeability material into cracked areas to provide a seal to control vertical or horizontal water flows. There are various types of grouts that can be used but generally they will be either cement based or polyurethane resins (PUR). The use of injection grouting for remediating subsidence cracking has been pioneered in the southern coalfields of NSW and has been used to successfully repair cracking in surface and near surface rock substrates.

Grout is pumped into the targeted area at low pressure once the grouting holes have been drilled. High viscosity grouts are used for vertical fracturing as the setting time for vertical holes needs to be shorter to optimise the use of the grout which flows faster in vertical cracks under the influence of gravity. Lower viscosity grouts would be used where horizontal cross linking of cracks is present.

A specific example of where PUR grouting has been shown to successfully repair a rock substrate can be seen at Helensburgh Coal Pty Ltd (HCPL) in the NSW Southern Coalfields. Experience at HCPL has shown that grouting using PUR can be used to successfully fill cracks ranging from small sub millimetre sized cracks to open fractures greater than 100mm. A trial was conducted at HCPL on the WRS4 rock bar in the Waratah Rivulet and was followed by a remediation report (Waratah Rivulet Remediation Trial Activities – Completion Report (2007)). The main findings of the remediation report were:

- PUR is non-toxic
- PUR injection can be conducted in an environmentally acceptable fashion
- PUR injection is suitable for sealing cracking in rocks from less than 1mm to greater than 100mm
- Pre and post permeability testing showed that permeability was reduced by several orders of magnitude following PUR injection
- The PUR injection process was transferrable to other areas where cracking of rock had occurred

The HCPL PUR grouting programs are used to seal cracking in outcropping rock bars. However, it is considered that this technology is transferrable and can be used to seal cracks in swamp bases as a swamp base is analogous to a rock bar, albeit one covered with peat and sand. A comprehensive case study of the HCPL PUR grouting program is set out in Appendix 6.

Previous experience of subsidence cracking at Springvale and Angus Place and predictive modelling shows that significant subsidence cracking above the two collieries is unlikely. With the event of cracking unlikely, it is hence unlikely that grouting will need to be used to repair rock bars or swamp substrates. However, this technology has been identified as a proven remediation strategy should anomalous cracking be identified.

9.0 References

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Springvale Coal Pty Ltd (2010). Springvale Mine Longwalls 411-418 Subsidence Management Plan Variation Application. Variation of Installation Face Position for Longwall 414.

Springvale Coal Pty Ltd (2011). Subsidence Management and Reporting Plan for LW415 to 417. September 2011.

RPS 2012. Springvale Swamps Case Study

APPENDIX 1

MONITORING INVESTIGATION TRIGGER LEVELS

Monitoring Investigation Triggers Levels

Subsidence investigation trigger levels within 200 metres of a shrub swamp		
Longwall Identification		**Subsidence Modelling Predictions**
LW416 to 418	B and M lines	▪ Subsidence > 1.10m ▪ Tilt > 7mm/m ▪ Tensile Strain > 10mm/m ▪ Compressive Strain > 14mm/m (valleys), 6 mm/m (plateaus)
Sunnyside East Swamp	M, V and W Lines	▪ Subsidence >1.1 metres ▪ Tilt > 7 mm/metre ▪ Tensile Strain > 5 mm/metre ▪ Compressive Strain >14 mm/metre
Carne West Swamp	Y, X and B Lines	▪ Subsidence >1.1 metres ▪ Tilt > 7 mm/metre ▪ Tensile Strain > 5 mm/metre ▪ Compressive Strain >14 mm/metre

Triggers are considered to have been reached if subsidence is 15% greater than Subsidence Modelling Predictions

	Groundwater Level			
	Aquifer Piezometer	**Parameter**	**Monitoring Frequency**	**Investigation Trigger**
Impact Sites	RSS, SPR1101, SPR1104, SPR1107, SPR1109, SPR1110, SPR1110	Groundwater Level	Daily	Performance indicators will be considered to have been exceeded if statistically significant changes are indicated by the data such as: ▪ For short-term change – if the groundwater level < 5th percentile or > 95th percentile pre-mining groundwater level for more than one month ▪ For long-term change – if the post-mining 50th percentile groundwater level for any piezometer < 20th percentile or > 80th percentile pre-mining level
Reference Site	SPR1108, SPR1112, SPR1113, AP5PR	Groundwater Level	Daily	Performance indicators will be considered to have been exceeded if statistically significant changes are indicated by the data such as: ▪ For short-term change – if the groundwater level < 5th percentile or > 95th percentile pre-mining groundwater level for more than one month ▪ For long-term change – if the post-mining 50th percentile groundwater level for any piezometer < 20th percentile or > 80th percentile pre-mining level

	Groundwater Level			
	Shrub Swamp Piezometer	**Parameter**	**Monitoring Frequency**	**Investigation Trigger**
Impact Sites	Carne West Swamp CW1*, CW2*, CW3, CW4 Sunnyside East Swamp* Piezometers: SSE1, SSE2, SSE3*	Groundwater Level	Daily	Performance indicators will be considered to have been exceeded if statistically significant changes are indicated by the data such as: ▪ For short-term change – if the groundwater depth > 95th percentile pre-mining groundwater depth for more than 7 consecutive days ▪ For long-term change – if the post-mining 50th percentile groundwater depth for any piezometer > 80th percentile pre-mining level
Reference Site	Carne Central Swamp Piezometer: CC1* Marangaroo Swamp Piezometer: MS1* Tristar Swamp Piezometer: TS1 Twin Gully Swamp Piezometer: TG1	Groundwater Level	Daily	Performance indicators will be considered to have been exceeded if statistically significant changes are indicated by the data such as: ▪ For short-term change – if the groundwater depth > 95th percentile pre-mining groundwater depth for more than 7 consecutive days ▪ For long-term change – if the post-mining 50th percentile groundwater depth for any piezometer > 80th percentile pre-mining level

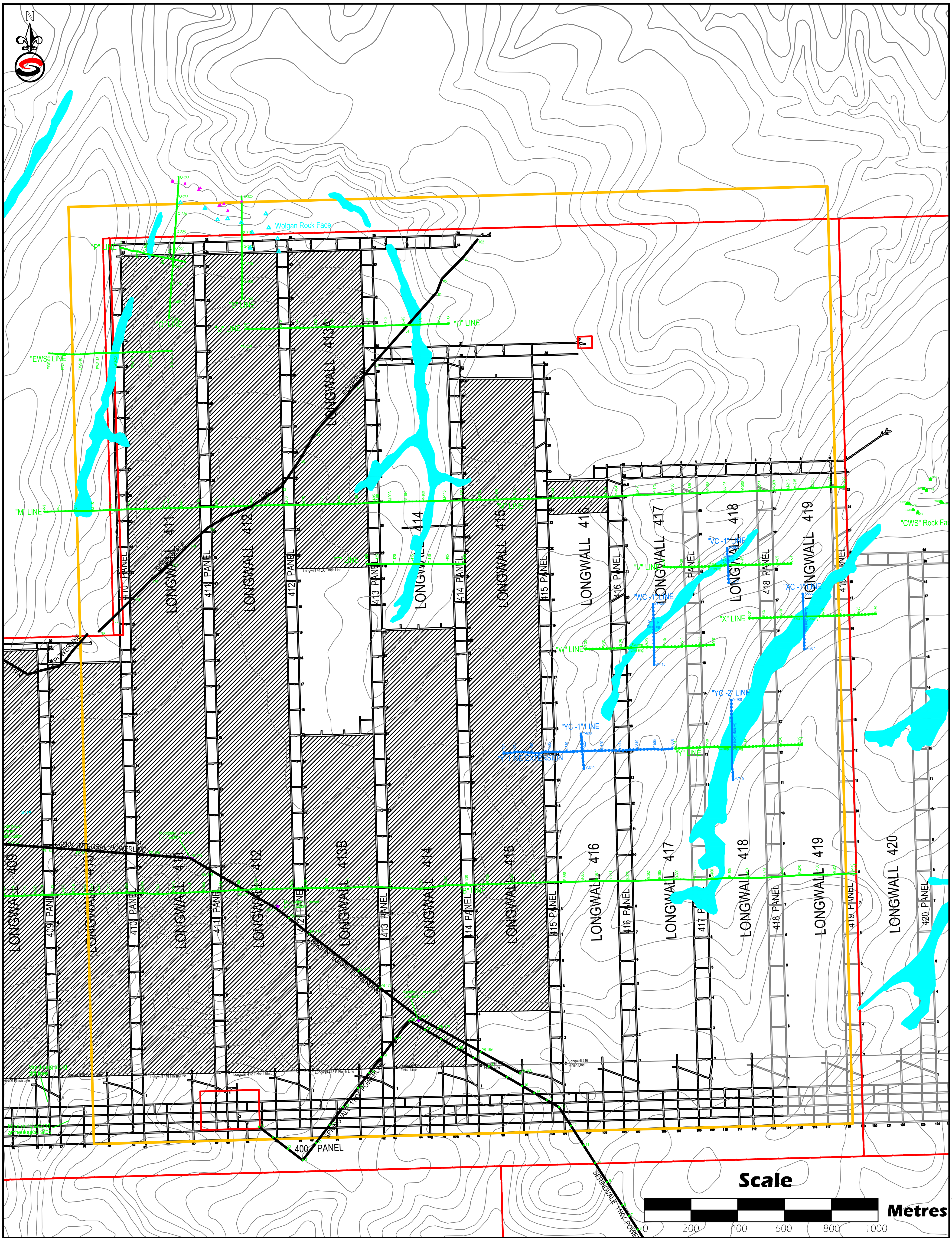
	Groundwater Quality			
	Shrub Swamps Piezometers	**Parameter**	**Monitoring Frequency**	**Investigation Trigger**
Impact Sites	Carne West Swamp *Piezometers:* CW1*, CW2*, CW3, CW4 Sunnyside East Swamp* *Piezometers:* SSE1, SSE2, SSE3*	EC, pH, Fe, Mn,	Monthly	Performance indicators will be considered to have been exceeded if statistically significant changes are indicated by the data such as: ▪ For short-term change – if any measured parameter > baseline 80th percentile by two standard deviations for more than two months. ▪ For long-term change – if the post-mining 50th percentile level for any analyte exceeds the 80th percentile pre-mining level
Reference Site	Carne Central Swamp *Piezometer:* CC1* Marangaroo Swamp *Piezometer:* MS1* Tristar Swamp *Piezometer:* TS1 Twin Gully Swamp *Piezometer:* TG1	EC, pH, Fe, Mn,	Monthly	Performance indicators will be considered to have been exceeded if statistically significant changes are indicated by the data such as: ▪ For short-term change – if any measured parameter > baseline 80th percentile by two standard deviations for more than two months. ▪ For long-term change – if the post-mining 50th percentile level for any analyte exceeds the 80th percentile pre-mining level

	Surface Water Quality			
	Shrub Swamp	**Parameter**	**Monitoring Frequency**	**Investigation Trigger**
Impact Sites	Carne West, Sunnyside East	EC, pH, Fe, Mn, TSS	Monthly	Performance indicators will be considered to have been exceeded if statistically significant changes are indicated by the data such as: ▪ For short-term change - if any measured parameter > baseline 80th percentile by two standard deviations for more than two months. ▪ For long-term change – if the post-mining 50th percentile level for any analyte exceeds the 80th percentile pre-mining level
Reference Site	*Surface Water Quality:* Marangaroo Upstream	EC, pH, Fe, Mn, TSS	Monthly	Performance indicators will be considered to have been exceeded if statistically significant changes are indicated by the data such as: ▪ For short-term change - if any measured parameter > baseline 80th percentile by two standard deviations for more than two months. ▪ For long-term change – if the post-mining 50th percentile level for any analyte exceeds the 80th percentile pre-mining level

	Flora Monitoring			
	Shrub Swamp	**Parameter**	**Monitoring Frequency**	**Investigation Trigger**
Impact Sites	Carne West Swamp* Quadrats: WC01 WC02 WC03 WC04 Sunnyside East Swamp* SSE01	Change in diversity of native species. Recruitment of eucalypt species. Condition of key species. Non-live ground cover. Non-native weeds.	Summer, autumn, spring	Indicators will be considered to have been exceeded if: Data indicates an increasing trend in non-native weeds A change in the number of species as detailed in the THPSS MMP. An increase in eucalypts in an impact site compared to reference sites as detailed in the THPSS MMP. A decline in condition score at an impact site as detailed in the THPSS MMP. An increase of bare ground as detailed in the THPSS MMP.

	Flora Monitoring			
	Shrub Swamp	**Parameter**	**Monitoring Frequency**	**Investigation Trigger**
Reference Site	Twin Gully Swamp TG01 TG02 Tri-star Swamp TRI01 TRI02 Carne Central Swamp CCS01 Lower Gang Gang Swamp LGG01 Upper Gang Gang East Swamp UGE01 Barrier Swamp BS01	Change in diversity of native species Recruitment of eucalypt species Condition of key species Non-live ground cover Non-native weeds	Summer, autumn, spring	Indicators will be considered to have been exceeded if: ▪ A change in the number of species as detailed in the THPSS MMP. ▪ An increase in eucalypts in an impact site compared to reference sites as detailed in the THPSS MMP ▪ A decline in condition score at an impact site as detailed in the THPSS MMP. ▪ An increase of bare ground as detailed in the THPSS MMP.

APPENDIX 2 PLANS



LEGEND:

- Mining Lease Boundary
- SMP Approved Area
- Subsidence Line - SMP Approval
- Subsidence Line - SEWPAC Approval
- Powerline Route
- Newnes Plateau Shrub Swamp

NOTES:

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PLAN No: SVY01942	COMPUTER PATH: S:\Survey\Z_Plans
INFORMATION SUPPLIED BY: Survey Department	
SCALE: SCALE 1:15000	A3V Sheet 1 of 1

SPRINGVALE MINE

TITLE:

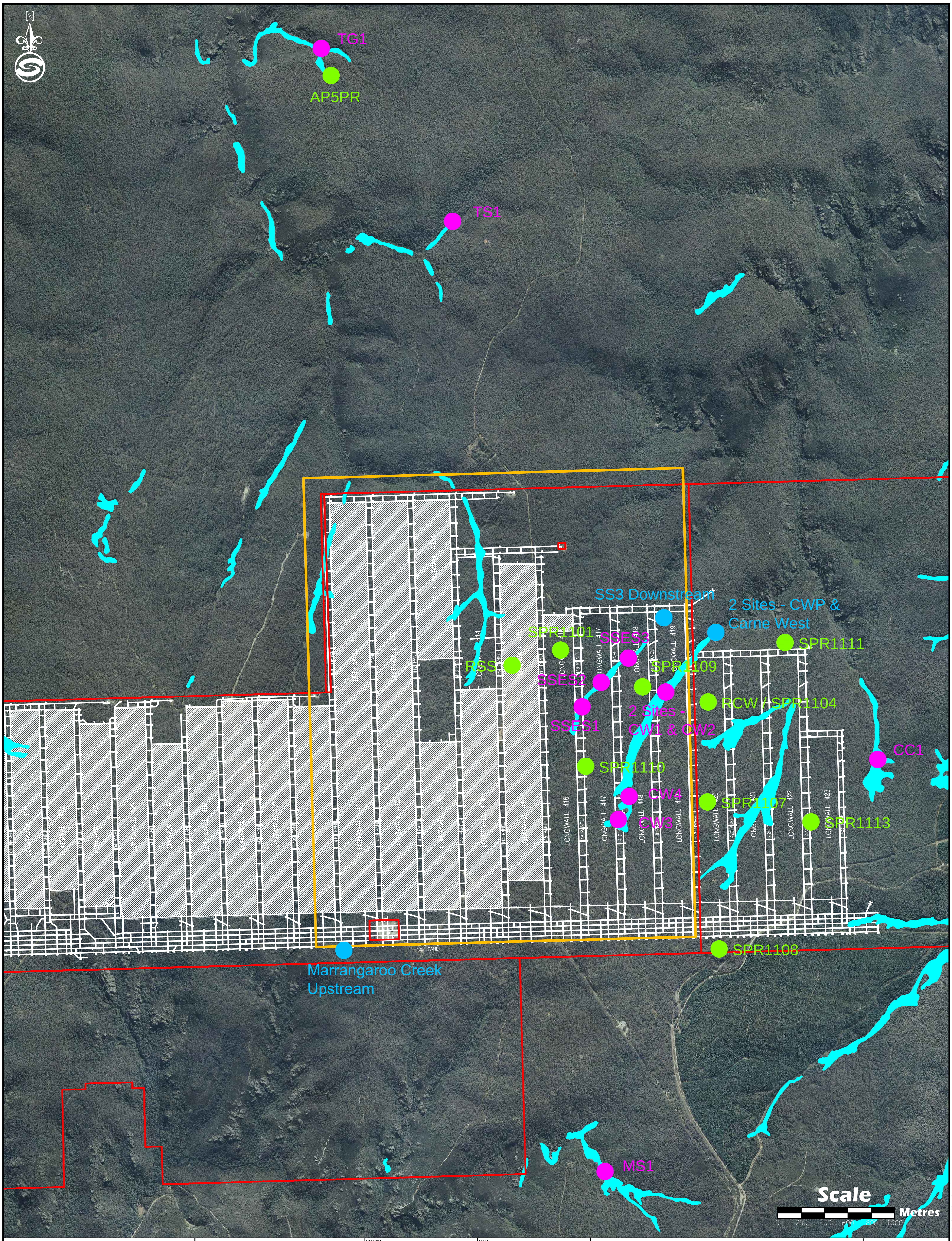
SMP EMP Longwalls 416 To 418

Subsidence Lines

Springvale Coal

SPRINGVALE MINE
Castlereagh HWY
Lidsdale NSW 2790
PO Box 198
Wallerawang NSW 2845
Phone: 02-63501600
Fax: 02-63551052

N:\Z_Environmental\SMP\EMP Condition\Subsidence Monitoring Sites.dwg



LEGEND:

- Mining Lease Boundary
- SMP Approved Area
- Groundwater Monitoring Site
- Surface Water Monitoring Site
- Aquifer Monitoring Site
- Newnes Plateau Shrub Swamp

NOTES:

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PLAN No: SVY01938	COMPUTER PATH: S:\Survey\Z_Plans
INFORMATION SUPPLIED BY: Monitoring Locations - Tony Nolan	
SCALE: SCALE 1:30000	A3V Sheet 1 of 1

SPRINGVALE MINE

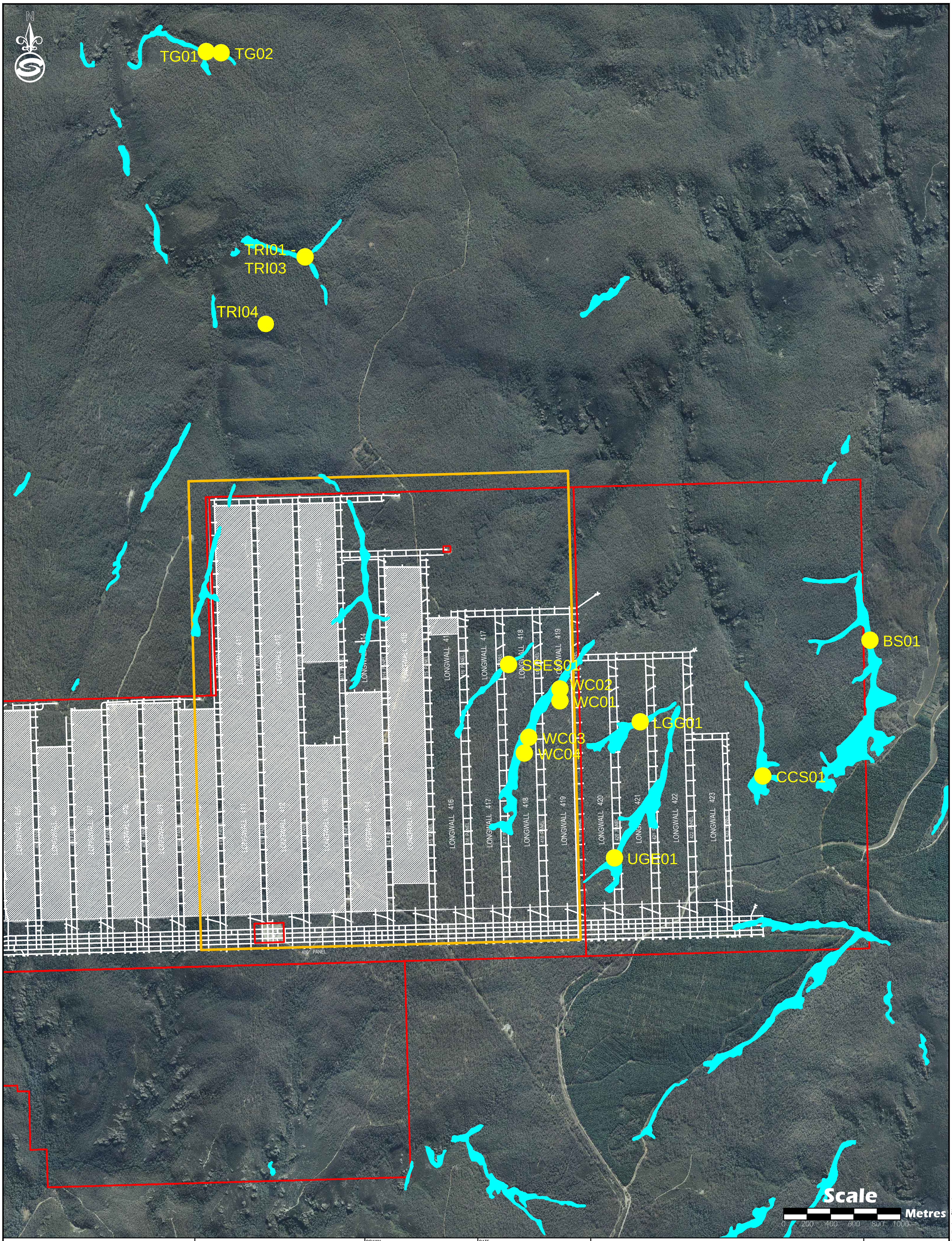
TITLE:

SMP EMP Longwalls 416 To 418

Water Monitoring Sites

Springvale Coal

SPRINGVALE MINE
Castlereagh HWY
Lidsdale NSW 2790
PO Box 198
Wallerawang NSW 2845
Phone: 02-63501600
Fax: 02-63551052



LEGEND:

- Mining Lease Boundary
- SMP Approved Area
- Flora Monitoring Site
- Newnes Plateau Shrub Swamp

NOTES:

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INFORMATION SUPPLIED BY: Monitoring Locations - Tony Nolan	
SCALE: SCALE 1:30000	A3V Sheet 1 of 1

SPRINGVALE MINE

TITLE:

SMP EMP Longwalls 416 To 418

Flora Monitoring Sites

Springvale Coal

SPRINGVALE MINE
Castlereagh HWY
Lidsdale NSW 2790
PO Box 198
Wallerawang NSW 2845
Phone: 02-63501600
Fax: 02-63551052

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LEGEND:

- Mining Lease Boundary
- SMP Approved Area
- Archaeological Site
- Newnes Plateau Shrub Swamp

DRAWN: Zac Burley	DATE: 12-11-2013
PLAN No: SVY01936	COMPUTER PATH: S:\!Survey\Z_Plans
INFORMATION SUPPLIED BY: Survey Department	
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SPRINGVALE MINE

TITLE:

SMP EMP Longwalls 416 To 418 Archaeological Sites

Springvale Coal
SPRINGVALE MINE
Castlereagh HWY
Lidsdale NSW 2790
PO Box 198
Wallerawang NSW 2845
Phone: 02-63501600
Fax: 02-63551052

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APPENDIX 3 CORRESPONDENCE

Trade & Investment
Resources & Energy

11/3964
OUT13/21877

Mr Robert Miller
Mine Manager
Springvale Colliery
PO Box 198
WALLERAWANG NSW 2845

Dear Mr Miller

Springvale Subsidence Management Plan Longwalls 411 to 418
Variation to the mining layout of Longwall 418

With reference to your application dated 11 April 2013 I, as the delegate of the Director-General, Department of Trade and Investment, Regional Infrastructure and Services NSW (delegation dated 17 November 2010) have approved the Springvale Longwall 411 to 418 Subsidence Management Plan Variation.

The Approved Plan is now Plan No: SVY01520/1 titled "Springvale Mine - Subsidence Management Plan - Variation Application – April 2013 – SMP Approved Plan" signed by the Mine Manager on 22 April 2013. The Approved Plan shows the varied extraction layout for Longwall 418.

The conditions of approval are the same as those issued in the approval for Longwalls LW411 to LW418 dated 7 March 2006 and are attached for your information.

The mine's Environmental Management Plan (EMP), titled "Springvale Coal Subsidence Environmental Monitoring Program (reference: SV-MS-036)" was last updated in August 2009. This plan must be updated and the revision approved by the Director of Environmental Sustainability within 4 months of this approval. The revised EMP must be prepared in consultation with relevant landholders and government agencies.

The EMP revision should address all requirements of conditions 7, 8, 9, 15 and 18 of the SMP approval for Longwalls 411 to 418. The revised EMP must address subsidence impacts on surface and groundwater, flora and fauna, swamps, archaeological sites and any other significant environmental features that may be effected by subsidence resulting from the proposed longwall extraction. Furthermore the revised EMP must include:

i) a detailed monitoring programme;
ii) trigger levels for subsidence impacts that require actions and responses;
iii) the procedures that would be followed in the event that the monitoring indicates an exceedance of trigger levels;
iv) measures to mitigate, remediate and/or compensate any identified impacts;
v) a protocol for the notification of identified exceedances of the trigger levels; and
vi) a contingency plan.

Mineral Resources – Office of the Executive Director
516 High Street MAITLAND NSW 2320 Australia
PO Box 344 Hunter Region Mail Centre NSW 2310 Australia
Tel: +612 4931 6422 Fax: +612 4931 6793 www.resources.nsw.gov.au ABN: 72 189 919 072

It should be noted that this Approval does not constitute an approval under the previous Section 138 of the Coal Mines Regulation Act 1982 or current Clause 88 of the Coal Mines Health and Safety Regulation 2006. Operators must comply with the requirements of the Section 138 or Clause 88 before extracting any pillars from first workings or longwall or other extraction systems.

If you have any further enquiries do not hesitate to contact Mr Paul Langley Subsidence Executive Officer on 02 4931 6448 or email on
paul.langley@industry.nsw.gov.au

Yours sincerely

B. W. Mullard 6/8/13

Brad Mullard,
Executive Director, Mineral Resources
Under delegation for the Director General

Australian Government
Department of the Environment

Our reference: 2013/06438

Contact Officer: Manny Hernandez
Telephone: 02 6275 9537 Facsimile: (02) 6274 1878
Email: post.approvals@environment.gov.au

Dr Bernie Kirsch
Regional Environment Manager West
Springvale Coal Pty Ltd
PO Box 198
WALLERAWANG NSW 2845

Dear Dr Kirsch

Approval condition 1, Longwalls 415, 416 and 417 at Springvale Colliery, NSW (EPBC 2011/5949)

I write in reference to your letter dated 27 March 2013 with attached supporting documentation seeking agreement from the Minister to vary condition 1 of the approval (EPBC 2011/5949) dated 14 March 2012 to allow for longwall mining under Temperate Highland Peat Swamps on Sandstone Ecological Communities (THPSSEC).

On 3 and 4 September 2013, and on the request of departmental officers, you provided additional documentation to support your request:

- Supplementary Data, Volumes One and Two, August 2013
- Dyadem Stature for Risk Managment, version 1
- Soft Engineering Solutions for Swamp Remediation; and
- an independent report by Professor David Mulligan, Director of Centre for Mined Land Rehabilitations, University of Queensland

These documents have been reviewed by departmental officers.

As delegate of the Minister for the Environment I have decided to agree to your request under condition 1 of EPBC approval 2011/5949 to allow for mining of longwalls 415, 416 and 417 under THPSSEC.

In agreeing to your request I remind you of your obligations under the following conditions of the approval:

- Condition 9 – that you implement the approved Monitoring and Management Plan.

- Condition 10 – that you annually provide the Minister an independently reviewed report detailing the results of actions carried out under the Monitoring and Management Plan.

- Condition 11 – that you, upon first becoming aware, of an impact on THPSSEC report the impact to the department as per the requirements of this condition.

Please ensure that you maintain accurate records of all activities associated with, or relevant to the conditions of approval, so that they can be made available to the Department on request. Such documents may be subject to audit and used to verify compliance. Summaries of results of audits may be published by the Department. Information about the monitoring and audit program can be found on the Department's web site at www.environment.gov.au/epbc/compliance/auditing.html.

If you have any questions, or require further information regarding this matter, please contact Manny Hernandez 02 6275 9537.

Yours sincerely

S.Gaddes

Shane Gaddes
Assistant Secretary
Compliance & Enforcement Branch
Environment Assessment and Compliance Division

21 October 2013

APPENDIX 4

SOFT ENGINEERING GUIDELINE

Soft-engineering solutions for swamp remediation a "how-to" guide

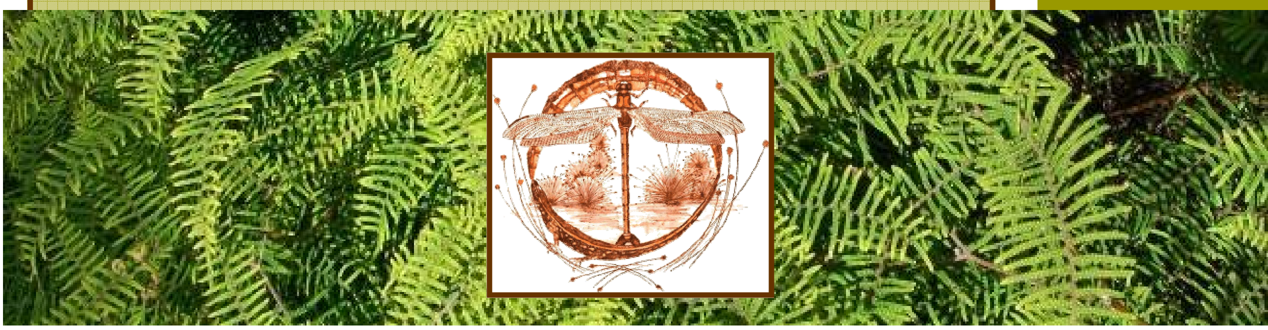
Section Three

Case Studies

- Braeside Swamp
- Marmion Swamp
- Wentworth Falls Swamp
- Happy Valley Swamp
- Ellem Gully Swamp
- Paddy's River Swamp

Glossary

References



Braeside Swamp Blue Mountains LGA

- check dams/water spreaders/infiltration cells

Context


Streambank stabilization on the edge of Braeside Swamp

Braeside swamp was being influenced by two water-courses; an intermittently high flow stream which was transporting the majority of the stormwater generated from the upstream urbanised areas around the swamp edges, as well as a smaller low flow accessory (historical drainage?) channel within the swamp itself.

The banks of the high flow stream were being actively eroded and required stabilisation.

The channel was dewatering the swamp resulting in desiccation of the swamp substrates, the die back of swamp vegetation and the subsequent domination of the swamp substrates by exotic weed grasses.

Treatment

The low flow characteristics of the accessory channel and the diversion of the more highly erosive stormwater flows around the site by the stream made the swamp suitable for remediation.

The banks of the high flow stream required bank stabilisation, toe protection and revegetation. Check dams supported by channel packing were placed at several points along the channel to prevent further dewatering subsequently causing the channel to fill up with water. Overflows were then spread over the desiccated swamp substrates with the aid of water spreading structures, and held in a series of infiltration cells. This encouraged the vertical rehydration of the swamp substrates and the recreation of the pre-channel waterlogged swamp conditions.

The water logging resulted in the die-back of the exotic weed grasses and their replacement with native sedges. More elevated areas on the edges of the swamp which were not fully rehydrated were planted out with swamp specialist Leptospermum *spp.* including *L. grandifolium, L. polyfgalifolium and L. juniperinum* to create a tea-tree thicket buffer to the swamp.

The structures created a trajectory of change that favoured swamp vegetation over the exotic grasses and resulted in spontaneous natural regeneration of swamp vegetation with very little intensive bush regeneration or planting being required. The soft engineering solution provided a cost effective and long term solution to a previously open ended and labour intensive struggle with exotic weed grasses.

Swamp remediation snapshot over a 12 month period: Braeside Swamp

- Installation of water spreaders and infiltration cells into degraded swamp substrates dominated by exotic grasses as a result of desiccation.

- Same location 6 months after installation.

Note recolonisation by sedges and the natural die-back of exotic grasses due to the increased water-logging.

- Same location 12 months after installation. Sedge species have re-established and soft engineering structures are barely visible.

Marmion Swamp Blue Mountains LGA

- check dams/sediment fencing infiltration devices/wooden bed control structures

Context

Surface stormwater flows had resulted in the chanellisation of Marmion Swamp causing desiccation of swamp substrates and the death of swamp vegetation adjacent to the channelised areas. *Blechnum nudum* ferns had begun to colonise the degraded areas of swamp.

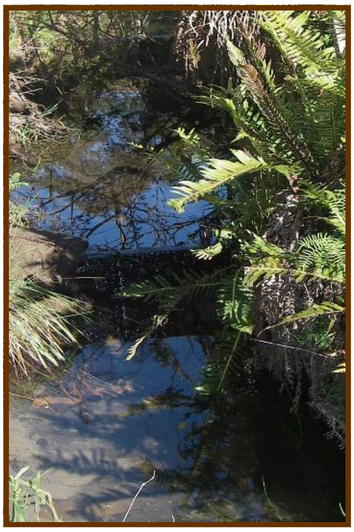
Treatment

Reinforced sediment fences were installed in the open grassed areas above the swamp to act as detention and infiltration devices to encourage surface water to infiltrate into the groundwater (rather than entering the swamp as high velocity erosive surface flows) pictured below.

Revegetation of the extensive grassed areas above the swamp was also undertaken to increase infiltration rates.

Check dams and channel packing were installed to retain water in the system and encourage the lateral hydration of swamp substrates through the channel walls.

Wooden streambed stabilisation structures were also installed to reduce further deepening of the channel and to gradually raise the streambed of the channel (below).



Wentworth Falls Lake Swamp Blue Mountains LGA

- water spreaders/infiltration cells/landowner incentives

Context

A large sediment plug associated with stormwater discharge was smothering swamp vegetation on the eastern margin of Wentworth Falls Lake through hanging swamp, and supporting an extensive area of exotic grasses.

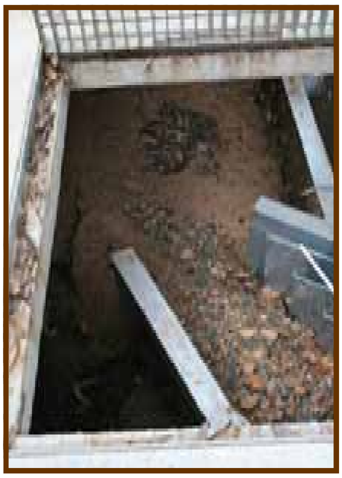
Treatment

Road verges in the catchment were bollarded to restrict vehicle movement and parking, activities which were denuding them of vegetation making them vulnerable to erosion. Rainwater rebates, driveway sealing and verge revegetation and mulching incentives were offered to landowners in the catchment.

To prevent further inputs of sediment into the swamp, a Baramy Trap was installed upstream of the swamp, below a stormwater discharge pipe adjacent to the road (below).

A series of water spreaders and infiltration cells were installed to help waterlog the sediments to alter the trajectory of change to favour native sedge growth over exotic grasses.

The sediment was further consolidated and held by infiltration cells preventing additional movement into the system. The sediment plug was essentially converted into a giant native sedge sand filter cleansing stormwater inputs into the swamp.



Above: *Baramy Trap to catch sediment.*

Happy Valley Swamp Lithgow LGA

- water spreaders/infiltration cells/access management

Context

The electricity infrastructure corridor and the associated maintenance trails on either side of Happy Valley Swamp created a desire line across the swamp for 4WD users and trail bikes to link the trails by tracking across the swamp.

Over time the impact zone continued to be widened as crossing points became impassable and new ones were created and as 4WD users tested their machines performance in adjacent areas of swamp. Large amounts of sediment were deposited in the swamp from the heavily eroding access trails.

Treatment

A single track on the least erodible approach was hardened and left open to maintain a thoroughfare along the desire line to reduce the risk of new tracks being created in response to track closures. Extensive soil conservation works were undertaken along all the associated access tracks to reduce sources of sediment and stormwater flow.

Channelised areas of Newnes Plateau Shrub Swamp adjacent the site had check dams installed to divert water out of the channels. The diverted water was then directed over the highly compacted and desiccated areas of swamp substrates damaged by vehicular traffic. Infiltration cells were used to hold the diverted water over the degraded areas to encourage vertical rehydration of the desiccated swamp substrates.

4WD deterrent pits, barrier fencing, brushmatting, jute matting, and planting were installed to close duplicate tracks, prevent erosion and encourage revegetation.

Educational presentations to 4WD clubs and Trail bike clubs were conducted to educate members about their impacts. Workshops with NSW Forest and Integral Energy staff on how to cooperatively address the issues were also held.

Happy Valley Swamp

Ellem Gully Hanging Swamp Gosford LGA

- soil conservation and water management

Context

Ellem Gully hanging swamp is a small swamp system within McPherson State Forest west of Wyong NSW, and is classified as a Gosford Sandstone Hanging Swamp. The catchment area is approximately 4ha in size, is comprised entirely of bushland and sits atop a broad plateau. The surrounding catchment to the swamp has few disturbances except for existing formed dirt roads for logging operations, road maintenance activities (i.e. grading etc), and use by recreational vehicles (occasional 4WDs, although predominantly trail bikes).

Approximately half of the upstream catchment draining into the swamp is a revegetation area, initially planted with Blackbutt trees (*E. pilularis*) after an historic airstrip had been in use for some 15 years across the plateau. Initially established nearly 30 years ago these trees are now quite mature, with little diversity in the regenerating understory (below right).

Despite nearly 3 decades since revegetation works were undertaken, the footprint of the airstrip is still very clear from aerial photography (left).

Stakeholder observations had noted that over the last decade the swamp had not been retaining or seeping as much water as historically, and upstream ephemeral flows (including subsurface/subterranean) flows not as evident as had been in previous years.

Vegetation changes were also being observed in the swamp itself (i.e. the increasing dominance of shrubs such as *Callistemon* and *Banksia*), in preference to sedges.

Issues included;

- Upstream erosion and compaction caused by vehicle access above the swamp (predominantly trail-bikes (i.e. tracks)
- Changes to surface water-flows and hydrology
- Road maintenance activities and earth-works/soil conservation.

Investigation through the revegetated airstrip revealed many of the planted Blackbutt trees adjacent to drainage works or trail-bike ruts where water was being detained in pools, had considerably thicker trunks than neighbouring trees across flatter terrain where surface flows sheeted freely. This was consistent across the revegetation area.

Treatment

Works were applied to remove numerous earth barriers and trail bike paths across the upper catchment to help facilitate the free flow of surface water to the downstream swamp.

It was theorised that pooling water being detained in these formed earth basins may be providing additional water to these trees rather than travelling downstream to the swamp itself. The trail bike paths and mitre drains could be creating opportunities for water to be shifted from the road pooling along wheel ruts and end-points of the drains.

Tracks and inroads were reshaped, jute mesh and a number of coir logs were installed to armour the soil and redirect surface flows.

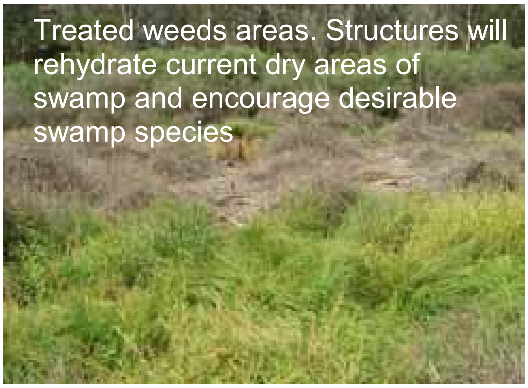
The project is being monitored to assess hydrological changes over time.

Paddy's River Swamp Wingecarribee LGA

- hydrological management and weed control

Intact swamp and wetland systems

Range of weeds within swamp



Treated weeds areas. Structures will rehydrate current dry areas of swamp and encourage desirable swamp species

Context

Paddys River swamp and wetland system has portions of swamp where the natural hydrological cycles have been altered by upstream issues in the catchment resulting in channelling and stream incision .

With this has come sediment deposition in parts of the swamp and the subsequent drying out of sections of swamp.

The fluctuations in water levels has allowed some desirable native swamp species to establish however as the areas subsequently dry out, terrestrial native plants and weeds particularly Japanese Honeysuckle and Blackberry are able to colonise the area out-competing the desirable native swamp vegetation.

Treatment

Hardwood and log structures have been installed in-stream in order to retain water to encourage 'wet' native species to permanently occupy the site and effectively out-compete the exotic species.

This will improve the overall hydrological function of the swamp as a system, and the health and vigour of native vegetation will increase as optimum conditions are returned.

In the longer term, the area should require less labour input in regard to weed management in the future as opportunities for weed establishment are reduced.

Glossary

anaerobic	Having little or no oxygen.
anthropogenic	Of or relating to humans; caused by humans.
aquifer	An underground bed or layer of rock, sediment or soil which yields water.
base flows	The usual, reliable, background level of a river or stream maintained generally by seepage from groundwater storage.
basal	Beginning or basic; of primary importance; relating to or forming a base.
biodegradable	Capable of being decomposed by biological agents, especially bacteria, commonly organic materials.
bio-filters	A pollution control technique using living material to capture and biologically degrade nutrients and other pollutants, resulting in improved water quality.
bio-region	An area constituting a natural ecological community with characteristic flora, fauna, and environmental conditions and bounded by natural rather than artificial borders.
channeling	An erosional process by which stormwater incises a drainage channel through swamps, resulting in dewatering of the swamp, lowering of the ground watertable and desiccation of swamp substrates.
check bank	A short level earth bank constructed to slow and spread runoff flows from other structures.
degraded	An area low in functionality and sustainability.
desiccated	Dried out.
dewatered	Has had water removed.
endangered	A species in danger of extinction in the near future throughout all or a significant proportion of a species range.
erosion	The process of eroding or the condition of being eroded: where material is worn away from the earths surface, and in this case from swamps, streambeds, trails, banks, the catchment etc.
eutrophication	The natural and artificial addition of nutrients to lakes, streams, wetlands, swamps and estuaries and the effects of this addition.
extraction	Removal of a substance from it’s constituent body: e.g. of metals or water from the earth.
friable	A soil texture that is loose and crumbly i.e. not strongly coherent and easily eroded by water.

geomorphology	The study of the earths landforms and the forces and processes which have shaped them.
groundwater extraction	Removal of subsurface water from the soil and rock substrate.
hydrology	Study of water and its relationship with living things, its occurrence, distribution and effects on the earth.
hydrophobic	Water repelling soils.
impeded	Retarded or obstructed process.
impermeable	A surface or material through which water is unable to permeate.
impervious	A surface or material through which water is unable to penetrate.
infiltration	The process of water entering the soil.
Key threatening process	Actions or threats which adversely affect threatened species, their populations and ecological communities, or could cause them to become threatened.
loams	Soil composed of a mixture of sand, clay, silt, and organic
mudstone	Fine grained sedimentary rock, hardened mud, originally consisting of clays and mud. May include shales and/or argillite.
peat	Consolidated organic matter formed by the breakdown of swamp plant species in acidic and anaerobic conditions.
percolate	To drain or seep though a porous material.
permeable	A surface or material through which water can move through.
piping	An erosional process in which stormwater bores a narrow diameter subsurface tunnel through the swamp substrates which acts like a drainage pipe, dewatering swamp substrates.
rehabilitation	Treatment to an area to restore it as close as possible to its original condition.
remediation	Act or process of correcting a fault or deficiency.
restoration	The act of bringing an area back to its original more resilient and authentic condition. Involves re-instating biodiversity and natural ecological processes or systems, where significance disturbance has occurred and where other regeneration techniques may fail.

retention	Holding back of water or sediment.
rhizomatous	A horizontal, usually underground stem that often sends out roots and shoots from its nodes
sediment	Solid fragments of inorganic or organic material that come from the weathering of rock and soil. Sediments are frequently carried in suspension in stormwater and are deposited when water velocities slow.
sedimentation	Act or process of depositing sediment.
seepage lines	Areas where groundwater is forced to the surface by the outcropping of impermeable rock layers. They frequently occur as horizontal bands or as springs.
shale	A fissile rock composed of layers of claylike, fine-grained sediments.
silviculture	Forestry works and cultivation.
skeletal soils	Soils which are very shallow and are low in nutrients and organic material.
Sphagnum	A moss species, growing in wet conditions on peat soils.
swamp substrates	An underlying layer or substratum, of highly organic peaty medium on which swamps grow.
slumping	Channelling, tunnelling or piping creates voids into which the swamp substrates collapse or ‘slump’.
swale	A vegetated permeable bund which allows infiltration of water along it whilst at the same time providing a erosion resistant conduit for surface stormwater flows.
temperate	An area characterised by moderate temperatures; neither hot nor cold.
threatened	A species at risk of extinction. Categories based on the level of risk include vulnerable, endangered or critically endangered.
tunneling	An erosional process in which stormwater bores a large diameter subsurface tunnel through the swamp substrates which acts like a large drainage pipe, dewatering swamp substrates.

urbanization	An area which is becoming more developed with housing, roads etc resulting in more hardened or impermeable surfaces, in its structure and composition.
velocity	The rate or speed with which water moves.
vulnerable	A species facing a high risk of extinction in the medium term future throughout all or a significant proportion of a species range.
watercourse	A natural or artificial channel though which water flows; ie: stream or a drain.

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APPENDIX 5 HARD ENGINEERING CASE STUDY

APPENDIX 5

HARD ENGINEERING SWAMP REMEDIATION CASE STUDY

1.0 INTRODUCTION

The following case study has been compiled to document an investigation into hard engineering solutions that have been used to repair cracking in surface and near surface rock strata caused by longwall mining. The case study largely focuses on the work done by Helensburgh Coal Pty Ltd (HCPL) in the NSW southern coalfields. The HCPL example was chosen as it is one of the few available examples where the remediation process and the verification of success have been closely monitored and documented in consultation with major stakeholders.

The HCPL example involves the use of polyurethane resin (PUR) which has been injected into pre drilled boreholes to repair cracked rock strata. This process is referred to as grouting. The grouting of a cracked rock bar (WRS4) was carried out on a stream known as the Waratah Rivulet which is located within the Sydney Catchment Authority (SCA) area between Sydney and Wollongong in NSW. Detailed ecotoxicology testing on the PUR was carried out due to the sensitive nature of the location.

PUR was chosen as the grouting medium because it has been used routinely to successfully stabilise rock strata in underground mines for decades. The properties and handling of PUR are well known and there are contracting companies that are set up and well experienced in delivering PUR for strata stabilisation. The favourable ecotoxicology results conducted recently were also a major consideration.

The grouting remediation work carried out at HCPL was focussed on the repair of rock bars in the Waratah Rivulet. This case study focuses on the WRS 4 rock bar experience. This is a slightly different environment to temperate highland peat swamps on sandstone (THPSS) which are found above the Springvale mine workings and therefore will require a slightly different approach with respect to planning. However, the grouting process and environmental controls would be very similar. A THPSS is largely a rock bar covered in peat and vegetation. Full details of how grouting would be done above the Springvale operation will be set out in a Response Strategy consistent with condition 13 of the EPBC Approval 2011/5949 should a severe impact be detected.

2.0 PURPOSE OF THIS CASE STUDY

The purpose of this case study is to investigate and document the grouting process used to repair surface and sub-surface rock strata by HCPL in the Waratah Rivulet and to discuss how this process can be transferred to THPSS.

3.0 IMPACT IDENTIFICATION

The first step in the grouting remediation process is identifying whether an impact has occurred. In the case of the HCPL example and the Waratah Rivulet, an impact can be identified when there is a non-climatic related reduction in stream flow and pool water depth within the stream system as well as the presence of surface cracking. In the case of THPSS systems, an impact would initially be determined by a non-climate related reduction in groundwater level and/or quality when monitoring data is compared to response triggers set out in the Springvale Temperate Highland Peat Swamps on Sandstone Monitoring and Management Plan (MMP). An impact may also be detected by using lagging triggers for surface water and swamp health. The above indicators are only relevant to mining if mining is in the proximity of the impact location.

The detection of an impact results in an immediate investigation into the cause of the impact and likely extent. If a severe impact on THPSS is detected then a Response Strategy would be developed for approval and implementation consistent with condition 13 of EPBC Approval 2011/5949.

4.0 GROUTING PROCESS

If a severe impact such as cracking of the base of a THPSS was detected then the most effective remediation option would be grouting of the rock strata at the base of the THPSS. The following section summarises the process successfully developed for the HCPL operation and which is proposed for the Springvale operation should it be required.

The grouting remediation work at HCPL involved the use of PUR to fill cracks and voids created as a result of longwall mining subsidence. PUR is a quick setting 2 part polyurethane resin that reacts and sets following the mixing of the 2 components. The components are made up of various polyols and additives which are then combined with a polyisocyanate component to form the hard setting final PUR product. The PUR components were supplied by contracting company Minova.

4.1 Initial 20m Trial Section of WRS4 Rock Bar

The WRS4 rock bar extends for a length of around 75m in an east west traverse across the Waratah Rivulet. It was decided to conduct an initial trial on a 20m section of the rock bar to test the effectiveness of the grouting process and related environmental controls. The aim of the trial was to decrease the hydraulic conductivity of the rock bar so that water would pool behind the bar as it did prior to mining beneath the area. The trial was conducted in consultation with the SCA and other key stakeholders.

The first step in the grouting process was to dewater the area in the Rivulet around where the injection holes and injection procedure was planned to occur. This was done by installing by pass pumps to reticulate upstream flows around the work site and through to downstream areas. Fifteen holes were drilled in a predetermined pattern following dewatering of the work area. The holes were then tested with an electronic calliper to determine the extent and location of cracks and voids below the surface. This was done to also determine the most advantageous depths in the holes to inject the grout.

It was decided that the best way to inject the PUR grout was to use a series of "packers" which would be used to inject grout from the bottom of the holes and progressively to the surface. A packer is a device that seals the hole at a predetermined depth whilst allowing PUR to be pumped through the middle of the packer and injected below. The packer acts as an obstruction across the hole so that the PUR is forced horizontally under a predetermined pressure into voids and cracks below the packer and outward from the hole. The PUR would simply fill the hole and not the horizontal cracks and voids if packers were not used. All 15 holes were injected at the same time at a pressure of up to 100 bar. A series of packers were used progressively at depths of 13, 8, 5, 3 and 1m from the bottom of the holes.

The 100 bar pressure was estimated from experience in repairing fractured rock strata in underground mines. It is important to not over pressurise holes during the injection process as too much pressure could cause pressure related fracturing. A check on borehole collar RL's following grout injection confirmed that there had not been any upward movement of the rock bar and therefore no pressure induced cracking.

The final step in the grouting process was to verify the success of the procedure by measuring the post grouting hydraulic conductivity of the rock bar and comparing it to the pre grouting hydraulic conductivity. The results showed that there was a decrease in hydraulic conductivity of a least 3 orders of magnitude. Data from water quality monitoring revealed that there were no significant environmental impacts and that the environmental controls put in place proved to be effective.

The main conclusions reached following the grouting remediation of the WRS4 rock bar include:

- PUR proved to be an effective grouting medium for repair of the cracked WRS4 rock bar on the Waratah
- The hydraulic conductivity of the WRS4 rock bar was significantly reduced by at least 3 orders of magnitude following grouting with PUR
- The environmental controls used to prevent impacts during the grouting process proved to be effective

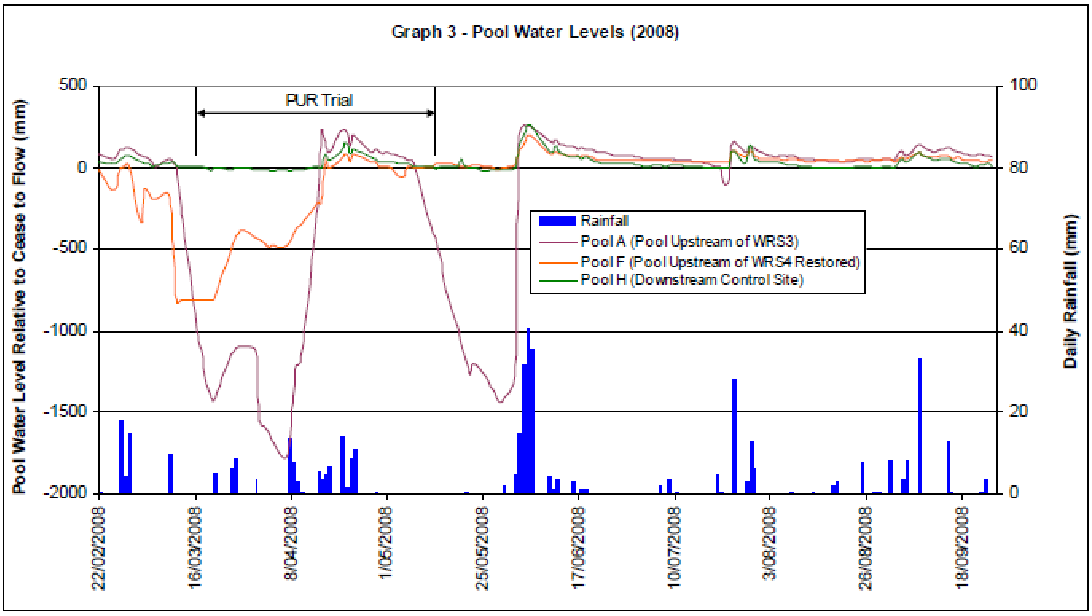
On the basis of the success of the initial 20m trial, HCPL were granted approval to proceed with grouting of the remainder of the WRS4 rock bar.

4.2 Expanded 75m Rock Bar Grouting Trial

It was decided to proceed with grouting a further 55m section of the WRS4 rock bar following the success of the initial 20m trial described in section 4.1 above. This involved grouting a 20m section to the east of the initial 20m trial and a 35m section to the west of the initial 20m trial. Lessons learnt from the initial 20m trial were incorporated into the expanded grouting exercise. This included a modified drill pattern for injection holes but the main process of injecting PUR grout into predrilled holes was similar to the initial 20m trial. The expanded trial was completed in May 2008.

The first indication that the expanded trial had been successful was the overtopping of water across the crest of the WRS4 rock bar i.e. water had started to pond behind the rock bar and form a pool which was present pre-mining. This occurred even though there was no rain at the time which indicated that the surface and sub-surface flows that had been previously flowing through the cracked rock bar were now accumulating behind it due to the post grouting reduction in hydraulic conductivity.

Further hydraulic conductivity testing was conducted across the expanded section of the WRS4 rock bar to quantify the success of the grouting program. The hydraulic conductivity testing showed that there was a reduction in hydraulic conductivity of up to 5 orders of magnitude following grouting of the WRS4 rock bar. This testing was followed up by stream flow monitoring that compared the behaviour of the rock pool behind the WRS4 rock bar and other non-impacted pools. This monitoring confirmed that the previously cracked WRS4 rock bar rock pool was now retaining water in a similar manner to non- impacted rock bar / pool systems within the Rivulet. This is shown graphically in Graph 3 below. Ongoing flow and rock pool level monitoring continues to confirm the success of the grouting program on the WRS4 rock bar.



Water quality monitoring data, which is provided to the SCA, also confirms that the environmental controls put in place during grouting were successful and also confirms the ecotoxicology results that were done in the initial stages of the grouting program.

5.0 KEY CONCLUSIONS

The following points summarise the key conclusions following grouting remediation of the WRS4 rock bar.

- PUR is a suitable medium that can be used to remediate cracking in surface and sub-surface rock strata. The WRS4 rock bar remediation demonstrated that injection of PUR resulted in a significant decrease in the hydraulic conductivity of the rock bar

- The WRS4 rock bar was remediated to a standard that restored the integrity of a rock pool behind the bar which was present prior to undermining but damaged by mining
- There are suitable contractors and equipment available to deliver PUR to surface and sub-surface cracked rock strata in an environmentally and technically responsible manner
- The environmental controls used during the PUR grouting program were effective in preventing environmental impacts during the drilling and injection process
- Water quality monitoring before, during and following the grouting program showed that there were no impacts on water quality from the use of PUR during the grouting program
- HCPL concluded that the grouting program is transportable to other similar situations along the Waratah Rivulet

6.0 TRANSFERABILITY OF THE GROUTING PROCESS TO THPSS

One of the main conclusions to be drawn from the WRS4 rock bar grouting remediation program is the transferrable nature of the process (Waratah Rivulet Remediation Trial Activities – Completion Report October 2008). One of the key limiting factors for transferring this grouting process to other locations is access. Good access for machinery and related equipment as well as for establishing environmental controls is required for the program to be developed and implemented. It is possible to drop machinery and related equipment in by helicopter but this adds to the expense and logistics of the operation (pers comm Minova).

Springvale Coal conducted a site inspection of the THPSS (Sunnyside East and Carne West) above the Springvale mine with representatives of the contracting firm Minova to determine the logistics of carrying out a grouting operation similar to that on the WRS4 rock bar. Minova are well experienced in this work including the WRS4 rock bar and confirmed during the site inspection that there was suitable access to the Sunnyside East and Carne West THPSS to allow a grouting program to be carried out if necessary. The WRS4 grouting process would require some modification to adapt it to a THPSS system however the basic drill, injection grouting, environmental management, environmental monitoring and verification procedures would be largely the same. Full details of how this will be done will be set out in a Response Strategy consistent with condition 13 of EPBC Approval 2011/5949 if a severe impact was detected in THPSS above the Springvale operation.