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Tahmoor Coal Pty Ltd

LONGWALL 32

Environmental Management Plan

04 May 2019

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Document Control

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Table of Contents

1 Introduction

1.1 Overview

The Tahmoor Coal Mine (**Tahmoor Mine**) has been operated by Tahmoor Coal Pty Ltd (**Tahmoor Coal**) since the mine commenced in 1979 and via longwall mining methods since 1987.

Tahmoor Coal, trading as Tahmoor Coking Coal Operations (**TCCO**) is a subsidiary within the SIMEC Mining Division (**SIMEC**) of the GFG Alliance (**GFG**).

This Environmental Management Plan (**EMP**) provides detailed information about how the risks associated with mining Longwall 32 (**LW32**) beneath environmental significant and natural features and how the subsidence impacts on surface and groundwater, flora and fauna and archaeological sites will be managed by TCCO.

1.2 Objectives

The objectives of this EMP are to establish procedures to measure, control, mitigate and repair potential impacts that might occur to environmental significant and natural features and how the subsidence impacts on surface and groundwater, flora and fauna and archaeological sites.

The objectives of the EMP have been developed to:

- Ensure the safe and serviceable operation of environmental significant and natural features.
- Ensure that public and workplace safety is paramount. Ensure that the health and safety of people who may be present on public or private property are not put at risk due to mine subsidence;
- Provide a detailed monitoring program for environmental significant and natural features;
- Monitor ground movements and the condition of environmental significant and natural features during mining;
- Provide trigger levels for subsidence impacts that require action and responses;
- Provide procedures to be followed for subsidence impacts that require actions from monitoring showing an exceedance of trigger levels;
- Initiate action to mitigate or remediate and /or compensate potential significant impacts that are expected to occur on the surface;
- Provide a plan of action in the event that the impacts of mine subsidence are greater than those that are predicted;
- Establish a clearly defined decision-making process to ensure timely implementation of risk control measures;
- Provide a forum to report, notify, discuss and record subsidence impacts;
- Establish lines of communication and emergency contacts;
- Consider contingency planning; and
- Outline annual reporting procedures.

1.3 Scope

The EMP is to be used to protect and monitor the condition of environmental significant and natural features identified to be at risk due to mine subsidence.

The potential environmental significant and natural features at risk are:

- Surface water, including quality and quantity and dams;
- Groundwater including quality and quantity;
- Ecology including flora and fauna;
- Aboriginal cultural heritage including archaeological sites;
- European heritage;
- Fluvial geomorphology including rock bars and pools; and
- Steep slopes.

The EMP only covers the environmental significant and natural features that is located within the limit of subsidence, which defines the extent of land that may be affected by mine subsidence as a result of mining LW32 only.

The EMP does not include other environmental significant and natural features, which lie outside the extent of this area.

2 SMP Approval

2.1 SMP Approval

TCCO received Subsidence Management Plan (**SMP**) Approval (**SMP Approval**) for LW32 on the on 14 September 2018 for the initial 1,100 metres.

TCCO submitted an application to the Division of Resources and Geosciences of the Department of Planning and Environment (**DPE-DRG**) on 3 March 2019 for the extension of the LW32 SMP Approval to enable the full extraction of the LW32 from 1,100 metres to 2,378 metres.

2.2 SMP Condition 12

Condition 12 of the LW32 SMP Approval requires an EMP to be prepared.

Condition 12 states the following:

> *12. The Leaseholder must submit to the Director Compliance Operations for approval an Environmental Management Plan (EMP) for the panels which are the subject of this Approval. The EMP is to be incorporated as an appendix to the Leaseholders Mining Operations Plan.*
>
> *This plan must address subsidence impacts on:*
>
> > *a) surface and groundwater (quality and quantity);*
> >
> > *b) flora and fauna;*
> >
> > *c) archaeological sites; and*
> >
> > *d) any other significant environmental features that may be effected by subsidence resulting from the proposed longwall extraction.*
>
> *The leaseholder must not operate beyond chainage 1,100m of Longwall 32 other than in accordance with an EMP approved by the Director Compliance Operations as an appendix*

to the Leaseholders Mining Operations Plan. This plan must address subsidence impacts above and must include:

a) a detailed monitoring program;

b) trigger levels for subsidence impacts that require actions and responses;

c) the procedures that would be followed in the event that the monitoring indicates an exceedance of trigger levels;

d) measures to mitigate, remediate and/or compensate any identified impacts;

e) a protocol for the notification of identified exceedances of the trigger levels;

f) a contingency plan; and

g) annual reporting procedures

This plan must be prepared in consultation with relevant landholders and government agencies.

The Leaseholder must not cause subsidence impacts prior to the Environmental Management Plan being approved.

Note: The plan should be submitted to the Director Compliance Operations at least 30 days prior to the expected commencement of operations beyond chainage 1,100m so as to enable sufficient time for the assessment of the plan. The Director may require the provision of further information to assist in the assessment of the plan or a resubmission of the plan if it is considered inadequate. Complex issues or the need for additional information or a resubmission of the plan may require a longer assessment period.

3 Enviromental Conditions

3.1 Regional Catchment

The Nepean River rises in the Great Dividing Range to the west of Picton. Its headwaters also lie in the coastal ranges to the east of Picton. Flows in the upper reaches of the Nepean River are highly regulated by the Upper Nepean Water Supply Scheme, operated by WaterNSW that incorporates four major water supply dams on the Cataract, Cordeaux, Avon and Nepean Rivers. Releases from the Cordeaux, Avon and Nepean Dams are made to enable withdrawal for water supply purposes from the Pheasant's Nest Weir located further downstream on the Nepean River.

The Nepean Dam is situated some 18 km upstream of the Bargo River confluence, while the Pheasant's Nest Weir is located approximately 7 km upstream of the confluence. Flows in the Nepean River near and downstream of the Project Area (downstream of the Peasant's Nest Weir) are not part of a WaterNSW Drinking Water Catchment Area.

Further downstream, the Nepean River has been extensively modified by the construction of a series of in-stream weirs which have created a series of pondages, such as the Maldon Weir. Ponding behind the Maldon Weir does not affect water levels far upstream.

The Nepean River flows into the Warragamba River near Wallacia downstream of which it is referred to as the Hawkesbury-Nepean River. The Hawkesbury- Nepean catchment is one of the largest coastal catchments in NSW with an area of some 21,400 km^2 at its mouth in Broken Bay on the northern side of the Sydney Metropolitan area.

Stonequarry Creek, Cedar Creek, Matthews Creek and Redbank Creek, which all traverse the local area, are tributaries of the Nepean River.

3.2 Redbank Creek Catchment

Redbank Creek is a stream with 3rd order or higher channel, whilst its tributaries are streams with 1st or 2nd order channels.

The topography in the vicinity of Redbank Creek is varied, ranging from gently undulating plateaux, ridges and low hills in the upland areas, to a rugged landscape of deeply dissected valleys and gorges in Hawkesbury Sandstone.

Redbank Creek flows roughly west to east through the township of Thirlmere before joining Stonequarry Creek just south of Picton, approximately 2.5 km upstream of the junction with the Nepean River. The Redbank Creek total catchment covers an area of approximately 8 km^2 and incorporates areas of both Thirlmere and Picton townships. The remainder of the catchment is undeveloped or agricultural land or mixed industrial/residential urban area.

Redbank Creeks contain a sequence of clay /sand based alluvial pools, exposed sandstone rock bars and creek beds, boulder fields and gravel / cobble riffles, with varying degrees and types of riparian and stream bed vegetative cover.

Flooding in Redbank Creek is typically contained in the creek channel with the exception of overbank flow located in the north-eastern extent of the hydraulic model downstream of the Antill Street culvert and in the vicinity of the Argyle Street Bridge. Depths in these areas range between 0.2 m and 1.0 m. Depths in the creek channel are significant in places with flood depths in excess of 4.0 m located downstream of the Argyle Street bridge.

Stream velocities in Redbank Creek are high (point velocities greater than 2.5 m/s) during the 1% the AEP design event. The velocities in the overbank flow path downstream of Antill Street and in the vicinity of the Argyle Street Bridge are slightly lower (less than 2.0 m/s).

Mapped pools along Redbank Creek are shown on **Figure 1**.

TCCO established gauging stations along Redbank Creek at 11 sites, as shown on **Figure 2**, and has undertaken a flow gauging program to develop flow ratings for each station. A baseline water quality monitoring program has also been undertaken at each gauging station, such that gauging station sites are paired with water quality monitoring sites.

In terms of gauging stations locations, the sites are categorised as the following:

- Control site (R1 and R11): a site which is to provide control data against which future subsidence impacts can be compared; or
- Baseline/impact site (R2 to R10): a site which is to be used to compare conditions before, during and after subsidence.

TCCO has nine (9) piezometers (P1 to P9) where regular manual and data logger based standing water level monitoring has been conducted since June 2004 for some locations, as shown on **Figure 3**.

3.3 Rainfall

Regional rainfall monitoring stations in the vicinity of the Redbank Creek have varying periods of record, as outlined on **Table 1**. The Buxton and Picton stations are the closest BoM stations with long term records without significant gaps in the data record.

BoM Station Number	Station Name	Year of Establishment & Closure	Percent Complete Record	Latitude (degrees south)	Longitude (degrees east)	Elevation (m AHD*)	Distance from Pit Top (km)
068166	Buxton	1967 - Open	92%	34.24	150.52	420	5.5
068052	Picton	1880 - Open	91%	34.17	150.61	165	9.3
068016	Cataract Dam	1904 - 2013	93%	34.26	150.81	340	21.3
068159	Wedderburn	1964 - Open	62%	34.17	150.81	250	23.1
068122	Cawdor	1962 - Open	88%	34.1	150.64	132	17.6
068216	Menangle Bridge	1963 - Open	94%	34.12	150.74	-	20.7
068200	Douglas Park	1974 - Open	98%	34.21	150.71	165	12.9

* Australian Height Datum. The existing Tahmoor pit top is at approximately 290m AHD.

Table 1: Summary of Regional Rainfall Monitoring Stations

Monthly long-term average rainfalls for the BoM stations and the record obtained for the Project site from the SILO Data Drill are summarised in **Table 2**. A comparison of monthly average rainfall totals from the Data Drill and local BoM rainfall data sites indicates that the Data Drill data are similar to nearby BoM station records.

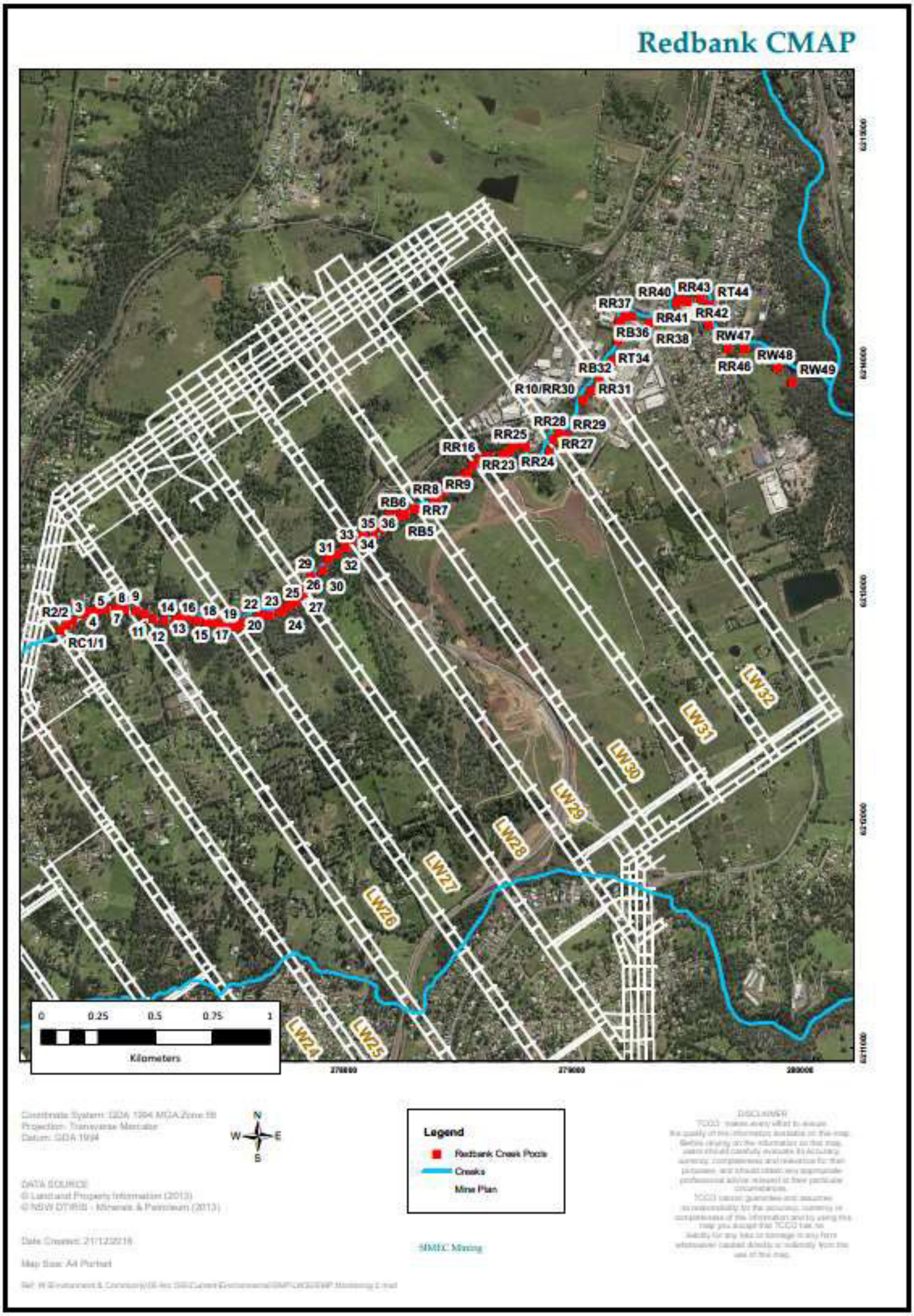

Figure 1: Redbank Creek Pools

Figure 2: Redbank Creek Monitoring Gauge Stations

Figure 3: Redbank Creek Groundwater Monitoring Bores

Data Source	Data Drill for Project Site	Picton Council Depot	Buxton	Douglas Park
Number of Years of Record	129	116	51	44
BoM Station Number	-	068052	068166	068200
	Rainfall (mm)	Rainfall (mm)	Rainfall (mm)	Rainfall (mm)
January	89.5	87	92.2	69.6
February	95.4	89.9	125.5	88.1
March	89.3	89.3	82.2	85.4
April	74.5	69.6	74	64.2
May	64.0	55.8	51.6	57.4
June	77.9	67.6	67.3	70.8
July	55.1	49.4	35.8	41
August	50.0	44.8	51.2	43.8
September	47.0	43.7	44.4	41.2
October	60.4	62.7	62	54.9
November	70.0	71.6	90.2	72.3
December	72.1	70.1	78	57.1
Annual Average	845.2	805	858.8	758.6

Table 2: Summary of Mean Rainfall Statistics

Rainfall data for the Picton Council Depot BoM station is shown on **Figure 4**.

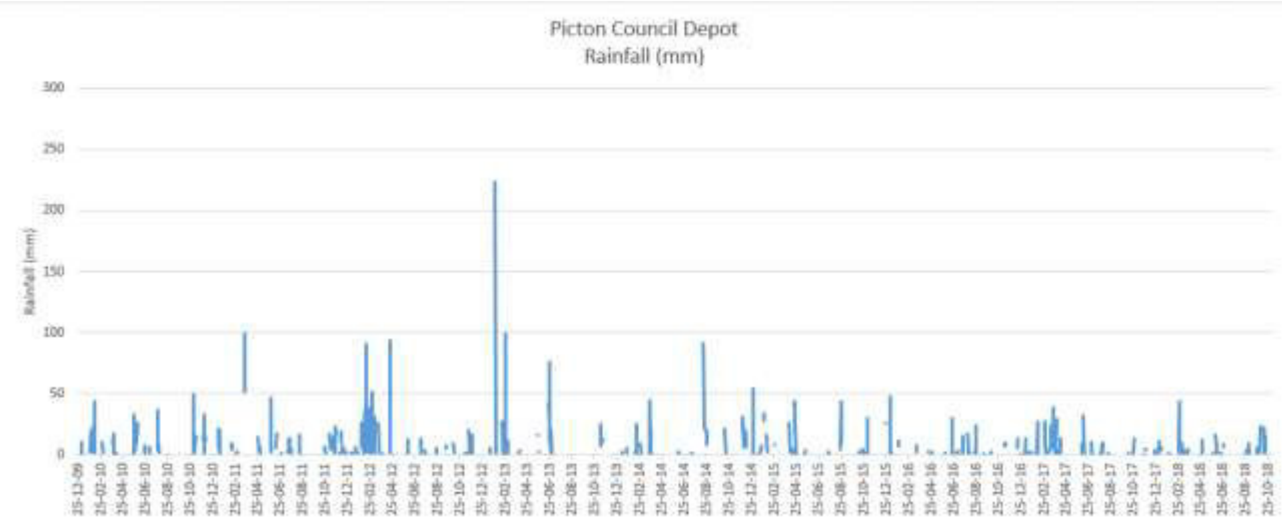

Figure 4: Picton Council Depot BoM Station Rainfall

The probability of low rainfall has been assessed using the Data Drill data suite, which shows, in **Figure 5**, the probability of low rainfall periods as the percentage of time that the total rainfall for different numbers of consecutive day periods has been less than or equal to the amount shown.

There is a 50% chance that 20mm of rainfall or less will fall in any 30 day period. There is also a 30% chance that 5mm or less will fall in any 10 day period. This indicates that the area in the vicinity of Redbank Creek has a relatively low probability of persistent dry/low rainfall.

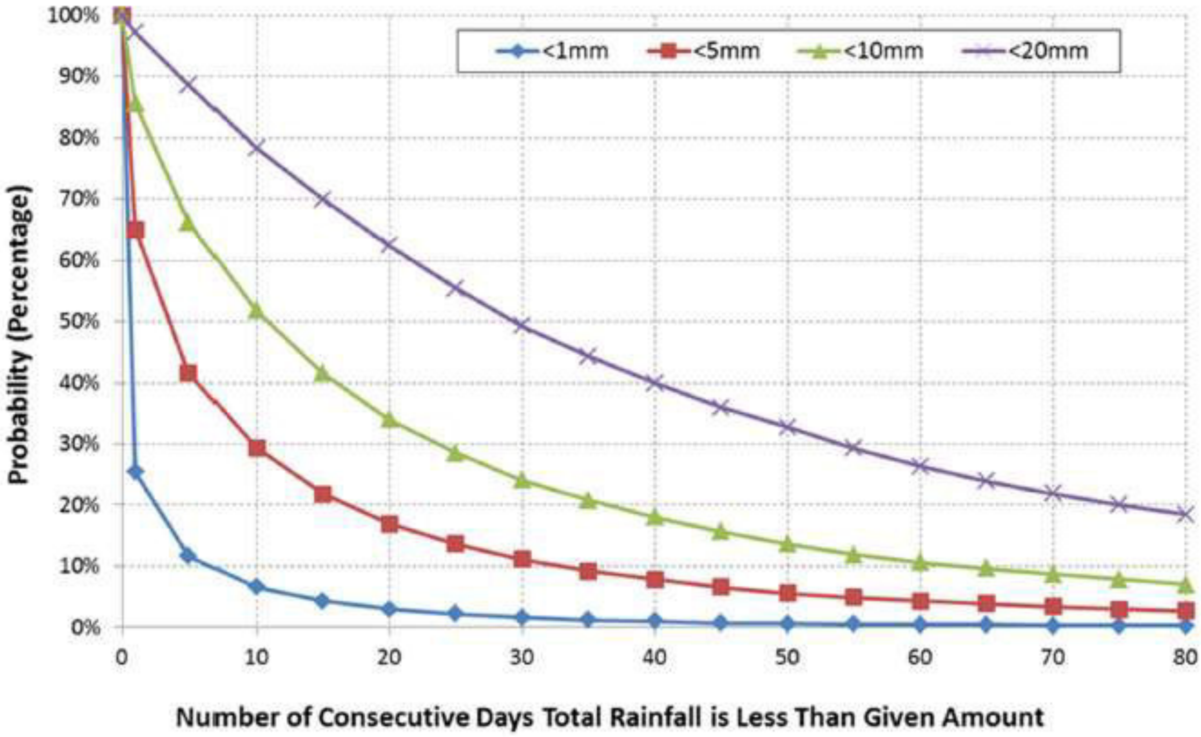

Figure 5: Low Rainfall Persistence Characteristics

3.4 Evaporation

The closest BoM climate station with pan evaporation (**PE**) data is Prospect Reservoir (0670191), which is located about 40 km to the northeast of Redbank Creek. Mean annual pan evaporation at Prospect is 1,314 mm.

Pan evaporation data was obtained from the SILO Data Drill for the site location and monthly estimates of point potential evapotranspiration2 were also taken from BoM mapping. A summary of monthly average Data Drill estimated pan evaporation and average monthly point potential evapotranspiration from BoM mapping are presented in **Table 3** along with the average monthly rainfall derived from the nearest Data Drill point.

The average site evaporation from the SILO Data Drill is consistently lower than the point potential evapotranspiration taken from the Climatic Atlas of Australia. Average evaporation exceeds average rainfall in all months except June when there is an average excess of rainfall. The greatest evaporation deficit occurs in June and the greatest excess occurs in December.

Month	Average Evaporation Data Drill	Climate Atlas of Australia (Point Potential Evapotranspiration)	Average Data Drill Rainfall
January	177.7	195	89.5
February	154.7	160	95.4
March	127.7	150	89.3
April	94.9	105	74.5
May	65.0	75	64.0
June	55.7	60	77.9
July	56.3	60	55.1
August	79.8	90	50.0
September	107.3	120	47.0
October	133.0	160	60.4
November	162.2	180	70.0
December	181.6	195	72.1
Annual Average	1,368	1,500	845.2

Table 3: Summary of Average Rainfall and Evaporation (mm)

4 Subsidence Processes

4.1 Definition of Active Subsidence Zone

As a longwall progresses, subsidence begins to develop at a point in front of the longwall face and continues to develop after the longwall passes. The majority of subsidence movement typically occurs within an area 150 metres in front of the longwall face to an area 450 metres behind the longwall face.

This is termed the *"active subsidence zone"* for the purposes of this EMP, where surface monitoring is generally conducted. The active subsidence zone for each longwall is defined by the area bounded by the predicted 20 mm subsidence contour for the active longwall and a distance of 150 metres in front and 450 metres behind the active longwall face, as shown by **Figure 6**.

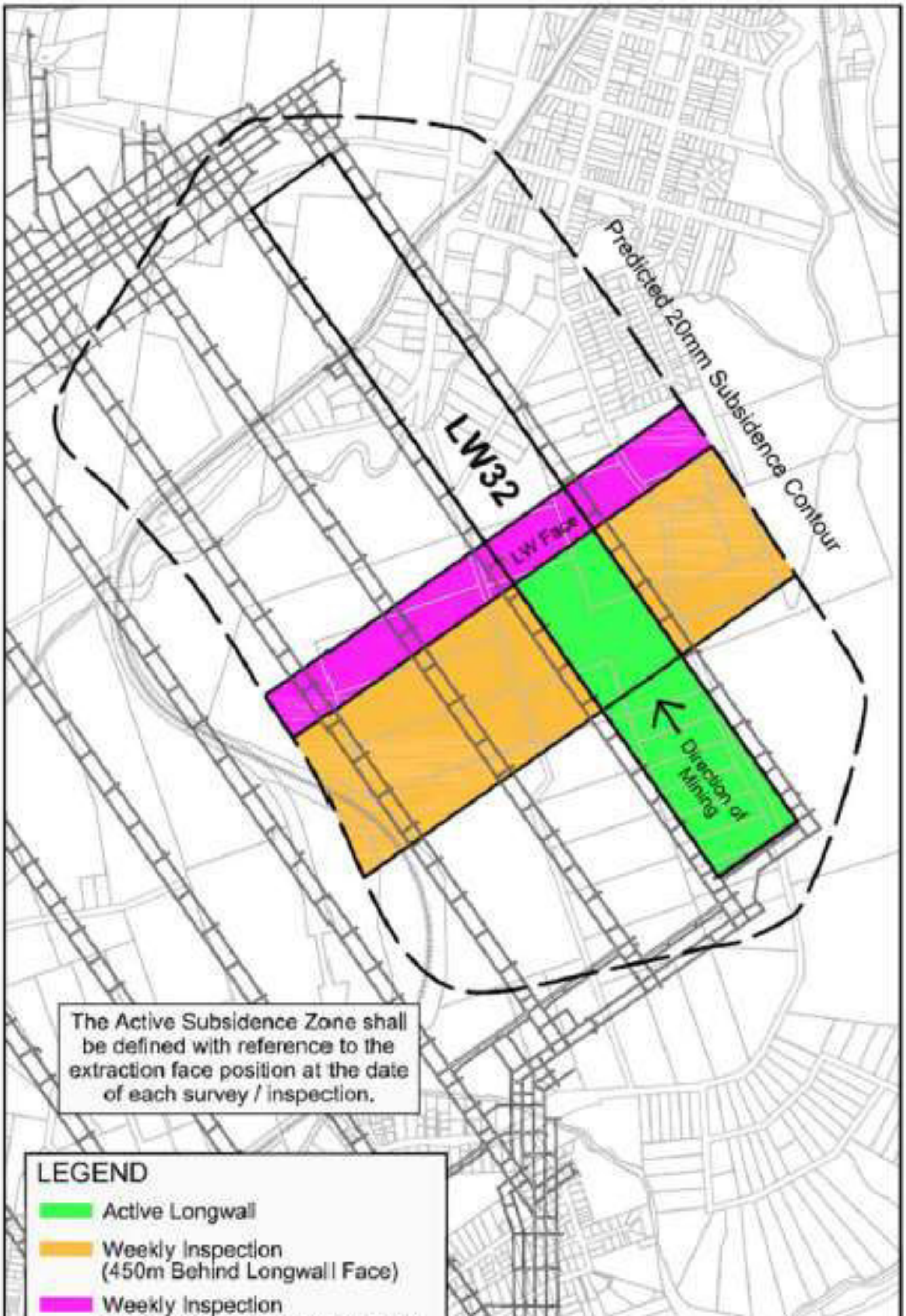

Figure 6: Diagrammatic Representation of Active Subsidence Zone

4.2 Subsidence Mechanisms

Following the Southern Coalfield Inquiry in 2008, it has become common practice in NSW to differentiate between subsidence effects, subsidence impacts and the resulting environmental consequences.

- **Subsidence Effect -** the nature of mining-induced deformation of the ground mass. This includes all mining-induced ground movements such as vertical and horizontal displacements and their expression as ground curvatures, strains and tilts.
- **Subsidence Impact -** any physical change caused by subsidence effects to the fabric of the ground, the ground surface, or a structure. In the natural environment these impacts are principally tensile and shear cracking of the rock mass, localised buckling of the strata and changes in ground profile.
- **Environmental Consequence -** any change caused by a subsidence impact to the amenity, function or risk profile of a natural or constructed feature. Some consequences may give rise to secondary consequences. Environmental consequences of subsidence could include the redirection of surface water to the subsurface through mining-induced fractures may be a primary consequence for water inflow and result in secondary consequences for surface ecology. Additionally, could also include loss of stream flow, loss of vegetation and faunal habitat, erosion, scouring, ponding and development of iron staining.

4.2.1 Subsidence Effects

The term subsidence effects to describe subsidence itself, that is, deformation of the ground mass caused by mining, including all mining-induced ground movements such as vertical and horizontal displacements and curvature as measured by tilts and strains.

Maximum subsidence varies and is directly dependent on a number of factors, including:

- Depth of cover;
- Panel width;
- Pillar width;
- Panel width to depth ratio;
- Seam thickness extracted;
- Proximity of adjacent previously mined panels in current seam; and
- Proximity of adjacent previously mined panels in other seams under multi-seam conditions.

The overburden is usually comprised of near-horizontally bedded strata. Sag results in each stratum being ‘stretched’ and placed into tension. Because rock is very weak when under tension, this is conductive to the opening up of existing geological joints and the formation of fresh near vertical fractures. In the process of sagging, shearing also occurs along the bedding planes between and within the various strata. Fresh near-horizontal fractures may also be formed. These sliding surfaces can develop into open cracks, which may become quite wide if the lower bed of rock sags more than the adjacent upper bed. Hence, a well developed and connected vertical and horizontal fracture network is likely to exist in the rock mass immediately overlying the caved material in a goaf. This network defines the fractured zone.

The caved material bulks and occupies a greater volume when it falls. A point is reached where, with increasing excavation width (W), the roof fall will choke itself off and act as a cushion to the overlying strata. It is known from theoretical calculations and field measurements that this caving height typically ranges from 3 to 10 times the mining height, depending on the nature of the roof strata. Highly-laminated strata tend to fall like a deck of cards and so have a low bulking factor, resulting in the caved zone extending to a considerable height. Falls comprising blocky material, such as sandstone, tend to bulk up and choke off quickly. The caving height defines the limit of the caved zone shown on **Figure 7**.

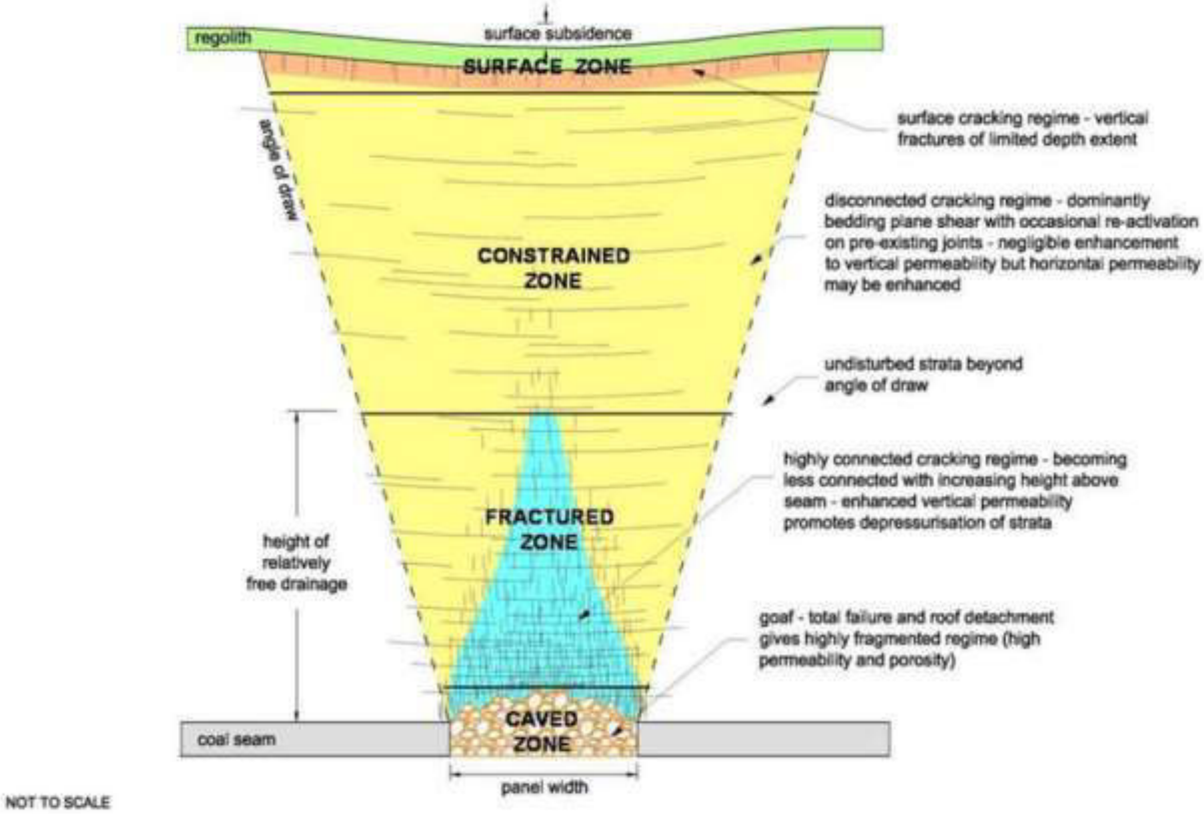

Figure 7: Conceptual Model of Caving and Fracturing

The lateral extent of sag increases with distance above the excavation. This results in a decreasing rate of deflection, or curvature, in the upper strata and a corresponding reduction in shear and tensile stresses. Given sufficient depth, a point is reached where the tensile stresses become too low in the upper strata to cause joints to open or new vertical fractures to develop on a regular or continuous basis. Horizontal fracture planes may still be activated as a result of sagging strata sliding past each other but the magnitude of these displacements also reduces as curvature decreases. The zone in which this behaviour occurs is referred to as the constrained zone. It is characterised by strata which have not suffered significant alteration of their physical properties, and therefore there is negligible change in vertical permeability and only a slight increase in horizontal permeability. The surface zone lies above the constrained zone.

The surface above coal mine workings usually subsides in the form of a subsidence trough, taking on a saucer-shaped appearance. The angle of draw is a subsidence engineering term used to define the limits of the subsidence trough. It is the angle between two lines drawn from the edge of the mine workings, one a vertical line and the other a line to the limit of vertical displacement on the surface. Because surface movements can also be caused by natural effects such as seasonal variations or drought leading to swelling or shrinkage of near-surface soil and sediment, it can be very difficult to identify where vertical movement due to mining ceases. It is standard practice to specify a limiting value for vertical displacement which might be attributable to mining and this value is usually 20 mm of vertical subsidence.

Curvature in an outwards direction results in the ground ‘stretching’ or ‘hogging’ and is referred to as convex curvature. Curvature in an inwards direction causes the ground to sag and move closer together and is referred to as concave curvature.

Features of curvature include:

- Curvature results in points on the surface moving in both a vertical direction and a horizontal direction as they subside into a subsidence trough;
- Curvature changes the slope, or horizontal level, of the surface which, in turn, changes the tilt, or vertical level, of surface features;
- Convex curvature induces tension on the surface;
- Concave curvature induces compression on the surface;
- Bending is induced in long features located on curvature surfaces; and
- Near-surface strata may shear along bedding planes and fresh fracture surfaces as they bend and subside into the subsidence trough.

As mining approaches a site, the site will begin to tilt towards the excavation. Maximum tilt occurs at the point of inflection between concave and convex curvature. The amount of horizontal extension or compression induced over a given distance on the surface is expressed in terms of strain, as shown on **Figure 8**.

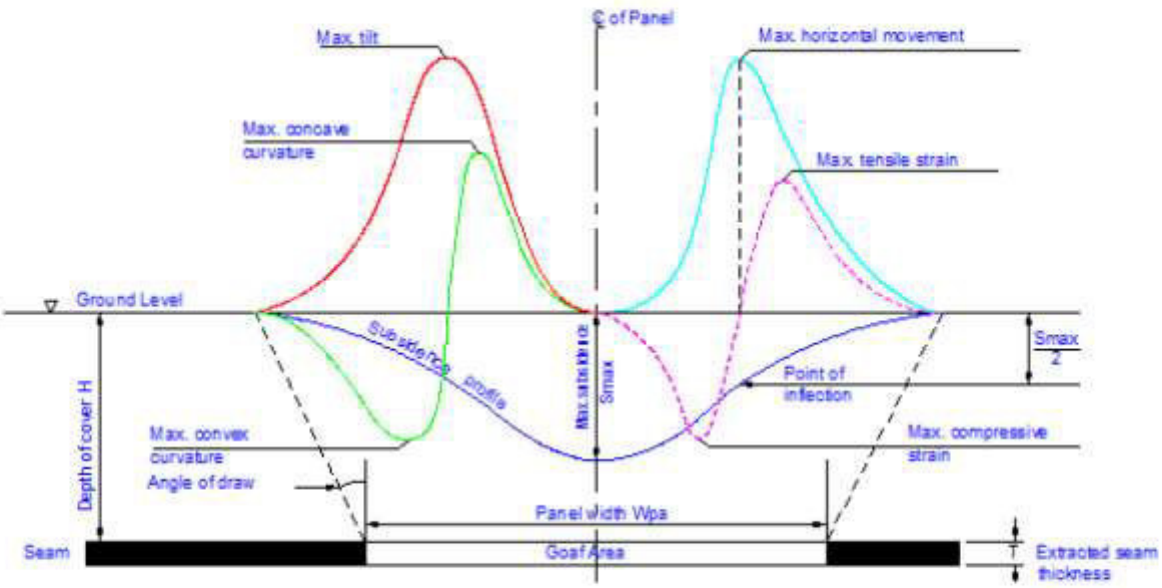

Figure 8: Subsidence Parameters

Strain is also expressed in terms of mm/m, that is, millimetres of stretch or millimetres of shortening per metre of distance. As the edge of an excavation is approached from the solid side, tensile strain begins to increase and builds up to a maximum value which usually occurs over the excavation. From that point, there is a graduation from the point of maximum tensile strain, through a point of zero strain, to a point of maximum compressive strain. Surface strain changes from tensile to compressive at the point of inflection.

The near surface rocks over coal mine workings are usually comprised of laminated strata. In order for the strata to sag and subside, the individual strata have to slide past each other, as shown in **Figure 9**. This shear movement may or may not significantly enhance horizontal permeability. Additionally, when one face of a stratum is subjected to tension, its opposite face is subjected to compression. Because rocks have very low tensile strength (rocks are typically 10 to 30 times weaker in tension than compression), surfaces in tension are susceptible to fracturing and to the opening of pre-mining fractures.

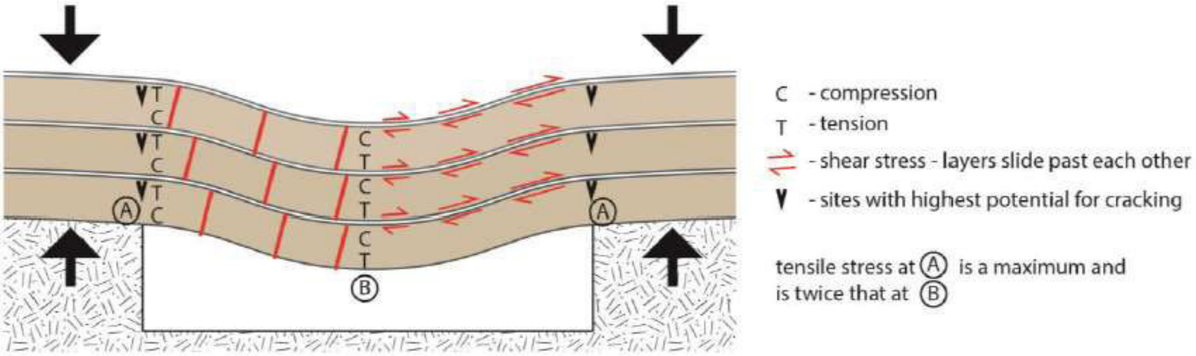

Figure 9: Shear Diagrammatic Representation

4.2.2 Subsidence Impacts

The term subsidence impacts is then used to describe the physical changes to the ground and its surface caused by these subsidence effects.

These impacts are principally tensile and shear cracking of the rock mass and localised buckling of strata caused by valley closure and upsidence but also include subsidence depressions or troughs.

The environmental consequences of these impacts include:

- Loss of surface flows to the subsurface;
- Loss of standing pools;
- Water quality impacts;
- Development of iron bacterial mats;
- Cliff falls and rock falls;
- Damage to Aboriginal heritage sites; and
- Impacts on aquatic ecology and ponding.

4.3 Valley Closure

4.3.1 Valley Closure Mechanics

As erosion has taken place over geologic time, the vertical (loading) stresses have been relieved but a component of the horizontal stress remains locked in the seams and surrounding strata. Tectonic processes associated with the movement of continental plates may have imprinted additional horizontal stresses, which are often strongly directional. Therefore, it is not uncommon in coalfield strata for the horizontal stress in at least one direction to be up to three times greater than the vertical stress.

Steep, incised topography interrupts the transmission of horizontal stress, causing it to be redirected from the hills and into the floor of the valleys or gorges. This can lead to overstressing of valley floors, with the near-surface rock strata uplifting under the effects of bending and buckling. The valley is deepened which, in turn, causes an increase in the horizontal stress redirected into the floor of the valley. This very slow, self-perpetuating natural process is referred to as valley bulging.

Mining causes further disruptions to this natural regional horizontal stress system because:

- Causes a void which then redirects horizontal stress into the roof and floor of the void. The effective height of the void is increased if fracturing and/or caving of the undermined strata occur. If a constrained zone exists above the mine workings, some of the horizontal stress will be redistributed through this zone. This increases the horizontal stress acting across the valley floor; and

- Removes or reduces the resistance to horizontal movement in the zone comprised of caved and fractured material, thereby permitting the surrounding rock mass to relax and to move towards the excavation.

When mining-induced fractures are created within the overburden strata more generally during the incremental vertical subsidence that is characteristic of longwall mining, the volume occupied by the fractures is additional to the original volume of the rock strata so there is an overall increase in volume called dilation. Mining-induced horizontal compression across the creek channel is generated by dilation (volume increase) of the overburden strata located to either side of the channel.

The dilation of the strata on either side of a topographic low point, such as creek channels, becomes concentrated at these topographic low points because there is freedom for the valley sides to move toward the valley and the confining pressures provided by the overburden strata to either side are not present at the creek line, as shown on **Figure 10.**

Two responses arising from these mining-related stress behaviours are:

- Valley closure, whereby the two sides of a valley move horizontally towards the valley centreline; and
- Uplift of the valley floor, as a result of valley bulging and buckling and shearing of the valley floor and near surface strata.

The ground movements that occur around excavations in steeply incised terrain in a high horizontal stress environment are complex and it is difficult to identify the individual contribution of the various components to these movements, which include:

- Conventional subsidence movements;
- Elastic ground movements associated with redistribution of horizontal stress on a regional
- basis;
- Movements associated with localised buckling and shear failure; and
- Gravity-induced downhill slippage.

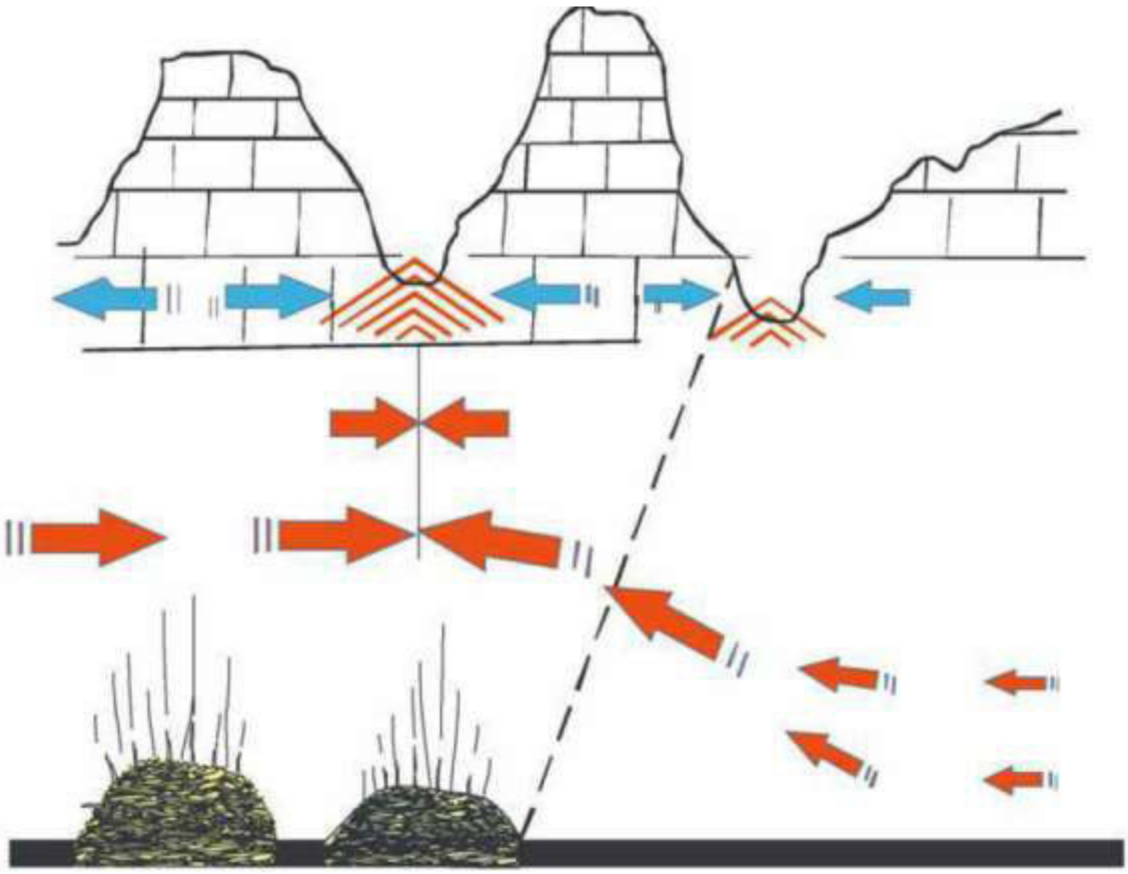

Figure 10: Valley Closure Conceptualisation

4.3.2 Valley Closure Impacts

Buckling and shear in the near-surface strata, which leads to upsidence, can also generate an extensive network of fractures and voids in the valley floor. Ground movements due to conventional subsidence can also contribute to the formation of this network if the upsidence occurs within the angle of draw of the mine workings. The main fracture network extends to a depth of about 12 metres and bed separation extends to a depth of some 20 metres, as shown on **Figure 11**.

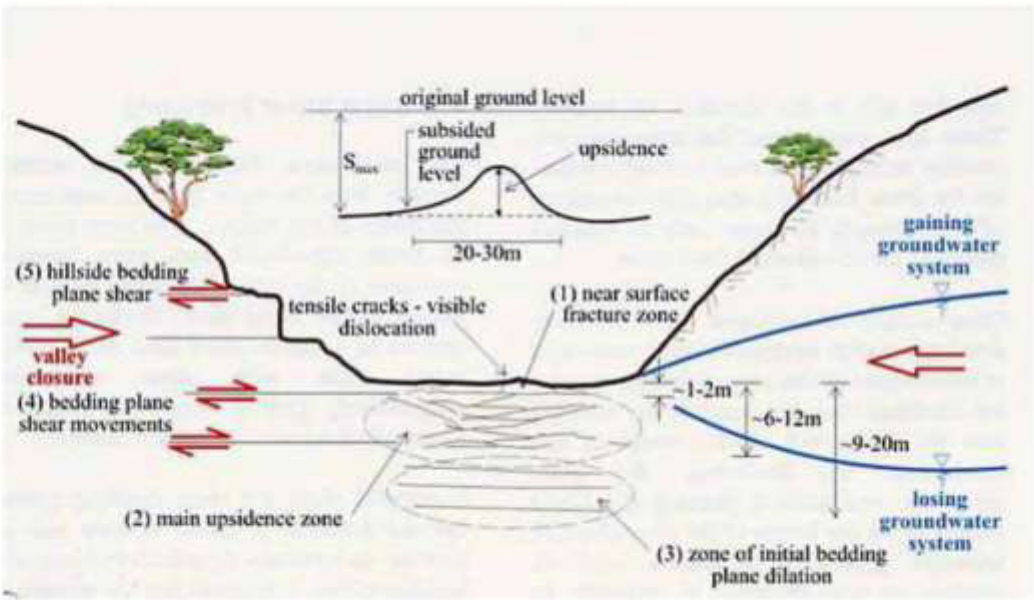

Figure 11: Mechanisms of Valley Closure and Upsidence

4.3.3 Valley Closure Consequences

The process of valley closure occurs naturally as valleys are cut down into the host rock by the erosive action of the creek. The interaction of vertical stress relief and diurnal and annual temperature variations causes rock close to the surface to become overloaded and fractured. Generally, the rates of natural processes are slow enough that sufficient sediment is deposited within the fracture network to maintain a high proportion of the total flow as surface flow.

However, subsidence effects can enhance the impacts of valley closure once compression movements increase sufficiently, fresh fractures are created within the sandstone strata in the bed of the creek and existing fractures that may have become sealed with sediment over time are remobilised. Open fractures within the near surface strata provide an alternative pathway for surface flow. Flow that previously flowed on the surface can now flow through this sub-surface fracture network, at least during periods of low flow.

Mining-induced surface flow diversion into subterranean flows occurs where there is an upwards thrust of bedrock, resulting in fracturing of the rock and redirection of surface water through the dilated strata beneath it. The water reappears downstream of the fractured zone as the water is only redirected below the river bed for the extent of the subsidence induced fracturing, as outlined on **Figure 12**.

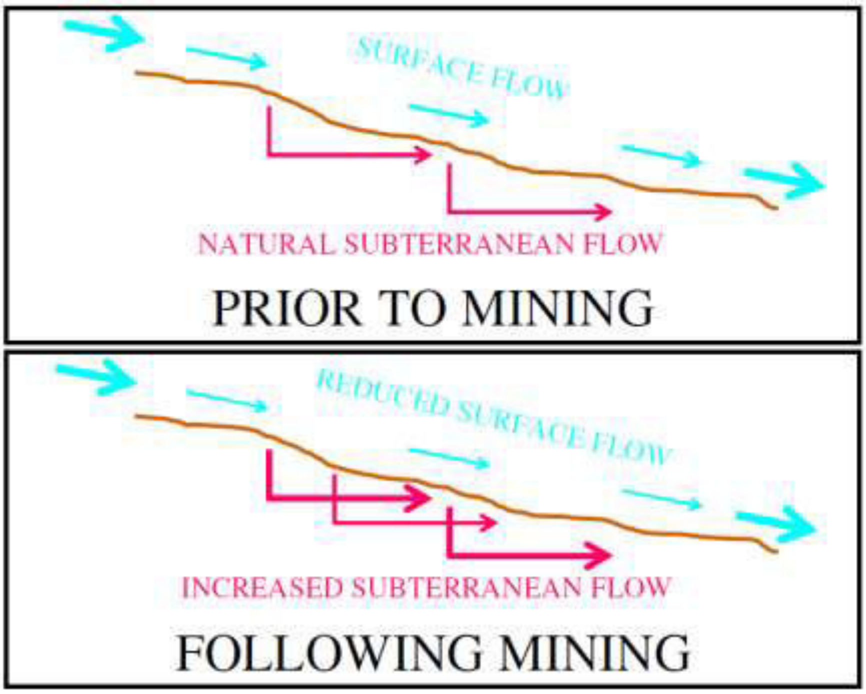

Figure 12: Diagrammatic Representation of Subterranean Flows

During periods of high flow such as immediately after heavy rain, frictional resistance requires an increase in head to drive the additional flow through the sub-surface fracture network. With sufficient flow, as occurs after heavy rain, this head increases to reach the surface and gives the appearance that flow has returned to the surface.

As the flow reduces again, the fracture network becomes able to accommodate all the flow without the need for the hydraulic gradient to rise above the surface. Although water is still flowing in the creek system, the surface pools appear to have dried out.

The fracture network is generally a zone of intense fracturing below the creek bed. This zone is typically evident to a depth of less than 6 metres, but has been observed to range up to about 12 to 20 metres below the surface. The intense fracturing is evident as open fractures of up to several hundred millimetres wide. These develop as low angle conjugate fractures to form wedges that lift the surface causing localised upward movement or upsidence directly above the zone of intense fracturing.

A basal shear plane extends outward from the base of the zone of intense fracturing on either side of the river channel. Shear on this basal plane enables horizontal movement of the valley sides inward toward the creek to generate the zone of intense fracturing. Measurements at various sites indicate that basal shear planes are likely to follow bedding and may extend hundreds of metres either side of the valley. They may be formed as part of natural valley forming processes and are then remobilised by the dilation associated with mining subsidence.

Depending on the magnitude of valley closure, both the zone of intense fracturing and the basal shear plane have potential to be hydraulically conductive. At low flows, all the flow in the creek can flow through these fracture networks without appearing on the surface.

Mining-induced surface flow diversion due to rockbar leakage occurs in a similar manner to the above mechanism, except that the rockbar is elevated above the rest of the river bed and the general water table. The rate of leakage is dependent, among other things, on the extent of horizontal fracturing within the depth of the rock bar and the water level. The rockbar leaks at a higher rate when the pool is full as there is access to all drainage paths and the water pressure is at its highest. However, as the pool level falls, the drainage rate reduces as the water pressure falls and access is restricted to drainage paths near the base of the rockbar, as outlined on **Figure 13**.

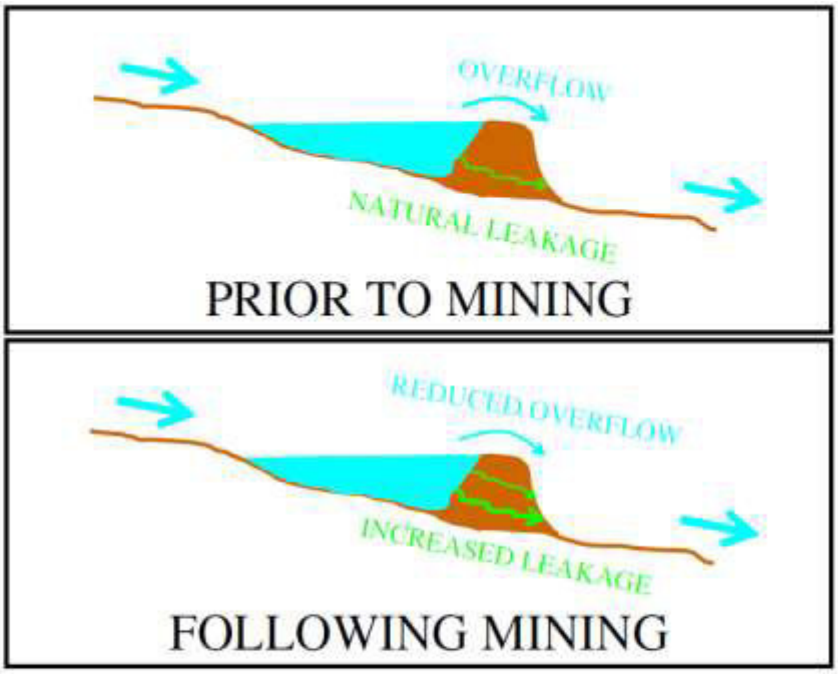

Figure 13: Diagrammatic Representation of Rockbar Leakage

5 Longwall 32 Mining Parameters

5.1 Background

Tahmoor Mine is located approximately 80 km south-west of Sydney in the township of Tahmoor NSW.

TCCO has previously mined 31 longwalls to the north and west of the mine's current location.

TCCO is currently mining LW32.

LW32 is a continuation of a series of longwalls that extend into the Tahmoor North Lease area, which began with Longwall 22. The longwall panels are located between the Bargo River in the south-east, the township of Thirlmere in the west and Picton in the north.

LW32 is located beneath the rural area between Tahmoor, Thirlmere and Picton, including part of the South Picton industrial area.

Table 4 provides a summary of the dimensions of LW32.

Longwall	Overall void length including the installation heading (m)	Overall void width including the first workings (m)	Overall tailgate chain pillar width (m)
Longwall 32	2,378	283	39

Table 4: Longwall 32 Dimensions

5.2 Mining Schedule

LW32 is planned to extract coal working northwest from the south-eastern end.

The EMP covers longwall mining until completion of mining in LW32 and for sufficient time thereafter to allow for completion of subsidence effects.

Table 5 outlines the current schedule of mining.

Longwall	Start Date	Completion Date
Longwall 32	October 2018	October 2019

Table 5: Longwall 32 Mining Schedule

6 Longwall 32 Subsidence Parameters

6.1 Longwall 32 Subsidence Predictions

Predicted mining-induced conventional subsidence movements were outlined within TCCO's SMP Approval application for Longwalls 31 to 37, and includes predictions due to the extraction of LW32.

A summary of the maximum predicted incremental subsidence parameters due to the extraction of LW32 only and the maximum predicted total conventional subsidence parameters due to the extraction of Longwalls 22 to 32, are provided in **Table 6**.

Longwall	Maximum Predicted Subsidence (mm)	Maximum Predicted Tilt (mm/m)	Maximum Predicted Hogging Curvature (1/km)	Maximum Predicted Sagging Curvature (1/km)
Increment due to LW32 only	700	5.5	0.06	0.12
Total after extraction of LWs 22 to 32	1,225	6.0	0.09	0.13

Table 6: Incremental and Maximum Predicted Conventional Subsidence Parameters for LW32

The values provided in the above table are the maximum predicted conventional subsidence parameters which occur within the general longwall mining area, including the predicted movements resulting from the extraction of Longwalls 22 to 32.

The location of the maximum predicted total subsidence is not directly above LW32. Predicted maximum total subsidence directly above LW32 is approximately 800 mm.

6.2 Observed Subsidence Longwalls 22 to 31

The extraction of longwalls at Tahmoor Mine has generally resulted in mine subsidence movements that are typical of those observed above other coal mines located within the Southern Coalfield of NSW at comparable depths of cover.

However, observed subsidence was greater than the predicted values over Longwalls 24A and the southern parts of Longwalls 25 to 27, likely to be associated with proximity to the Nepean Fault geological structure.

Monitoring during the mining of Longwalls 28 to 31 has found that subsidence behaviour has returned to normal levels, as shown on **Figure 14**.

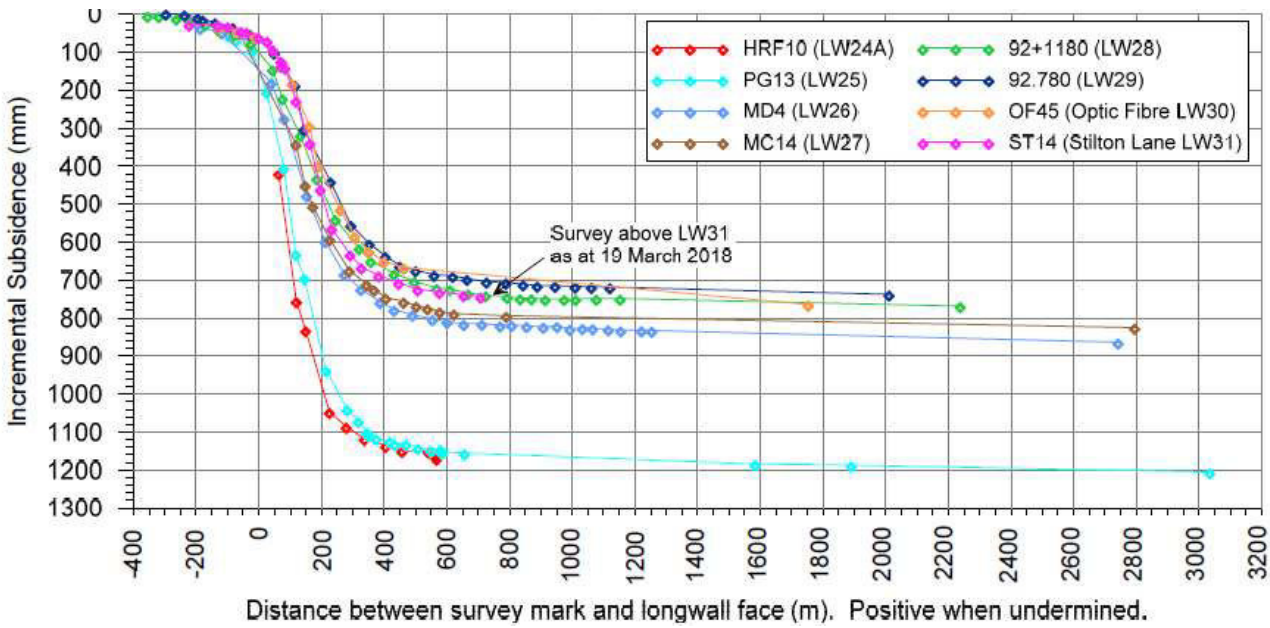

Figure 14: Observed Development of Subsidence Above Centrelines of Longwalls 24A to 31

SIMEC

6.3 Predicted Strain

The prediction of strain is more difficult than the predictions of subsidence, tilt and curvature. The reason for this is that strain is affected by many factors, including curvature and horizontal movement, as well as local variations in the near surface geology, the locations of pre-existing natural joints at bedrock, and the depth of bedrock. Survey tolerance can also represent a substantial portion of the measured strain, where the strains are of a low order of magnitude. The profiles of observed strain, therefore, can be irregular even when the profiles of observed subsidence, tilt and curvature are relatively smooth.

For features that are in discrete locations, such as archaeological sites, it is appropriate to assess the frequency of the observed maximum strains for individual survey bays.

6.3.1 Predictions of Strain Above Goaf

The survey database has been analysed to extract the maximum tensile and compressive strains that have been measured at any time during the extraction of Longwalls 22 to 28 at Tahmoor Mine, for survey bays that were located directly above goaf or the chain pillars that are located between the extracted longwalls, which has been referred to as "*above goaf*".

The histogram of the maximum observed total tensile and compressive strains measured in survey bays above goaf at Tahmoor Mine is outlined in **Figure 15**.

The 95 % confidence levels for the maximum total strains that the individual survey bays above goaf experienced at any time during mining are 0.9 mm/m tensile and 1.8 mm/m compressive. The 99 % confidence levels for the maximum total strains that the individual survey bays above goaf experienced at any time during mining are 1.5 mm/m tensile and 3.5 mm/m compressive.

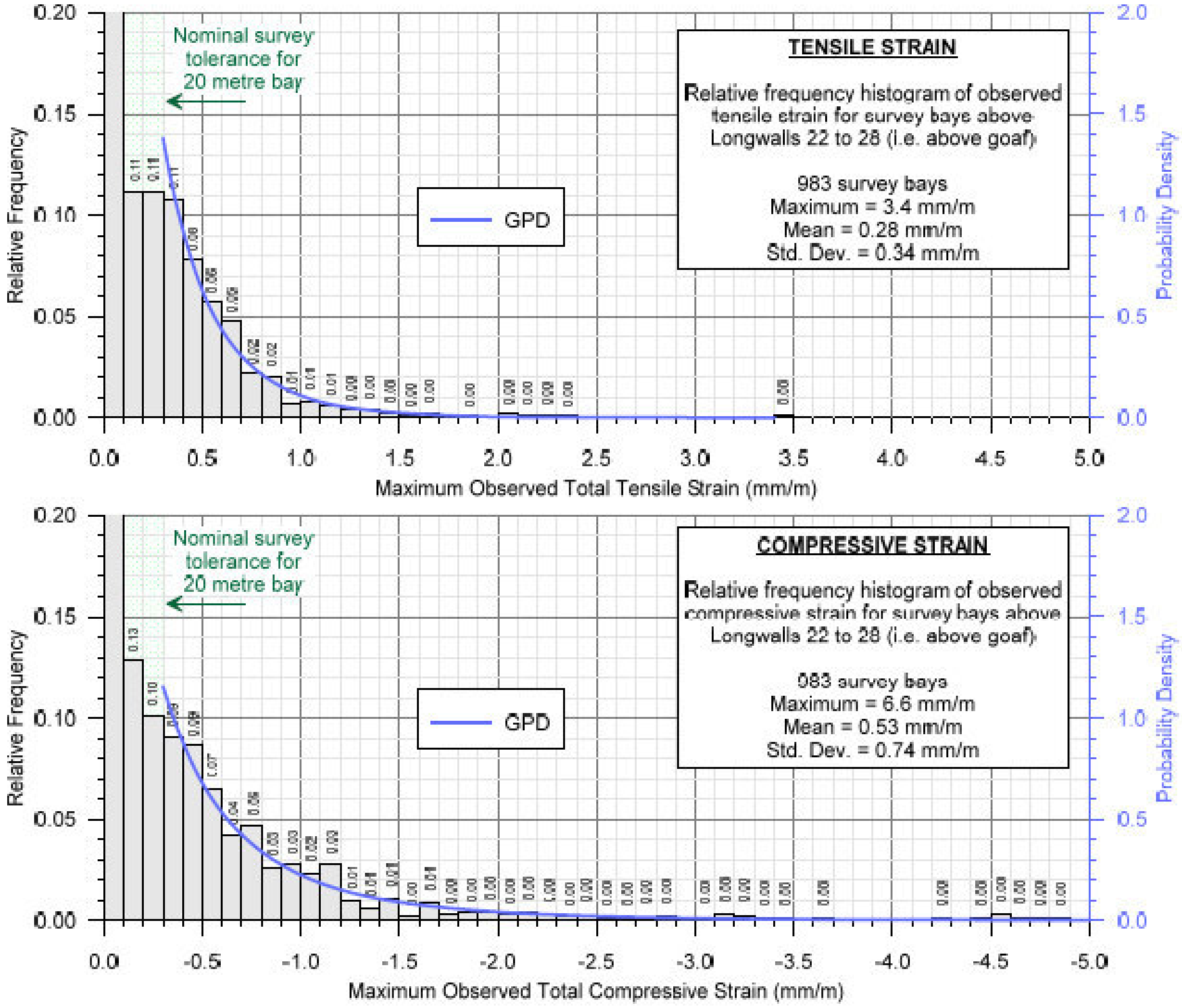

Figure 15: Distributions of Maximum Tensile and Compressive Strains above Goaf

6.3.2 Predictions of Strain Above Solid Coal

The survey database has also been analysed to extract the maximum tensile and compressive strains that have been measured at any time during the extraction of Longwalls 22 to 28 at Tahmoor Mine, for survey bays that were located outside and within 200 metres of the nearest longwall goaf edge, which has been referred to as "*above solid coal*".

The histogram of the maximum observed tensile and compressive strains measured in survey bays above solid coal at Tahmoor Mine is outlined in **Figure 16**.

The 95 % confidence levels for the maximum total strains that the individual survey bays above solid coal experienced at any time during mining are 0.6 mm/m tensile and 0.5 mm/m compressive. The 99 % confidence levels for the maximum total strains that the individual survey bays above solid coal experienced at any time during mining are 1.1 mm/m tensile and 0.9 mm/m compressive.

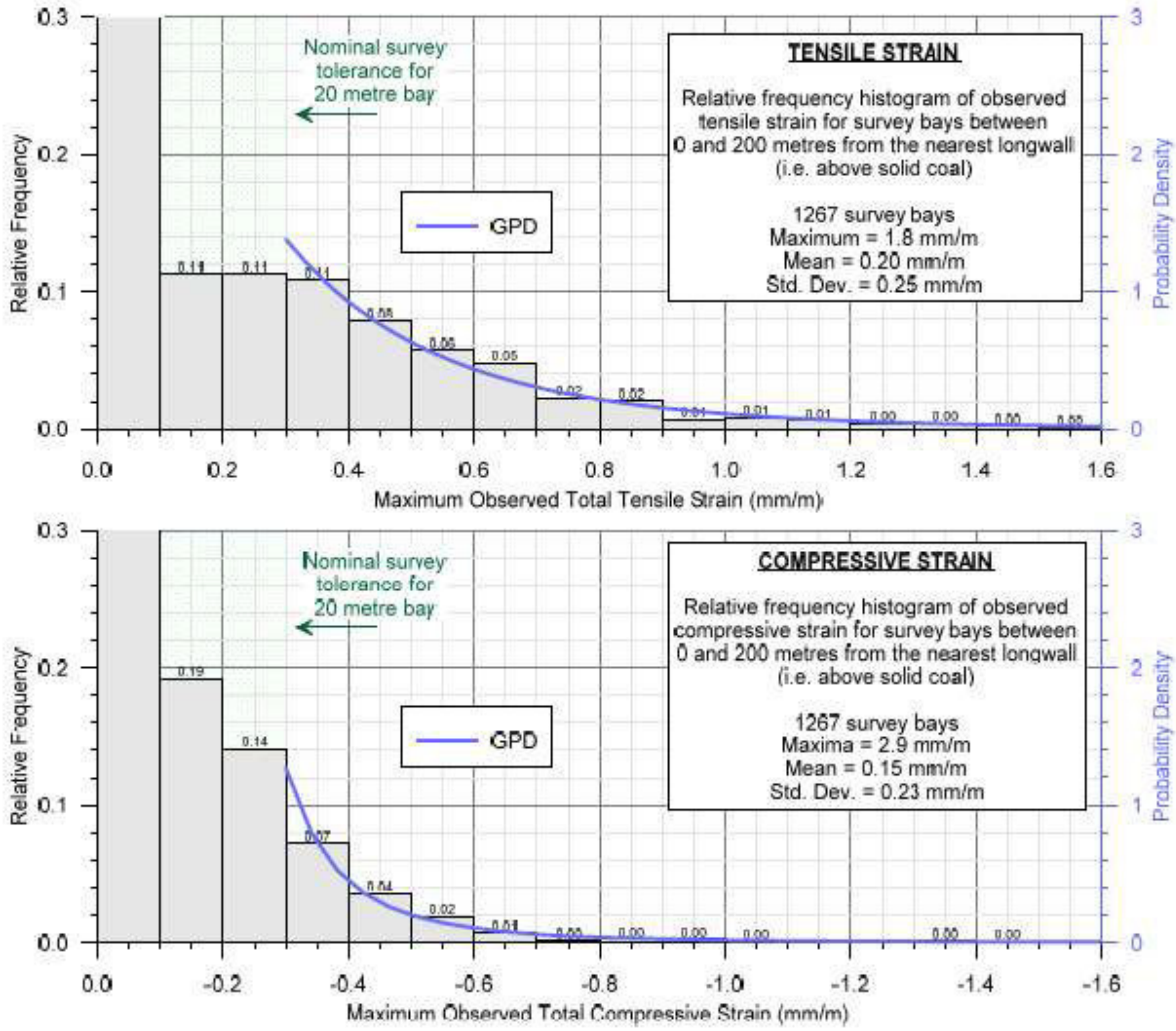

Figure 16: Distributions of Measured Maximum Tensile and Compressive Strains Above Solid Coal

6.4 Redbank Creek Valley Closure

A summary of the maximum predicted values of total subsidence, upsidence and closure along these creeks, after the extraction of each of the proposed longwalls, is provided in **Table 7**.

The predicted subsidence movements are the maximum values which occur along the stream, including the predicted movements resulting from the extraction of Longwalls 22 to 30. The predicted upsidence and closure movements are the maximum values which occur within the predicted limits of 20 mm additional upsidence and 20 mm additional closure, due to the extraction of Longwalls 31 to 32, but also include the predicted movements resulting from the extraction of Longwalls 22 to 30.

Longwall	Maximum Predicted Total Subsidence (mm)	Maximum Predicted Total Upsidence (mm)	Maximum Predicted Total Closure (mm)
After LW30	1,250	500	500
After LW31	1,250	525	575
After LW32	1,250	575	625

Table 7: Maximum Predicted Total Subsidence, Upsidence and Closure

7 Risk Management

7.1 General

The method of assessing potential mine subsidence impacts in this EMP is consistent with the Australian/New Zealand Standard for Risk Management (**AS/NZS 4360:1999 – Risk Management**).

The Standard defines the terms used in the risk management process, which includes the identification, analysis, assessment, treatment and monitoring of potential mine subsidence impacts. In this context:-

7.2 Consequence

AS/NZS 4360:1999 defines consequence as:

> *The outcome of an event expressed qualitatively or quantitatively, being a loss, injury, disadvantage or gain. There may be a range of possible outcomes associated with an event.*

The consequences of a hazard are rated from very slight to very severe.

7.3 Likelihood

AS/NZS 4360:1999 defines likelihood as:

> *Used as a qualitative description of probability or frequency.*

The likelihood can range from very rare to almost certain.

7.4 Hazard

AS/NZS 4360:1999 defines hazard as:

> *A source of potential harm or a situation with a potential to cause loss.*

7.5 Method of Assessment

The method of assessing potential mine subsidence impacts combines the likelihood of an impact occurring with the consequence of the impact occurring.

In this EMP, the likelihood and consequence are combined using the SIMEC Mining Risk Matrix to determine an estimated level of risk for particular events or situations.

7.6 Risk Assessment

A risk assessment for LW32 was conducted on 24 May 2018 that considered the natural features outlined within this EMP.

8 Potential Subsidence Impacts

8.1 Surface Water

8.1.1 Redbank Creek

Redbank Creek will be directly mined beneath by Longwall 32.

Redbank Creek flows over predominantly Hawkesbury Sandstone bedrock with natural iron hydroxide containing seepage flowing into the creek, resulting in red colouration of the banks and pools.

The main channel of Redbank Creek within the Longwall 32 active subsidence zone is developed principally for industrial use on both the northern and southern banks, with lesser semi-rural residential development on the southern bank. Agricultural land on the southern bank is used for mainly cattle and horse grazing.

The stream bed and banks are generally well vegetated with predominantly native vegetation intermixed with weeds, and do not show significant erosion or bank instability.

Redbank Creek flows above Longwalls 32 and towards the north-east, where it joins Stonequarry Creek approximately 830 metres (m) east of proposed Longwall 32, it then drains to the Nepean River. The creek falls approximately 30 metres over a total length of approximately 2,300m, with an inferred average gradient of 13mm/m.

There are a number of channel constraints, including rockbars, boulders and rock shelves, which form standing pools along the alignment of the creek. Natural iron seepage flows into the creek, resulting in red colouration of the banks and pools.

The pools along the streams have flow controlling features along their alignments that include rockbars, boulders, tree roots and gravel.

Redbank Creek is the primary watercourse that will experience subsidence impacts due to the extraction of Longwall 32. A tributary to Redbank Creek was mined directly beneath by Longwall 31 and is located to the southern side of Longwall 32. The tributary is located within pasture land.

It is expected that fracturing could develop along the sections of Redbank Creek located directly above Longwall 32, as experienced along Redbank Creek during the mining of previous longwalls. In some locations along Redbank Creek, the surface water flows will be diverted into the dilated strata beneath the beds, which could result in the partial or complete loss of surface water flows and the drainage of pools. It is unlikely that there would be any net loss of water from the catchment, as the depth of buckling and dilation resulting from longwall mining is generally less than 10 metres to 15 metres, with the diverted flows expected to re-emerge further downstream.

8.1.2 Fluvial Geomorphology

8.1.2.1 Change of Grade Impacting Pool Levels

No reversal of flow, increased levels of ponding or increased levels of scouring have been observed in Redbank Creek during the mining of Longwalls 22 to 31. This is because the mining induced tilts are significantly smaller than the natural creek gradients. A similar outcome is expected to occur along Redbank Creeks due to mining Longwall 32.

The maximum predicted changes in grade along the alignments of Redbank Creek is 6 mm/m (i.e. 0.6 %). The natural grade along the alignment of Redbank Creek varies between 5 mm/m and 40 mm/m, with an average natural grade of 15 mm/m.

The predicted systematic tilts along the alignments of the creek is small compared to the existing natural grades and are unlikely, therefore, to result in any significant increases in the levels of ponding, flooding or scouring.

The creek has highly variable perennial stream flow over Longwall 32 and partially serves as drainage conduit for runoff from the industrial, urban and rural areas within the creek catchment in Thirlmere.

As a result of the generally moderate flow and low gradient, it is assessed that the small changes in grade imposed by subsidence will have an insignificant effect on the aquatic habitat of Redbank Creek over Longwall 32.

8.1.2.2 Creek Bed Fracturing

Overall, there have been adverse effects on pool depth and longevity, connected stream flow and water quality in Redbank Creek over the subsided longwalls after extraction of Longwalls 25 to 31.

Regular visual inspections have identified subsidence related cracking of numerous sandstone rockbars and rock shelves in Redbank Creek above Longwalls 26 to 31, which has affected pool water levels and pool longevity upstream of the affected rockbars, as well as generating disconnected stream flow.

In addition, new ferruginous springs have been generated, reduced or relocated downstream, which sequentially change location downstream as the longwalls advance down the gradient of the creek.

It is possible that additional fracturing may occur in the creek bed as a result of mining Longwall 32 with similar associated effects on pools and stream flow over Longwall 32.

Some subsidence related fractures may not be visible, however, due to sediment and vegetation cover within and on the banks of the creek.

8.1.2.3 Surface Water Flow Diversion

As stream bed fracturing and surface flow diversions have been observed over Longwalls 25 to 31, sandstone stream bed fracturing and surface water flow diversion are possible within Redbank Creeks over and downstream of Longwall 32.

Compressive strains due to closure are expected to be sufficient to potentially cause the underlying strata to dilate and buckle and induce cracking in the stream bed at some locations which could lead to additional diversion of water from the creek bed into dilated strata beneath it.

It is unlikely, however, based on previous observations over Longwalls 25 to 31 that there will be any net loss of water from the catchment since re-directed flow has previously emerged further downstream.

If significant stream bed fracturing occurs, it is possible that partial or complete loss of pool standing water levels and connected stream flow may occur in some stream reaches if the rate of diversion exceeds upstream inflow.

In times of heavy rainfall, the majority of runoff flows on / in the creek bed, in addition to the diverted flow within subsidence related dilated strata below the creek bed. In times of low flow, however, some or all of the stream flow is diverted into the dilated / fractured strata below the creek bed, with no overland flow which affects the quantity and quality of observable water flowing in the creek.

Sediments in some sections of the creek cover the sandstone bedrock and any fractures that occur are unlikely to be visible.

Bedrock is exposed in some sections of the creek and fractures may be visible in these locations, including in pools with controlling rockbars where fracturing and surface water flow diversion may occur through the rockbars.

8.1.2.4 Bed, Bank Erosion and Bed Load Movement

Cracking of creek beds and banks can create new surface water conduits and therefore subsidence may induce minor bed or bank erosion. The potential for creek bed and bank erosion of sediments, however, is considered to be unlikely as the majority of cracking is observed within exposed sandstone in the creek bed and pool sides.

Dislocation of fractured/dilated sandstone sheets from subsided sections of the creek has been observed over Longwalls 26 to 30, and it is possible that dislocation of rock sheets could occur to the creek bed during subsidence of LW32.

If erosion occurs in the creek, it may cause a minor increase in potential bed load movement and require remediation.

8.1.3 Stream Water Quality

Within Redbank Creek pre-mining ferruginous seeps were observed over Longwalls 25 to 31 prior to these locations being undermined.

If stream water quality changes through the development of a new or change to an existing ferruginous spring the effect will be localised around the point of discharge and may result in potential increase in salinity.

The water quality in the creek is highly variable and depends on the amount of flow in the creek at any one time.

8.1.4 Dams

A number of dams are located directly above or adjacent to Longwall 32.

The mining induced tilts are predicted to result in changes in freeboard up to a maximum of 200 mm, which is unlikely to result in any significant reductions in the capacities of the farm dams.

Subsidence impacts could result in cracking or deformations in the dam bases or walls. TCCO's experience of mining directly beneath farm dams indicates that the likelihood of adverse impacts on the dams is very low.

TCCO has developed subsidence management plans for managing the potential impacts on farm dams during the mining of Longwalls 22 to 31.

A Built Features Management Plan has been prepared and implemented, which includes visual inspections of farm dams.

If impacts occur to the dams, TCCO will supply water to the landowner on a temporary basis until the dam is repaired.

8.2 Groundwater

8.2.1 Groundwater Quantity

TCCO experience with aquifer interconnection has been that hydraulic connection of surface water or alluvial groundwater systems to the mine workings have a very low likelihood at mining depths of cover greater than 150 metres.

A temporary lowering of the regional piezometric surface over the subsidence area due to horizontal dilation of strata could occur due to the increase in secondary porosity and permeability. This effect would be most notable directly over the area of greatest subsidence and dilation, and will dissipate laterally out to the edge of the subsidence zone.

Based on similar observations within the Longwall 22 to 31 mining area, groundwater levels may reduce by up to 15 metres, and may stay at that reduced level until maximum subsidence develops at a specific location. The duration of the reduced groundwater levels depends on the time required to develop maximum subsidence, the time for subsidence effects to migrate away from a location as mining advances and the length of time required to recharge the secondary voids.

On the basis that the pre-mining circumstances of rainfall recharge and bore pumping remain the same, and based on observation of groundwater levels over Longwalls 22 to 31, it is anticipated that groundwater levels generally recover over a few months to a year or so as the secondary void space is recharged by rainfall infiltration.

8.2.2 Groundwater Quality

It is possible that groundwater seepage may discharge in the streams in addition to the non-mining induced springs observed in Redbank Creek. If an adverse change in stream water quality occurs through development of an isolated new or change to an existing ferruginous spring, it is anticipated that due to the ephemeral nature of the streams and the generally low flow volumes in the creeks, the effect will be localised around the point of discharge and will not adversely affect the overall water quality.

The local groundwater bores are currently used for domestic garden supply, with the water quality being suitable for selected livestock and limited irrigation use, but not potable water.

No adverse changes to groundwater quality of subsided bores or piezometers have been observed during the mining of Longwalls 25 to 31, apart from minor increases in dissolved iron.

8.2.3 Wells and Bores

It is possible that the groundwater bores will experience impacts as the result of the proposed mining, particularly those located directly above the proposed longwalls. Impacts would include lowering of the piezometric surface, blockage of the bore due to differential horizontal displacements at different horizons within the strata and changes to groundwater quality.

One groundwater bores (GW105813) is located directly above LW32. TCCO have completed a pre-mining bore census that records pre-mining level, quality, yield and flow from the bore.

Near surface ground water levels may be affected by mine subsidence. If impacts occur to the bores, TCCO would supply water to the landowner on a temporary basis, until the bore returns to operation, or is reinstated or replaced by the Subsidence Advisory NSW.

8.3 Ecology

8.3.1 Flora

No Critical Habitat has been declared for any ecological values within the LW32 active subsidence zone of Longwall 32 and no Critical Habitat will be impacted.

Vegetation along the banks of Redbank Creek has been mapped as Cumberland Shale Sandstone Transition Forest, with the vegetation along the upper banks of the creek containing diagnostic overstorey species: *Eucalyptus crebra*, *Eucalyptus punctata* and *Angophora floribunda*, and understorey species consisting of *Acacia parramattensis*, *Sigesbeckia orientalis*, and *Indigofera australis*.

The majority of vegetation within the active subsidence zone of LW32 would not be impacted by subsidence due to underground mining but impacts may potentially occur for riparian vegetation. Riparian vegetation potentially impacted by subsidence is generally not mapped as discrete vegetation communities, rather these areas display structural and floristic variation within their composite community in response to more frequent contact with the local water table. As such, it would be hard to distinguish impacts to truly riparian vegetation and the intergrade between riparian and woodland communities.

Vegetation which occurs on undulating lands or on ridgelines is unlikely to be impacted by subsidence.

8.3.2 Fauna

The Cumberland Plain Land Snail has been previously recorded to the immediate west of LW32 at Innes Street, Thirlmere. The species is likely to occupy areas of Cumberland Plain Woodland within the locality.

Fauna that occur within LW32 is unlikely to be impacted by subsidence.

8.3.3 Aquatic Ecology

Aquatic habitat for LW32 consists predominately of Redbank Creek pools with little to no riffles present, with most sites having moderate to high quality riparian and channel health. The stream is controlled by the sandstone geology with bedrock a common component of the stream morphology. There was very little cobble/boulder habitat and stream benthos is dominated by finer sand/silt sized sediment where bedrock did not occur.

Macrophyte occurrence varies between sites within Redbank Creek, as shown on **Figure 17** and outlined within the RCE inventory scores in **Table 8**. An RCE score below 20 indicates that the stream is in very poor condition. RCE Scores of 20-40 indicate a stream is in moderate condition and greater than 40 indicates a stream is considered to be in good condition with potential for higher biodiversity values.

Stream	Redbank Creek		
Site	1	2	3
RCE Score	35	38	39

Table 8: Redbank Creek – RCE Inventory Scores

- **Site 1 Redbank Creek - Down Stream**

  The site is located immediately downstream of LW32. The stream is in a moderate condition (RCE score 35) however there were high levels of disturbance including bank erosion, sedimentation and weeds. Canopy vegetation was dominated by weeds including Large Leaf Privet, Small Leaf Privet. *Eucalyptus tereticornis* was also present. The dominant midstorey species was Turkey Rhubarb and ground cover dominated by *Tradescantia spp*., *Commelina cyanea*, and *Microleana stipoides*. The vegetation provided moderate shading of the stream.

  This stream at the location was mostly shallow (<1m depth) with 2m modal width. The benthic substrate of the stream contained some gravel but was dominated by finer sized sediment including sand and silt. There were few macrophytes present at this site (approximately<3% of the reach contained macrophytes) with the distribution of the macrophytes being confined to the stream edge. There are pools present, however there is commonly little flow.

- **Site 2 Redbank Creek – LW32**

  The site is located over the proposed LW32. The stream is in a moderate condition (RCE 38) but shows high levels of disturbance including sedimentation, and dominance of weeds in the riparian vegetation. Canopy vegetation was dominated by weeds Large Leaf Privet and Small Leaf Privet. *Eucalyptus moluccana* and *Angophora floribunda* also occurred. Weedy shrubs dominated the mid-storey including Large and Small Leaf Privet and Lantana

(*Lantana camara*). Ground cover was dominated by weeds Wandering Jew (*Tradescantia spp*.), Panic Veldt Grass (*Erharta erecta*), as well as native species *Microleana stipoides*. The vegetation provided moderate shading of the stream.

- **Site 3 Redbank Creek – Upstream LW31**

  The site is located on the left bank of Redbank Creek and over Longwall 31. The stream was in moderate condition (RCE 39) however showed high levels of disturbance including rubbish, and dominance of weeds. Canopy vegetation was dominated *Backhousia myrhfolia*, and weeds including Large and Small Leaf Privet. The mid-storey was dominated by Bursaria spinulosa and the ground cover by *Lomandra longifolia, Microleana stipodes, Commelina cyanea* as well as the weed Wandering Jew (Tradescantia spp.). The vegetation provided moderate shading of the stream.

  This stream is shallow (<1m depth) with 2.5m modal width. The stream substrate consists of bedrock, sand and silt. There are no macrophytes observed at this site. There are pools present, however there was little flow.

Results of macroinvertebrates at these sampling sites within Redbank Creek are presented in **Table 9**, which shows that 39 different taxa are found in Redbank Creek, with the number of taxa ranging from 9-17 between the sites.

Redbank Creek scored low SIGNAL values indicating that sites are severely polluted as they contain pollution tolerant macroinvertebrate families. This indicates that there are more pollution sensitive invertebrates at these sites and the presence of these fauna infer that these streams are unlikely to be severely affected by pollution. One family in particular, Leptophlebiidae (SIGNAL 8) was notably absent from all Redbank Creek sites. The family is common among the ephemeral/semi-permanent streams in the area and its absence may show that Redbank Creek is under natural or anthropogenic stress.

Stream	Redbank Creek		
Site	**1**	**2**	**3**
No of taxa	9	16	10
OE 50)	0.68	0.78	0.53
Signal	3.44	3.44	4
Band	B	B	B

Table 9: Redbank Creek – AUSRIVAS Results

Water quality sampling for aquatic ecology, as shown on **Table 10**, found that temperature varies seasonally whilst conductivity ranged between 212-2,003 µ/cm. Sites in Redbank Creek had raised electrical conductivity. Turbidity was low.

Considering the sampling was conducted after a moderate rainfall event this result is not considered environmentally significant. Dissolved oxygen ranged between 61 – 90.1% saturation, with most sites falling outside of ANZECC trigger values. Lower dissolved oxygen however is a characteristic of the non-flowing semi-permanent/ephemeral groundwater baseflow dependent ecosystems in the region so these values are not considered environmentally significant. The pH range was generally low (3.88—7.02) and was exceeded at all three sites.

Stream	Redbank Creek		
Site	1	2	3
Temperature (ºC)	13	13.05	12.34
Electrical conductivity (µS/cm) ANZECC	1,521	1,478	2,003
Turbidity (NTU)	10	150	12
Dissolved (oxygen saturation)	71	77.6	84.7
pH	6.4	6.14	3.88
Alkalinity (mg CaCa3/L)	15	15	0
Oxygen reduction potential (mV)	270	146	370

Table 10: Redbank Creek – Water Quality

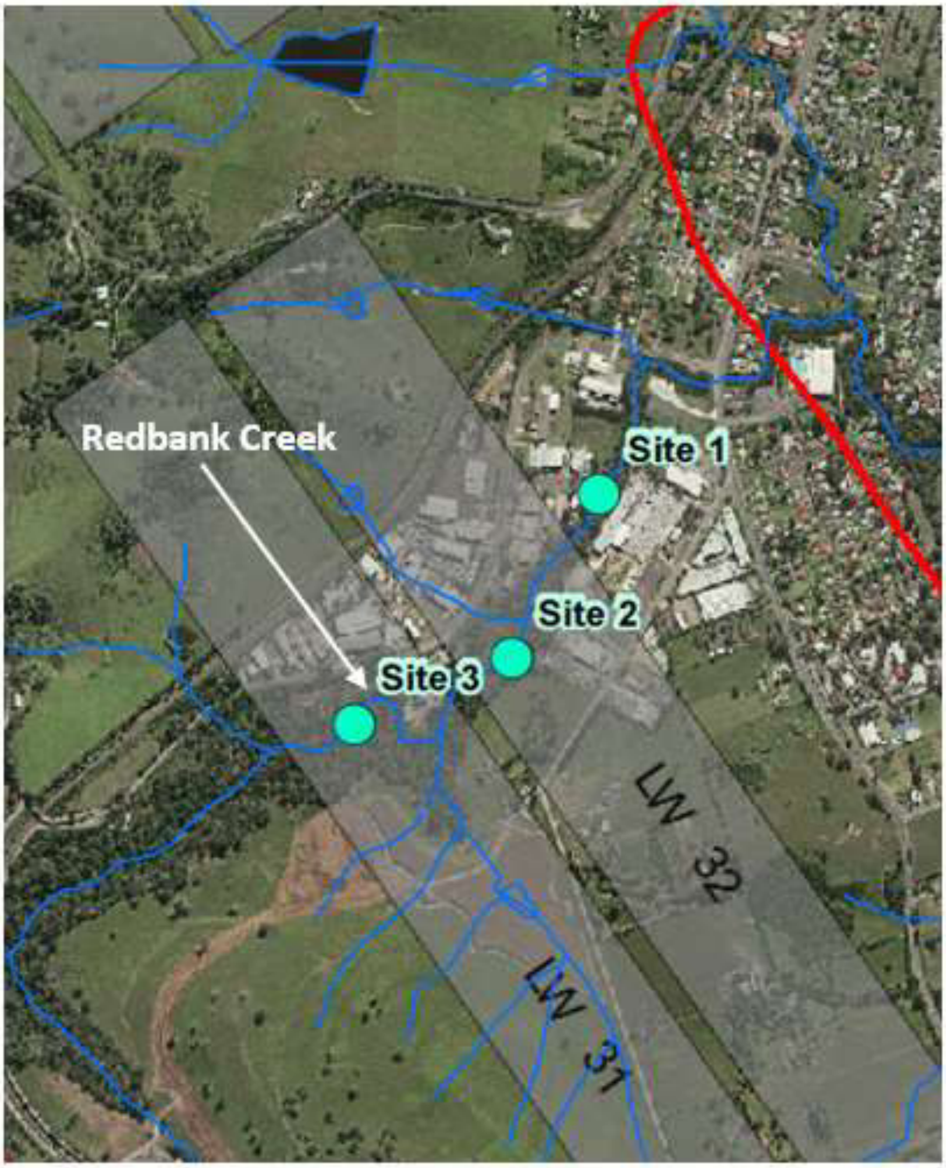

Figure 17: Redbank Creek – Aquatic Ecology Sites

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8.3.4 Key Fish Habitat

Redbank Creek is mapped as *'key fish habitat'* and is classed as having TYPE 1 highly sensitive and TYPE 2 moderately sensitive aquatic habitat.

Redbank Creek is classed as TYPE 2 fish passage and has moderate key fish habitat.

It is possible that there will be a net reduction in key fish habitat as a result of localised flow diversion and draining of pools. Stream connectivity and hence fish passage will be accessible in periods of higher flow.

8.4 Aboriginal Cultural Heritage

Two archaeological sites are located directly above LW32, as shown on **Figure 18**.

The sites comprise an open camp site and a grinding groove site.

The open camp site is unlikely to experience adverse subsidence impacts resulting from the proposed LW32 mining. It is possible that fracturing could occur in the vicinity of the grinding groove site as a result of the proposed LW32 mining.

TCCO has submitted a Section 90 application to OEH.

Site Number and Name	Site Type	Archaeological Significance	Potential For Impact	Recommendations
52-2-2082 Redbank Creek 4	Grinding Groove Site	Low	Moderate	S90 Consent to Disturb from OEH ACHMP prepared which details monitoring by an archaeologist and Aboriginal Stakeholders

Table 11: Aboriginal Cultural Heritage

Figure 1: Aboriginal Archaeological Sites

8.5 European Heritage

Koorana House is located directly above proposed LW32 and Mill Hill located beyond the finishing end of proposed LW32, as shown on **Figure 19**.

The heritage properties could experience subsidence impacts, but are expected to remain safe, serviceable and repairable. TCCO has identified, investigated and analysed mine subsidence hazards at the properties in a systematic manner, with inspections and investigations by a structural engineer, and a heritage consultant.

TCCO has developed and implemented Property Subsidence Management Plan (**PSMP**) for the mining of LW32 in consultation with the owners of each heritage property.

The PSMPs includes ground surveys and visual inspections.

The Fairley Residence, as shown on **Figure 19**, on Argyle Street is located approximately 400 metres to the side of LW32 and is expected to experience minor subsidence movements during the extraction of proposed LW32. A PSMP for Fairley House has been developed and implemented with the property owner.

Site Name	Structure Type	Heritage Significance	Potential Impact	Recommendations
Koorana Homestead Complex 2240 Remembrance Drive, Tahmoor	- Main federation style house - Stables - Cottage - 3 brick wells	Local	Low	Specific Statement of Heritage Impact and Property Subsidence Management Plan developed in consultation with property owner and submitted to Wollondilly Shire Council prior to subsidence.
Mill Hill Millers House and Archaeological Relics 675 Thirlmere Way, Picton	- Federation style weatherboard house - small cottage - brick well - possible archaeological remains of windmill	Local	Low	Specific Statement of Heritage Impact and Property Subsidence Management Plan developed in consultation with property owner and submitted to Wollondilly Shire Council prior to subsidence.

Table 12: European Historical Heritage

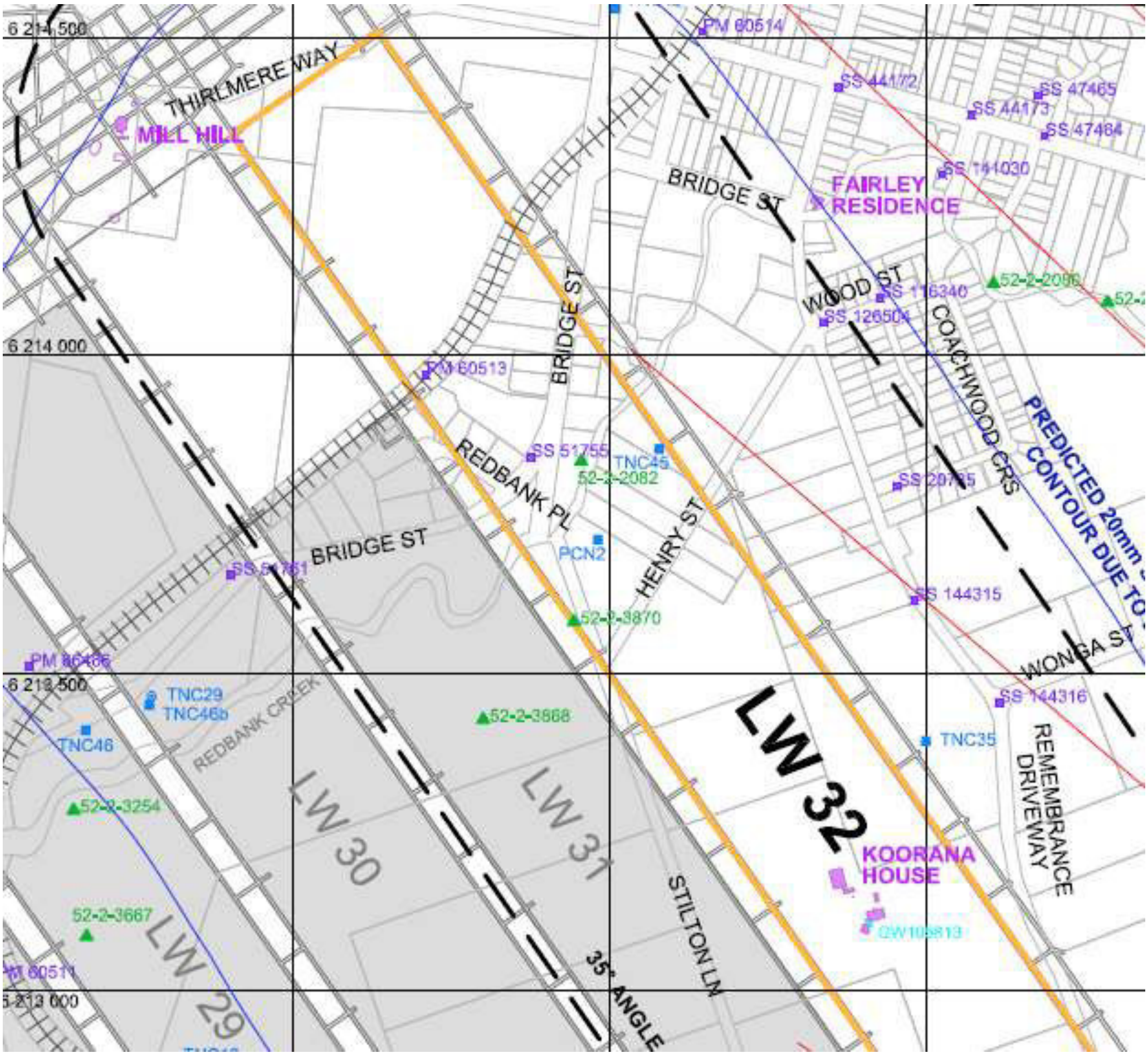

Figure 19: European Heritage Sites

8.6 Steep Slopes

The locations of the steep slopes are shown on **Figure 20**.

A steep slope is defined as *"an area of land having a natural gradient greater than 1 in 3 (i.e. a grade of 33 %, or an angle to the horizontal of 18°)"*.

Slopes with grades greater than 1 in 3 have been identified on the slopes of Redbank Range within LW32.

There are no identified cliffs located within LW32.

As shown on **Figure 20**, natural steep slopes exist directly above and adjacent to LW32 along the banks of Redbank Creek and along the sides of ridges, such as the Redbank Range and alongside Thirlmere Way. Some structures are located on or near steep slopes, with no impacts observed during the mining of Longwall 31.

Tension cracks could develop at the tops and along the sides of the steep slopes and compression ridges could develop at the bases of these slopes. Localised natural slope slippage has been observed along the Redbank Range and it is possible, therefore, that further localised slope slippages could develop along the ridges that may be attributable to either natural causes, mine subsidence, or both.

Experience indicates that the probability of large scale slope slippage due to the proposed mining is extremely low due to the significant depth of cover beneath the ridges. No large-scale mining-induced slope failures have been observed in the NSW Southern Coalfield at depths of cover exceeding 400 metres.

While the risk is extremely low, some risk remains and attention must therefore be paid to any structures or roads that may be located in the vicinity of steep slopes.

TCCO has developed the Built Features SMP for managing the potential impacts on steep slopes during the mining of LW32. A geotechnical engineering inspection and assessment has been undertaken for steep slopes located near structures. The Built Features Management Plan includes ground surveys and visual inspections of structures near steep slopes.

A geotechnical engineering inspection has been undertaken in relation to the steep slopes that are located to the side of Thirlmere Way, which runs along the top of a ridge near the finishing ends of Longwalls 31 and 32. Whilst no concerns were raised from the inspection, specific management strategies have been developed for Thirlmere Way in consultation with Wollondilly Shire Council and survey pegs have been installed. TCCO has developed the Council Infrastructure SMP in consultation with Wollondilly Shire Council.

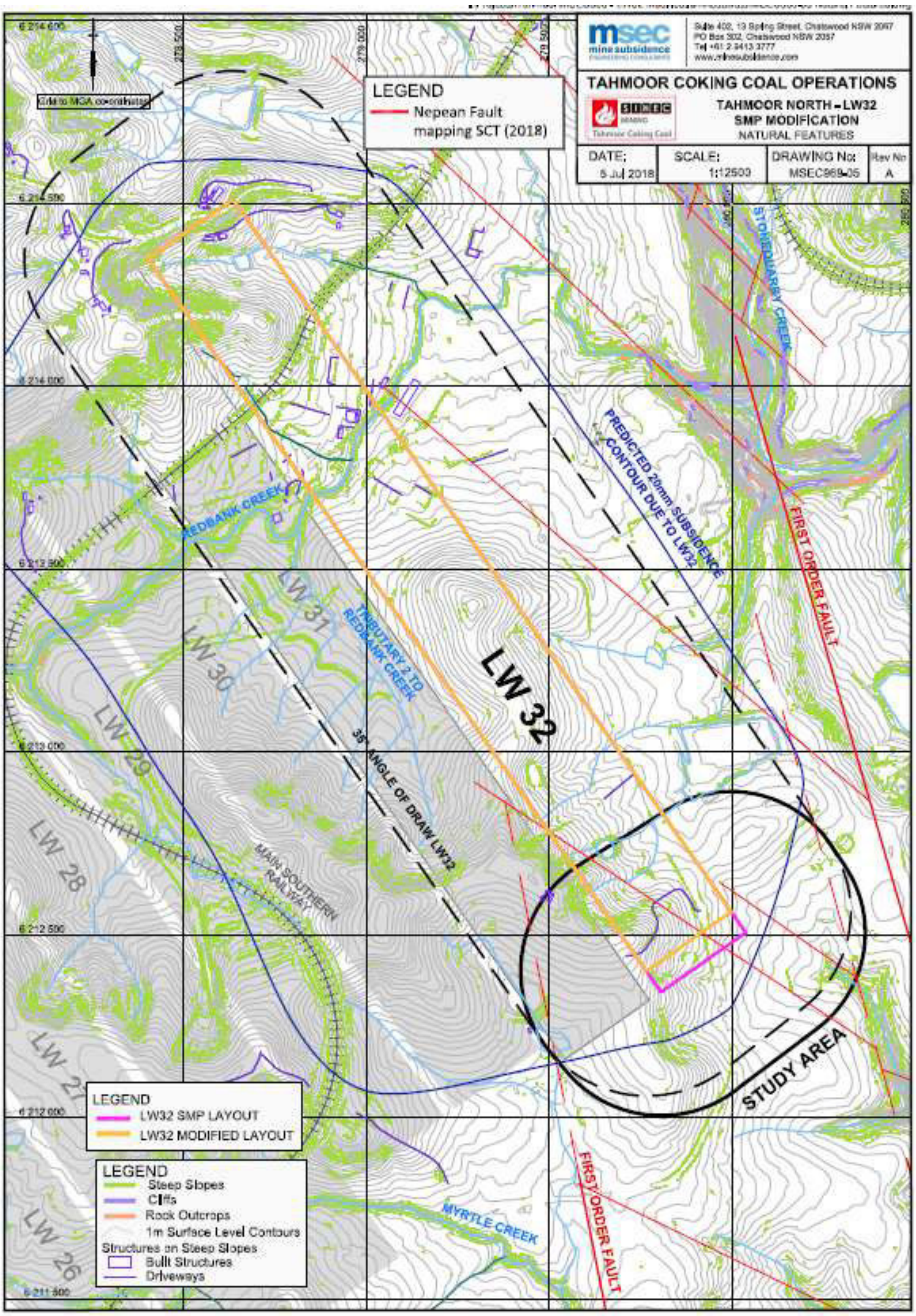

Figure 20: LW32 – Steep Slopes

9 Monitoring Program

A detailed monitoring plan is outlined within **Appendix 1**.

10 Subsidence Impact Response

10.1 Trigger Action Response Plan

Trigger, Action, Response Plans (**TARPs**) are a common management tool used to manage risk in many industries, including the underground coal mining industry in NSW.

TARPs involve a set of clear and quantifiable triggers. When any one monitoring trigger is met, it automatically leads to a pre-defined management action and to any pre-agreed mitigatory or remedial response. Once a subsidence impact or environmental consequence is identified, it triggers a series of actions according to the level or significance of the impact. TARP triggers are typically sequential, so that, subsidence impacts or environmental consequences may initially be reported as Level 1 and later progress to Level 2 and maybe Level 3 if successive triggers are exceeded.

The TARP system provides a simple, transparent and useable reference of the monitoring of environmental performance and the implementation of management and/or contingency measures. It provides a transparent method to monitor the environmental performance and, where required, implement management and/or contingency measures where the components of the proposed monitoring will serve to alert the mine if an abnormal problem does, or potentially may, exist.

The TARP is designed with consideration of baseline conditions and predicted subsidence impacts and comprises the following:

- Trigger levels from monitoring to assess performance; and
- Triggers that flag implementation of contingency measures.

The TARP is designed to identify, assess and respond to impacts, including impacts greater than predicted, in the proposed mining area.

The TARP outlines what actions will be taken in the case where exceedance of the approved impact assessment criteria occur.

Site specific mitigation, or corrective management action plans (**CMAP**), can be required, and may include:

- Description of the impact to be managed;
- Results of the investigations;
- Aims and objectives for the Plan;
- Specific actions required to mitigate/manage the issue;
- Timeframes for implementation;
- Roles and responsibilities;
- Identification of and gaining appropriate approvals from key government agencies; and
- Providing a consultation and communication plan.

The proposed triggers are based on baseline monitoring and predicted subsidence impacts, with monitoring changes and/or specific triggers continuing to be developed as monitoring matures and is refined.

Where a trigger is exceeded, the cause and effect can be investigated and a CMAP can be developed if the cause is directly related to mining.

Refined triggers can be proposed within End of Panel (**EOP**) reports or TCCO Annual Environmental Management Report (**AEMR**).

10.2 Trigger Levels

The proposed triggers are based on baseline monitoring and anticipated subsidence effects are outlined in **Appendix 2**, with monitoring changes and/or specific triggers continuing to be developed as monitoring matures and refined.

Where a trigger is exceeded, the cause and effect can be investigated and a CMAP developed if the cause is directly related to mining.

10.3 Trigger Level Exceedances

The TARP, contained within **Appendix 2,** outlines what actions will be taken in the case if exceedances of the impact assessment criteria occur.

Site specific mitigation or CMAP are required, and can include:

- Notification to stakeholders;
- Description of the impact to be managed;
- Results of the investigations;
- Aims and objections for the plan;
- Specific actions required to mitigate/manage the issue;
- Timeframes for implementation;
- Roles and responsibilities;
- Identification of and gaining approvals from government agencies; and
- Providing a consultation and communication plan.

The mitigation or remediation plans will outline methods to ensure that ongoing impacts reduce to levels below the impact assessment criteria as quickly as possible.

10.4 Mitigation and Remediation Measures

The TARP, contained within **Appendix 2**, outlines mitigation and remediation measures.

10.5 Exceedances Notification

The TARP, contained within Appendix A, contains actions if the trigger values exceed predictions that require TCCO to notify the following stakeholders:

- Resources Regulator - Principal Subsidence Engineer;
- Resources Regulator - Director Compliance Operations;
- Subsidence Advisory NSW;
- Department of Industry – Water; and
- Other relevant government stakeholders, such as OEH or Wollondilly Shire Council.

Condition 14 of the SMP Approval has additional requirements for reporting and states the following:

Incident and Ongoing Management Reporting

14. The Leaseholder must, within 24 hours of becoming aware of the occurrence, notify:

a) the Principal Subsidence Engineer;

b) Director Compliance Operations;

c) SA;

d) NSWOW;

e) other relevant stakeholders and any Government Agency with a regulatory role if they request such notification, of the following:

i. Any significant unpredicted and/or higher-than-predicted subsidence and/or abnormalities in the development of subsidence;

ii. Any exceedance of predicted impacts on groundwater resources and/or the natural environment that may have been caused (whether partly or wholly) by subsidence;

iii. Any observed subsidence impacts adverse to the serviceability and/or safety of infrastructure and other built structures that may be affected by longwall mining;

iv. Any significant subsidence-induced cracking and/or ground deformations observed in any surface areas within the SMP application area;

v. Any buildings, structure and infrastructure, which have become or likely to become hazardous as a result of subsidence, and

vi. Development of instability and/or falls of rocks within any areas with cliff formation and/or steep slopes that may have been affected by subsidence.

f) the operators of infrastructure affected by subsidence.

Note: Under Condition 11, the Leaseholder can be directed to, among other things, prepare a report on an incident reported under this condition. A report on the details of the incident, including likely or known causes, response action and proposed response measures will generally be required for incidents that involve material property or environmental damage or have the potential to cause such damage.

10.6 Contingency Plan

In the event that LW32 triggers are considered to have been exceeded, or are likely to be exceeded, TCCO will implement a Contingency Plan to manage any unpredicted impacts and their consequences.

The Contingency Plan would involve the following actions:

- Capture record of the exceedance immediately;
- Notify relevant stakeholders as soon as practicable;
- Notify relevant agencies and specialists as soon as practicable;
- Conduct site visits with stakeholders as required;
- Contract specialists to investigate and report on identified impacts;
- Provide incident report to relevant agencies within seven days;
- Undertake a condition assessment to record impacts within 14 days;
- Establish weekly monitoring frequency until any unstable area/s are stabilised;
- Monthly updates from specialists on investigation process;
- Inform relevant agencies and stakeholders of results of investigation within 1 week of completion;

- Develop site Corrective Management Actions (**CMA**) in consultation with key stakeholders if required within 1 month, (pending stakeholder availability) and seek approvals;
- Implement CMA as agreed with stakeholders following approvals;
- Conduct initial follow up monitoring and reporting within two months of CMA completion;
- Review management and implementation controls for the CMAP within three months; and
- Report results in regular reporting e.g. AEMR.

10.7 Reporting

10.7.1 Longwall 32 Status Report

Condition 15 of the SMP Approval requires a Subsidence Management Status Report be updated at least every 14 days and states the following:

Status Report

15. The Leaseholder must prepare and maintain a Subsidence Management Status Report which must include but not be limited to:

a) the current face position of the panel being extracted;

b) a summary of any subsidence management actions undertaken by the Leaseholder;

c) a summary of any comments, advice and feedback from consultation with stakeholders in relation to the implementation of this Approval (including the preparation, implementation and review of plans, programs, reports or strategies required by this approval) undertaken or received and a summary of the Leaseholder's response to the comments, advice and feedback given by the stakeholders;

d) a summary of the observed and/or reported subsidence impacts, incidents, service difficulties, community complaints, and any other relevant information reported to the Leaseholder and a summary of the Leaseholder's response to these impacts, incidents, service difficulties and complaints;

e) a summary of subsidence development based on monitoring information compared with any defined triggers and/or the predicted subsidence to facilitate early detection of potential subsidence impacts;

f) a summary of the adequacy, quality and effectiveness of the implemented management processes based on the monitoring and consultation information summarised above; and

g) a statement regarding any additional and/or outstanding management actions to be undertaken or the need for early responses or emergency procedures to ensure adequate management of any potential subsidence impacts due to longwall mining.

The Subsidence Management Status Report must be updated at least every 14 days to reflect any changes in the information required to be included in the Report. The Status Report (as updated from time to time) must be provided, upon request, to SA, the Director of Compliance Operations, the Principal Subsidence Engineer, owners/operators of any infrastructure within the application area and any other relevant government agencies.

TCCO's subsidence consultant MSEC prepares a weekly LW32 Subsidence Status Report that is distributed to a range of stakeholders, including:

- Resources Regulator;
- Subsidence Advisory NSW;
- OEH; and
- Wollondilly Shire Council.

10.7.2 Monthly Longwall Report Newsletter

TCCO produce a Monthly Longwall Report Newsletter that outlines the monthly longwall status and is distributed to key stakeholders during the extraction of LW32 and includes the following information:

- Monitoring period;
- Current length of extraction;
- Distance travelled by longwall since previous report;
- Distance to completion of longwall;
- Summary of observed ground movements;
- Have any triggers been reached; and
- Monitoring results for natural features outlined in this Management Plan.

10.7.3 End of Panel Report

A LW32 End of Panel (**EOP**) Report will be prepared that will include:

- A summary of the subsidence and environmental monitoring results for the year;
- An analysis of the monitoring results against the relevant impact assessment criteria;
- Monitoring results from previous panels;
- Assessment against subsidence predictions;
- Identification of any trends in the monitoring results; and
- Description of actions taken to ensure management of any potential or actual subsidence impacts due to mining.

The EOP Report will be submitted with the TCCO Annual Review required as a condition of the development consent and the SMP Approval.

10.7.4 Annual Report

Condition 16 of the SMP Approval requires an Annual Report be prepared and states the following:

> ***Annual Report***
>
> *16.*
>
> *a) The Leaseholder shall prepare an annual report. This report shall be submitted to the Secretary within twelve months of the date of this approval and annually thereafter. The annual report must:*
>
> *b) include a summary of the subsidence and environmental monitoring results for the year;*
>
> *c) include an analysis of these monitoring results against the relevant;*

- *impact assessment criteria;*
- *monitoring results from previous panels; and*
- *predictions in the SMP;*

d) identify any trends in the monitoring results over the life of the activity; and

e) describe what actions were taken to ensure adequate management of any potential or actual subsidence impacts due to mining.

Note: The requirement of this condition may be satisfied via an Annual Review prepared under conditions of development consent or project approval.

TCCO produces an Annual Review, which is a requirement of conditions of the development consent and the SMP Approval.

11 Plan Administration

11.1 Consultation

A crucial aspect to the success of managing the consultation aspects of the implementation of the LW32 EMP is ensuring that ongoing, transparent and two way communication is adopted between TCCO and relevant stakeholders with an ongoing interest in the successful implementation of the LW32 EMP.

Stakeholders that have been consulted in the preparation of this LW32 EMP are outlined on **Table 13**.

Stakeholder	Form of Consultation	Date
Wollondilly Shire Council	Meeting and presentation	22 March 2019
OEH	Meeting and presentation	21 March 2019
Department of Industry - Water	Email	21 March 2019
OEH	AHIP Application	24 October 2018

Table 13: EMP Stakeholder Consultation

11.2 Enquiry Management

TCCO has a 24 hour community phone line (**1800 154 415**) for community enquiries. This phone line will be utilised to manage all enquiries relating to the LW32 EMP. They will be recorded in the TCCO Environment & Community Stakeholder database, administered by the TCCO Community Coordinator.

TCCO has an enquiry email (tahmoorenquiries@simecgfg.com) and a TCCO website (http://www.simec.com/mining/tahmoor-coking-coal-operations/).

The TCCO Community Coordinator and/or the TCCO Environment Coordinator and/or the Environment Projects Coordinator will be responsible for responding to all email enquiries. An email response will be sent as soon as possible to all email enquiries.

11.3 Roles and Responsibilities

All statutory obligations applicable to the LW32 EMP are identified and managed via the TCCO CMO compliance management system administered by the TCCO Compliance Coordinator.

The overall responsibility for the implementation of the LW32 EMP resides with the TCCO Environment & Community Manager.

The responsibilities of the following TCCO staff related to the management and implementation of the LW32 EMP are outlined on **Table 14**.

Role	Redbank Creek EMP Accountabilities
General Manager	• Ensure that LW32 EMP implementation is managed and adequately resourced so that works can be completed in a manner that is safe and in compliance with the requirements of the LW32 EMP.
Environment and Community Manager	• Ensure sufficient resource allocation for the implementation of the LW32 EMP. • Ensure LW32 EMP implementation works are planned and budgeted within the TCCO LOM and budget planning process. • Ensure all internal and external reporting, reviews, audits, non-conformances and improvement requirements are met, including incident reporting. • Proactively engage government and community stakeholders as required. • Review and approve internal and external reports e.g. Annual Report. • Ensure effective management of all community complaints. • Review, approve and endorse any LW32 EMP amendments to DPE-RR (Environment) for approval.
Community Coordinator	• Coordinate ongoing stakeholder consultation. • Preparation and distribution of the TCCO monthly newsletters.
Environment Coordinator	• LW32 EMP implementation. • Implementation of Contingency Plan (if required). • Preparation and management of LW32 EMP reporting, audits and reviews for review and approval by the TCCO Environment & Community Manager. • Assist with the preparation and ongoing management of the Stakeholder and Consultation Plan, stakeholder consultation and Contingency Plan. • Assist in preparation and distribution of TCCO monthly newsletters. • Identification and reporting of any incidents, non-conformances identified during the implementation of the LW32 EMP.
Environment Projects Coordinator	• LW32 EMP implementation. • Implementation of Contingency Plan (if required). • Preparation and management of LW32 EMP reporting, audits and reviews for review and approval by the TCCO Environment & Community Manager. • Assist with the preparation and ongoing management of the Stakeholder and Consultation Plan, stakeholder consultation and Contingency Plan. • Assist in preparation and distribution of TCCO monthly newsletters. • Identification and reporting of any incidents, non-conformances identified during the implementation of the LW32 EMP.
Compliance Coordinator	• Administration of the TCCO CMO compliance management system. • Administration of the TCCO document control system.
Training Coordinator	• Administration of TCCO training records

Table 14: LW32 EMP Roles and Responsibilities

11.4 Incidents, Compliants, Non-Conformances & Corrective Actions

11.4.1 Incidents

TCCO will notify the NSW Resources Regulator and any other relevant agencies of any incident associated with the implementation of the LW32 EMP as soon as practicable after TCCO confirms the incident.

TCCO will provide the NSW Resources Regulator and any relevant agencies with a detailed report on the incident within seven days of confirmation of any event.

11.4.2 Compliants

To ensure any community complaints related to the LW32 EMP are addressed in a timely and satisfactory manner, TCCO will:

- Provide a readily accessible contact point through a 24 hour toll-free Community Call Line (**1800 154 415**) or TCCO enquiries email (tahmoorenquiries@simecgfg.com);
- The number will be displayed prominently on work sites in a position visible by the public as well as on publications provided to the local community, such as TCCO newsletters;
- Respond to complaints in accordance with the TCCO Community Complaints Procedure;
- Maintain good relations and communication lines between the community and TCCO staff; and
- Keep a register of any complaints, including the details of the complaint.

11.4.3 Non-Conformance Protocol

The requirement to comply with all approvals, plans and procedures is the responsibility of all personnel (staff and contractors) employed for or in association with the LW32 EMP. Regular inspections, internal audits and initiation of any remediation/rectification work in relation to the LW32 EMP will be undertaken by the TCCO Environment & Community Manager.

Non-conformities, corrective actions and preventative actions are managed in accordance with the TCCO Non-Conformance, Preventative and Corrective Action Procedure. This procedure details the processes to be utilized with respect to the identification of non-conformances, the application of appropriate corrective actions(s) to address non-conformances and the establishment of preventative actions to avoid non-conformances. The key elements of the process include:

- Identification of non-conformance and/or non-compliances;
- Recording of non-conformance and/or non-compliance;
- Evaluation of the non-conformance and/or non-compliance to determine specific corrective and preventative actions;
- Corrective and preventative actions to be assigned to the responsible person; and
- Management review of corrective actions to ensure the status and effectiveness of the actions.

The LW32 EMP will be administered in accordance with the requirements of the TCCO Environmental Management System (**EMS**) and all relevant Development Consent Conditions. An Annual Review will be undertaken to assess the LW32 EMP compliance with all conditions of the relevant Development Consent, mining leases and all other approvals and licenses.

11.4.4 Corrective Action

Non-conformances relating to the content of this LW32 EMP will be identified through the following methods:

- Weekly inspections:
- Monitoring and surveys:
- Reporting;
- Incident and hazard reporting; and
- Reviews and audits.

The TCCO Environment & Community Manager and/or other delegated TCCO senior Manager or TCCO Compliance Coordinator will investigate all non-conformances identified, and ensure corrective actions are defined, implemented and monitored.

Identifying and tracking of remedial corrective action will via the TCCO CMO compliance management system administered by the TCCO Compliance Coordinator.

Corrective action processes and/or investigations will be undertaken and recorded. Investigations will determine cause, corrective action, and action to prevent reoccurrence. Action plans will be developed and responsibilities defined and assigned. Results and action undertaken will be communicated back to the relevant stakeholders and recorded within CMO by the TCCO Compliance Coordinator.

11.5 Document Control

11.5.1 Document Control

The LW32 EMP, including all associated ancillary management plans, reports, monitoring, procedures and other documents, are subject to the TCCO document and record control system administered by the TCCO Compliance Coordinator.

The controlled document of this LW32 EMP is that document appearing on the TCCO electronic intranet.

11.5.2 Record Keeping

Records will be retained at the mine for a period of 7 years from the date the record was made.

Records related to the LW32 EMP include:

- Risk assessments;
- Reports and monitoring;
- Events;
- Non-conformances- corrective action;
- Audits; and
- Reviews.

11.6 Audit

Audits of the LW32 EMP will be conducted by the TCCO Environment & Community Manager and/or other delegated TCCO senior Manager or TCCO Compliance Coordinator on an as required basis but with at least one audit conducted annually. Audits will be conducted in consultation with the relevant TCCO staff and will focus on the content and implementation of the LW32 EMP.

Audits on the content will consist of a determination of understanding of the LW32 EMP by the individual's allocated responsibility under the LW32 EMP.

Audits on the implementation shall consist of reviews of the safe working procedures and risk assessments developed to ensure safe operation of the LW32 EMP. These audits may also involve discussions with personnel involved in the management of works to determine understanding and compliance.

Should an audit of the LW32 EMP determine that a deficiency is evident in the content or implementation; a corrective action must be developed and implemented. Actions will be assigned to a nominated individual and tracked in CMO administered by the TCCO Compliance Coordinator.

Any changes LW32 EMP are to be managed and communicated to all personnel in line with the TCCO Change Management Process administered by the TCCO Compliance Coordinator.

11.7 Change Management

Full details of the document history are recorded in the document control register, by version is outlined on **Table 15**.

Version	Date Reviewed	Reviewer	Change Summary
1.0	10/03/2019	Ron Bush	New document
2.0	04/05/2019	Ron Bush	Changes to Monitoring Plan and reference to Redbank Creek CMAP following feedback from Resource Regulator review of Version 1.

Table 15: LW32 EMP Document Control Register

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APPENDIX 1

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Feature	Monitoring		
	Prior to Mining	**During Mining**	**Post Mining**
Rainfall Sites TCCO Pit Top Met Station and Picton Council Met Station	Continuous daily rainfall monitoring for at least two months prior to mining	Continuous daily rainfall monitoring	Continuous daily rainfall monitoring for minimum of 12 months post mining
Groundwater Quality Bore P10	Field water quality (EC, pH) monthly Laboratory analysis monthly for TDS, Na, K, Ca, Mg, F, Cl, SO4, HCO3, NO3, Total N, Total P, Cu, Pb, Zn, Ni, Fe, Mn, As, Se, Cd, (filtered)	400 metres before and after LW32 face Field water quality (EC, pH) weekly Laboratory analysis weekly for TDS, Na, K, Ca, Mg, F, Cl, SO4, HCO3, NO3, Total N, Total P, Cu, Pb, Zn, Ni, Fe, Mn, As, Se, Cd, (filtered)	Field water quality (EC, pH) bi-monthly for a minimum period of 12 months after LW32 completed Laboratory analysis bi-monthly for a minimum period of 12 months after LW32 completed for TDS, Na, K, Ca, Mg, F, Cl, SO4, HCO3, NO3, Total N, Total P, Cu, Pb, Zn, Ni, Fe, Mn, As, Se, Cd, (filtered)
Groundwater Quality Bores P1, P2, P3, P4, P5, P6, P7, P8, P9 and P11	Field water quality (EC, pH) bi-monthly Laboratory analysis bi-monthly for TDS, Na, K, Ca, Mg, F, Cl, SO4, HCO3, NO3, Total N, Total P, Cu, Pb, Zn, Ni, Fe, Mn, As, Se, Cd, (filtered)	Field water quality (EC, pH) bi-monthly Laboratory analysis bi-monthly for TDS, Na, K, Ca, Mg, F, Cl, SO4, HCO3, NO3, Total N, Total P, Cu, Pb, Zn, Ni, Fe, Mn, As, Se, Cd, (filtered)	Field water quality (EC, pH) bi-monthly for a minimum period of 12 months after LW32 completed Laboratory analysis bi-monthly for a minimum period of 12 months after LW32 completed for TDS, Na, K, Ca, Mg, F, Cl, SO4, HCO3, NO3, Total N, Total P, Cu, Pb, Zn, Ni, Fe, Mn, As, Se, Cd, (filtered)
Groundwater Levels Bore P10	Minimum continuous 24-hourly readings with monthly logger download and dip meter	400 metres before and after LW32 face Minimum continuous 24-hourly readings with weekly logger download and dip meter	Minimum continuous 24-hourly readings with monthly logger download and dip meter for a minimum period of 12 months after LW32 completed

	Prior to Mining	During Mining	Post Mining
Groundwater Levels Bores P1, P2, P3, P4, P5, P6, P7, P8, P9 and P11	Minimum continuous 24-hourly readings with bi-monthly logger download and dip meter	400 metres before and after LW32 face Minimum continuous 24-hourly readings with bi-monthly logger download and dip meter	Minimum continuous 24-hourly readings with bi-monthly logger download and dip meter for a minimum period of 12 months after LW32 completed
Groundwater Pressures VWPs TNC37, 40, 43	Minimum continuous 24-hourly readings Bi- monthly logger download	Minimum continuous 24-hourly readings Bi-monthly logger download	Minimum continuous 24-hourly for a minimum period of 12 months after LW32 completed Bi- monthly logger download for a minimum period of 12 months after LW32 completed
Groundwater Quality (no SWL due to pump installation) GW105813	Field water quality (EC, pH) 1 month before active subsidence period Laboratory analysis for TDS, Na, K, Ca, Mg, F, Cl, SO4, HCO3, NO3, Total N, Total P, Cu, Pb, Zn, Ni, Fe, Mn, As, Se, Cd, (filtered) 1 month before active subsidence period Bore flow test 1 month before active subsidence period	400 metres before and after LW32 face Field water quality (EC, pH) sample during active subsidence period Laboratory analysis for TDS, Na, K, Ca, Mg, F, Cl, SO4, HCO3, NO3, Total N, Total P, Cu, Pb, Zn, Ni, Fe, Mn, As, Se, Cd, (filtered) sample during active subsidence period Bore flow test during active subsidence period	Field water quality (EC, pH) 6- monthly after active subsidence period Laboratory analysis for TDS, Na, K, Ca, Mg, F, Cl, SO4, HCO3, NO3, Total N, Total P, Cu, Pb, Zn, Ni, Fe, Mn, As, Se, Cd, (filtered) 6- monthly after active subsidence period Bore flow test 6- monthly after active subsidence period

	Prior to Mining	During Mining	Post Mining
Stream Water Quality Sites RC1, RC2, RC3, RC4, RC5 and RC6	Monthly manual field analysis (EC, pH, DO, ORP, temp) Monthly Laboratory Analysis of TDS, Na, K, Ca, Mg, F, Cl, SO4, HCO3, NO3, Total N, Total P, Cu, Pb, Zn, Ni, Fe, Mn, As, Li, Ba, (filtered) DOC, Tot. Alkalinity Monthly observation of iron hydroxide staining using photo points	Monthly manual field analysis (EC, pH, DO, ORP, temp) Monthly Laboratory Analysis of TDS, Na, K, Ca, Mg, F, Cl, SO4, HCO3, NO3, Total N, Total P, Cu, Pb, Zn, Ni, Fe, Mn, As, Li, Ba, (filtered) DOC, Tot. Alkalinity Monthly observation of iron hydroxide staining using photo points	Monthly manual field analysis (EC, pH, DO, ORP, temp) for a minimum period of 12 months after LW32 completed Monthly Laboratory Analysis of TDS, Na, K, Ca, Mg, F, Cl, SO4, HCO3, NO3, Total N, Total P, Cu, Pb, Zn, Ni, Fe, Mn, As, Li, Ba, (filtered) DOC, Tot. Alkalinity for a minimum period of 12 months after LW32 completed Monthly observation of iron hydroxide staining using photo points for a minimum period of 12 months after LW32
Stream Flow/Water Level Sites R1- R11	Minimum continuous 24-hourly, with monthly downloads.	Minimum continuous 24-hourly, with monthly downloads	Minimum continuous 24-hourly, with monthly downloads for minimum of 12 months post mining.
Stream Flow/Water Level Sites RC1, RC2 and RC3	Minimum continuous 24-hourly, with monthly downloads.	Minimum continuous 24-hourly, with monthly downloads	Minimum continuous 24-hourly, with monthly downloads for minimum of 12 months post mining or until remediation works have been completed to the satisfaction of the Resources Regulator.
General Stream Sites RC1,2,3 R1- R11	Observations every month for at least two months prior to mining using photo points.	400 metres before and after LW32 face Observations weekly during active subsidence period using photo points	Observations every month for a minimum period of 12 months after LW32
Aquatic Ecology	Aquatic ecology monitoring during Autumn and Spring seasons for a minimum of 12 months prior to mining.	Aquatic ecology monitoring during Autumn and Spring seasons during active subsidence period.	EOP observations and report by Aquatic Ecology consultant.
Private Dams	Dam wall integrity and water level observation every month for at least two months prior to mining using photo points.	Dam wall integrity and water level observation every week during active subsidence period by TCCO's Subsidence & Building Inspector using photo points.	Dam wall integrity and water level observation 3-monthly for minimum of 12 months after LW32 using photo points.

	Prior to Mining	During Mining	Post Mining
Steep Slopes	Observations every month for at least two months prior to mining using photo points.	Observation every week during active subsidence period by TCCO's Subsidence & Building Inspector using photo points.	Observation 3-monthly for minimum of 12 months after LW32 using photo points.
Aboriginal Archaeology Sites	Baseline archival recording at least two months prior to mining	Observations weekly during active subsidence period	EOP observations and report by Heritage consultant
Heritage Properties **Koorana House** **Mill Hill** **Fairley House**	Preparation of Heritage Impact Statement and Property Subsidence Management Plan prepared by specialist consultants including heritage consultant, structural engineer and subsidence engineer at least two months prior to mining.	Observations weekly during active subsidence period by TCCO's Subsidence & Building Inspector	EOP observations and report by Heritage consultant

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APPENDIX 2

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Feature	Management	
Groundwater Quality Bore P10	**Trigger**	**Action**
	NORMAL	**NORMAL**
	No observable mining induced change	Continue monitoring program, report in EOP report and AEMR. Ongoing review of water quality data
	WITHIN PREDICTION	**WITHIN PREDICTION**
	Short term increase (< 3 months) in salinity or reduction in pH outside of baseline variability, with the effect not persisting after a significant rainfall recharge event	Continue monitoring program, report in EOP report and AEMR. Ongoing review of water quality data
	EXCEEDS PREDICTION	**EXCEEDS PREDICTION**
	Increase in salinity or reduction in pH outside of baseline variability with the effect persisting for greater than 3 months or after a significant rainfall recharge event	Notify within 48 hours NSW Resources Regulator – Director Compliance Operations and Principal Subsidence Engineer, Subsidence Advisory NSW, Wollondilly Shire Council, DI-Water and OEH of exceedance. Provide written Status Report to NSW Resources Regulator – Director Compliance Operations within 4 weeks of notification reviewing requirement, need and potential cost/benefit of preparation and implementation of a corrective action management plan. Investigate the potential source/s of any water quality trigger exceedance Report notification in EOP report and AEMR.

Groundwater Quality Bores P1, P2, P3, P4, P5, P6, P7, P8, P9 and P11	Trigger	Action
	NORMAL	**NORMAL**
	No observable mining induced change	Continue monitoring program, report in EOP report and AEMR. Ongoing review of water quality data
	WITHIN PREDICTION	**WITHIN PREDICTION**
	Short term increase (< 3 months) in salinity or reduction in pH outside of baseline variability, with the effect not persisting after a significant rainfall recharge event	Continue monitoring program, report in EOP report and AEMR. Ongoing review of water quality data
	EXCEEDS PREDICTION	**EXCEEDS PREDICTION**
	Increase in salinity or reduction in pH outside of baseline variability with the effect persisting for greater than 3 months or after a significant rainfall recharge event	Notify within 48 hours NSW Resources Regulator – Director Compliance Operations and Principal Subsidence Engineer, Subsidence Advisory NSW, Wollondilly Shire Council, DI-Water and OEH of exceedance. Provide written Status Report to NSW Resources Regulator – Director Compliance Operations within 4 weeks of notification reviewing requirement, need and potential cost/benefit of preparation and implementation of a corrective action management plan. Investigate the potential source/s of any water quality trigger exceedance Report notification in EOP report and AEMR.

Groundwater Levels Bore P10	Trigger	Action
	NORMAL	**NORMAL**
	No observable mining induced change	Continue monitoring program, report in EOP report and AEMR. Ongoing review of water level data
	WITHIN PREDICTION	**WITHIN PREDICTION**
	Up to 2m water level reduction	Continue monitoring program, report in EOP report and AEMR. Ongoing review of water level data
	EXCEEDS PREDICTION	**EXCEEDS PREDICTION**
	Greater than 2m water level reduction for a period greater than 3 months Water level (for a specific depressurisation event) does not return to within 1m of the pre "event" level (or trend occurring prior to the "event") after 3 months of the "event"	Notify within 48 hours NSW Resources Regulator – Director Compliance Operations and Principal Subsidence Engineer, Subsidence Advisory NSW, Wollondilly Shire Council, DI-Water and OEH of exceedance. Provide written Status Report to NSW Resources Regulator – Director Compliance Operations within 4 weeks of notification reviewing requirement, need and potential cost/benefit of preparation and implementation of a corrective action management plan. Investigate the potential cause / fate of any water level trigger exceedance Report notification in EOP report and AEMR

Groundwater Levels Bores P1, P2, P3, P4, P5, P6, P7, P8, P9 and P11	Trigger	Action
	NORMAL	**NORMAL**
	No observable mining induced change	Continue monitoring program, report in EOP report and AEMR. Ongoing review of water level data
	WITHIN PREDICTION	**WITHIN PREDICTION**
	Up to 2m water level reduction for less than 3 months	Continue monitoring program, report in EOP report and AEMR. Ongoing review of water level data
	EXCEEDS PREDICTION	**EXCEEDS PREDICTION**
	Greater than 2m water level reduction for a period greater than 3 months Water level (for a specific depressurisation event) does not return to within 1m of the pre "event" level (or trend occurring prior to the "event") after 3 months of the "event"	Notify within 48 hours NSW Resources Regulator – Director Compliance Operations and Principal Subsidence Engineer, Subsidence Advisory NSW, Wollondilly Shire Council, DI-Water and OEH of exceedance. Provide written Status Report to NSW Resources Regulator – Director Compliance Operations within 4 weeks of notification reviewing requirement, need and potential cost/benefit of preparation and implementation of a corrective action management plan. Iinvestigate the potential cause / fate of any water level trigger exceedance Report notification in EOP report and AEMR

Groundwater Pressures VWPs TNC 37, 40, 43	Trigger	Action
	NORMAL	**NORMAL**
	No observable mining induced change in the upper Hawkesbury Sandstone VWP intake	Continue monitoring program, report in EOP report and AEMR. Ongoing review of water pressure data
	WITHIN PREDICTION	**WITHIN PREDICTION**
	Up to 2m water level reduction in the upper Hawkesbury Sandstone VWP intake	Continue monitoring program, report in EOP report and AEMR. Ongoing review of water pressure data
	EXCEEDS PREDICTION	**EXCEEDS PREDICTION**
	Greater than 2m water level reduction in the upper Hawkesbury Sandstone VWP intake for a period greater than 3 months Water level (for a specific depressurisation event) does not return to within 1m of the pre "event" level (or trend occurring prior to the "event") after 3 months of the "event" in the upper Hawkesbury Sandstone VWP intake	Notify within 48 hours NSW Resources Regulator – Director Compliance Operations and Principal Subsidence Engineer, Subsidence Advisory NSW, Wollondilly Shire Council, DI-Water and OEH of exceedance. Provide written Status Report to NSW Resources Regulator – Director Compliance Operations within 4 weeks of notification reviewing requirement, need and potential cost/benefit of preparation and implementation of a corrective action management plan. Investigate the potential cause / fate of any water level trigger exceedance Report notification in EOP report and AEMR

Groundwater Quality (no SWL due to pump installation) GW	Trigger	Action
	NORMAL	**NORMAL**
	No observable mining induced change	Continue monitoring program, report in EOP report and AEMR. Ongoing review of water quality data
	WITHIN PREDICTION	**WITHIN PREDICTION**
	Short term increase (< 3 months) in salinity or reduction in pH outside of baseline variability, with the effect not persisting after a significant rainfall recharge event	Continue monitoring program, report in EOP report and AEMR. Ongoing review of water quality data
	EXCEEDS PREDICTION	**EXCEEDS PREDICTION**
	Increase in salinity or reduction in pH outside of baseline variability with the effect persisting for greater than 3 months or after a significant rainfall recharge event Increase of metal suite of analytes outside of baseline variability with the effect persisting for greater than 3 months or after a significant rainfall recharge event	Notify within 48 hours NSW Resources Regulator – Director Compliance Operations and Principal Subsidence Engineer, Subsidence Advisory NSW, Wollondilly Shire Council, DI-Water and OEH of exceedance. Provide written Status Report to NSW Resources Regulator – Director Compliance Operations within 4 weeks of notification reviewing requirement, need and potential cost/benefit of preparation and implementation of a corrective action management plan. Investigate the potential source/s of any water quality trigger exceedance Report notification in EOP report and AEMR.

Stream Water Quality Sites RC1, RC2, RC3, RC4, RC5 and RC6	Trigger	Action
	NORMAL	**NORMAL**
	No observable mining induced change	Continue monitoring program, report in EOP report and AEMR. Ongoing review of water quality data
	WITHIN PREDICTION	**WITHIN PREDICTION**
	Short term increase (< 3 months) in salinity or reduction in pH outside of baseline variability Increase in stream Fe hydroxide precipitation compared to baseline	Continue monitoring program, report in EOP report and AEMR. Ongoing review of water quality data
	EXCEEDS PREDICTION	**EXCEEDS PREDICTION**
	Significant reduction compared to baseline variability and predicted impacts last over >3 months in water quality at downstream monitoring site compared to baseline and / or significant observable increase in Fe hydroxide precipitate compared to baseline observations	Notify within 48 hours NSW Resources Regulator – Director Compliance Operations and Principal Subsidence Engineer, Subsidence Advisory NSW, Wollondilly Shire Council, DI-Water and OEH of exceedance. Site visit within 1 week Record photographically within 1 week Collect laboratory samples within 1 weeks and analyse for standard analytes Provide written Status Report to NSW Resources Regulator – Director Compliance Operations within 4 weeks of notification reviewing requirement, need and potential cost/benefit of preparation and implementation of a corrective action management plan. Investigate the potential source/s of any water quality trigger exceedance Report notification in EOP report and AEMR.

Stream Flow/Water Level Sites R1- R11 RC1, RC2 and RC3	Trigger	Action
	NORMAL	**NORMAL**
	No observable mining induced change	Continue monitoring program, report in EOP report and AEMR. Ongoing review of water flow and pool level data
	WITHIN PREDICTION	**WITHIN PREDICTION**
	Within baseline variability or temporary reduction over < 3 month period for pool levels and stream flow, considering rainfall / runoff variability. Minor fracturing of bedrock in directly undermined channels Pool level / flow decline <20% during mining compared to baseline for > 3 months	Continue monitoring program, report in EOP report and AEMR. Ongoing review of water flow and pool level data
	EXCEEDS PREDICTION	**EXCEEDS PREDICTION**
	Significant fracturing of bedrock in stream reach directly or not directly undermined Re-direction of surface water flows through rock fractures Pool level / flow decline >20% during mining compared to baseline for > 3 months, considering rainfall / runoff variability	Notify within 48 hours NSW Resources Regulator – Director Compliance Operations and Principal Subsidence Engineer, Subsidence Advisory NSW, Wollondilly Shire Council, DI-Water and OEH of exceedance. Site visit within 1 week Record photographically within 1 week Provide written Status Report to NSW Resources Regulator – Director Compliance Operations within 4 weeks of notification reviewing requirement, need and potential cost/benefit of preparation and implementation of a corrective action management plan. Investigate the potential source/s of any water quality trigger exceedance Report notification in EOP report and AEMR.

General Stream Sites RC1,2,3 R1- R11	Trigger	Action
	NORMAL	**NORMAL**
	No observable mining induced change	Continue monitoring program, report in EOP report and AEMR. Ongoing review of water flow and pool level data
	WITHIN PREDICTION	**WITHIN PREDICTION**
	Minor fracturing of bedrock in directly undermined channels Pool level / flow decline <20% during mining compared to baseline for > 3 months	Continue monitoring program, report in EOP report and AEMR. Ongoing review of water flow and pool level data
	EXCEEDS PREDICTION	**EXCEEDS PREDICTION**
	Significant fracturing of bedrock in stream reach directly or not directly undermined Re-direction of surface water flows through rock fractures Pool level / flow decline >20% during mining compared to baseline for > 3 months, considering rainfall / runoff variability	Notify within 48 hours NSW Resources Regulator – Director Compliance Operations and Principal Subsidence Engineer, Subsidence Advisory NSW, Wollondilly Shire Council, DI-Water and OEH of exceedance. Site visit within 1 week Record photographically within 1 week Provide written Status Report to NSW Resources Regulator – Director Compliance Operations within 4 weeks of notification reviewing requirement, need and potential cost/benefit of preparation and implementation of a corrective action management plan. Investigate the potential source/s of any water quality trigger exceedance Report notification in EOP report and AEMR.

Aquatic Ecology	Trigger	Action
	NORMAL	**NORMAL**
	No change in aquatic habitat compared to baseline observed	Continue monitoring program, report in EOP report and AEMR. Ongoing review of monitoring data
	WITHIN PREDICTION	**WITHIN PREDICTION**
	No change in aquatic habitat compared to baseline observed Water flow and quality results within predictions. Observational monitoring within baseline variability.	Continue monitoring program, report in EOP report and AEMR. Ongoing review of monitoring data
	EXCEEDS PREDICTION	**EXCEEDS PREDICTION**
	Water flow and quality results exceed predictions. Observational monitoring shows significant change observed in aquatic habitat compared to baseline observed	Notify within 48 hours NSW Resources Regulator – Director Compliance Operations and Principal Subsidence Engineer, Subsidence Advisory NSW, Wollondilly Shire Council, DI-Water and OEH of exceedance. Site visit within 1 week Record photographically within 1 week Provide written Status Report to NSW Resources Regulator – Director Compliance Operations within 4 weeks of notification reviewing requirement, need and potential cost/benefit of preparation and implementation of a corrective action management plan. Investigate the potential source/s of any water quality trigger exceedance Report notification in EOP report and AEMR.

Private Dams	Trigger	Action
	NORMAL	**NORMAL**
	No change in dam wall integrity and water level	Continue monitoring program, report in EOP report and AEMR.
	WITHIN PREDICTION	**WITHIN PREDICTION**
	No change in dam wall integrity and minor changes to water level	Continue monitoring program, report in EOP report and AEMR. Ongoing review of monitoring data
	EXCEEDS PREDICTION	**EXCEEDS PREDICTION**
	Observed changes in dam wall integrity and water levels, development of seepage at dam wall toe	Notify within 48 hours NSW Resources Regulator – Director Compliance Operations and Principal Subsidence Engineer, Subsidence Advisory NSW, Wollondilly Shire Council, DI-Water and OEH of exceedance. Notify landowner. Site visit within 1 week Record photographically within 1 week Provide written Status Report to NSW Resources Regulator – Director Compliance Operations within 4 weeks of notification reviewing requirement, need and potential cost/benefit of preparation and implementation of a corrective action management plan. Investigate the potential source/s of any water quality trigger exceedance Report notification in EOP report and AEMR.

Steep Slopes	Trigger	Action
	NORMAL	**NORMAL**
	No observed changes in slopes	Continue monitoring program, report in EOP report and AEMR.
	WITHIN PREDICTION	**WITHIN PREDICTION**
	No observed changes in slopes, minor erosional movement in slopes	Continue monitoring program, report in EOP report and AEMR.
	EXCEEDS PREDICTION	**EXCEEDS PREDICTION**
	Observed changes in slopes with indication of slope movement	Notify within 48 hours NSW Resources Regulator – Director Compliance Operations and Principal Subsidence Engineer, Subsidence Advisory NSW, Wollondilly Shire Council, DI-Water and OEH of exceedance. Site visit within 1 week Record photographically within 1 week Provide written Status Report to NSW Resources Regulator – Director Compliance Operations within 4 weeks of notification reviewing requirement, need and potential cost/benefit of preparation and implementation of a corrective action management plan. Investigate the potential source/s of any water quality trigger exceedance Report notification in EOP report and AEMR.

Aboriginal Archaeology Sites	**Trigger**	**Action**
	NORMAL	**NORMAL**
	No observable mining induced change	Continue monitoring program, report in EOP report and AEMR.
	WITHIN PREDICTION	**WITHIN PREDICTION**
	No observable mining induced change Rock fracturing within 2 metres of Aboriginal archaeology site	Continue monitoring program, report in EOP report and AEMR.
	EXCEEDS PREDICTION	**EXCEEDS PREDICTION**
	Rock fracturing of Aboriginal archaeology site	Notify within 48 hours NSW Resources Regulator – Director Compliance Operations and Principal Subsidence Engineer, Subsidence Advisory NSW, Wollondilly Shire Council, DI-Water and OEH of exceedance. Site visit within 1 week Record photographically within 1 week Provide written Status Report to NSW Resources Regulator – Director Compliance Operations within 4 weeks of notification reviewing requirement, need and potential cost/benefit of preparation and implementation of a corrective action management plan. Report notification in EOP report and AEMR.
Heritage Properties • **Koorana House** • **Mill Hill** • **Fairley House**	As per specific Property Subsidence Management Plans for each heritage property	As per specific Property Subsidence Management Plans for each heritage property