Tahmoor Colliery
Longwalls 27 to 30

ENVIRONMENTAL MANAGEMENT PLAN

REVISION D

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February 2013

GENERAL

AUTHORISATION OF MANAGEMENT PLAN

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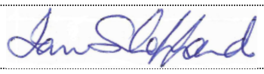
Signature:	
Position:	Manager Environment and Community
Date:	6 February 2013

REVIEW

Date	Rev	Comments
6 Dec 2012	A	Draft – Updated to include requirements included in condition 13 of SMP approval 11/3219 dated 31 October 2012 for Longwalls 27-30
14 Jan 2013	B	Draft – For Review
25 Jan 2013	C	Draft – For Review
6 Feb 2013	D	Final – Minor amendments to TARP regarding groundwater levels and mine inflows

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Glossary

Angle of draw	The angle of inclination from the vertical of the line connecting the goaf edge of the workings and the limit of subsidence (which is usually taken as 20 mm of subsidence).
Chain pillar	A block of coal left unmined between the longwall extraction panels.
Cover depth (H)	The depth from the surface to the top of the seam. Cover depth is normally provided as an average over the area of the panel.
Critical area	The area of extraction at which the maximum possible subsidence of one point on the surface occurs.
Curvature	The change in tilt between two adjacent sections of the tilt profile divided by the average horizontal length of those sections.
Extracted seam	The thickness of coal that is extracted. The extracted seam thickness is thickness normally given as an average over the area of the panel.
Face length	The width of the coalface measured across the longwall panel.
Goaf	The void created by the extraction of the coal into which the immediate roof layers collapse.
Goaf end factor	A factor applied to reduce the predicted incremental subsidence at points lying close to the commencing or finishing ribs of a panel.
Horizontal displacement	The horizontal movement of a point on the surface of the ground as it settles above an extracted panel.
Inflection point	The point on the subsidence profile where the profile changes from a convex curvature to a concave curvature. At this point the strain changes sign and subsidence is approximately one half of S max.
Incremental subsidence	The difference between the subsidence at a point before and after a panel is mined. It is therefore the additional subsidence at a point resulting from the excavation of a panel.
Overlap adjustment factor	A factor that defines the ratio between the maximum incremental subsidence of a panel and the maximum incremental subsidence of that panel if it were the first panel in a series.
Panel	The plan area of coal extraction.
Panel length (L)	The longitudinal distance along a panel measured in the direction of (mining from the commencing rib to the finishing rib.
Panel width (Wv)	The transverse distance across a panel, usually equal to the face length plus the widths of the roadways on each side.
Panel centre line	An imaginary line drawn down the middle of the panel.
Pillar	A block of coal left unmined.
Pillar width (Wpi)	The shortest dimension of a pillar measured from the vertical edges of the coal pillar, i.e. from rib to rib.
Strain	The change in the horizontal distance between two points divided by the original horizontal distance between the points.
Sub-critical area	An area of panel smaller than the critical area.
Subsidence	The vertical movement of a point on the surface of the ground as it settles above an extracted panel.
Super-critical area	An area of panel greater than the critical area.
Tilt	The difference in subsidence between two points divided by the horizontal distance between the points.
Uplift	An increase in the level of a point relative to its original position.
Upsidence	A reduction in the expected subsidence at a point, being the difference between the predicted subsidence and the subsidence actually measured.

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CHAPTER 1. INTRODUCTION

1.1. Background

Tahmoor Colliery is managed and operated by Tahmoor Coal Pty Limited, a fully owned subsidiary of Xstrata Coal Limited. Tahmoor Coal holds coal and mining leases CCL 716, ML 1539 and ML 1376 encompassing the proposed longwall extraction.

1.2. Current and Proposed Operations

Tahmoor Colliery has previously mined 26 longwalls generally to the north and west of the mine's pit top location. It has recently completed extraction of Longwall 26.

Longwalls 27 to 30 are 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. Natural features are located within these areas.

A number of natural features have been identified in the vicinity of the proposed mining of longwalls 27 to 30. Assessment of the impact of subsidence as a result of that mining, and planned monitoring, management and remediation activities, is the subject of this plan.

1.3. Aims and Objectives

The overall aims of the Plan are to:-

- Minimise or avoid impact on the natural environment
- Minimise the risk to public safety to within tolerable limits
- Minimise the level of public disruption and inconvenience

The objectives of this Environmental Management Plan (EMP) are to establish procedures to measure, manage, mitigate and repair potential impacts that might occur to natural features.

These objectives will be met by using the following methods:-

- Assess the potential subsidence impacts to natural features resulting from the proposed mining
- Monitoring ground movements and the condition of natural features during mining
- Initiating action to mitigate or remedy potential significant impacts that are expected to occur on the surface
- Providing a plan of action in the event that the impacts of mine subsidence are greater than those that are predicted
- Providing a forum to report, discuss and record impacts to the surface - this will involve Tahmoor Colliery, stakeholders, Department of Trade & Investment, Regional Infrastructure and Services – Division of Resources and Energy (DRE), and consultants as required
- Establishing lines of communication and emergency contacts

The EMP has been prepared in accordance with the requirements of Condition 13 (Environmental Management) of the Subsidence Management Plan Approval for Tahmoor Colliery Longwalls 27 – 30, which was received on 31/10/2012.

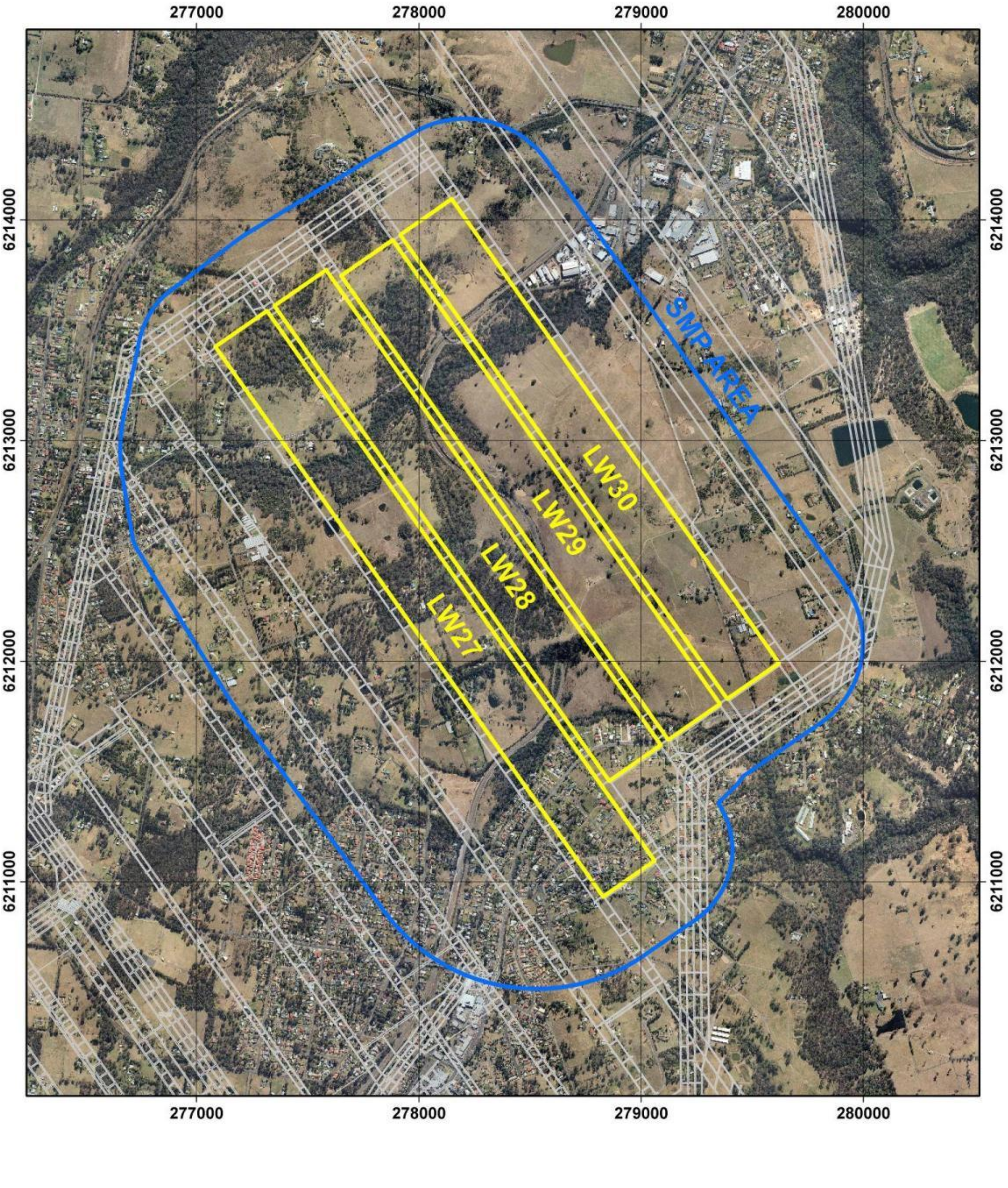

Figure 1.1 Aerial Photograph and Mine Plan

1.4. Scope

The EMP will be used to protect and monitor the condition of natural features identified to be at risk due to mine subsidence. The components covered by this Plan are:

- Surface water quality and quantity (including Myrtle Creek, Redbank Creek and dams);
- Groundwater quality and quantity (including private bores and Xstrata piezometers in the SMP area);
- Flora and fauna;
- Heritage sites (including Aboriginal heritage), and;
- Geomorphology (including rock bars and cliff lines).

This EMP covers the specified features located within the general application area, which defines the extent of land that may be affected by mine subsidence as a result of mining Longwalls 27 to 30. The plan does not include areas outside the extent of the SMP area.

The EMP also applies to persons employed or engaged by Tahmoor Colliery requiring them to carry out activities described by this plan.

1.5. Proposed Mining Schedule

It is planned that each longwall will extract coal working northwest from the south-eastern ends.

This Plan covers longwall mining until completion of mining in Longwall 30 and for sufficient time thereafter to allow for completion of subsidence effects.

The current proposed schedule of mining is shown in Table 1.1.

Table 1.1 Schedule of Mining

Longwall	Start Date	Completion Date
Longwall 27	November 2012	February 2014
Longwall 28	March 2014	January 2015
Longwall 29	March 2015	January 2016
Longwall 30	February 2016	November 2016

1.6. 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. 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 1.2.

Figure 1.2 Diagrammatic Representation of Active Subsidence Zone

1.7. Consultation

This Plan was prepared in consultation with the regulatory agencies.

Copies of the draft plan were sent to DoPI, NOW and DRE, and the agencies were asked to comment on the plan prior to its finalisation.

Responses were received from DoPI, NOW and DRE, and their comments were taken into account when compiling this document.

1.8. Performance Measures

As the streams and groundwater systems are hydrologically interconnected, the following performance measures apply equally across the systems.

The proposed extraction will conform to the relevant performance criteria outlined below;

Myrtle Creek and Redbank Creek

Minor environmental consequences

Other Watercourses

No greater subsidence impact or environmental consequences than predicted in the SMP

Cliffs Flanking Redbank Creek and Other Cliffs

Minor environmental consequences

Threatened Species and Populations or Endangered Ecological Communities

Negligible environmental consequences

Aboriginal Features

Negligible alteration or damage to the feature or site that may be determined to hold ”special significance”

Other Heritage Features

Minor alteration or damage to the feature or site

Negligible is defined as being small and unimportant, such as to be not worth considering.

Minor is defined as being relatively small in quantity, size and degree given the relative context.

The Performance measures will be achieved through adherence to the procedures and methods outlined in the Trigger Action Remediation Plan.

If a performance criteria;

i. has been exceeded or is likely to be exceeded, an assessment will be made against the performance criteria;
ii. is likely to be exceeded if management measures are not implemented, the mine will implement suitable management measures and continue to monitor, and;
iii. is considered likely to have been exceeded or is likely to be exceeded, the mine will implement suitable contingency measures and continue to monitor the relevant sites in consultation with the DRE (Director Environmental Sustainability and Land Use, Principal Subsidence Engineer) as well as NOW and DoPI.

CHAPTER 2. SUBSIDENCE PREDICTIONS

2.1. Maximum Predicted Systematic Parameters

Predicted mining-induced systematic subsidence movements were provided in Report No. MSEC355 which was prepared as part of Tahmoor Colliery's SMP Application for Longwalls 27 to 30.

A summary of the maximum predicted incremental systematic subsidence parameters due to the extraction of each of the proposed longwalls is provided in Table 2.1. A summary of the maximum predicted cumulative systematic subsidence parameters after the extraction of each of the proposed longwalls is provided in Table 2.2

A summary of the maximum predicted travelling parameters, during the extraction of each of the proposed longwalls, is provided in Table 2.3.

Table 2.1 Maximum Predicted Incremental Systematic Subsidence Parameters due to the Extraction of Each of the Proposed Longwalls 27 to 30

Longwall	Maximum Predicted Incremental Subsidence (mm)	Maximum Predicted Incremental Tilt (mm/m)	Maximum Predicted Incremental Hogging Curvature (1/km)	Maximum Predicted Incremental Sagging Curvature (1/km)
After LW27	755	6.0	0.07	0.14
After LW28	735	5.9	0.07	0.13
After LW29	735	5.9	0.06	0.13
After LW30	725	5.8	0.06	0.13

Table 2.2 Maximum Predicted Cumulative Systematic Subsidence Parameters after the Extraction of Each of the Proposed Longwalls 27 to 30

Longwall	Maximum Predicted Cumulative Subsidence (mm)	Maximum Predicted Cumulative Tilt (mm/m)	Maximum Predicted Cumulative Hogging Curvature (1/km)	Maximum Predicted Cumulative Sagging Curvature (1/km)
After LW27	1260	6.3	0.09	0.15
After LW28	1270	6.2	0.09	0.14
After LW29	1270	6.1	0.09	0.14
After LW30	1270	6.3	0.09	0.14

The values provided in the above table are the maximum predicted cumulative systematic subsidence parameters which occur within the general SMP Area, including the predicted movements resulting from the extraction of Longwalls 22 to 30.

Table 2.3 Maximum Predicted Travelling Subsidence Parameters during the Extraction of Each of the Proposed Longwalls 27 to 30

Longwall	Maximum Predicted Travelling Tilt (mm/m)	Maximum Predicted Travelling Hogging Curvature (1/km)	Maximum Predicted Travelling Sagging Curvature (1/km)
During LW27	3.1	0.04	0.03
During LW28	3.0	0.03	0.03
During LW29	3.0	0.03	0.03
During LW30	3.0	0.03	0.03

2.2. Observed Subsidence during the mining of Longwalls 22 to 26

Extensive ground monitoring within the urban areas of Tahmoor has allowed detailed comparisons to be made between predicted and observed subsidence, tilt, strain and curvature during the mining of Longwalls 22 to 26.

In summary, there is generally a good correlation between observed and predicted subsidence, tilt and curvature. Observed subsidence was generally slightly greater than predicted in areas that were located directly above previously extracted areas and areas of low level subsidence (typically less than 100 mm) was generally observed to extend further than predicted.

While there is generally a good correlation between observed and predicted subsidence, substantially increased subsidence has been observed above most of Longwall 24A and the southern ends of Longwalls 25 and 26. This was a very unusual event for the Southern Coalfield.

Observed Increased Subsidence during the mining of Longwall 24A

Observed subsidence was greatest above the southern half of Longwall 24A, that gradually reduced in magnitude towards the northern half of the longwall, and was directly beneath the urban area of Tahmoor. These observations are shown graphically in Figure. 2.1, which shows observed subsidence at survey pegs located along the centreline of Longwall 24A.

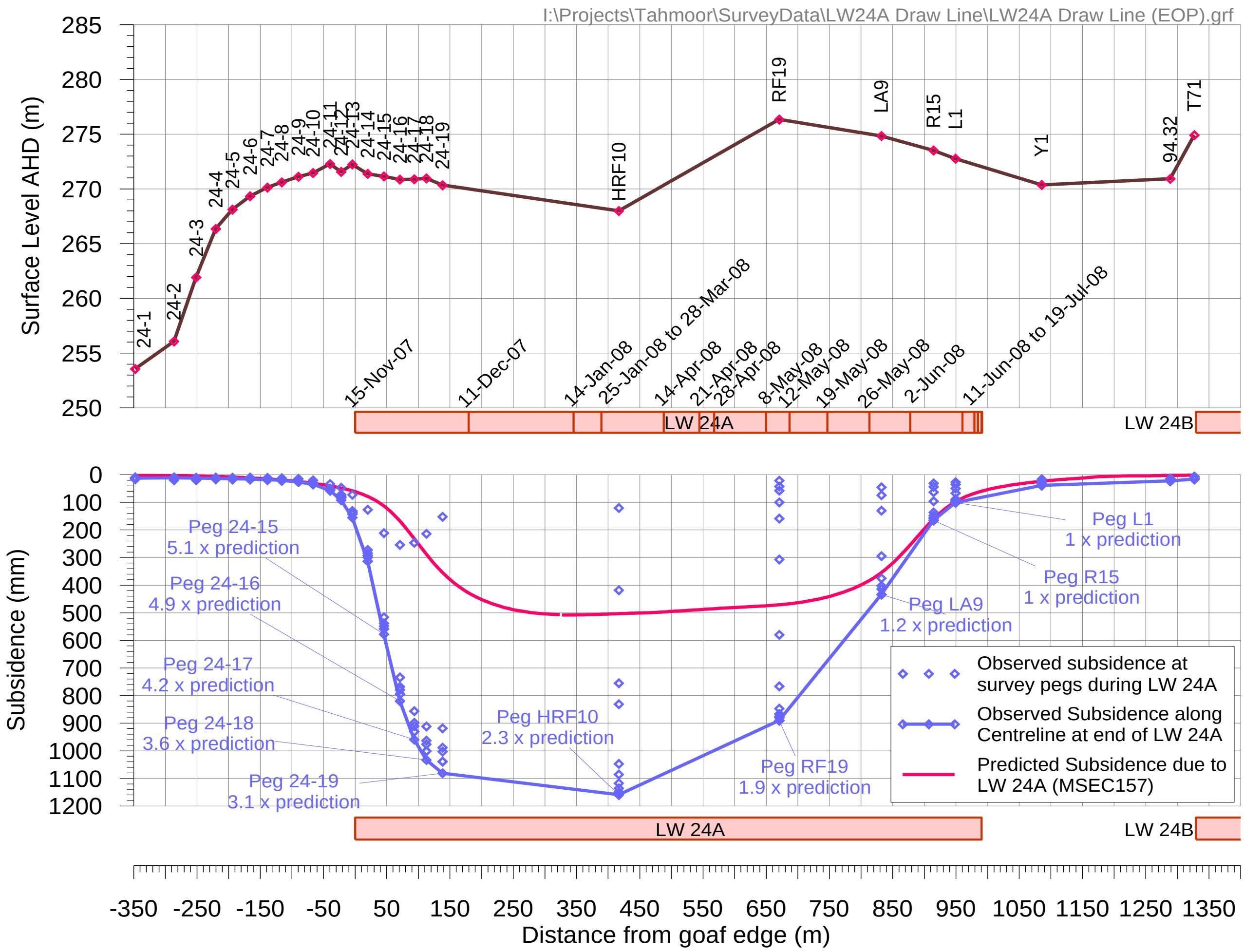

Figure. 2.1 Observed Subsidence along Centreline of Longwall 24A

It can be seen from Figure. 2.1 that observed subsidence was more than twice the predicted maximum value, reaching to a maximum of 1169 mm at Peg HRF10.

It is possible that actual maximum subsidence developed somewhere between Pegs HRF10 and RF19, though this was not measured. Observed subsidence was similar to prediction near Peg R15 on Remembrance Drive. Survey pegs RF19 and LA9 are located within a transition zone where subsidence gradually reduced from areas of maximum increased subsidence to areas of normal subsidence.

Observed Increased Subsidence during the mining of Longwall 25

Increased subsidence was observed during the first stages of mining Longwall 25. These observations are shown graphically in Figure. 2.2, which shows observed subsidence at survey pegs located along the centreline of Longwall 25.

It can be seen from Figure. 2.2 that observed subsidence was approximately twice the predicted maximum value, with maximum subsidence of 1216 mm at Peg 25-28.

Observed subsidence is similar to but slightly more than predicted at Peg RE7 and is similar to prediction at Peg Y20 and at all pegs located further along the panel. Survey pegs A6, A7, A8 and A9 are located within a transition zone where subsidence has gradually reduced from areas of maximum increased subsidence to areas of normal subsidence.

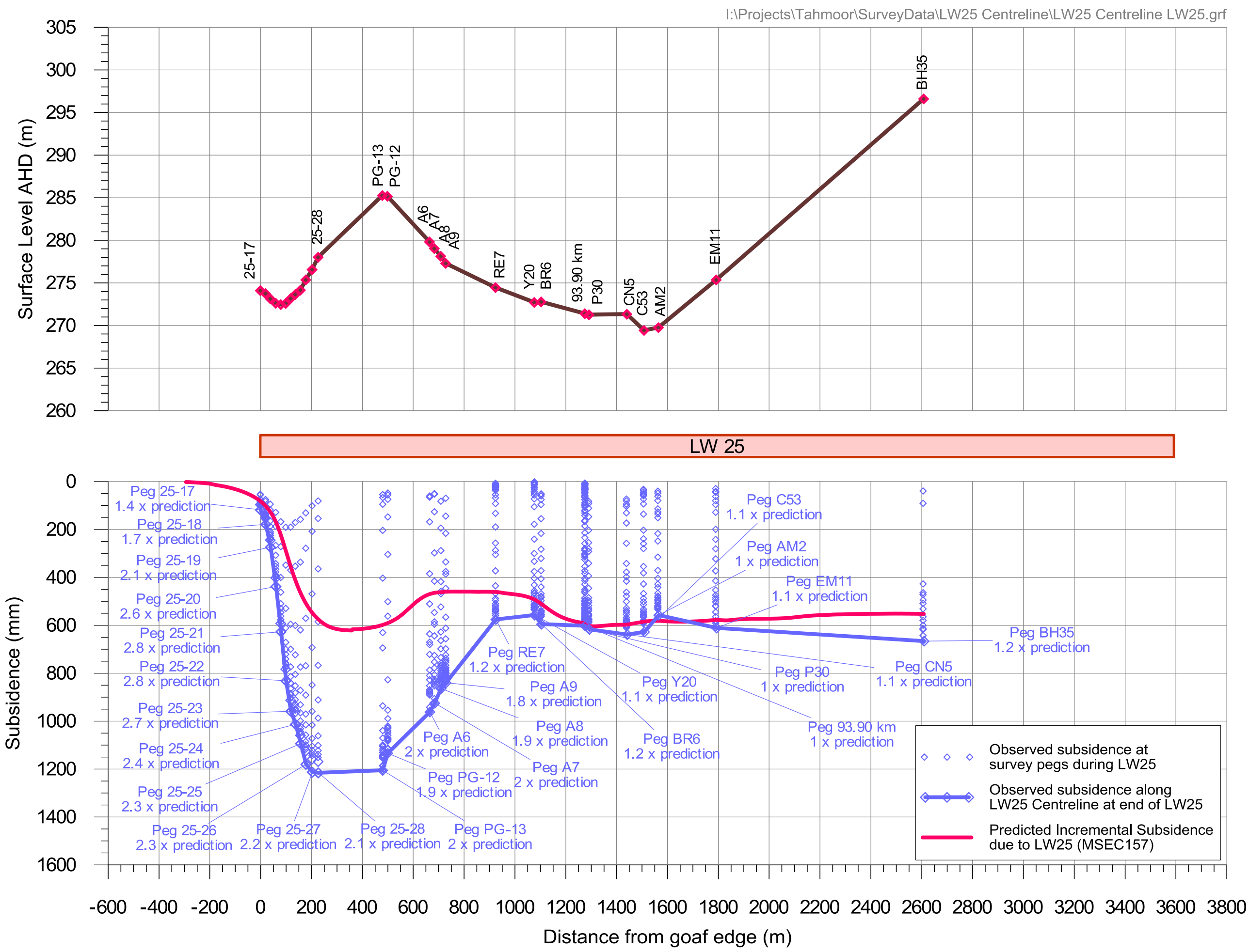

Figure. 2.2 Observed Subsidence along Centreline of Longwall 25

Observed Increased Subsidence during the mining of Longwall 26

Increased subsidence was observed during the first stages of mining Longwall 26, but at a reduced magnitude compared to the subsidence observed above Longwalls 24A and 25. These observations are shown graphically in Figure 2.3, which shows observed subsidence at survey pegs located along the centreline of Longwall 26. The graph shows the latest survey results for each monitoring line as at August 2012. It is likely that further small increases in subsidence will be observed at these pegs when they are surveyed at the completion of Longwall 26.

It can be seen from Figure 2.3 that observed subsidence was approximately 1.3 times the predicted maximum value, with maximum subsidence of 867 mm at Peg TM26.

Observed subsidence reduced along the panel until Peg Y40 on York Street, where it was less than prediction. Survey pegs S9, and RE27 are located within a transition zone where subsidence has gradually reduced from areas of maximum increased subsidence between Pegs TM26 and MD4 to areas of normal subsidence at Peg Y40 and beyond.

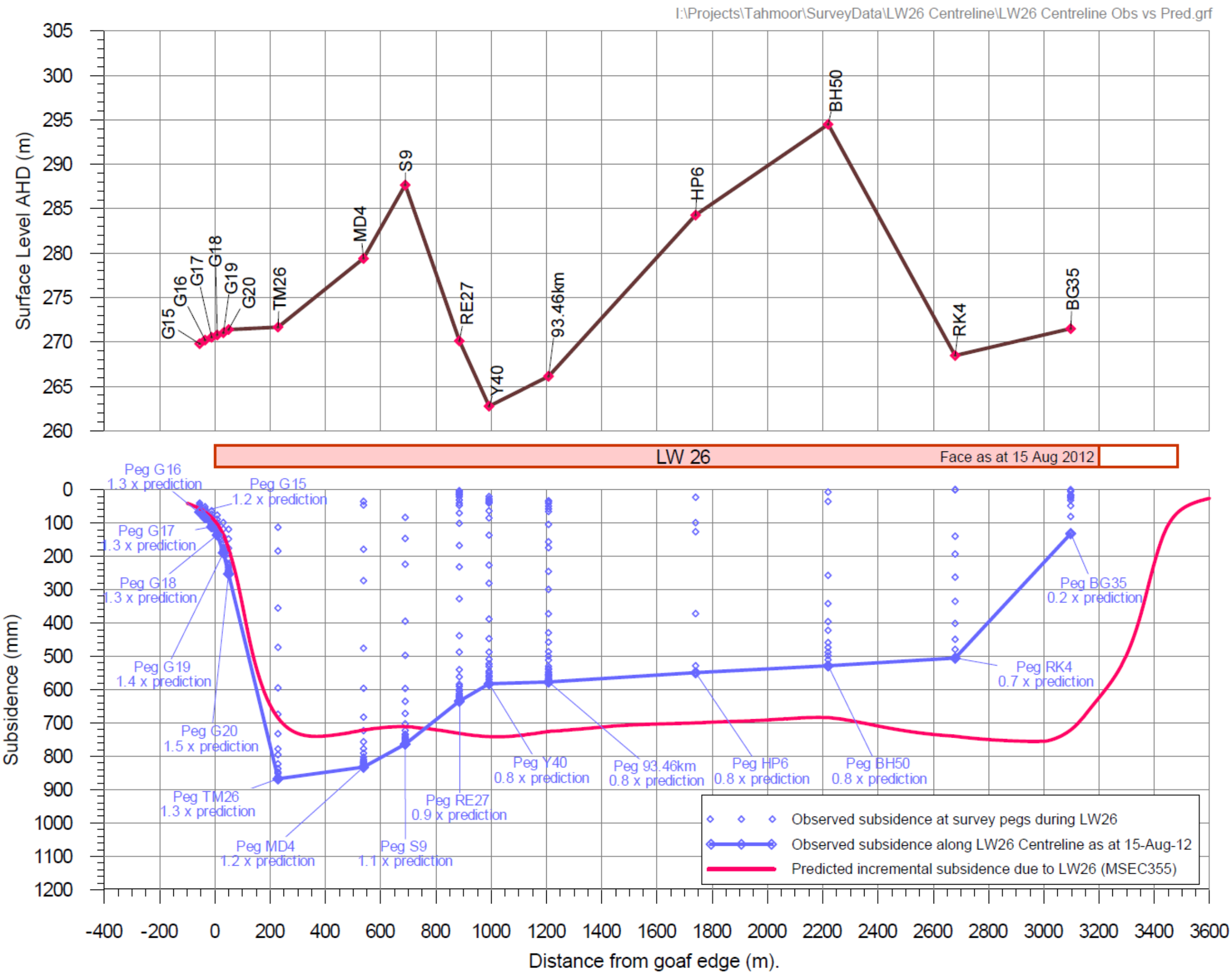

Figure 2.3 Observed Subsidence along Centreline of Longwall 26 as at August 2012

Analysis and commentary

The cause for the increased subsidence has been investigated by Strata Control Technologies on behalf of Tahmoor Colliery (Gale and Sheppard, 2011). The investigations concluded that the increased subsidence is consistent with localised weathering of joint and bedding planes above a depressed water table adjacent to an incised gorge.

In light of the above observations, the region above the extracted longwalls at Tahmoor has been partitioned into three zones:

1. Normal subsidence zone – where the observed vertical subsidence is within the normal range and correlates well with predictions
2. Maximum increased subsidence zone – where the observed vertical subsidence is substantially greater than predictions but has reached it upper limit. Maximum subsidence above the centreline of the longwalls appears to be approximately 1.2 metres above Longwalls 24A and 25, and 900 mm above Longwall 26.
3. Transition zone – where the subsidence behaviour appears to have transitioned between areas of maximum increased subsidence and normal subsidence.

When the locations of the three zones are plotted on a map, as shown in Drawing No. MSEC567-00-01 (refer Appendix), it can be seen that the transition zone is roughly consistent in width above Longwall 24A, Longwall 25 and Longwall 26. The orientation of the transition zone is also roughly parallel to the Nepean Fault and not the Bargo River.

Prior to the mining of Longwall 26, it was not yet known whether the location of the transition zone was related to the alignment of the Nepean Fault or the Bargo River as both features were aligned approximately parallel to each other adjacent to previously extracted Longwalls 24A and 25.

The Bargo River, however, abruptly turns a sharp bend near the end of Longwalls 25 and 26 and observations during the mining of Longwall 26 were able to provide a first indication that the location of the transition zone was related to the alignment of the Nepean Fault, rather than the Bargo River.

The magnitude of subsidence above Longwall 26 is reduced compared to Longwalls 24A and 25.

Given that the alignment of the Nepean Fault moves away from the Bargo River above Longwall 26, it appears that the magnitude of increased subsidence is linked to the proximity of the Bargo River. This observation confirms the findings of Gale and Sheppard that the increased subsidence is linked to localised weathering of joint and bedding planes above a depressed water table adjacent to the incised gorge of the Bargo River.

In summary, it appears that the location of increased subsidence is linked to the alignment of the Nepean Fault and the magnitude of the increased subsidence is linked to the proximity to the Bargo River.

The zones have been projected above Longwalls 27 to 30 from the observed zones above Longwalls 24A and 26, as shown in Drawing No. MSEC567-00-02 (refer Appendix). The projection is based on the orientation of the Nepean Fault. It can be seen that the transition zone extends to sections of Myrtle Creek Avenue, Remembrance Drive, Myrtle Creek and the Main Southern Railway.

Given that Longwall 27 is located further away from the Bargo River than Longwall 26, it is expected that the magnitude of maximum subsidence at the commencing end of Longwall 27 will be less than 900 mm. The amount of reduction in maximum subsidence is difficult to predict. The difference in maximum subsidence between Longwalls 24A and 25 and Longwall 26 is approximately 300 mm. If maximum subsidence at the commencing end of Longwall 27 reduces a further 300 mm, the magnitude of subsidence at the commencing end will return to normal levels.

It is recognised that despite the above analysis and projections, substantially increased subsidence could develop as the mining of Longwall 27 progresses. This Plan has been developed to manage potential impacts if substantial additional subsidence were to occur.

2.3. Predicted Strain

The prediction of strain is more difficult than the predictions of subsidence, tilt and curvature. The reasons for this are that strain is affected by many factors, including ground curvature and horizontal movement, as well as local variations in the near surface geology, the locations of joints at bedrock, and the depth of bedrock. The measurements are also affected by survey tolerance. The profiles of observed strain can, therefore, be irregular even when the profiles of observed subsidence, tilt and curvature are relatively smooth.

The relative frequency distribution of maximum observed tensile strains and compressive strains for survey bays located directly above goaf is provided in Figure 2.4.

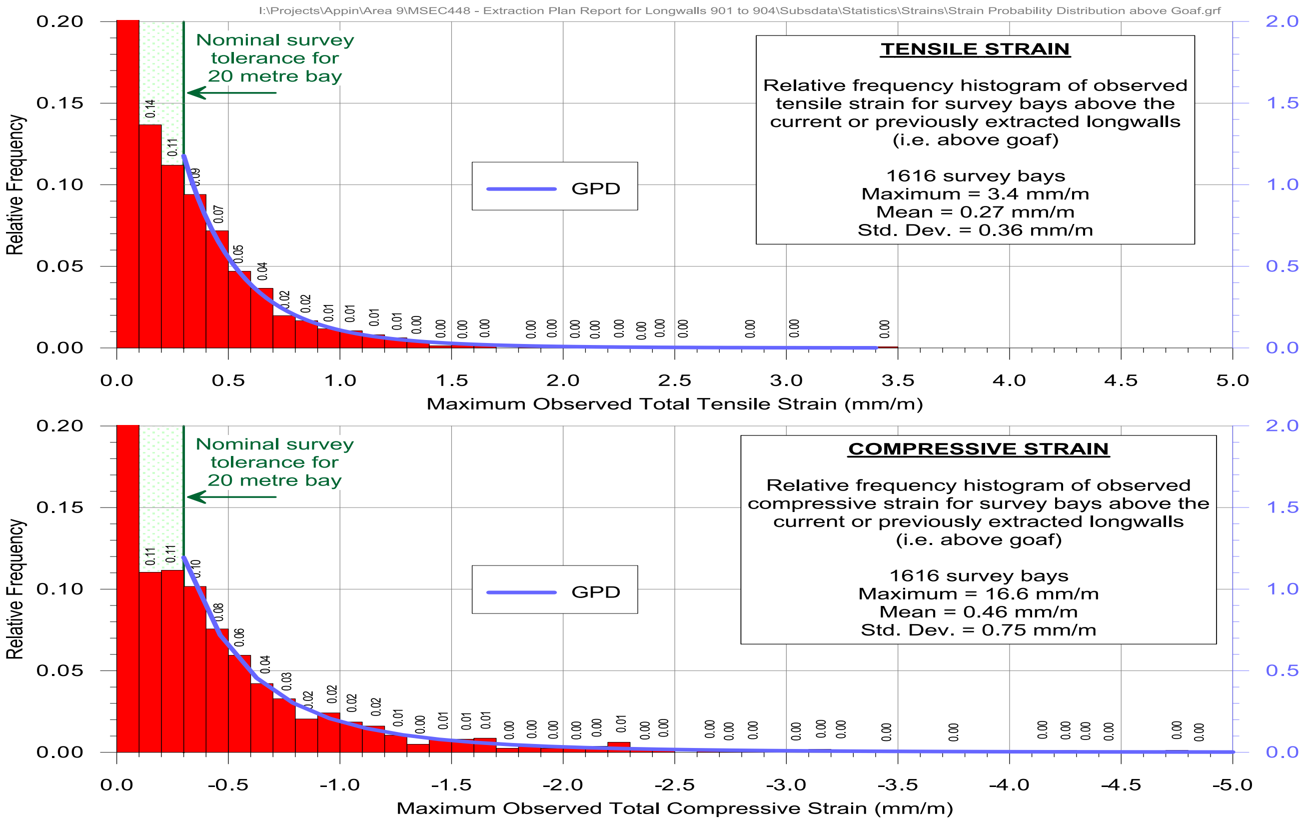

Figure 2.4 Distributions of Measured Maximum Tensile and Compressive Strains at Any Time for Pegs Located Above Goaf in the Southern Coalfield

While not shown in Figure 2.4, it is noted that the maximum observed compressive strain of 16.6 mm/m, which occurred along the T-Line above Appin Longwall 408, was the result of movements along a low angle thrust fault within the Cataract Tunnel. All remaining compressive strains in this dataset (which exclude valley related movements) were less than 5 mm/m.

The relative frequency distribution of maximum observed tensile strains and compressive strains above solid coal is provided in Figure 2.5.

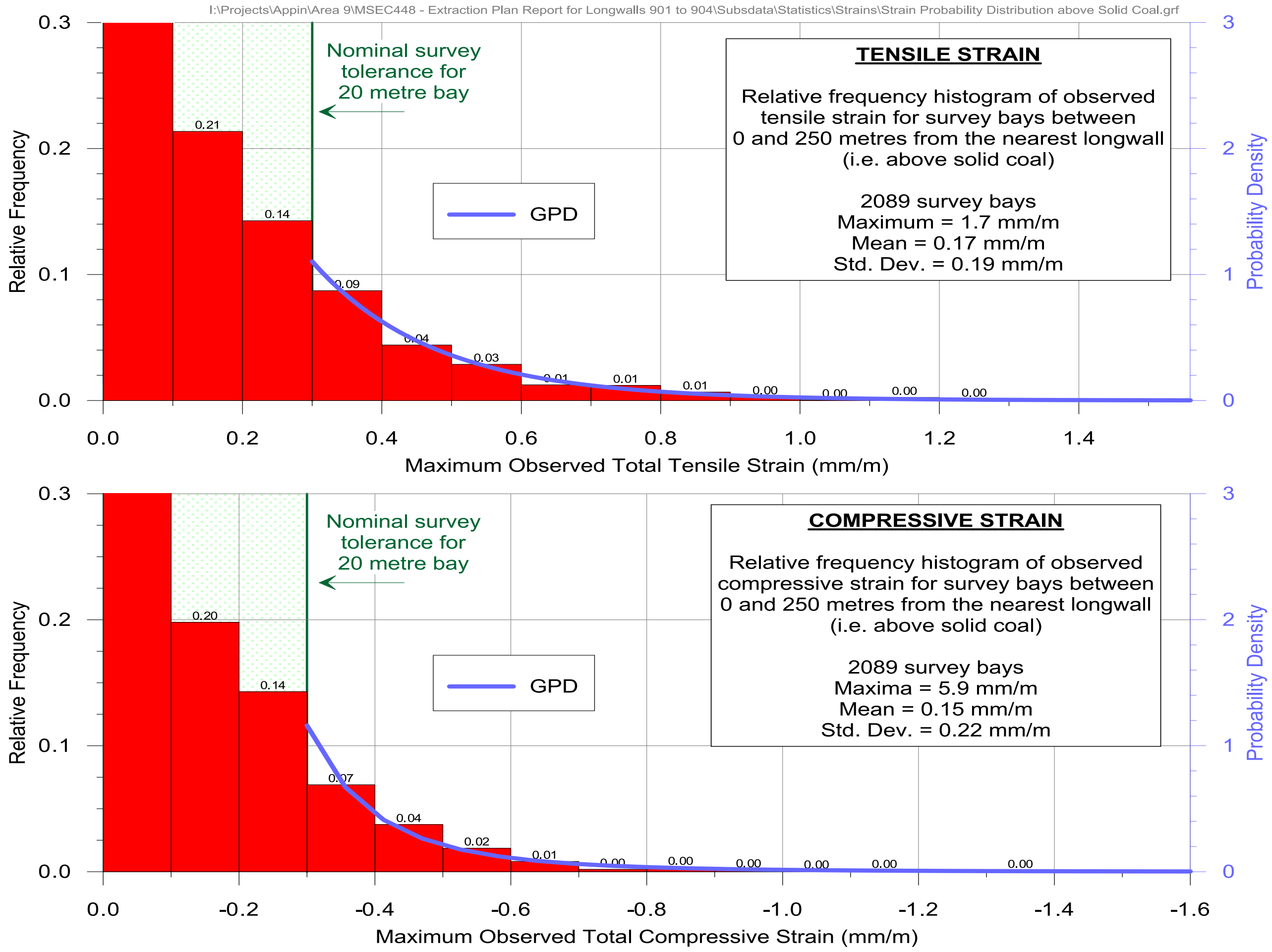

Figure 2.5 Distributions of Measured Maximum Tensile and Compressive Strains at Any Time for Pegs Located Above Solid Coal in the Southern Coalfield

While not shown in Figure 2.5, it is noted that the maximum observed compressive strain of 5.9 mm/m, which occurred along the T-Line above Appin Longwall 408, was the result of movements along a low angle thrust fault within the Cataract Tunnel as Longwall 408 approached the monitoring line. A maximum observed compressive strain of 3.1 mm/m was observed across the fault at the completion of Longwall 407. All remaining compressive strains in this dataset (which exclude valley related movements) were less than 5 mm/m.

2.4. Predicted and Observed Valley Closure Across Creeks

Myrtle Creek and tributaries

A map of monitoring lines across Myrtle Creek and a small unnamed tributary creek that crosses the Main Southern Railway (at a location called the Skew Culvert) is shown in Figure 2.6.

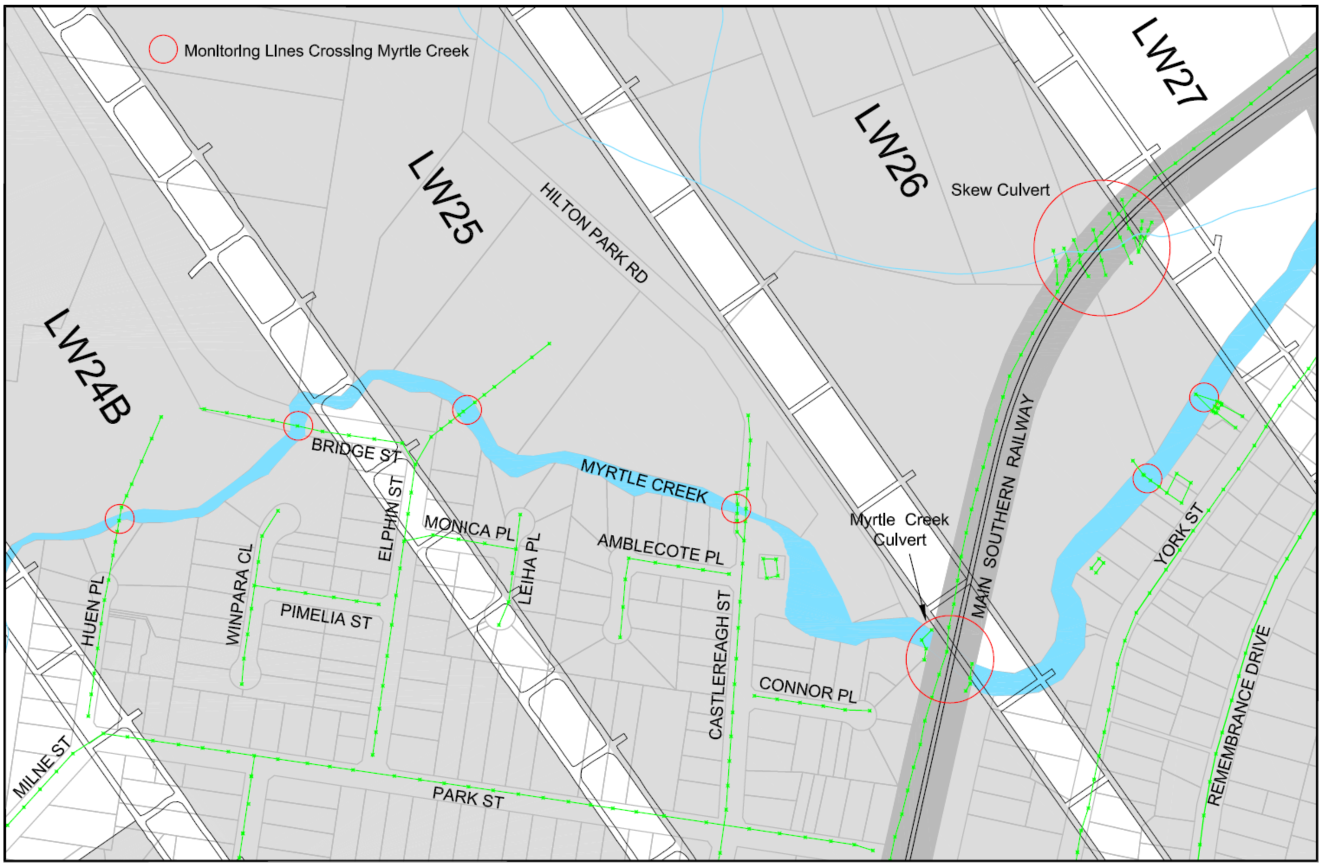

Figure 2.6 Monitoring lines across Myrtle Creek and Skew Culvert

A summary graph showing the development of valley closure across the Myrtle Creek at each monitoring line is shown in Figure 2.7.

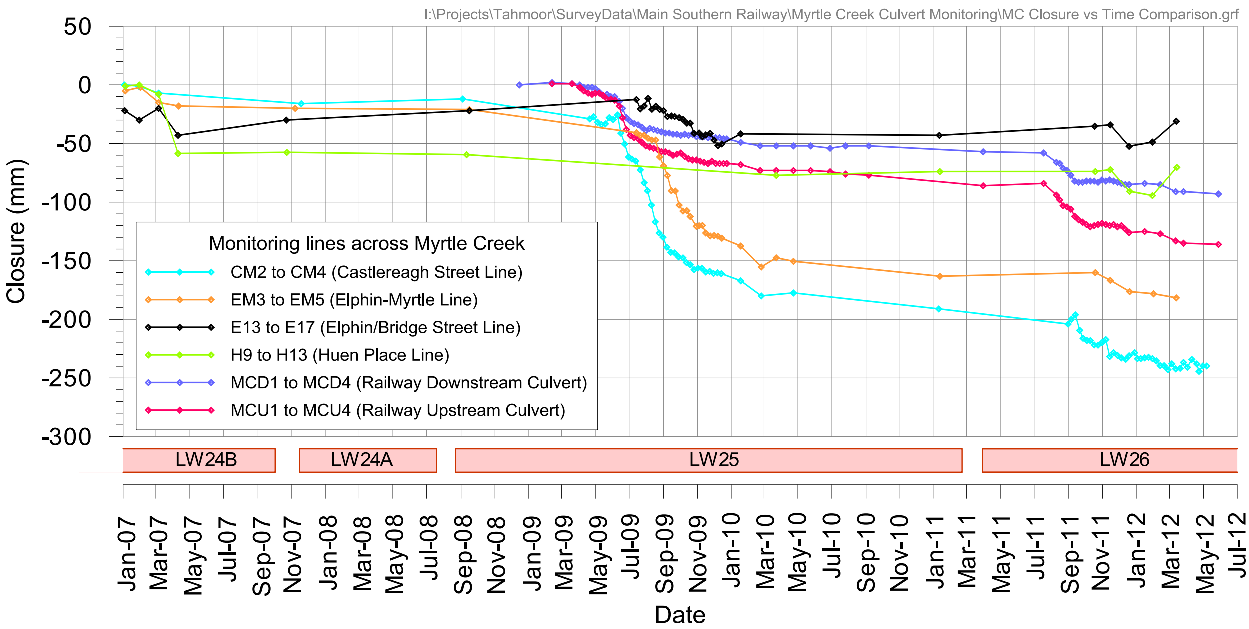

Figure 2.7 Development of closure across Myrtle Creek during the mining of Longwalls 24B to 26

The development of valley closure across the creek at the Skew Culvert is shown in Figure 2.8.

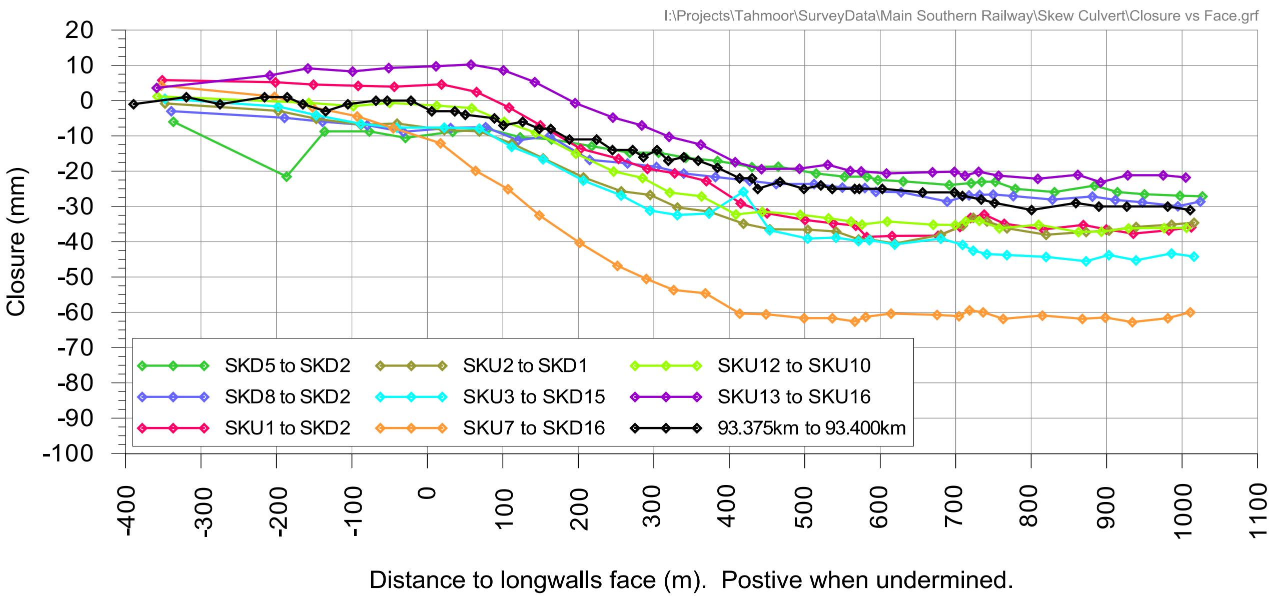

Figure 2.8 Development of closure across Skew Culvert during the mining of Longwall 26 as at 27 March 2012

A summary of predicted and observed valley closure across Myrtle Creek is provided in Table 2.4. The predictions are consistent with those provided in Report No. MSEC355, in support of Tahmoor Colliery's SMP application to extract longwalls 27 to 30.

Table 2.4 Predicted and Observed Incremental Valley Closure across Myrtle Creek and Skew Culvert at monitoring lines

		Predicted and Observed Valley Closure due to mining of each longwall(s)		
		Due to LW24 (mm)	Due to LW25 (mm)	Due to LW26 (mm)
Castlereagh Street (Pegs C2 to C4)	Predicted	30	55	45
	Observed	12	179	49
Elphin-Myrtle (Pegs EM3 to EM5)	Predicted	60	70	40
	Observed	21	142	22
Elphin Street / Bridge Street (Pegs E13 to E17)	Predicted	75	75	30
	Observed	0	21	6
Huen Place (Pegs H9 to H13)	Predicted	60	35	15
	Observed	58	15	20
Main Southern Railway Upstream (MCU1 to MCU4) Downstream (MCD1 to MCD4)	Predicted	15	30	30
	Observed	-	57 (d/s) to 86 (u/s)	36 (d/s) to 50 (u/s)
Skew Culvert (8 cross sections)	Predicted	< 5	10	25
	Observed	-	-	21 to 60 (avg 36)
13 York Street (Y64-6 to Y64-9)	Predicted	-	-	65
	Observed	-	-	60
9a York Street (Y67-10 to Y67-14)	Predicted	-	-	85
	Observed	-	-	73

It can be seen that observed valley closure has substantially exceeded predictions at the Castlereagh Street crossing, at the crossing of the Elphin-Myrtle monitoring line and to a lesser extent the crossing of the Main Southern Railway during the mining of Longwall 25. It is considered that the reason for the differences in observations may be linked to the change in orientation of Myrtle Creek as the three above-mentioned monitoring lines are located along the same stretch of Myrtle Creek.

Observed valley closure across the creek at the Skew Culvert has also slightly exceeded predictions, where the differences between predicted and observed closure are relatively small for most cross sections.

Redbank Creek

The ability to survey valley closure across the creek has been constrained by refusal by landowners to provide access. There is no access on the northern bank and limited access on the southern bank.

In light of the access constraints, ground surveys are being undertaken in relative 3D from Bridge Street to a new monitoring line that is located in cleared pasture land along the top of the valley. This will provide measurements of total valley closure. Some survey pegs have been installed along a fence line on the southern side to a point where surveyors can sight a survey peg on Bridge Street. Despite the best efforts of the survey team, the accuracy of the survey is challenged by the lack of cross lines across Redbank Creek. Baseline monitoring indicates that the valley closure measurements will be accurate to approximately 20 to 30 mm.

Figure 2.9 Location of survey marks across Redbank Creek

The development of valley closure across Redbank Creek during the mining of Longwall 26 is shown in Figure 2.10. The results indicate that valley closure has developed across Redbank Creek, particularly where the longwall face has passed directly beneath the creek.

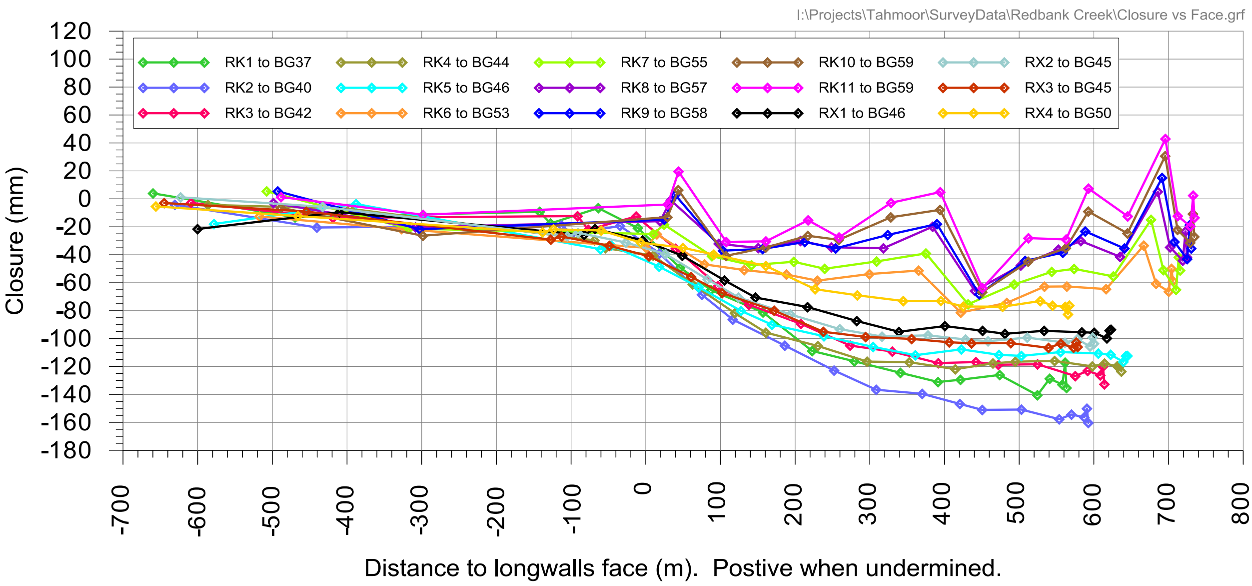

Figure 2.10 Observed development of closure across Redbank Creek

Maximum predicted valley closure due to extraction of Longwall 26 was 120 mm. As shown in Figure 2.10, observed valley closure was slightly greater than predicted closure at this stage of mining but much less than the predicted total closure of 500 mm due to the mining of Longwalls 22 to 30.

CHAPTER 3. POTENTIAL SUBSIDENCE IMPACTS

3.1. Myrtle and Redbank Creeks

Myrtle and Redbank Creeks will be directly mined beneath by Longwalls 27 to 30.

The catchment of Myrtle Creek within longwalls 27 to 30 active subsidence zone is developed for residential land use, as well as semi-rural residential development on the fringes of Tahmoor village. Agricultural land on the outskirts of the town is used for orchards, vegetable green houses, duck farms and turkey processing as well as limited cattle and horse grazing. Myrtle Creek, in the vicinity of Tahmoor, is generally in a poor state, with a high content of weeds and rubbish that has been dumped or washed into it, whilst outside the residential area the creek is generally in better condition. Some creek sections have been rehabilitated by local community or Landcare groups, such as near monitoring Site MYC1, which is upstream of Panel 22 (figure 4.3). The stream bed and banks of the creek are generally well vegetated, albeit mostly with weeds, and do not show significant erosion or bank instability (GeoTerra 2009).

The catchment of Redbank Creek within longwalls 27 to 30 active subsidence zone is developed for residential use, as well as semi-rural residential development on the fringes of Thirlmere. Agricultural land on the outskirts of the towns is used for orchards, vegetable green houses, as well as limited cattle and horse grazing. The creek in the vicinity of Thirlmere is generally in a poor state, with a high content of weeds and rubbish that has been dumped or washed into it, whilst the creek outside of the residential area is generally in better condition. Some creek sections have been rehabilitated by local community or Landcare groups, such as the Thirlmere Wetlands, upstream of Site RC1, as well as near monitoring Site RC3 near Remembrance Drive. The wetlands form an aquatic and riparian habitat for plants, animals and birds whilst improving runoff water quality. The stream bed and banks of the creek are generally well vegetated, and do not show significant erosion or bank instability (GeoTerra 2009).

Redbank Creek drains into Stonequarry Creek over the proposed Panel 34, which subsequently flows to the Nepean River approximately 3km downstream of the SMP area. The local residents have undertaken bed and bank restoration works at isolated locations over longwall 27. The creek does not exhibit significant bed and bank erosion, and is not significantly eroded due to the high vegetative and weed cover along the creek banks.

A summary of the maximum predicted values of cumulative subsidence, upsidence and closure anywhere along these creeks within the SMP Area, after the extraction of each of the proposed longwalls, is provided in Table 3.1.

Table 3.1 Maximum Predicted Cumulative Subsidence, Upsidence and Closure at Myrtle and Redbank Creeks Resulting from the Extraction of Longwalls 22 to 30

Drainage Line	Longwall	Maximum Predicted Cumulative Subsidence (mm)	Maximum Predicted Cumulative Upsidence (mm)	Maximum Predicted Cumulative Closure (mm)
Myrtle Creek	After LW26	1135	230	215
	After LW27	1215	265	280
	After LW28	1230	440	410
	After LW29	1230	540	475
	After LW30	1230	610	530
Redbank Creek	After LW26	820	175	165
	After LW27	1070	305	280
	After LW28	1140	420	390
	After LW29	1210	475	455
	After LW30	1225	510	500

The maximum predicted subsidence in the above table includes the predicted movements resulting from the extraction of Longwalls 22 to 26. The maximum predicted upsidence and closure movements in the above table 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 27 to 30, as well as Longwalls 22 to 26.

3.1.1. Change of Grade Affecting Pool Levels

No reversal of flow, increased levels of ponding or increased levels of scouring have been observed in Myrtle Creek during the mining of Longwalls 22 to 26. This is because the mining-induced tilts are significantly smaller than the natural creek gradients. A similar outcome is expected to occur along Myrtle and Redbank Creeks due to the mining of Longwalls 27 to 30.

The maximum predicted changes in grade along the alignments of both Myrtle and Redbank Creeks are 6 mm/m (i.e. 0.6 %).

The natural grade along the alignment of Myrtle Creek within the general SMP Area varies between a minimum of 10 mm/m and a maximum of 40 mm/m, with an average natural grade of 19 mm/m. The natural grade along the alignment of Redbank Creek within the general SMP Area varies between a minimum of 10 mm/m and a maximum of 70 mm/m, with an average natural grade of 27 mm/m.

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

Both creeks are ephemeral with a few standing pools and partially serve as drainage conduits for the urban and rural areas of Tahmoor/Thirlmere. As a result of the generally low flow it is assessed that the small changes in grade will have an insignificant effect on flow rates or aquatic habitat.

3.1.2. Raising Flood Levels Above Habitable Floor Levels as a Result of Gradient Change

Please refer to the findings of a separate flood study by Hughes Trueman (2009) regarding the potential for increased levels of flooding in Myrtle and Redbank Creeks. The study found that subsidence is not likely to result in any habitable floor levels of a house subsiding below the 100 year ARI flood level.

Slight mining-induced grade changes are predicted to occur as a result of mining.

3.1.3. Fracturing in Creek Beds

As described in Section 2.4, it can be seen that observed valley closure has substantially exceeded predictions at the Castlereagh Street crossing, at the crossing of the Elphin-Myrtle monitoring line and to a lesser extent the crossing of the Main Southern Railway during the mining of Longwall 25. Observed valley closure across the creek at the Skew Culvert has also slightly exceeded predictions, where the differences between predicted and observed closure are relatively small for most cross sections.

Overall, however, there has been no adverse effect on stream flow, water quality and bed or bank stability in Myrtle Creek or the small unnamed gullies over the subsided longwalls during the mining of Longwalls 22 to 26.

Subsidence within the creek has generated limited short term (<2 month) exposed sandstone stream bed cracking or isolated exposed sandstone through flow in four locations over Longwalls 22, 23B and 25, along with soil cracks in the upper banks and flanks over Longwall 23B. Three areas of isolated cracking of exposed sandstone were observed in the base or sides of generally dry pools above Longwall 25.

To date, outside of the isolated, limited and short term effects on pooled water in the exposed, cracked sandstone sites, no adverse effect on stream flow in Myrtle Creek has been observed, and no new springs have been generated, or reduced, during the mining of Longwalls 22 to 26. No observable adverse effects on stream water quality due to subsidence following extraction of Longwalls 22 to 26 have been observed in Myrtle Creek.

Pre-mining visual inspections have detected two existing cracks in a rockbar in Redbank Creek, which is located directly above Longwall 26. The crack does not appear to have affected water levels as water remains standing in a pool upstream of the rockbar.

It is possible that some fracturing may occur in the creek bed as a result of mining Longwalls 27 to 30.

Any fracturing that does occur is likely to be localised in nature. Some fractures may not be visible due to a thick covering of sediment and vegetation, whilst the sediment in the creeks could also fill mining-induced fractures that may occur and reduce the rate of any surface flow diversion.

3.1.4. Surface Water Flow Diversion Beyond Natural Levels

The potential for surface water flow diversion is discussed in Report No. MSEC355.

No surface water flow diversion has been observed by Tahmoor Colliery's inspectors in Myrtle Creek or Redbank Creek during the mining of Longwalls 22 to 26. By comparison, however, the sections of Myrtle and Redbank Creeks within the SMP Area are deeper and more incised compared to the section of Myrtle Creek above Longwalls 22 to 26 and the section of Redbank Creek above Longwall 26. As a result, the predicted maximum upsidence and closure movements are approximately double for Myrtle and Redbank Creeks during the mining of Longwalls 27 to 30 when compared to those provided for Myrtle Creek above Longwalls 22 to 26.

While no surface flow diversions have been confirmed from previous mining, major fracturing and sub-surface water flow diversion could occur in Myrtle and Redbank Creeks during the mining of Longwalls 27 to 30. Compressive strains due to closure are expected to be sufficient to potentially cause the underlying strata to dilate and buckle and induce cracking at the surface at some locations. This could potentially lead to the diversion of water from the creek beds into the dilated strata beneath it.

It is unlikely, however, that there would be any net loss of water from the catchment since any redirected flow would be expected to emerge further downstream. This statement is based on studies of water flows in large streams that have previously experienced mine subsidence movements and impacts in the Southern Coalfield (DoP, 2008).

If significant fracturing were to occur, it is possible that partial or complete loss of water may occur at some locations if the rate of flow diversion is greater than the rate of incoming surface water. In times of heavy rainfall, the majority of the runoff would flow over the beds of the creeks and would not be diverted into the dilated strata below the creek beds. In times of low flow, however, some or all of the water could be diverted into the strata below the creeks. This could temporarily affect the quantity and quality of the water flowing in the creeks.

Both Myrtle and Redbank Creeks contain a high nutrient and sediment load. The sediments in some sections of the creeks cover the sandstone bedrock and any fractures that occur are unlikely to be visible. The sediments in the creeks could also fill any mining-induced fractures that occur and reduce the rate of surface flow diversion.

Bedrock is exposed in some sections of the creeks and fractures may be visible in these locations. These include controlling rockbars at two pools that have been identified in Redbank Creek (Biosis, 2009b). Pool 1 in Redbank Creek is located directly above Longwall 29. It is possible that fracturing and surface water flow diversion may occur at this rockbar.

If it is found that the fractures in the creek beds do not seal naturally, some remedial measures may be required after subsidence at a particular location is completed. Remediation of fractured rockbars has been successfully undertaken at other streams in the Southern Coalfield (DoP, 2008).

As a surface diversion requires flow and an absence of the sealing effect of natural sediment load, the likelihood of surface diversion is considered unlikely. The consequence, if diversion were to occur, is assessed as essentially aesthetic, ephemeral to intermittent and limited to observers with access to the location and is therefore considered medium.

3.1.5. Creek Bed and Bank Erosion and Bed Load Movement

Cracking of creek beds and banks can create new surface water conduits thus subsidence may induce minor bed or bank erosion (Geoterra, 2009). As the creeks are well vegetated, no significant change is anticipated (Geoterra, 2009).

The potential for creek bed and bank erosion is considered to be unlikely.

If erosion occurs in the creek, it may cause a minor increase in potential bed load movement (Geoterra, 2009). If erosion and bed load movement occurs, remediation may be required.

3.1.6. Impacts on Stream Water Quality

There have been no adverse impacts on water quality in Myrtle Creek or Redbank Creek during the mining of Longwalls 22 to 26. Geoterra (2009) found that while no adverse impacts to water quality have been observed along Myrtle Creek, some impacts could occur during the mining of the proposed longwalls as the valleys become more incised within the SMP Area. If an adverse change in stream water quality occurs through development of an isolated new, or change to an existing ferruginous spring occurs, 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 discharging out of the SMP Area.

Cracking of sewer mains that are located near the creeks have the potential to contribute to existing sewage contamination from both septic leakage and livestock faecal contamination in both Myrtle and Redbank Creeks. This specific issue is addressed in Sydney Water - Sewer Management Plan.

The water quality in the creeks is highly variable and dependent on the amount of flow and therefore the consequence of impacts on water quality is assessed as minor.

3.2. Private Dams

To date, no dams that have been undermined by Longwalls 22 to 26 have shown any adverse effects on their water holding capacity, dam wall stability or water quality due to subsidence.

On the basis that the proposed mine plan and geomorphological characteristics of the proposed longwalls and the overlying dams are similar to previously undermined areas, it is not anticipated that adverse effects on dams due to undermining will be observed.

3.3. Groundwater Resources

There are 4 registered bores near or directly above Longwalls 27 to 30 and one bore located just outside the SMP Area. Four bores are registered water supply bores and one is a registered groundwater piezometer. All bores are used for domestic garden supply (Geoterra, 2009).

Vibrating wire piezometer arrays were installed in the exploration bores TNC28 and TNC29 as listed below;

- Open standpipe piezometers GW67570, 105254, 107918, 109010, 109224
- Vibrating wire piezometer arrays TNC 28, 29, 40, 43

A disused well is located near Structure W50a, which is located above the pillar between Longwalls 25 and 26 and its location is also shown in Figure 3.1.

Piezometers used for monitoring surface and groundwater within the SMP Area and the locations of these are shown in Figure 3.1. In addition, a number of exploration bores were installed by Tahmoor Colliery in the vicinity of the SMP Area that may also be affected by far-field movements, or change in water quality or supply. These bores are generally sealed from seam to surface after drilling is completed. Their locations are shown in Figure 3.1.

The potential for adverse impacts on groundwater and baseflow seeps as a result of mine subsidence is summarised in the following sections.

Where access is granted by the landowner, all relevant private bores and piezometers located within a 3km limit of mining in Longwall 27, then subsequently 28, 29 and 30 will be monitored, with locations of the groundwater monitoring suite shown in Figure 3.1 .

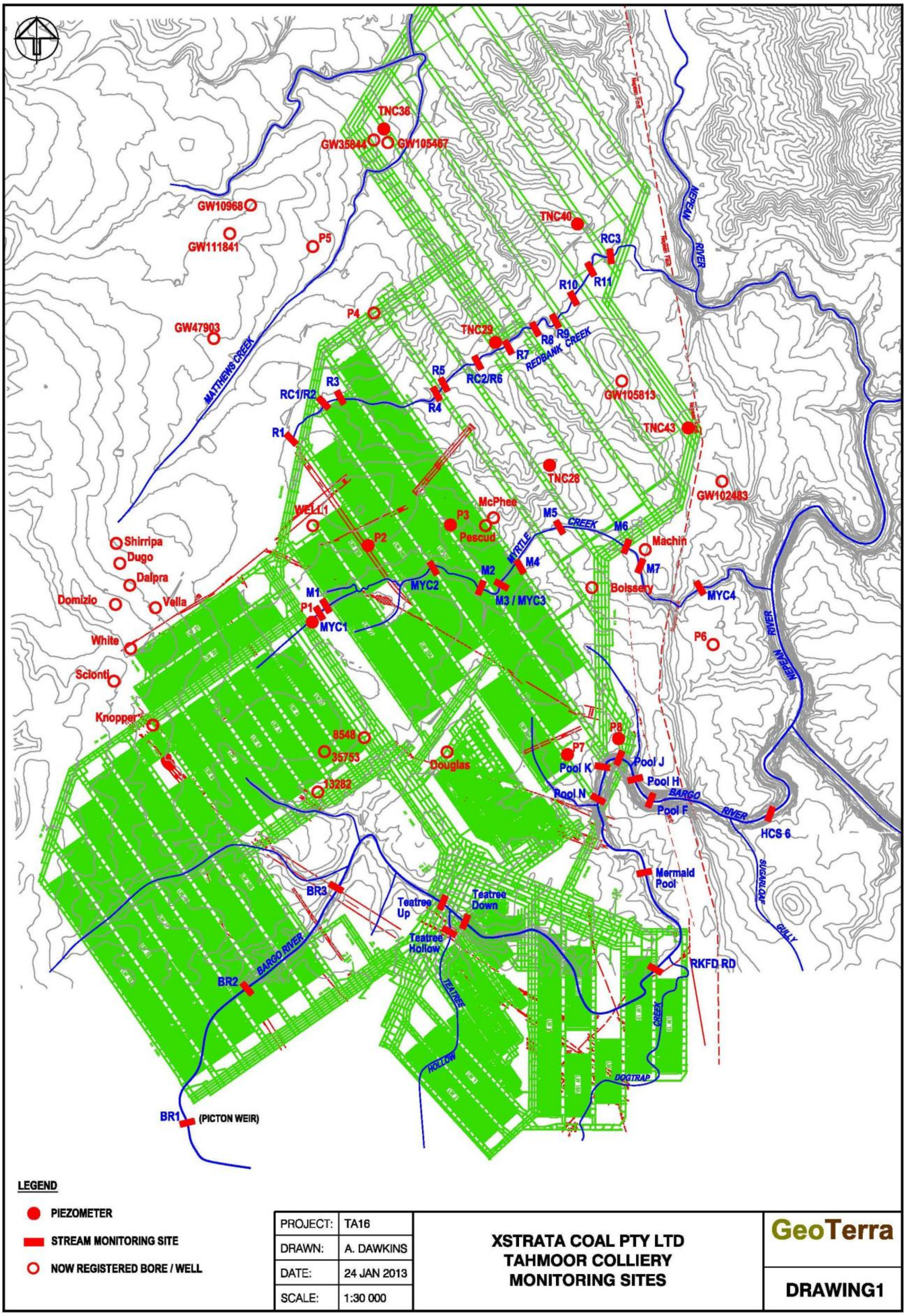

Figure 3.1 Location of Groundwater Bores

3.3.1. Groundwater Levels and Bore Yields > 20m Below Ground Level

In relation to aquifer / aquitard interconnection, from past experience in the Southern Coalfield, it has been assessed that hydraulic connection of surface water or alluvial groundwater systems is not likely at mining depths of cover greater than 150m (Geoterra, 2009).

A temporary lowering of the regional piezometric surface over the subsidence area due to horizontal dilation of strata may occur due to the increase in secondary porosity and permeability. This effect will be more 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 in the Southern Coalfields, 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 levels depends on the time required to develop maximum subsidence, the time for subsidence effects to migrate away from a location as mining advances to subsequent panels, and the length of time required to recharge the secondary voids (Geoterra, 2009).

3.3.2. Groundwater Quality

The 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 complaints regarding groundwater quality changes have been reported during the mining of Longwalls 22 to 26, though a complaint was received during the mining of Longwall 21. No adverse changes to groundwater quality of subsided bores or piezometers have been observed during the mining of Longwalls 22 to 26, along with no distinctive increase in dissolved iron.

Reduction in groundwater quality is assessed as likely.

3.3.3. Upland Spring Induction

Subsidence in upland areas can cause increased separation between bedding planes in Hawkesbury Sandstone as well as the interface between Wianamatta shale and Hawkesbury Sandstone lithologies. This can increase fracture and/or interface drainage of shallow groundwater which in turn can alter baseflow drainage to creeks. As a result, outflow from affected areas can appear as either more saline and / or more ferruginous seeps, whilst existing seepage outflows may be relocated down gradient in the stream channel.

Bacterial action in the interstitial spaces can cause enhanced iron/manganese concentrations in water that exits in these induced springs.

In addition the addition of nutrients to the shallow groundwater system may occur where sewage system leaks occur if pipes are broken.

Pre-existing ferruginous seeps have been observed in Redbank Creek over Longwall 27 (Site RC2) in an area that has not been undermined.

If an adverse change in stream water quality occurs through development of an isolated new, or change to an existing, ferruginous spring occurs, 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 discharging out of the SMP Area.

Previous observations across the Southern Coalfield indicate that water quality and water levels in subsided bores has not generally been affected by the process.

3.4. Flora & Fauna

3.4.1. Terrestrial Flora and Fauna

Biosis Research (2009) undertook a terrestrial flora and fauna impact assessment for potential subsidence impacts predicted for proposed longwall mining at Tahmoor Colliery, specifically Longwalls 27-30.

Four Endangered Ecological Communities (EECs) were recorded within the Study Area: Cumberland Plain Woodland, Shale Sandstone Transition Forest, River-flat Eucalypt Forest and Moist Shale Woodland. These communities are listed as EECs under the NSW *Threatened Species Conservation Act 1995* (TSC Act) and/or the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). The assessment concluded that the Mining of Longwalls 27-30 is unlikely to have a significant impact on any of these EEC's.

No threatened flora species were recorded in the Study Area; however the Study Area provides potential habitat for four threatened flora species that may potentially be impacted by subsidence: *Epacris purpurascens var. purpurascens, Persicaria elatior, Pomaderris brunnea* and *Pterostylis saxicola*. The Proposal has the potential to alter habitat for these species. The assessment concluded that the Proposal is unlikely to have a significant impact on any of these threatened plant species.

The Study Area contains limited potential habitat for a total of 31 threatened and/or migratory animal species. Three of these species Large-footed Myotis *Myotis macropus*, Spotted-tailed Quoll *Dasyurus maculates*, and Large-eared Pied-bat *Chalinolobus dwyeri* were considered to have potential habitat that may be impacted by subsidence. The assessment concluded that the Proposal is unlikely to have a significant impact on a local population of any of these threatened animal species.

3.4.2. Aquatic Ecology

Biosis Research (2009) provided an aquatic ecological assessment of Myrtle Creek in Tahmoor and Redbank Creek in Thirlmere. Sections of both of these creeks lie within the Subsidence Management Plan (SMP) area for proposed Longwalls 27 to 30 of Tahmoor Colliery, which is operated by Tahmoor Coal.

The aim of this report was to assess the current ecological conditions within sections of Myrtle and Redbank Creeks that were either within or nearby to the SMP Area for Longwalls 27 to 30. In order to do that, databases were searched for any endangered or threatened aquatic species or communities within the SMP area or its vicinity. Field surveys were also conducted so that existing habitat conditions could be described and aquatic ecosystem health could be assessed using the AUSRIVAS Rapid Assessment Method, which measures the diversity of macroinvertebrate communities.

Three threatened aquatic species were identified through database searches as potentially occurring in the vicinity of the Study Area, these were Macquarie Perch (*Macquaria australasica),* Sydney Hawk Dragonfly (*Austrocordulia leonardi)* and Adam's Emerald Dragonfly (*Archaeophya adamsi).* However habitat requirements for these species were not recorded with any aquatic habitats recorded within the Study Area. Therefore Species Impact Statements and/or Referrals to the Environment Minister were not recommended for any species.

3.4.3. Upland Spring Induction Affecting Habitat in the Immediate Vicinity of the Spring During Low Water Flow (<3ML/day)

Previous observations across the Southern Coalfield indicate that the potential for damage to habitat in close proximity to the spring under low flow conditions may be reasonably large. However, the impacts are limited to the immediate spring area and don't proceed down creek to any great distance. The existing goaf areas adjacent to the SMP area have not indicated a propensity for ferruginous spring induction.

3.5. Heritage Sites

3.5.1. Archaeological sites

Biosis (2009) undertook an Archaeological and Cultural Heritage Assessment of proposed Longwalls 27 to 30.

There are 6 Aboriginal archaeological sites within the Subsidence Management Plan (SMP) Area. The sites consist of shelters with artefacts/deposit (*n*=2); Potential Archaeological Deposit (*n*=1) and open sites with artefacts (*n*=3). A summary of these sites are provided in Table 3.2 below. Also Refer Figure 3.2.

Table 3.2 Aboriginal Archaeology Summary (Biosis 2009)

Site Number and Name	Site Type	Archaeological Significance	Potential For Impact	Recommendations
52-2-2078 Tahmoor 1	Shelter with Art and Deposit	Low	Very Low	• No further action necessary
52-2-3254 Redbank Creek 1	Shelter with Art and Deposit	Low	Moderate	• S90 Consent to Disturb from OEH • Develop a ACHMP which details monitoring by an archaeologist and Aboriginal Stakeholders
52-2-3363 Myrtle Creek PAD-1	Potential Archaeological Deposit	Low	Negligible	• No further action necessary
52-2-3664 Redbank Creek OCS-1	Open Camp Site	Low	Negligible	• No further action necessary
52-2-3665 Redbank Creek OCS-2	Open Camp Site	Low	Negligible	• No further action necessary
52-2-3667 IA-1	Isolated Artefact	Low	Negligible	• No further action necessary

Previous studies have shown that stone artefact sites in an open context are not affected by subsidence movements, so there will be no impact to the four open sites from the proposed mining of longwalls in the SMP Area.

Sandstone shelter sites, with art or deposit, have been demonstrated to be susceptible to damage from subsidence movements. If a shelter is situated directly over a longwall or pillar, then there is a greater risk of impact, as these areas are subject to the greatest subsidence movements. There are two sandstone shelter sites located directly over longwalls in the Tahmoor Colliery Longwalls 27 to 30 SMP Area. There is a risk of impact to these shelters, either through cracking of rock surfaces, sheering or movement on bedding planes and joints, or block fall.

Generally large shelters are more likely to be affected by subsidence movements, as these are naturally more unstable. Monitoring programs have shown that only shelters with internal volumes of greater than $50m^3$, situated directly over a longwall, have suffered impacts from subsidence related movements. Total collapse of archaeological shelter sites has not been observed during previous monitoring programs of subsidence impacts. Of the two shelter sites directly above the longwall layout, one has a volume greater than $50m^3$, putting it in the higher risk category. However, other natural processes and features that destabilise sandstone overhangs include block fall, exfoliation, cracking and associated changes in water seepage. Neither of the shelter with art and/or deposit sites exhibits such features or natural process, decreasing the likelihood of impact from subsidence movements.

These observations, in conjunction with the subsidence predictions provided by MSEC, suggest there is moderate potential for subsidence movements to impact on shelter with art site Redbank Creek 1 (52-2-3254) and very low potential for impacts to Tahmoor 1 (52-2-2078).

Based on the subsidence predictions provided by MSEC (2009), it is unlikely that there will be impacts to known open archaeological sites resulting from the proposed longwall mining. However, based on the size and nature of the overhang at archaeological site Redbank Creek 1 (52-2-3254), this site could potentially be affected by subsidence movements.

3.5.2. Historic Heritage

Biosis (2009) identified nine heritage items in the SMP Area. Based on the subsidence predictions and recommendations provided by MSEC, five of the nine identified historical heritage items are at very low risk of impact from the proposed mining. Refer Figure 3.2.

There is a higher risk of impact to three of the items, namely 10 Hilton Park Road, Tahmoor; 55-59 Remembrance Drive, Tahmoor; and Tahmoor House, 27 Remembrance Drive, Tahmoor. The nature of the risk to the final item, Myrtle Creek Bridge, requires that preventative works be undertaken before the commencement of the mining with the potential to cause the impact. Table 3.3 provides a summary of the relevant items, their significance, potential impact and recommendations. Further details are available in Biosis (2009).

Table 3.3 Summary table of Historical Archaeological Recommendations (Biosis 2009)

Site Name	Structure Type	Heritage Significance	Potential Impact	Recommendations
Koorana group	Built, garden, relics	Local	Low	• Wollondilly Shire Council should be consulted prior to the commencement of the mining. • Condition of the standing structures within the Study Area be assessed and recorded by a structural engineer prior to the commencement of mining.
Myrtle Creek Bridge	Built	Local	High	• Wollondilly Shire Council should be consulted prior to the commencement of the mining. • Condition of the standing structures within the Study Area be assessed and recorded by structural engineer prior to the commencement of mining. • The condition of the structures should then be monitored over the course of the period during which subsidence is likely to occur. • Mitigation measures be designed to minimise the chance of impact on the Bridge. These measures should be designed by a structural engineer in conjunction with a heritage consultant, in order to minimise the heritage impact of the work. • A Statement of Heritage Impact should be prepared and submitted to Wollondilly Shire Council together with the application to carry out the mitigation measures. • The mitigation measures should be carried out prior to the period in which subsidence has the potential to impact upon the Bridge.

Site Name	Structure Type	Heritage Significance	Potential Impact	Recommendations
Tahmoor House	Built, garden, relics	State	High	• Wollondilly Shire Council should be consulted prior to the commencement of the mining. • Condition of the standing structures within the Study Area be assessed and recorded by structural engineer prior to the commencement of mining. • That a preliminary plan of management be developed for the property. This should be produced by a structural engineer in conjunction with a heritage consultant.
Queen Victoria Gardens	Built, garden, relics	State	Low	• Wollondilly Shire Council should be consulted prior to the commencement of the mining.
Mill Hill	Built, relics	Local	Low	• Should Wollondilly LEP 2009 come into force during the course of the proposed work, this item should be added to the consultation and plan of management. • Condition of the standing structures within the Study Area be assessed and recorded by structural engineer prior to the commencement of mining.
Cottage, 55-59 Remembrance Drive	Built, garden, relics	Local	Moderate	• Wollondilly Shire Council should be consulted prior to the commencement of the mining. • Condition of the standing structures within the Study Area be assessed and recorded by structural engineer prior to the commencement of mining.
220 Bridge Street	Relics	State	Low	• Condition of the standing structures within the Study Area be assessed and recorded by structural engineer prior to the commencement of mining.
2425 Remembrance Drive	Built, moveable	Local	Low	• Condition of the standing structures within the Study Area be assessed and recorded by structural engineer prior to the commencement of mining.
10 Hilton Park Road	Built, garden	Local	Moderate	• Condition of the standing structures within the Study Area be assessed and recorded by structural engineer prior to the commencement of mining. • The structures should then be monitored when subsidence is likely to occur.

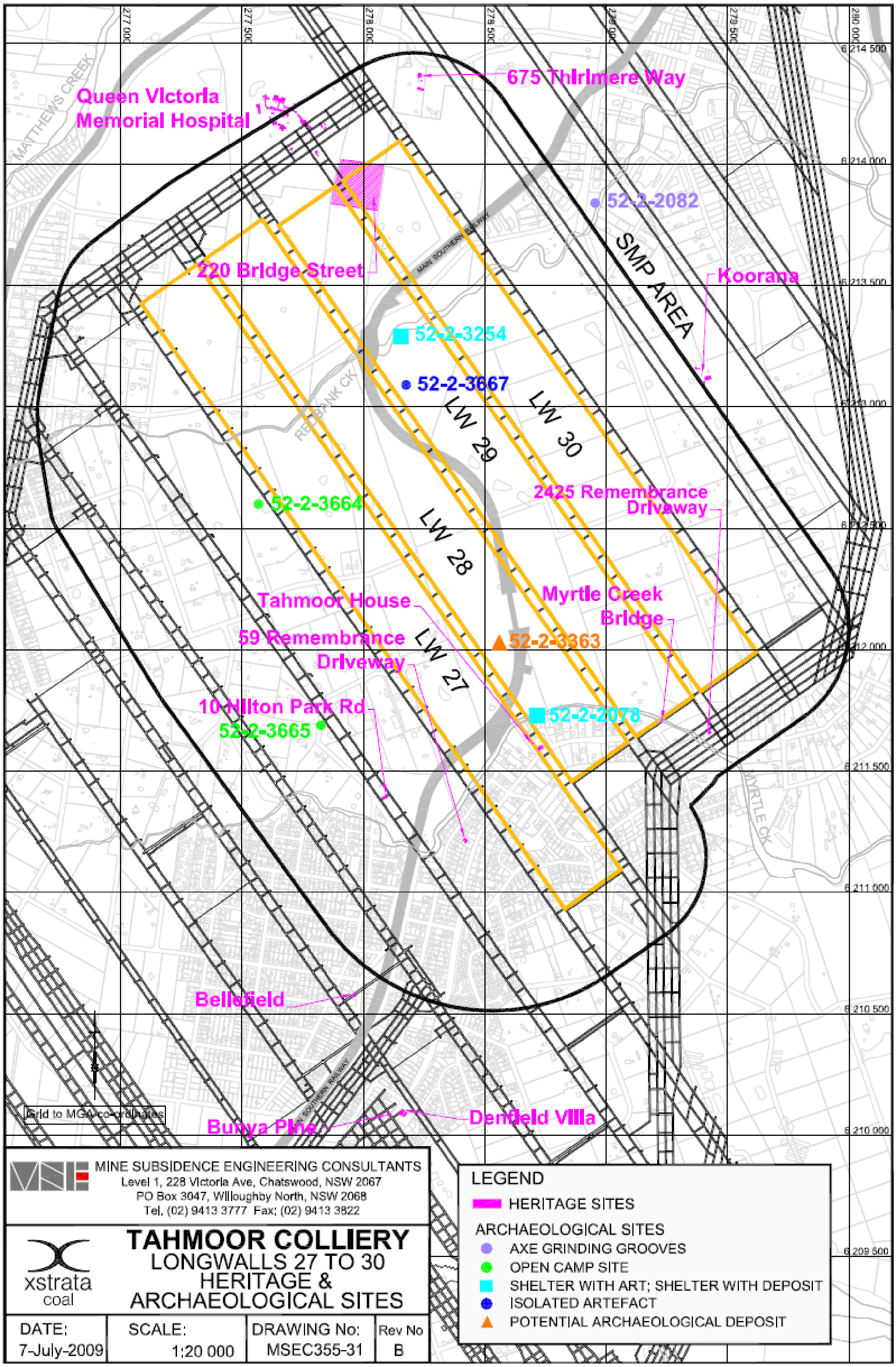

Figure. 3.2 Heritage and Archaeological Sites

3.6. Geomorphology

3.6.1. Rock Bars

Both Myrtle and 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.

Detailed pre subsidence stream bed mapping, photography, water quality characterisation and, subsequently, regular monitoring of these parameters in both creeks during and after undermining has been conducted over Longwalls 25, 26 and 27 and part of Longwall 28 to monitor for any subsidence induced changes in the creek bed/s.

The integrity of rock bars and their pool holding capacity monitored during extraction of Longwalls 22 to 26 has indicated that some exposed sandstone rock bars have been cracked through subsidence effects, and that in the small rock bar constrained pools affected by cracking, their water holding capacity has been reduced. However, all affected pools have been small and were naturally ephemeral, prior to undermining.

Post mining, the pools dried out at a quicker rate, however the stream flow connectivity and water quality has not been observably adversely affected.

On the basis of previous observations, and on the basis that the proposed longwalls have similar mine layout and geomorphological relationships to the creek beds as previous longwalls, it is anticipated that further, downstream, rock bars may be cracked and their pool holding capacities and longevity may be reduced, particularly as the creek is moving into a more incised channels, particularly in Redbank Creek.

3.6.2. Cliffs

The locations of cliffs directly above Longwalls 27 to 30 are shown in Figure. 3.3.

Given that the Longwall 29 will mine directly beneath the cliffs, it is possible that rockfalls could occur. Studies of mining directly beneath cliffs located along the Nepean, Cataract and Bargo Rivers, suggests that the probability of impact is between 2% and 5% of the cliff line located directly above the extracted longwalls. The cliffs on Redbank Creek are substantially smaller in height (10 to 15 metres) than those along the above-mentioned rivers.

The cliffs are located on privately owned land that is thick with vegetation. The probability that a person or persons would be present if and when a rockfall occurred is considered to be extremely low.

Tahmoor Colliery will manage the potential consequences of rockfalls at the cliffs during mining by consulting the landowner to not walk in the vicinity of the cliffs. Signage will also be erected downstream of the railway culvert warning of the potential of cliff fall prior to the influence of Longwall 28. Visual inspections will also be undertaken from a safe vantage point before and after the completion of Longwalls 28 to 30.

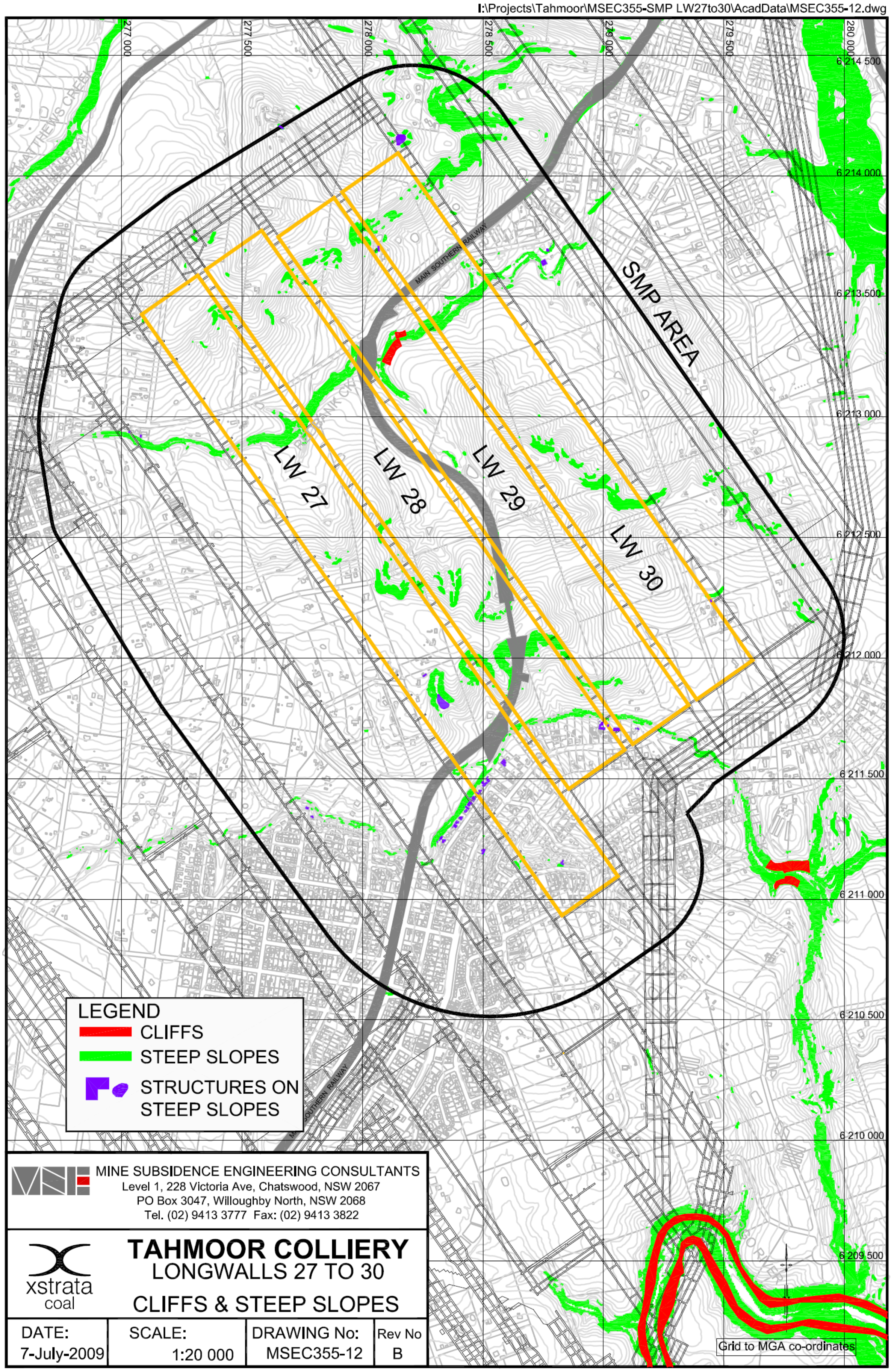

Figure. 3.3 Location of Cliffs

CHAPTER 4. MONITORING

4.1. Streams

4.1.1. Myrtle Creek Subsidence Survey

The Castlereagh – Myrtle survey line will be surveyed weekly within active subsidence zone commencing after 600m of extraction of longwall 27.

The York Street survey line will be surveyed weekly within the active subsidence zone commencing after 500m of extraction of longwall 27.

Two new survey lines will be installed across Myrtle Creek near centreline of LW27 and maingate of LW27 (subject to completion of rail deviation) with baseline surveys prior to start of longwall 27 impacts. Surveys will then be weekly within active subsidence zone and commence after 550m of extraction of longwall 27.

4.1.2. Redbank Creek Subsidence Survey

The survey network on either side of Redbank Creek has been extended for Longwall 27 as shown in Drawing No. MSEC567-00-03 and will be further extended as required for Longwalls 28 to 30 in consultation with and final approval by DRE.

Baseline monitoring indicates that the valley closure measurements will be accurate to approximately 20 to 30 mm.

The revised strategy is to monitor valley closure over long bay lengths using absolute and relative 3D survey techniques. A survey line has been installed with pegs spaced approximately every 50 metres along the southern side of the valley, where the land has already been cleared. Valley closure can be calculated from changes in horizontal distance between these pegs and those located every 20 metres along Bridge Street.

A partial cross line has been installed above Longwall 26 along a fence line, where surveyors have found a clear line of sight to Bridge Street from the southern bank. A complete cross line has also been installed within the rail corridor and at three other locations downstream of the railway crossing. These cross line will provide information on the distribution of valley closure across Redbank Creek plus enable the surveyors to connect between the two main monitoring lines.

A 3D baseline survey has been undertaken in absolute coordinates and a final end of panel survey will also be undertaken in absolute coordinates. A local, relative 3D survey will be undertaken on a weekly basis for pegs located directly above Longwall 27.

4.1.3. Visual Inspection

Factors to be monitored in both creeks includes;

- Stream flow and connectivity
- Pool longevity and levels
- Rock bar and exposed sandstone creek bed integrity / cracking
- Field pH, EC, DO, oC and Eh
- Laboratory water quality analysis (as required)
- Spring / seep generation, relocation or modification
- Presence / alteration of ferruginous precipitation
- Bed and bank stability

4.7.2.1 Myrtle Creek

Weekly visual inspections will be undertaken along Myrtle Creek and on the steep slopes in the backyard of properties in York Street adjacent to Myrtle Creek during the extraction of longwalls 27 to 30 while in the active subsidence zone. Visual inspections can be compared to detailed photographic surveys of Myrtle Creek that were taken prior to mining.

4.7.2.2 Redbank Creek

Weekly visual inspections will be undertaken along Redbank Creek during the mining of longwalls 27 to 30 during the active subsidence zone.

4.1.4. Stream Water Level Monitoring

Water level monitoring is undertaken monthly at identified pools in Myrtle and Redbank Creeks (figure 4.3). 11 stream depth monitoring sites using pressure transducers and loggers were instigated by Hydrometric Consulting Systems (HCS) in Redbank Creek during March 2010 and 7 in Myrtle Creek during June 2010.

Baseline water level monitoring data for Myrtle and Redbank Creeks has been collected in excess of 2 years prior to longwall 27 active subsidence zone at both Myrtle and Redbank Creeks. Water level monitoring is not determined by longwall position.

Data is recorded continuously, collected monthly, and is ongoing. It is reported in Tahmoor Colliery End of Panel (EoP) Reports.

4.1.5. Stream Water Quality Monitoring

Water quality monitoring is undertaken in both Myrtle and Redbank Creeks (fig 4.3). Water quality monitoring in Myrtle Creek started in December 2004 and began in Redbank Creek in April 2005.

No surface water extraction licences are registered with the NOW in streams over longwalls 27 to 30.

Water quality monitoring is not determined by longwall position. Water quality data is collected monthly at Myrtle and Redbank Creek monitoring sites (fig 4.3), is ongoing and is reported in Tahmoor Colliery EoP Reports.

4.2. Dam Monitoring

Based on the observation that no dams have been adversely affected by previous subsidence over Longwalls 22 to 26, it is proposed that only dams directly overlying a subject panel will be monitored for the following parameters both prior to and after undermining by a longwall;

- Dam wall stability / erosion / cracking
- Water level and water holding capacity

The dams will be monitored through a photographic record before and after undermining, as well as through correspondence with landholders, who are anticipated tom advise the mine if they assess any adverse effects have been imposed on their dam/s due to subsidence.

As no water quality effects have been observed, or are anticipated, and as all dam water quality monitored to date has been significantly affected by sewage and animal waste runoff, it is not proposed to conduct water quality monitoring of the subject dams.

Dams to be monitored only include those that directly overly an actively subsided longwall or associated chain pillars. Dams outside of the active longwall and associated chain pillar do not require monitoring at locations shown in Figure. 3.3.

Dams to be monitored include;

- Longwall 27 W23c,d,e, 24d, 37b, 40/1i,j, 42d, 55c,d, V02i, V02/1e, f and V031d
- Longwall 28 W37a,c, 40/1i,j, 55c and V02/2f
- Longwall 29 GG04, 08a,b,c
- Longwall 30 GG04a, 05g, and V11a, c, e, f, g

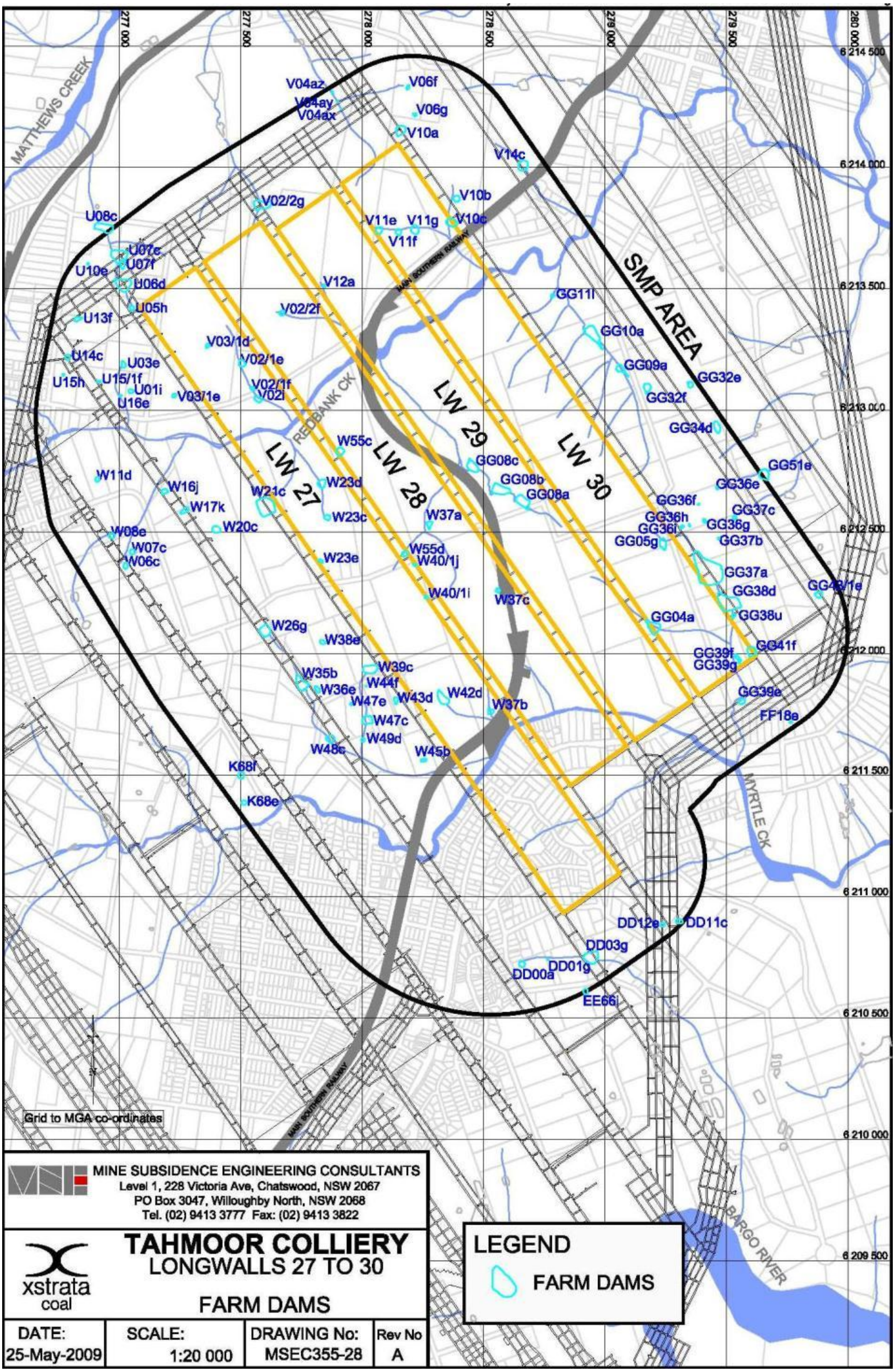
MATTHEWS CREEK
SMP AREA
LW 27
LW 28
LW 29
LW 30
REDBANK CK
MYRTLE CK
BARGO RIVER
MAIN SOUTHERN RAILWAY
277 000
277 500
278 000
278 500
279 000
279 500
280 000
6 214 500
6 214 000
6 213 500
6 213 000
6 212 500
6 212 000
6 211 500
6 211 000
6 210 500
6 210 000
6 209 500
V04az
V04ay
V04ax
V06f
V06g
V10a
V14c
V10b
V10c
V02/2g
V11e
V11g
V11f
U08c
U07e
U07f
U10e
U06d
U05h
U13f
V12a
V02/2f
GG11l
GG10a
V03/1d
V02/1e
U14c
U03e
U15h
U15/1f
U01i
U16e
V03/1e
V02/1f
V02i
GG09a
GG32e
GG32f
GG34d
W55c
GG08c
GG51e
W11d
W16j
W17k
W21c
W23d
GG08b
GG08a
GG36e
GG36f
GG37c
W23c
W37a
GG36h
GG36i
GG36g
W08e
W20c
GG05g
GG37b
W07c
W06c
W55d
W40/1j
W23e
GG37a
GG38d
GG40/1e
W40/1i
W37c
GG38u
GG04a
W26g
W38e
GG41f
GG39f
GG39g
W35b
W39c
W36e
W44f
W43d
W42d
W47e
W37b
GG39e
FF18e
W47c
W49d
W48c
W45b
K68f
K68e
DD12e
DD11c
DD03g
DD00a
DD01g
EE66i
Grid to MGA co-ordinates
MINE SUBSIDENCE ENGINEERING CONSULTANTS
Level 1, 228 Victoria Ave, Chatswood, NSW 2067
PO Box 3047, Willoughby North, NSW 2068
Tel. (02) 9413 3777 Fax: (02) 9413 3822
xstrata coal
TAHMOOR COLLIERY
LONGWALLS 27 TO 30
FARM DAMS
LEGEND
FARM DAMS
DATE: 25-May-2009
SCALE: 1:20 000
DRAWING No: MSEC355-28
Rev No A

Figure. 4.1   Location of Dams

4.3. Groundwater Monitoring

4.3.1. Groundwater Level and Water Quality

All groundwater monitoring will be consistent with the Murray Darling Basin Authority's "*Groundwater Quality Guideline*" and the "*Groundwater Sampling and Analysis Field Guideline*".

Piezometric water levels and water quality will be tested in the private groundwater bores and Xstrata piezometers listed in Table 4.2 and shown in Figure. 3.3.

Monitoring data is acquired from the vibrating wire piezometers and reported in Tahmoor Colliery EoP Reports.

Data during the extraction of the current longwall will be reported in the subsequent EoP Report which will summarise all monitoring over that period. The report will outline any changes in the surface water or groundwater system in the mined areas. All results will be reviewed at the end of each longwall.

4.3.2. Mine Water Monitoring

Tahmoor Colliery has continuous water monitoring and data recording for all potable and recycled water delivered into, and for all process, waste and ground water pumped from, the underground mine workings.

Monitoring of this water flow allows Tahmoor to maintain an overall mine water balance, and to monitor and analyse any short term changes and long term trends in water flows as mining progresses.

4.3.3. Groundwater Modelling

To date, a groundwater model has not been prepared for Tahmoor North.

However, Dr Noel Merrick, consulting hydro geologist from Heritage Computing, is currently developing a comprehensive groundwater model for the Bargo-Tahmoor-Tahmoor North region. This model is being constructed and calibrated utilising comprehensive water monitoring data collected from multi-level piezometers progressively being installed and continuously monitored through this region. The piezometer installations will be completed by the end of 2013, after which the model can be finalised.

This model will comply with the National Water Commission's "Australian Groundwater Modelling Guidelines".

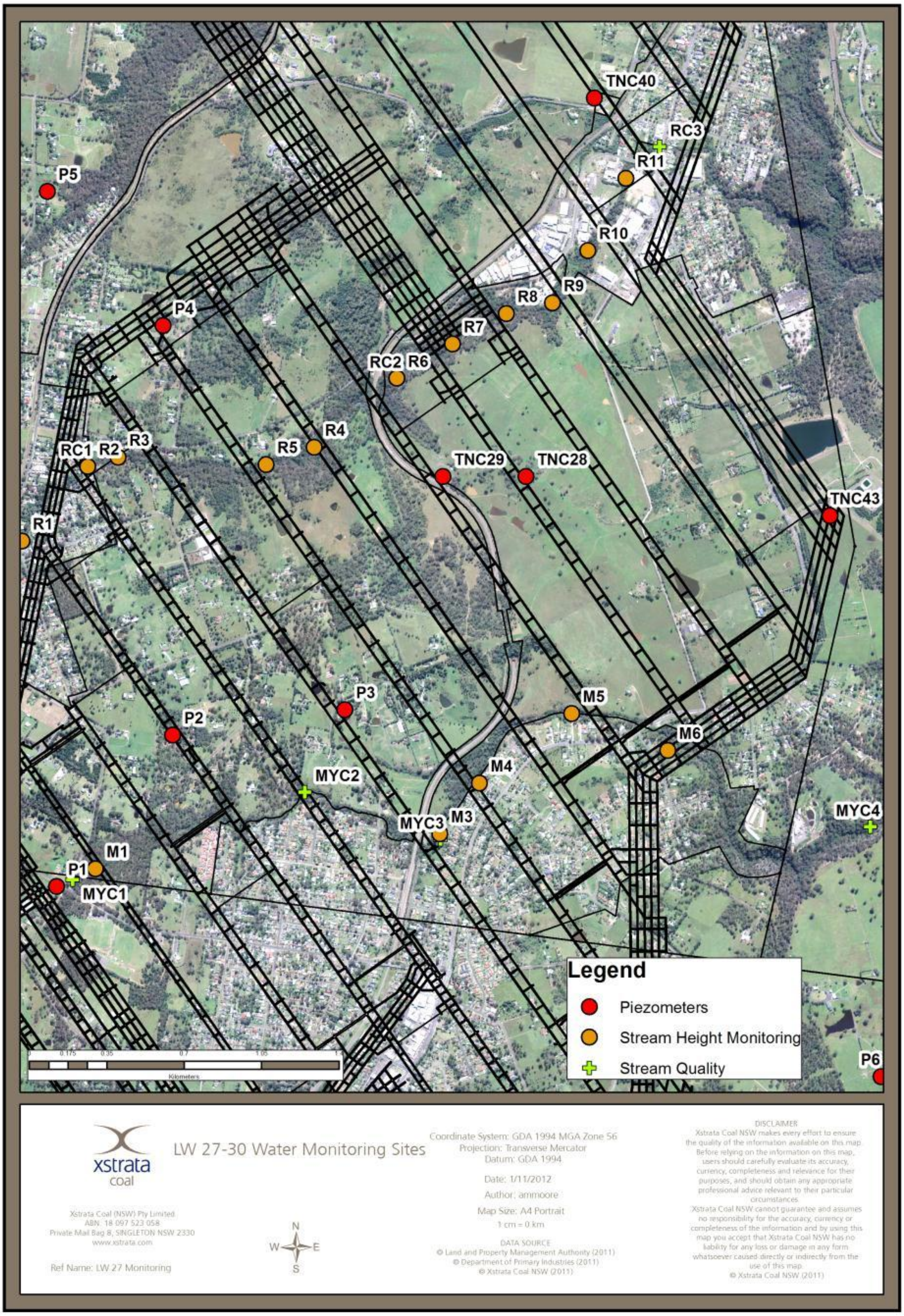

Figure 4.3 Tahmoor Colliery Stream and Bore Monitoring Sites

4.4. Flora and Fauna Monitoring

No terrestrial or aquatic threatened species were identified in field surveys undertaken by Biosis (2009). Impact assessments concluded that mining Longwalls 27-30 would not have a significant impact on any threatened species or Endangered Ecological Community (EEC). Therefore no formalised monitoring is proposed.

Aquatic and riparian habitat monitoring will be conducted as part of the stream visual inspections outlined in Section 4.1.3. Further Flora and Fauna monitoring may be triggered if impacts are identified by this and the other standard visual inspections that occur in the subsidence zone (e.g. if patches of unexplained vegetation die- off occur for example).

4.5. Heritage Monitoring

4.5.1. Aboriginal Archaeological Monitoring

A section 90 application will be sought from OEH for Aboriginal archaeological site Redbank Creek 1 (52-2-3254). To facilitate this, an Aboriginal Cultural Heritage Management Plan (ACHMP) will be developed. This will outline the management of Redbank Creek 1 (52-2-3254).

A program of archaeological monitoring will be designed and implemented for the site. The program will aim to replicate and where possible develop the recording methods and action triggers already established by Sefton (2000). A program of archaeological monitoring will be designed and implemented for the other sites potentially affected by subsidence movements, where appropriate.

This ACHMP will describe Aboriginal community consultation and involvement of registered stakeholder groups.

4.5.2. Historical Heritage Monitoring

Council consultation

Wollondilly Shire Council will be consulted, prior to the commencement of impacts from the mining of Longwalls 27 to 30, with regard to the heritage items identified in *Wollondilly LEP 2011* and therefore protected by that Plan, and the additional one item identified in the *Wollondilly Heritage Study*;

- Koorana group, Lot 2 DP 207443, Remembrance Drive, Picton;
- Myrtle Creek bridge, adjoining Remembrance Drive, Tahmoor;
- Tahmoor House, Lot 12 DP 10669, Remembrance Drive, Tahmoor;
- Queen Victoria Gardens, Lot 3 DP 264150, Thirlmere Way, Thirlmere; and
- Cottage, 55-59 Remembrance Drive, Tahmoor (Lots 141 & 142 DP 864238).
- Mill Hill, Miller's House and archaeological relics, 675 Thirlmere Way, Picton (Lot 31 DP 867897).

The consultation should result in the production of a plan of management for these items, to allow any necessary emergency stabilisation work to be carried out.

Heritage Items with Low Potential of Impact

The mining of Longwalls 27 to 30 is predicted to have a negligible to low chance of impacting the following five items of historical heritage significance:

- Mill Hill, Miller's House and archaeological relics, 675 Thirlmere Way, Picton (Lot 31 DP 867897);
- Queen Victoria Gardens, 615 Thirlmere Way, Thirlmere (Lot 32 DP1022462);
- 220 Bridge Street, Thirlmere (Lot 31 DP 1022462);
- 2425 Remembrance Drive, Tahmoor (Lot 29 DP 658453); and
- Koorana, 2240 Remembrance Drive, Picton (Lot 2 DP 207443).

The condition of the standing structures within the Study Area will be assessed and recorded by a structural engineer prior to the commencement of impacts from mining.

The owners and occupants of the properties will be informed of the commencement of mining with the potential to affect the relevant area, and requested to report any impact immediately.

Any impact will be assessed by a structural engineer and a heritage consultant, and measures put in place to stabilise the affected item and retain the heritage significance.

Any such work will require the submission of a Statement of Heritage Impact to Wollondilly Shire Council in the case of Queen Victoria Gardens (formerly Queen Victoria Memorial Hospital) and Koorana. Should the work be likely to impact archaeological relics, an Excavation Permit or Exception Notification from the Heritage Branch of the Department of Planning will be required.

Consultation with the RSL Lifecare will also be undertaken with regard to any work proposed for the Queen Victoria Gardens.

Heritage Items with Increased Potential of Impact

The proposed mining has an increased chance of impacting the following four items of historical heritage significance:

- 10 Hilton Park Road, Tahmoor;
- Cottage, 55-59 Remembrance Drive, Tahmoor;
- Tahmoor House, 27 Remembrance Drive, Tahmoor; and
- Myrtle Creek Bridge.

Separate Plans of Management are being developed by Tahmoor Colliery for these items.

Condition of the standing structures will be assessed and recorded by a structural engineer prior to the commencement of mining. This assessment and monitoring will allow management measures to be put in place should unexpected impact occur.

Tahmoor House

Due to the high level of significance of Tahmoor House, and the higher risk of impact should the area of increased subsidence continue into the Study Area, a preliminary plan of management is being developed for the property by a structural engineer in conjunction with a heritage consultant, and is addressing the potential structural and heritage impacts.

Myrtle Creek Bridge

Mitigation measures will be designed to minimise the potential impacts on the Bridge. These measures will be designed by a structural engineer in conjunction with a heritage consultant, in order to minimise the heritage impact of the work. A Statement of Heritage Impact will be prepared and submitted to Wollondilly Shire Council together with the application to carry out the mitigation measures. The mitigation measures should be carried out prior to the period in which subsidence has the potential to impact upon the Bridge. The MSEC355 report (2009), notes the works should be carried out prior to the mining of Longwall 29.

Any impact will be assessed by a structural engineer and a heritage consultant, and measures put in place to stabilise the affected item and retain the heritage significance. Any such work will require the submission of a Statement of Heritage Impact to Wollondilly Shire Council. Should the work be likely to impact archaeological relics, an Excavation Permit or Exception Notification from the Heritage Branch of the Department of Planning will be required.

4.6. Geomorphology Monitoring

4.6.1. Rock Bars

Rock Bars are to be monitored as detailed in Section 4.1.

4.6.2. Cliff Lines

The only cliffs present in the SMP area are located over Longwall 29

Observation, photographing and documentation of an actively undermined cliff area will be conducted prior to, during and after mining to assess if any rock falls or potentially unstable rock faces have developed due to subsidence that may require remediation.

CHAPTER 5. SURFACE AND GROUNDWATER RESPONSE PLAN

5.1. Trigger Action Response Plan

The Trigger Action Response Plan (TARP), as presented in Appendix A, has been designed to illustrate how the various predicted or potential subsidence impacts, monitoring components, performance measures, and responsibilities are structured to achieve compliance with the relevant statutory requirements, and the framework for management and contingency actions.

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.

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 framework for the various components of this EMP illustrate how the various predicted subsidence impacts, monitoring components, performance measures and responsibilities are structured to achieve compliance with the relevant statutory requirements, along with the framework for management and contingency actions.

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

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 Principal TARPs represent actions to be taken where a defined trigger is exceeded and requires corrective management in consultation with stakeholders to manage an observed impact in accordance with relevant approvals.

Monitoring of environmental aspects provide the key data to determine if there is a requirement for mitigation or rehabilitation.

Specialist investigations and reports may include:

- analysis of trends;
- assessment of any impacts against predictions;
- assessing the cause of any change or impact;
- assessing options for management and mitigation;
- assessment for the need for contingent measures;
- providing recommended changes to this plan, and;
- stakeholder consultation.

The TARP will be reviewed and any improvement opportunities will be proposed within each End of Panel report.

Management actions will be implemented if a subsidence impact exceeding the predictions has been identified. Some measures, such as grouting, would be implemented following the completion of the majority of subsidence movements in that area.

5.2. Trigger Levels

The proposed triggers are based on baseline monitoring and anticipated subsidence effects as shown in Appendix A, with monitoring changes and / or specific triggers continuing to be developed as monitoring matures and refined in consultation with key stakeholders and subject to approval by the relevant departments.

Where a trigger is exceeded, the cause and effect should be investigated and a management plan developed if the cause is directly related to mining. The use of soft engineering works will be considered in consultation with the relevant agencies.

Refined triggers will be proposed, where required, within End of Panel or Annual Environmental Management Reports (AEMR).

5.3. Response to TARP Criteria Exceedences

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

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

- 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 appropriate approvals from government agencies, and;
- providing a cnsultation 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.

5.4. General Contingency Issues

Subsidence rehabilitation programs have successfully been implemented by BHPBilliton – Illawarra Coal (BHPBIC) and Metropolitan Coal in the Georges River and Waratah Rivulet, where rehabilitation focused on grouting mining induced fractures and strata dilation to reinstate the water holding capacity of the bedrock using poly urethane resin (PUR) and other grout materials (BHPBIC, 2010).

In these cases, systematic and/or valley related movements resulted in the fracturing and dilation of underlying stream strata above the extraction area and generated localised diversion of flow or pool leakage.

Injection grouting was used in the Georges River to successfully rehabilitate a river reach undermined by West Cliff Colliery. Where pool bases and controlling rockbars were rehabilitated using this method continuity of flow was achieved (BHPBIC, 2010).

Xstrata will actively consult with its colleagues in the Southern Coalfield in relation to these new and emerging technologies.

Should rehabilitation be necessary, the best option will be identified and, with approval, will be implemented.

The management program provides a basis for the design and implementation of any mitigation and remediation, whilst monitoring of the area's environmental aspects will provide key data when determining any requirement for mitigation or rehabilitation.

In the event that the observed parameters or impacts exceed or are considered likely to exceed the performance measures detailed in the TARP, Xstrata will implement the following Contingency Plan:

- The observation will be reported to the Environment and Community Manager or representative within 24 hours.
- The observation will be recorded.
- Xstrata will report any exceedence of the performance measure immediately to the DRE and other relevant stakeholders.
- Xstrata will assess the exceedences referred to in the relevant TARP and where appropriate, implement the measures in accordance with the appropriate Management Plan/s.
- The Environment and Community Manager will investigate any potential contributing factors and identify an appropriate action plan to manage the identified impact(s), in consultation with specialists and/or relevant agencies if necessary.
- Xstrata will identify an appropriate action plan to manage the identified impact(s), in consultation with other specialists and/or key stakeholders.
- Xstrata will submit the proposed course of action to the DRE for approval.
- Xstrata will implement the approved course of action to the satisfaction of the DRE.
- Xstrata will continue to monitor performance with the new action plan in place and, if successful will formalise these actions as part of a revised Management Plan.

Contingency measures will be developed in consideration of the specific circumstances of the issue and the assessment of consequences as outlined below.

5.5. Stream Mitigation and Remediation

The aims of the stream mitigation and remediation measures include:

- conducting remediation works that protect to the greatest practicable extent the ecological values of the area;
- repairing aesthetic values where necessary;
- reducing the interaction of surface and groundwater flow where enhanced through mining;
- having creeks and pools function in a similar manner to the pre-impact state;
- having surface flows and pool water quality continue to provide suitable aquatic habitat;
- re-establishing the ecological values to a similar state to before mining;
- creeks and catchments yielding similar water quantity and quality following mining, and;
- monitoring and reporting effectiveness of the program.

Examples of potential corrective management actions are discussed below.

5.5.1. Natural Stream Remediation

Subsidence cracks in stream beds can seal through natural erosion and deposition.

The sediment nature, dynamics and flow permanence in a stream will determine the rate and degree of sealing, and in some circumstances, the natural process may be insufficient to protect the stream and anthropogenic rehabilitation may be required.

5.5.2. Hand Mortaring

Where stream flow transfer is observed through joints or fractures, they can be sealed using a variety of products, some of which can be applied in wet conditions or under water and are normally applied using small held-held equipment in localised situations.

Should large fractures occur in the base of a pool, they can be sealed with hand placed cement grout and natural oxides, such as occurred at "Marhnyes Hole" near Appin over West Cliff Colliery, prior to pattern grouting (BHPBIC, 2010).

5.5.3. Injection Grouting

Where creeks are fractured and have a limited ability to naturally seal, it may be necessary to conduct remedial measures which usually include grouting to return surface water flow back to the stream bed.

Grout can be delivered by small handheld or truck-mounted equipment for deeper holes, with angled, vertical or horizontal drilling techniques utilised to position the grout.

The engineering techniques are well established and used in the mining and construction industries and are readily adapted to rehabilitation activities.

A number of grouts are available, including cement, pulverised ash and chemical grouts, with or without fillers (such as sand, gravel or vegetable fibres).

The choice of grout will be determined based on the nature and extent of the fracturing, the surface/ground water interaction and the objectives of the rehabilitation program.

The rehabilitation has the potential to cause adverse environmental impacts through the materials used as well as disturbance associated with access and will be carefully planned to avoid contamination of watercourses.

Coffer dams or bunds can be built to isolate the grouting operations and collect any materials spillage for later off-site disposal at mixing points.

The materials used in these processes are non-toxic, environmentally inert and do not significantly impact upon the natural habitats of aquatic species.

5.5.4. Pattern Grouting

Large fractured reaches of a stream may be sealed using grid pattern grouting.

A range of specialist grouts and techniques can be used including cement, bentonite, mixes, micro fine cements and sodium silicate-based grouts. The selection of a particular grout includes an analysis of potential aquatic ecosystem toxicity.

A number of passes is generally required to seal the subsurface, which involves grout and/or filler injection into the voids, with the intention being to achieve a low permeability `layer' below the stream to restore flow and pool water levels.

Grout holes are drilled at a 1 x 1m to 2 x 2m spacing, with small hand held tools used to minimise the potential environmental impact which are powered by compressed air distributed to the work area from a compressor.

Once specially designed packers are installed at the surface, grout is injected sequentially into the holes at a low pressure from a small tank and mixed and pumped according to the preferred grout design.

A grout of high viscosity will be used if vertical fracturing is present as it has a faster setting time, with lower viscosities used if cross-linking is noted.

Once the grout has been installed the packers are removed and the area is cleaned.

After the grout hardens the area may be in-filled with additional holes targeting areas of significant grout take that were identified in previous passes.

Once the grout take in the area is reduced and the material has cured, the grouted section of the pool is allowed to fill with water and is monitored.

The process is iterative and relies on detailed monitoring of grout injection quantities, backpressure analysis and water holding capacities to attain the desired end point, with the choice of grout being dependent upon the permeability of the rock.

5.5.5. Deep Angled Hole Grouting

Where access difficulties make pattern grouting inappropriate, i.e., where a pool has not totally drained, directional drilled holes used for grouting may be installed at a distance away from the pool.

The grout usually comprises 2% bentonite and general purpose cement with a specific gravity of 1.57 delivered to the directionally drilled holes through a packer system with pumping continuing until the grout returns to the top of the delivery holes.

Regular inspections are undertaken throughout and following the operation to ensure there are no significant releases of grout into the river.

5.5.6. Permeation Grouting

Permeation grouting involves the introduction of grout and filling materials into an individual pool or a stream flow, where the material is drawn into and seals voids in the creek bed.

5.5.7. Impermeable Blankets or Linings

Impermeable blankets or linings involves the installation of a waterproof lining to a pool to prevent loss of water into the underlying voids, with a variety of materials available, depending on site-specific circumstances.

5.5.8. Curtain Grouting

Curtain grouting involves installation of a grout curtain to the depth of fracturing to create an impermeable barrier to bypass flow, with a variety of materials available, depending on site-specific circumstances.

5.5.9. Stream Surface Treatment

Where cracking develops and natural sealing is not viable, the cracks may require forking over and compacting of alluvial or colluvial sedimentary deposits to prevent subsequent erosion.

Larger cracks may require more work, with mulch or other protection used to prevent the development of erosion channels, with the surface protection remaining in place until revegetation stabilises the disturbed area.

Some cases may require the use of gravel or sand to fill up to surface then revegetation with local native plants.

Such rehabilitation measures have the potential to cause impact through the materials used and the disturbance associated with access and therefore, considerable care and relevant approvals will be obtained to ensure the protection of the environment.

5.5.10. Ferruginous Springs

The effect of ferruginous springs can be mitigated by placing coarse limestone downstream of the spring to increase pH, increase stream aeration and to initiate precipitation of dissolved iron.

The effect of ferruginous springs is generally aesthetic and does not generally pose an adverse risk to stream ecology due to the relatively short length and high gradient of the Study Area streams.

Liming of streams with granular agricultural grade limestone (CaC03) is generally preferred to restore aquatic ecosystems under stress from acidification and Fe / Mn / heavy metal precipitation at the point of emergence. Placement of limestone would provide a continual reactive surface for:

- Neutralisation of excessive acidity;
- Localised precipitation of Fe and Mn hydrous oxides with adsorptive removal of potential eco-toxic trace metals;
- Increasing he hardness of the water and encouraging settling of dispersed sodic 2:1 layer clays, and;
- Accelerating natural remediation of cracks in the base pools.

Limestone is relatively insoluble above pH 6.5 and the calcium and carbonate alkalinity dissolution products are non-toxic and will have no effect on the water quality.

Precipitation of hydrous iron and manganese oxides from ferruginous springs can also be addressed through manually placed rocks obtained from local outcrops positioned at the emergence point. This can increase turbulence as well as oxidation rates and precipitation of hydrous oxides and allow downstream flow to ameliorate the effects.

5.5.11. Riparian Land Stability

Specific actions to address subsidence impacts on cliffs and steep slopes will be developed and implemented where adverse subsidence impacts occur.

Rock falls from cliff lines and slope slippage could be precipitated by the levels of movement that have been predicted, particularly where rocks and slopes are marginally stable.

Remediation requirements for mining related rock falls and slippage would be to the satisfaction of DRE and SCA. Measures may include:

- Surface water management measures to minimise sediment mobilisation;
- Erosion and sedimentation control measures to minimise downstream effects;
- Revegetation of disturbed areas;
- Preventive measures such as removal or stabilisation of loose boulders and scaling of loose rocks from cliff faces, or;
- Filling and mulching over large cracks to prevent the development of erosion channels.

5.5.12. Stream Gas

A typical driver of gas release at the surface is pressure changes, dilation and/or fracturing of the rock mass and associated release with groundwater flow to the surface.

Grouting can reduce these associated gas flows.

In all circumstances in the Southern Coalfield the gas releases have diminished over time, ranging from months to years, with long running releases significantly reducing over time.

Where vegetation is impacted by gas, the affected area can be revegetated once the gas has ceased or reduced to an extent where vegetation is no longer affected.

However, after 30 years of mining, no gas releases have been observed in stream or pools above any mining at Tahmoor Colliery.

5.6. Stream, Groundwater, Flora / Fauna, Rock Bar and Cliff Contingency Measures

In the event that the observed parameters or impacts exceed or are considered likely to exceed the performance measures detailed in the Plan, Xstrata will implement the following Contingency Plan, where:

- The observation will be reported to the Environment and Community Manager or representative within 24 hours.
- The observation will be recorded.
- Xstrata will report any exceedence of the performance measure to the DRE and other relevant stakeholder as soon as practicable after Xstrata becomes aware of the exceedence.
- Xstrata will assess the exceedences referred to in the relevant TARP and where appropriate, implement safety measures in accordance with the appropriate Management Plan/s.
- The Environment and Community Manager will investigate any potential contributing factors and identify an appropriate action plan to manage the identified impact(s), in consultation with specialists and/or relevant agencies if necessary.
- Xstrata will identify an appropriate action plan to manage the identified impact(s), in consultation with other specialists and/or key stakeholders.
- Xstrata will submit the proposed course of action to the DRE for approval.
- Xstrata will implement the approved course of action to the satisfaction of DRE.
- Xstrata will continue to monitor performance with the new action plan in place and, if successful will formalise these actions as part of the Management Plan.

Contingency measures will be developed in consideration of the specific circumstances of the issue and the assessment of consequences.

Contingency options will be implemented if it is demonstrated the environmental, water or safety impacts are greater than predicted, with the management framework involving the following components:

- Identifying features/values of significance and impact prediction to determine the range of possible events and impacts;
- Risk assessment in terms of determining the probability and consequence of an event occurring;
- Defining triggers and trigger levels for features/values affected and/or the identified events/impacts;
- Defining and implementing environmental monitoring;
- Identifying responses/actions to be taken when different triggers and trigger levels are reached, including response measures and actions relating to avoidance, minimisation, mitigation and compensation and contingency plans and emergency responses;
- Identifying roles and responsibilities of various stakeholders, and;
- Assessing measured and predicted impacts as mining progresses for features/values affected and implement responses/actions identified based on triggers and various pre-defined trigger levels being exceeded. Impacts need to be assessed based on the significance, extent, scale or longevity of impact and practical aspects of mitigation/rehabilitation.

With the provision of contingency measures, there is the potential to cause secondary impacts through the introduction of materials to the area or any disturbance associated with the activity.

Considerable care and relevant approvals will be obtained to ensure the protection of the environment as such works are executed.

Contingency measures would be monitored to confirm maintenance of the ecological values of the area and to confirm that measures in place to manage secondary impacts are effective.

It is possible that a longwall could gradually affect only a small area and that the remainder, being unaffected, will continue to provide unaffected habitats for terrestrial and aquatic species immediately adjacent to impacted areas. To minimise the impacts associated with subsidence and rehabilitation works a number of measures can be implemented. These include:

- Relocation of fauna and fish;
- Temporary maintenance of individual species such as watering aquatic plants;
- Provision of compensatory habitat;
- Revegetation;
- Timing of works;
- Staged work programs, and;
- Altering mining methods or modifying the mining area.

If pools are substantially drained, large aquatic fauna can be relocated to ensure they are not significantly impacted prior to rehabilitation being completed in consultation with DPI Fisheries and other agencies as required.

If rehabilitation of aquatic habitats is required, a catalogue of the habitat will be developed and used in site preparation to assist with rehabilitation. Boulders and logs can be removed during site preparation and returned to pre-disturbance positions.

Stockpiling rocks and logs adjacent to the watercourse and marking pre-disturbance positions with a nontoxic marking paint assist this process.

Larger aquatic plants can be removed during site preparation in a non-destructive manner (i.e. by shovel) which allows the macrophytes to be stored off-site and replanted on completion of works.

Patches of aquatic vegetation that do not need to be removed, but are left stranded by a fall in water level, could be watered until water levels are restored.

5.7. Groundwater Mitigation and Remediation

5.7.1. Mine Inflows

Application of an appropriate technique to manage an abnormal inflow to the mine, although considered extremely unlikely due to the high depth of cover, will be determined by agreement with all stakeholders based on the advice of hydro geologists and ground consolidation technical experts.

Selection of the optimum application and combination of materials and techniques will depend on the nature and magnitude of the inflow, technical advice and on stakeholder input.

Xstrata would work closely with specialist ground support and PUR injection companies with appropriate experience in chemical injection techniques for consolidation of unstable and porous ground and in the use of such measures to control ground water flows.

Water quality monitoring of mine water to identify any measureable abnormal inflow to the mine related to mine subsidence impacts is considered impractical due to the existing high water inflows and outflows to and from the mine. Historic and expected water inflow from deep level aquifers immediately above the Bulli seam from the Scarborough Sandstone and Bulgo Sandstones are consistently up to 2-3 megalitres per day.

In addition to this, underground process water supply to the mine varies around 1 megalitre per day, which also adds to the pumped outflow, raising it to the long term average pumped outflow of 3-4 megalitres per day. The quality of this outflow will now be further modified by the imminent connection of the mine's water recycling plant to the underground process water supply, which will substitute treated mine water for the potable water currently supplied underground.

Practically, this will mean that a water quality trigger would be impractical, as the high water volumes and variable water supply chemistry from the recycled water plant, supplemented by potable water during peak demand, would substantially dilute and mask any measureable water quality change that may occur due to potential subsidence impacts.

The water volume trigger is considered the most appropriate trigger for mine inflow monitoring, as this would show any significant water inflow change long before any observable or measureable change or trend was detected in water quality.

Triggers that will initiate the decision to use such remedial techniques are defined in **Appendix A.**

5.8. Heritage Site Mitigation and Remediation

As outlined in Section 4.5.2, the condition of the standing structures will be assessed and recorded by a structural engineer prior to the commencement impacts from mining. This assessment and monitoring will allow any mitigation and management measures to be put in place prior to mining if appropriate.

Where appropriate, mitigation measures will be designed to minimise the effects of impact on the relevant heritage item. These measures will be designed by a structural engineer (sometimes in conjunction with a heritage consultant), in order to minimise the heritage impact of the work.

Any impact will be assessed by a structural engineer (and if required a heritage consultant), and measures put in place to stabilise the affected item and retain the heritage significance. Any such work will require the submission of a Statement of Heritage Impact to Wollondilly Shire Council. Should the work be likely to impact archaeological relics, an Excavation Permit or Exception Notification from the Heritage Branch of the Department of Planning will be required.

Significant heritage items such as Tahmoor House and Myrtle Creek Bridge will have dedicated plans of management, developed by a structural engineer in conjunction with a heritage consultant, addressing the potential structural and heritage impacts, and appropriate mitigation and remedial actions.

5.9. Cliff Mitigation and Remediation

Potential measures that may be required in terms of mitigation and / or remediation of subsidence affected cliffs may involve;

- installation of rock bolts, cable bolts etc;
- installation of standing supports (timber props, rock, sand bags etc)
- planting of native vegetation at the base of the cliff
- scaling / dislodgement / removal of loose rock
- installation of sediment fences downstream of erosion areas

CHAPTER 6. MANAGEMENT PLAN REVIEW MEETINGS

The monitoring of natural surface features will be carried out by Tahmoor Colliery. Management Plan Review Meetings will be held between Tahmoor Colliery, stakeholders, and / or the DRE for discussion and resolution of issues raised in the operation of the Management Plan. The frequency of the Plan Review Meetings will be as required during the mining period.

A secretary will be appointed at the Plan Review Meeting. All documentation, distribution of meeting minutes and organising of meeting times will be undertaken by the secretary.

Plan Review Meetings will discuss any incidents reported in relation to the relevant surface feature, the progress of mining, the degree of mine subsidence that has occurred, and comparisons between observed and predicted ground movements.

It will be the responsibility of the meeting representatives to determine whether the incidents reported are due to the impacts of mine subsidence, and what action will be taken in response.

In the event that a significant risk is identified for a particular surface feature, any party may call an emergency Plan Review Meeting, with one day's notice, to discuss proposed actions and to keep other parties informed of developments in the monitoring of the surface feature.

Tahmoor Colliery will keep and distribute regular minutes of each Plan Review Meeting.

CHAPTER 7. AUDIT AND REVIEW

Should an audit of the Management Plan be required during that period, an auditor shall be appointed by Tahmoor Colliery to review the operation of the Management Plan and report at the next scheduled Plan Review Meeting.

Other factors that may require a review of the Management Plan are observation of:-

- greater impacts on surface features due to mine subsidence than was previously expected;
- fewer impacts or no impacts on surface features due to mine subsidence than was previously expected, and;
- significant variation between observed and predicted subsidence.

CHAPTER 8. INCIDENTS, COMPLAINTS AND NON-CONFORMANCES

8.1. Incidents

An incident is defined as a set of circumstances that causes or threatens to cause material harm to the environment, and/or breaches or exceeds the limits or performance measures/criteria in the SMP Approval.

Incidents will be managed through established Xstrata procedures in as detailed the Environmental Management Strategy.

Xstrata will notify the appropriate stakeholders of any incident in accordance with the requirements of the SMP Approval.

8.2. Complaints Handing

Complaints will be managed through established XSTRATA procedures as detailed in the Environmental Management System.

8.3. Non-Conformance Protocol

Xstrata will manage and report non-compliances relevant against statutory requirements in accordance with an established protocol developed as a component of the Environmental Management Strategy.

Compliance with all approvals, plans and procedures will be the responsibility of all personnel (staff and contractors) employed on or in association with Xstrata, and will be promoted through direct consultation and direction of the Mine's Environment and Community Manager.

Regular inspections and/or internal audits will be undertaken as required by suitably qualified personnel under the direction of the Environment and Community Manager, to identify any remediation/rectification work required, and areas of actual or potential non-compliance.

A Compliance Register has been established to monitor compliance against development consent criteria, mining leases etc.

Non-compliances will be reported to the Director Environmental Sustainability and Land Use, and/or Principal Subsidence Engineer as appropriate and corrective actions will be implemented as required.

CHAPTER 9. PLAN ADMINISTRATION

9.1. Roles and Responsibilities

Environment and community management is regarded as part of the responsibilities of all Colliery personnel.

The roles and function of the key personnel responsible for the implementation of environmental and community management including the plans, procedures and action plans contained in this EMP are outlined detailed as part of the Tahmoor Colliery Environmental Management System.

9.2. Resources Required

Xstrata shall ensure that the appropriate resources are made available to achieve the implementation of this Plan.

It is the role of the Environment and Community Manager to ensure that these requirements are sufficient to implement the plan and to seek additional resources if required..

9.3. Training and Inductions

All required training and inductions for employees, contractors and consultants will be undertaken in accordance with Xstrata training procedures.

In the event that there are specific environmental management requirements relating to a contractor's work activities, details of these requirements are to be issued to the contractor in writing as a part of the induction.

Records, which detail the attendees, content of the induction/training as well as any additional information provided, will be maintained.

In addition to the induction program, training will be provided as deemed necessary to contractors to provide them with the knowledge, skills and awareness to minimise environmental impact. At a minimum this should include:

- contractors whose activities are not directly supervised by Colliery personnel, and;
- contractors whose activities are ongoing and have the potential to result in an environmental incident.

CHAPTER 10. CONTACT LIST

Organisation	Contact	Phone	Email / Mail	Fax
NSW Department of Trade and Investment, Regional Infrastructure and Services, Division of Resources and Energy (DRE)	Phil Steuart	(02) 4931 6648	phil.steuart@industry.nsw.gov.au	(02) 4931 6790
	Gang Li	(02) 4931 6644 0409 227 986	gang.li@industry.nsw.gov.au	(02) 4931 6790
	Ray Ramage	(02) 4931 6645 0402 477 620	ray.ramage@industry.nsw.gov.au	(02) 4931 6790
	Greg Kininmonth	(02) 4222 8310	greg.kininmonth@industry.nsw.gov.au	
Geoterra	Andrew Dawkins	(02) 9560 6583	geoterra@iinet.net.au	(02) 9560 6584
Hydrometric Consulting Services (HCS)	Steve Swanbury	(02) 4889 5102	steves@mitmania.net.au	
Mine Subsidence Engineering Consultants (MSEC)	Daryl Kay	(02) 9413 3777	daryl@minesubsidence.com	(02) 9413 3822
Sunrise Building and Property Services (SBPS)	John Schwarz	(02) 4883 9030 0400 390 058	sunbuilding@bigpond.com.au	(02) 4883 9738
Xstrata Coal Tahmoor Colliery – Environment and Community Manager	Ian Sheppard	(02) 4640 0156 0408 444 257	isheppard@xstratacoal.com.au	(02) 4640 0140
Xstrata Coal Tahmoor Colliery – Community Coordinator	Belinda Clayton	(02) 4640 0133	bclayton@xstratacoal.com.au	(02) 4640 0140

APPENDIX A. TRIGGER ACTION RESPONSE PLAN

TAHMOOR LONGWALLS 27 to 30 - Trigger Action Response Plan

NOTE: the TARP triggers and management actions have been determined to achieve the performance outcomes outlined in the accompanying EMP text

Feature	MONITORING			MANAGEMENT	
	Prior to Mining	During Mining	Post Mining	Trigger	Action
Groundwater quality **Piezometers / bores** **P1,2,3 P4(GW67570), P5(GW63525), P6, 7, 8 GW10968, 35844, 47903, 102483, 105254, 105467, 105813, 107918, 109010, 109224, 111841**	Field water quality (EC, pH) bi-monthly Laboratory analysis every twelve months 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 pre longwall extraction 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, until LW27-30 mining is completed, and then as required based on EMP modification Laboratory analysis every twelve months 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) until agreed end point	**NORMAL** No observable mining induced change **WITHIN PREDICTION** Short term increase (< 2month) in salinity or reduction in pH outside of baseline variability, with the effect not persisting after a significant rainfall recharge event **EXCEEDS PREDICTIONS** Increase in salinity or reduction in pH outside of baseline variability, with the effect persisting after a significant rainfall recharge event	Continue monitoring program, discuss in end of panel report or AEMR as required. Ongoing review of water quality data Continue monitoring program, discuss in end of panel report or AEMR as required. Ongoing review of water quality data Immediately inform NOW and DRE Director Environmental Sustainability and Land Use, Principal Subsidence Engineer of any exceedances Discuss requirement, need and potential cost / benefit of a mitigation / action plan with stakeholders Investigate the potential source/s of any water quality trigger exceedance
Groundwater Levels Piezometers / Bores **P1,2,3 P4(GW67570), P5(GW63525), P6, 7, 8, GW10968, 35844, 47903, 102483, 105254, 105467, 105813, 107918, 109010, 109224, 111841**	Minimum continuous 12 hourly Bi- monthly logger download and dip meter	Minimum continuous 12 hourly readings Bi-monthly logger download and dip meter whilst bore is actively undermined	Minimum continuous 12 hourly for a period agreed between the mine operator and the relevant regulators (minimum 1 year) after the bore is undermined Bi- monthly logger download and dip meter for an agreed period (minimum 1 year) after the bore is undermined	**NORMAL** No observable mining induced change **WITHIN PREDICTION** Up to 10m water level reduction for less than 3 months **EXCEEDS PREDICTIONS** Greater than 10m water level reduction 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”	Continue monitoring program, discuss in end of panel report or AEMR as required. Ongoing review of water level data No observable mining induced change Ongoing review of water level data Immediately inform NOW and DRE Director Environmental Sustainability and Land Use, Principal Subsidence Engineer Discuss requirement, need and potential cost / benefit of a mitigation / action plan with stakeholders Investigate the potential cause / fate of any water level trigger exceedance

TAHMOOR LONGWALLS 27 to 30 - Trigger Action Response Plan

NOTE: the TARP triggers and management actions have been determined to achieve the performance outcomes outlined in the accompanying EMP text

Feature	MONITORING			MANAGEMENT	
	Prior to Mining	During Mining	Post Mining	Trigger	Action
Groundwater Pressures **VWPs** **TNC28, 29, 40, 43**	Minimum continuous 12 hourly Bi- monthly logger download and dip meter	Minimum continuous 12 hourly readings Bi-monthly logger download whilst bore is being actively undermined	Minimum continuous 12 hourly for a period agreed between the mine operator and the relevant regulators (minimum 1 year) after the bore is undermined Bi- monthly logger download and dip meter for an agreed period (minimum 1 year) after the bore is undermined	**NORMAL** No observable mining induced change in the upper Hawkesbury Sandstone VWP intake	Continue monitoring program, discuss in end of panel report or AEMR as required. Ongoing review of water pressure data
				WITHIN PREDICTION Up to 10m water level reduction for less than 3 months in the upper Hawkesbury Sandstone VWP intake	No observable mining induced change Ongoing review of water pressure data
				EXCEEDS PREDICTIONS Greater than 10m water level reduction in the upper Hawkesbury Sandstone VWP intake 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	Immediately inform DRE Director Environmental Sustainability and Land Use, Principal Subsidence Engineer Discuss requirement, need and potential cost / benefit of a mitigation / action plan with stakeholders Investigate the potential cause / fate of any water level trigger exceedance

TAHMOOR LONGWALLS 27 to 30 - Trigger Action Response Plan

NOTE: the TARP triggers and management actions have been determined to achieve the performance outcomes outlined in the accompanying EMP text

Feature	MONITORING			MANAGEMENT	
	Prior to Mining	During Mining	Post Mining	Trigger	Action
Mine inflow	Daily volumetric flow monitoring of mine inflow and discharge	Daily volumetric flow monitoring of mine inflow and discharge	Daily volumetric monitoring of mine inflow and discharge	**NORMAL** No observable mining induced change in water pump out volumes or water quality discharge compared to baseline	Continue monitoring program, discuss in end of panel report or AEMR as required. Ongoing review of mine water pump in / out, derived groundwater inflow and water balance data.
				WITHIN PREDICTIONS Mine pump in / out volume and discharge water quality within historic monitored range.	Continue monitoring program, discuss in end of panel report or AEMR as required. Ongoing review of mine water pump in / out, derived groundwater inflow and water balance data.
				EXCEEDS PREDICTIONS Increase in water discharge of >1ML/day for 7 successive days from active mining areas which are suspected to be as a result of mine subsidence and excluding elevated inflows such as increased water volume pumped in to the workings	Immediately inform NOW and DRE Director Environmental Sustainability and Land Use, Principal Subsidence Engineer Instigate investigation within 1 week of trigger exceedence being noted Engage hydrogeologist to investigate and report on the cause of trigger exceedences where the cause may not be directly related increased water pump in volumes Inform NOW & DRE of investigation outcomes Discuss requirement, need and potential cost / benefit of a mitigation / action plan with stakeholders If required, prepare and implement a site mitigation/action plan in consultation with NOW / DRE as necessary Report on mitigation as soon as practicable and in AEMR

TAHMOOR LONGWALLS 27 to 30 - Trigger Action Response Plan

NOTE: the TARP triggers and management actions have been determined to achieve the performance outcomes outlined in the accompanying EMP text

Feature	MONITORING			MANAGEMENT	
	Prior to Mining	During Mining	Post Mining	Trigger	Action
Stream Water Quality **MYC1,2,3,4** **RC1,2,3**	Bi-monthly manual field analysis (EC, pH, DO, ORP, temp) Annual 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 Observable iron hydroxide staining using photo points	Weekly field analysis during active undermining of any 3rd order stream reach Bi-monthly lab analysis during active undermining in relevant stream reach Weekly observations during active undermining of 3rd order stream reach using photo points	Field analysis every 2 months for agreed period (minimum 1 yr) Lab analysis for agreed period (minimum 1 yr) every two months Observations every 2 months for agreed period (minimum 1 yr) using photo points after mining is completed in LW27-30	**NORMAL** No observable mining induced change	Continue monitoring program, discuss in end of panel report or AEMR as required. Ongoing review of water quality data
				WITHIN PREDICTIONS <2 mth change within baseline variability or water quality reduction over minimum 2 month period Increase in stream Fe hydroxide precipitation compared to baseline	Continue monitoring program, review monitoring frequency, discuss in end of panel report or AEMR as required. Ongoing review of water quality data
				EXCEEDS PREDICTIONS Significant reduction compared to baseline and predicted impacts last over >2mthsand > 2 STD deviation reduction in water quality at downstream monitoring site compared to baseline and / or significant observable increase in Fe hydroxide precipitate compared to baseline observations	Immediately inform NOW and DRE Director Environmental Sustainability and Land Use, Principal Subsidence Engineer Notify technical specialists immediately Site visit with stakeholders within 1 month Record photographically immediately Collect laboratory samples within 2 weeks and analyse for standard analytes Review sampling program within 1 mth and review accordingly Inform NOW & DRE of investigation Prepare and implement a site mitigation/action plan within 1 mth (pending stakeholder availability) and seek approvals from key agencies if required Complete works asap and additional post works monitoring / reporting within 1 mth as required Discuss in EoP or AEMR reports as required

TAHMOOR LONGWALLS 27 to 30 - Trigger Action Response Plan

NOTE: the TARP triggers and management actions have been determined to achieve the performance outcomes outlined in the accompanying EMP text

Feature	MONITORING			MANAGEMENT	
	Prior to Mining	During Mining	Post Mining	Trigger	Action
Stream Flow / Water Level **Sites** **M1 - M6** **R1- R11**	Minimum continuous 6 hourly, with 2 monthly downloads Minimum continuous 2 hourly, with monthly downloads when longwall is < 250m from monitoring site	Minimum continuous hourly with weekly downloads for 2 month before / after active mining within 100m of a 3rd order or higher channel in a relevant actively undermined stream reach	Minimum continuous 6 hourly with downloads every two months for agreed period (minimum 1 yr) after mining is completed in LW27 - 30	**NORMAL** No observable mining induced change	Continue monitoring program, discuss in end of panel report or AEMR as required. Ongoing review of stream flow / level data
				WITHIN PREDICTIONS (< 2mths) - within baseline variability or temporary reduction over < 2mth period for pool levels and stream flow, considering rainfall / runoff variability.	Continue monitoring program, discuss in end of panel report or AEMR as required. Ongoing review of water pressure data
				WITHIN PREDICTIONS (>2 mths) fracturing of bedrock in directly undermined channels Pool level / flow decline <20% during mining compared to baseline for > 2 mths	Continue monitoring program, review monitoring frequency, discuss in end of panel report or AEMR as required. Ongoing review of water pressure data
				EXCEEDS PREDICTIONS fracturing of bedrock in stream reach directly or not directly undermined re-direction of surface water flows and pool level / flow decline >20% during mining compared to baseline for > 2mths, considering rainfall / runoff variability	Immediately inform NOW and DRE Director Environmental Sustainability and Land Use, Principal Subsidence Engineer Notify technical specialists immediately Site visit with stakeholders within 1 mth Record photographically immediately Review monitoring program within 2 weeks and review accordingly Inform NOW and DRE of investigation results Prepare and implement a site mitigation/action plan within 1 mth (pending stakeholder availability) and seek approvals from key agencies if required Complete works asap Additional post works monitoring and reporting within 1 mth as required Discuss in EoP or AEMR reports as required

TAHMOOR LONGWALLS 27 to 30 - Trigger Action Response Plan

NOTE: the TARP triggers and management actions have been determined to achieve the performance outcomes outlined in the accompanying EMP text

Feature	MONITORING			MANAGEMENT	
	Prior to Mining	During Mining	Post Mining	Trigger	Action
General Stream Sites **MYC1,2,3,4** **RC1,2,3** **M1 - M6** **R1- R11**	Observations every month for at least two months prior to mining using photo points	Observations every week during active undermining of 3rd order streams using photo points	Observations every 2 months for an agreed period (minimum 1 yr) after mining is completed in LW27-30 using photo points	**NORMAL** No observable mining induced change	Continue monitoring program, discuss in end of panel report or AEMR as required. Ongoing review of stream condition
				WITHIN PREDICTIONS No observable change to stream bed or bank; erosion turbidity iron staining algal growth vegetation compared to baseline conditions	Continue monitoring program, discuss in end of panel report or AEMR as required. Ongoing review of stream condition
				EXCEEDS PREDICTIONS Observable increase in stream bed or bank; erosion turbidity iron staining algal growth vegetation compared to pre mining conditions	Immediately inform NOW and DRE Director Environmental Sustainability and Land Use, Principal Subsidence Engineer Notify technical specialists immediately Site visit with stakeholders within 1 mth Record photographically immediately Review monitoring program within 2 weeks and review accordingly Inform NOW and DRE of investigation results Prepare and implement a site mitigation/action plan within 1 mth (pending stakeholder availability) and seek approvals from key agencies if required Complete works asap Additional post works monitoring and reporting within 1 mth as required Discuss in EoP or AEMR reports as required

TAHMOOR LONGWALLS 27 to 30 - Trigger Action Response Plan

NOTE: the TARP triggers and management actions have been determined to achieve the performance outcomes outlined in the accompanying EMP text

Feature	MONITORING			MANAGEMENT	
	Prior to Mining	**During Mining**	**Post Mining**	**Trigger**	**Action**
Private Dams **Sites as outlined in EMP text**	Dam wall integrity and water level observation prior to undermining using photo points	Dam wall integrity and water level observation prior to undermining using photo points if requested by landowner	Dam wall integrity and water level observation after undermining using photo points	**NORMAL** No observable mining induced change **WITHIN PREDICTIONS** No observable change to dam wall integrity or water levels due to subsidence compared to pre mining conditions **EXCEEDS PREDICTIONS** Observable adverse effect in dam wall integrity or water holding capacity of dam compared to pre mining conditions	Continue monitoring program, discuss in end of panel report or AEMR as required. Continue monitoring program, discuss in end of panel report or AEMR as required. Immediately inform NOW and DRE Director Environmental Sustainability and Land Use, Principal Subsidence Engineer Notify technical specialists immediately Site visit with stakeholders within 1 mth Record photographically immediately Review monitoring program within 2 weeks and review accordingly Inform NOW and DRE of investigation results Prepare and implement a site mitigation/action plan within 1 mth (pending stakeholder availability) and seek approvals from key agencies if required Complete works asap Additional post works monitoring and reporting within 1 mth as required Discuss in EoP or AEMR reports as required
Rainfall **Sites – Tahmoor Colliery and Picton**	Continuous daily rainfall monitoring	Continuous daily rainfall monitoring	Continuous daily rainfall monitoring	n/a	n/a

TAHMOOR LONGWALLS 27 to 30 - Trigger Action Response Plan

NOTE: the TARP triggers and management actions have been determined to achieve the performance outcomes outlined in the accompanying EMP text

Feature	MONITORING			MANAGEMENT	
	Prior to Mining	During Mining	Post Mining	Trigger	Action
Cliffs **(Over LW29)**	Observation and documentation of Cliff - Once prior to mining	Monthly observations during mining	Monthly observations for 6 Months	Minor cracking on exposed rock faces (<10mm)	Notification to DRE within 24 hrs, using photographic record Warning sign/s erection Reported in EOP and AEMR
				Major cracking (>10mm) on exposed rock faces	Notification to DRE immediately Make area safe immediately including erection of warning sign/s and barrier fencing Incident Report and Mitigation Proposal to Agencies within a week. Mitigation Report and AEMR. Review mining options Reported in EOP and AEMR
				Major cliff/rock collapse or steep slope movement	Notification to DRE immediately Make area safe immediately including warning sign/s erection and barrier fencing Proposal for rectification within 1 week Completion of works following approval from Agencies Additional monitoring as agreed Mitigation Report. Review mining options Reported in EOP and AEMR

TAHMOOR LONGWALLS 27 to 30 - Trigger Action Response Plan

NOTE: the TARP triggers and management actions have been determined to achieve the performance outcomes outlined in the accompanying EMP text

Feature	MONITORING			MANAGEMENT	
	Prior to Mining	During Mining	Post Mining	Trigger	Action
Aboriginal Archaeology Aboriginal Sandstone shelter sites: 52-2-3254 52-2-2078 And other identified sites.	Baseline archival recording: prior to longwall mining Re-recording of the principal components identified by Sefton (Sefton 2000) Macro and micro recording using digital photography (Navin Officer 2003) Detailed elevation plans of shelter walls recording structural and surface features including but not limited to the art itself, graffiti, joints , bedding planes, exfoliation scars, cracks, mineral and microorganism growth, drip line and water seepage locations	First impact assessment recording following initial subsidence movement of the site Sandstone shelter and Aboriginal sites will be monitored during mining	Further impact assessment recording: twelve months after undermining or final subsidence movement of the site	**Negligible** Change in shelter conditions not attributable to natural weathering or preservation that do not alter the heritage values of the place – e.g. mineral growth or micro-organism growth Changes external to shelter that effect the sites context – e.g. ground cracking, boulder slumping, rock and/or tree falls	Continue with monitoring program if safe to do so Condition assessment and photographic record Notify other relevant specialists Notify key stakeholders e.g. Aboriginal Groups, DRE, OEH. Report in End of panel report and AEMR

TAHMOOR LONGWALLS 27 to 30 - Trigger Action Response Plan

NOTE: the TARP triggers and management actions have been determined to achieve the performance outcomes outlined in the accompanying EMP text

Feature	MONITORING			MANAGEMENT	
	Prior to Mining	During Mining	Post Mining	Trigger	Action
				Major Change in shelter conditions not attributable to natural weathering or preservation –change in drip line or seepage, e.g. cracking or exfoliation of overhang or shelter, movement or opening of existing planes and joints	Continue with proposed monitoring program Condition assessment recorded Notify relevant technical specialists and seek advice on any corrective management action (CMA) required Notify key stakeholders e.g. Aboriginal Groups, DRE, OEH. Implement agreed CMAs as approved Report in Mitigation report, End of panel report and AEMR
				Severe Change in shelter conditions not attributable to natural weathering or preservation – e.g. cracking or exfoliation of art panel, movement of existing planes and joints at panel, block fall within shelter or overhang, shelter or overhang collapse	Continue with proposed monitoring program Immediately notify relevant Aboriginal Groups, government agencies, other resource managers and relevant technical specialists and seek advice on any CMA required. Site visits with stakeholders if required Develop site CMA in consultation with key stakeholders within 1 month. Completion of works following approvals Issue CMA report within 1 month of works completion Conduct initial follow up monitoring & reporting within 2 months of CMA completion if required Report in Mitigation report, End of panel report and AEMR

TAHMOOR LONGWALLS 27 to 30 - Trigger Action Response Plan

NOTE: the TARP triggers and management actions have been determined to achieve the performance outcomes outlined in the accompanying EMP text

Feature	MONITORING			MANAGEMENT	
	Prior to Mining	During Mining	Post Mining	Trigger	Action
Historic Heritage Sites Note: Tahmoor House and Myrtle Creek Bridge will have specific management plans in place prior to subsidence.	The condition of the standing structures within the Study Area will be assessed and recorded by a structural engineer prior to the commencement of mining.	Once for any item reported to have observed impacts such as: surface cracking, damage.	Once 3-6 months post mining (if not already undertaken post subsidence).	Observation of cracking, defects, unstable conditions, structural damage, etc. Subsidence movement exceeding the expected maximum predictions.	The owners and occupants of the properties will be informed of the commencement of mining with the potential to affect the relevant area, and requested to report any impact immediately. Report impacts to Mine Subsidence Board (MSB) as required. Any impact will be assessed by a structural engineer and if required, a heritage consultant, and measures put in place to stabilise the affected item and retain the heritage significance. Notify stakeholders, MSB, OEH, Wollondilly Council, DRE as required. Submit a Statement of Heritage Impact to Wollondilly Shire Council, or (should the work be likely to impact archaeological relics), an Excavation Permit or Exception Notification, if required. Review and undertake remediation options as agreed with MSB, stakeholders and Agencies. Report in Mitigation report, End of panel report and AEMR.

TAHMOOR LONGWALLS 27 to 30 - Trigger Action Response Plan

NOTE: the TARP triggers and management actions have been determined to achieve the performance outcomes outlined in the accompanying EMP text

Feature	MONITORING			MANAGEMENT	
	Prior to Mining	During Mining	Post Mining	Trigger	Action
Aquatic Ecology	Observational monitoring for presence/absence of aquatic habitat during water quality monitoring regime	Observational monitoring for presence/absence of aquatic habitat during water quality monitoring regime	Observational monitoring for presence/absence of aquatic habitat during water quality monitoring regime for a minimum of one year post-mining.	**NORMAL** No change in aquatic habitat compared to baseline observed	Continue monitoring Report in end of panel report
				WITHIN PREDICTIONS Water flow and quality results within predictions. Observational monitoring within baseline variability.	Continue monitoring Report in end of panel report
				EXCEEDS PREDICTIONS Water flow and quality results exceed predictions. Observational monitoring shows significant change observed in aquatic habitat compared to baseline observed	Notification to DRE/NOW immediately Proposal for any proposed additional aquatic ecology monitoring and management measures within 1 week if required Completion of agreed management tasks following approval from DRE/NOW. Additional monitoring as required by the relevant government agencies Report in end of panel report Reporting in Incident and AEMR

APPENDIX B. DRAWINGS AND DOCUMENTATION

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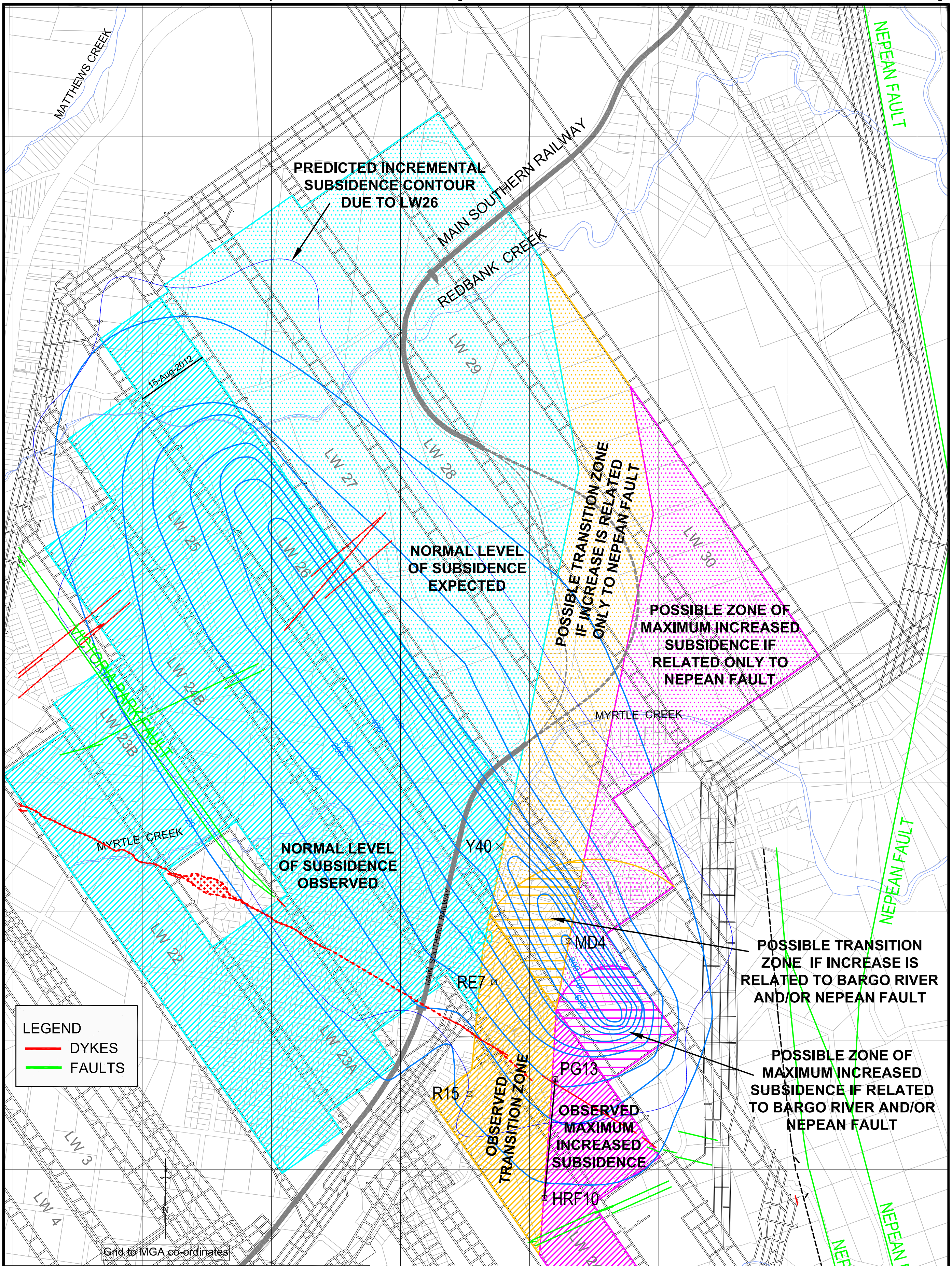

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TAHMOOR COLLIERY

TAHMOOR NORTH - LONGWALL 27
OBSERVED INCREMENTAL SUBSIDENCE
DUE TO LW26 AS AT 15-AUG-2012

DATE:	SCALE:	DRAWING No:	Rev No
23-Aug-2012	1:20000	MSEC567-00-01	A

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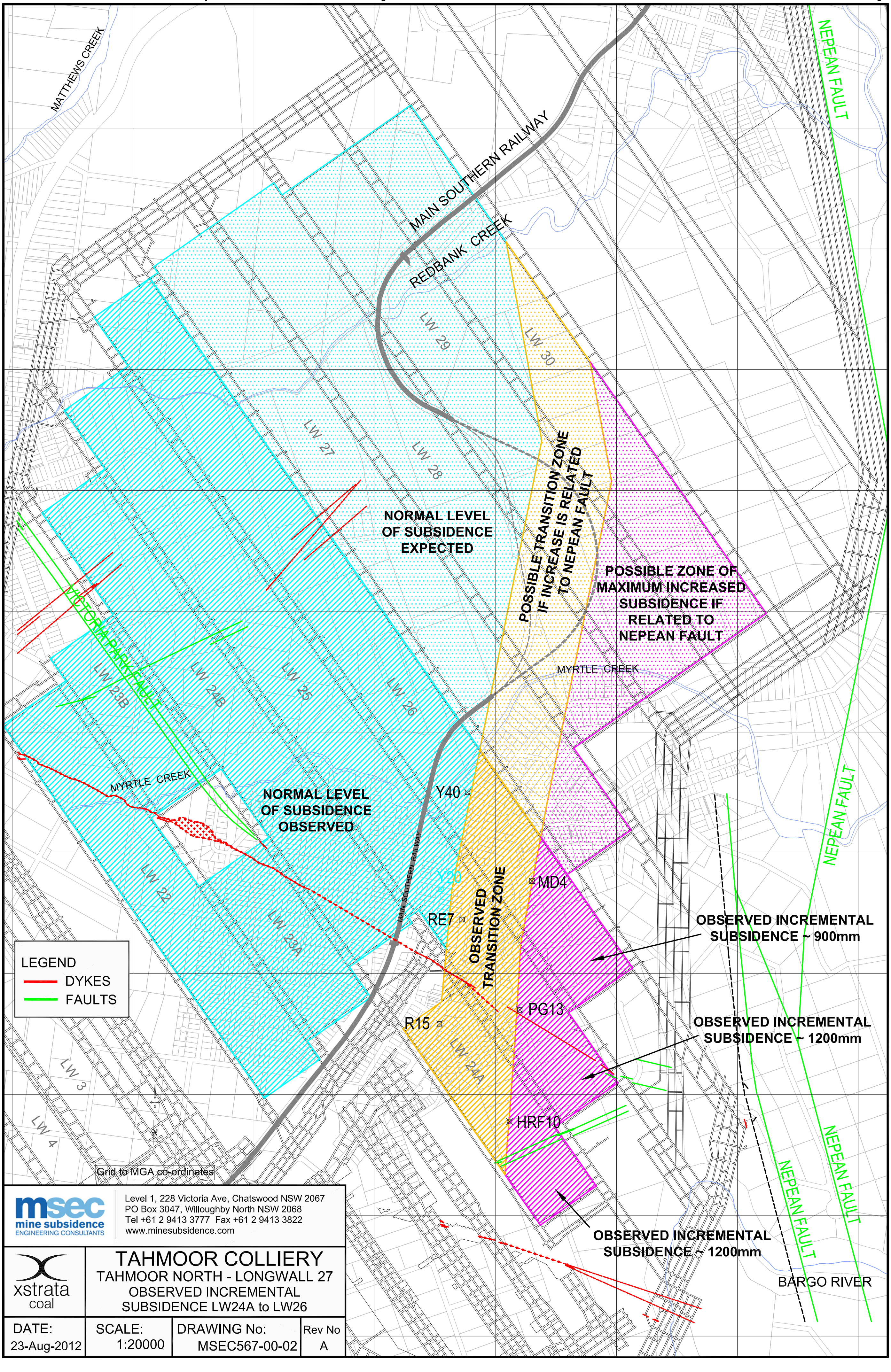

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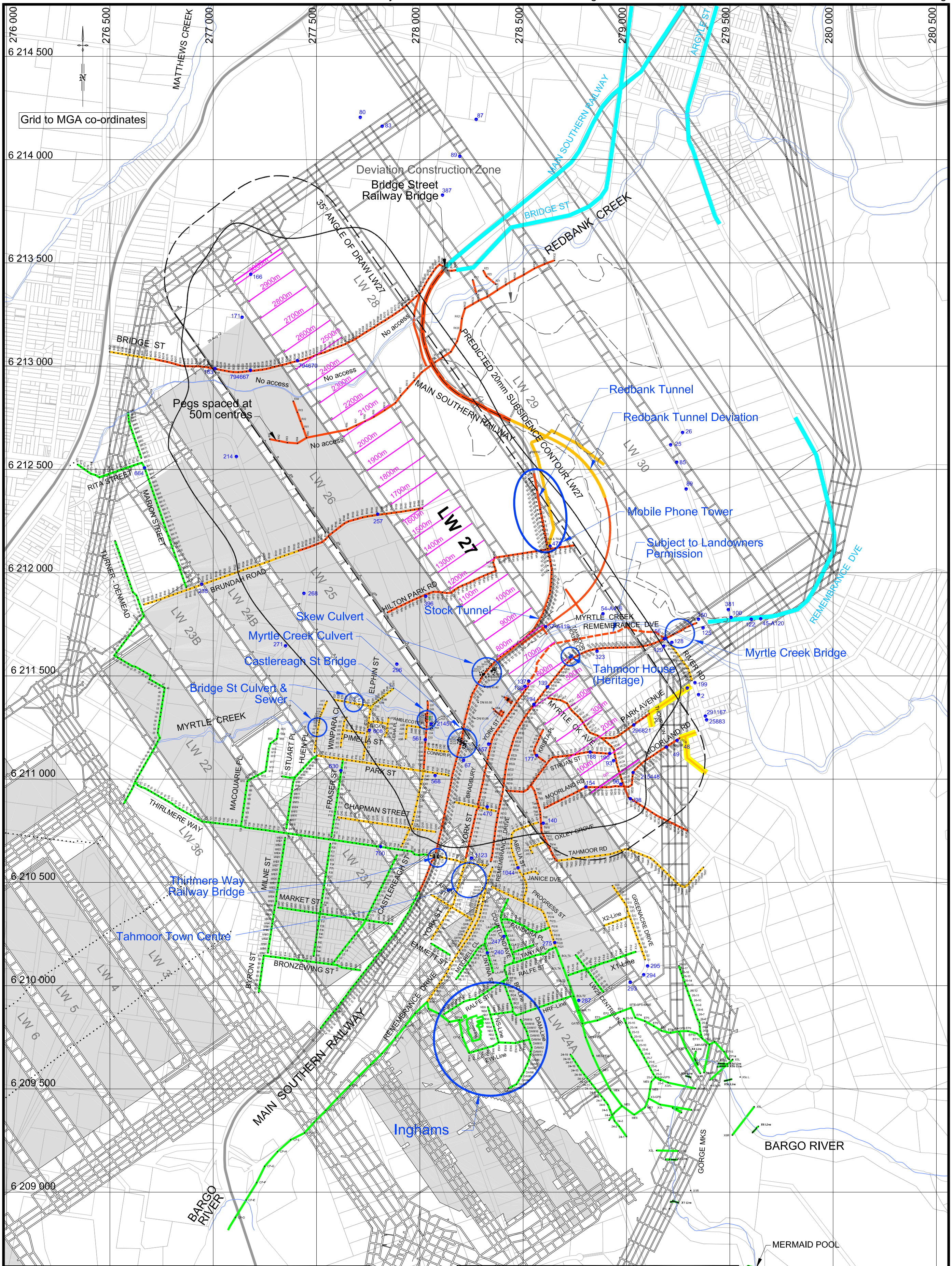

LEGEND

- Existing Monitoring Lines
- Future Monitoring Lines
- Future Monitoring Lines Prior to LW27
- Monitoring Lines Before & End of LW27
- Surveys During LW27
- Critical Power Poles
- Specific Structure Inspections

Refer to Management Plans for Timing & Frequencies

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TAHMOOR COLLIERY

TAHMOOR NORTH - LONGWALL 27 MONITORING OVER LW27

DATE:	SCALE:	DRAWING No:	Rev No
26-Sep-2012	1:25000	MSEC567-00-03	B