WONGAWILLI COLLIERY

NEBO AREA

END OF PANEL REPORT FOR LONGWALL N2

EXECUTIVE SUMMARY

Wongawilli Coal Pty Limited, a subsidiary of Wollongong Coal Limited, operates the Wongawilli Colliery, located approximately 15 km south-west of Wollongong. Longwall mining operations in the Nebo Area at Wongawilli Colliery are undertaken pursuant to Project Approval 09_0162 and Subsidence Management Plan Approval 09_5341. This End of Panel Report has been prepared in accordance with Condition 18 of Subsidence Management Plan Approval 09_5341. This End of Panel Report describes the subsidence effects and environmental consequences observed during mining of Longwall N2, and compares these to the predicted subsidence effects and consequences.

Secondary extraction of Longwall N2 panel was undertaken from 12 June 2013 to 26 February 2014. Extraction of Longwall N2 has been suspended due to a roof fall on the longwall miner, with recommencement unlikely for an indeterminate period.

The observed subsidence effects induced by mining of Longwall N2 are generally consistent with the predictions for Longwall N2 and N3, as indicated in the table below.

	Maximum Vertical Subsidence (mm)	Maximum Tilt (mm/m)	Maximum Tensile Strain (mm/m)	Maximum Compressive Strain (mm/m)
Predicted Subsidence for LW N2 and LW N3	230	1.7	0.3 – 0.4	0.5
Observed Subsidence for LW N2	92	0.5	0.2	0.2

The mining of Longwall N2 did not result in any environmental consequences that were greater than the predicted environmental consequences, as summarised in the table below.

Feature	Predicted Consequences	Actual Consequences
Transmission Lines	No observable impact on the transmission line poles	No observed impacts to transmission line poles
Access Tracks	No potential for significant impact	No impacts observed
Historic Heritage Sites	Potential for ground cracking or tree falls	No impacts

Feature	Predicted Consequences	Actual Consequences
Surface Water	• No impact on stream flows • Potential increase in iron hydroxide precipitation • Potential lowering of pH	No changes to stream flows or water chemistry were identified.
Groundwater	• No connectivity of aquifers and aquitards within 20 m of surface • Increased rainfall recharge to basement • Reduction in water levels of up to 10 m, followed by full recovery • Increase in iron and manganese hydroxide precipitation • Potential lowering of pH	• No connectivity between aquifers and aquitards within 20 m of surface has been identified • No increase in rate of rainfall recharge to basement has been identified • Water levels reduced by a maximum of 8 m and have recovered to 4 m (to date) • No observed change in water chemistry
Aquatic Ecology	No observable impact to ecological values	No observed impact to ecological values
Terrestrial Ecology	No observable impact to ecological values	No observed impact to ecological values

The observed consequences did not exceed any of the triggers in the relevant Trigger Action Response Plans. As such, no additional management or mitigation measures are required for Longwall N2. Wollongong Coal Limited will continue to undertake monitoring activities as required.

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1. INTRODUCTION

1.1. Background

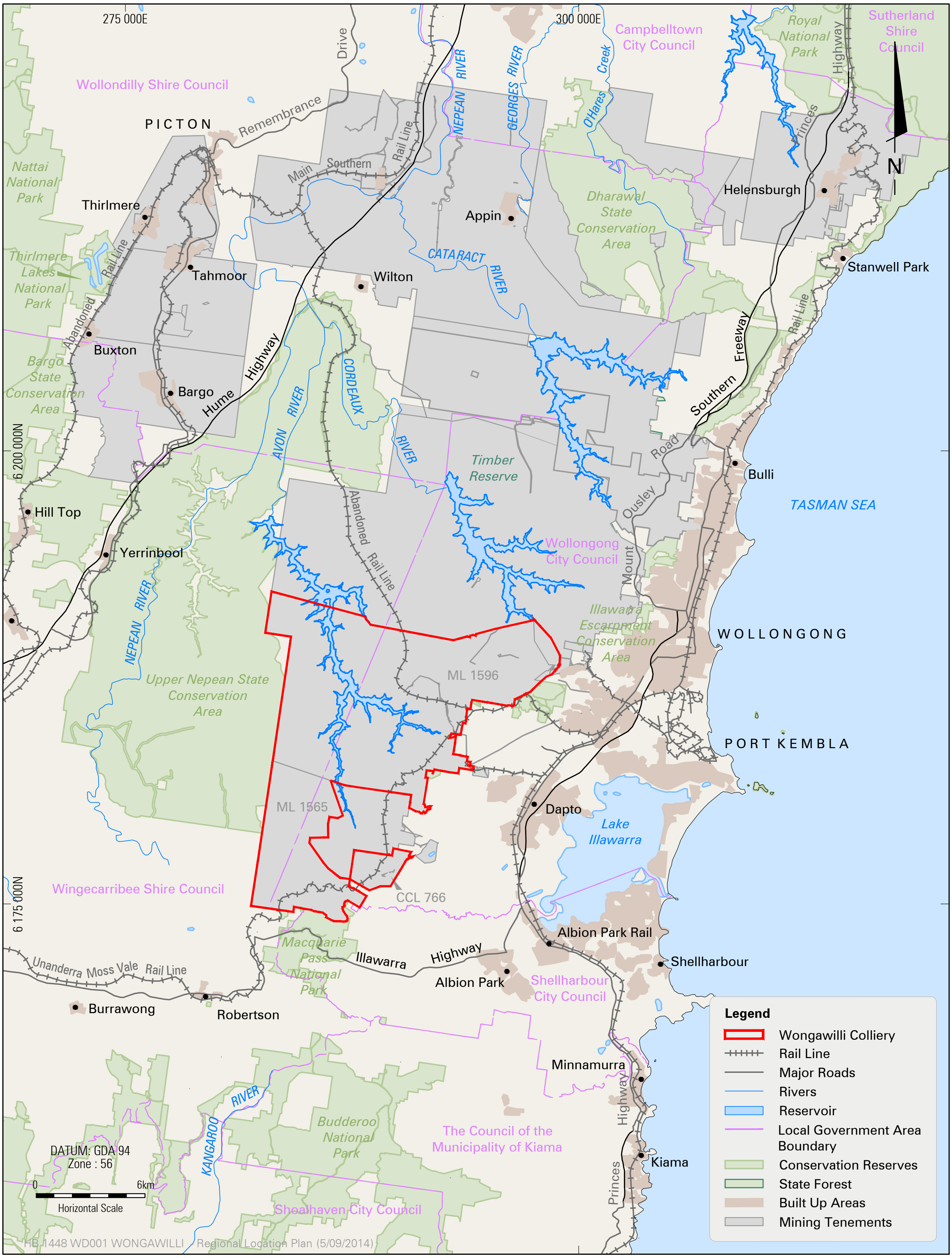
Wongawilli Coal Pty Limited operates the Wongawilli Colliery in the Southern Coalfield of New South Wales. Wongawilli Coal Pty Limited is a wholly owned subsidiary of Wollongong Coal Limited (WCL), formerly known as Gujarat NRE Coking Coal Limited. Wongawilli Colliery is located approximately 15 km south-west of Wollongong (see **Figure 1**), within the Wollongong and Wingecarribee Local Government Areas (LGAs).

Mining activities have been undertaken at the site since 1912. The WCL Wongawilli Colliery amalgamates the mining areas of the historical Elouera, Huntley and Avondale Collieries. Mining activities at Wongawilli Colliery are currently undertaken within Mining Lease (ML) 1565, ML 1596 and Consolidated Coal Lease (CCL) 766.

WCL has approval to mine six longwall panels (LW N1 to LW N6) in an area within ML 1596 known as the Nebo Area (see **Figure 2**). The Nebo Area includes Longwall N2 (LW N2), which is the subject of this End of Panel Report. LW N2 was the first of the longwall panels in the Nebo Area to be extracted. Secondary extraction of this panel was undertaken from 12 June 2013 to 26 February 2014. Extraction of LW N2 was undertaken in a south to north direction and was discontinued at the point where panel intersects the completed first workings in the Wongawilli seam (see **Figure 2**). Mining of LW N2 was suspended due to a roof fall on the longwall miner.

An Extraction Plan (formerly a Subsidence Management Plan) was prepared for longwall mining of LW N1 to LW N6 (Niche Environment and Heritage, 2012). This Extraction Plan was approved by the Division of Resources and Energy (DRE) on 25 January 2013. This End of Panel report has been prepared to satisfy the conditions of this Subsidence Management Plan (SMP) Approval (09/5341).

There is unlikely to be further extraction in LW N2 for an indeterminate period. As such, WCL has prepared this End of Panel Report which describes the subsidence effects and environmental consequences that resulted from the extraction of LW N2 (to date) and compares the observed impacts with earlier predictions. The information provided in this report has been collated by WCL and the specialist consultants responsible for environmental monitoring at Wongawilli Colliery.



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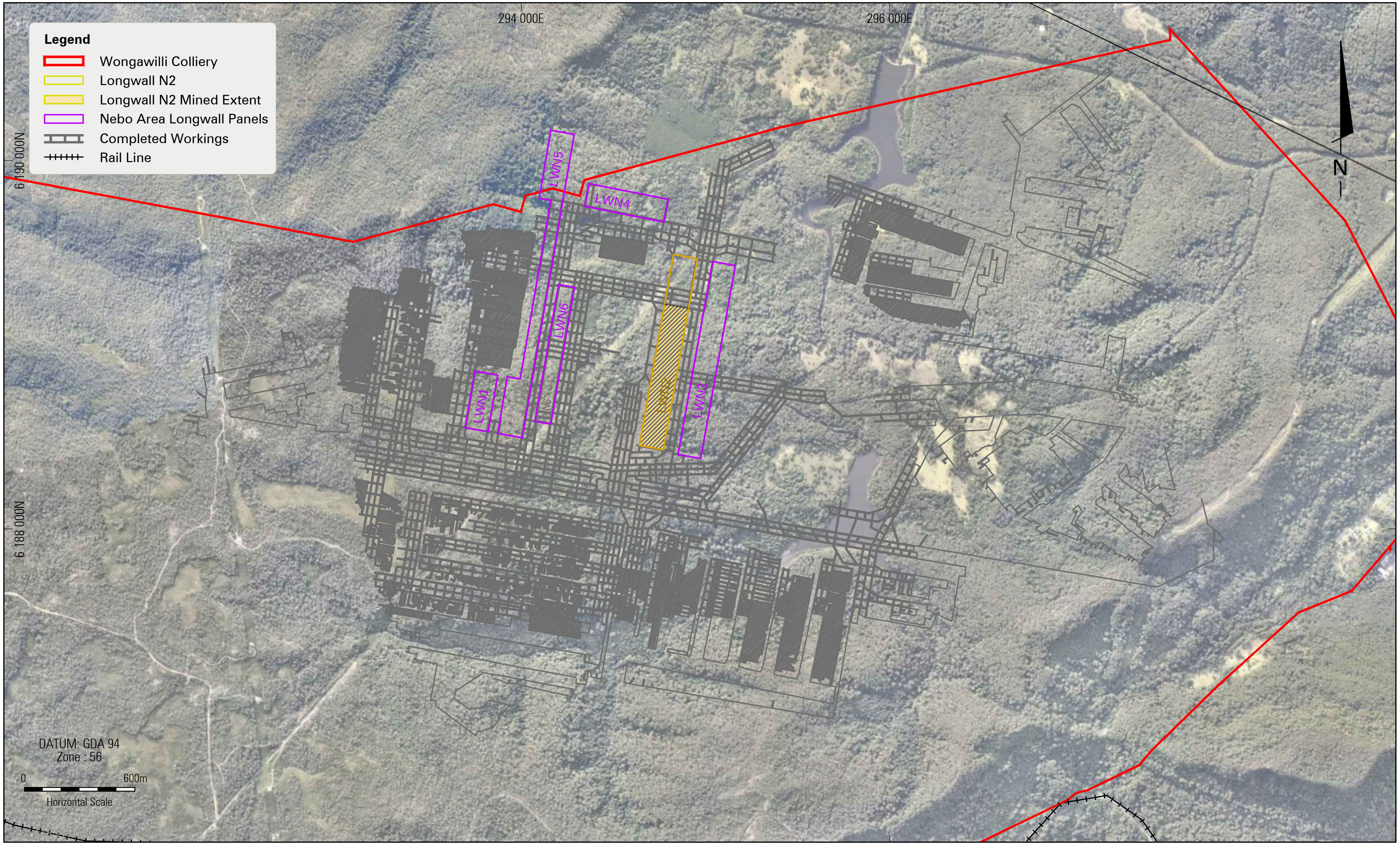
Regional Locality

FIGURE 1



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Site Layout

FIGURE 2

1.2. Regulatory Framework

In 2009, WCL made an application (MP 09_0162) for planning approval to mine six longwall panels (LW N1 to LW N6) in the Nebo Area. A detailed assessment of the potential subsidence related impacts of these longwall was presented in the *NRE Wongawilli Colliery Nebo Area Environmental Assessment* (ERM, 2010) (Nebo EA). These workings are located within the Wongawilli coal seam. Project Approval under section 75J of the *Environmental Planning and Assessment Act 1979* (EP&A Act) was granted on 2 November 2011. Project Approval 09_0162 enables mining activities in the Nebo Area to take place until 31 December 2015.

In accordance with the conditions of Project Approval and ML 1596, WCL prepared an Extraction Plan for LW N1 to LW N6 in the Nebo Area, for which SMP Approval (09/5341) was granted. Condition 18 of SMP Approval 09/5341 requires that an End of Panel Report be prepared following the completion of a longwall panel. Condition 18 also outlines the requirements for an End of Panel Report.

Table 1 lists each of these requirements and indicates where these requirements have been addressed in this report.

Table 1
End of Panel Report Requirements

Requirement	Relevant Sections
Within 4 months of the completion of each longwall panel, an end of panel report must be submitted to the Director-General. The end of panel report must: a) Include a summary of the subsidence and environmental monitoring results for the applicable longwall panel;	**Sections 2, 3 & 4**
b) Include an analysis of these monitoring results against the relevant: • Impact assessment criteria; • Monitoring results from previous panels; • Predictions in the SMP	**Sections 2, 3 & 4** LW N2 is the first panel mined in the Nebo Area
c) Identify any trends in the monitoring results over the life of the activity; and	**Sections 2, 3 & 4**
d) Describe what actions were taken to ensure adequate management of any potential subsidence impacts due to longwall mining.	**Section 5**

1.3. Report Structure

This End of Panel Report is structured as follows:

- **Section 2** presents the subsidence predictions contained in the Nebo EA and the SMP and summarises the subsidence effects measured during the mining of LW N2;
- **Section 3** describes the environmental consequences of subsidence that relate to built features and compares predicted environmental consequences with actual observations;
- **Section 4** describes the environmental consequences of subsidence that relate to natural features and compares predicted environmental consequences with actual observations;
- **Section 5** outlines the management and mitigation measures that have been and will be implemented to minimise and / or remediate environmental consequences;
- **Section 6** defines the abbreviations and terminology used in this report; and
- **Section 0** lists the sources referenced in this report.

Detailed analyses of monitoring results are provided in the appendices to this report, including:

- **Appendix A** provides a comprehensive discussion of subsidence monitoring results;
- **Appendix B** discusses impacts on Indigenous and historical heritage sites;
- **Appendix C** provides a comprehensive discussion of surface water and groundwater monitoring results; and
- **Appendix D** discusses impacts on aquatic and terrestrial ecology.

2. SUBSIDENCE EFFECTS

Strata Control Technology (SCT) has undertaken a detailed analysis of subsidence monitoring data and has compared the observed subsidence to the predictions in the Extraction Plan. This report is provided in **Appendix A**. A summary is provided below.

2.1. Mining Parameters

The depth of cover for LW N2 ranges from approximately 280 m at its southern end to 125 m at its northern end. A subsidence monitoring line (300 Line) crosses the panel at approximately mid-panel. The depth of cover at this subsidence monitoring line is approximately 180 m. Subsidence monitoring lines are shown on **Figure 3**.

The completed mining of LW N2 has generated a void that is approximately 789 m long and 132 m wide. The extraction height for the completion section of LW N2 ranged from 3.3 m to 3.4 m.

The overburden sequence has been intruded by a crinanite sill. This sill varies in thickness from 55 m to 98 m. The base of the sill is located 70 m to 120 m above the longwall panel, with the greatest separation occurring at the southern end of the panel.

2.2. Predicted Subsidence

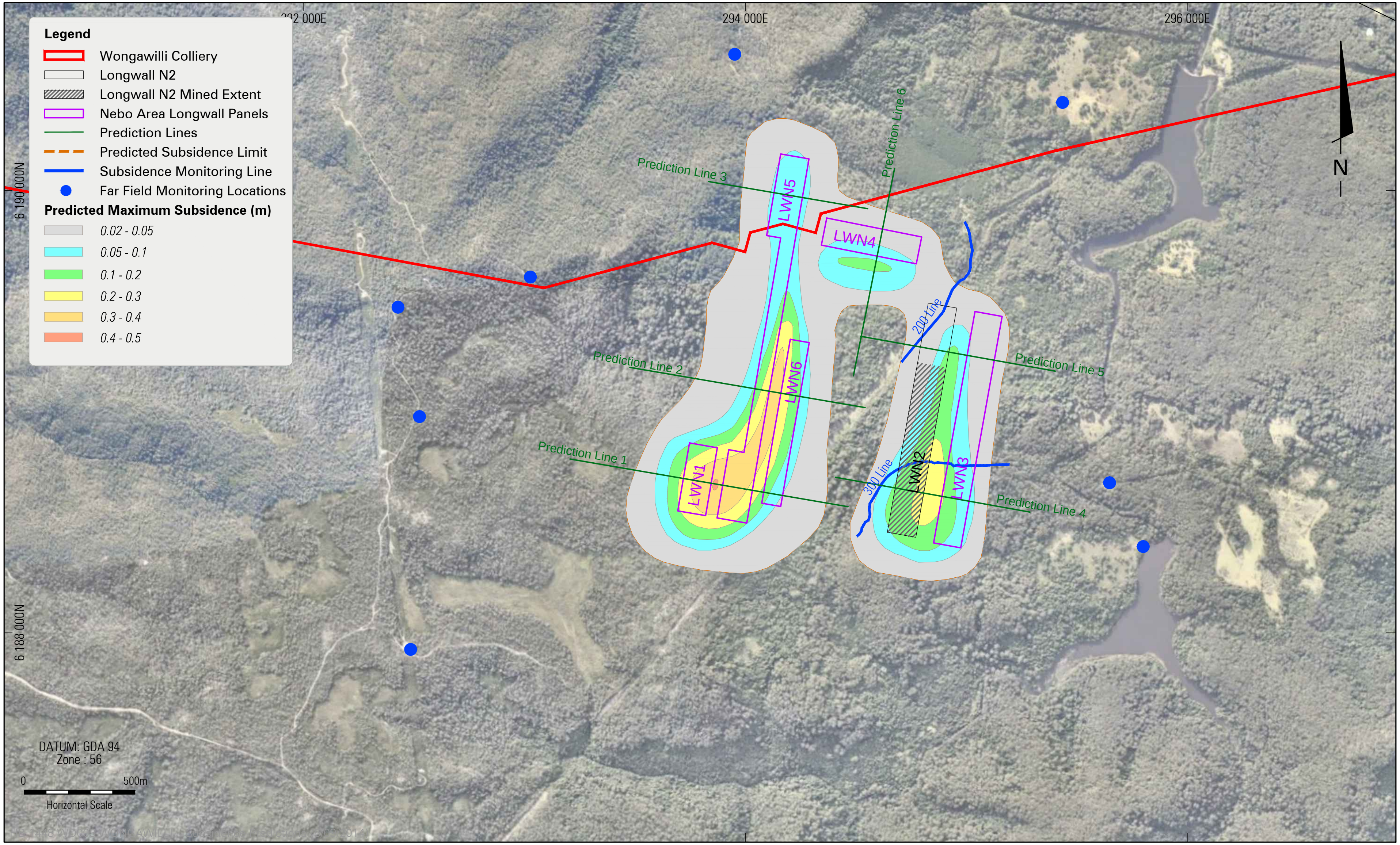
Mine Subsidence Engineering Consultants (MSEC) predicted the subsidence effects and consequences resulting from mining of the Nebo Area longwall panels. These subsidence predictions were included in the Extraction Plan. The predicted systematic subsidence is shown in **Figure 3**.

MSEC provided predictions of subsidence effects using six prediction lines (see **Figure 3**). Prediction Line 4 intersects both LW N2 and LW N3. For the purposes of comparing predictions with measured values, Prediction Line 4 is most comparable to the 300 Line.

MSEC predicted the following systematic subsidence movements for LW N2 and LW N3:

- Maximum conventional subsidence of 230 mm;
- Maximum conventional tilt of 1.7 mm/m;
- Maximum tensile strain of 0.3 mm/m; and
- Maximum compressive strain of 0.5 mm/m.

Predictions are only available for the cumulative impacts of LW N2 and LW N3. As expected, the recorded subsidence effects are less than the predicted values for LW N2 and LW N3.



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Subsidence Predictions and Monitoring

FIGURE 3

2.3. Subsidence Monitoring Measures

The 300 Line follows an access road that crosses LW N2 at approximately mid-panel length. The 300 Line serves as the mid-panel crossline.

A second subsidence monitoring line (200 Line) has been established along the alignment of a nearby 33 kV transmission line (see **Figure 3**).

To measure far-field movements, nine pegs remote from the panel were surveyed using GPS. These far-field monitoring locations are shown on **Figure 3**.

2.4. Observed Subsidence

Mining of LW N2 to date has resulted in minimal systematic subsidence. The maximum vertical subsidence measured along the 300 Line is 92 mm. Vertical subsidence of approximately 90 mm occurs uniformly along the central 100 m of the panel width. The uniformity of the vertical subsidence is consistent with bridging of the overlying crinanite sill. As a result, there is minimal sagging above the panel void. Rather, the observed subsidence is due to compression of the abutment coal. This compression tapers symmetrically from the goaf edge for a distance of about 200 m on both sides of the panel. The result is a broad zone of low magnitude compression that is approximately 500 m wide.

The measured maximum tilt is approximately 90 mm over a distance of 200 m, equating to a tilt of less than 0.5 mm/m. This level of tilt is imperceptible for all practical purposes.

The horizontal movements measured on 300 Line are smaller than the vertical subsidence movements. Measured horizontal movement along the axis of the panel is less than the survey tolerance of ±20mm. Horizontal movement across the panel is symmetrical about the centreline of the panel, with peak movement of approximately 30 mm occurring at a distance of 100 m out from the goaf edge. Measured horizontal strain is in the order of 30 mm over 150 m (or 0.2mm/m). This level of strain is imperceptible for all practical purposes.

As shown in **Table 2**, the subsidence effects measured during mining of LW N2 are substantially lower than the predictions for the cumulative impact of LW N2 and LW N3. The observed subsidence movements resulting from mining of LW N2 are consistent with these predictions.

Table 2
Comparison of Predicted versus Observed Subsidence

	Maximum Vertical Subsidence (mm)	Maximum Tilt (mm/m)	Maximum Tensile Strain (mm/m)	Maximum Compressive Strain (mm/m)
Predicted Subsidence for LW N2 and LW N3	230	1.7	0.3 – 0.4	0.5
Observed Subsidence for LW N2	92	0.5	0.2	0.2

3. BUILT FEATURES

3.1. Surface Infrastructure

SCT has assessed the impacts of the observed subsidence movements on surface infrastructure. SCT has also compared the observed environmental consequences with the predictions in the Extraction Plan. This analysis is provided in **Appendix A** and is summarised in this section.

3.1.1. Description of Features

Two 33 kV electricity transmission lines pass over the northern portion of LW N2 (see **Figure 4**). The portion of LW N2 directly beneath the transmission lines has not been mined to date. One transmission line is owned by Sydney Water and is used to supply power to the Avon pump station. The other transmission line is owned by WCL and used to supply power to the No. 4 Ventilation Shaft Site for Wongawilli Colliery. Both 33 kV transmission lines are supported by timber poles.

An unsealed 4WD track crosses LW N2 and LW N3.

3.1.2. Predicted Consequences

Transmission Lines

The Extraction Plan predicted that the transmission lines will be subject to maximum vertical subsidence of 40 mm and maximum tilt of <0.1 mm/m. These small subsidence movements are unlikely to impact the poles supporting these transmission lines.

Access Tracks and Fire Trails

Subsidence movements along the unsealed 4WD track were predicted to be similar to the predicted profile for Prediction Line 4. The maximum predicted tensile and compressive strains were 0.3 mm/m and 0.5 mm/m respectively. These small subsidence movements are unlikely to impact the use of this track.

3.1.3. Observed Consequences

Transmission Lines

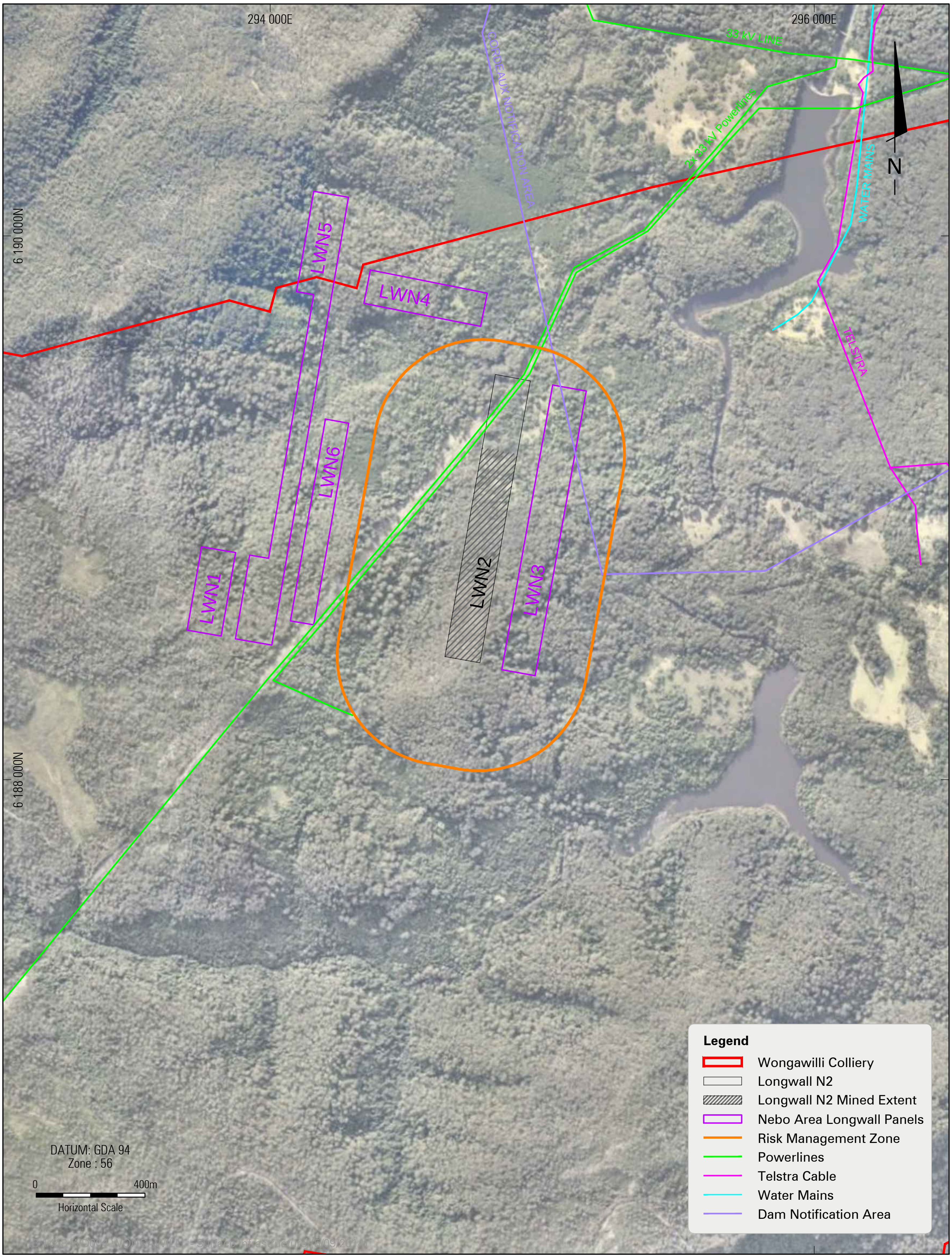
The poles along the two 33kV transmission lines were surveyed for tilt in both directions using an electronic protractor. The surveys found that no detectable tilts were observed within the 0.5 mm/m accuracy of the measurement system used.

The nearest power poles are PP15 and PP16. PP16 is likely to have experienced up to 30 mm of subsidence and a similar level of eastward horizontal movement toward LW N2. PP15 is likely to have subsided or moved southward 20 mm. The other poles on the line are unlikely to have experienced any subsidence movements as a result of mining LW N2.

The observed tilts and strains are very small and do not present any risk of impacts to these transmission lines.

Access Tracks and Fire Trails

The observed levels of subsidence, tilt and strain do not have the potential to cause any significant impacts to access tracks and fire trails.



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Surface Infrastructure

FIGURE 4

3.2. Heritage Sites

Biosis has assessed the impacts of the observed subsidence movements on heritage sites. Biosis has also compared the observed environmental consequences with the predictions in the Extraction Plan. This analysis is provided in **Appendix B** and is summarised below.

3.2.1. Description of Features

Three historic heritage sites are located within the Nebo Area (see **Figure 5**):

- Cordeaux River Historic Site 1;
- Cordeaux River Historic Site 2; and
- Cordeaux River Historic Site 3.

The Southern Coalfields Inquiry concluded that subsidence impacts resulting from longwall mining will generally occur within 400 m of the boundary of secondary extraction. The area within 400 m of the extracted extent of LW N2 has been adopted as the Risk Management Zone (RMZ). Monitoring is only necessary for heritage sites located within the RMZ.

Cordeaux River Historic Site 3 is the only heritage site located within the RMZ for LW N2. This site consists of non-native floral gardens, remains of building foundations and historical artefact scatters of glass, metals and ceramics.

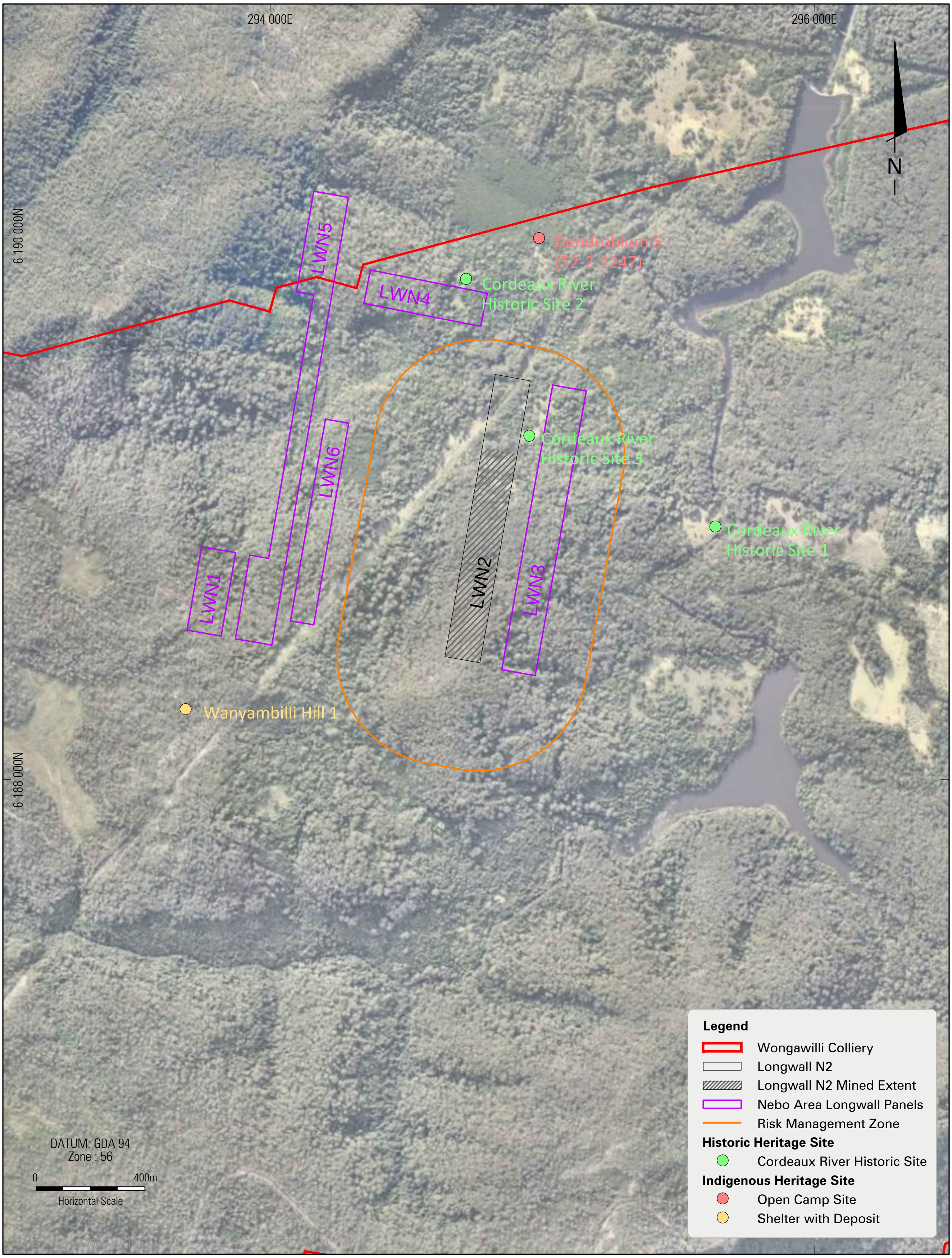
Two Indigenous heritage sites (Dendrobium 5 and Wanyambilli Hill 1) are located in the vicinity of the Nebo Area but are outside of the RMZ.

3.2.2. Predicted Consequences

The Extraction Plan predicted that Cordeaux River Historic Site 3 has the potential to be impacted through ground cracking or tree falls.

3.2.3. Observed Consequences

Baseline monitoring of Cordeaux River Historic Site 3 was undertaken on 9 November 2011. Subsequent monitoring was undertaken on 26 February 2014 (during mining) and 2 June 2014 (post-mining) to determine whether there were any impacts caused by mining of LW N2. No changes to the condition of the artefact scatter were observed. Accordingly, mining of LW N2 did not trigger any management actions under the Trigger Action Response Plan (TARP) contained in the Extraction Plan.



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Heritage Sites

FIGURE 5

4. NATURAL FEATURES

4.1. Surface Water

GeoTerra has assessed the impacts of the observed subsidence movements on streams, and has compared the observed environmental consequences with the predictions in the Extraction Plan. This analysis is provided in **Appendix C** and is summarised in this section.

4.1.1. Description of Features

The streams in the vicinity of the Nebo Area are Wattle Tree Creek, Little Wattle Tree Creek and Jacksons Creek. Wattle Tree Creek is a third-order stream immediately north of LW N2. Baseflow supports continuous flow in the 3rd order reaches of this stream. Jacksons Creek is a 2nd order tributary of Wattle Tree Creek.

Little Wattle Tree Creek is a 2nd order stream characterised by a series of small boulder and cobble based pools. Wattle Tree Creek and Little Wattle Tree Creek both drain to Upper Cordeaux no. 2 Reservoir.

4.1.2. Predicted Consequences

Due to the small magnitude of the predicted strains and tilts, there was not expected to be any impact on stream flows.

Mining of LW N2 has the potential to result in a change to surface water chemistry. There was predicted to be the potential for increased iron hydroxide precipitation and lowering of pH.

4.1.3. Observed Consequences

The surface water monitoring network consists of five sites across Wattle Tree Creek, Little Wattle Tree Creek and Jacksons Creek. These monitoring locations are shown in **Figure 6**. Surface water monitoring has been undertaken at these monitoring locations since 2009.

Compared with baseline data, mining of LW N2 did not have any observable impact on the water levels in Wattle Tree Creek, Little Wattle Tree Creek and Jacksons Creek.

Water quality monitoring data indicates that salinity ranges from 50 – 250 µS/cm and pH ranges from 5.5 to 8.0. Elevated pH readings (up to 10.0) were identified to be a result of cement contamination of the pH probe. Laboratory analyses indicate that concentrations of nitrogen, phosphorous and some metals are regularly above the thresholds in the ANZECC guidelines. This is consistent with the background water quality monitoring data.

Compared to baseline conditions, mining of LW N2 did not result in any observable changes to water quality beyond variability caused by climatic influences.

The observed impacts do not trigger any management actions under the TARP contained in the Extraction Plan.

4.2. Groundwater

GeoTerra has assessed the impacts of the observed subsidence movements on groundwater systems as a result of mining LW N2, and has compared the observed environmental consequences with the predictions in the Extraction Plan. This analysis is provided in **Appendix C** and is summarised in this section.

4.2.1. Description of Features

The crinanite sill is the dominant structure in the overburden sequence. This sill is up to 98 m thick and possesses very low hydraulic conductivity. The crinanite acts as an aquitard, providing separation between the creeks and the coal seams.

The crinanite is underlain by the sedimentary units of the Narrabeen Group. The sandstones within the Narrabeen Group provide porous storage but with limited transmitting capacity. The mudstones, siltstones and shales within the Narrabeen Group are effectively aquitards. The Bulli, Balgownie and Wongawilli coal seams underlie the Narrabeen Group.

4.2.2. Predicted Consequences

Subsidence resulting from mining of LW N2 has the potential to increase rainfall recharge by increasing secondary permeability through fracturing of the rock strata. However, mining was not expected to result in interconnection of aquifers and aquitards within 20 m of the surface.

Depressurisation of groundwater systems was predicted to result in up to a 10 m reduction in water levels. Water levels were expected to recover as the newly developed secondary permeability is recharged. Water levels were expected to recover fully over time unless a new outflow path develops.

Mining of LW N2 has the potential to result in a change to groundwater chemistry. There was predicted to be the potential for increased iron and manganese hydroxide precipitation and a lowering of pH.

4.2.3. Observed Consequences

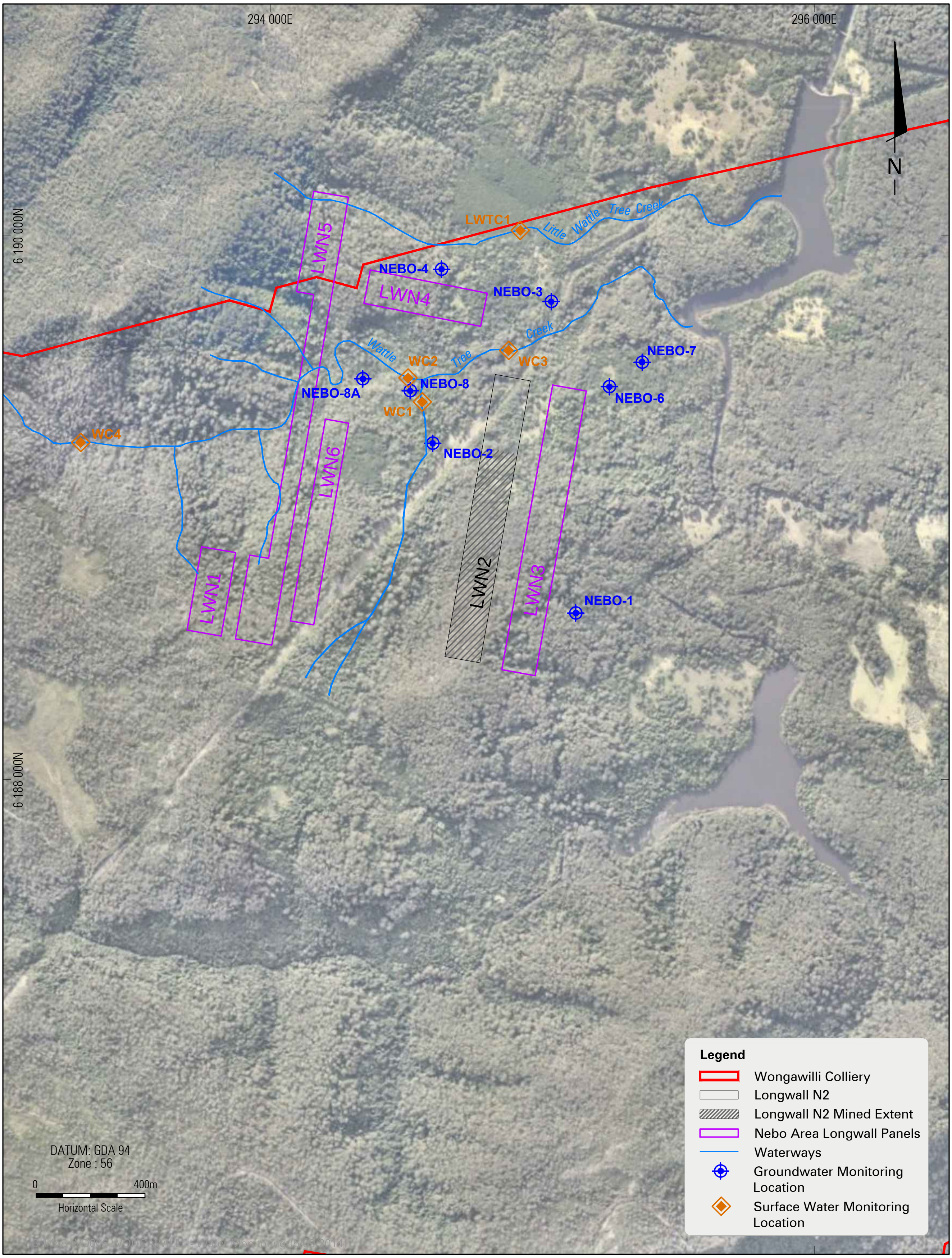
The groundwater monitoring network consists of 6 open standpipe piezometers and 4 vibrating wire piezometers (see **Figure 6**). All piezometers were installed during 2009 and 2010.

Monitoring data indicates that there has been no increase in the rate of groundwater recharge as a result of mining LW N2. Similarly, subsidence has not resulted in connectivity of aquifers and aquitards within 20 m of the surface.

Water level monitoring was undertaken for all locations prior to and during mining of LW N2. A decline in the water level was observed at piezometer Nebo1D. A maximum reduction of 8 m was observed, followed by the partial recovery of the water level. To date, the water level has recovered to approximately 4 m below pre-mining levels and expected to continue to recover. This impact is within the predicted maximum drawdown of 10 m. No responses to mining have been recorded at any of the other monitoring locations.

A number of the monitoring locations exhibited elevated pH (alkalinity) due to cement contamination during installation or sampling. Groundwater samples also contained elevated concentrations of metals due to the elevated solubility of metals in alkaline conditions. Groundwater quality during mining was similar with baseline monitoring data, indicating that mining of LW N2 did not have any impacts on groundwater quality.

The observed impacts did not trigger any management actions under the TARP contained in the Extraction Plan.



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Water Monitoring

FIGURE 6

4.3. Aquatic Ecology

Biosis has assessed the impacts of the observed subsidence movement on aquatic ecology, and has compared the observed environmental consequences with the predictions in the Extraction Plan. This analysis is provided in **Appendix D** and is summarised in this section.

4.3.1. Description of Features

Wattle Tree Creek is relatively undisturbed and provides suitable habitat for an extensive suite of aquatic organisms. Wattle Tree Creek exhibits continuous flow characterised by small, shallow pools separated by frequent short riffle sequences.

Little Wattle Tree Creek is a second-order stream located north of Wattle Tree Creek. Little Wattle Tree Creek is an ephemeral stream characterised by small pools that dry out during prolonged dry periods. Little Wattle Tree Creek provides limited habitat for aquatic organisms.

Three listed aquatic species are considered as having the potential to occur in the vicinity of the Nebo Area:

- Adam's Emerald Dragonfly (*Archaeophya adamsi*);
- Sydney Hawk Dragonfly (*Austrocordulia leonardi*); and
- Macquarie Perch (*Macquaria australasica)*.

4.3.2. Predicted Consequences

The systematic tilts and strains resulting from mining of LW N2 were predicted to be minimal. The strains were not expected to result in cracking of the bedrock along the streams. The predicted tilts were not expected to result in additional ponding, flooding or scouring. Accordingly, mining of LW N2 was not expected to impact threatened species and populations in Wattle Tree Creek and Little Wattle Tree Creek.

4.3.3. Observed Consequences

Aquatic ecology monitoring in the Nebo Area has been undertaken since March 2011. The following seasonal surveys have been completed to date:

- Autumn 2011;
- Autumn and Spring 2012;
- Autumn and Spring 2013; and
- Autumn 2014.

The ecological monitoring program utilises a Before-After Control Impact (BACI) design. This approach involves comparing sites that are predicted to be subject to subsidence (known as impact sites) with sites that are not predicted to be subject to subsidence (known as control sites). A BACI approach also involves comparing impact sites before and after mining (see **Figure 7**). A visual habitat inspection (HABSCORE) was undertaken at each monitoring site. Water quality monitoring was also undertaken at each site during each survey period. No adverse impacts on water quality have been observed during and after mining of LW N2.

The monitoring undertaken to date has found that the ecological values at the impact sites have remained consistent with baseline data. The ecological values at the impact sites are also comparable with those at the control sites. Therefore, mining of LW N2 has not adversely impacted the threatened species and populations in Wattle Tree Creek and Little Wattle Tree Creek.

4.4. Terrestrial Ecology

Biosis has assessed the impacts of the observed subsidence movement on terrestrial ecology, and has compared the observed environmental consequences with the predictions in the Extraction Plan. This analysis is provided in **Appendix D** and is summarised in this section.

4.4.1. Description of Features

Eleven vegetation communities were identified within the Nebo Area. Two rare flora species listed on the Rare or Threatened Australian Plants (RoTAP) register were recorded, namely *Darwinia grandiflora* and *Boronia fraseri*. An additional 12 rare and threatened flora species have the potential to occur.

The following threatened species were recorded in the Nebo Area during ecological surveys:

- Rosenberg's Goanna;
- Giant Dragonfly;
- Powerful Owl;
- Beautiful Firetail;
- Southern Emu Wren;
- Eastern Bent-wing Bat; and
- Koala.

No threatened frog species were recorded, however the following species are considered as having the potential to occur:

- Giant Burrowing Frog;
- Red-crowned Toadlet;
- Littlejohn's Tree Frog; and
- Stuttering Barred Frog.

4.4.2. Predicted Consequences

Subsidence has the potential to impact terrestrial species and populations through a variety of mechanisms, including:

- Cracking of bedrock and changes to morphology of streams;
- Changes to stream water quality;
- Depressurisation of groundwater systems;
- Tree falls due to tilt; and
- Cracking or collapse of clifflines.

Due to the small magnitude of the predicted subsidence movements, terrestrial species and populations were not expected to be impacted by mining of LW N2.

4.4.3. Observed Consequences

The terrestrial ecology monitoring network is shown in **Figure 8**. The ecological monitoring program utilises a BACI design. This approach involves comparing sites that are predicted to be subject to subsidence (known as impact sites) with sites that are not predicted to be subject to subsidence (known as control sites). A BACI approach also involves comparing impact sites before and after mining.

Terrestrial ecological monitoring in the Nebo Area has been undertaken since Spring 2010. The following seasonal surveys have been completed to date:

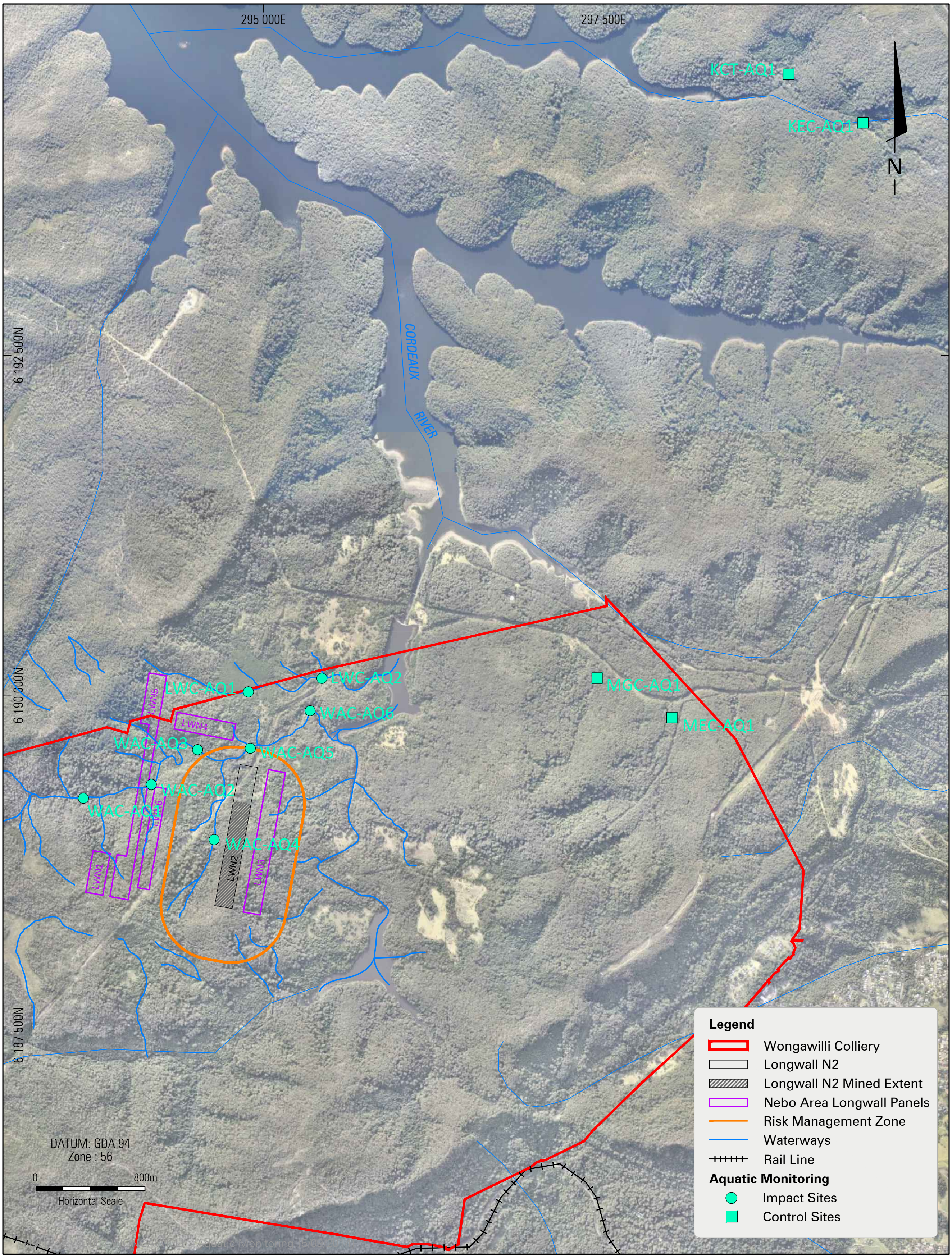
- Spring 2010;
- Autumn and Spring 2011;
- Autumn and Spring 2012;
- Autumn and Spring 2013; and
- Autumn 2014.

All of the monitoring sites are established at a creek location. At each monitoring site, riparian vegetation surveys are undertaken within three quadrats (20 m x 20 m). A subjective cover abundance score is given for each quadrat using a modified Braun-Blanquet scale. In additional, nocturnal frog surveys are undertaken along three transects (50 m long) at each monitoring site. Monitoring of riparian vegetation was also undertaken at the control sites between 2004 and 2009.

Based on the monitoring undertaken to date, there are no observable impacts on terrestrial species and populations as a result of mining LW N2. Mining of LW N2 has not triggered any management actions under the TARP contained in the Extraction Plan.

5. MANAGEMENT AND MITIGATION MEASURES

As discussed in **Sections 3**, **4** and **5**, the observed subsidence effects and environmental consequences during mining of LW N2 are less than the predicted effects and consequences for LW N2 and LW N3. The observed effects and consequences have not activated any of the triggers under the relevant TARPs. Therefore, no additional management or mitigation measures are necessary. WCL will continue to monitor subsidence effects and environmental consequences in accordance with its approved management plans and record the observations for the cumulative mining of LW N2 and LW N3.



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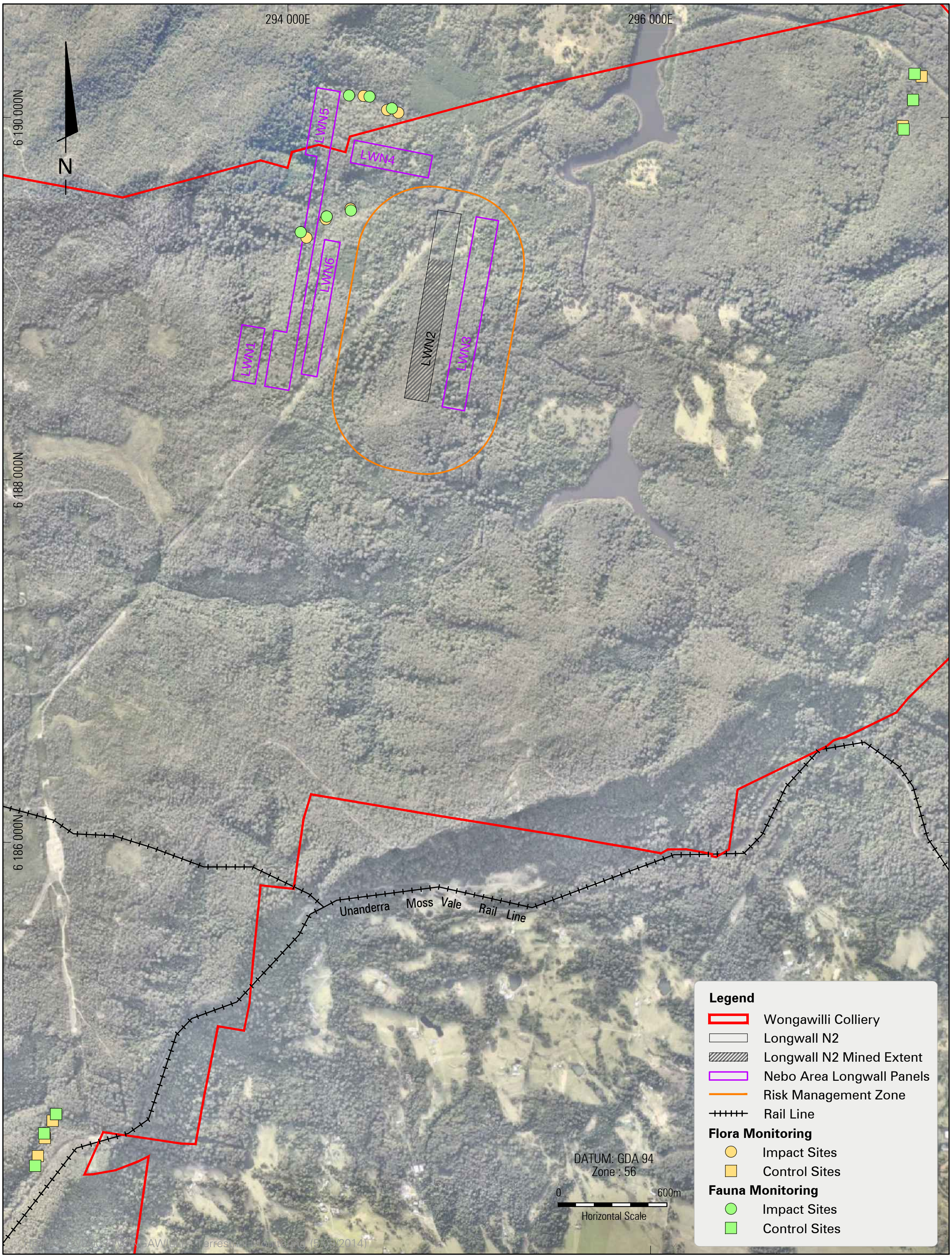
Aquatic Ecology Monitoring

FIGURE 7



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Terrestrial Ecology Monitoring

FIGURE 8

6. ABBREVIATIONS

Table 3
Abbreviations

Term	Definition
ANZECC	Australian and New Zealand Environment Conservation Council
BACI	Before-After Control-Impact
CCL	Consolidated Coal Lease
DRE	Division of Resources and Energy (with the Department of Trade & Investment, Regional Infrastructure and Services)
EP&A Act	*Environmental Planning & Assessment Act 1979*
GPS	Global Positioning System
kV	Kilovolt
LGA	Local Government Area
LW	Longwall
ML	Mining Lease
MSEC	Mine Subsidence Engineering Consultants
Nebo EA	*NRE Wongawilli Colliery Nebo Area Environmental Assessment* (ERM, 2010)
RoTAP Register	Rare or Threatened Australian Plants Register
SMP	Subsidence Management Plan
TARP	Trigger Action Response Plan
WCL	Wollongong Coal Limited

7. REFERENCES

- ERM (2010) NRE Wongawilli Colliery Nebo Area Environmental Assessment
- Niche Environment and Heritage (2012), *NRE Wongawilli Colliery Nebo Longwalls N1-N6 Extraction Plan November 2012 – Revision 1*

8. CONTROL AND REVISION HISTORY

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1	04/09/14	Andrew Wu Hansen Bailey	Draft for WCL review
2	04/09/14	David Clarkson WCL	Minor amendments
3			

APPENDIX A
Wongawilli Colliery – LWN2
End of Panel Subsidence Report

Strata Control Technology

R E P O R T T O :

WOLLONGONG COAL LIMITED

Wongawilli Colliery – LWN2 End of Panel Subsidence Report

WCW04319

Mining Research and Consulting Group
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REPORT TO	David Clarkson Group Environment Manager Wollongong Coal Limited 7 Princes Highway, cnr Bellambi Lane Corrimal NSW 2518
SUBJECT	Wongawilli Colliery – LWN2 End of Panel Subsidence Report
REPORT NO	WCW04319
PREPARED BY	Ken Mills
DATE	29 August 2014

Ken Mills
Principal Geotechnical Engineer

SUMMARY

Wollongong Coal Limited (WCL) has mined Longwall LWN2 in the Wongawilli Seam at Wongawilli Colliery. Mining commenced on 12 June 2013 and continued until 26 February 2014 when mining was suspended due to a roof fall on the longwall face. WCL measured the surface subsidence on one mid-panel subsidence line that follows an access road across the panel, a line along a power transmission line to the side of and north of the panel, and at a number of remote far field monitoring stations. WCL commissioned SCT Operations Pty Ltd (SCT) to analyse the subsidence monitoring, to compare the results with subsidence predictions made in the Extraction Plan / SMP (Niche 2012) based on the Part 3A Application (MSEC 2010), and to prepare a report suitable to meet the end of panel requirements for subsidence. This report presents the results of our analysis and review of the subsidence monitoring data from Longwall LWN2 in accordance with Condition 18 of SMP Approval 09/5341.

Vertical subsidence was measured above LWN2 with a nominal survey accuracy of ±20mm consistent with normal survey practice. A maximum measured value of approximately 90mm was observed uniformly across the central 100m of the panel. This level of movement is imperceptible for all practical purposes. There is no significant sag directly over the panel consistent with the anticipated bridging of the crinanite. All the subsidence comes from compression of the abutment coal. This compression tapers symmetrically from the goaf edge for a distance of about 200m on both sides of the panel and represents a broad zone of compression that is about 500m wide and of low magnitude.

The subsidence behaviour observed above LWN2 is consistent with the predictions made in the EP/SMP and Part 3A Application. Subsidence predictions of 230mm and 110mm were made on Prediction Lines 4 and 5 respectively for the combined extraction of Longwalls LWN2 and LWN3. The 300 Line subsidence monitoring line is located between these two prediction lines. The maximum measured subsidence on the 300 Line after completion of mining of LWN2 was approximately 90mm and so is within the range that would be expected for just the first panel mined. Maximum tilts were predicted to be between 1.2mm/m and 1.7mm/m. The measured maximum tilt was 0.5mm/m and less than predicted. Maximum strains were predicted to be 0.3-0.4mm/m in tensile and 0.5mm/m compressive. Maximum measured strains were 0.2mm/m in both tension and compression and less than predicted.

Horizontal movements measured on 300 Line are smaller than the vertical subsidence. Horizontal movements along the axis of the panel are less than survey tolerance of ±20mm. Horizontal movements across the panel are symmetrical about the centreline of the panel with peak movement of about 30mm occurring at a distance of 100m out from the goaf edge.

Bridging of the crinanite intrusion within the overburden strata has limited the magnitude of the maximum subsidence and associated parameters to the low levels observed. These low levels of subsidence, horizontal

movement, tilt, and strain are imperceptible for all practical purposes and are not considered to have any potential to cause any significant impacts to power lines, access roads, or any other man-made or natural features in the vicinity of LWN2 consistent with the predictions made in the EP/SMP and Part 3A Application.

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1. INTRODUCTION

Wollongong Coal Limited (WCL) has mined Longwall LWN2 in the Wongawilli Seam at Wongawilli Colliery. Mining commenced on 12 June 2013 and continued until 26 February 2014 when mining was suspended due to a roof fall on the longwall face. WCL measured the surface subsidence on one mid-panel subsidence line that follows an access road across the panel, a line along a power transmission line to the side of and north of the panel, and at a number of remote far field monitoring stations. WCL commissioned SCT Operations Pty Ltd (SCT) to analyse the subsidence monitoring, to compare the results with subsidence predictions made in the Extraction Plan / SMP (Niche 2012) based on the Part 3A Application (MSEC 2010), and to prepare a report suitable to meet the end of panel requirements for subsidence. This report presents the results of our analysis and review of the subsidence monitoring data from Longwall LWN2 in accordance with Condition 18 of SMP Approval 09/5341.

The report is structured to provide a site description in Section 2, a summary of the results in Section 3, a comparison with predictions in Section 4, and conclusions in Section 5.

2. SITE DESCRIPTION

LWN2 is located 13km due west of Wollongong in NSW in the upper reaches of the Cordeaux River valley. The mining area was originally developed as part of Nebo Colliery but has subsequently been longwall mined by WCL from Wongawilli Colliery.

Figure 1 shows a plan of the mining layout superimposed onto a 1:25,000 topographic series map. The locations of the two subsidence monitoring lines are also shown. Some of the monitoring pegs on the 200 Line (northern line) near the end of LWN2 were disturbed by power line maintenance work during the period of monitoring and did not yield meaningful data.

The panel is located some 100-200m east of an unnamed tributary to Wattle Creek and was mined from south to north below a topographic spur that slopes to the north.

The panel is located outside the Dams Safety Committee Notification Area.

The panel created a void that is 132m wide and 789m long. The mining height on the longwall face ranged from 3.3m to 3.4m increasing locally at the dyke directly below the subsidence line over a narrow band. The depth to the mining horizon ranges from 280m at the start of the panel to 125m at the northern end and is approximately 180m directly below the mid-panel subsidence line.

The overburden strata in the general vicinity has been intruded by a crinanite (dolerite) sill as shown in Figure 2. This crinanite intrusion ranges in thickness from 55m to 98m generally thickening toward the south and east.

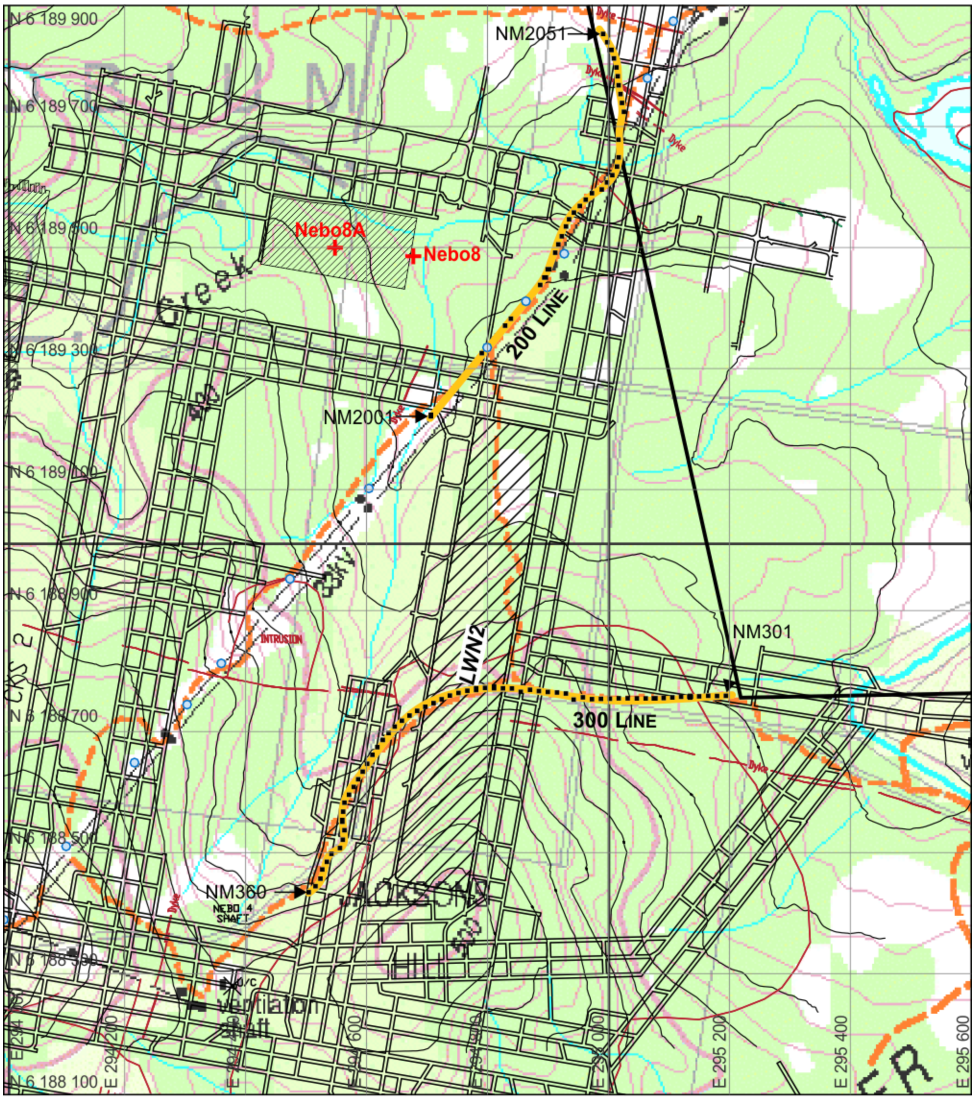

Figure: 1: Site plan showing location of LWN2 plotted on 1:25,000 series topographic map.

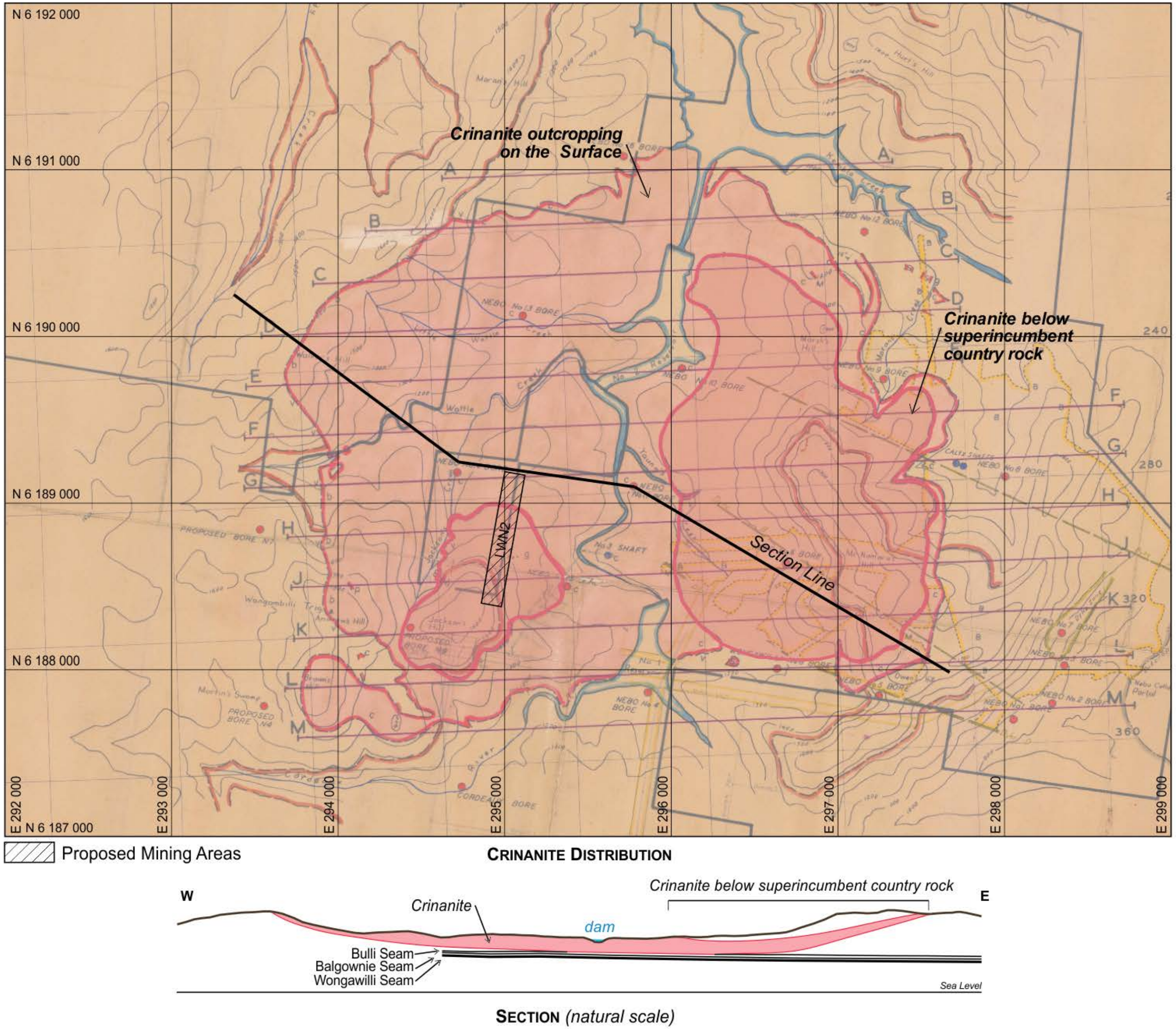

Figure 2: Crinanite distribution based on AIS Coal Geology Plan S3-64 *(accuracy is estimated to be generally better than 50m).*

The base of the crinanite is located approximately 70m above the mining horizon at the northern end of the panel and about 120m at the southern end of the panel. Exploratory work undertaken in support of the Part 3A Application for a panel to the northwest (SCT 2010) showed that a 65m section of the crinanite is sufficiently massive to be able to bridge across a 120m wide void at an overburden depth to the mining horizon of 116m. Subsidence behaviour is expected to have been significantly influenced by the presence of this crinanite sill.

3. SUBSIDENCE MONITORING RESULTS

In this section, the subsidence monitoring results from the mid panel cross-line (300 Line) located alongside an access road, the northern line (200 Line) located alongside the power transmission line, and the far field monitoring array are presented and discussed.

3.1 300 Line

The locations of the individual pegs on 300 Line are shown in Figure 1. The line follows an access track that crosses LWN2 in about the middle of the panel.

Figure 3 shows a plot of the subsidence movements measured on the 300 Line subsidence line with the horizontal axis plotted as distance relative to the western edge of the panel as if the line were located perpendicular to the panel. All three components of movement are plotted with the two horizontal components resolved into cross panel movements and along panel movements positive to the east and the north (i.e. the direction of mining).

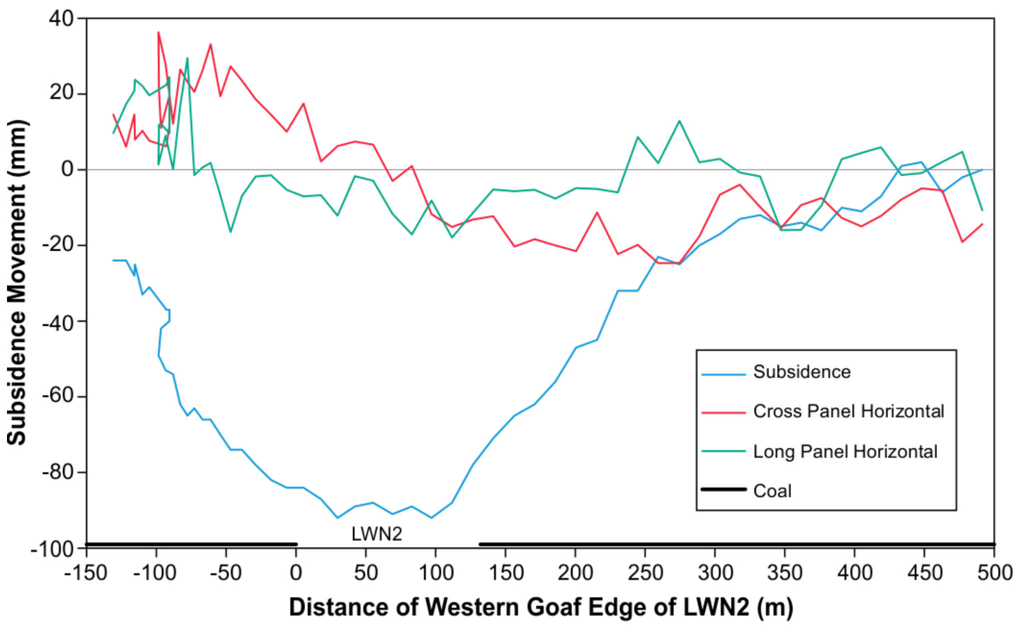

Figure 3: 300 Line subsidence movements measured above LWN2.

Vertical subsidence has been assumed to be zero at the eastern end of the line remote from mining and given the flat subsidence profile over the next 200m toward the longwall this appears to be a reasonable assumption. Vertical subsidence reaches a peak of approximately 90mm across the central 100m of the panel. For all practical purposes this level of subsidence is imperceptible.

There is no significant sag directly over the panel consistent with the anticipated bridging of the crinanite. All the subsidence comes from compression of the abutment coal. This compression tapers symmetrically from the goaf edge for a distance of about 200m on both sides of the panel and represents a broad zone of compression that is about 500m wide and of low magnitude.

Maximum tilt is about 90mm over 200m or less than 0.5mm/m. This level of tilt is imperceptible for all practical purposes.

The horizontal movements measured on 300 Line are smaller than the vertical subsidence. Horizontal movement along the axis of the panel is less than survey tolerance of ±20mm. Horizontal movement across the panel is symmetrical about the centreline of the panel with peak movement of about 30mm occurring at a distance of 100m out from the goaf edge.

Horizontal strain is of the order of 30mm over 150m or 0.2mm/m. This level of strain is imperceptible for all practical purposes.

3.2 200 Line

The positions of the pegs on 200 Line are shown in Figure 1. The pegs were initially set out at about 15m centres from Peg NM2001 in the south to PegNM2051 in the north. However, power line maintenance activities caused many of the pegs at the southern end of the line to be damaged.

Figure 4 shows a plot of the subsidence movements measured on the individual pegs that remain. The vertical and horizontal movements are plotted as a function of distance from the northern end of LWN2. Peg NM2001 is plotted as being 14m over the goaf, but it should be recognised that this peg is actually located 70m to the west of the western edge of the panel. The subsidence movements are determined relative to an assumed reference. In Figure 3, the data plotted has been adjusted to reduce offset errors by using the section of line 150m to 500m north of the line as a control and assuming this section has not moved as a result of mining subsidence. The adjustments to all the data have been 6mm down, 25mm to the east (for the eastward component), and 5mm to the south (for the northward component).

In general, the subsidence movements measured on 200 Line are less than survey tolerance. The eastward horizontal movement of 30mm observed on Peg NM2001 is consistent with the cross panel movements observed on 300 Line. The vertical subsidence is only just greater than survey tolerance but is also consistent with the 300 Line data recognising that subsidence is likely to be reduced around the end of the panel.

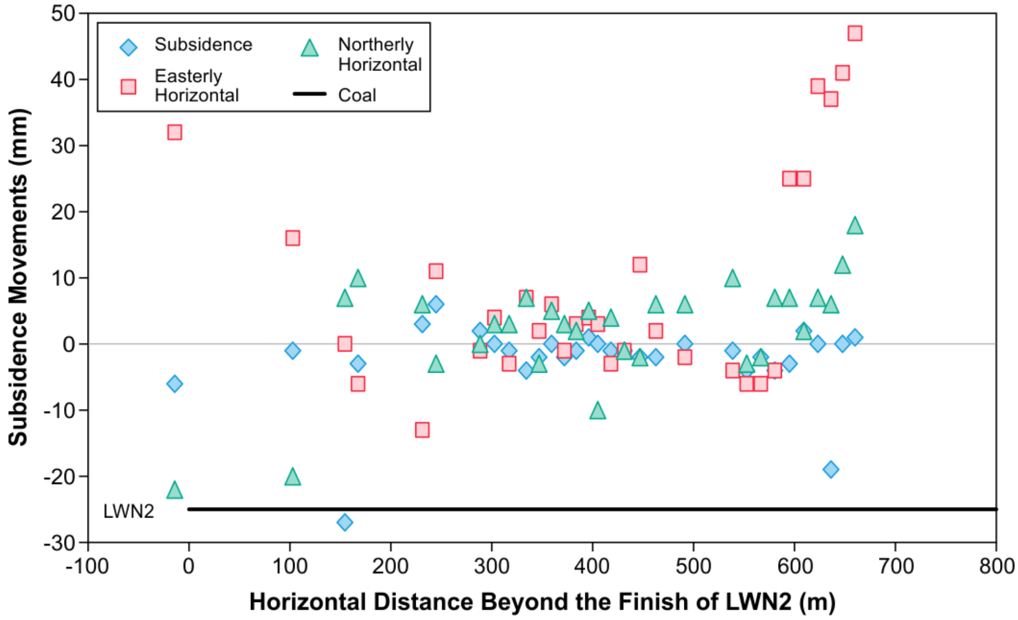

Figure 4: 200 Line subsidence movements measured north of LWN2.

The eastward horizontal movements on a group of pegs 600m to the north of the end of the panel is considered likely to be a survey control issue and not mining related.

3.3 Regional Ground Movements

An array of nine pegs located remote from LWN2 on all sides of the panel were surveyed using GPS to determine if there was any pattern of consistent far field movements that could be related to mining.

Figure 5 shows the locations of the points and the horizontal vectors of movement that were observed. There is no consistent pattern apparent. This result indicates that the survey results are random variations within survey tolerance rather than meaningful measurements of any systematic process. The low levels of far field movements are consistent with the low levels of horizontal ground movements observed immediately adjacent to the longwall panel on 300 Line.

3.4 Measurements on Power Poles

The poles on two 33kV power lines located to the west of LWN2 were surveyed for tilt in both directions using an electronic protractor. The surveyor reports that no detectable tilts were observed within the 0.5mm/m accuracy of the measurement system used.

The nearest poles on these lines are PP16, located 150m to the west of LWN2 about 180m from the point where the longwall has stopped, and PP15, located 105m north of where the longwall has stopped. PP16 is likely to have experienced up to 30mm of subsidence and a similar level of eastward horizontal movement toward LWN2. PP15 is likely to have subsided or moved southward 20mm. The other poles on the line are unlikely to have been impacted by mining subsidence at all.

Figure 5: Far-field horizontal movements measured on distributed array of pegs.

4. COMPARISON WITH PREDICTIONS

Mine Subsidence Engineering Consultants (MSEC) provided predictions of the subsidence parameters and likely impacts of mining in the Part 3A Application for Longwalls N1 to N6 (MSEC 2010) and these predictions were used in the EP/SMP Application (Niche 2012).

Figure 6 shows the predictions of subsidence that were made above LWN2. The subsidence behaviour observed above LWN2 is consistent with the predictions made in the EP/SMP and Part 3A Application.

Subsidence of 230mm and 110mm was predicted on Prediction Lines 4 and 5 respectively for the combined extraction of Longwalls LWN2 and LWN3. The 300 Line subsidence monitoring line is located between these two prediction lines. The maximum measured subsidence on the 300 Line after completion of mining of LWN2 was approximately 90mm and so is within the range that would be expected for just the first panel mined. Maximum tilts were predicted to be between 1.2mm/m and 1.7mm/m. The measured maximum tilt was 0.5mm/m and less than predicted. Maximum strains were predicted to be 0.3-0.4mm/m in tensile and 0.5mm/m compressive. Maximum measured strains were 0.2mm/m in both tension and compression and less than predicted.

The subsidence observed above LWN2 is considered to be consistent with the predictions made in the EP/SMP and Part 3A Application. Bridging of the crinanite intrusion within the overburden strata has limited the magnitude of the maximum subsidence and associated parameters to levels that are imperceptible for all practical purposes.

At these low levels of ground movement, there is considered to be no potential for significant impacts on the power lines, access roads, or any natural features including cliffs and steep slopes in the vicinity of LWN2.

5. CONCLUSIONS

Vertical subsidence above LWN2 reached a maximum measured value of approximately 90mm uniformly across the central 100m of the panel, and would be imperceptible for all practical purposes. There is no significant sag directly over the panel consistent with the anticipated bridging of the crinanite. All the subsidence comes from compression of the abutment coal. This compression tapers symmetrically from the goaf edge for a distance of about 200m on both sides of the panel and represents a broad zone of compression that is about 500m wide and of low magnitude.

Maximum average tilt is less than 0.5mm/m. The horizontal movements measured on 300 Line are smaller than the vertical subsidence. Horizontal movement along the axis of the panel is less than survey tolerance of ±20mm. Horizontal movement across the panel is symmetrical about the centreline of the panel with peak movement of about 30mm occurring at a distance of 100m out from the goaf edge. Maximum average horizontal strain is of the order of 30mm over 150m or 0.2mm/m.

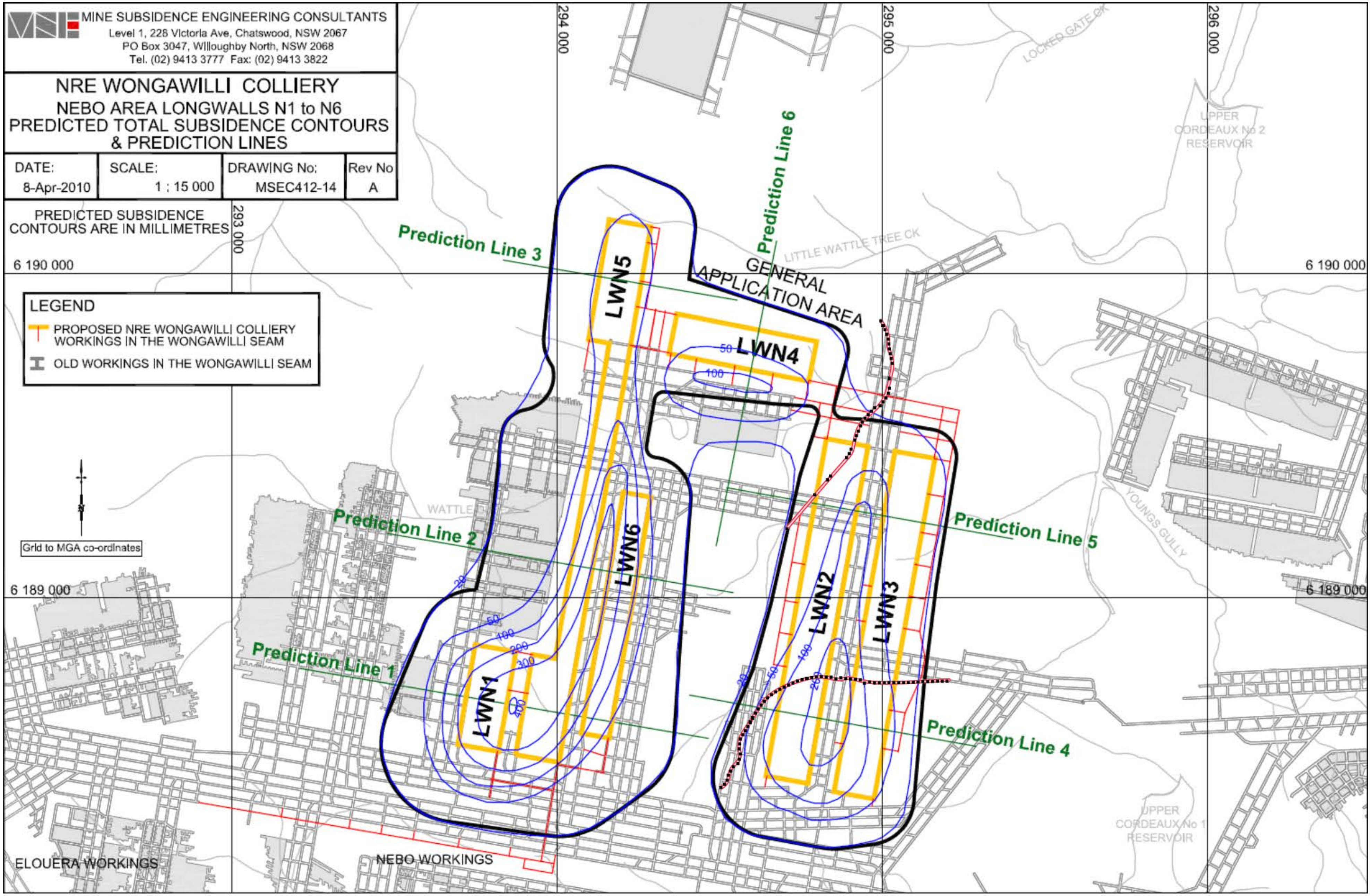

Figure 6: Subsidence predicted in MSEC (2010) with subsidence lines superimposed.

Bridging of the crinanite intrusion within the overburden strata has limited the magnitude of the maximum subsidence and associated parameters to the low levels observed. These low levels of subsidence, horizontal movement, tilt, and strain are imperceptible for all practical purposes and are not considered to have any potential to cause any significant impacts to power lines, access roads, or any other man-made or natural features in the vicinity of LWN2.

The subsidence behaviour observed above LWN2 is consistent with the predictions made in the EP/SMP and Part 3A Application.

6. REFERENCES

MSEC 2010 "Prediction of subsidence parameters and the assessment of mine impacts on natural features and surface infrastructure resulting from the proposed extraction of Longwalls N1 to N6 in the Nebo area in support of a Part 3A Application" Report to Gujarat NRE FCGL Pty Ltd, Report Number MSEC412, Revision B, dated June 2010.

Niche 2012 "NRE Wongawilli Colliery Nebo Longwalls N1-N6 Extraction Plan – November 2012 – Revision 1" Niche Environment and Heritage Report to Gujarat NRE Wonga Pty Ltd dated 22 November 2012.

SCT 2010 "Implications of Nebo 8/8A results for subsidence and groundwater modelling" SCT Report GUJW03548A dated 8 April 2010.

APPENDIX B

Nebo Area – Longwall 2
End of Panel Report (Heritage)

Nebo Area - Longwall N2
End of Panel Report (Heritage)

Prepared for Wollongong Coal Limited

4 September 2014

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- Wollongong Coal: Dave Clarkson, Kristen Lee
- Hansen Bailey: Andrew Wu and Dianne Munro

The following Biosis staff were involved in this project:

- Ashleigh Pritchard for mapping
- Alexander Beben and Nathan Garvey for quality assurance

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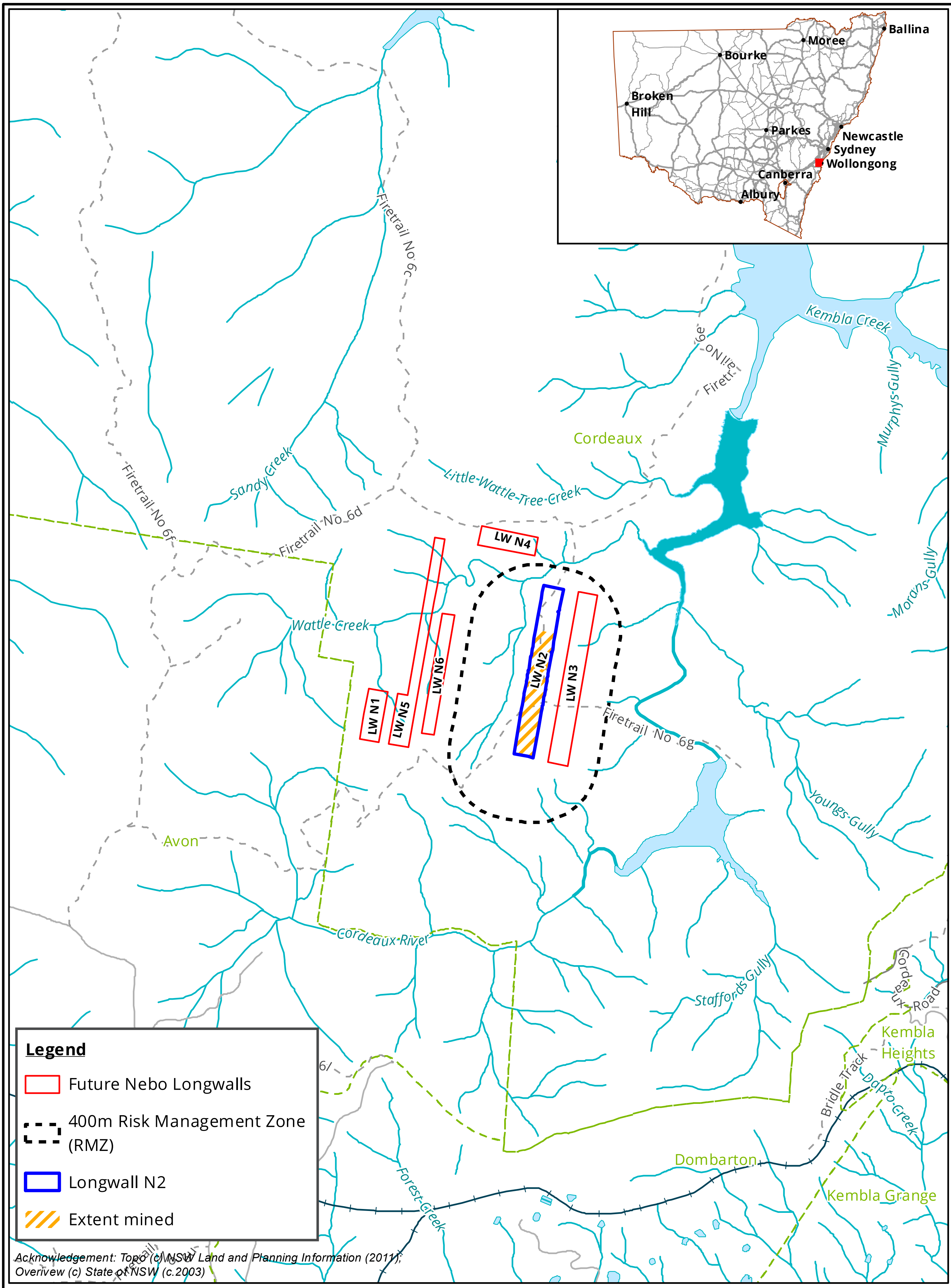
1 Introduction

Biosis Pty Ltd (Biosis) was commissioned by Wollongong Coal Ltd (WCL) to undertake an End of Panel (EoP) assessment of potential impacts from extraction of Longwall N2 in the Nebo Area at Wongawilli Colliery. This report assesses the post mining conditions in relation to cultural and historic heritage within the area potentially impacted by subsidence effects associated with mining of Longwall N2 (Figure 1).

Extraction of secondary workings was completed between 12th June 2013 and 26th February 2014. The full longwall panel length was not extracted. Figure 1 illustrates both the initial estimated extraction area for Longwall N2 and the completed extraction area.

This report has been prepared in accordance with Subsidence Management Plan Approval 09/5341 (Condition 18) (DTIRIS, 2013) and includes:

- An outline of monitoring programs conducted to date.
- An assessment of the results of monitoring undertaken to date.
- A comparison of observed impacts versus those predicted to occur.
- An assessment of whether any actions outlined in the Trigger Action Response Plan (TARP) have been triggered.
- Conclusions on impacts to heritage resulting from the extraction of Longwall N2, as well as cumulative impacts from longwall mining in the Nebo Area.



Acknowledgement: Topo (c) NSW Land and Planning Information (2011); Overivew (c) State of NSW (c.2003)

Figure 1: Longwall N2, Nebo Area

Biosis Pty Ltd
Ballarat, Brisbane, Canberra, Melbourne, Newcastle, Sydney, Wangaratta & Wollongong

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2 Monitoring program

Three historic sites (Cordeaux River Historic Site 1, Cordeaux River Historic 2 and Cordeaux River Historic 3) and two Aboriginal sites (Dendrobium 5 and Wanyambilli Hill 1) were identified within the Nebo Area (Biosis, 2013). A full description of these sites is provided in Biosis (2013).

The heritage monitoring program for the Nebo Area is detailed within the Nebo Longwalls N1-N6 Subsidence Monitoring Plan (NRE, 2014), Nebo Longwalls N1-N6 Extraction Plan (Chapter 10: Heritage Management Plan) (Niche, 2012) and the Nebo Area Environmental Assessment (ERM, 2010). These documents outline the heritage monitoring actions that are required to satisfy on-going conditions of approval as detailed within the Nebo Longwalls N1-N6 Subsidence Management Plan Approval (DTIRIS, 2013) and NRE Wongawilli Colliery – Nebo Area Project Approval (MP09_0161).

Two sites, Cordeaux River Historic 2 and Cordeaux River Historic 3, are located within the predicted subsidence impact boundary of the Nebo Area (Biosis 2013). These sites are monitored as a part of the approved Heritage Monitoring Plan (Niche 2012).

Monitoring is undertaken within three months of a longwall making it closest traverse to a site (Biosis, 2013). Impact monitoring was scheduled for the heritage sites, Cordeaux River Historic 2 and Cordeaux River Historic 3, as they fell within a 400 metre Risk Management Zone (RMZ) (based on the full length of Longwall N2 being mined). Monitoring of heritage sites Cordeaux River Historic 2 and Cordeaux River Historic 3 commenced with baseline archival recording being conducted on 9 November 2011 (Biosis, 2013).

Extraction of Longwall N2 has been suspended short of the full panel length. As a result, Cordeaux River Historic 2 is located outside a 400 metre RMZ. Accordingly, monitoring during mining and the Trigger Action Response Plan (TARP) was no longer applicable for this site. Monitoring continued to be conducted for Cordeaux River Historic 3 as seen below.

2.1 Heritage monitoring program

The heritage monitoring program consists of monitoring of heritage sites that have experienced mining activity within the Nebo Area. Monitoring is conducted prior to the commencement of mining as a part of the baseline archival recording, during mining (within 3-6 months of the longwall closest point of approach) and after mining (within six months of the completion of mining).

Baseline recording was conducted for Cordeaux River Historic 2 and Cordeaux River Historic 3 on 9 November 2011. Cordeaux River Historic 3 was inspected during mining on 26 February 2014 and most recently after mining on 2 June 2014. Cordeaux River Historic 2 was not required to be monitored during mining due to the site being outside of a 400 metre RMZ. Heritage monitoring sites are shown in Figure 2. Table 1 below provides an outline of the heritage monitoring methodology.

Table 1: Heritage monitoring program

Monitoring	Site(s)	Methodology	Frequency	Most recently monitored
Cordeaux River Historic 2 (historical artefact scatter) (Figure 2: Heritage Monitoring Sites)	Historical artefact scatter	Visual observation, photographic coverage.	Baseline recording,	Baseline monitoring conducted on 9 November 2011

Cordeaux River Historic 3 (historical artefact scatter) (Figure 2: Heritage Monitoring Sites)	Historical artefact scatter	Visual observation, photographic coverage.	Baseline recording, during mining and within 6 months of completion of mining.	2 June 2014

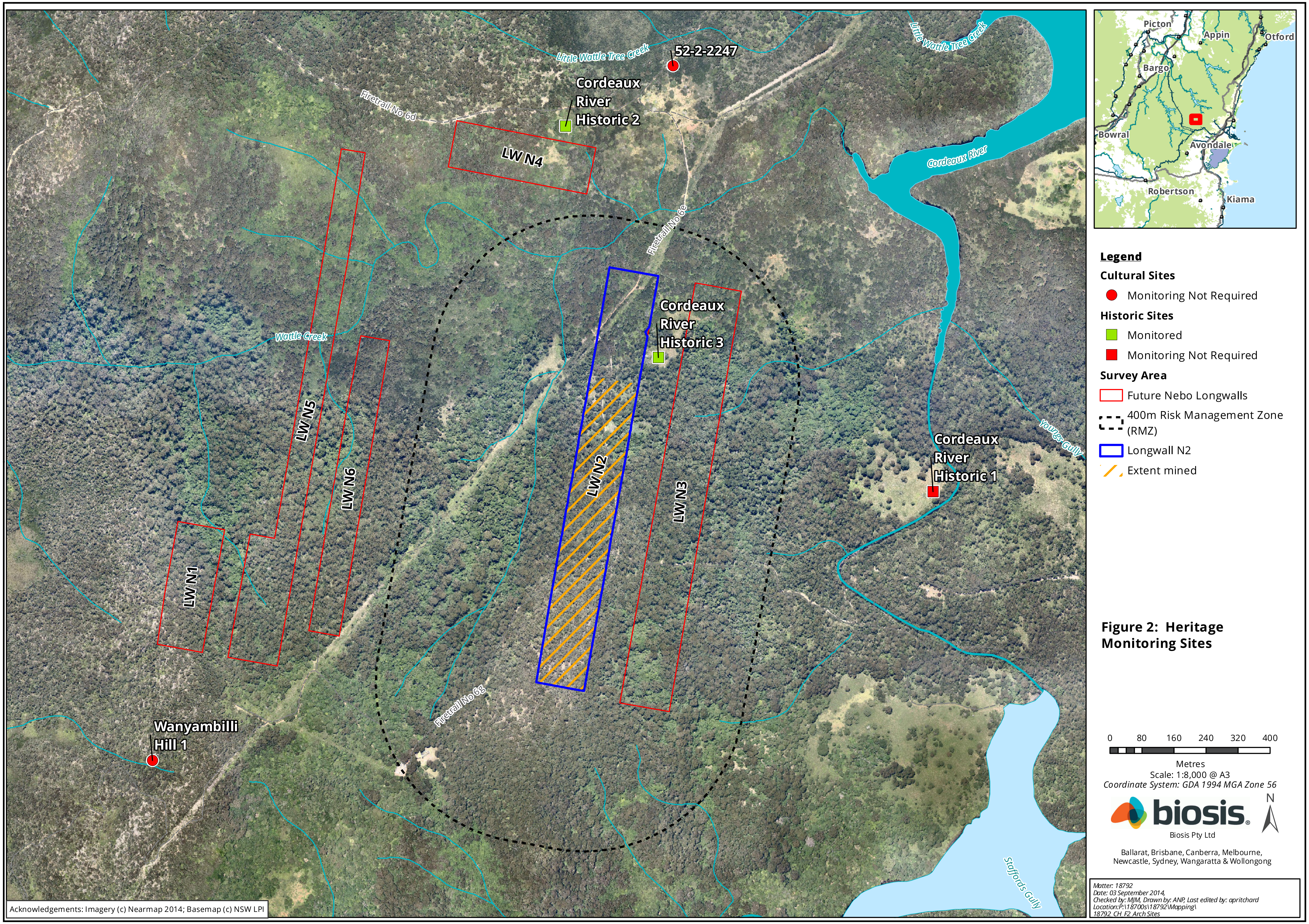

Figure 2: Heritage Monitoring Sites

Acknowledgements: Imagery (c) Nearmap 2014; Basemap (c) NSW LPI

3 Impact Assessment

3.1 Subsidence monitoring program

A maximum of approximately 90 millimetres of vertical subsidence was observed across the central 100 metres of the panel, with maximum average tilt of less than 0.5 mm/m and strain of 0.2 mm/m (SCT Operations 2014).

This measured value is below the maximum predicted subsidence levels for Prediction Lines 4 (NM3) and 5 (NM2) (Niche Environment & Heritage 2012). As this is the first longwall extracted within the Nebo Area, there is no cumulative subsidence.

3.2 Results of monitoring programs

Baseline recording of Cordeaux River Historic 3 was undertaken on 9 November 2011. Monitoring of Cordeaux River Historic 3 occurred on 26 February 2014 (during mining) and most recently on 2 June 2014 (after mining). No impacts to heritage values have been documented during monitoring (see Plate 21 to Plate 4).

Plate 1: Baseline recording of Cordeaux River Historic 3 – detailed view of building foundations

Plate 2: Most recent monitoring at Cordeaux River Historic 3 – detailed view of building foundations

Plate 3: Baseline recording of Cordeaux River Historic 3 –concrete blocks view south-west

Plate 4: Most recent monitoring at Cordeaux River Historic 3 –concrete blocks view south-west

3.3 Observed versus predicted impacts

A summary of predicted versus observed impacts is provided in Table 2 below.

Table 2: Observed versus predicted impacts

Value	Predicted Impact (Niche 2012)	Observed Impact	Within Prediction
Cordeaux River Historic 3 (historical artefact scatter)	The low levels of subsidence predicted at the sites are not expected to result in any impacts to the Cordeaux River Historic Site 2 and Cordeaux River Historic Site 3.	No change in the condition of the artefact scatter was observed.	Yes

3.4 TARP assessment

A Trigger Action Response Plan (TARP) was developed for Longwalls N1-6 as a part of the Cultural Heritage Management Plan (Niche Environment and Heritage, 2012). This section assesses whether triggers have been met and whether additional actions are required due to extraction of Longwall N2.

A TARP assessment is provided in Table 3.

3.4.2 Longwall N2

No impacts to heritage site Cordeaux River Historic 3 were observed. Thus we conclude that this does not trigger any actions.

No further management actions have been triggered by Longwall 2.

3.4.3 Cumulative Impacts within the Nebo Mining Domain

Longwall N2 is the first longwall to be mined within the Nebo Area. As such, there are no cumulative impacts to be assessed until further longwall mining takes place within the Nebo Area.

4 Conclusions and Recommendations

This report assesses the post mining conditions in relation to heritage within the area potentially impacted by subsidence effects associated with extraction of Longwall N2, and compares these observed impacts to impacts predicted to occur.

We conclude that observed impacts are within predictions and that significant impacts to heritage values have not resulted from extraction of Longwall N2. No management actions have been triggered.

We make the following recommendations:

- Final monitoring of Cordeaux River Historic 3 be undertaken.
- Monitoring of heritage items that may be subsided by other longwalls continue as per the approved Heritage Management Plan (Niche 2012).

5 References

Biosis 2011. NRE Wongawilli Colliery Nebo Longwalls N1 - N6: Heritage Management Plan. Report prepared for Gujarat NRE Coking Coal Ltd. Authors: Ford A, Biosis Pty Ltd. Project 13748.

Biosis 2013. NRE Wongawilli Colliery, Nebo Longwalls N1-N6: Heritage Baseline Recording Report. Report prepared for Gujarat NRE Coking Coal Ltd. Authors: Ford A, Biosis Pty Ltd. Project 13748.

Niche Environment & Heritage 2012. Nebo Longwalls N1-N6 Extraction Plan. Prepared for Gujarat NRE and NSW Department of Planning and Infrastructure.

Appendices

Appendix 1: Trigger Action Response Plan

Table 3: Trigger Action Response Plan (TARP) Table for Heritage, including assessment of actions required by the Subsidence Monitoring Plan for Longwalls N1-N6

Feature	Monitoring Plan			Impact Assessment		TARPs		
	Prior to Mining	**During Mining**	**Post mining and Future Monitoring**	**Predicted Impacts**	**Observed Impacts**	**Trigger**	**Response**	**Action as a result of Longwall N2**
Heritage sites: Cordeaux River Historic 2 and Cordeaux River Historic 3	Baseline heritage assessment involves baseline archival recording prior to longwall mining beginning in the SMP Area. This provides a set of baseline records for the monitoring program. Completed for Cordeaux River Historic Site 2 and 3.	Impact Assessment recording, three to six months after each predicted subsidence movement at the site (that is when a longwall makes it closest traverse to the site), and/or (if the longwall is to finish mining within six months). Completed for Cordeaux River Historic Site 3, not required for Cordeaux River Historic Site 2.	Final assessment recording at the completion of all subsidence movements at the site. The results of the assessment to be reported in End of Panel Reports and/or Annual Environmental management reports. To be completed.	Ground cracking or tree fall may impact potential archaeological deposits.	No impacts to heritage sites monitored were observed.	**NORMAL** No change as compared to baseline observed.	• Continue monitoring • Report in end of panel report. No further mitigation or management required	No management action/s required. No change in heritage sites observed when compared to baseline recording.
						WITHIN PREDICTIONS Survey results within performance criteria. Observation of unstable conditions or damage, cracking or tree falls. If a change is observed but no threat to heritage values is identified then the monitoring program should continue.	• Continue monitoring • Report impacts as required in end of panel report. • Site inspection with registered Aboriginal parties to document and photograph any observed changes / impacts to Aboriginal sites. • Inform RAPs and OEH in writing.	
						EXCEEDS PREDICTIONS Observed physical impacts to heritage that exceeds the performance criteria. If a change is observed then an appropriate mitigation strategy should be developed in consultation with a heritage specialist, registered Aboriginal parties, and the landowner to avoid or minimise impacts to	• Notify relevant government agencies including OEH, DP&E, DRE and SCA immediately. • Review and undertake remediation options as agreed with Agencies. • Consultation with OEH will be required if remediation or mitigation measures affect the archaeological values at individual sites • Commence preparation of mitigation/action plan within 1 week if	

Feature	Monitoring Plan			Impact Assessment		TARPs		
	Prior to Mining	During Mining	Post mining and Future Monitoring	Predicted Impacts	Observed Impacts	Trigger	Response	Action as a result of Longwall N2
						heritage values.	required • Results of investigation reported to SCA, OEH and DRE within 1 week of completion • Monthly updates of investigation progress, if required by SCA / OEH • If subsidence movement occurs above the expected maximum predictions in the SMP, then site inspections of Dendrobium 5 and Wanyambilli Hill 1 (located outside the application area) should occur in consultation with Registered Aboriginal parties including the Illawarra LALC and CBNTCAC to document and photograph any observed changes / impacts. • Site inspection by archaeologist to document and photograph any observed changes / impacts. • Report in End of panel report • Reporting in Incident and Annual Reviews	

APPENDIX C

Wongawilli Colliery Nebo Area Longwall N2 Groundwater & Surface Water End of Panel Report

GeoTerra

WOLLONGONG COAL LTD

WONGAWILLI COLLIERY

NEBO AREA

LONGWALL N2

GROUNDWATER & SURFACE WATER

END OF PANEL REPORT

Wollongong, NSW

NEB4-R1A

4 SEPTEMBER 2014

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Name:	Andrew Dawkins
Signature:	
Position:	Managing Geoscientist

Date	Rev	Comments
02.09.2014		Initial Report
04.09.2014	A	Incorporate review comments

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DRAWINGS

1. INTRODUCTION

This document outlines the observed variations in the surface water and groundwater systems associated with extraction of Longwall N2 in the Nebo Area within the Wollongong Coal Limited (WCL) operated Wongawilli Colliery.

Extraction of the Wongawilli Seam in Longwall N2 was conducted between 12/6/2013 and 26/2/2014, with the planned longwall extraction suspended due to collapse of the roof onto the longwall equipment mid way through the panel.

The mining created a void 132m wide, 789m long with a mined face of 3.3 – 3.4m high, and had a 125 – 280m depth of cover.

1.1 Subsidence

Up to 210mm of subsidence was predicted along the 300 subsidence line (after the extraction of both N2 and LWN3), with a maximum of 92mm observed over Longwall N2, along with a tilt of <0.5mm/m and tensile strain of 0.2m/m (SCT Operations, 2014).

No subsidence related TARP trigger levels have been reached or exceeded during extraction of Longwall N2 and no ameliorative actions are required.

2. SCOPE OF WORK

GeoTerra were commissioned by WCL to report on any observed groundwater system or surface water changes resulting from extraction of Longwall N2 in accordance with the Nebo Longwalls N1-N6 Extraction Plan (Niche 2011).

3. WATER MONITORING DESCRIPTIONS

3.1 Surface Water

Surface water monitoring associated with the extraction of N2 comprised field and laboratory assessment of five stream sites in three streams as shown in **Table 1.**

Monitoring sites were initiated in Wattle Tree Creek, Little Wattle Tree Creek and Jacksons Creek in June 2009 by GeoTerra as shown in **Drawing 1**, with the field and laboratory monitoring program subsequently conducted by WCL up to July 2014.

Table 1 Wattle Creek Stream Monitoring Sites

SITE	E (MGA)	N (MGA)	DESCRIPTION
WC1	294560	6189435	2nd order tributary draining off Jacksons / Wanyambilli Hill
WC2	294530	6189470	2nd order tributary draining over LWN5
WC3	294875	6189570	3rd order channel downstream of WC1 / WC2 junction
WC4	293303	6189240	Wattle Creek headwaters west of Nebo workings
LWTC1	294920	6190020	At Fire Road 6 crossing

3.2 Groundwater

No NOW registered private bores are located within the Nebo area as it is within a restricted access water catchment area administered by the SCA.

It is worth noting that the overburden strata at Nebo is significantly different to the standard Southern Coalfield stratigraphy, as the igneous Cordeaux Crinanite sill complex has intruded into the overburden and dominates the overburden profile.

In some cases the sill complex has replaced the majority of the standard sequence of sandstone / shale seen in all other Southern Coalfields mining areas. In the vicinity of N2, the crinanite varies from 55 - 98m thick and lies from 70 – 120m above the mining horizon of N2.

3.2.1 Open Standpipe Piezometers

Open standpipe piezometers installed within the Nebo area include seven (6.5 to 109.5m deep) open standpipe piezometers installed by Gujarat NRE FCGL Pty Ltd (now Wollongong Coal Limited) in January 2010 as summarised in **Table 2** and shown in **Drawing 2**.

Each piezometer has been installed with a pressure transducer that reads water pressure at least twice per day.

Table 2 Nebo Open Standpipe Piezometers

Piezometer	Licence	E	N	RL mAHD	TD mbg	Intake (mbgl)
Nebo 1 (S)	10BL603365	295153	6188762	366.4	6.0	5.0 – 6.0
Nebo 1 (D)	10BL603365	295152	6188761	366.5	97.6	85.6 – 97.6
Nebo 2 (S)	10BL603365	294662	6189246	347.7	6.5	5.5 – 6.5
Nebo 2 (D)	10BL603365	294662	6189237	348.5	31.0	19.0 – 31.0
Nebo 3	10BL603365	295033	6189838	356.7	33.6	21.6 – 33.6
Nebo 4	10BL603365	294661	6189893	374.1	110.0	107.5 – 109.5

NOTE: n/a - not available mbgl - metres below ground level SWL - standing water level
mbtoc - metres below top of casing Nebo 5 was not drilled all bores drilled in Dec 2009

3.2.2 Vibrating Wire Piezometers

Four vibrating wire piezometer arrays were installed within the Nebo area in December 2009 and January 2010 as outlined in **Table 3** and shown in **Drawing 2.**

Table 3 Nebo Vibrating Wire Piezometers

Piezometer	Installed	E	N	RL mAHD	TD mbg	VWP Intakes (mbgl)
Nebo 6	Dec 2009	295237	6189510	354.2	119	60, 80, 100 (CC), 119 (KS)
Nebo 7	Dec 2009	295477	6189585	336.4	92	30, 45, 63 (CC), 90 (WW)
Nebo 8	Dec 2009	294679	6189485	343.4	91	15, 35, 52 (CC), 72 (SS)
Nebo 8A	Jan 2010	294549	6189499	359.6	69	25, 45, (CC)

NOTE: CC – Cordeaux Crinanite SS - Scarborough Sandstone WW – Wongawilli Coal Seam
KS – Kembla Sandstone

4. PREDICTED AND OBSERVED GROUNDWATER IMPACTS

4.1 Aquifer / Aquitard Interconnection

4.1.1 Potential Impacts

- no adverse interconnection of aquifers and aquitards was anticipated within 20m of the surface;
- potential increase in the rate of groundwater recharge into the basement following rainfall due to increased porosity and permeability of the fractured strata.

4.1.2 Aquifer / Aquitard Interconnection Observations

No adverse aquitard / aquifer interconnection or increased recharge has been observed in the vicinity of, or resulting from, extraction of Longwall N2.

No aquifer / aquitard interconnection TARP trigger levels have been reached or exceeded during extraction of Longwall N2 and no ameliorative actions are required.

4.2 Groundwater Levels

The open standpipe and vibrating wire piezometer (VWP) piezometer suite has been used to determine the pre, during and post Longwall N2 groundwater levels and head pressures.

The data has been used to indicate variations in groundwater systems within the alluvial / colluvial and basement strata to a maximum depth of 119m below surface.

4.2.1 Potential Impacts

The following groundwater level impacts could potentially occur;

- groundwater levels may reduce by up to 10m, and may stay at that reduced level until maximum subsidence develops at a specific location;
- groundwater levels should recover over a few months as the newly developed secondary porosity is recharged by rainfall;
- no permanent post mining reduction in groundwater levels unless a new outflow path develops, and;
- temporary lowering of the deep piezometric surface over the subsidence area due to horizontal dilation of strata and resultant increase in secondary porosity.

4.2.2 Groundwater Level Observations

Standing water levels in the open standpipe piezometers range from

- 4.5 - 5.0 mbgl in the soil / colluvium / alluvium piezometers
- 4.5 - 14.5 mbgl in the crinanite
- 51mbgl in the Narrabeen group and
- 92mbgl in the Bulli Seam

Neither of the shallow soil / alluvium / colluvium piezometers Nebo1S or Nebo2S overlie N2, and both have varied in response to rainfall in the catchment as shown in **Figure 1**, with no influence from N2 during its period of extraction.

Neither of the crinanite piezometers Nebo2D or Nebo3 overlie N2, and both have varied in response to rainfall in the catchment as shown in **Figure 2**, with no apparent diversion from the natural water level trends from N2 during its period of extraction.

Piezometer Nebo1D was installed in the Narrabeen Group approximately 110m east of N2, between the longwall and 125m west of an inflow channel of Cordeaux Dam, above the Full Storage Level of the dam. Nebo1D showed a response to extraction of N2 as shown in **Figure 3**, with a maximum reduction in its water level of 8m, followed by a recovery to 4m below its pre N2 level.

Piezometer Nebo4, which was installed in the Bulli Seam, to the north of LWN4, showed a rising water level during extraction of N2, albeit with short term drops and recoveries following water extraction sampling events, along with no response to extraction of N2, as shown in **Figure 4**.

The vibrating wire array installed in Nebo6 demonstrated a significant rise in the two shallowest crinanite intakes (60, 80mbgl) of 40.83m and 22.42m, whilst the lower crinanite (100mbgl) and coal measures (115m) showed no response during early October to mid December 2011, some 2½ years before the start of N2. Both shallower intakes then showed a reduction in water level, with a more pronounced reduction at 80mbgl, prior to the start of N2. During mining of N2, the 60m crinanite intake showed no response to N2 extraction, whilst the falling trend at 80mbgl gradually tailed off during and after extraction of N2. The lack of response to N2 extraction was apparent in the underlying 100m crinanite or 115m coal measure intakes which indicates no mining subsidence effect in the crinanite. In addition, no correlation with the water level of Cordeaux dam and Nebo6 is apparent.

The 45m deep crinanite intake in Nebo7 showed a significantly smaller recharge at the same time as the recharge observed in Nebo6, however no notable response to the recharge event occurred in the 30m and 63m deep crinanite or the 90m coal measure intakes. No response to extraction of N2 and no correlation to dam levels in any of the Nebo7 intakes are apparent.

The 15m deep crinanite intake in Nebo8 showed a significantly smaller recharge at the same time as the recharge observed in Nebo6, however no notable response to the recharge event occurred in the 52m crinanite or 72m deep coal measure intakes. No response to extraction of N2 and no correlation to dam levels in any of the Nebo8 intakes are apparent.

No response to the mid to late 2011 recharge event is apparent in the Nebo8A VWP, with no response to extraction of N2 and no correlation to groundwater levels in Cordeaux Dam.

No basement groundwater level related TARP triggers were exceeded during extraction of Longwall N2 and no ameliorative action are required.

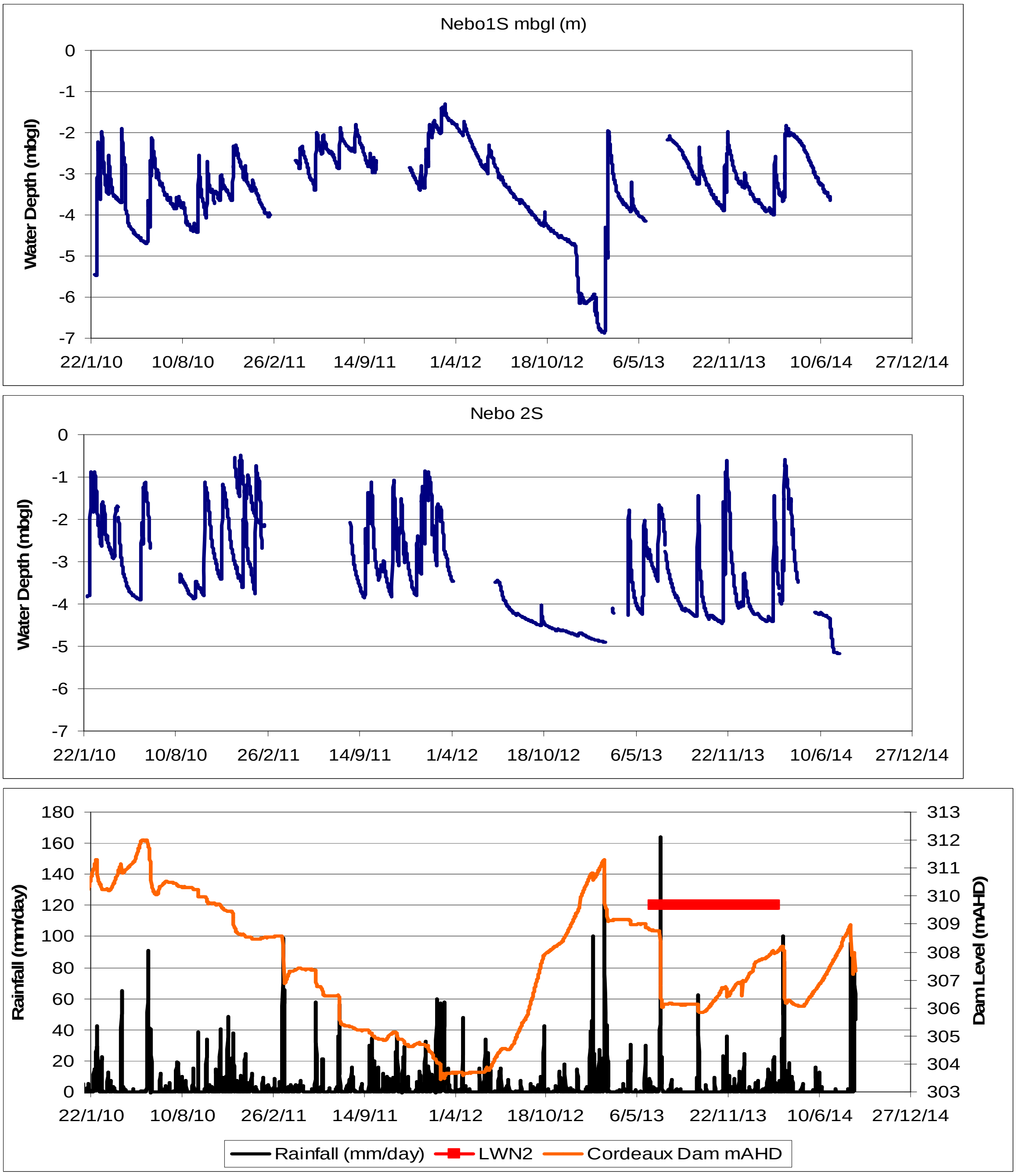


Figure 1 Alluvium / Colluvium Groundwater Levels

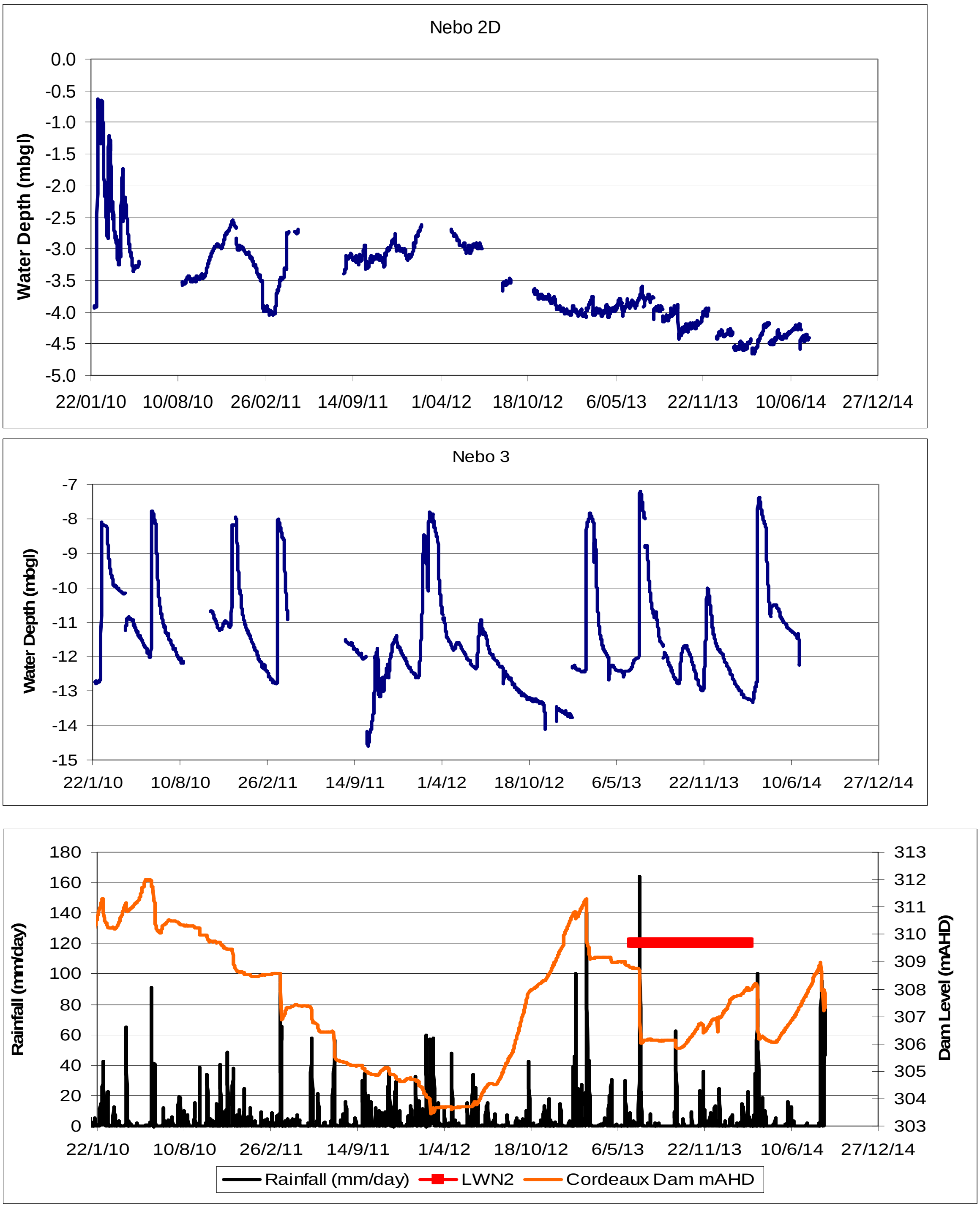


Figure 2 Crinanite Groundwater Levels

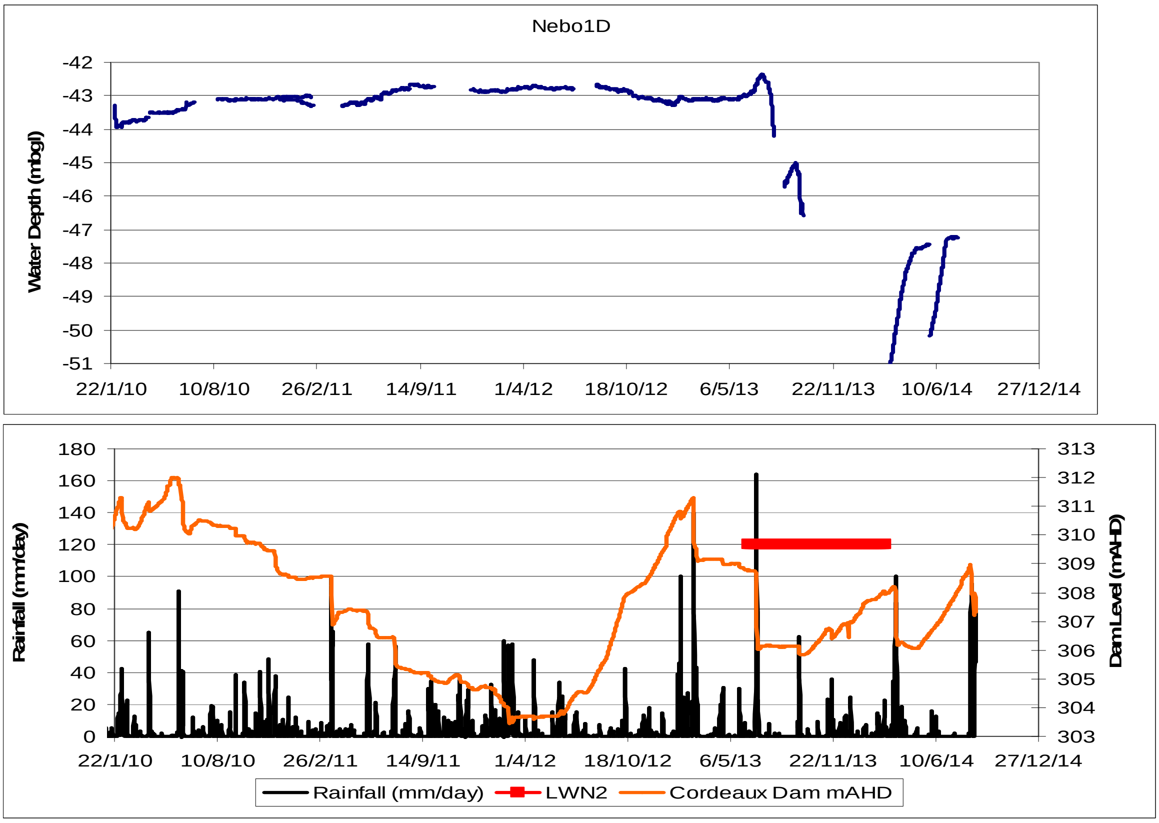


Figure 3 Narrabeen Group Groundwater Levels

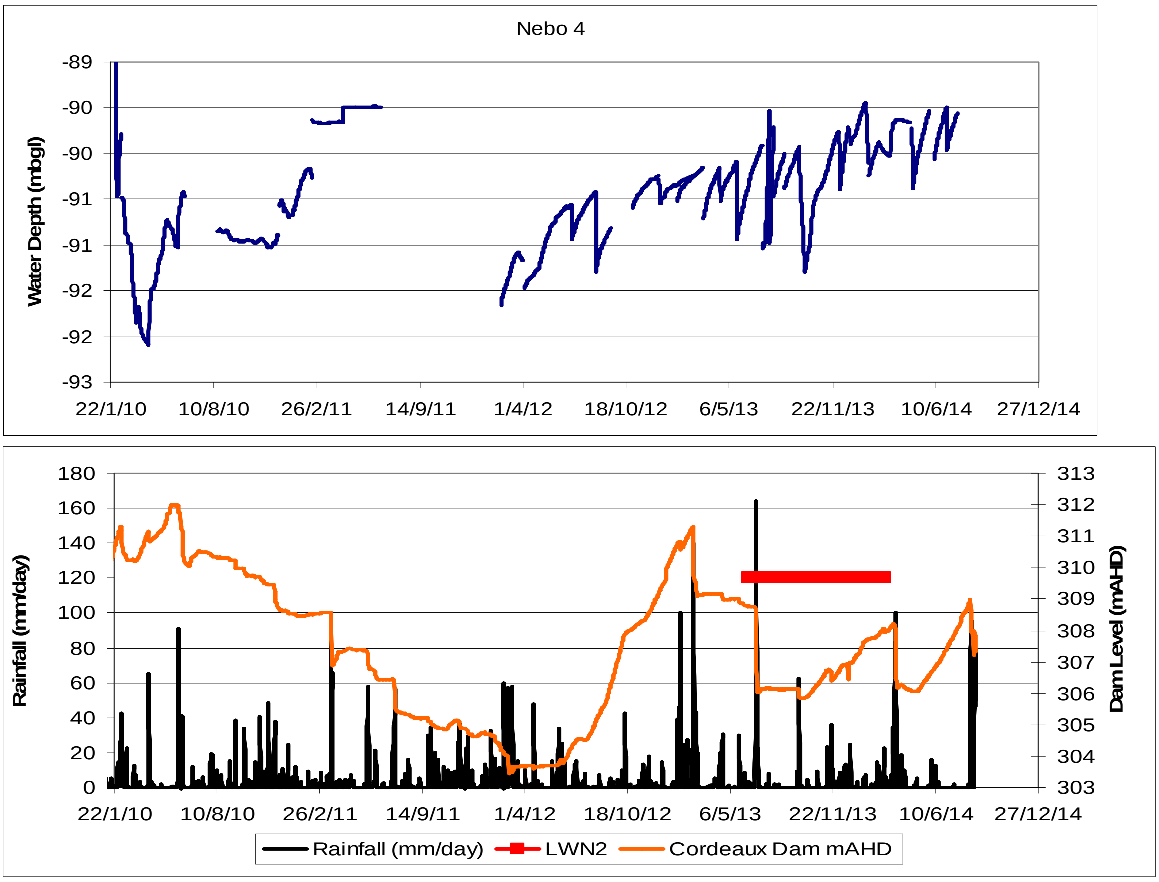
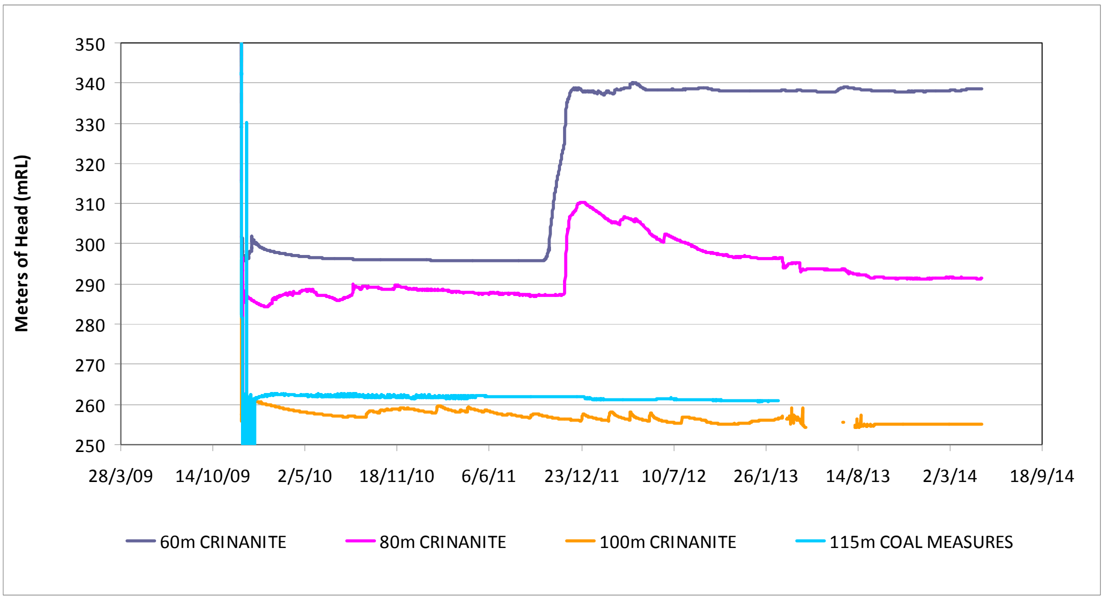
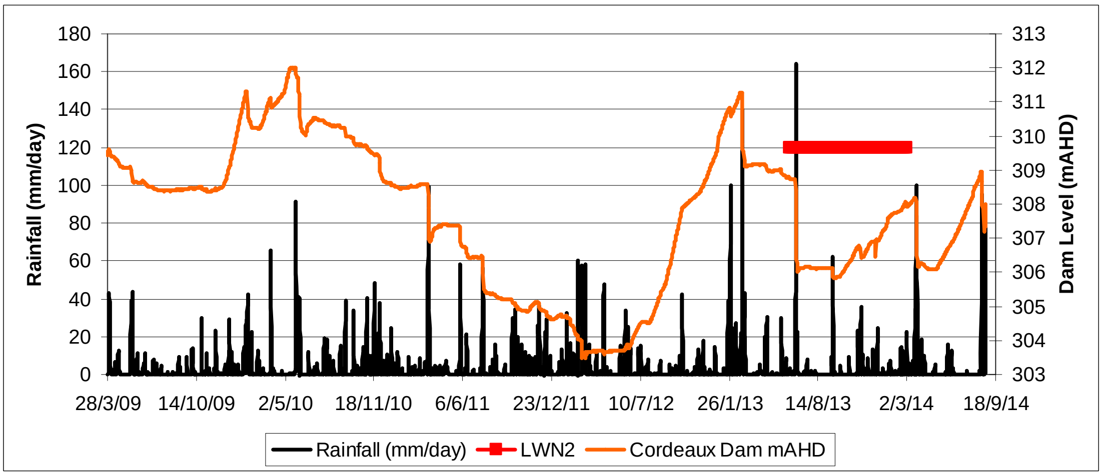


Figure 4 Bulli Seam Groundwater Levels





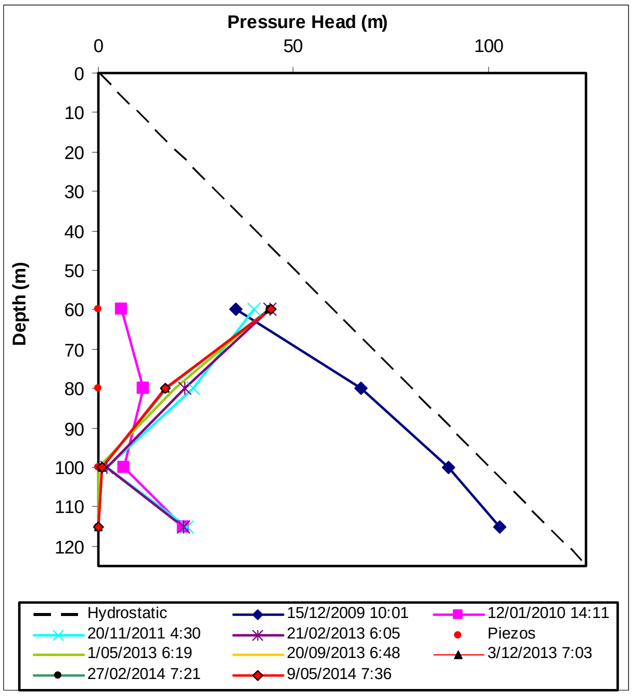


Figure 5 Nebo 6 VWP

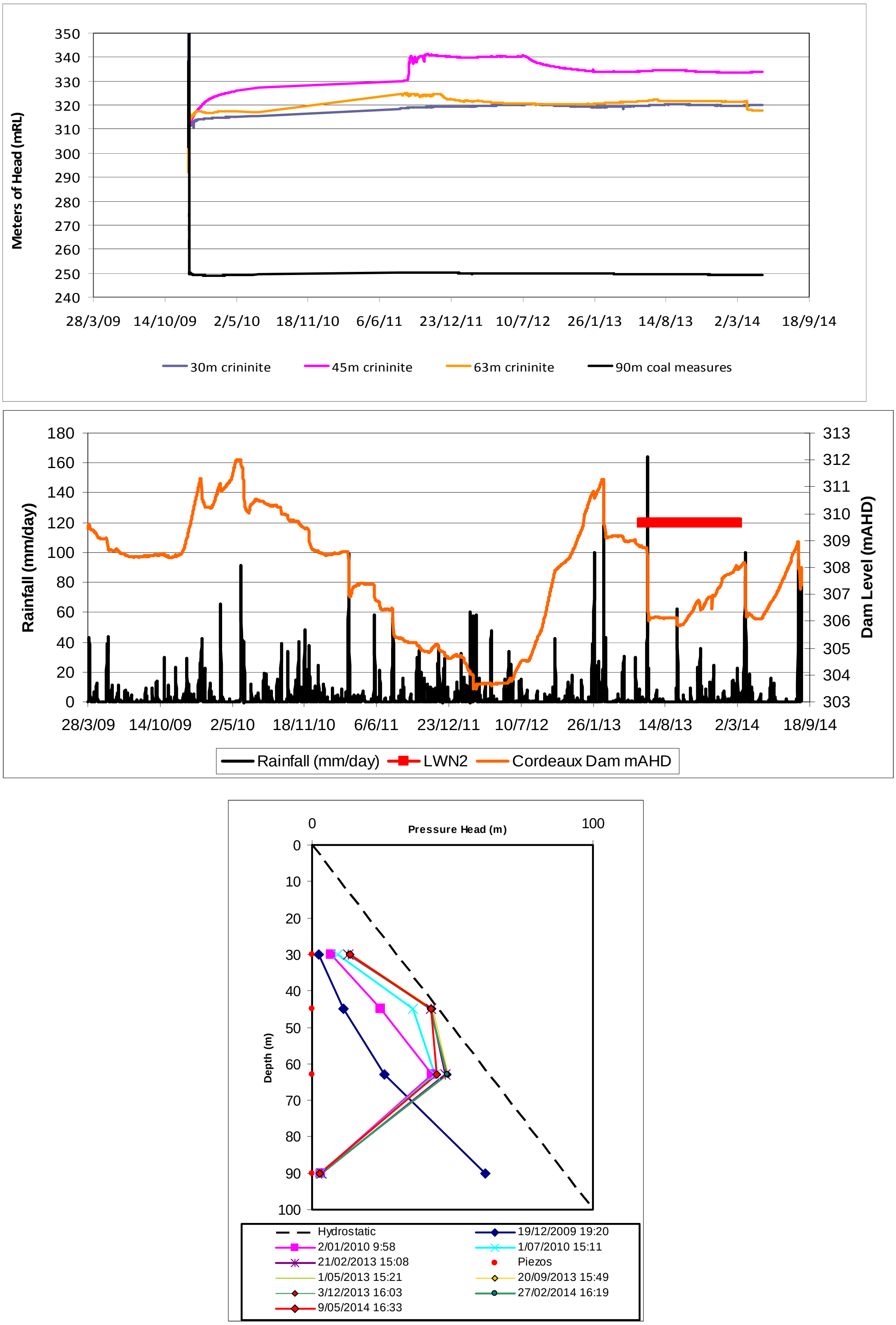


Figure 6 Nebo 7 VWP

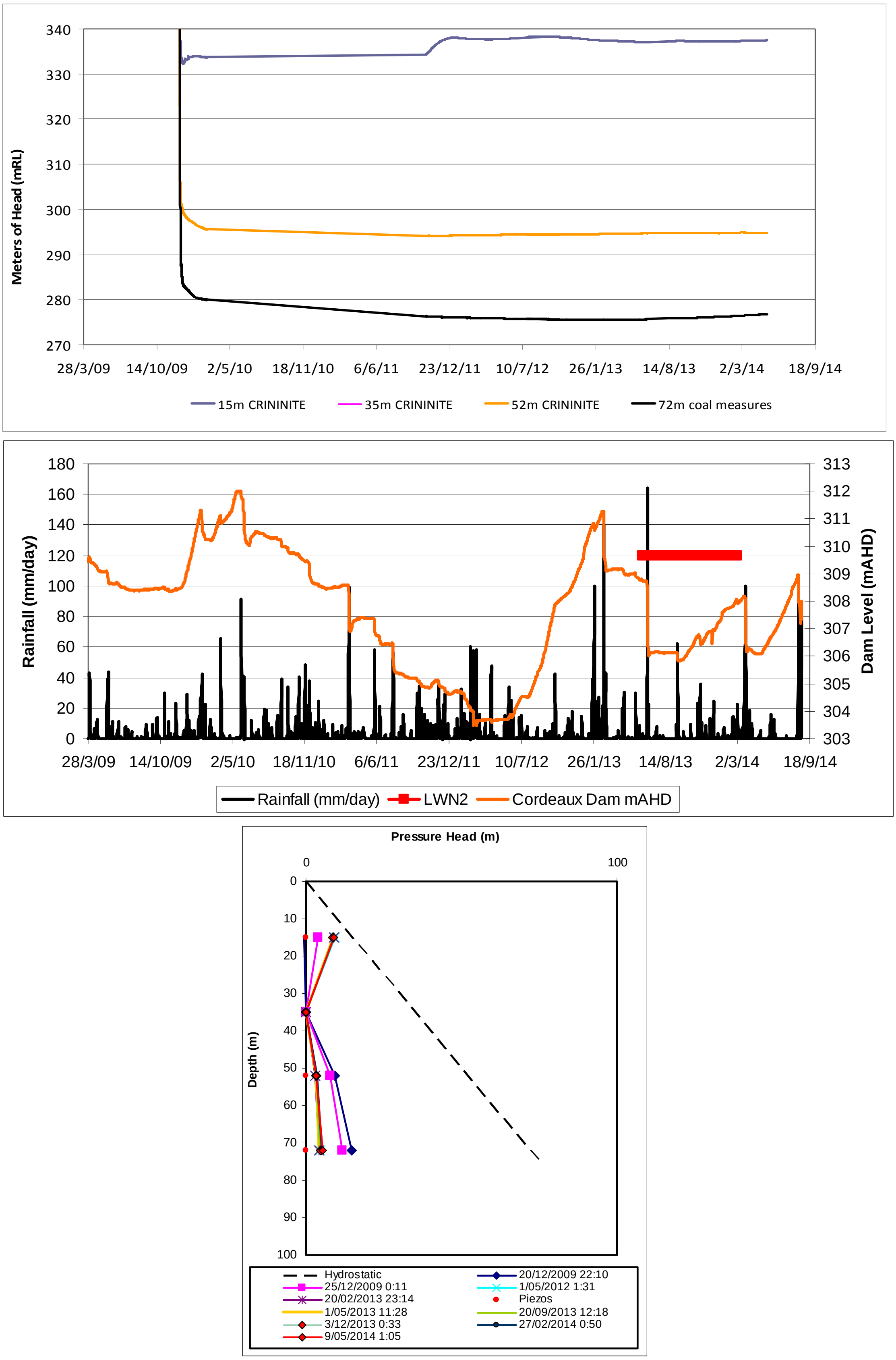
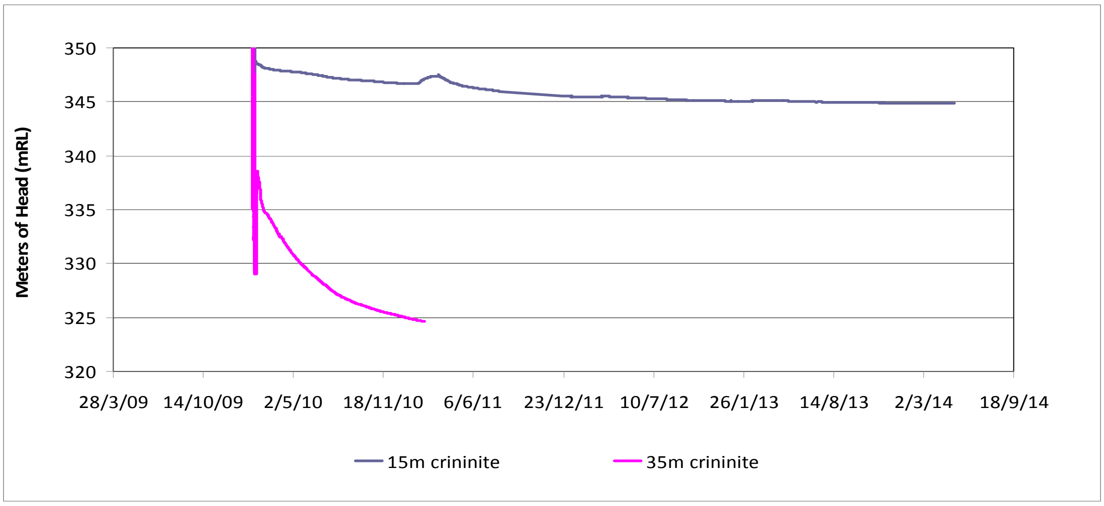
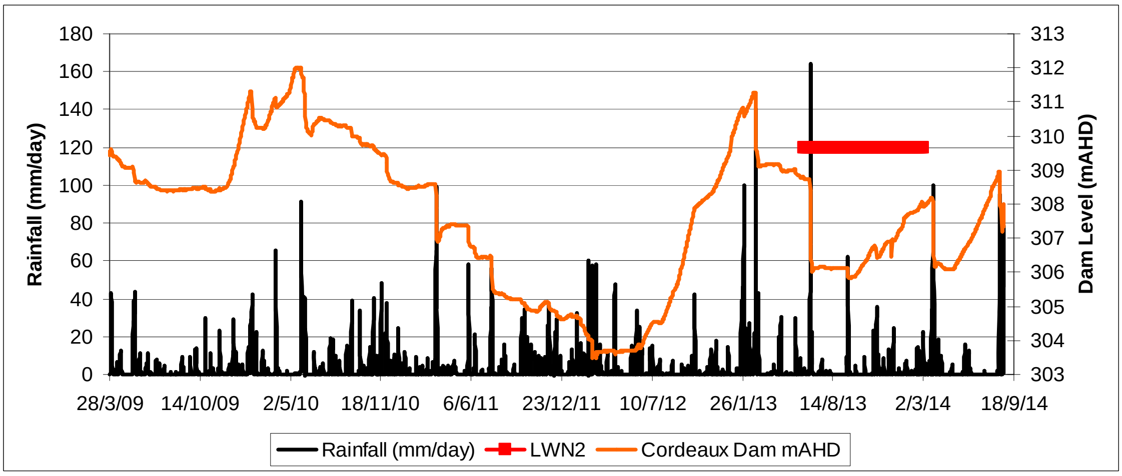


Figure 7 Nebo 8 VWP





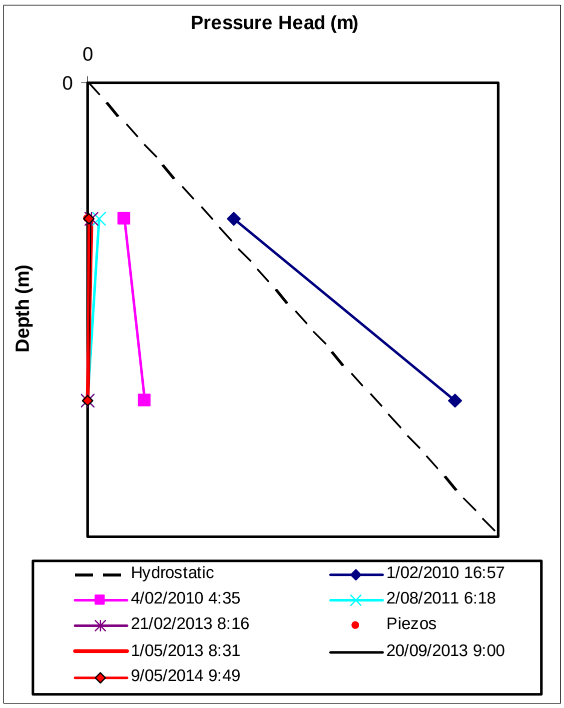


Figure 8 Nebo 8A VWP

4.5 Groundwater Chemistry

4.5.1 Potential Impacts

The potential impacts from extraction of the workings at Nebo in relation to groundwater chemistry were;

- increased iron and manganese hydroxide precipitation in groundwater, and;
- lowering (acidification) of pH.
- minor to moderate increase in salinity

4.5.2 Groundwater Chemistry Observations

The water quality data obtained by WCL from the shallow soil / alluvium / colluvium piezometers as shown in **Figure 9** and **Appendix A** indicate the Quaternary aquifers have generally low salinity (<400µS/cm) and pH ranging from 5.0 – 7.0 (except when cement contamination of the bore and / or sampling equipment significantly raises the alkalinity). The laboratory analyses indicate the Quaternary aquifers are generally outside of ANZECC 2000 Upland Stream and 95% Protection of Freshwater Aquatic Ecosystems guidelines for total Nitrogen and phosphorous, filtered copper and zinc, and occasionally for filtered lead, nickel, and aluminium.

Its should be noted that due to the high pH (6 - 9.5 for 1S, 5 – 9 for 2S) as a result of cement contamination either during piezometer installation or sampling of these waters, they contain unnaturally elevated metals due to their high solubility of the metals in the highly alkaline conditions.

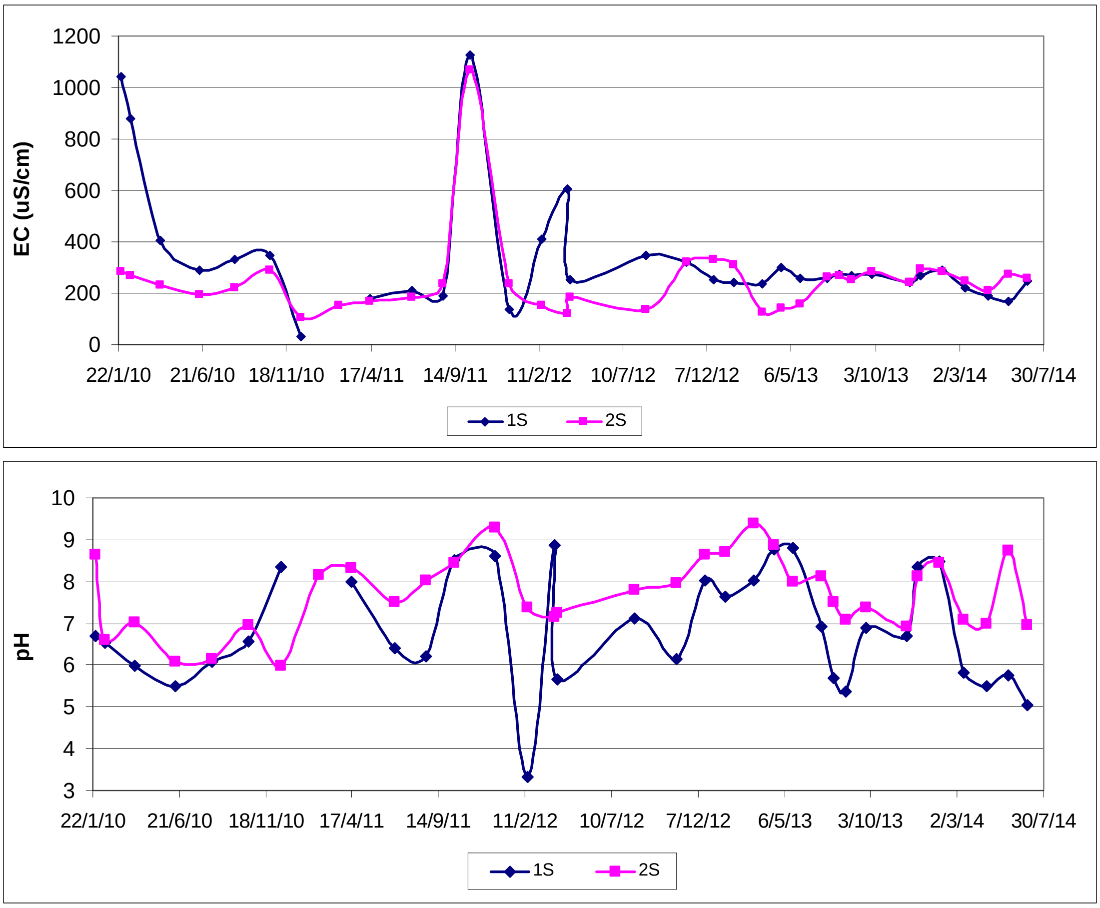
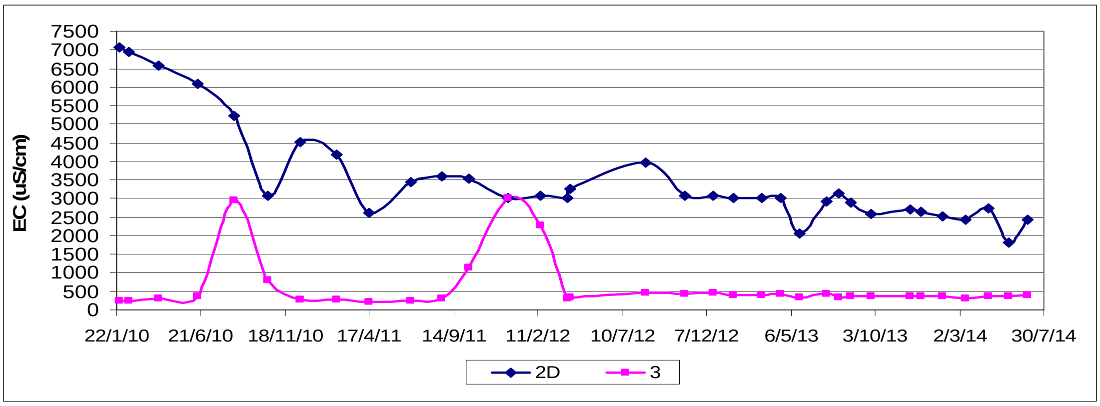


Figure 9 Alluvium / Colluvium pH and EC

The water quality data obtained by WCL from the crinanite piezometers as shown in **Figure 10** and **Appendix A** indicate the crinanite has low salinity (<500µS/cm) in Nebo 3 but high salinity (due to cement contamination) in Nebo 2D (7000 µS/cm, reducing to 1880 µS/cm more recently) and pH ranging from 7.0 - 10 in Nebo 3 and 11 – 13.5 in Nebo 2D (due to cement contamination of both piezometers). The laboratory analyses indicate the crinanite is generally outside of ANZECC 2000 Upland Stream and 95% Protection of Freshwater Aquatic Ecosystems guidelines for total Nitrogen and phosphorous, filtered copper and zinc, and occasionally for filtered lead, nickel, and aluminium.

Its should be noted that the high pH in the piezometers is due to cement contamination either during piezometer installation or sampling of these waters, and that they contain unnaturally elevated metals due to their high solubility of the metals in the strongly alkaline conditions.



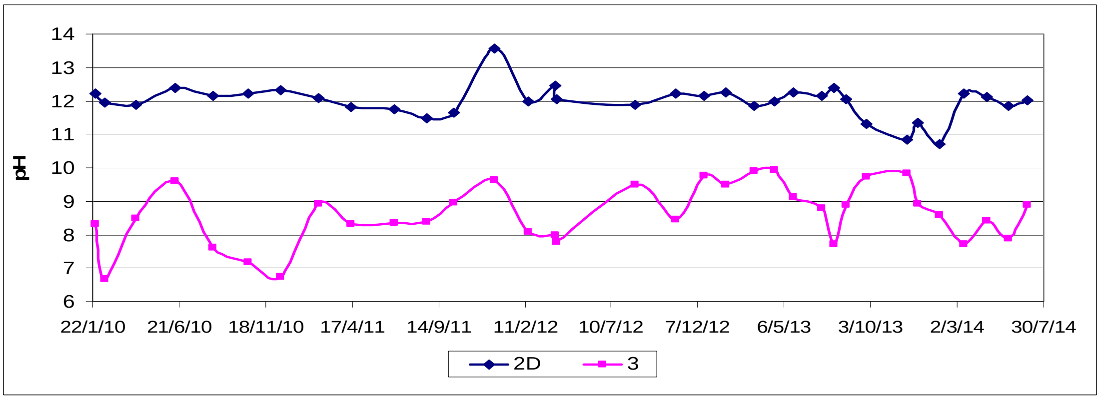


Figure 10 Crinanite pH and EC

The water quality data obtained by WCL from the Narrabeen Group piezometer as shown in **Figure 11** and **Appendix A** indicate the Narrabeen Group has low to moderate salinity (450 - 1450µS/cm) in Nebo 1D and pH ranging from 7.0 – 10.5 (due to cement contamination). The laboratory analyses indicate the Nebo1D waters are generally outside of ANZECC 2000 Upland Stream and 95% Protection of Freshwater Aquatic Ecosystems guidelines for total Nitrogen and phosphorous, filtered copper and zinc, and occasionally for filtered lead and aluminium.

Its should be noted that the high pH in the piezometer is due to cement contamination either during piezometer installation or sampling of these waters, and that it contains unnaturally elevated metals due to the high solubility of the metals in the strongly alkaline conditions.

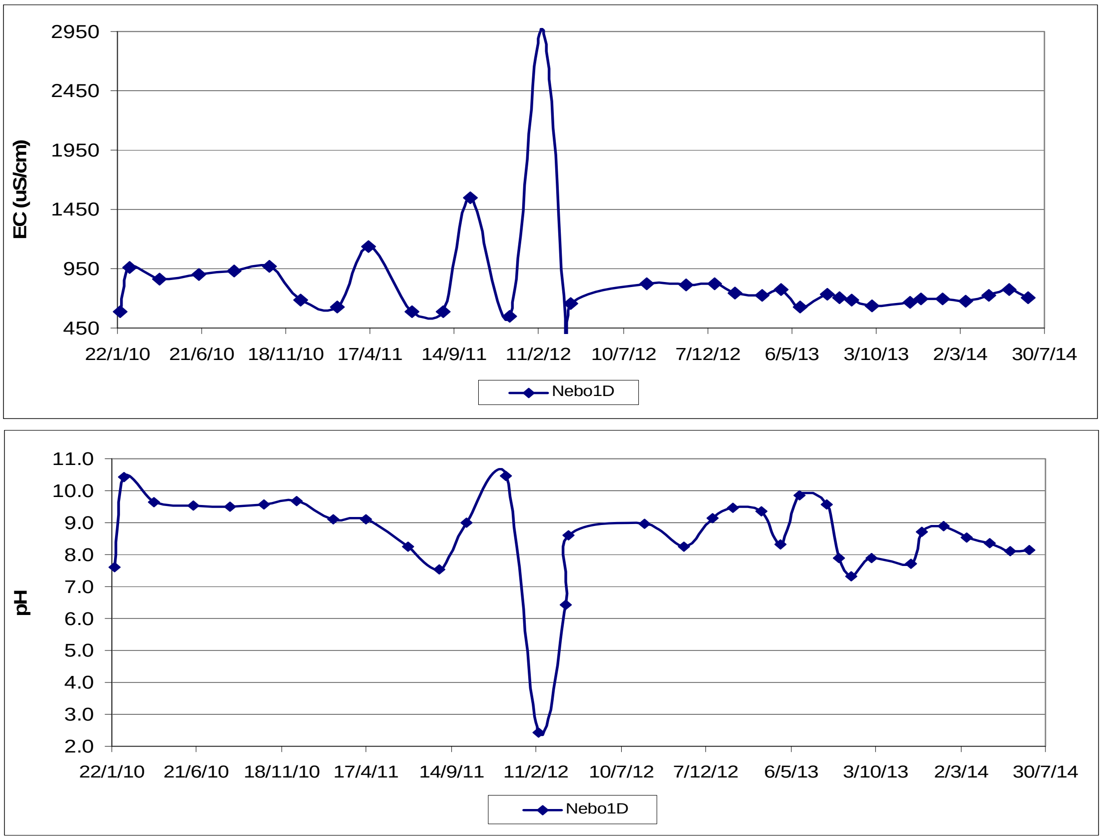


Figure 11 Narrabeen Group pH and EC

The water quality data obtained by WCL from the Bulli Seam piezometer as shown in **Figure 12** and **Appendix A** indicate the Bulli Seam has moderate to high salinity (1100 - 1440µS/cm) in Nebo4 and pH ranging from 8.0 – 14 due to cement contamination. The laboratory analyses indicate the Nebo4 waters are generally outside of ANZECC 2000 Upland Stream and 95% Protection of Freshwater Aquatic Ecosystems guidelines for total Nitrogen and phosphorous, filtered copper, lead, zinc and aluminium, and occasionally for filtered nickel.

Its should be noted that the high pH in the piezometer is due to cement contamination either during piezometer installation or sampling of these waters, and that it contains unnaturally elevated metals due to the high solubility of the metals in the strongly alkaline conditions.

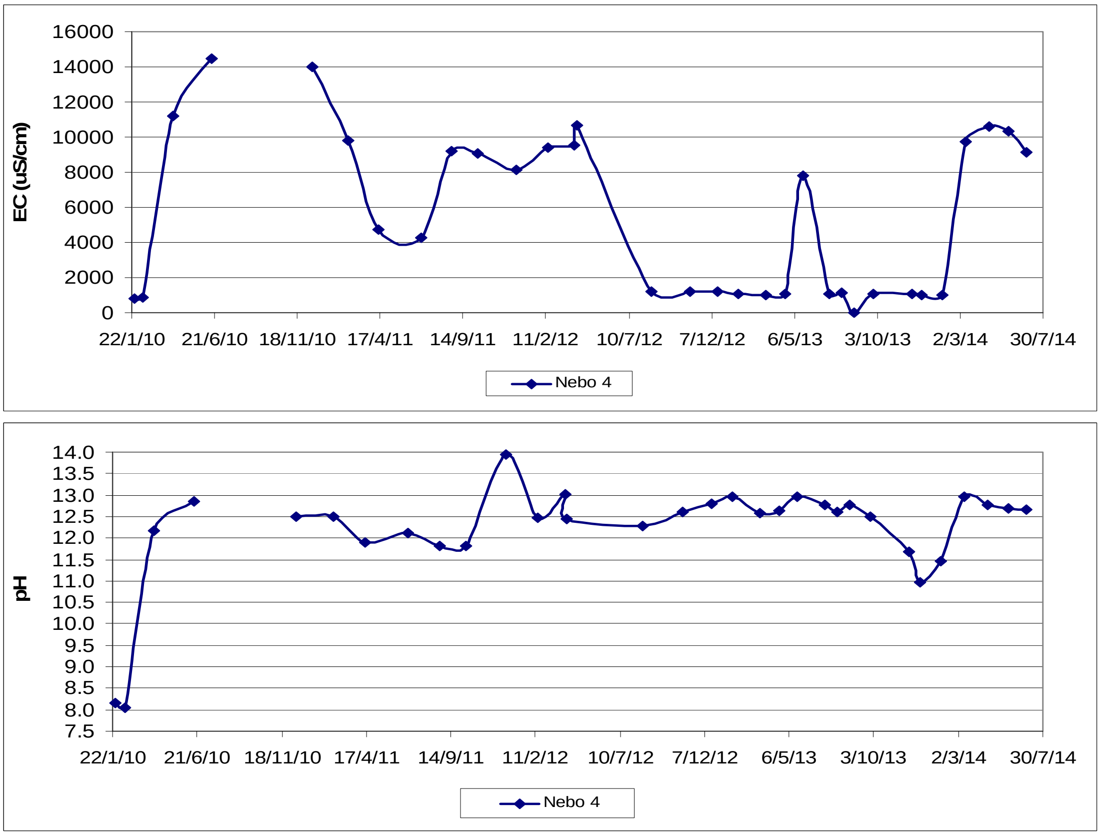


Figure 12 Bulli Seam pH and EC

Overall, there was no observable trend in pH due to extraction of Longwall N2 in all monitored bores.

The piezometers at Nebo also contain elevated iron and manganese due to their solubility in the highly alkaline water, however no increasing or decreasing trend in these metals is evident during the sampling period as shown in **Figure 13**.

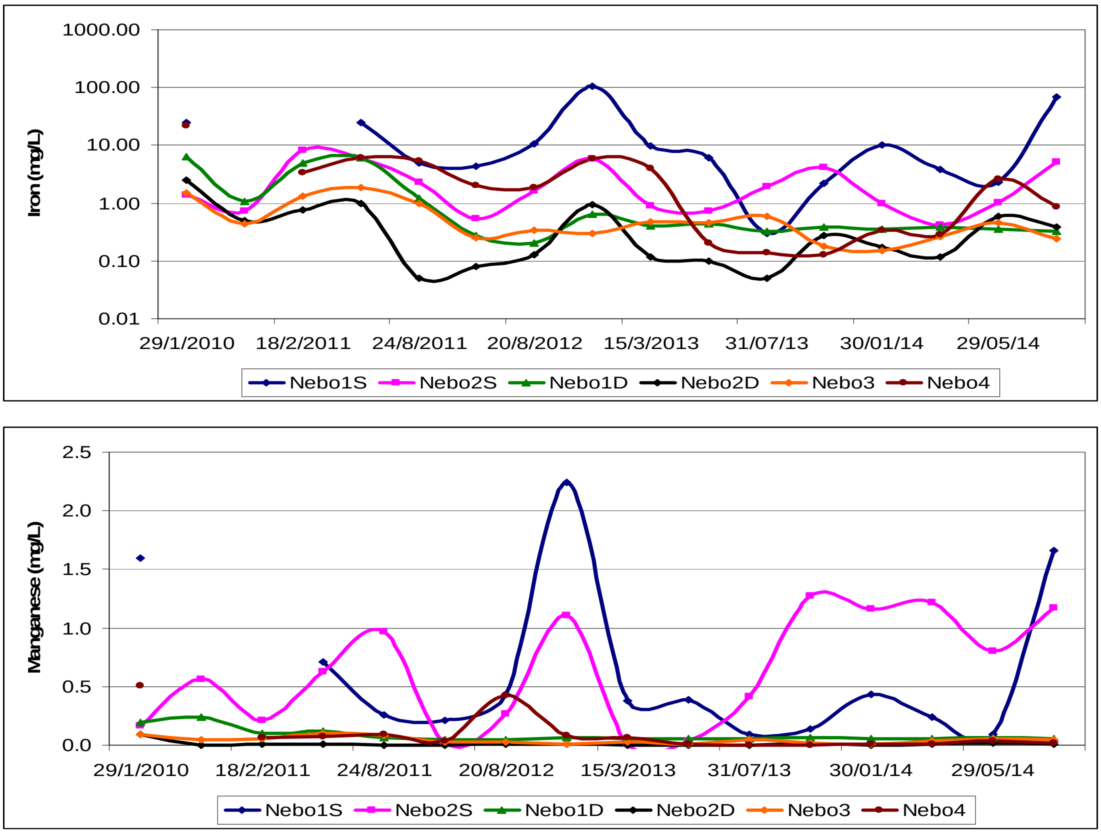


Figure 13 Iron and manganese (mg/L)

4.6 Inflow to Mine Workings

4.6.1 Predicted Impacts

- No observable increase in groundwater inflow to mine workings.

4.6.2 Mine Inflow Observations

No mine water was discharged from the Wongawilli mine, including from the Nebo workings, during the extraction period of N2

Based on mine pump out data records, no observable increased inflow to the Wongawilli mine workings following extraction of Longwall N2 has occurred and no TARP trigger levels have been reached or exceeded.

5 PREDICTED AND OBSERVED SURFACE WATER SYSTEM IMPACTS

5.1 Stream Flow

5.1.1 Potential Impacts

- No anticipated adverse effect on stream flow in the Nebo Creeks and tributaries.

5.1.2 Stream Water Level and Flow Observations

No observed adverse stream flow or pool level effects on Wattle Creek or its tributary, Jacksons Creek (WC1) has been observed due to extraction of Longwall N2 as shown in **Figure 14**.

Visual observation has not indicated any adverse effects on Little Wattle Tree Creek stream flow or pool levels.

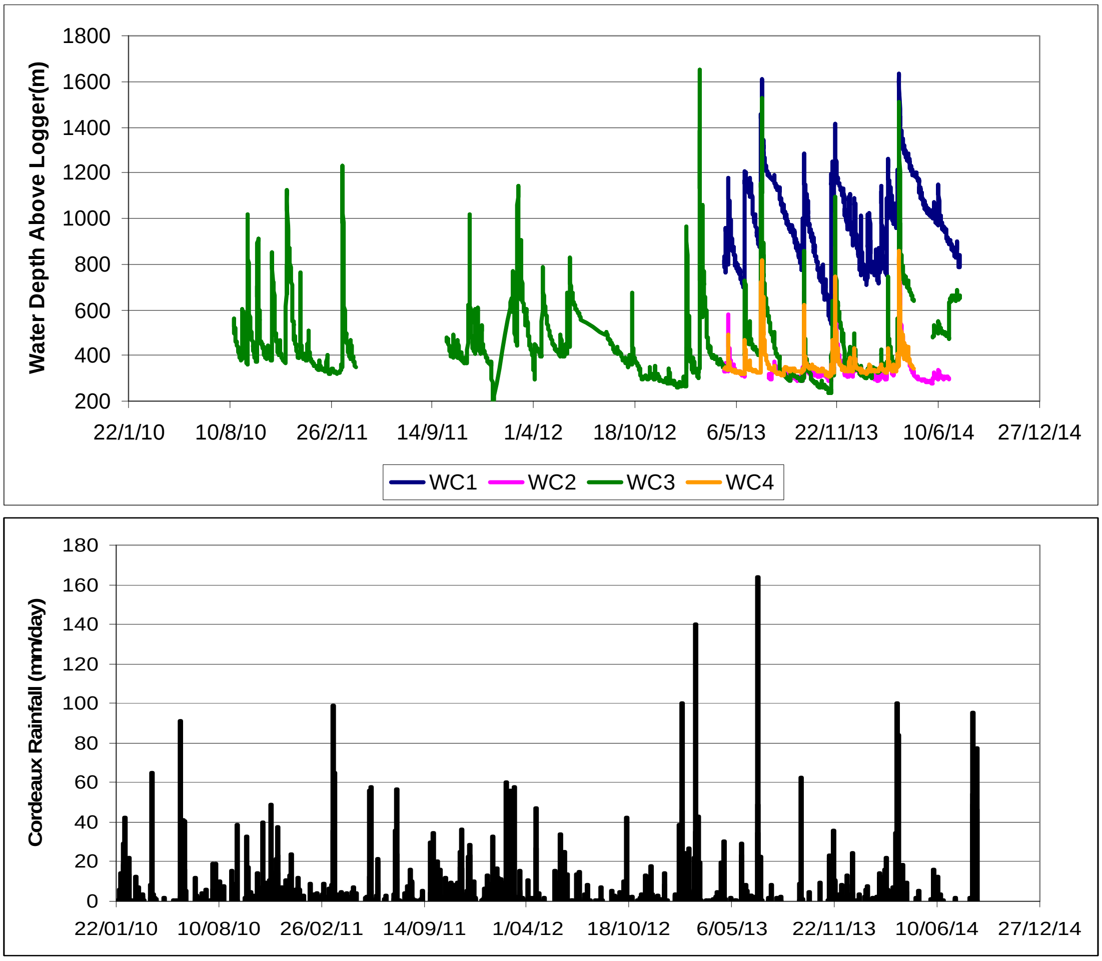


Figure 14 Nebo Stream Water Level

<u>No stream flow or pool level related TARP trigger levels have been reached or exceeded and no ameliorative actions are required due to extraction of Longwall N2.</u>

5.2 Stream Water Quality

5.2.1 Potential Impacts

- increased iron hydroxide precipitation, and;
- lowering (acidification) of pH, and;
- minor to moderate increase in salinity.

5.2.2 Creek Observations

During and after extraction of Longwall N2, field water quality in Wattle Creek, Little Wattle Tree Creek and Jacksons Creek did not observably change outside of climatic influences as shown in **Figure 15**.

The field and laboratory data supplied by WCL indicates that the creek salinity generally varies from 50 – 250uS/cm, whereas the pH, which is naturally between 5.5 and 8, is shown as reaching up to 10; however the more alkaline readings are a result of cement contamination of the pH probe.

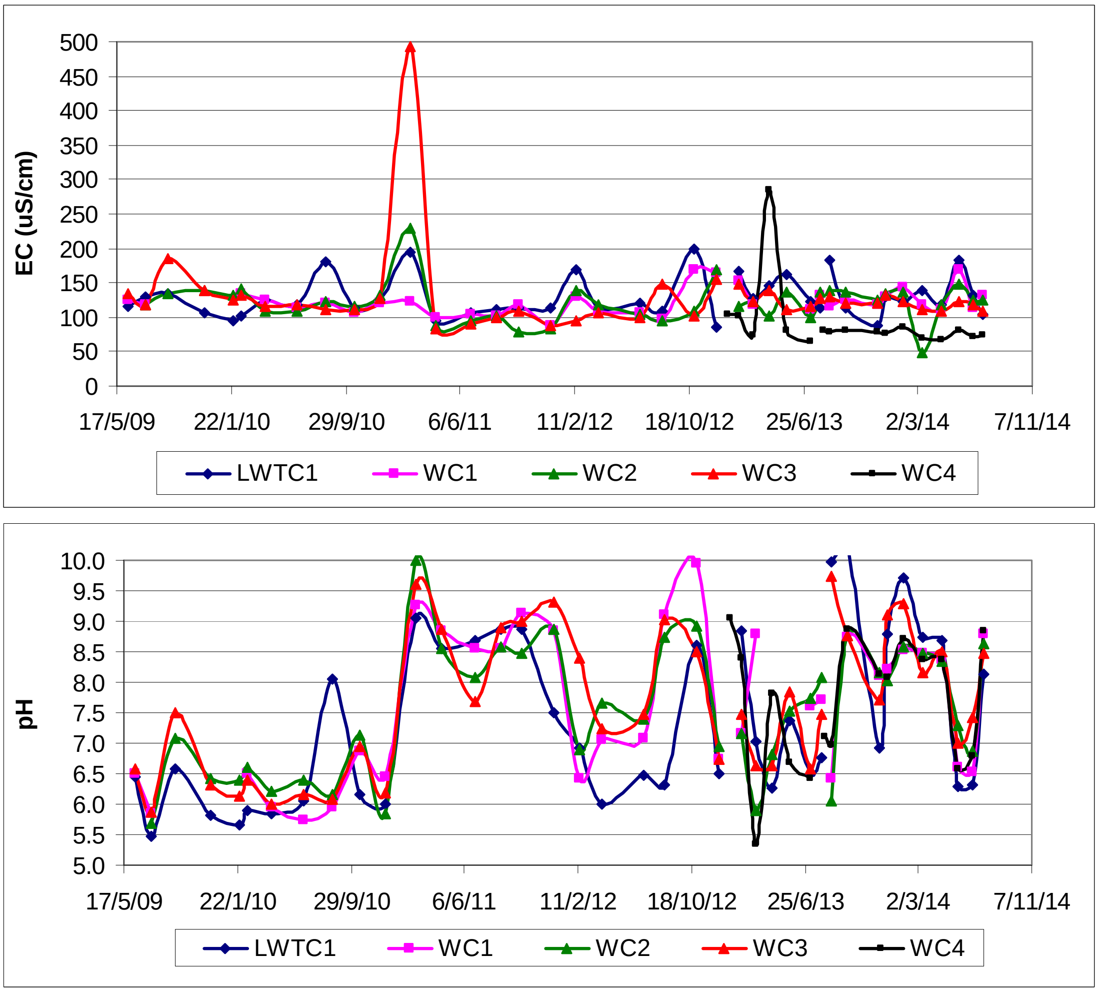


Figure 15 Stream Salinity and pH

The laboratory analyses indicate the Jacksons Creek (WC1), WC2 (Wattle Creek upstream of Jacksons Creek) and WC3 (downstream of Jacksons Creek waters are occasionally to generally outside of ANZECC 2000 Upland Stream and 95% Protection of Freshwater Aquatic Ecosystems guidelines for total Nitrogen and phosphorous, as well as filtered aluminium, and occasionally for filtered copper, lead, zinc and nickel.

The headwaters of Wattle Creek at WC4, however, exceeded the guidelines for filtered zinc in all samples, and occasionally for total nitrogen and total phosphorous, as well as aluminium.

The stream water quality related TARP trigger levels in the Nebo area were not exceeded during extraction of Longwall N2.

5.3 Stream Bed and Bank Stability

5.3.1 Potential Impacts

- increased stream bed or bank instability;
- cracking of exposed sandstone rock faces;
- no anticipated adverse effect on Wattle, Little Wattle Tree or Jacksons Creeks resulting from extraction of Longwall N2.

5.3.2 Observed Impacts

No observed adverse effect has been observed on the main creek channels or tributaries in the Nebo area resulting from extraction of Longwall N2.

No stream bed or bank stability TARP trigger levels have been reached or exceeded and no ameliorative actions are required due to extraction of Longwall N2.

6 SUMMARY OF RESULTS

During extraction of Longwall N2, no surface water or groundwater TARP triggers have been exceeded.

Table 4 summarises the predicted and observed effects on the Nebo area surface water and groundwater systems.

Table 4 Summary of Groundwater and Surface Water Impacts

Predicted Impacts	Observed Impacts Due to Extraction of Longwall N2
Adverse interconnection of aquifers and aquitards is not anticipated within 20m of the surface	No adverse interconnection between aquifers and aquitards has been observed within 20m of the surface
Potential increased rate of recharge into the plateau	No increased rate of recharge has been observed
Temporary lowering of shallow groundwater by up to 10m which may stay at that level until maximum subsidence develops	Based on the available data, no above trigger lowering of the shallow piezometric surface has been observed in relation to extraction of Longwall N2, however Nebo1 fell by approximately 8m and subsequently recovered to 4m below the pre N2 level, which was within the predicted water level change parameters.
Shallow groundwater levels should recover over a few months	Based on the available data, the Nebo1D water level is recovering
No permanent post mining reduction in the shallow groundwater levels unless a new outflow path develops	Based on the available data, the Nedo1D water level has not yet fully recovered
Strata dilation and subsequent re-filling of secondary voids may temporarily lower the shallow standing water levels	Based on the available data, the Nebo1D water level has not yet recovered
The shallow piezometers may experience increased iron / manganese hydroxide precipitation and / or lowering of pH	The water quality in the shallow piezometers has not been affected by subsidence related effects
Interface drainage, ferruginous, brackish seeps may be generated in streams	No interface drainage, ferruginous, brackish seeps have been generated in local streams
Increased basement groundwater seepage inflow into the workings should not occur	No increased rate of groundwater seepage into the workings has occurred
Stream flow in creeks overlying the extracted workings may be adversely affected by subsidence	Stream flow in local streams has not been adversely affected by subsidence related effects
Stream water quality may be adversely affected by subsidence	Stream water quality in local streams has not been affected in the long term, with both pH and EC remaining in their baseline, pre N2 range
Stream bed and bank stability may be adversely affected by subsidence	Stream bed and bank stability in the local creeks has not been adversely affected by subsidence related effects

7 REFERENCES

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MSEC, 2010 Prediction of Subsidence Parameters and the Assessment of Mine Subsidence Impacts of Natural Features and Surface Infrastructure Resulting From the Proposed Extraction of Longwalls N1 to N6 in the Nebo Area in Support of a Part 3A Application

Niche, 2011 Gujarat NRE FCGL Pty Ltd NRE Wongawilli Colliery Nebo Longwalls N1-N6 Extraction Plan, Rev. D2

SCT Operations, 2014 Wongawilli Colliery N2 End of Panel Subsidence Report

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In preparing this report, GeoTerra has relied upon certain verbal information and documentation provided by the client and / or third parties. GeoTerra did not attempt to independently verify the accuracy or completeness of that information. To the extent that the conclusions and recommendations in this report are based in whole or in part on such information, they are contingent on its validity. GeoTerra assume no responsibility for any consequences arising from any information or condition that was concealed, withheld, misrepresented, or otherwise not fully disclosed or available to GeoTerra.

Interpretations and recommendations provided in this report are opinions provided for our Client's sole use in accordance with the specified brief. As such they do not necessarily address all aspects of water, soil or rock conditions on the subject site. The responsibility of GeoTerra is solely to its client and it is not intended that this report be relied upon by any third party, who should make their own enquiries.

The advice herein relates only to this project and all results, conclusions and recommendations made should be reviewed by a competent and experienced person with experience in environmental and / or hydrological investigations before being used for any other purpose. The client should rely on its own knowledge and experience of local conditions in applying the interpretations contained herein.

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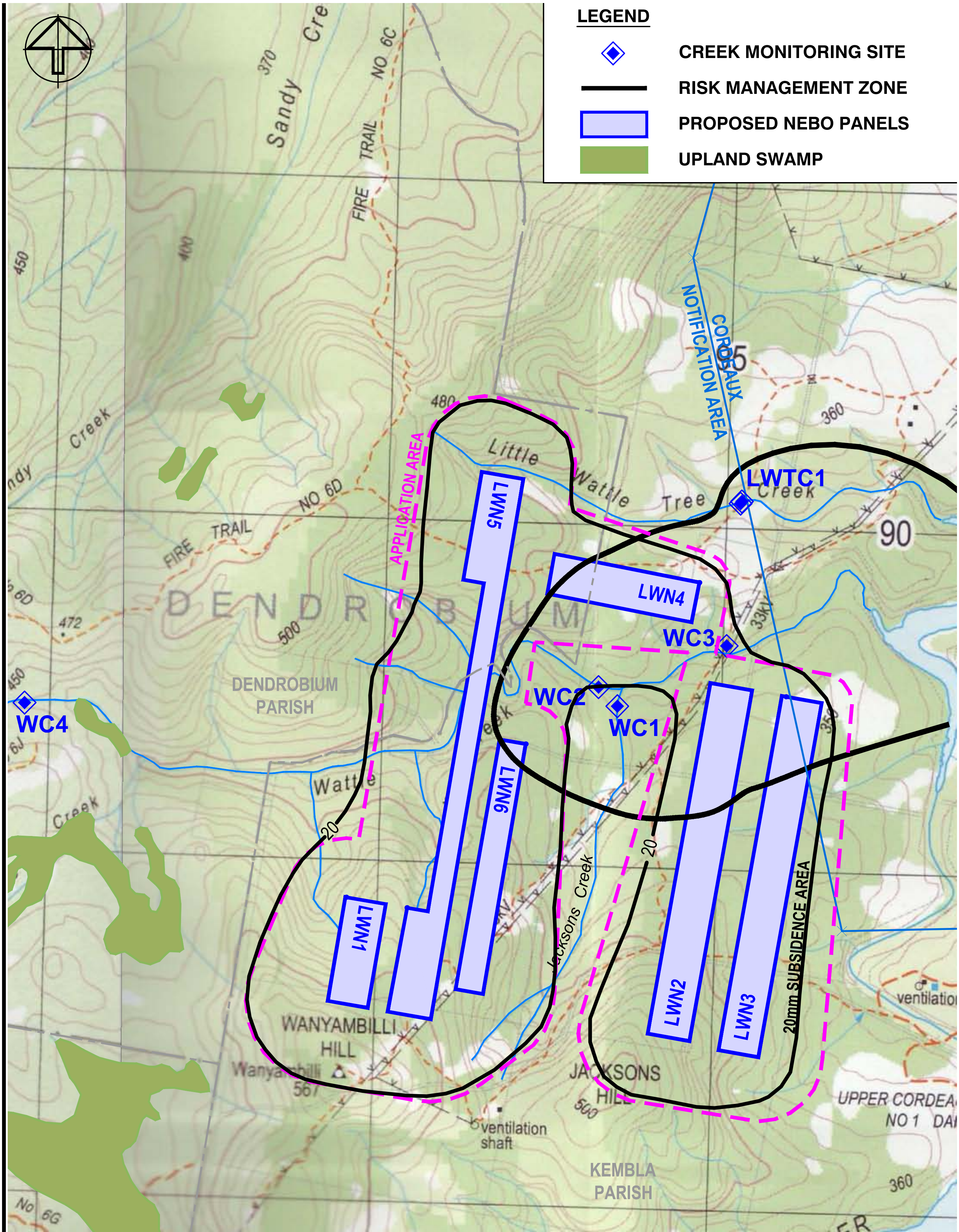
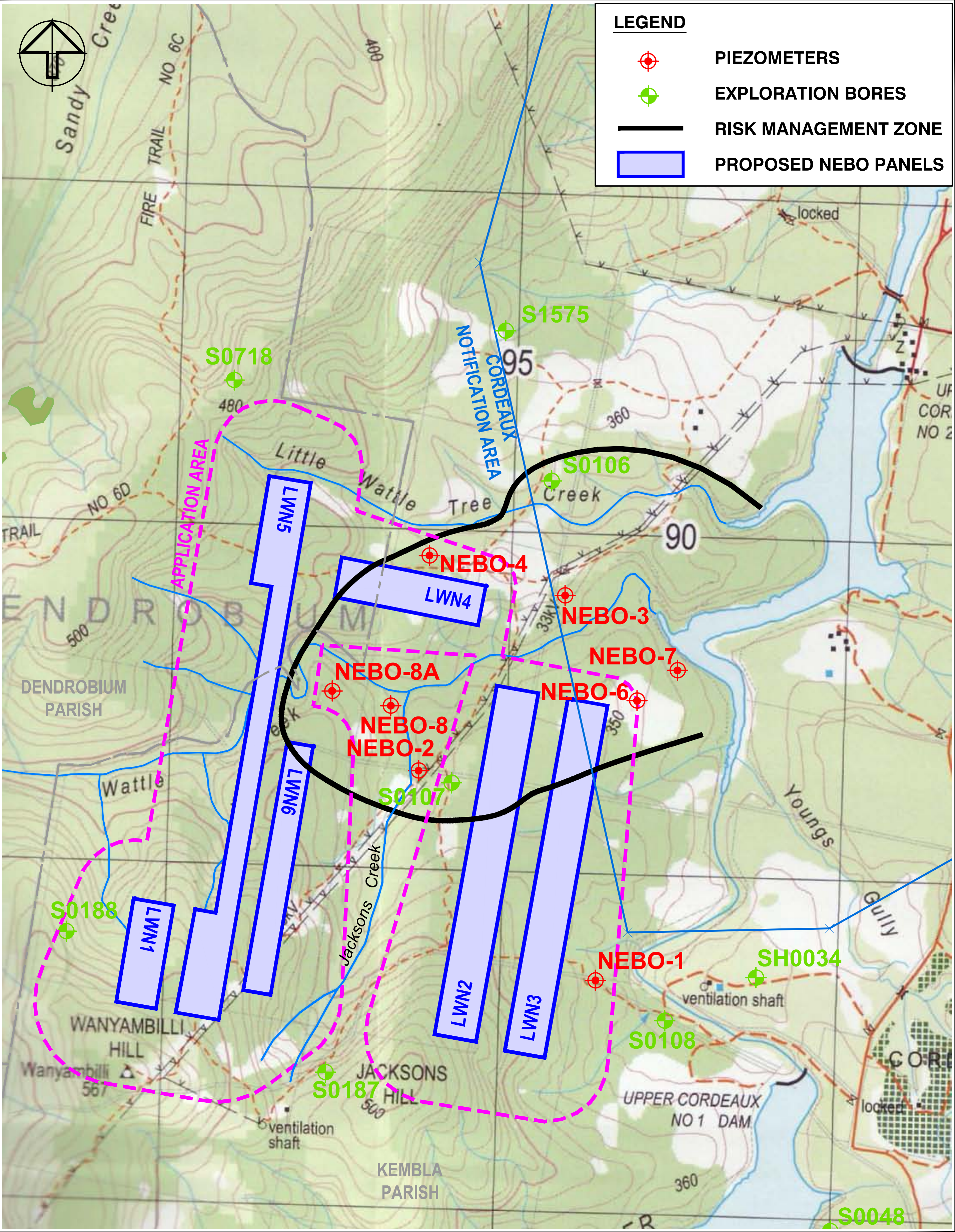


PROJECT:	NEB4-R1
DRAWN:	A. DAWKINS
DATE:	1 SEP 2014
SCALE:	1:15 000

WOLLONGONG COAL PTY LTD
NEBO LONGWALL LWN2
SURFACE WATER
MONITORING LOCATIONS

DRAWING 1



PROJECT:	NEB4-R1
DRAWN:	A. DAWKINS
DATE:	1 Sep 2014
SCALE:	1:15 000

WOLLONGONG COAL pTY LTD
NEBO LONGWALL LWN2

PIEZOMETER LOCATIONS

DRAWING 2

APPENDIX A

WATER CHEMISTRY ANALYSES

Nebo Surface Water Laboratory Analyses (mg/L)

ANZECC												0.25	0.02			1.9	1.9	0.0014	0.0034	0.008	0.011	0.055	0.024 (III) / 0.013(V)
		DOC	TDS	Na	Ca	K	Mg	Cl	F	SO4	HCO3	Tot N	Tot P	Fe	Fe Filt	Mn	Filt Mn	Filt Cu	Filt Pb	Filt Zn	Filt Ni	Filt Al	Filt As
9/6/2009	WC1	2	78	17	4.2	0.5	5.3	36	0.10	4	33	0.50	0.01	0.17	0.13	0.020	0.01	0.001	0.001	0.002	0.01	0.100	0.01
17/7/2009	WC1	1	69	14	4.1	0.7	5.3	26	0.10	4	26	0.20	0.03	0.08	0.1	0.010	0.01	0.001	0.001	0.01	0.01	0.030	0.01
6/4/2010	WC1	3	65	12	5.3	0.4	4.9	20	0.10	4	31	0.40	0.01	1.5	0.13	0.070	0.06	0.001	0.001	0.012	0.01	0.030	0.01
15/6/2010	WC1	2	65	12	5.2	0.2	3.6	21	0.10	4	25	0.20	0.01	0.12	0.09	0.01	0.01	0.001	0.001	0.002	0.01	0.03	0.01
18/8/2010	WC1	1	87	11	3	1	4	20	0.50	3	35	0.10	0.01	0.05	0.05	0.001	0.001	0.001	0.001	0.005	0.001	0.060	0.001
19/10/2010	WC1	1	72	13	3	1	4	20	0.10	3	27	0.10	0.01	0.09	0.05	0.002	0.002	0.001	0.001	0.005	0.001	0.1	0.001
14/12/2010	WC1	1	65	12	4	1	4	26	0.10	3	24	0.10	0.01	0.15	0.25	0.002	0.007	0.031	0.06	0.15	0.028	0.1	0.001
18/2/2011	WC1	1	69	15	4	1	5	20	0.2	3	25	0.10	0.01	0.18	0.06	0.006	0.004	0.001	0.001	0.005	0.001	0.06	0.001
15/4/2011	WC1	2	101	13	4	1	4	18	0.10	3	25	0.30	0.15	0.21	0.14	0.01	0.007	0.001	0.001	0.005	0.001	0.09	0.001
7/1/2011	WC1	1	81	12	4	1	5	20	0.10	14	18	0.20	0.01	0.21	0.13	0.004	0.001	0.001	0.001	0.005	0.001	0.19	0.001
26/8/2011	WC1	2	71	11	4	1	4	21	0.10	3	25	0.50	0.01	0.12	0.09	0.002	0.001	0.001	0.001	0.005	0.001	0.12	0.001
20/12/2011	WC1	1	89	14	4	1	5	21	0.10	3	28	0.40	0.02	0.14	0.07	0.002	0.002	0.001	0.001	0.005	0.001	0.07	0.001
16/2/12	WC1	8	91	11	3	1	4	19	0.10	3	20	0.40	0.03	0.38	0.19	0.008	0.006	0.001	0.001	0.005	0.001	0.2	0.001
4/3/2012	WC1	1	69	13	4	1	5	21	0.10	3	22	0.40	0.01	0.23	0.09	0.006	0.004	0.001	0.001	0.005	0.001	0.05	0.001
7/4/2012	WC1	1	75	12	4	1	4	22	0.10	3	23	0.40	0.01	0.16	0.1	0.004	0.002	0.001	0.001	0.005	0.001	0.07	0.001
20/8/2012	WC1	1	86	12	3	1	4	23	0.10	4	22	0.20	0.01	0.47	0.15	0.006	0.005	0.001	0.001	0.005	0.001	0.08	0.001
30/10/2012	WC1	1	72	14	4	1	6	24	0.10	4	27	0.80	0.02	0.4	0.24	0.011	0.006	0.001	0.001	0.005	0.001	0.02	0.001
17/12/2012	WC1	1	119	13	4	2	5	23	0.10	4	30	0.40	0.04	0.55	0.38	0.014	0.007	0.001	0.001	0.005	0.001	0.04	0.001
4/2/2013	WC1	2	89	14	4	1	4	25	0.10	4	17	1.10	0.01	0.1	0.005	0.003	0.001	0.001	0.001	0.005	0.001	0.05	0.001
8/3/2013	WC1	2	92	11	3	1	4	21	0.10	4	14	0.50	0.01	0.09	0.05	0.002	0.001	0.001	0.001	0.005	0.001	0.05	0.001
31/7/2013	WC1	1	88	11	2	1	2	21	0.10	4	13	0.20	0.07	0.1	0.05	0.001	0.001	0.001	0.001	0.005	0.001	0.14	0.001
1/10/2013	WC1	5	73	13	4	1	4	19	0.10	3	29	0.40	0.01	0.11	0.08	0.001	0.001	0.001	0.001	0.005	0.001	0.14	0.001
5/12/2013	WC1	1	97	12	3	1	4	20	0.10	4	21	0.10	0.01	0.08	0.07	0.002	0.001	0.001	0.001	0.005	0.001	0.08	0.001
13/3/2014	WC1	1	69	13	4	1	4	25	0.10	3	25	0.20	0.01	0.05	0.05	0.002	0.002	0.001	0.001	0.005	0.001	0.05	0.001
30/5/2014	WC1	1	65	15	3	1	4	17	0.01	4	26	0.50	0.01	0.43	0.14	0.038	0.019	0.001	0.001	0.007	0.001	0.08	0.001
23/7/2014	WC1	1	92	15	4	1	4	19	0.1	4	26	0.90	0.04	1.47	0.15	0.073	0.024	0.001	0.001	0.016	0.001	0.12	0.001
	ST Dev	1.564	13.623	1.532	0.713	0.302	0.770	3.738	0.083	2.115	5.278	0.25	0.030	0.376	0.079	0.019	0.012	0.006	0.012	0.028	0.006	0.047	0.003
	Max	8.000	119.000	17.000	5.300	2.000	6.000	36.000	0.500	14.000	35.000	1.10	0.150	1.500	0.380	0.073	0.060	0.031	0.060	0.150	0.028	0.200	0.010
	Min	1.000	65.000	11.000	2.000	0.200	2.000	17.000	0.010	3.000	13.000	0.10	0.010	0.050	0.005	0.001	0.001	0.001	0.001	0.002	0.001	0.020	0.001
	Median	1.000	76.500	13.000	4.000	1.000	4.000	21.000	0.100	4.000	25.000	0.40	0.010	0.155	0.095	0.005	0.004	0.001	0.001	0.005	0.001	0.075	0.001

Nebo Surface Water Laboratory Analyses (mg/L)

ANZECC												0.25	0.02			1.9	1.9	0.0014	0.0034	0.008	0.011	0.055	0.024 (III) / 0.013(V)
		DOC	TDS	Na	Ca	K	Mg	Cl	F	SO4	HCO3	Tot N	Tot P	Fe	Fe Filt	Mn	Filt Mn	Filt Cu	Filt Pb	Filt Zn	Filt Ni	Filt Al	Filt As
17/7/2009	WC2	2	68	16	4.1	0.7	5.1	27	0.01	5	25	0.10	0.01	0.2	0.12	0.01	0.01	0.001	0.001	0.006	0.01	0.040	0.01
7/9/2009	WC2	2	62	12	3.5	0.5	5	21	0.01	5	25	0.10	0.01	0.19	0.14	0.020	0.01	0.002	0.001	0.003	0.01	0.020	0.01
27/11/2009	WC2	3	65	14	3.6	0.6	5.2	23	0.01	4	32	0.10	0.01	0.3	0.28	0.01	0.01	0.001	0.001	0.005	0.01	0.030	0.01
29/1/2010	WC2	4	73	14	4.9	0.8	5.2	24	0.01	3	36	0.10	0.03	1.3	0.45	0.040	0.02	0.001	0.001	0.005	0.01	0.030	0.01
6/4/2010	WC2	4	68	14	3.8	0.3	5	23	0.01	4	26	0.40	0.01	9.2	0.17	0.100	0.05	0.001	0.001	0.011	0.01	0.030	0.01
15/6/2010	WC2	2	67	14	5.7	0.3	4.7	25	0.01	4	28	0.10	0.01	0.16	0.11	0.01	0.01	0.001	0.001	0.001	0.01	0.02	0.01
18/8/2010	WC2	1	78	12	3	1	4	21	0.50	4	26.8	0.10	0.08	0.18	0.1	0.005	0.005	0.001	0.001	0.005	0.001	0.030	0.001
19/10/2010	WC2	1	72	14	3	1	4	22	0.01	4	25	0.20	0.11	0.24	0.16	0.008	0.007	0.001	0.001	0.007	0.001	0.05	0.001
14/12/2010	WC2	2	76	14	4	1	5	28	0.01	3	28	0.10	0.01	0.33	0.26	0.007	0.011	0.01	0.016	0.04	0.008	0.08	0.001
18/2/2011	WC2	3	58	14	3	1	5	21	0.4	3	31	0.10	0.06	1.16	0.34	0.046	0.008	0.001	0.001	0.005	0.001	0.05	0.001
15/4/2011	WC2	2	87	14	4	1	5	21	0.1	3	23	0.20	0.06	0.26	0.2	0.007	0.006	0.001	0.001	0.005	0.001	0.05	0.001
7/1/2011	WC2	1	96	13	4	1	5	21	0.1	4	16	0.10	0.01	0.29	0.19	0.009	0.007	0.001	0.001	0.005	0.001	0.1	0.001
26/8/2011	WC2	2	71	12	3	1	5	20	0.1	4	21	0.10	0.01	0.21	0.16	0.006	0.006	0.001	0.001	0.005	0.001	0.09	0.001
20/12/2011	WC2	2	77	13	3	1	4	20	0.1	2	15	0.10	0.02	0.4	0.37	0.011	0.012	0.001	0.001	0.005	0.001	0.13	0.001
16/2/12	WC2	3	90	12	3	1	4	19	0.1	2	20	0.10	0.03	0.51	0.27	0.021	0.016	0.001	0.001	0.005	0.002	0.16	0.001
4/3/2012	WC2	2	74	14	4	1	5	22	0.1	3	24	0.20	0.01	0.67	0.32	0.017	0.014	0.001	0.001	0.005	0.001	0.07	0.001
7/4/2012	WC2	1	71	13	3	1	4	22	0.1	3	24	0.30	0.01	0.34	0.18	0.007	0.005	0.001	0.001	0.005	0.001	0.03	0.001
20/8/2012	WC2	1	62	13	3	1	4	22	0.1	4	28	0.10	0.01	0.24	0.19	0.005	0.005	0.001	0.001	0.005	0.001	0.02	0.001
30/10/2012	WC2	1	88	16	5	1	6	23	0.1	5	26	0.50	0.02	0.59	0.25	0.02	0.005	0.001	0.001	0.005	0.001	0.02	0.001
17/12/2012	WC2	1	111	13	4	1	5	23	0.1	4	31	0.20	0.2	0.48	0.36	0.012	0.008	0.001	0.001	0.005	0.001	0.02	0.001
4/2/2013	WC2	3	86	16	3	1	4	25	0.1	6	18	0.30	0.01	0.38	0.23	0.018	0.011	0.001	0.001	0.005	0.001	0.06	0.001
8/3/2013	WC2	2	84	12	3	1	4	22	0.1	4	15	0.10	0.01	0.25	0.17	0.014	0.01	0.001	0.001	0.005	0.001	0.07	0.001
12/4/2013	WC2	2	64	14	4	1	5	21	0.1	5	27	0.40	0.01	0.2	0.16	0.009	0.008	0.001	0.001	0.01	0.001	0.03	0.001
31/7/2013	WC2	2	101	12	2	1	3	23	0.1	4	18	0.30	0.02	0.3	0.11	0.011	0.005	0.001	0.001	0.005	0.001	0.04	0.001
1/10/2013	WC2	5	70	14	4	1	4	21	0.1	4	31	0.20	0.04	0.17	0.11	0.006	0.005	0.001	0.001	0.005	0.001	0.05	0.001
5/12/2013	WC2	3	72	13	3	1	4	21	0.1	5	24	0.10	0.01	0.23	0.18	0.008	0.007	0.001	0.001	0.005	0.001	0.08	0.001
30/1/2014	WC2	2	81	22	4	1	5	24	0.1	4	24	0.10	0.24	0.26	0.16	0.009	0.008	0.001	0.001	0.005	0.001	0.02	0.001
13/3/2014	WC2	2	83	15	4	1	5	27	0.1	3	26	0.10	0.01	0.31	0.25	0.009	0.008	0.001	0.001	0.005	0.001	0.04	0.001
30/5/2014	WC2	2	72	16	4	1	5	23	0.1	4	29	0.40	0.01	0.14	0.11	0.005	0.005	0.001	0.001	0.005	0.001	0.02	0.001
23/7/2014	WC2	1	82	17	4	1	5	23	0.1	2	27	1.00	0.01	0.09	0.06	0.007	0.003	0.001	0.001	0.005	0.001	0.01	0.001

ST Dev	1.008	12.175	2.033	0.756	0.208	0.624	2.143	0.104	0.961	5.130	0.19	0.056	1.637	0.093	0.019	0.008	0.002	0.003	0.007	0.004	0.035	0.004
Max	5.000	111.000	22.000	5.700	1.000	6.000	28.000	0.500	6.000	36.000	1.00	0.240	9.200	0.450	0.100	0.050	0.010	0.016	0.040	0.010	0.160	0.010
Min	1.000	58.000	12.000	2.000	0.300	3.000	19.000	0.010	2.000	15.000	0.10	0.010	0.090	0.060	0.005	0.003	0.001	0.001	0.001	0.001	0.010	0.001
Median	2.000	73.500	14.000	3.900	1.000	5.000	22.000	0.100	4.000	25.500	0.10	0.010	0.275	0.180	0.010	0.008	0.001	0.001	0.005	0.001	0.040	0.001

Nebo Surface Water Laboratory Analyses (mg/L)

ANZECC												0.25	0.02			1.900	1.9	0.0014	0.0034	0.008	0.011	0.055	0.024 (III) / 0.013(V)
		DOC	**TDS**	**Na**	**Ca**	**K**	**Mg**	**Cl**	**F**	**SO4**	**HCO3**	**Tot N**	**Tot P**	**Fe**	**Fe Filt**	**Mn**	**Filt Mn**	**Filt Cu**	**Filt Pb**	**Filt Zn**	**Filt Ni**	**Filt Al**	**Filt As**
9/6/2009	**WC3**	3	140	37	4.7	0.9	7.6	57	0.10	11	35	0.70	0.05	0.26	0.17	0.010	0.01	0.001	0.001	0.004	0.01	0.100	0.01
17/7/2009	**WC3**	2	68	15	3.4	0.8	4.8	26	0.10	5	22	0.10	0.01	0.51	0.11	0.01	0.01	0.001	0.001	0.008	0.01	0.020	0.01
7/9/2009	**WC3**	2	55	11	3.3	0.6	4.7	19	0.10	4	25	0.10	0.03	0.27	0.15	0.020	0.01	0.002	0.001	0.003	0.01	0.040	0.01
27/11/2009	**WC3**	3	61	13	3.1	0.9	5.1	22	0.10	3	31	0.10	0.01	0.36	0.33	0.01	0.01	0.001	0.001	0.006	0.01	0.030	0.01
29/1/2010	**WC3**	3	90	16	12	1	3.6	24	0.10	3	57	0.10	0.01	1.3	0.6	0.040	0.03	0.001	0.001	0.001	0.01	0.030	0.01
6/4/2010	**WC3**	3	65	13	3.8	0.4	5.1	22	0.10	4	26	0.20	0.01	1.7	0.16	0.080	0.03	0.001	0.001	0.007	0.01	0.030	0.01
15/6/2010	**WC3**	1	65	14	3.8	0.2	4.3	23	0.10	4	27	0.20	0.01	0.75	0.10	0.03	0.01	0.001	0.001	0.001	0.01	0.02	0.01
18/8/2010	**WC3**	1	82	12	2	1	4	19	0.40	4	22	0.10	0.01	0.12	0.09	0.004	0.005	0.001	0.001	0.005	0.001	0.030	0.001
19/10/2010	**WC3**	1	78	13	3	1	4	21	0.10	3	23	0.10	0.08	0.24	0.17	0.011	0.009	0.001	0.001	0.005	0.001	0.05	0.001
14/12/2010	**WC3**	2	66	14	4	1	5	25	0.10	3	27	0.10	0.01	0.5	0.28	0.015	0.013	0.018	0.017	0.056	0.015	0.11	0.001
18/2/2011	**WC3**	3	66	14	4	1	5	20	0.3	3	24	0.10	0.04	0.58	0.31	0.014	0.01	0.001	0.001	0.005	0.001	0.07	0.001
15/4/2011	**WC3**	2	87	13	3	1	4	18	0.10	3	21	0.30	0.14	0.22	0.14	0.011	0.01	0.001	0.001	0.005	0.001	0.03	0.001
7/1/2011	**WC3**	1	73	12	4	1	4	20	0.10	3	25	0.10	0.01	0.24	0.15	0.008	0.006	0.001	0.001	0.005	0.001	0.09	0.001
26/8/2011	**WC3**	1	72	11	3	1	4	21	0.10	3	17	0.10	0.01	0.34	0.18	0.01	0.006	0.001	0.001	0.01	0.001	0.08	0.001
20/12/2011	**WC3**	2	85	12	3	1	4	20	0.10	2	16	0.40	0.01	0.36	0.24	0.011	0.008	0.001	0.001	0.007	0.001	0.13	0.001
16/2/12	**WC3**	4	94	11	3	1	4	19	0.10	2	20	0.20	0.02	0.46	0.26	0.015	0.011	0.001	0.001	0.005	0.001	0.17	0.001
4/3/2012	**WC3**	1	75	13	4	1	5	22	0.10	3	24	0.30	0.01	0.64	0.31	0.022	0.016	0.001	0.001	0.037	0.001	0.08	0.001
7/4/2012	**WC3**	1	65	12	3	1	4	18	0.10	3	22	0.20	0.01	0.26	0.14	0.006	0.005	0.001	0.001	0.005	0.001	0.03	0.001
20/8/2012	**WC3**	1	77	11	3	1	4	20	0.10	4	26	0.10	0.01	0.19	0.13	0.006	0.006	0.001	0.001	0.005	0.001	0.03	0.001
30/10/2012	**WC3**	1	78	13	4	1	5	21	0.10	4	24	0.50	0.01	0.61	0.34	0.024	0.017	0.001	0.001	0.005	0.001	0.02	0.001
17/12/2012	**WC3**	1	98	12	4	1	5	22	0.10	3	27	0.20	0.2	0.65	0.45	0.025	0.023	0.001	0.001	0.005	0.001	0.02	0.001
4/2/2013	**WC3**	3	93	15	3	1	4	25	0.10	6	18	0.40	0.01	0.28	0.26	0.008	0.01	0.001	0.001	0.005	0.001	0.08	0.001
8/3/2013	**WC3**	2	118	12	3	1	4	24	0.10	4	24	0.80	0.01	0.29	0.16	0.017	0.014	0.001	0.001	0.005	0.001	0.07	0.001
12/4/2013	**WC3**	1	57	14	4	1	4	20	0.10	4	23	0.10	0.01	0.18	0.11	0.011	0.011	0.001	0.001	0.005	0.001	0.02	0.001
31/7/2013	**WC3**	1	105	11	2	1	3	20	0.10	4	16	0.20	0.06	0.18	0.12	0.008	0.008	0.001	0.001	0.005	0.001	0.06	0.001
1/10/2013	**WC3**	5	67	13	3	1	4	18	0.10	4	26	0.20	0.03	0.17	0.11	0.01	0.006	0.001	0.001	0.005	0.001	0.06	0.001
5/12/2013	**WC3**	3	76	13	3	1	4	15	0.10	4	22	0.20	0.01	0.49	0.26	0.031	0.026	0.001	0.001	0.005	0.001	0.09	0.001
30/1/2014	**WC3**	2	81	14	4	1	5	22	0.10	3	23	2.30	0.01	0.22	0.13	0.014	0.011	0.001	0.001	0.005	0.001	0.03	0.001
13/3/2014	**WC3**	2	79	13	4	1	4	26	0.10	3	23	0.10	0.01	0.27	0.2	0.01	0.009	0.001	0.001	0.005	0.001	0.05	0.001
29/5/2014	**WC3**	1	52	13	2	1	4	20	0.10	3	21	0.30	0.07	0.46	0.08	0.026	0.008	0.001	0.001	0.005	0.001		0.001
23/7/2014	**WC3**	1	84	16	3	1	4	20	0.10	9	23	1.00	0.01	0.17	0.05	0.012	0.006	0.001	0.001	0.005	0.001	0.03	0.001

ST Dev	1.063	18.600	4.531	1.690	0.188	0.795	6.932	0.064	1.832	7.211	0.43	0.043	0.336	0.118	0.014	0.007	0.003	0.003	0.011	0.004	0.037	0.004
Max	5.000	140.000	37.000	12.000	1.000	7.600	57.000	0.400	11.000	57.000	2.30	0.200	1.700	0.600	0.080	0.030	0.018	0.017	0.056	0.015	0.170	0.010
Min	1.000	52.000	11.000	2.000	0.200	3.000	15.000	0.100	2.000	16.000	0.10	0.010	0.120	0.050	0.004	0.005	0.001	0.001	0.001	0.001	0.020	0.001
Median	2.000	77.000	13.000	3.100	1.000	4.000	21.000	0.100	3.000	23.000	0.20	0.010	0.290	0.160	0.011	0.010	0.001	0.001	0.005	0.001	0.045	0.001

Nebo Surface Water Laboratory Analyses (mg/L)

ANZECC												0.25	0.02			1.9	1.9	0.0014	0.0034	0.008	0.011	0.055	0.024 (III) / 0.013(V)
		DOC	TDS	Na	Ca	K	Mg	Cl	F	SO4	HCO3	Tot N	Tot P	Fe	Fe Filt	Mn	Filt Mn	Filt Cu	Filt Pb	Filt Zn	Filt Ni	Filt Al	Filt As
10/1/2013	WC4	2	69	10	1	1	2	20	0.1	5	3	0.1	0.01	0.42	0.14	0.112	0.106	0.001	0.001	0.011	0.002	0.02	0.001
5/2/2013	WC4	1	61	12	1	1	2	21	0.1	6	2	0.1	0.1	0.19	0.15	0.116	0.11	0.001	0.001	0.014	0.002	0.04	0.001
8/3/2013	WC4	2	50	9	1	1	1	15	0.1	4	1	0.30	0.01	0.41	0.13	0.099	0.088	0.001	0.001	0.012	0.002	0.12	0.001
12/4/2013	WC4	1	37	10	1	1	2	17	0.1	5	2	0.1	0.01	0.37	0.12	0.099	0.088	0.001	0.001	0.012	0.002	0.02	0.001
7/8/2013	WC4	2	38	10	1	1	1	23	0.1	4	1	0.20	0.02	0.29	0.16	0.081	0.08	0.001	0.001	0.015	0.001	0.04	0.001
2/10/2013	WC4	1	37	10	1	1	2	10	0.1	4	1	0.20	0.06	0.3	0.11	0.069	0.065	0.001	0.001	0.014	0.002	0.04	0.001
5/12/2013	WC4	2	51	10	1	1	1	12	0.1	4	1	0.10	0.02	0.3	0.09	0.07	0.067	0.001	0.001	0.012	0.001	0.06	0.001
30/1/2014	WC4	1	51	11	1	1	2	20	0.1	4	1	0.1	0.01	0.19	0.06	0.062	0.056	0.001	0.001	0.014	0.002	0.01	0.001
13/3/2014	WC4	1	34	10	1	1	2	24	0.1	3	1	0.1	0.01	0.2	0.09	0.067	0.062	0.001	0.001	0.011	0.001	0.02	0.001
30/5/2014	WC4	6	40	11	1	1	1	16	0.1	4	3	0.10	0.01	0.32	0.1	0.075	0.068	0.001	0.001	0.011	0.002	0.02	0.001
23/7/2014	WC4	1	56	12	1	1	2	18	0.1	6	2	0.40	0.01	0.22	0.1	0.061	0.055	0.001	0.001	0.012	0.001	0.01	0.001
	ST Dev	1.471	11.387	0.934	0.000	0.000	0.505	4.378	0.000	0.934	0.809	0.10	0.029	0.085	0.030	0.020	0.019	0.000	0.000	0.001	0.001	0.032	0.000
	Max	6.000	69.000	12.000	1.000	1.000	2.000	24.000	0.100	6.000	3.000	0.40	0.100	0.420	0.160	0.116	0.110	0.001	0.001	0.015	0.002	0.120	0.001
	Min	1.000	34.000	9.000	1.000	1.000	1.000	10.000	0.100	3.000	1.000	0.10	0.010	0.190	0.060	0.061	0.055	0.001	0.001	0.011	0.001	0.010	0.001
	Median	1.000	50.000	10.000	1.000	1.000	2.000	18.000	0.100	4.000	1.000	0.10	0.010	0.300	0.110	0.075	0.068	0.001	0.001	0.012	0.002	0.020	0.001

Nebo Groundwater Chemistry

	ANZECC 2000											0.25	0.02			1.9	1.9	0.0014	0.0034	0.008	0.011	0.055	0.013(V)
		DOC	TDS	Na	Ca	K	Mg	Cl	F	SO4	HCO3	Tot N	Tot P	Fe	Fe Filt	Mn	Filt Mn	Filt Cu	Filt Pb	Filt Zn	Filt Ni	Filt Al	Filt As
29/1/2010	**Nebo 1S**	2	675	135	72	2.1	28	89	0.11	175	370	1.5	3.6	25.00	0.08	1.600	0.63	0.002	0.001	0.005	0.01	0.04	0.01
30/6/2011	**Nebo 1S**	1	194	27	10	2	7	4.1	0.1	18	48	3.4	1.17	25.30	0.5	0.712	0.304	0.008	0.001	0.029	0.01	0.03	0.001
24/8/2011	**Nebo 1S**		171	26	5	1	5	53	0.1	4	17	0.3	0.13	4.89	0.05	0.260	0.199	0.012	0.001	0.024	0.016	0.04	0.001
16/2/2012	**Nebo 1S**	2	200	24	4	1	4	39	0.1	21	1	15.7	0.23	4.33	0.18	0.215	0.156	0.008	0.001	0.013	0.007	0.14	0.001
20/8/2012	**Nebo 1S**	1	176	35	4	2	7	68	0.1	4	27	0.8	0.54	10.60	0.18	0.438	0.385	0.011	0.001	0.028	0.014	0.05	0.001
24/1/2013	**Nebo 1S**	3	128	26	5	2	4	44	0.1	6	31	2.9	6.26	106.00	13.4	2.240	0.797	0.001	0.001	0.017	0.012	0.03	0.001
15/3/2013	**Nebo 1S**	2	136	24	6	1	6	39	0.1	5	35	0.9	0.5	9.55	0.07	0.378	0.205	0.013	0.001	0.055	0.014	0.1	0.001
18/04/2013	**Nebo 1S**	2	182	43	5	2	6	62	0.1	11	8	5.2	0.08	6.11	0.05	0.386	0.216	0.015	0.001	0.055	0.017	0.06	0.001
31/07/2013	**Nebo 1S**	1	151	30	2	2	5	64	0.1	4	1	6	0.02	0.30	0.05	0.096	0.093	0.009	0.001	0.03	0.009	0.08	0.001
4/12/2013	**Nebo 1S**	4	141	34	5	2	6	58	0.1	4	15	0.3	0.14	2.25	0.2	0.142	0.197	0.018	0.001	0.051	0.01	0.011	0.001
30/01/2014	**Nebo 1S**	2	171	38	4	2	7	68	0.1	4	14	0.3	0.44	10.20	0.49	0.437	0.233	0.009	0.001	0.042	0.011	0.05	0.001
13/03/2014	**Nebo 1S**	1	151	31	4	1	5	57	0.1	4	16	0.2	0.15	3.85	0.16	0.242	0.158	0.006	0.001	0.028	0.009	0.1	0.001
29/05/2014	**Nebo 1S**	5	80	19	3	2	3	24	0.1	4	26	1.1	0.07	2.30	0.21	0.093	0.067	0.007	0.001	0.076	0.006		0.001
23/07/2014	**Nebo 1S**	6	194	43	4	2	5	66	0.1	4	27	2.6	3.92	70.10	12	1.660	0.849	0.007	0.001	0.075	0.01	0.18	0.001
29/1/2010	**Nebo 2S**	2	140	17	23	1.9	8.7	24		15	110	0.3	0.1	1.40	0.02	0.170	0.05	0.003	0.005	0.042	0.01	0.01	0.01
18/8/2010	**Nebo 2S**	5	138	14	11	2	10	16	1.1	6	96	0.5	0.25	0.72	0.11	0.566	0.566	0.003	0.001	0.036	0.004	0.01	0.001
18/2/2011	**Nebo 2S**	10	93	11	16	6	5	9	0.5	6	62	1.2	0.01	8.38	0.93	0.21	0.165	0.006	0.001	0.02	0.004	0.05	0.001
30/6/2011	**Nebo 2S**	6	158	15	13	3	10	15	0.1	13	69	2.3	0.02	5.75	0.45	0.627	0.518	0.004	0.001	0.026	0.008	0.04	0.001
24/8/2011	**Nebo 2S**		176	17	11	1	15	19	0.2	1	96	0.7	0.16	2.26	1.72	0.97	0.924	0.001	0.001	0.006	0.003	0.01	0.001
16/2/2012	**Nebo 2S**	7	140	7	28	4	2	9	0.1	45	14	6.3	0.1	0.55	0.33	0.018	0.005	0.006	0.001	0.017	0.002	0.06	0.001
20/8/2012	**Nebo 2S**	5	118	12	17	4	8	10	0.2	7	90	1.4	0.05	1.62	0.05	0.272	0.012	0.007	0.001	0.196	0.002	0.02	0.001
24/1/2013	**Nebo 2S**	4	166	20	13	1	20	22	0.2	1	130	0.9	0.09	5.84	0.05	1.110	1.1	0.002	0.001	0.01	0.004	0.01	0.001
15/3/2013	**Nebo 2S**	6	62	6	11	2	1	10	0.1	4	29	1.1	0.02	0.92	0.24	0.013	0.004	0.005	0.001	0.015	0.004	0.02	0.001
18/04/2013	**Nebo 2S**	5	131	8	13	5	2	10	0.1	7	1	14.8	0.01	0.72	0.2	0.036	0.026	0.006	0.001	0.019	0.006	0.03	0.001
31/07/2013	**Nebo 2S**	3	138	17	9	2	12	11	0.3	3	93	1.4	0.06	1.92	1.28	0.419	0.339	0.008	0.005	0.026	0.004	0.15	0.001
4/12/2013	**Nebo 2S**	4	140	17	14	1	14	21	0.2	1	94	0.2	0.08	4.16	2.14	1.270	0.903	0.004	0.001	0.013	0.01	0.01	0.003
30/01/2014	**Nebo 2S**	4	164	20	13	2	19	20	0.2	1	112	1.2	0.05	0.98	0.32	1.160	1.05	0.002	0.001	0.009	0.008	0.01	0.001
13/03/2014	**Nebo 2S**	1	181	20	11	1	16	22	0.3	1	110	0.3	0.08	0.42	0.17	1.220	1.19	0.001	0.001	0.005	0.005	0.01	0.001
29/05/2014	**Nebo 2S**	4	138	18	10	2	12	13	0.3	1	100	1	0.03	1.03	0.24	0.800	0.759	0.002	0.001	0.022	0.004		0.001

23/07/2014	**Nebo 2S**	4	156	23	11	1	15	16	0.3	3	119	0.18	0.06	5.24	0.37	1.170	1.09	0.002	0.001	0.012	0.003	0.02	0.001
	ST Dev	**2.2**	**101.3**	**22.8**	**12.8**	**1.2**	**6.2**	**23.9**	**0.2**	**31.9**	**71.4**	**3.85**	**1.42**	**22.40**	**3.17**	**0.571**	**0.388**	**0.004**	**0.001**	**0.036**	**0.004**	**0.05**	**0.002**
	Max	**10.0**	**675.0**	**135.0**	**72.0**	**6.0**	**28.0**	**89.0**	**1.1**	**175.0**	**370.0**	**15.70**	**6.26**	**106.00**	**13.40**	**2.240**	**1.190**	**0.018**	**0.005**	**0.196**	**0.017**	**0.18**	**0.010**
	Min	**1.0**	**62.0**	**6.0**	**2.0**	**1.0**	**1.0**	**4.1**	**0.1**	**1.0**	**1.0**	**0.18**	**0.01**	**0.30**	**0.02**	**0.013**	**0.004**	**0.001**	**0.001**	**0.005**	**0.002**	**0.01**	**0.001**
	Median	**4.0**	**151.0**	**20.0**	**10.5**	**2.0**	**7.0**	**22.0**	**0.1**	**4.0**	**41.5**	**1.10**	**0.10**	**4.01**	**0.21**	**0.428**	**0.269**	**0.006**	**0.001**	**0.025**	**0.008**	**0.04**	**0.001**

Nebo Groundwater Chemistry

	ANZECC 2000											0.25	0.02			1.9	1.9	0.0014	0.0034	0.008	0.011	0.055	0.013(V)
		DOC	TDS	Na	Ca	K	Mg	Cl	F	SO4	HCO3	Tot N	Tot P	Fe	Fe Filt	Mn	Filt Mn	Filt Cu	Filt Pb	Filt Zn	Filt Ni	Filt Al	Filt As
29/1/2010	**Nebo 1D**	8	340	110	12	6.9	7.8	51	0.14	11	270	1.5	0.37	6.50	0.04	0.190	0.04	0.009	0.084	0.47	0.01	0.04	0.01
18/8/2010	**Nebo 1D**	1	226	29	11	1	6	48	0.1	6	38	0.4	0.25	1.09	0.12	0.240	0.261	0.015	0.001	0.021	0.011	0.12	0.001
18/2/2011	**Nebo 1D**	8	440	125	8	26	5	42	2	103	168	2.4	0.08	5.02	0.05	0.103	0.023	0.001	0.001	0.005	0.002	0.15	0.003
30/6/2011	**Nebo 1D**	8	452	121	6	19	5	41	0.3	118	146	5.8	0.18	6.04	0.1	0.12	0.032	0.003	0.001	0.018	0.002	0.15	0.002
24/8/2011	**Nebo 1D**		464	123	6	19	6	47	0.4	100	150	2.1	0.11	1.22	0.05	0.065	0.033	0.002	0.001	0.02	0.002	0.06	0.002
16/2/2012	**Nebo 1D**	4	910	133	9	18	6	43	0.3	430	1	47	0.01	0.28	0.06	0.047	0.042	0.003	0.001	0.014	0.003	0.05	0.003
20/8/2012	**Nebo 1D**	4	392	134	8	16	6	48	0.3	104	181	2.1	0.07	0.2	0.07	0.049	0.048	0.002	0.001	0.006	0.002	0.04	0.003
24/1/2013	**Nebo 1D**	5	370	150	10	14	7	50	0.3	126	183	2.2	0.07	0.65	0.11	0.06	0.05	0.002	0.001	0.011	0.002	0.04	0.002
15/3/2013	**Nebo 1D**	2	378	124	9	13	7	44	0.3	93	177	1.7	0.07	0.41	0.07	0.057	0.049	0.002	0.001	0.006	0.002	0.03	0.002
18/04/2013	**Nebo 1D**	4	354	140	8	18	6	47	0.4	103	186	5.8	0.02	0.43	0.07	0.055	0.053	0.002	0.001	0.005	0.002	0.04	0.002
31/07/2013	**Nebo 1D**	5	425	123	7	14	5	48	0.4	95	158	3.9	0.01	0.32	0.05	0.058	0.05	0.002	0.001	0.009	0.002	0.04	0.002
4/12/2013	**Nebo 1D**	8	385	139	6	16	5	52	0.4	94	168	0.4	0.08	0.38	0.08	0.064	0.048	0.011	0.001	0.035	0.005	0.04	0.003
30/01/2014	**Nebo 1D**	4	403	132	6	16	5	48	0.4	85	181	1.2	0.05	0.35	0.06	0.056	0.046	0.002	0.001	0.01	0.004	0.03	0.002
13/03/2014	**Nebo 1D**	4	327	119	8	14	6	49	0.4	91	169	1.5	0.06	0.39	0.05	0.052	0.044	0.001	0.001	0.006	0.005	0.03	0.002
30/05/2014	**Nebo 1D**	6	360	136	6	13	5	47	0.4	79	200	2.1	0.1	0.35	0.1	0.065	0.053	0.002	0.001	0.016	0.005		0.002
23/07/2014	**Nebo 1D**	4	392	138	9	12	6	45	0.4	103	197	1.5	0.08	0.32	0.13	0.055	0.054	0.001	0.001	0.007	0.003	0.04	0.003

ST Dev	**2**	**144**	**27**	**2**	**5.5**	**0.9**	**3.1**	**0.4**	**91.8**	**62.2**	**11.3**	**0.09**	**2.20**	**0.03**	**0.056**	**0.055**	**0.004**	**0.022**	**0.115**	**0.003**	**0.044**	**0.002**
Max	**8**	**910**	**150**	**12**	**26.0**	**7.8**	**52.0**	**2.0**	**430.0**	**270.0**	**47.0**	**0.37**	**6.50**	**0.13**	**0.240**	**0.261**	**0.015**	**0.084**	**0.470**	**0.011**	**0.150**	**0.010**
Min	**1**	**226**	**29**	**6**	**1.0**	**5.0**	**41.0**	**0.1**	**6.0**	**1.0**	**0.4**	**0.01**	**0.20**	**0.04**	**0.047**	**0.023**	**0.001**	**0.001**	**0.005**	**0.002**	**0.030**	**0.001**
Median	**5**	**392**	**125**	**8**	**16**	**6**	**48**	**0**	**100**	**168**	**2.10**	**0.07**	**0.43**	**0.07**	**0.060**	**0.048**	**0.002**	**0.001**	**0.011**	**0.002**	**0.040**	**0.002**

Nebo Groundwater Chemistry

	ANZECC 2000											0.25	0.02			1.9	1.9	0.0014	0.0034	0.008	0.011	0.055	0.013(V)
		DOC	TDS	Na	Ca	K	Mg	Cl	F	SO4	HCO3	Tot N	Tot P	Fe	Fe Filt	Mn	Filt Mn	Filt Cu	Filt Pb	Filt Zn	Filt Ni	Filt Al	Filt As
29/1/2010	Nebo 2D	25	2410	80	770	105	50	47	0.1	860	1	2.2	0.06	2.50	0.01	0.090	0.01	0.003	0.003	0.013	0.01	0.03	0.01
18/8/2010	Nebo 2D	29	2080	51	596	47	1	28	0.1	569	1	0.7	0.21	0.5	0.05	0.004	0.001	0.025	0.003	0.027	0.005	0.05	0.001
18/2/2011	Nebo 2D	59	1780	57	505	42	1	26	0.1	392	868	1.7	0.05	0.75	0.05	0.011	0.001	0.031	0.003	0.018	0.002	0.05	0.001
30/6/2011	Nebo 2D	74	1630	72	335	39	1	21	0.1	331	734	3.3	0.03	0.97	0.5	0.012	0.001	0.031	0.004	0.018	0.005	0.07	0.001
24/8/2011	Nebo 2D		1720	65	309	32	1	21	0.1	254	702	2.1	0.08	0.05	0.5	0.003	0.001	0.03	0.002	0.01	0.005	0.02	0.001
16/2/2012	Nebo 2D	57	1500	78	343	42	1	18	0.1	397	609	13.9	0.1	0.08	0.05	0.001	0.001	0.03	0.002	0.011	0.003	0.04	0.001
20/8/2012	Nebo 2D	58	1930	80	248	33	1	23	0.1	238	496	2.9	0.02	0.13	0.05	0.008	0.001	0.039	0.004	0.014	0.004	0.12	0.001
24/1/2013	Nebo 2D	58	1350	80	280	29	1	29	0.1	285	495	6.3	0.03	0.93	0.05	0.013	0.002	0.036	0.002	0.014	0.004	0.08	0.001
15/3/2013	Nebo 2D	66	1300	82	305	32	1	25	0.1	260	585	3.5	0.05	0.12	0.05	0.003	0.001	0.038	0.002	0.013	0.005	0.19	0.001
18/04/2013	Nebo 2D	57	1340	81	202	28	1	31	0.1	350	270	7.2	0.01	0.1	0.05	0.003	0.001	0.033	0.002	0.007	0.004	0.1	0.001
31/07/2013	Nebo 2D	115	1230	82	257	28	1	31	0.1	338	372	3.1	0.09	0.05	0.05	0.002	0.001	0.041	0.002	0.008	0.003	0.05	0.001
4/12/2013	Nebo 2D	63	1160	108	262	34	1	30	0.1	293	418	2.4	0.02	0.27	0.05	0.006	0.001	0.048	0.002	0.012	0.005	0.06	0.001
30/01/2014	Nebo 2D	55	1200	102	214	31	1	30	0.1	292	366	2.8	0.02	0.17	0.05	0.003	0.002	0.038	0.001	0.008	0.004	0.05	0.001
13/03/2014	Nebo 2D	56	1190	90	234	28	1	31	0.1	261	359	3	0.01	0.12	0.05	0.005	0.003	0.036	0.001	0.005	0.004	0.09	0.001
30/05/2014	Nebo 2D	59	896	104	200	26	1	28	0.1	231	346	3.7	0.02	0.6	0.05	0.015	0.002	0.034	0.001	0.039	0.004		0.001
23/07/2014	Nebo 2D	210	1100	97	192	23	1	28	0.1	258	320	1.9	0.01	0.38	0.05	0.007	0.001	0.028	0.001	0.011	0.004	0.17	0.001
29/1/2010	Nebo 3	3	130	27	17	2.6	5.7	16	0.1	12	120	1	0.13	1.50	0.02	0.090	0.04	0.004	0.05	0.091	0.01	0.01	0.01
18/8/2010	Nebo 3	7	240	26	20	2	6	9	0.1	12	80	0.12	0.08	0.43	0.05	0.042	0.001	0.001	0.001	0.005	0.001	0.03	0.001
18/2/2011	Nebo 3	10	148	33	21	3	6	12	0.6	9	129	0.9	0.01	1.34	0.05	0.054	0.007	0.005	0.001	0.068	0.008	0.06	0.001
30/6/2011	Nebo 3	9	252	37	19	4	7	13	0.3	23	118	1.6	0.02	1.87	0.1	0.1	0.069	0.031	0.048	0.097	0.03	0.18	0.001
24/8/2011	Nebo 3		242	41	20	5	7	13	0.4	10	146	1.4	0.3	0.97	0.05	0.082	0.061	0.003	0.011	0.034	0.014	0.06	0.001
16/2/2012	Nebo 3	18	272	52	17	5	6	13	0.6	33	133	3.6	0.07	0.25	0.05	0.027	0.018	0.003	0.004	0.034	0.19	0.03	0.001
20/8/2012	Nebo 3	15	206	62	19	4	5	13	0.6	22	152	7.4	0.08	0.34	0.05	0.024	0.008	0.004	0.004	0.032	0.016	0.03	0.001
24/1/2013	Nebo 3	10	156	70	13	4	5	13	0.5	20	165	2	0.06	0.3	0.05	0.011	0.007	0.002	0.001	0.024	0.009	0.04	0.001
15/3/2013	Nebo 3	11	300	65	13	3	4	12	0.8	13	165	1.9	0.1	0.48	0.05	0.024	0.015	0.006	0.001	0.017	0.008	0.06	0.001
18/04/2013	Nebo 3	8	256	62	9	3	4	8	0.8	18	142	1.6	0.11	0.46	0.05	0.01	0.004	0.002	0.001	0.01	0.008	0.05	0.001
31/07/2013	Nebo 3	10	184	66	7	3	3	10	0.8	17	139	2.1	0.01	0.59	0.05	0.042	0.007	0.004	0.001	0.019	0.008	0.09	0.001
4/12/2013	Nebo 3	10	230	68	10	4	4	10	0.8	17	155	0.7	0.04	0.18	0.05	0.019	0.011	0.004	0.003	0.018	0.007	0.07	0.001
30/01/2014	Nebo 3	6	217	64	5	4	3	8	0.8	17	146	1.5	0.05	0.15	0.05	0.012	0.007	0.003	0.001	0.02	0.008	0.01	0.001

13/03/2014	**Nebo 3**	3	222	66	9	4	4	9	0.8	20	138	1.7	0.11	0.26	0.05	0.041	0.021	0.001	0.001	0.014	0.008	0.01	0.001
30/05/2014	**Nebo 3**	4	231	74	5	3	2	9	0.9	19	142	1.6	0.14	0.46	0.05	0.057	0.034	0.001	0.001	0.014	0.007		0.002
23/07/2014	**Nebo 3**	5	231	78	7	3	3	10	0.9	21	152	1.7	0.11	0.24	0.05	0.047	0.044	0.001	0.001	0.018	0.007	0.02	0.001
	ST Dev	**43.7**	**406.5**	**16.0**	**161.3**	**19.2**	**12.3**	**6.5**	**0.0**	**160.0**	**237.8**	**3.1**	**0.052**	**0.623**	**0.155**	**0.021**	**0.002**	**0.010**	**0.001**	**0.008**	**0.002**	**0.049**	**0.002**
	Max	**210.0**	**2410.0**	**108.0**	**770.0**	**105.0**	**50.0**	**47.0**	**0.1**	**860.0**	**868.0**	**13.9**	**0.210**	**2.500**	**0.500**	**0.090**	**0.010**	**0.048**	**0.004**	**0.039**	**0.010**	**0.190**	**0.010**
	Min	**25.0**	**896.0**	**51.0**	**192.0**	**23.0**	**1.0**	**18.0**	**0.1**	**231.0**	**1.0**	**0.7**	**0.010**	**0.050**	**0.010**	**0.001**	**0.001**	**0.003**	**0.001**	**0.005**	**0.002**	**0.020**	**0.001**
	Median	**58.0**	**1345.0**	**80.5**	**271.0**	**32.0**	**1.0**	**28.0**	**0.1**	**292.5**	**395.0**	**3.0**	**0.030**	**0.220**	**0.050**	**0.006**	**0.001**	**0.034**	**0.002**	**0.013**	**0.004**	**0.060**	**0.001**

Nebo Groundwater Chemistry

	ANZECC 2000											0.25	0.02			1.900	1.9	0.0014	0.0034	0.008	0.011	0.055	0.013(V)
		DOC	TDS	Na	Ca	K	Mg	Cl	F	SO4	HCO3	Tot N	Tot P	Fe	Fe Filt	Mn	Filt Mn	Filt Cu	Filt Pb	Filt Zn	Filt Ni	Filt Al	Filt As
29/1/2010	Nebo 4	18	460	130	30	7.1	15	110	0.16	6	310	4.1	0.19	22.00	0.06	0.510	0.13	0.008	0.16	1.2	0.01	0.04	0.01
18/2/2011	Nebo 4	17	2760	249	681	300	1	29	0.1	1	2710	8.3	0.01	3.32	0.05	0.06	0.001	0.022	0.012	0.084	0.005	0.31	0.001
30/6/2011	Nebo 4	13	3030	241	534	292	1	34	0.1	11	2100	9.8	0.14	6.14	0.5	0.076	0.001	0.017	0.006	0.074	0.005	0.38	0.001
24/8/2011	Nebo 4		3020	251	506	287	1	28	0.1	1	2290	12.2	0.41	5.36	0.55	0.088	0.078	0.014	0.043	0.067	0.17	0.43	0.001
16/2/2012	Nebo 4	3	2920	264	425	230	1	24	0.1	14	2110	17	0.16	2.03	0.05	0.038	0.001	0.097	0.02	0.115	0.002	0.37	0.001
20/8/2012	Nebo 4	13	2630	282	397	229	1	35	0.1	4	2040	12.5	0.1	1.85	0.5	0.42	0.001	0.076	0.017	0.1	0.003	0.36	0.001
24/4/2013	Nebo 4	11	2600	258	641	181	1	41	0.1	3	2380	14	0.17	5.76	0.05	0.083	0.001	0.054	0.02	0.076	0.002	0.39	0.001
15/3/2013	Nebo 4	14	2340	241	736	154	1	36	0.1	2	2300	12.1	0.15	3.98	0.024	0.067	0.001	0.046	0.024	0.07	0.002	0.42	0.001
18/04/2013	Nebo 4	11	2270	225	528	162	1	45	0.1	1	1880	14.1	0.02	0.2	0.05	0.005	0.001	0.049	0.018	0.058	0.002	0.46	0.001
31/07/2013	Nebo 4	12	6560	239	677	219	1	47	0.1	1	2190	16.6	0.14	0.14	0.05	0.004	0.001	0.057	0.014	0.065	0.002	0.4	0.001
4/12/2013	Nebo 4	13	2390	224	465	203	1	51	0.1	1	1840	8.8	0.01	0.13	0.05	0.003	0.001	0.082	0.016	0.073	0.003	0.35	0.001
30/01/2014	Nebo 4	9	2370	205	742	156	1	51	0.1	1	2200	9.3	0.01	0.34	0.05	0.009	0.001	0.071	0.016	0.059	0.002	0.37	0.001
13/03/2014	Nebo 4	15	2420	242	704	181	1	49	0.1	1	2160	12.1	0.03	0.29	0.05	0.006	0.001	0.103	0.012	0.062	0.003	0.42	0.001
30/05/2014	Nebo 4	16	2380	254	780	282	1	45	0.1	1	2480	10.3	0.2	2.59	0.05	0.04	0.001	0.077	0.012	0.042	0.003		0.001
23/07/2014	Nebo 4	14	2330	233	730	142	1	47	0.1	8	2130	16.6	0.04	0.86	0.05	0.017	0.002	0.074	0.008	0.068	0.003	0.42	0.001

ST Dev	3.7	1225.7	34.5	195.4	76.4	3.9	20.0	0.0	4.3	535.0	3.6	0.11	5.87	0.21	0.154	0.040	0.030	0.038	0.292	0.043	0.104	0.002
Max	18.0	6560.0	282.0	780.0	300.0	15.0	110.0	0.2	14.0	2710.0	17.0	0.41	22.00	0.55	0.510	0.130	0.103	0.160	1.200	0.170	0.460	0.010
Min	3.0	460.0	130.0	30.0	7.1	1.0	24.0	0.1	1.0	310.0	4.1	0.01	0.13	0.02	0.003	0.001	0.008	0.006	0.042	0.002	0.040	0.001
Median	13.0	2615.0	241.0	531.0	211.0	1.0	38.5	0.1	1.5	2150.0	12.2	0.14	2.68	0.05	0.064	0.001	0.052	0.018	0.074	0.003	0.375	0.001

APPENDIX D

Nebo Area – Longwall 2 End of Panel Report (Ecology)

Nebo Area - Longwall N2
End of Panel Report (Ecology)

Prepared for Wollongong Coal Limited

4 September 2014

Document information

Report to:	Wollongong Coal Ltd
Prepared by:	Mathew Misdale, Jodie Cooper, and Anthony Steelcable
Biosis project no.:	18792

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- Ashleigh Pritchard and for mapping
- Nathan Garvey for quality assurance

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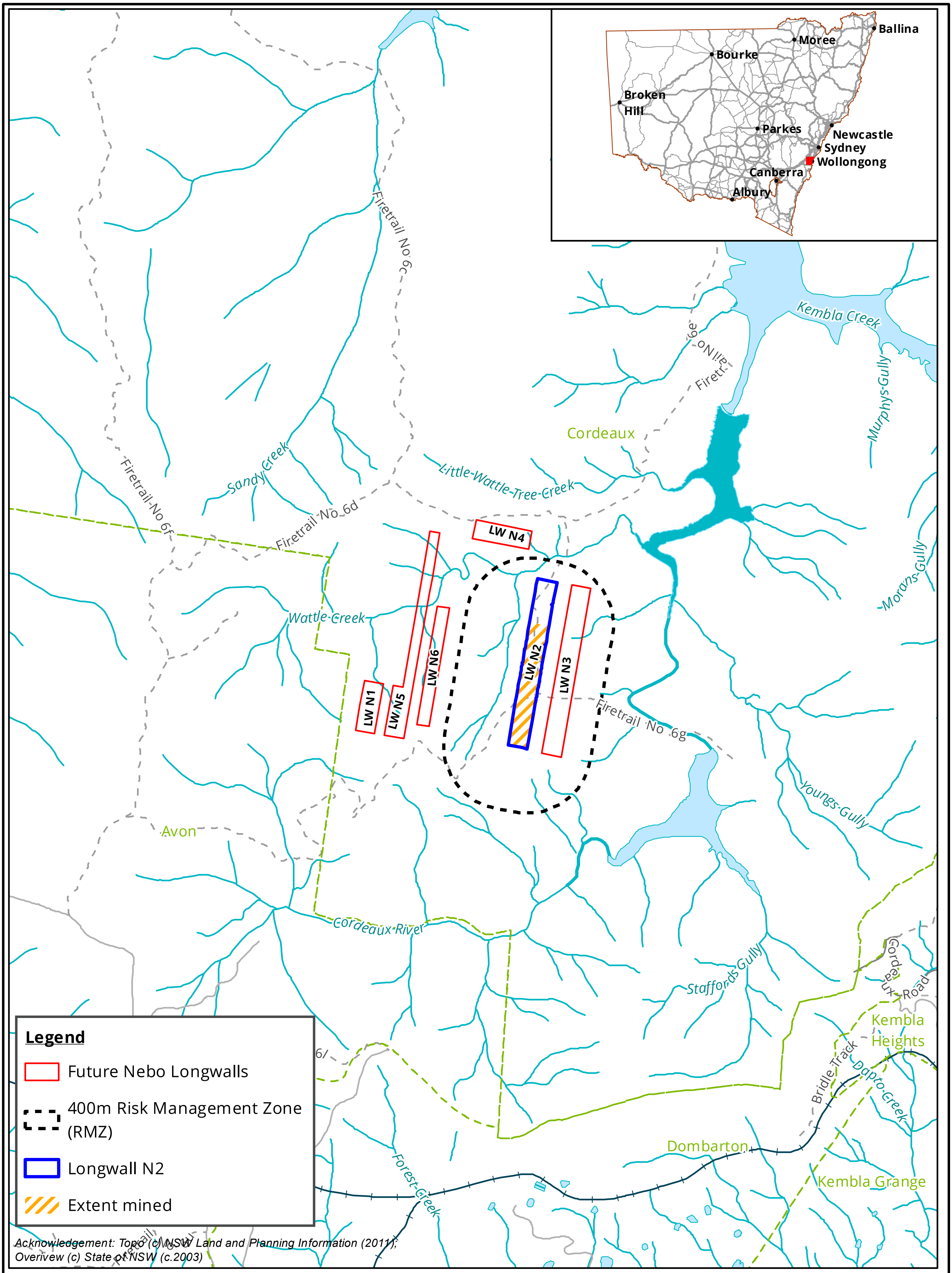
1 Introduction

Biosis Pty Ltd (Biosis) was commissioned by Wollongong Coal Ltd (WCL) to undertake an End of Panel assessment of potential impacts from extraction of Longwall N2 in the Nebo Area at Wongawilli Colliery. This report assesses the post mining conditions in relation to terrestrial and aquatic ecology within the area potentially impacted by subsidence effects associated with mining of Longwall N2 (Figure 1).

Extraction of secondary workings was completed between 12th June 2013 and 26th February 2014. The full longwall panel length was not extracted. Figure 1 illustrates both the initial estimated extraction area for Longwall N2 and the completed extraction area.

This report has been prepared in accordance with Subsidence Management Plan Approval 09/5341 (Condition 18) (DTIRIS, 2013) and includes:

- An outline of monitoring programs conducted to date.
- An assessment of the results of monitoring undertaken to date.
- A comparison of observed impacts versus those predicted to occur.
- An assessment of whether any actions outlined in the Trigger Action Response Plan (TARP) have been triggered.
- Conclusions on impacts to ecology resulting from the extraction of Longwall N2, as well as cumulative impacts from longwall mining in the Nebo Area.



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Ballarat, Brisbane, Canberra, Melbourne, Newcastle, Sydney, Wangaratta & Wollongong

Figure 1: Longwall N2, Nebo Area

Matter: 18792
Date: 03 September 2014,
Checked by: MJM, Drawn by: ANP, Last edited by: apritchard
Location:P:\18700s\18792\Mapping\

2 Monitoring programs

The ecological monitoring programs for the Nebo Area are detailed within the Nebo Longwalls N1-N6 Subsidence Monitoring Plan (NRE, 2014), Nebo Longwalls N1-N6 Extraction Plan (Chapter 8: Biodiversity Management Plan) (Niche, 2012) and the Nebo Area Environmental Assessment (ERM, 2010). These documents outline the biodiversity monitoring actions that are required to satisfy on-going conditions of approval as detailed within the Nebo Longwalls N1-N6 Subsidence Management Plan Approval (DTIRIS, 2013) and NRE Wongawilli Colliery – Nebo Area Project Approval (MP09_0161).

Ecological monitoring to date within the Nebo Area has been completed within the requirements set out in Niche (2012) and summarized in Appendix 1: Tables 4- 6. Details of the terrestrial and aquatic monitoring programs are provided below.

2.1 Terrestrial ecology monitoring program

The terrestrial ecological monitoring program for Longwalls N1- N6 includes:

- Flora monitoring, including:
  - Riparian vegetation monitoring conducted at two creek line impact sites (Figure 2) and two control sites (Figure 3). Each creekline site contains three quadrat locations.
  - Photo point monitoring at each creek monitoring site (control and impact) (Figure 2 and Figure 3).
- Fauna monitoring, including:
  - Nocturnal frog monitoring conducted at two creek line impact sites (Figure 2) and two control sites (Figure 3).

There are no significant swamps, threatened frog habitat (Biosis, 2014) or ridgeline features in the vicinity of Longwall N2.

Terrestrial monitoring, including collection of baseline data, commenced in December 2010. To date, two and a half years of baseline data has been collected prior to mining. Monitoring is scheduled to be conducted during mining and for a minimum of one year post mining, or greater if required to detect impacts.

The terrestrial monitoring program, including monitoring type, sites, site type and methodology, is outlined in

Table 1.

2.1.2 Monitoring to Date

The terrestrial flora and fauna monitoring program commenced in spring 2010 and has been completed for:

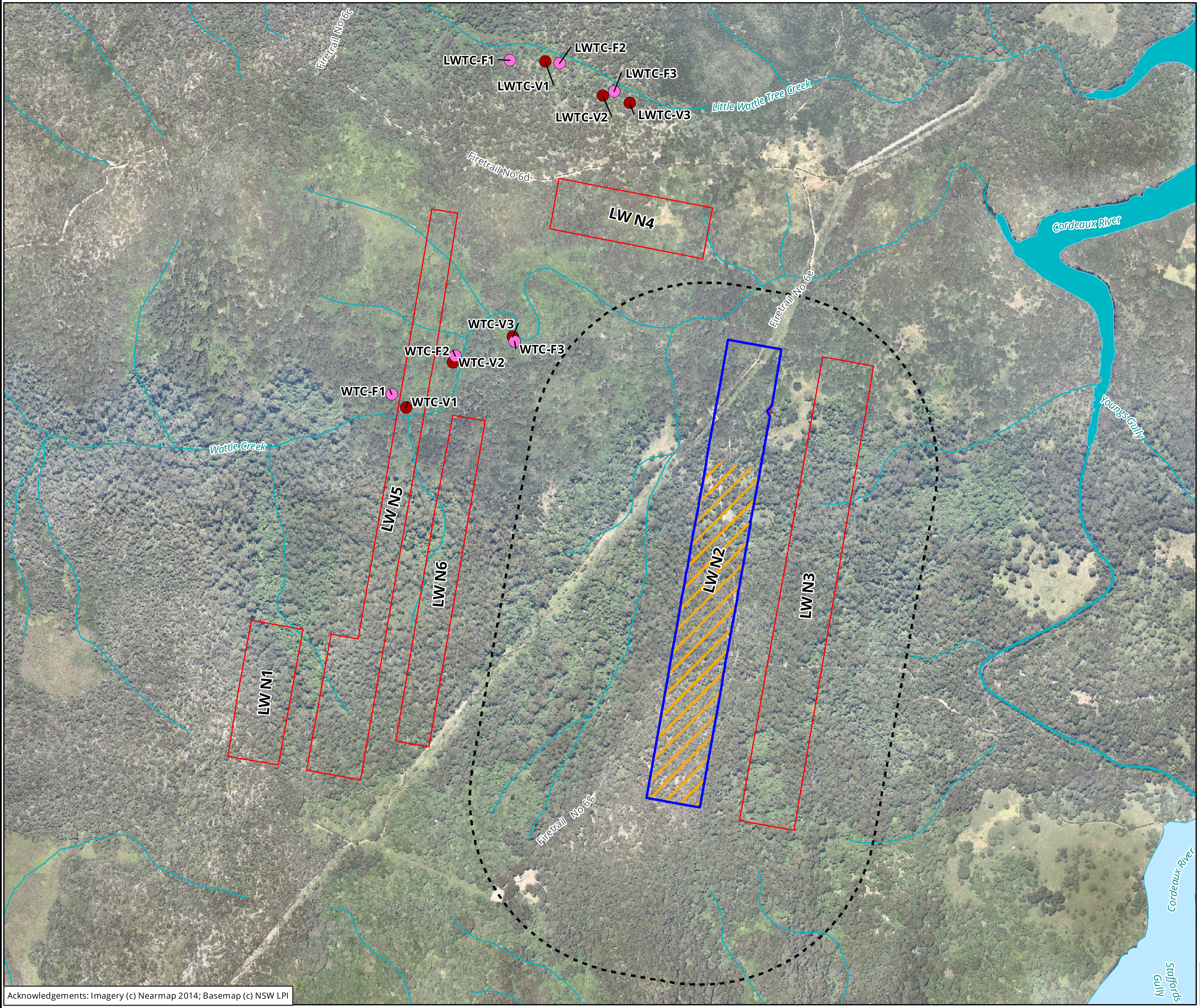
- Spring 2010.
- Autumn and spring 2011.
- Autumn and spring 2012.
- Autumn and spring 2013.
- Autumn 2014.

Riparian vegetation monitoring was also conducted at Morans Gully and Flying Fox #3 control sites between 2004 and 2009 (Figure 3).

The terrestrial ecological monitoring programs employ a Before-After Control-Impact (BACI) design, comparing sites pre- and post-mining and comparing sites that have been mined beneath (impact sites) with sites that have not been mined beneath (control sites).

Table 1: Terrestrial ecology monitoring program

Monitoring	Impact Sites (Figure 2)	Control Sites (Figure 3)	Methodology
Riparian Vegetation	Wattle Tree Creek Little Wattle Tree Creek	Flying Fox Creek #3 Morans Gully	Vegetation surveys within creeks are undertaken at three 20m x 20m (400m^2) quadrats per creek located at least 150m apart. Within each quadrat, subjective cover abundance scores are given to each species occurring within the quadrat using a modified Braun-Blanquet scale. Where there is potential for misidentification, or where species cannot be reliably identified to species level in the field, species have been grouped into identification units for analysis. Each of these units is referred to as a species complex. Surveys are undertaken once in spring and once in autumn each year.
Frogs – Point Surveys	Wattle Tree Creek Little Wattle Tree Creek	Flying Fox Creek #3 Morans Gully	Nocturnal frog surveys within creeks are undertaken at three 50m long transects per creek located at least 150m apart. Transects are surveyed by walking down the creek and counting all frogs seen or heard. Counts of tadpoles and egg mass are also undertaken where present.



Legend

Flora Monitoring

- Flora creek impact site

Fauna Monitoring

- Fauna creek impact site

Survey Area

- Future Nebo Longwalls
- 400m Risk Management Zone (RMZ)
- Longwall N2
- Extent mined

Figure 2: Terrestrial ecology monitoring impact sites

0 80 160 240 320 400

Metres

Scale: 1:8,000 @ A3

Coordinate System: GDA 1994 MGA Zone 56

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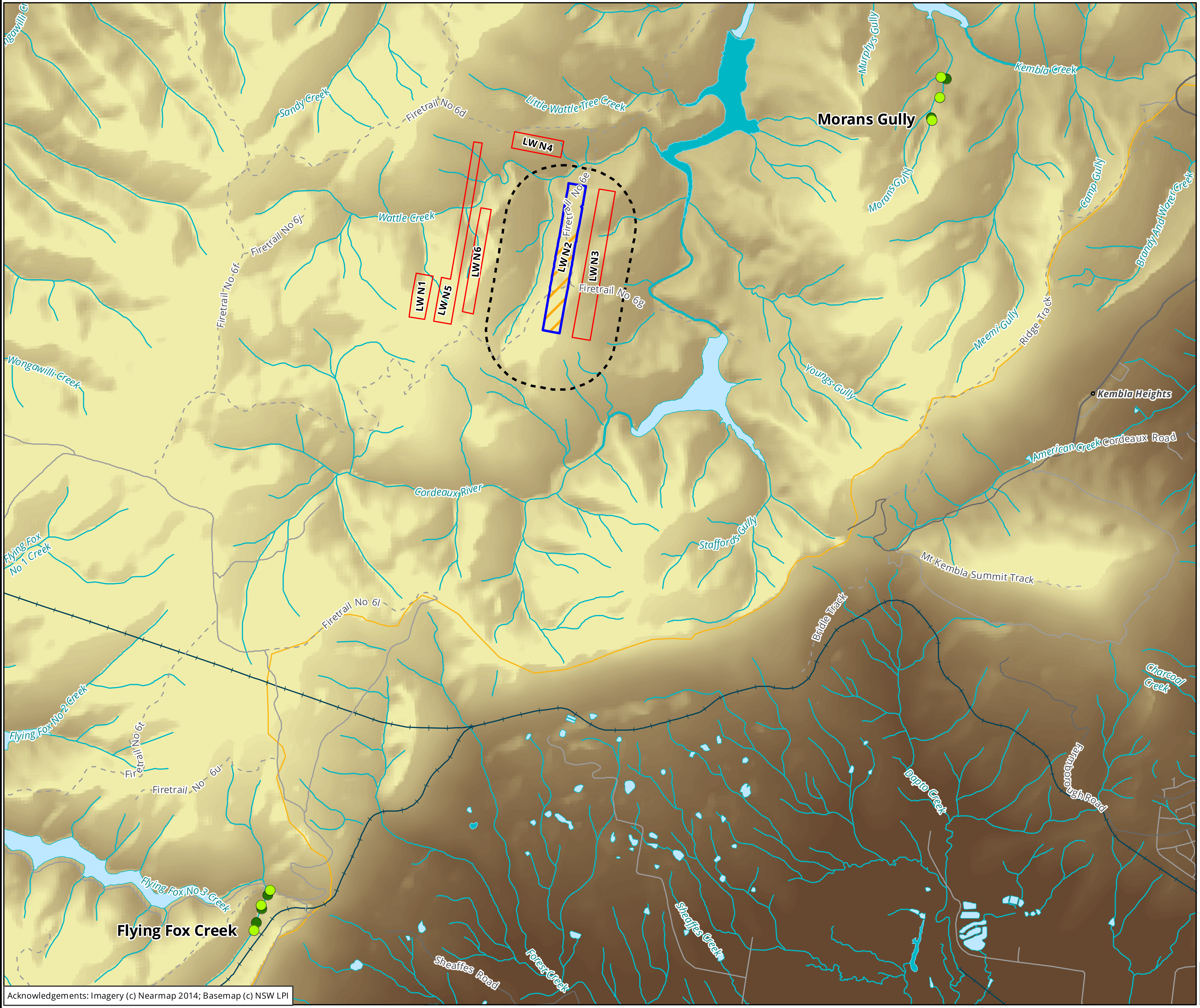
Ballarat, Brisbane, Canberra, Melbourne, Newcastle, Sydney, Wangaratta & Wollongong

Matter: 18792
Date: 03 September 2014,
Checked by: MJM, Drawn by: ANP, Last edited by: apritchard
Location:P:\18700s\18792\Mapping
18792_F2_Eco Impact Monitoring



Legend

Flora Monitoring

- Flora creek control site

Fauna Monitoring

- Fauna creek control site

Survey Area

- F uture Nebo Longwalls
- 400m Risk Management Zone (RMZ)
- Longwall N2
- Extent mined

Figure 3: Terrestrial ecology monitoring control sites

0 250 500 750 1,000 1,250

Metres

Scale: 1:25,000 @ A3

Coordinate System: GDA 1994 MGA Zone 56

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18792_F3_Eco Control Monitoring

2.2 Aquatic ecology monitoring program

The aquatic ecology monitoring program is shown on Figure 4 for Longwalls N1-6 and includes:

- Aquatic habitat monitoring, including surface water quality monitoring, at eight impact sites and four control sites (Figure 4) during spring and autumn.
- Monitoring of aquatic macroinvertebrates (AUSRIVAS) at eight impact sites and four control sites (Figure 4).
- Photo point monitoring at eight impact sites and four control sites (Figure 4).

The aquatic ecology monitoring program is scheduled to be conducted for a minimum of two year's pre-mining, during mining and a minimum of one year post mining. The aquatic monitoring program, including monitoring type, monitoring reaches, and methodology, is outlined in Table 2: Aquatic ecology monitoring program Table 2.

2.2.2 Monitoring to Date

The aquatic ecological monitoring commenced in March 2011 and has been completed for:

- Autumn 2011.
- Autumn and spring 2012.
- Autumn and spring 2013.
- Autumn 2014.

The aquatic ecological monitoring programs employ a Before-After Control-Impact (BACI) design, comparing sites pre- and post- mining and comparing sites that have been mined beneath (impact sites) with sites that have not been mined beneath (control sites).

Table 2: Aquatic ecology monitoring program

Monitoring	Impact Reaches (Figure 4)	Control Reaches (Figure 4)	Methodology
Aquatic Habitat monitoring including surface water quality monitoring	WAC-AQ3 WAC-AQ4 WAC-AQ5 WAC-AQ6	KEC-AQ1 KCT-AQ1 MGC-AQ1 MEC-AQ1	At each monitoring reach, a visually based habitat assessment (HABSCORE) is undertaken, which evaluates the structure of the surrounding physical habitat that influences the quality of the water resource and the condition of the resident aquatic community (Barbour et al. 1999). Based on this methodology, the aquatic habitat within the study area is described in terms of four category types: Optimal, Suboptimal, Marginal or Poor. Physico-chemical water quality variables are measured at each monitoring reach. These are collected to support the data analysis of aquatic ecological values and are not used as an indicator for potential impacts from underground mining.

Monitoring	Impact Reaches (Figure 4)	Control Reaches (Figure 4)	Methodology
			Habitat assessments and surface water quality measurements are undertaken once in spring and once in autumn each year.
Aquatic Macroinvertebrate Monitoring	WAC-AQ3 WAC-AQ4 WAC-AQ5 WAC-AQ6	KEC-AQ1 KCT-AQ1 MGC-AQ1 MEC-AQ1	At each monitoring reach, aquatic macroinvertebrates are surveyed according to the techniques described in the NSW AUSRIVAS Rapid Assessment Method (Turak et al. 2004). This methodology provides for an assessment of the ecological health of each reach through its respective macroinvertebrate community via the application of a data modelling approach. Each year, monitoring is conducted between March 15 and June 15 (autumn survey), and between September 15 and December 15 (spring survey) in order to appropriately apply the AUSRIVAS modelling approach.
Photopoint Monitoring	WAC-AQ3 WAC-AQ4 WAC-AQ5 WAC-AQ6	KEC-AQ1 KCT-AQ1 MGC-AQ1 MEC-AQ1	Permanent photo monitoring points have been established at each aquatic monitoring reach. Photos are taken of the wetted channel at each fixed point in a (1) downstream and an (2) upstream direction. Photos are taken once in spring and once in autumn each year.

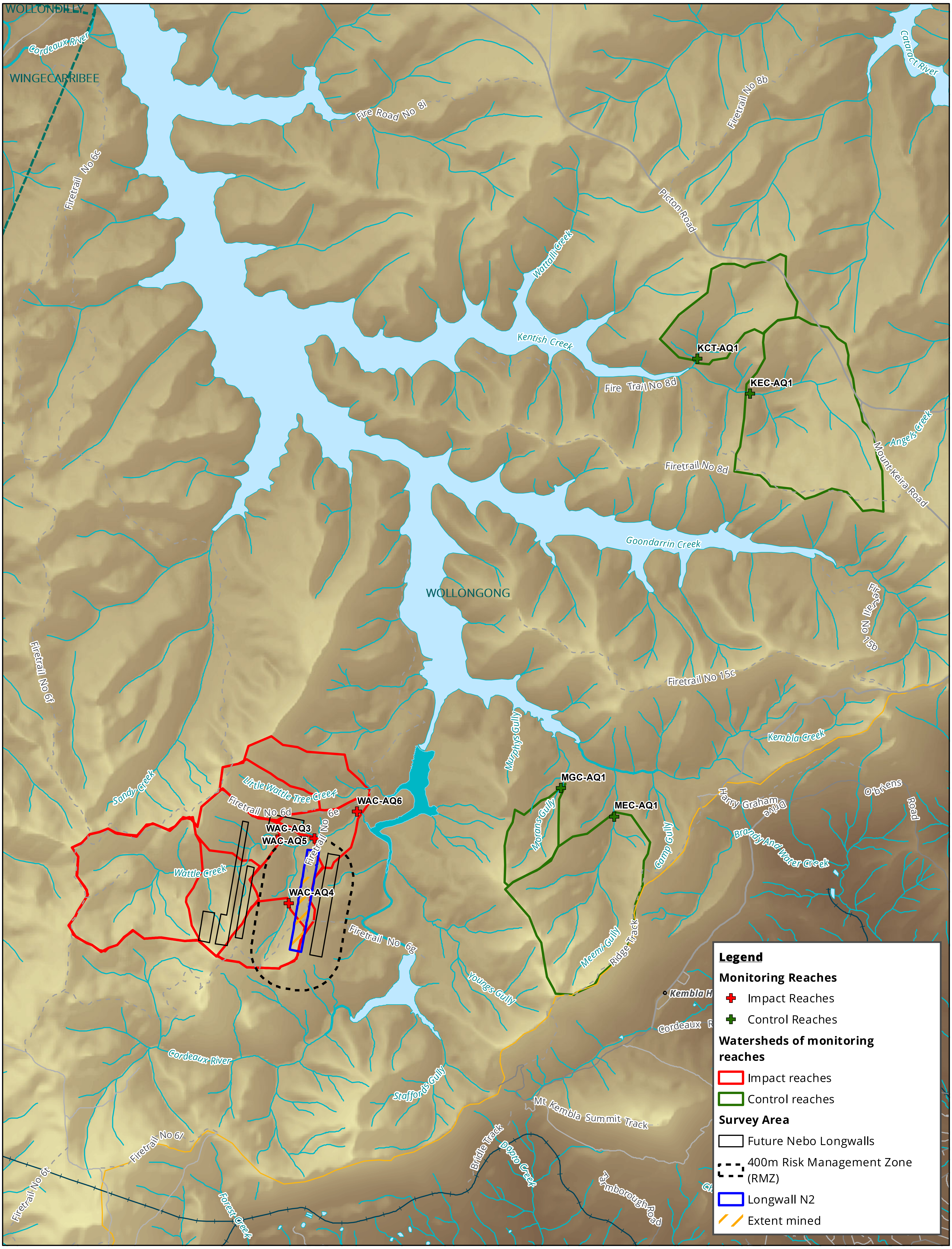

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Figure 4: Aquatic ecology monitoring control and impact reaches

Acknowledgements: Topo (c) NSW Land and Planning Information (2012)

Matter: 18792
Date: 03 September 2014,
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Location:P:\18700s\18792\Mapping\18792_F4_CatchmentsOverview

Scale 1:35,000 @ A3
Coordinate System: GDA 1994 MGA Zone 56

3 Impact Assessment

3.1 Subsidence monitoring program

A maximum of approximately 90 millimetres of vertical subsidence was observed across the central 100 metres of the panel, with maximum average tilt of less than 0.5 mm/m and strain of 0.2 mm/m (SCT Operations 2014).

This measured value is below the maximum predicted subsidence levels for Prediction Lines 4 (NM3) and 5 (NM2) (Niche Environment & Heritage 2012). As this is the first longwall extracted within the Nebo Area, there is no cumulative subsidence.

3.2 Results of monitoring programs

3.2.2 Terrestrial ecology

The Nebo terrestrial ecological monitoring program has been underway since spring 2010. Natural features requiring monitoring included Wattle Tree Creek and Little Wattle Tree Creek. The creekline impact sites listed in

Table 1 are not positioned to detect potential impacts from Longwall N2. No significant terrestrial ecological features were identified within the Longwall N2 area therefore, no terrestrial monitoring is outlined in the approved Biodiversity Management Plan (Niche 2012).

The monitoring sites at Wattle Tree Creek and Little Wattle Tree Creek are currently monitored to collect baseline data within a 400 metre Risk Management Zone (RMZ) for Longwalls 4 and 5. Detailed results of the terrestrial ecology monitoring program are presented in the annual monitoring reports (Biosis, In Draft a).

3.2.3 Aquatic ecology

To date, results from aquatic monitoring listed in Table 2 have not detected any subsidence effects on aquatic ecological values in the Wattle Tree Creek and Little Wattle Tree Creek catchments. Detailed results of the aquatic ecology monitoring program are presented in the annual monitoring reports (Biosis, In Draft b). The aquatic survey data collected indicates that aquatic ecological values have not deviated from baseline and remain comparable with control sites.

3.3 Observed versus predicted impacts

A summary of predicted versus observed impacts as per Niche (2012) is provided in Table 3 below.

Table 3: Observed versus predicted impacts

Value	Predicted Impact (Niche 2012)	Observed Impact	Within Prediction
Rivers (creeks, streams, tributaries)	Low - The maximum predicted subsidence along the creeks is approximately 250mm which occurs above Longwall N5. The predicted subsidence movements and valley related movements along the creeks are predicted to be very low (MSEC 2010). GeoTerra (2010) anticipate that no significant adverse effects will be observed in the creek bed or catchment of Wattle Creek or Little Wattle Tree Creek. Consequently the potential for related impacts on flora and fauna will be low.	No observable changes to frog populations in Wattle Tree Creek or Little Wattle Tree Creek.	Yes
Vegetation	Low – Tree tilt and fall has potential to occur within terrestrial habitats. Low – The maximum subsidence prediction is within rainforest communities including Coachwood Warm Temperate Rainforest and Moist Gully Gum Forest. The potential for impacts on the	No observable changes to vegetation composition in Wattle Tree Creek or Little Wattle Tree Creek.	Yes

Value	Predicted Impact (Niche 2012)	Observed Impact	Within Prediction
	water table in this locality are expected to be low. As a result the potential for associated consequences for flora and fauna are expected to be low		
Upland Swamps	Low – Swamp No.22 and Swamp No.39 are at least 40m from the predicted subsidence footprint and over 400m from the greatest predicted subsidence. The potential for the predicted subsidence to impact on upland swamps is therefore expected to be low.	No upland swamps are located in the vicinity of Longwall N2.	N/A
Rocky habitats	Low - There are no rock faces or rocky areas within the zone of greatest subsidence.	No rocky habitats are located in the vicinity of Longwall N2.	N/A

3.4 TARP assessment

A Trigger Action Response Plan (TARP) was developed for Longwalls N1-N6 as a part of the Biodiversity Management Plan (Niche, 2012). This section assesses whether triggers have been met and whether additional actions are required due to extraction of Longwall N2.

A TARP assessment is provided in Table 4 (riparian vegetation), Table 5 (amphibians), and Table 6 (aquatic ecology).

3.4.2 Longwall N2

Monitoring to date in the Nebo Area has not identified any impacts to flora and fauna, and aquatic ecology sites as a result of subsidence associated with mining of Longwall N2. No other management actions have been triggered under the TARP (Table 4, Table 5 and Table 6).

3.4.3 Cumulative Impacts within the Nebo Mining Domain

Longwall N2 is the first longwall extraction completed within the within the Nebo Area. Therefore, there is no cumulative data to be reported on.

4 Conclusions and Recommendations

This report assesses the post mining conditions in relation to terrestrial and aquatic ecology within the area potentially impacted by subsidence effects associated with mining of Longwall N2, and compares these observed impacts to impacts predicted to occur.

Observed impacts are within predictions and significant impacts to ecological values have not resulted from the extraction of Longwall N2. No management actions under the TARP have been triggered.

It is recommended that monitoring of all natural features above Longwall N2 be monitored for one year post-mining. If no impacts are observed during this time monitoring should cease, as per the Biodiversity Management Plan (Niche 2012).

5 References

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Appendices

Appendix 1: Trigger Action Response Plan

Table 4: Trigger Action Response Plan (TARP) Table, Riparian Vegetation, including assessment of actions required by the Subsidence Monitoring Plan for Longwalls N1-N6

Feature	Monitoring Program			Impact Assessment		TARPs		
	Prior to Mining	During Mining	Post mining and Future Monitoring	Predicted Impacts	Observed Impacts	Trigger	Response	Action as a result of Longwall N2
Riparian vegetation 3 Monitoring sites on Wattle Tree Creek 3 Monitoring sites on Little Wattle Tree Creek 6 Reference sites	Species inventory and modified Braun Blanquette cover - Abundance for each species. At least once prior to mining (conducted Autumn and Spring). Baseline monitoring ongoing.	Species inventory and modified Braun Blanquette cover - Abundance for each species. Autumn and spring during entire extraction period. Not started.	Species inventory and modified Braun Blanquette cover - Abundance for each species. Autumn and Spring for a minimum of one year post-mining (in consultation with key regulators. Not started.	Unlikely that any threatened flora species would be significantly impacted by subsidence resulting from Longwall mining. Unlikely to be impacts to vegetation communities.	No impact to flora species or vegetation communities observed to date.	**NORMAL** No change as compared to baseline observed	• Continue monitoring • Report in end of panel report	No management action/s required.
						WITHIN PREDICTIONS Survey results within baseline variability	• Continue monitoring • Report in end of panel report	No change to flora species or vegetation communities was observed when compared to baseline and control sites.
						EXCEEDS PREDICTIONS Observed deterioration in vegetation health against baseline surveys Significant change/ decline in cover - abundance against baseline surveys. Statistically significant change in species composition against baseline surveys	• Notification to SCA/DP&E/OEH immediately • Proposal for management within 1 week if required • Completion of management task following approval from agencies • Additional monitoring as required by the relevant government agencies • Report in end of panel report • Reporting in Incident Reports and Annual Reviews	

Table 5: Trigger Action Response Plan (TARP) Table, Amphibians, including assessment of actions required by the Subsidence Monitoring Plan for Longwalls N1-N6

Feature	Monitoring Program			Impact Assessment		TARPs		
	Prior to Mining	During Mining	Post mining and Future Monitoring	Predicted Impacts	Observed Impacts	Trigger	Response	Action as a result of Longwall N2
Amphibians 3 Monitoring sites on Wattle Tree Creek 3 Monitoring sites on Little Wattle Tree Creek 6 Reference sites	Baseline ecological assessment. Observational monitoring– 50 m nocturnal stream searches and tadpole surveys at three locations ~150-200m apart along Wattle Tree Creek and Little Wattle Tree Creek conducted Autumn and Spring. Baseline monitoring ongoing. Targeted Threatened Amphibian searches each Winter along Wattle Tree Creek and Little Wattle Tree Creek. Completed, no threatened frog habitat found.	Observational monitoring– 50 m nocturnal stream searches and tadpole surveys at three locations ~150-200m apart along Wattle Creek and Little Wattle Tree Creek conducted Autumn and Spring during entire extraction period. Not started. Targeted Threatened Amphibian searches each Winter along Wattle Tree Creek and Little Wattle Tree Creek. Not required.	Observational monitoring– Autumn and Spring for a minimum of one year post-mining (in consultation with key regulators). Not started. Targeted Threatened Amphibian searches in Winter period for a minimum of one year post-mining (in consultation with key regulators). Not required.	Unlikely that any threatened amphibian species would be significantly impacted by subsidence resulting from Longwall mining. Unlikely to be impacts to amphibians or loss of amphibian habitat.	No impact to amphibian populations or habitats observed to date.	**NORMAL** No change as compared to baseline observed	• Continue monitoring • Report in end of panel report	No management action/s required.
						WITHIN PREDICTIONS Survey results within baseline variability	• Continue monitoring • Report in end of panel report	No changes in amphibian populations or habitats were observed when compared to baseline and control sites.
						EXCEEDS PREDICTIONS Observed physical impacts to habitat. Statistically significant decrease in population numbers and/or species composition against baseline	• Notification to SCA/D&PE/OEH immediately • Proposal for threatened species management within 1 week if required • Completion of management task following approval from agencies • Additional monitoring as required by the relevant government agencies • Report in end of panel report • Reporting in Incident Reports and Annual Reviews	

Table 6: Trigger Action Response Plan (TARP) Table, Aquatic Ecology, including assessment of actions required by the Subsidence Monitoring Plan for Longwalls N1-N6

Feature	Monitoring Program			Impact Assessment		TARPs		
	Prior to Mining	During Mining	Post mining and Future Monitoring	Predicted Impacts	Observed Impacts	Trigger	Response	Action as a result of Longwall N2
Aquatic ecology 6 Monitoring sites on Wattle Tree Creek 2 Monitoring sites on Little Wattle Tree Creek 4 Reference sites	Observational monitoring for presence/absence of aquatic habitat during water quality monitoring regime Baseline monitoring completed for Longwall N2 and ongoing as it relates to the Nebo Area. AUSRIVAS macroinvertebrate sampling of reference and impact sites. Descriptions of instream habitat, algal levels, riparian condition, presence/absence of litter, flow level and water quality (Biannually in Autumn and Spring) Baseline monitoring completed for Longwall N2 and ongoing as it relates to the Nebo Area.	Observational monitoring for presence/absence of aquatic habitat during water quality monitoring regime Impact monitoring completed for this stage as it relates to the extraction of Longwall N2. AUSRIVAS macroinvertebrate sampling of reference and impact sites. Descriptions of instream habitat, algal levels, riparian condition, presence/ absence of litter, flow level and water quality (Biannually in Autumn and Spring). Impact monitoring completed for this stage as it relates to the extraction of Longwall N2	Observational monitoring for presence/absence of aquatic habitat during water quality monitoring regime for a minimum of one year post-mining (in consultation with key regulators) Monitoring ongoing for this stage as it relates to Longwall N2. AUSRIVAS macroinvertebrate sampling of reference and impact sites. Descriptions of instream habitat, algal levels, riparian condition, presence /absence of litter, flow level and water quality for a minimum of one year post-mining (in consultation with key regulators) (Biannually in Autumn and Spring) Monitoring ongoing for this stage as it relates to Longwall N2.	Unlikely that any threatened aquatic species would be significantly impacted by subsidence resulting from Longwall mining. Unlikely to be impacts to aquatic ecology or loss of aquatic habitat.	No impact to aquatic ecology or habitats observed to date.	**NORMAL** No change in aquatic biota compared to baseline observed **WITHIN PREDICTIONS** Water flow and quality results within predictions. Survey results within baseline variability **EXCEEDS PREDICTIONS** Water flow and quality results exceed predictions. Statistically significant change observed in survey results against baseline	• Continue monitoring. • Report in end of panel report. • Continue monitoring. • Report in end of panel report. • Notification to SCA/D&PE/OEH immediately. • Proposal for any proposed additional monitoring and management measures within 1 week if required. • Completion of agreed management task following approval from regulators. • Additional monitoring as required by the relevant government agencies. • Report in end of panel report. • Reporting in Incident Reports and Annual Review.	No management action/s required. No change in aquatic biota was observed when compared to baseline and control sites. Continue impact monitoring to the completion of one year post mining. Review post mining data and make recommendations on future requirements.