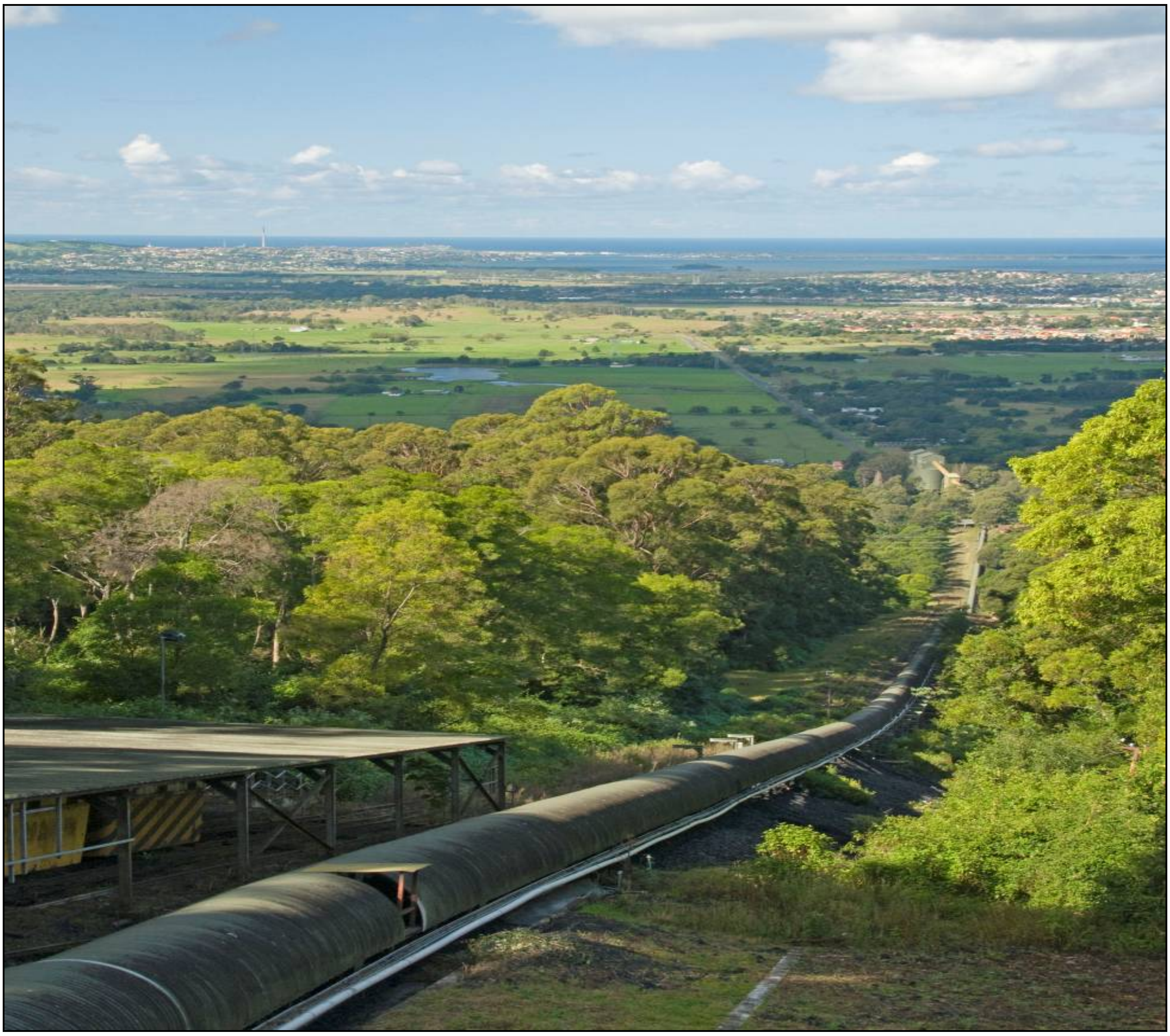
Wongawilli Colliery
Nebo Area Project Approval (MP 09_161)

ANNUAL REVIEW/ANNUAL ENVIRONMENTAL MANAGEMENT REPORT
(1 JULY 2018 – 30 JUNE 2019)



TITLE BLOCK

Name of Operation	Wongawilli Colliery
Name of Mine Operator	Wongawilli Coal Pty Limited
Project Approval	Nebo Area Project (MP09_0161)
Name of Holder of Project Approval	Wongawilli Coal Pty Limited
Mining Leases	ML 1596, ML 1565 and CCL 766
Name of Holder of Mining Lease	Wongawilli Pty Limited
Water Licence	WAL36487
Name of Holder of Water Licence	Wongawilli Coal Pty Limited
MOP Start Date	31 July 2017
MOP End Date	31 December 2020
Annual Review Start Date	1 July 2018
Annual Review End Date	30 June 2019
I, Ron Bush, certify that this audit report is a true and accurate record of the compliance status of Wongawilli Colliery for the period 1 July 2018 to 30 June 2019 and that I am authorised to make this statement on behalf of Wollongong Coal Limited.	
Name of Authorised Reporting Officer	Ron Bush
Title of Authorised Reporting Officer	Group Environment and Approvals Manager
Signature of Authorised Reporting Officer	RonBush
Date	25/02/2020

GLOSSARY OF TERMS AND ABBREVIATIONS

Abbreviations	
AEMR	Annual Environmental Management Report
AHD	Australian Height Datum
AHIMS	Aboriginal Heritage Information Management System
BAM	Beta Attenuation Monitors
CCC	Community Consultative Committee
CCL	Consolidated Coal Lease
CO_2-e	carbon dioxide equivalent
DPIE	NSW Department of Planning, Industry and Environment
DRG	Division of Resources and Geoscience
DSC	Dams Safety Committee
EA	Environmental Assessment
EPA	Environment Protection Agency
EEC	Endangered Ecological Community
EM	Environmental Manager
EO	Environmental Officer
EOM	End of Mine
EP&A Act	Environmental Planning and Assessment Act, 1979
EP&A Reg.	Environmental Planning and Assessment Regulation, 2000
EPBC Act	Commonwealth Environment Protection and Biodiversity Conservation Act, 1999
EPL	Environment Protection Licence
FY	Financial Year
GQC	Groundwater Quality Criteria
HIL	Health Investigation Levels
IEA	Independent Environmental Audit
IWMP	Integrated Wastewater Management Plan
LEP	Local Environment Plan
LGA	Local Government Area
LW	Longwall
km	kilometre
m	metre
mg/L	milligram per litre
ML	Mining Lease
ML/day	megalitre per day
MPL	Mining Purposes Lease
mm/m	millimetres per metre
Mtpa	Million tonnes per annum
NGER	National Greenhouse and Energy Reporting
NMP	Noise Management Plan
NRE	Gujarat NRE Coking Coal Ltd
NSW	New South Wales
PAH	Polycyclic Aromatic Hydrocarbons

PCA	Private Certifying Authority
PCB	Polychlorinated Biphenyl
PKCT	Port Kembla Coal Terminal
PIL	Pollution Limit Levels
PM_{10}	particulate matter less than 10 microns in size
REF	Review of Environmental Factors
RR	Resources Regulator
ROM	Run-of-Mine
SEPP	State Environmental Planning Policy
SMP	Subsidence Management Plan
TARP	Trigger Action Response Plan
TSR	Total Species Richness
WCC	Wollongong City Council
WCL	Wollongong Coal Limited
%	percent
^{0}	degree

Term	Definition
Alluvial	A general term for clay, silt, sand and gravel transported by water and deposited, on the bed of a flood plain, river or stream.
Baseline monitoring	Monitoring conducted over time to collect a body of information to define specific characteristics of an area (e.g. species occurrence or noise levels) prior to commencement of a specific activity.
Coking Coal	Self-coking coal with ash of less than 10% and volatile matter of 21-23%, excellent capacity for carrying 'soft' coking coals in a blend.
Continuous miner	A remote-controlled, tracked, electrically powered coal cutting and loading machine used to form mine roadways and extract coal pillars.
Conveyor	Fixed mechanical apparatus consisting of a continuous moving belt used to transport coal from one place to another.
Driveage	A horizontal or inclined heading or roadway in the process of construction. The road way will be used to access a new mining area within the lease.
Dyke	A sheet like vertical intrusion of igneous rock cutting across the strata of older rocks.
Ecosystem	An interacting system of animals, plants, other organisms and non-living parts of the environment.
Fault	Major fracture of the earth's crust caused by the relative movement of the rock masses on either side.
First Workings	Involves the development headings or roadways which will provide access to the coal resource. They are developed using continuous miners with integrated roof and rib bolting rigs. First workings leave the coal pillars intact and the overlying strata fully supported
Gate roads (main-gates and tailgates)	An underground roadway (tunnel) that provides access to a working longwall for continuous mining.
Goaf (or goafing)	The space left following extraction of the coal seam where the roof material is allowed to collapse.

Greenhouse gases	Gases with potential to cause climate change (e.g. methane, carbon dioxide and non-methane volatile organic compounds). Usually expressed in terms of carbon dioxide equivalent.
Groundwater	All waters occurring below the land surface; the upper surface of the soils saturated by groundwater in any particular area is called the water table.
Habitat	The particular local environment occupied by an organism.
Infrastructure	The supporting installations and services that supply the needs of the Project.
Longwall	A secondary extraction method of mining coal that continuously removes the coal from the working face onto a series of conveyors that transfer the coal to the surface. As the coal is cut away (a 'shear'), both the longwall machine (known as a 'shearer') and the hydraulic roof supports advance forward ready for the next shear.
Permeability	The ability of a rock or soil to allow fluid to pass through it.
Pillar Extraction	A continuous miner system of mining whereby coal pillars are systematically extracted.
Pillar Run	A large scale progressive collapse of coal pillars in a short period of time.
Potable water	Water of quality suitable for human consumption.
Project Approval	Nebo Area Project Approval (MP 09_0161)
Rehabilitation	The restoration of a landscape and especially the vegetation following its disturbance.
Run-of-mine (ROM)	Raw coal that is stockpiled and/or prior to being processed through a coal preparation plant.
Strain	The change in the horizontal distance between two points divided by the original horizontal distance between the points.
Subsidence	The deformation of the ground mass due to the mining activity, including both vertical and horizontal displacement, tilt, strain and curvature.
Terrestrial	Living or growing on the land.
Tilt	The difference in subsidence between two points divided by the horizontal distance between the points.
Upsidence	Relative upward movement, or uplift, created by the horizontal compression and buckling behaviour of the rock strata in the vicinity of a valley floor
Valley closure	A phenomenon whereby one or both sides of a valley move horizontally towards the valley centreline, due to changed stress conditions beneath the valley and its confining land masses

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APPENDICES

1 STATEMENT OF COMPLIANCE

The compliance status of Wongawilli Colliery at the end of reporting period is provided in **Table 1.1**.

Table 1.1: Statement of Compliance

Were all conditions of the relevant approvals complied with?	
MP 09_0161	No
ML 1565	Yes
ML 1596	No
CCL 766	Yes
EPL 1087	No

2 INTRODUCTION

Wongawilli Coal Pty Ltd operates the Wongawilli Colliery in the Southern Coalfield of New South Wales. Wongawilli Coal Pty Ltd is a wholly owned subsidiary of Wollongong Coal Limited (**WCL**). Wongawilli Colliery is located approximately 14 km south-west of Wollongong (**Figure 2.1**), within the Wollongong and Wingecarribee Local Government Areas (**LGAs**). **Figure 2.2** shows WCL's Wongawilli Colliery Assets and Leases which includes the Avondale site which is decommissioned (**Figure 2.3**).

The Wongawilli pit top contains the main mine portal and caters for men, mining equipment, vehicle and machinery maintenance, mine supplies, administration, coal transport to the surface, a 100,000 tonne capacity coal stockpiling facility and rail transportation facilities to load and transport coal to the PKCT. An overview of the Wongawilli Colliery operational areas and infrastructure is shown on **Figure 2.4** and **Figure 2.5**.

Figure 2.1: Location of Wongawilli Colliery

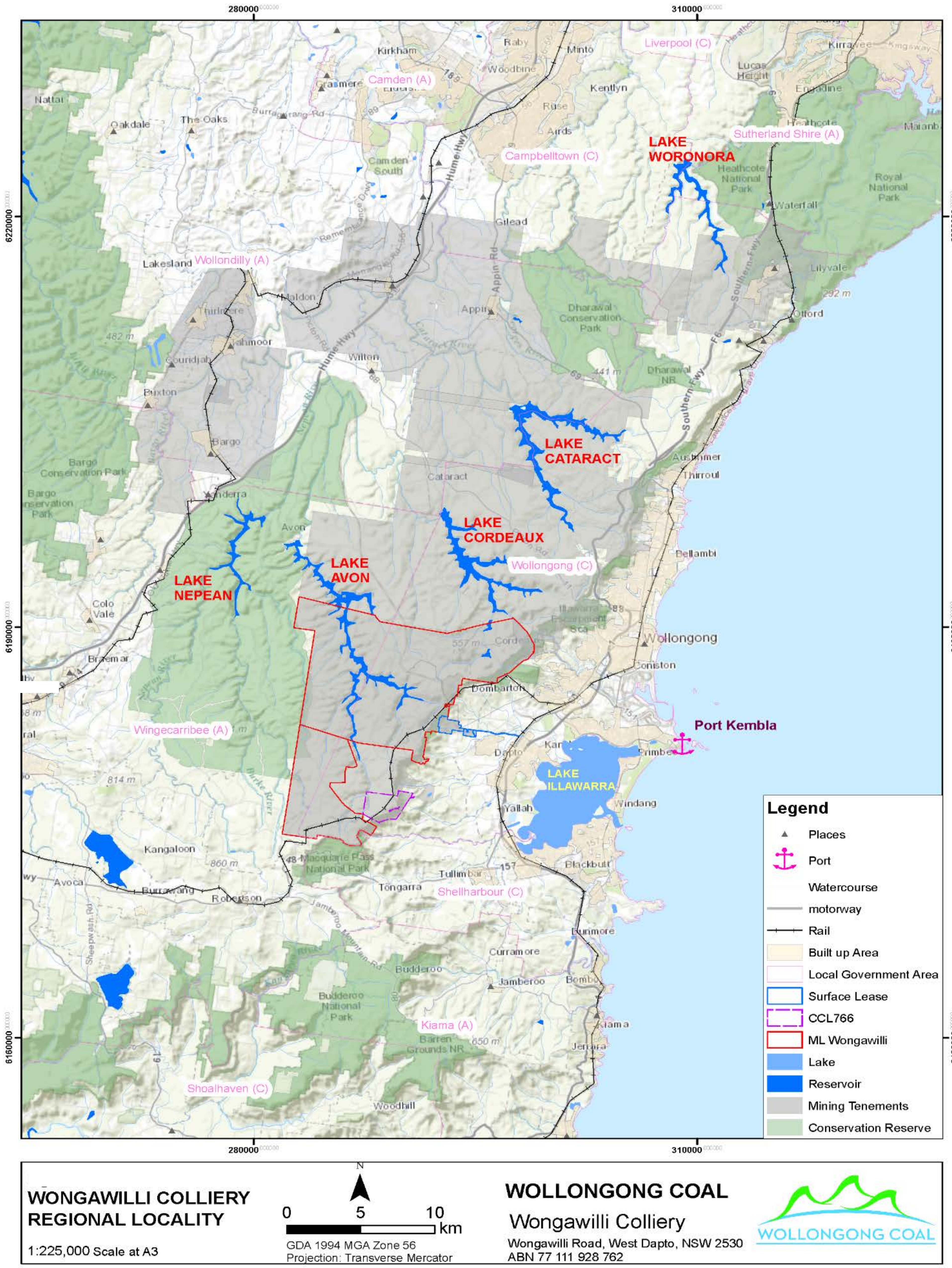
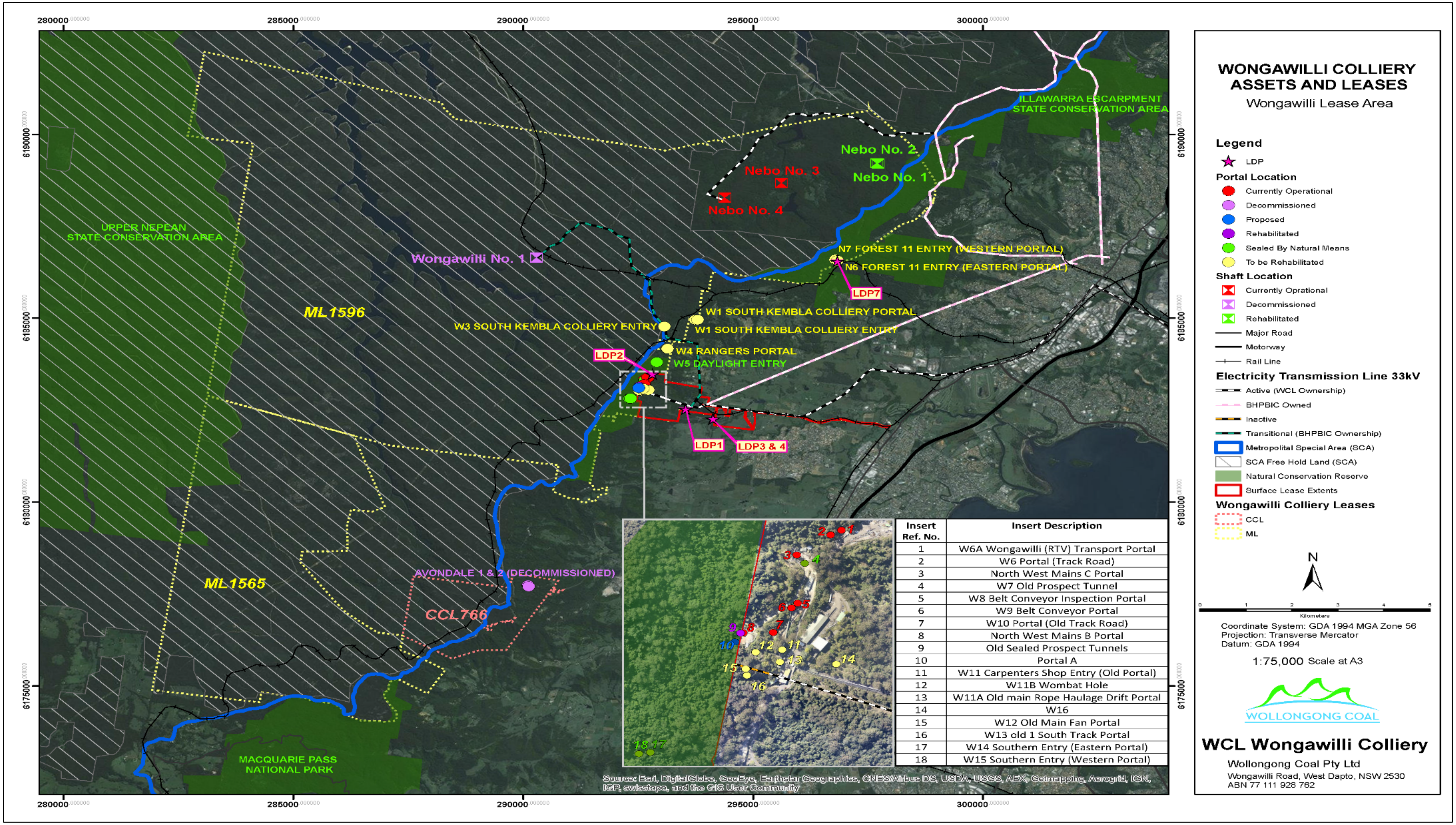


Figure 2.2: Wongawilli Assets and Leases



Insert Ref. No.	Insert Description
1	W6A Wongawilli (RTV) Transport Portal
2	W6 Portal (Track Road)
3	North West Mains C Portal
4	W7 Old Prospect Tunnel
5	W8 Belt Conveyor Inspection Portal
6	W9 Belt Conveyor Portal
7	W10 Portal (Old Track Road)
8	North West Mains B Portal
9	Old Sealed Prospect Tunnels
10	Portal A
11	W11 Carpenters Shop Entry (Old Portal)
12	W11B Wombat Hole
13	W11A Old main Rope Haulage Drift Portal
14	W16
15	W12 Old Main Fan Portal
16	W13 old 1 South Track Portal
17	W14 Southern Entry (Eastern Portal)
18	W15 Southern Entry (Western Portal)

Figure 2.3: Avondale Site (Decommissioned)

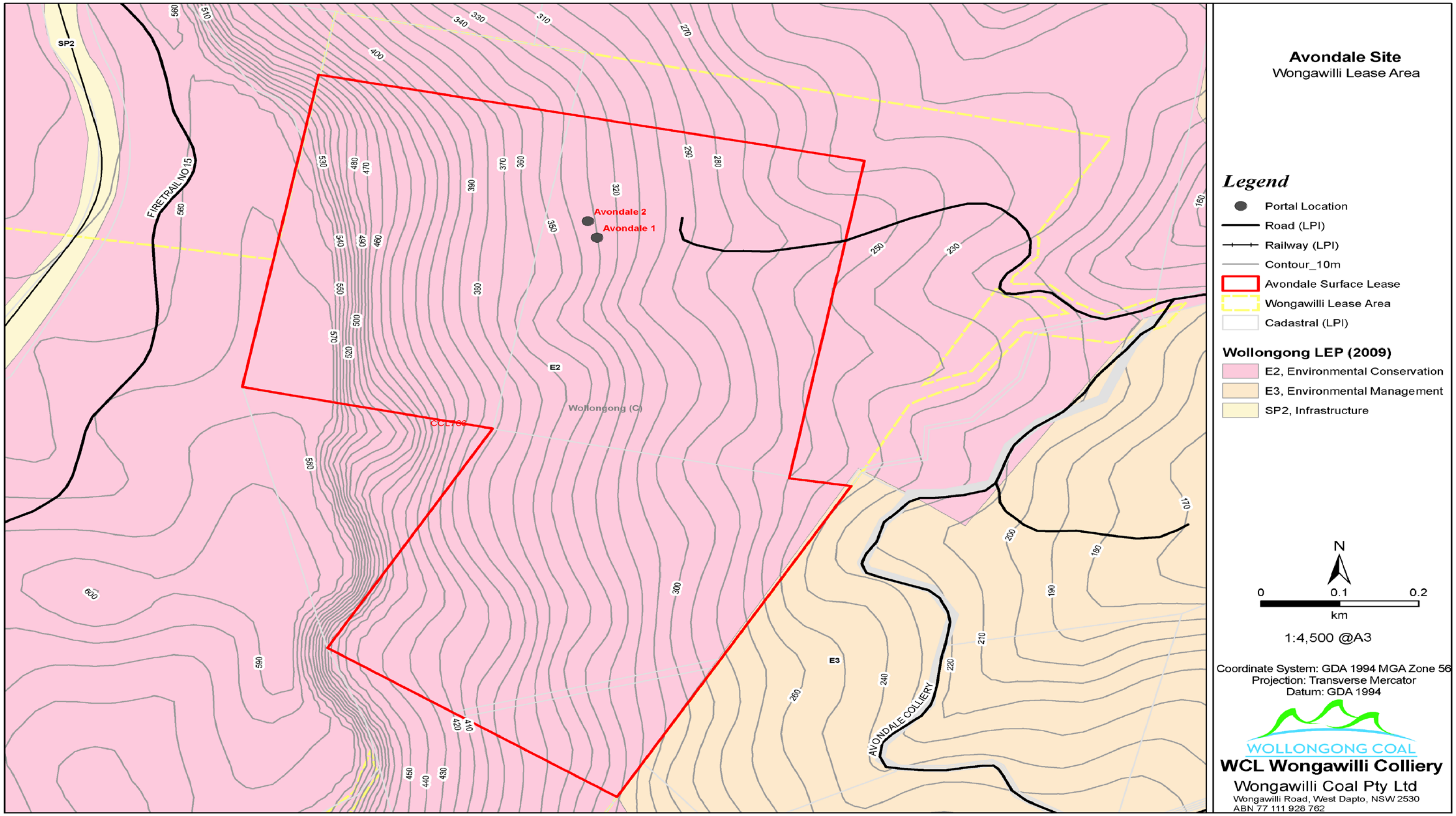
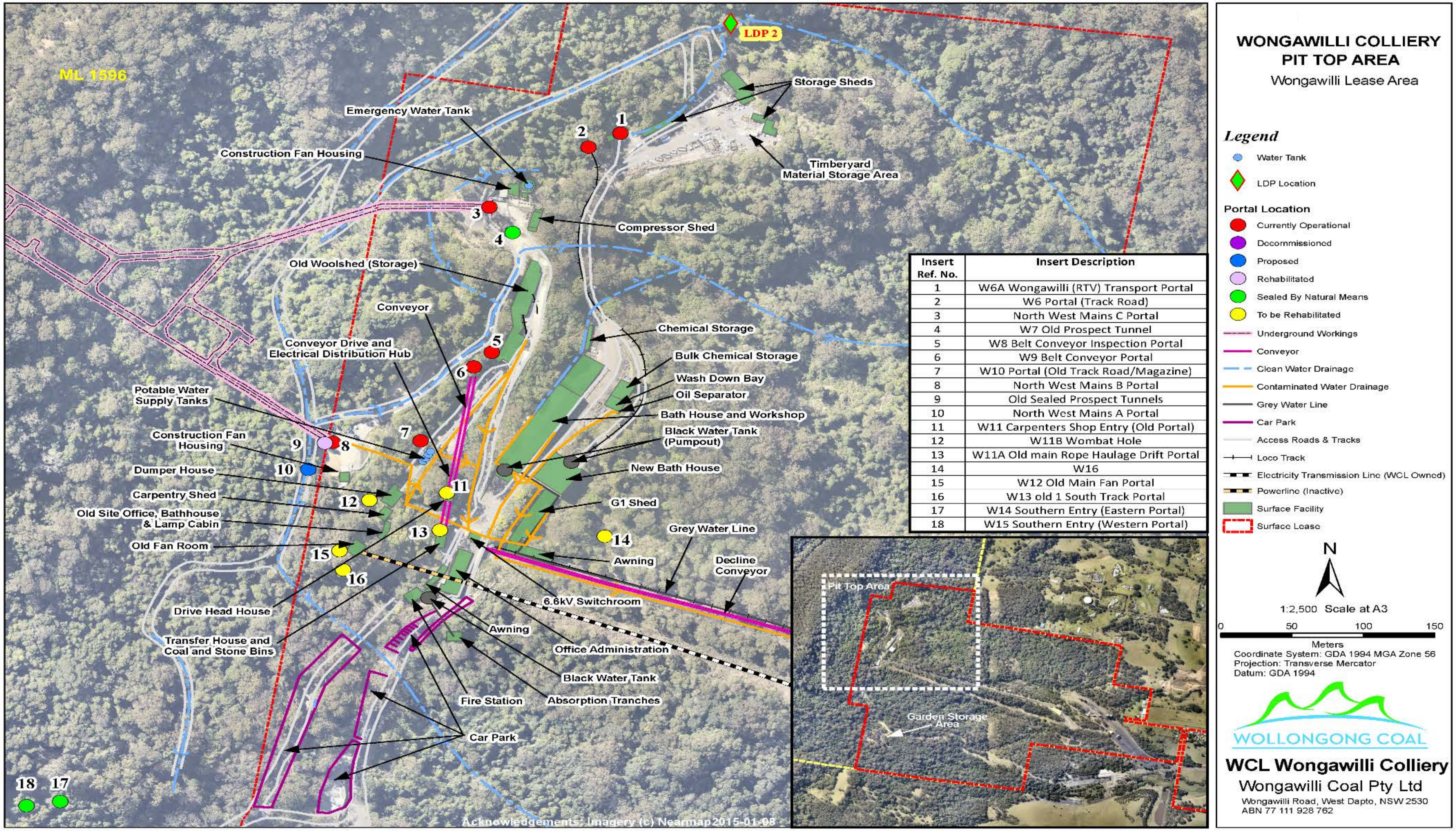
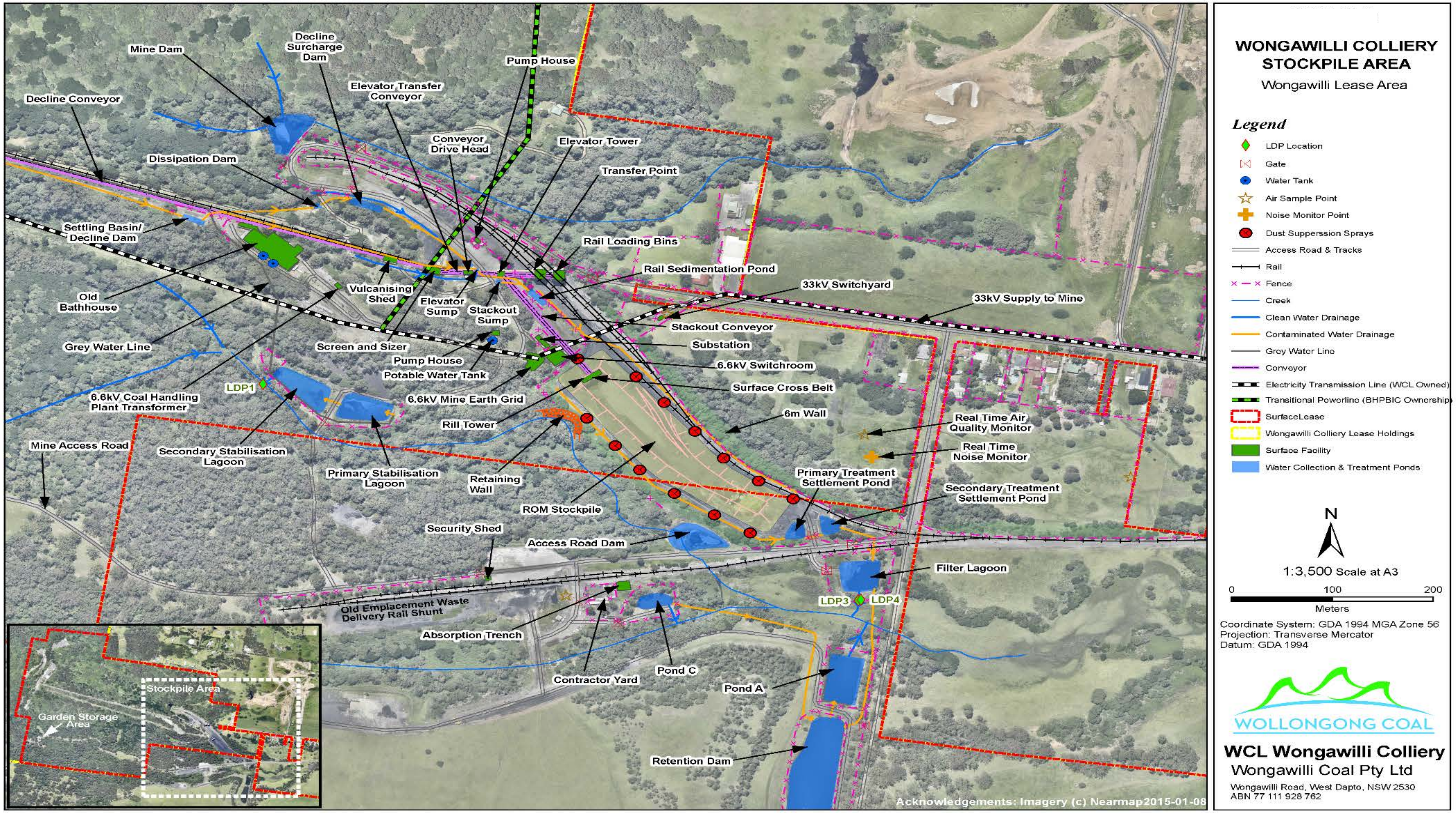


Figure 2.4: Wongawilli Pit Top



2.5: Wongawilli Stockpile Area



The Wongawilli Colliery currently operates under Project Approval (**MP 09_0161**) dated 02 November 2011. The project approval allows:

- Continued use of the surface infrastructure at the Wongawilli pit top as currently operated;
- Coal production at the historic level of up to 2 million tonnes per annum (mtpa);
- Longwall mining in the Nebo area in the north east corner of the lease area;
- Continued development and construction of the Western Drive;
- Continued transportation of run of mine coal from the Colliery to Port Kembla Coal Terminal (PKCT) by rail; and
- Rehabilitation of the site.

A modification (MOD1) to MP 10_0046 was approved on 27 November 2015. MOD1 authorised the continuation of mining operations until 31 December 2020.

Condition 3 of Schedule 6 of the Project Approval, requires Wongawilli Colliery to prepare an Annual Review report.

This Annual Review / Annual Environmental Management Report (**AR/AEMR**) is for the period 1 July 2018 to 30 June 2019. This AR/AEMR has been compiled, generally in accordance with, the NSW Government Annual Review Guideline (NSW Government, 2015).

2.1 Background

Wongawilli Colliery is an underground coal mine owned and operated by Wongawilli Coal Ltd. The mine site is located approximately 14 km south-west of Wollongong on the Illawarra escarpment at West Dapto (Wongawilli village). The total lease area covered by Wongawilli Colliery is 14,767 hectares.

Mining was proposed in the Wongawilli area in 1906 and began in 1912. Wongawilli Colliery was purchased by Hoskins in 1916 and the coal produced was washed and coked on site before being transported to the Lithgow Iron and Steel Plant. A blast furnace was commissioned by Hoskins at Port Kembla in 1927 and Australian Iron and Steel (**AIS**) was formed in 1928. Broken Hill Proprietary Company Ltd (**BHP**) acquired AIS in 1935.

The Elouera Colliery was formed from the merger of the Wongawilli and Nebo Collieries in 1993. These mines operated separately in adjoining reserves and mining had occurred in both the Bulli and Wongawilli seams. BHP became BHP Billiton Pty Ltd in 2000. The Colliery was operated by BHP Billiton Illawarra Coal (**BHPBIC**) until June 2005 and contract miner Delta commenced mining in October 2005. NRE acquired the mining lease in December 2007 and the site was renamed NRE Wongawilli Colliery. NRE was subsequently renamed Wollongong Coal Limited during 2014.

Historically, coal from the Colliery was transferred by rail to the Port Kembla Steelworks Coal Preparation Plant. Washed coal was used either in the steelworks or transferred to the Port Kembla Coal Terminal (PKCT) for shipping to both domestic and international markets. Coal wash reject from the washery was railed back to the Wongawilli emplacement area adjacent to the Wongawilli pit top.

The emplacement area ceased its operations in November 2005 and has been rehabilitated. Run of Mine (**ROM**) coal is now transported unprocessed, by rail to the PKCT (**Figure 2.6**).

Mining of the Wongawilli Coal Seam reserves in the area has been undertaken for more than 80 years. Prior to mining within the Wongawilli Coal Seam, initial mining in the area was undertaken in the Bulli Coal Seam.

The economic working section of the coal seam is in the order of 3.5 to 4.0 metres thick in the present mining area. The mined seam thickness is primarily governed by localised variations between marker bands as well as changes in stress magnitudes and stone rolls. Approximately 76% of the coal mined in this seam section is recoverable. The Wongawilli Coal Seam, mined from the Kembla Sandstone seam floor to one of the more prominent shale bands, is relatively high in ash content.

During the reporting period, Wongawilli Colliery undertook mining activities in the Wongawilli Coal Seam at a depth of cover varying between 100 to 360 metres. A typical stratigraphic section of the Illawarra Coal Measures with indicative depths of cover is shown in **Figure 2.7**.

Figure 2.6: Wongawilli Coal Haulage Route

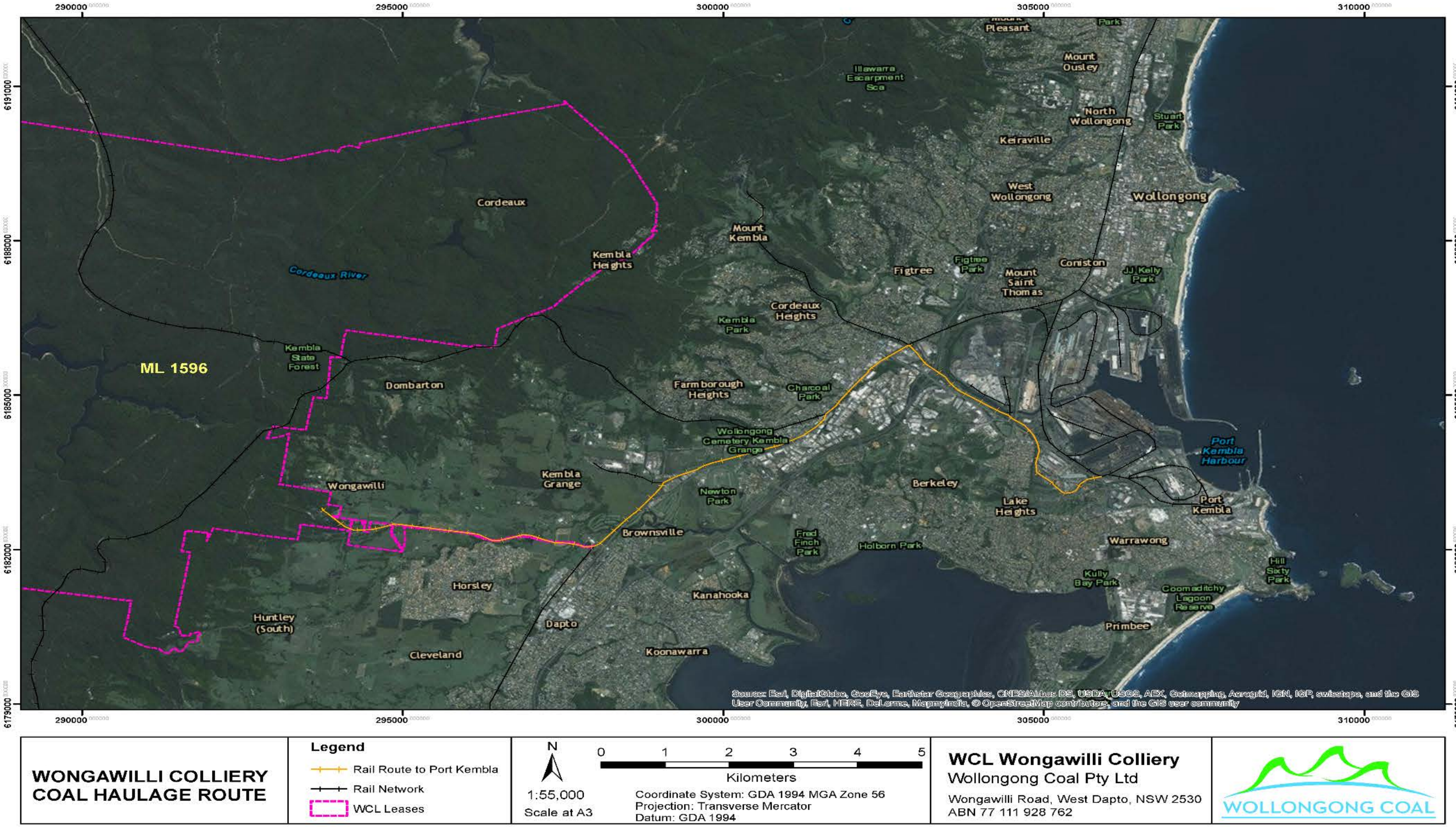


Figure 2.7: Typical Stratigraphic Section

AGE	GROUP	SUB-GRP	CODE	FORMATION & MEMBERS	
TRIASSIC	WIANAMATTA GROUP			BRINGELLY SHALE	
			WMSH	MINCHINBURY SANDSTONE	
				ASHFIELD SHALE	
				MITTAGONG FORMATION	
			HBSS	HAWKSBURY SANDSTONE	
	NARRABEEN GROUP	GOSFORD		NEWPORT FORMATION	
			GRFM	GARIE FORMATION	
		CLIFTON	BACS	BALD HILL CLAYSTONE	
			BGSS	BULGO SANDSTONE	
			SPCS	STANWELL PARK CLAYSTONE	
			SBSS	SCARBOROUGH SANDSTONE	
			WBCS	WOMBARRA CLAYSTONE	
			CCSS	COAL CLIFF SANDSTONE	
PERMIAN	ILLAWARRA COAL MEASURES	SYDNEY	BUSM	BULLI COAL	
			UNM1	LODDON SANDSTONE	
			BASM	BALGOWNIE COAL	
			LRSS	LAWRENCE SANDSTONE	
				BURRAGORANG CLAYSTONE	
			CHSM	ECKERSLEY FORMATION	CAPE HORN
			UNM2		UNNAMED MEMBER 2
					HARGRAVE COAL
					WORONORA COAL
					NOVICE SANDSTONE
			WW01-11	WONGAWILLI COAL	
			KBSS	KEMBLA SANDSTONE	
			ACSM	ALLANS CREEK FORMATION	AMERICAN CK. COAL
			APFM	DARKES FOREST SANDSTONE (APPIN FORMATION)	
				BARGO CLAYSTONE	HUNTLEY CLAYST.
					AUSTIMER SANDST.
			TGSM	TONGARRA COAL	
			WTFM	WILTON FORMATION	
				WOONONA COAL MEMBER	
				ERINS VALE FORMATION	
		CUMBERLAND		PHEASANTS NEST FORMATION	FIGTREE COAL
					UNANDERRA COAL
					BERKELEY LATITE
					MINNAMURRA LATITE
					CALDERWOOD LATITE
					FIVE ISLANDS LATITE
	SHOALHAVEN GROUP			BROUGHTON FORMATION	
				BERRY SILTSTONE	
				NOWRA SANDSTONE	
				WANDRAWANDIAN SILTSTONE	
				SNAPPER POINT FORMATION	
				PEBBLEY BEACH FORMATION	
	TALATERANG			CLYDE COAL MEASURES	
UNDIFFERENTIATED PALAEOZOIC (DEVONIAN, SILURIAN & ORDOVICIAN) ROCKS OF THE BASIN BASEMENT					
Information Sourced From - "Geological Survey Report No. GS1998/277 - R.S. Moffitt"					

The mine operates continuous miners for bord and pillar panel development. The Wongawilli Colliery site contains the main mine portal and caters for men, mining equipment, vehicle and machinery maintenance, mine supplies, administration, coal transport to the surface, and a 100,000 tonne capacity coal stockpiling facility and rail transportation facilities to transport coal to the PKCT.

There are currently two main transport entries into the mine, namely a roadway for rubber tyred vehicles and the other for rail mounted equipment. The rubber tyred vehicles are the primary transport system that services the mine. Coal is transported from the workings to the surface of the mine via an inclined conveyor approximately 2.5km in length.

The mining plan to uses conventional pillar extraction techniques. The pillar extraction method is an effective alternative to longwall mining in terms of maximising coal recovery.

In March 2017 WCL submitted a letter to the Department seeking approval to vary the Extraction Plan approved under Condition 7 of schedule 3 of the project approval for the Nebo Area Project (09_0161). The amended plans were submitted to the Department on the 27 April 2017.

Approval for this variation to mining was received from the Department on the 5 September 2017. Mining operations recommenced in a reduced capacity in October 2017.

2.2 Mine Contacts

The key contacts for Wongawilli Colliery are outlined in **Table 2.1**.

Table 2.1: Mine Contacts at Wongawilli Colliery

Contact	Position	Contact Details
Wayne Sly	Chief Operations Manager	Mobile: 0406 671 011
Peter Roser	General Manager (WWC)	Mobile: 0426 246 597
Ron Bush	Group Environment and Approvals Manager	Mobile: 0404 972 746
John Ross	Environment Manager (WWC)	Mobile: 0426 015 028

2.3 Distribution

Copies of this AR/AEMR will be distributed to the following stakeholders:

- Department of Planning, Industry & Environment (DPIE);
- Resources Regulator
- WaterNSW; and
- Wollongong City Council.

WCL will make this AR/AEMR available on its website. A hard copy will also be kept at the Wongawilli Colliery, Jersey Farm Road, via Wongawilli Road, West Dapto, NSW 2530.

Any revisions undertaken will be the responsibility of WCL and any notifications will be sent accordingly. WCL will not be responsible for maintaining uncontrolled copies beyond ensuring the most recent version is maintained on WCL's computer system, website, and hard copy at the Wongawilli Colliery, Jersey Farm Road, via Wongawilli Road, West Dapto, NSW 2530.

3 CONSENTS, LEASES & LICENCES

During the reporting period, Wongawilli Colliery held approvals for a variety of activities. These approvals include mining leases and related approvals (MOP and SMP), complying development certificates, development consents, major project approvals, environmental protection licences and a variety of other approvals. These are outlined in **Table 3.1**.

Table 3.1: Consents, Leases & Licences relevant to mining activities at Wongawilli Colliery

Licence and/or Approval	Document Number	Issue Date	Expiry Date
Mining Lease (DRG)	ML 1596	03/02/2012	07/10/2029
Mining Lease (DRG)	ML 1565	02/08/2006	9/10/2015 (Renewal Pending)
Consolidated Coal Lease (DRG)	CCL 766	27/06/2005	9/10/2015 (Renewal Pending)
Mine Operations Plan (DRG)	MOP	31/07/2017	31/12/2020
Subsidence Management Plan (DRG)	SMP LW11,12,15,16,19 & 20 (Mod)	01/06/2010	31/12/2017.
Subsidence Management Plan (DRG)	Nebo Longwalls N1-N6	17/12/2015	31/01/2020
Project Approval – Nebo Area Project (DPIE)	MP 09_0161	02/11/2011	31/12/2020
Complying Development Certificate for Temporary Stacker Conveyor (PCA)	CDC392/10	26/02/2010	NA
Complying Development Certificate for a ROM Coal Screening and Sizing Plant (PCA)	CDC272/09	24/02/2010	NA

Licence and/or Approval	Document Number	Issue Date	Expiry Date
Project Approval for the Construction of a New Bath House and Office Extensions (DPE)	MP 09_0030	03/02/2012	07/10/2029
Environmental Protection Licence - WCL Wongawilli Colliery (EPA)	EPL 1087	1st October (Anniversary Date)	NA
Environment Protection Licence WCL - Avondale Colliery (EPA)	EPL 12442	31 March (Anniversary Date)	NA
Radiation Control Licence/Registration (EPA)	5061480	-	13/08/2020
WaterNSW Special Areas Access Mining Consent (WaterNSW)	D2015/036046	04/03/2016	04/03/2021
WC_WONGAWILLI_1 (WCC)	16/1925	19/01/2016	30/06/2025
Surface Disturbance Notice (DRG)	06/3092	24/02/2010	NA
Surface Disturbance Notice (DRG)	11/19 & 06/3052	05/01/2011	NA
Part 5 Approval (WaterNSW) – Avon Water Quality monitoring	D2011/1059	09/05/2011	At Completion of Monitoring
Part 5 Approval (WaterNSW) – LW19 Subsidence Survey Line	D2011/13055	10/05/2011	At Completion of LW19
Part 5 Approval (WaterNSW) – Nebo Longwalls N1 to N6 Monitoring	D2013/18268	25/03/2013	31/03/2018
Water Licence (DPIE - Water)	10AL118768	11/03/2016	11/03/2021
License to Store (Class 1.1B & 1.1D Explosives)	XSTR200001	09/01/2017	13/12/2021

4 OPERATIONS DURING REPORTING PERIOD

The Wongawilli Colliery currently operates under Project Approval (MP 09_0161) dated 02 November 2011. A modification (MOD1) to MP 10_0046 was approved on 27 November 2015. MOD1 authorised the continuation of mining operations until 31 December 2020.

In March 2017 WCL sought to vary the Extraction Plan approved under Condition 7 of Schedule 3 of the Project Approval for the Nebo Area Project (09_0161), which was granted on 5 September 2017. Mining operations recommenced in a reduced capacity in October 2017.

Wongawilli Mine ceased the production of coal on 13 March 2019 in accordance with directions from inspectors of the DPIE. On 31 May 2019 WWC was placed into Care and Maintenance. From June 2019 the site workforce was reduced and site security has been increased.

4.1 Exploration

No exploration program for Wongawilli was undertaken during this reporting period. During the next reporting period WCL are planning to conduct an exploration program within the North West Domain. Up to 15 exploration holes are proposed.

4.2 Land Preparation

There were no new areas of land prepared for mining or mining related activities.

4.3 Construction

During the reporting period no construction activities were undertaken.

4.4 Mining

Mining ceased in March 2019 and in May 2019, WWC was placed into Care and Maintenance.

The total run-of-mine (ROM) annual coal production for period July 2018 - June 2019 which is outlined in **Table 4.1**.

Table 4.1: Wongawilli Colliery Annual ROM Coal Production during the Period

Year Ending	ROM Tonnes
July 2018 - June 2019	140,187

4.5 Mineral Processing

During the reporting period 5,000 tonnes of material was screened.

4.6 Waste Management

All rubbish from both the surface and underground operations is collected in portable skip bins and removed regularly from site to a licensed waste disposal depot.

Waste material on site is separated into general waste, cardboard/paper, wood, steel, waste oil and oily water. The correct use of onsite waste management facilities is an expectation of all workers. General housekeeping for all areas of the site is checked during Environmental Inspections. Any housekeeping deficiencies are discussed and communicated to the workforce using Toolbox Talks.

A humiceptor unit is installed at the workshop wash-down bay. This unit is maintained by utilising a sucker truck from a licenced waste removal provider to remove sludge and sediment from within the unit which is then removed from site by the provider. Waste oil and oily water that is generated or captured on site in tanks, holding pits, sumps or bunds is removed from site by an authorised oil recycling/disposal contractor.

During the reporting period clean-up activities were undertaken on the Pit Top. This is an ongoing process to tidy up the Pit Top. A large amount of scrap steel is expected to be removed from site during the next reporting period.

No major waste management activities occurred at the Avondale Colliery site during the reporting period.

Table 4.2 provides the waste streams and quantities generated at Wongawilli Colliery.

Table 4.2: Waste Streams at Wongawilli Colliery

Waste Stream	Volume/Weight	Contractor
Timber	Nil	REMONDIS Australia Pty Ltd
Cardboard/Paper	1.245 tonnes	REMONDIS Australia Pty Ltd
Oily Water	Nil	Cleanaway / National Wide Oils
Waste Oil	9,500 Lt	Cleanaway / National Wide Oils
General Wastes	13.23 tonnes	REMONDIS Australia Pty Ltd
Mixed Waste	119.10 tonnes	REMONDIS Australia Pty Ltd
Scrap Metal	Nil	East West Metal Trading
Black Water Waste	265,000 Litres	REMONDIS Australia Pty Ltd

4.7 Ore & Product Stockpiles

Wongawilli Colliery has a single ROM coal stockpile area. The site is approximately 300m long and 50m wide. The stockpile area occupies the south-eastern section of the site and is bounded by an 8 metre high concrete noise barrier to the north, open pasture to the south and east and to the west by the escarpment and the Wongawilli Colliery facilities.

ROM coal from the mine is transferred from the upper pit top on an overland conveyor belt down the decline corridor to the stockpile area. The decline conveyor delivers the coal to 2 x 2000 tonne rail loading bins after passing through a screen and sizer facility that allows screening of coal to minus 50mm to meet the requirements for acceptance by PKCT.

When the coal bins are full, the incoming coal flow from the decline conveyor can be diverted on a stack-out conveyor to twin rill towers on the stockpile area, after passing through the screen and sizer facility. The rill towers provide a live temporary stockpile of 20,000 tonnes. If further on-ground coal storage is required the temporary stockpile can be extended using trucks and front-end loaders or pushed by bulldozers. The maximum holding capacity of the stockpile is 100,000 tonnes.

Coal is managed on the stockpile with a bulldozer which pushes the coal out and also front-end loaders that shape the stockpile and retrieve the coal for loading into rail wagons. A private rail spur line from the Wongawilli Colliery stockpile area to the Illawarra Railway forms a transport link for coal supply to the PKCT.

The volume of stockpiled coal varies depending on mine production and the availability of trains to transport the product to the PKCT. During the current reporting period of July 2018 to June 2019, 140,187 tonnes of coal was transported to PKCT.

4.8 Hazardous Material Management

Fuels

Diesel fuel is brought to site by fuel tankers. Wongawilli Colliery uses low emission fuels with sulphur content less than 0.02%. The fuel is stored on site in a 25,000 L tank. This tank is situated under a roof within secondary containment, with fire-fighting facilities in close proximity. Fuel is pumped from this main storage tank into smaller transportable containment vessels for use underground. Diesel fuel consumption during this reporting period was 177,864 Litres.

Substance/Chemicals

Wongawilli Colliery maintains a register of Safety Data Sheets (SDS) for all chemicals used on site. This is located in the Control Room.

Explosives

An explosives magazine is located at the Pit Top area. The explosive magazine utilises a sealed disused portal entrance and is used to safely store explosive products required for use underground. All dangerous goods are stored in accordance with the WorkCover NSW Notification of Dangerous Goods requirements. The storage facility is under constant CCTV surveillance. No explosives were used in underground operations during the current reporting period.

Other

The dangerous goods kept at Wongawilli Colliery include compressed gases, flammable fluids, combustible liquids, poisonous substances and corrosive substances, none of which exceed the acceptable holding limits.

4.9 Other Infrastructure Management

Coal Stockpile and Rail Corridor

Management of the coal stockpile facilities and the rail corridor includes sediment, vegetation, dust, waste and water management. This will continue on a reduced scale during the C&M period. The WCL Logistics Manager acts as the Rail Infrastructure Manager (RIM).

The WCL Logistics Manager is responsible for the management of the rail line in both the stockpile and rail corridor areas. Contractors are employed to manage the stockpile and undertake the train loading from the stockpile area and rail bins and also water and dust management, transport management and slope stability management.

5 ENVIRONMENTAL MANAGEMENT AND PERFORMANCE

5.1 Actions from Previous Annual Review / AEMR's

Table 5.1: Actions from Previous Reporting Periods

Action Required	Requested by	Section in Report
1. Stormwater Management including clean out of dams.	DPE/DRG/EPA	Section 5.3
2. Landform and Stability of the perimeter bund and lower slope at the Timber Yard material storage area.	DRG	Section 5.3
3. Drainage system at the Timber Yard material storage area.	DRG	Section 5.3
4. Housekeeping at the Timber Yard material storage area.	DRG	Section 4.6
5. Weed Management.	DRG	Section 5.7

To ensure Wongawilli Colliery achieves regulatory compliance with the Project Approval, and EPL 1087, WCL have developed a number of approved management plans in consultation with the Regulators and other relevant stakeholders.

Management plans currently in place at Wongawilli Colliery include:

- Air Quality & Greenhouse Gas Management Plan;
- Bushfire Management Plan;
- Extraction Plan;
- Environmental Management Strategy;
- Heritage Management Plan;
- Integrated Wastewater Management Plan;
- Noise Management Plan;
- Surface Water Management Plan; and
- Pollution Incident Response Management Plan (PIRMP).

The above plans have been approved by DPIE as required by the conditions of the MOD 1 approval and WCL continues to manage the Wongawilli Colliery in accordance with the approved Management Plans. The plans will be reviewed during the following three months after the submission of the AR/AEMR and published as required.

5.2 Air Pollution

Environmental Management

Wongawilli Colliery Pit Top

Air quality is monitored in accordance with the approved Air Quality & Greenhouse Gas Management Plan.

Dust control measures applied to surface activities include:

- Use of the stockpile and stacker conveyor water sprays system. This facility can be automatically activated according to pre-set wind speed and direction controls; and
- Use of a water truck to wet down operational areas of the mine if required.

Air quality monitoring will continue to be undertaken in accordance with EPL1087 dust deposition requirements. The sampling period for dust is 30 ± 2 days and the first day starts at the beginning of the month. Analysis is conducted by a NATA certified laboratory.

In addition to dust deposition monitoring an extensive real time air and noise monitoring system has been installed on site.

This system allows the Colliery to continuously monitor weather conditions and alter pit top operations where appropriate. Wongawilli Colliery's real time air and noise monitoring system includes the follow:

- Continuous monitoring for PM_{10} and $PM_{2.5}$ using Beta Attenuation Monitors (BAMs); and
- Operation of a single automated weather station.

These systems will be managed by Wollongong Coal employees with consultant input when maintenance is required.

Avondale Pit Top

There are no mining activities at the Avondale Pit Top and all access and haul roads, laydown and operational area are grassed therefore not generating any airborne dust.

SMP and Catchment Lease Areas

The only activities in the catchment that could impact on air quality are related to exploration drilling, vehicle movements associated with monitoring and inspections and the operation and maintenance of ventilation shafts.

The possible impacts from these activities are:

- Particulates in exhaust air from the ventilation shafts;
- Road dust from travelling on catchment roads;
- Particulate emissions from motor vehicles and other fuel powered machinery; and
- Dust from drilling activities.

No exploration drilling has occurred during this reporting period.

Environmental Performance

Wongawilli Colliery Pit Top

Monitoring results for dust deposition, as shown in **Table 5.2**, indicate compliance with EPL1087 dust deposition requirements and Annual Averaging Period criteria (4 g/m2/month) stated in MP 09_0161 approval Condition 11 of Schedule 4.

Table 5.2: Wongawilli Colliery Dust Monitoring Results

EPL Monitoring Point	Analyte	Min (g/m²/month)	Annualised Average (g/m²/month)	Max (g/m²/month)	Annualised Yearly Average (EPA Guideline, g/m²/month)
9	Ash	0.1	0.6	1.4	4
	Combustible Matter	0.1	0.3	0.6	
	Insoluble Solids	0.1	0.9	2.0	
10	Ash	0.1	0.9	1.5	4
	Combustible Matter	0.2	0.8	2.1	
	Insoluble Solids	0.3	1.6	3.5	
11	Ash	0.2	1.0	3.2	4
	Combustible Matter	0.1	0.8	2.6	
	Insoluble Solids	0.3	1.9	5.8*	
12	Ash	0.1	0.5	1.3	4
	Combustible Matter	0.1	0.6	2.3	
	Insoluble Solids	0.2	1.2	3.6	
13	Ash	0.1	1.0	4.3**	4
	Combustible Matter	0.1	0.6	4.5**	
	Insoluble Solids	0.2	2.0	8.8**	

**Insoluble solids max result was above the EPA guideline of 4g/m²/month during January 2019. Visual lab analysis concluded that the sample consisted of 65% dirt, <5% coal, 30% insects and 5% vegetation.*
***All analyte max results were above the EPA guideline of 4g/m²/month during March 2019. Visual lab analysis concluded that the sample consisted of <5% dirt, <5% coal, 5% vegetation and 100% insects.*

A real time air quality monitoring system was implemented on site during December 2015. Monitoring results for PM_{10} are shown in **Table 5.3** below. For $PM_{10,}$ the real time air quality monitors did not record a 24 hour average above the criteria (50 µg/m³) stated in MP 09_0161 approval Condition 11 of Schedule 4 for the period July 2018 to June 2019.

Table 5.3: Wongawilli Colliery PM_{10} Monitoring Results (July 2018 to June 2019)

Month	BAM
	Monthly Average PM_{10} (µg/m3)
July 18	16.1*
Aug 18	22.0*
Sep 18	13.0*
Oct 18	-**
Nov 18	-**
Dec 18	-**
Jan 19	-**
Feb 19	9.3***
Mar 19	7.1***
April 19	10.2****
May 19	13.1****
Jun 19	11.7****

** The data recovery rate was 100% and there were no days over the criteria in the quarter.*
*** The data recovery rate was 0%.*
**** The data recovery rate was 48% and there were no days over the criteria in the quarter.*
*****The data recovery rate was96% and there was 2 days over the criteria in the quarter. Both the exceedances correlated with peaks in PM10 at Kembla Grange and Wollongong OEH stations therefore they are likely due to regional air quality.*

Avondale Pit Top

There are no mining activities at the Avondale Pit Top and all access and haul roads, laydown and operational area are grassed therefore there is no air quality monitoring conducted at Avondale Pit Top.

SMP and Catchment Lease Areas

The only activities that WCL have undertaken during this reporting period has been water monitoring which has minimal to no impact to air quality therefore there has been no air quality monitoring conducted in the SMP or catchment.

5.3 Erosion & Sediment

Environmental Management

Wongawilli Colliery Pit Top

The steep gradient from the pit top makes it difficult to manage erosion and sediment. A number of permanent erosion and sediment control measures are in place and they involve the use of a number of settlement structures. These are cleaned out as required.

Options are currently being investigated to address the surface water flow in the Timber Yard and also looking at reshaping the decline drain.

Avondale Pit Top

There are no mining activities at the Avondale Pit Top and all access and haul roads, laydown and operational area have a good covering of grasses therefore there is no erosion issue on site.

SMP and Catchment Lease Areas

As part of SMP monitoring, Wongawilli Colliery conducts regular inspections for impacts above the old longwall extraction areas that may have been affected by mine subsidence. Areas inspected that may experience soil erosion due to mine subsidence are generally restricted to rock outcrops, steep slopes and cliff lines, unpaved roads or tracks, creeks or streams and general soil cracking. These areas are checked regularly as part of the visual inspection monitoring program.

Wollongong Coal have engaged Southern Cross Consulting Services to undertake subsidence monitoring of all monitoring points, FFM, NM1 line, NM2 line, NM3 line, NM4 line, D2000 line and Powerlines in the Catchment Area.

The exploration program REF's address the following potential erosion and sediment risks as applicable to the activity being undertake:

- Disturbance to rock outcrops due to vehicle movements, access track clearance and borehole site preparation;
- Soil disturbance and compaction as a result of vehicle movements;
- Erosion and sedimentation and a result of vegetation clearance along borehole access tracks and borehole site preparation; and

- Alteration or disturbance of water courses due to access track crossings and associated vehicle movements.

The following sediment controls are implemented during drilling activities:

- Drill sites to be as flat as possible;
- Minimise the disturbance footprint at drilling sites;
- Clean water run-off diverted around the drill sites using bunds or catch-drains;
- Directing drilling process water to tanks so that drilling fluids can be removed from site;
- Use of filtration materials such as sediment fence to stop fine silt where necessary; and
- After completion of drilling, rehabilitate the site in accordance with WNSW requirements.

Environmental Performance

<u>Wongawilli Colliery Pit Top</u>

During the reporting period a number of activities were undertaken to improve / maintain erosion and sediment infrastructure on site. An excavator was used to do the required work.

Dissipation Dam: The small basin was desilted (**Figure 5.1**).

Figure 5.1: Dissipation Dam

Decline Dam: This dam at the base of the decline has been cleaned out several time during this reporting period. This is an ongoing activity.

Decline Surcharge Dam: This dam was cleaned out at the same time as the Dissipation Dam. This is an ongoing activity.

Stockpile Area Drain: This drainage line along the stockpile area was cleaned out to reclaim coal that had accumulated within the drain. This is an ongoing activity.

Primary Treatment Settlement Pond: This pond was cleaned out to reclaim coal that had accumulated within the pond. This is an ongoing activity.

Emplacement Erosion Scar: A significant amount of erosion has occurred on the eastern side of the emplacement area over several years. Remediation work was completed with in May 2018 (**Figure 5.2**). **Figure 5.3** shows the area one year after the completion of remediation.

Figure 5.2: Remediation Work May 2018

Figure 5.3: May 2019

Decline Drain: The drain has been maintained during the reporting period (**Figure 5.4**). Loose material is pulled out of the drain and the drain batters are repaired and shaped again.

Figure 5.4: Decline Drain Maintenance

Timber Yard: Up until May 2019 the Timber Yard has been a storage area for underground equipment, hence making it very difficult to get work completed in the yard. Since May the mine is undergoing an equipment/asset retrieval program and some of this material is also currently locate in the Timber Yard. Once it has been decided what equipment is needed for future activities and removed from site the Timber Yard will undergo a clean-up. Once the yard has been tidied up surface water flow will be assessed.

Avondale Pit Top

There are no disturbed areas and as such there have been no issues with erosion and sediment control at Avondale Pit Top.

SMP and Catchment Lease Areas

There has been no soil erosion issues observed in the LW11-20 extraction area and Nebo N1-6 extraction area during the reporting period.

Wollongong Coal engaged Southern Cross Consulting Services to undertake subsidence monitoring of all monitoring points. FFM, NM1 line, NM2 line, NM3 line, NM4 line, D2000 line and Powerlines in the Catchment Area.

5.4 Contaminated and/or Polluted Land

Environmental Management

Wongawilli Colliery Pit Top

An assessment of potential site contamination has been undertaken in the past at Wongawilli Colliery.

Douglas Partners completed the assessment in 2005 and comprised 22 test pit sites at various locations at the Colliery. Results for soil analysis showed that PAH, Pesticides and PCB levels were below HIL threshold levels and that no asbestos was detected. Arsenic, copper and zinc levels exceeded PIL guidelines but were under HIL threshold levels.

Avondale Pit Top

There are no potential contaminating substances stored at the Avondale Pit Top.

SMP and Catchment Lease Areas

The only activities involving materials that could potentially contaminate land are:

- The transport to the No.4 Shaft site of minor quantities of:
    - Diesel (200L) for the backup power generator should the electrical power supply cease working;
    - Cleaning chemicals (20L) for cleaning of ventilation shaft buildings and machinery;
    - Herbicide (20L);
- Diesel in vehicles accessing the ventilation shaft sites; and
- Hydrocarbon leaks from exploration activities.

All hydrocarbon products that were located inside the fan house at Wongawilli 4 Shaft have been removed from site. Herbicide is used to keep vegetation within the compound to a manageable level to reduce fire risk.

The only activities associated with the SMP areas involving materials that could potentially contaminate land are diesel fuel in vehicles accessing the SMP monitoring sites.

The exploration program REF's include management actions for pollution of soils and waterways as a result of oil and fuel spillages from vehicles and machines.

The following general management controls are implemented during drilling activities:

- Provision of spill kits during the drilling campaign;
- Bunding if required;
- Vehicle inspections;
- Environmental Inductions; and
- Site Inductions.

Environmental Performance

Wongawilli Colliery Pit Top

All potential contaminating substances are stored in bunded areas and bunded pallets are also used for storing small quantities. The surface oil storage facility continued to be used as the primary storage area for storing small quantities.

The petrotac bund has been reduced in size and a section of it is still being used to drain oil drums before disposal.

Avondale Pit Top

There has been no activity at the Pit Top nor are there any potentially contaminating substances stored at the site.

SMP and Catchment Lease Areas

The stockpile of contaminated soil at Nebo 3 Shaft was removed in October 2018 and taken to Wongawilli Colliery. In December 2018 both the Nebo 3 site and the Wonga 1 site were backfilled using VENM material.

The remediation of the stockpiled soil is progressing. A species of macrofungi has been observed under the tarp of the covered stockpile. This would indicate that there is sufficient nutrients in the soil to allow fungus spores to grow.

5.5 Threatened Flora

Environmental Management

Wongawilli Colliery Pit Top

Threatened flora is managed in accordance with the approved Biodiversity Management Plan. Ongoing operations in historically disturbed areas of the pit top site have no potential effects on threatened aquatic or terrestrial vegetation as none have been identified close to these areas. Over the entire history of its operation, the majority of the Wongawilli pit top area has been disturbed to some degree or another, resulting in large areas of native vegetation regrowth interspersed with introduced tree and weed species.

For activities that involve potential impacts on vegetation that is not covered by the Biodiversity Management Plan, an REF is undertaken. The outcome of the REF process is that no areas on site that contain endangered aquatic or terrestrial species or communities are disturbed in construction processes.

Wongawilli Colliery undertakes pit top vegetation management in the following manner as required:

- Vegetation risk assessments;
- Removal of dead, dying or dangerous trees;
- Removal of dangerous limbs from trees;
- Removal of regrowth trees that are beginning to pose a risk to machinery, buildings or other operational areas such as pipelines, dams, stockpiles etc;
- Removal of weeds and non-native groundcovers, bushes and trees;
- Approved bushfire management clearing; and
- Removal of vegetation beneath powerlines in accordance with guidelines for safe distances.

<u>Avondale Pit Top</u>

There are no mining activities at the Avondale Pit Top and there has been no vegetation disturbance at the site.

<u>SMP and Catchment Lease Areas</u>

Vegetation clearing around the firebreaks at the shaft sites involves management of regrowth areas only and doesn't impact on threatened species. An REF for approval to conduct ongoing vegetation management around Wongawilli Colliery infrastructure in the Catchment Lease Area remains in place with WaterNSW.

Areas potentially affected by mine subsidence associated with previous mining were assessed for threatened flora and are being monitoring in accordance with SMP and EP approval requirements to determine if there are any impacts from subsidence.

This work was established as part of the baseline studies needed for preparation of the SMPs for the extraction of Elouera LW11-20 and Nebo N1-N6 extraction panels. The ecological monitoring for Elouera LW11-20 extraction panels has ceased and the mining approvals for that project expired on the 31 December 2017.

Environmental Performance

<u>Wongawilli Colliery Pit Top</u>

No impacts on any threatened flora have occurred in the reporting period.

<u>Avondale Pit Top</u>

There has been no activity at the pit top and thus no impacts on threatened vegetation communities.

<u>SMP and Catchment Lease Areas</u>

There has been no impact to any threatened flora species at the ventilation shaft sites.

A combined annual report on the terrestrial and aquatic ecology monitoring program of the land potentially affected by subsidence above the Nebo Area for the 2018/2019 monitoring period is attached in **Appendix A**. Biosis have completed the Nebo LWN1 EoP reports for Nebo LWN1 in **Appendix B**, Nebo N3 & N5 in **Appendix C**.

5.6 Threatened Fauna

Environmental Management

Wongawilli Colliery Pit Top

Threatened fauna is managed in accordance with the approved Biodiversity Management Plan. Ongoing operations in historically disturbed areas of the site have no potential effects on threatened fauna habitat as none have been identified close to these areas.

For any mining / construction activities that may involve potential impacts on habitat a REF is undertaken and construction environmental management plan developed for the activity.

Wongawilli Colliery manages a deer culling program that is currently conducted by members of the Sporting Shooters Association of NSW in close consultation with Wollongong Coal staff. The purpose of the program is to reduce the overall population of deer at the Colliery. WCL record the number, approximate age, sex and species of deer removed in the program these results are displayed in **Table 5.4**.

Wongawilli Colliery will investigate options to increase management activities by engaging other suitably qualified individuals or organisations for deer removal. Records of the number of deer culled off WCL leased land by the local farmers will also be collected.

Table 5.4: Deer Control Program Results (2018 – 2019)

Month/Year	Number of Deer Culled	Species/Sex/Age
July 2018	1	Russa hind x 1 approx 3yrs
August 2018	No attendance	Nil
September 2018	1	Russa hind x 1 approx 3yrs
October 2018	2	Russa hind x 2. 1 x approx. 4yrs & 1 x approx 3yrs
November 2018	6	Spiker x 1yr, stag x 3.5yr, yearly x 1, hind x 3yr, hind x 2yr, stag x 2yr
December 2018	2	1 spiker, hind x 2 yrs
January 2019	No attendance	Nil
February 2019	No attendance	Nil
March 2019	No attendance	Nil
April 2019	No attendance	Nil
May 2019	2	Russa hinds x 2 x 2 years
June 2019	2	Russa hinds. 1 x approx 2.5 years and 1 x approx 3 years old.
Total	**16**	

Avondale Pit Top

There has been no mining activities on site and hence no impact on threatened fauna from mining.

SMP and Catchment Lease Areas

There has been no activity that could impact threatened fauna species at the ventilation shaft sites.

Areas potentially affected by mine subsidence associated with previous mining were assessed for threatened fauna and are being monitoring in accordance with SMP and EP approval requirements to determine if there are any impacts from subsidence. This work

was established as part of the baseline studies needed for preparation of the SMPs for the extraction of Elouera LW11-20 and Nebo N1-N6 extraction panels.

Except for water monitoring, the ecological monitoring for Elouera LW11-20 extraction panels has ceased.

Environmental Performance

Wongawilli Colliery Pit Top

All activities have been assessed for fauna and habitat impacts and have been implemented in accordance with approvals.

SMP and Catchment Lease Areas

There were no observations of dead or injured fauna at the ventilation shaft sites.

A combined annual report on the terrestrial and aquatic ecology monitoring program of the land potentially affected by subsidence above the Nebo Area for the 2018/2019 monitoring period is attached in **Appendix A**. Biosis have completed the Nebo LWN1 EoP reports for Nebo LWN1 in **Appendix B**, Nebo N3 & N5 in **Appendix C**.

A map showing aquatic monitoring points in the Nebo Area is shown on **Figure 5.5**. A map showing terrestrial monitoring points in the Nebo Area is shown on **Figure 5.6**.

5.5: Aquatic Ecology Monitoring

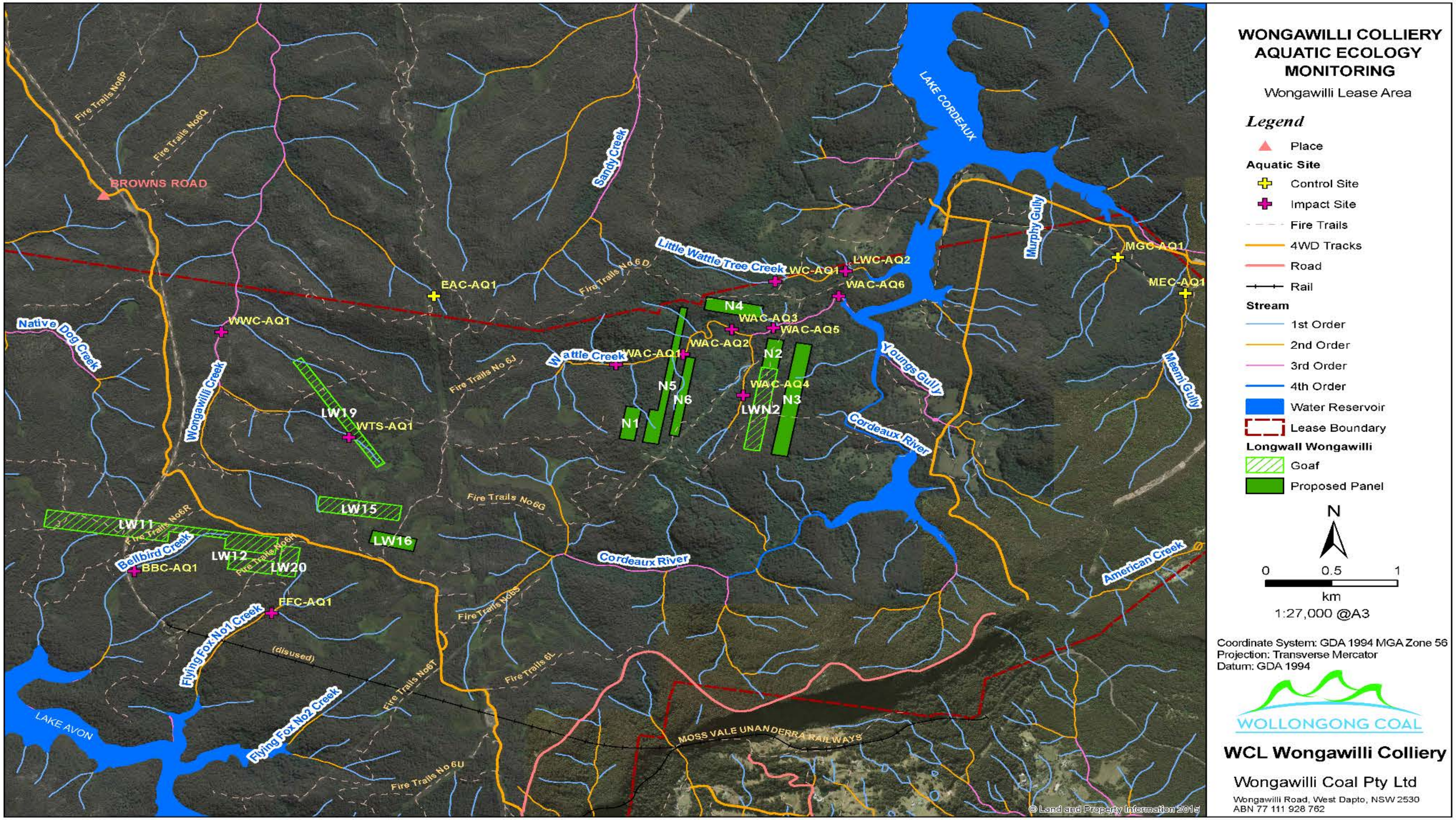
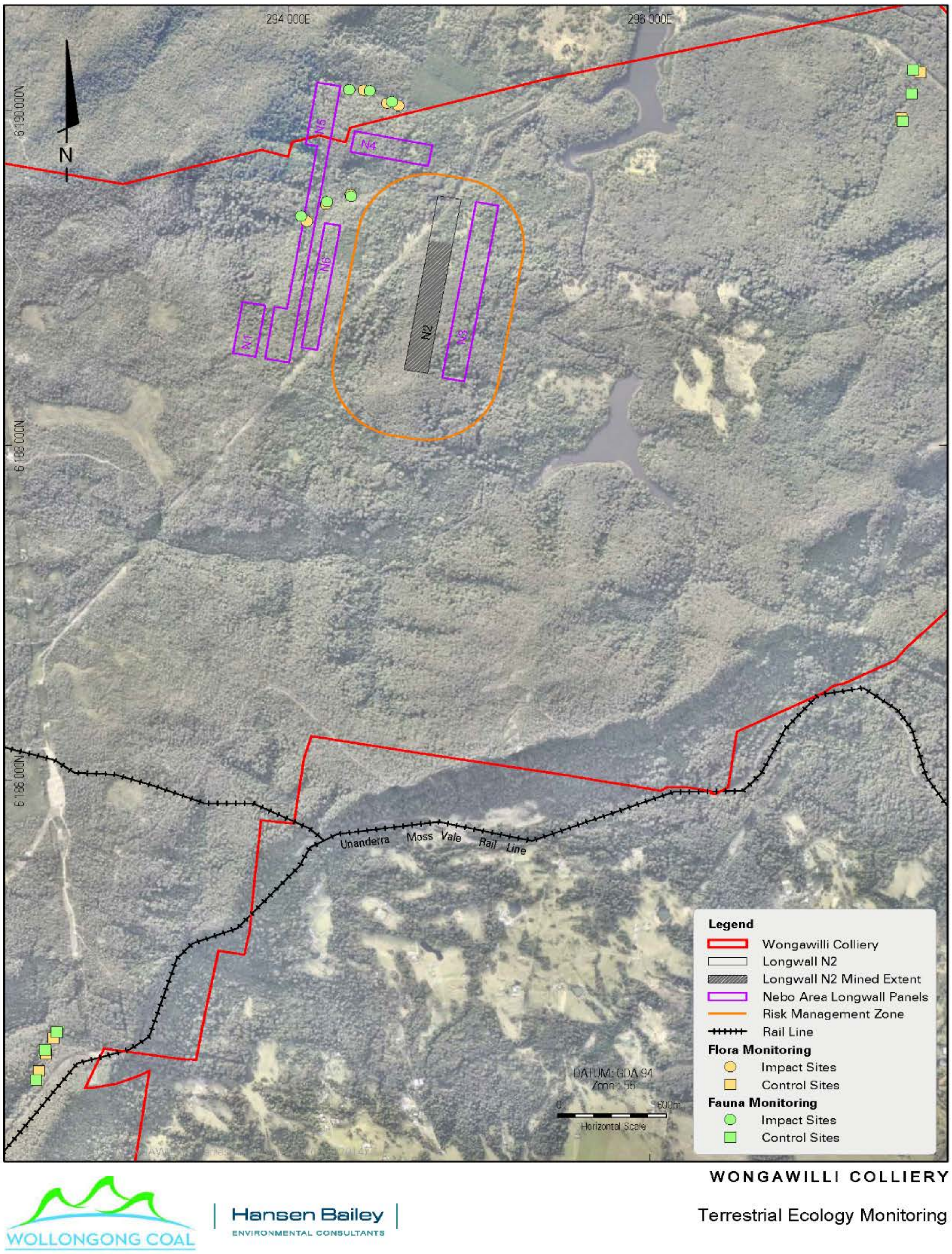


Figure 5.6: Terrestrial Ecology Monitoring



5.7 Weeds

Environmental Management

Wongawilli Colliery Pit Top

Wongawilli Colliery has worked with the Illawarra District Noxious Weeds Authority (**IDWNA**) to manage weeds at its Pit Top and also regular inspections for noxious weeds. During the reporting period WWC conducted its own weed management activities on site. A combination of physical control and spraying was undertaken at the pit top (**Figure 5.7**) and also near the stockpile area (**Figure 5.8**).

Issues were raised about potential snake habitat so the primary aim of the work was to reduce the amount of Crofton Weed encroaching on the road verges and work areas to reduce the safety risk to workers as well as weed reduction around assets and infrastructure.

Avondale Pit Top

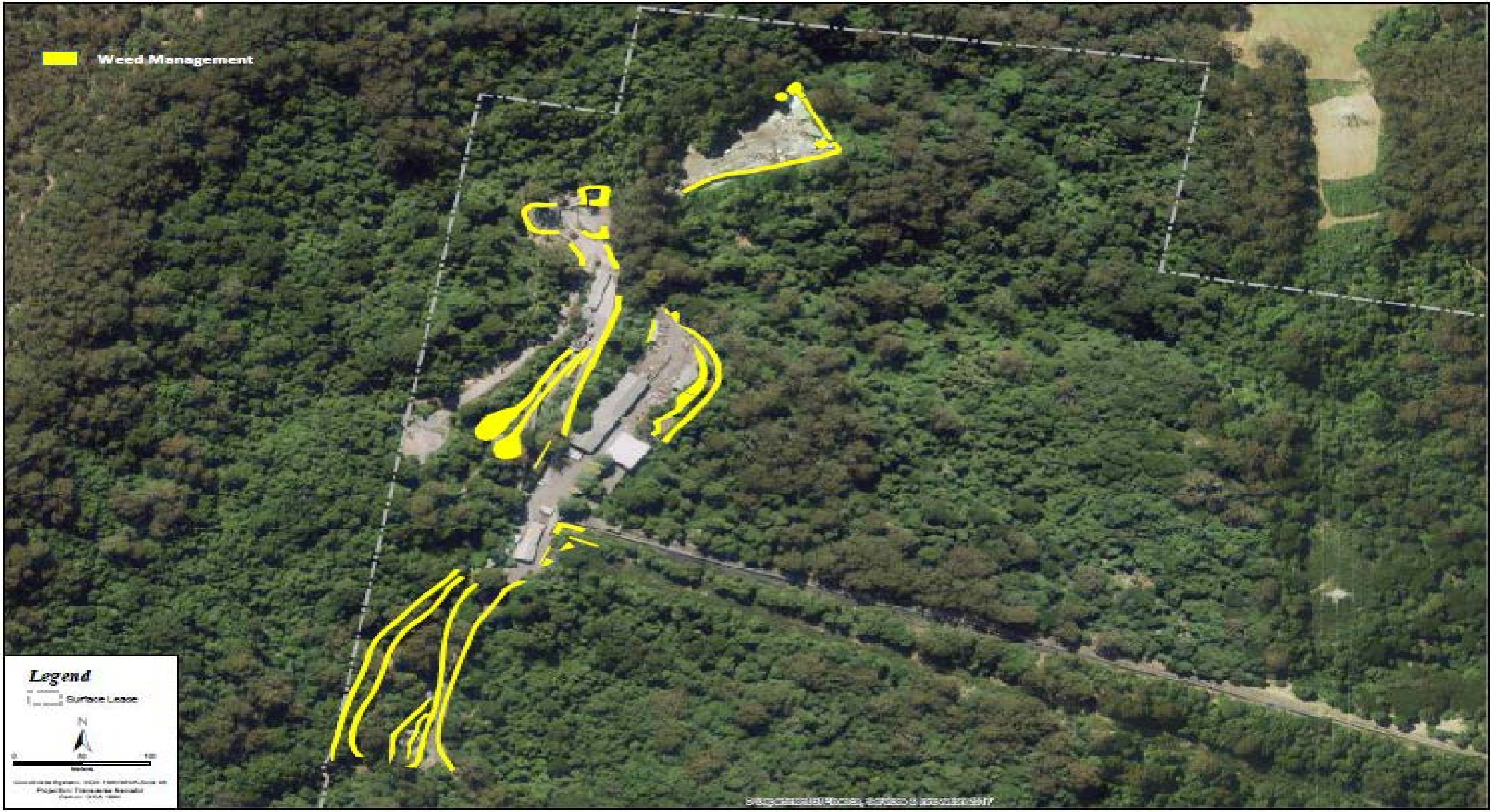
No major weed management activities occurred at Avondale during the reporting period. The areas that were utilised for operational activities in the past are relatively clear whilst the surrounding these areas are infested with Crofton and Lantana. Some minor physical weed removal occurred during site inspections this reporting period.

During one site inspection it was noticed that the haul roads up to the pit top had been slashed. It was found that owners of the property, Huntley Heritage Group had taken investors up to the pit top area to look at the area.

SMP and Catchment Lease Areas

During recent site clean-up work at the Wongawilli No 1 shaft, some time was spent hand pulling Crofton Weed around the site. During a site visit to the Nebo No 3 Shaft a few small Crofton Weed plants were physically removed.

5.7: Pit Top Weed Management



5.8: Stockpile Area Weed Management

5.8 Blasting

Small scale blasting (known as Shot Firing) occurs underground as the need arises. There have been no underground blasting activities undertaken during this reporting period.

5.9 Operational Noise

Environmental Management

Wongawilli Colliery Pit Top

There have been no noise complaints during the reporting period. Noise impacts are managed in accordance with the Noise Management Plan.

Generally, management procedures for noise control include:

- Continuous unattended real time noise monitors with audio capture and real time alerts;
- Operator attended noise monitoring at surrounding sensitive receivers on a quarterly basis;
- A six metre high concrete wall that separates the nearest residences from the coal Stockpile Area. This wall was constructed some years ago and provides both a visual benefit as well as noise attenuation benefits;
- A three metre high, 250 metre long earth bund adjacent to the rail line to the east of Jersey Farm Road. This bund was constructed to provide noise attenuation for local residents from the Jersey Farm Road rail crossing;
- Hours of operation within the Stockpile Area in terms of heavy machinery loading trains is limited to 7am to 6pm Monday to Friday and 8am to 4pm Saturday and no loading on Sundays and Public Holidays;
- Front end loaders and dump trucks operating in the Stockpile Area have exhaust systems that meet manufacturer specifications;
- Truck drivers are directed to drive slowly and have regard for Wongawilli residents' amenity; and
- Regular maintenance of the decline overland conveyor system.

Avondale Pit Top

There have been no noise generating activity at Avondale Pit Top during the reporting period.

SMP and Catchment Lease Areas

Due to the absence of potentially affected receivers in the SMP and catchment areas, noise is not an issue.

Environmental Performance

Wongawilli Colliery Pit Top

Attended noise monitoring is used to determine compliance with the Project Approval noise criteria and will be used to verify data collected from real time noise monitoring. The real time monitoring is used as a noise management tool and can provide 'early warning' information to inform WCL environmental personnel and give WCL the opportunity to review its activities and respond proactively".

The attended noise monitoring is undertaken at the site on Quarterly basis. Attended noise monitoring was undertaken during September 2018, January 2019, March 2019 and June 2019. The compliance monitoring found that the Project is operating within its required noise limits. The results from real time and attended noise monitoring for the period July 2018 to June 2019 are available on WCL website.

SMP and Catchment Lease Areas

Due to the absence of potentially affected receivers in the SMP and catchment areas, noise is not an issue.

5.10 Visual and/or Stray Light

Environmental Management

Wongawilli Colliery Pit Top

The lights from Wongawilli Colliery are visible due to its location on the escarpment. A lighting audit was undertaken for the site and due to the current Care and Maintenance operational status, site lighting is expected to be reduced.

Avondale Pit Top

There is no infrastructure, lighting or power at the Avondale site.

SMP and Catchment Lease Areas

The lights at the ventilation shaft are only turned on when required. Some of the other WCL infrastructure in the catchment do not emit light because they no longer have a power supply and no impact to the community. All mains power will be disconnected to the fan shaft and WWC are currently looking into installing solar lighting for security.

Environmental Performance

Wongawilli Colliery Pit Top

There is no monitoring of stray light or visual impact. The community has not raised the issue of stray light from, or the visual impact of the mine site facilities or mobile equipment as being a matter for concern.

Audit recommendations refer to tilting lights down to below the horizontal plan.

Avondale Pit Top

There is no activity at the site and therefore no monitoring for stray light or visual impact.

SMP and Catchment Lease Areas

There are no sensitive receivers in catchment areas that would be impacted by stray light or visual impact.

5.11 Aboriginal Heritage

Environmental Management

Wongawilli Colliery Pit Top

The Wongawilli Colliery pit top is listed in the Wollongong LEP 2009 and the Wollongong LEP (West Dapto) 2010 as having heritage significance, including Aboriginal heritage. Any construction activities undertaken at the site are subjected to an REF process to determine if there is likely to be any impact on Aboriginal heritage.

The Heritage Management Plan draws on the Heritage Constraints Report completed during the 2010-2011 reporting period. This plan identifies what impacts the listing on the Wollongong LEP 2009 and Wollongong LEP (West Dapto) 2010 will has on current and future activities at the Colliery and contains management plans for the management of heritage related aspects for these activities. Figure 5.9 shows Wongawilli Colliery Heritage Monitoring Locations.

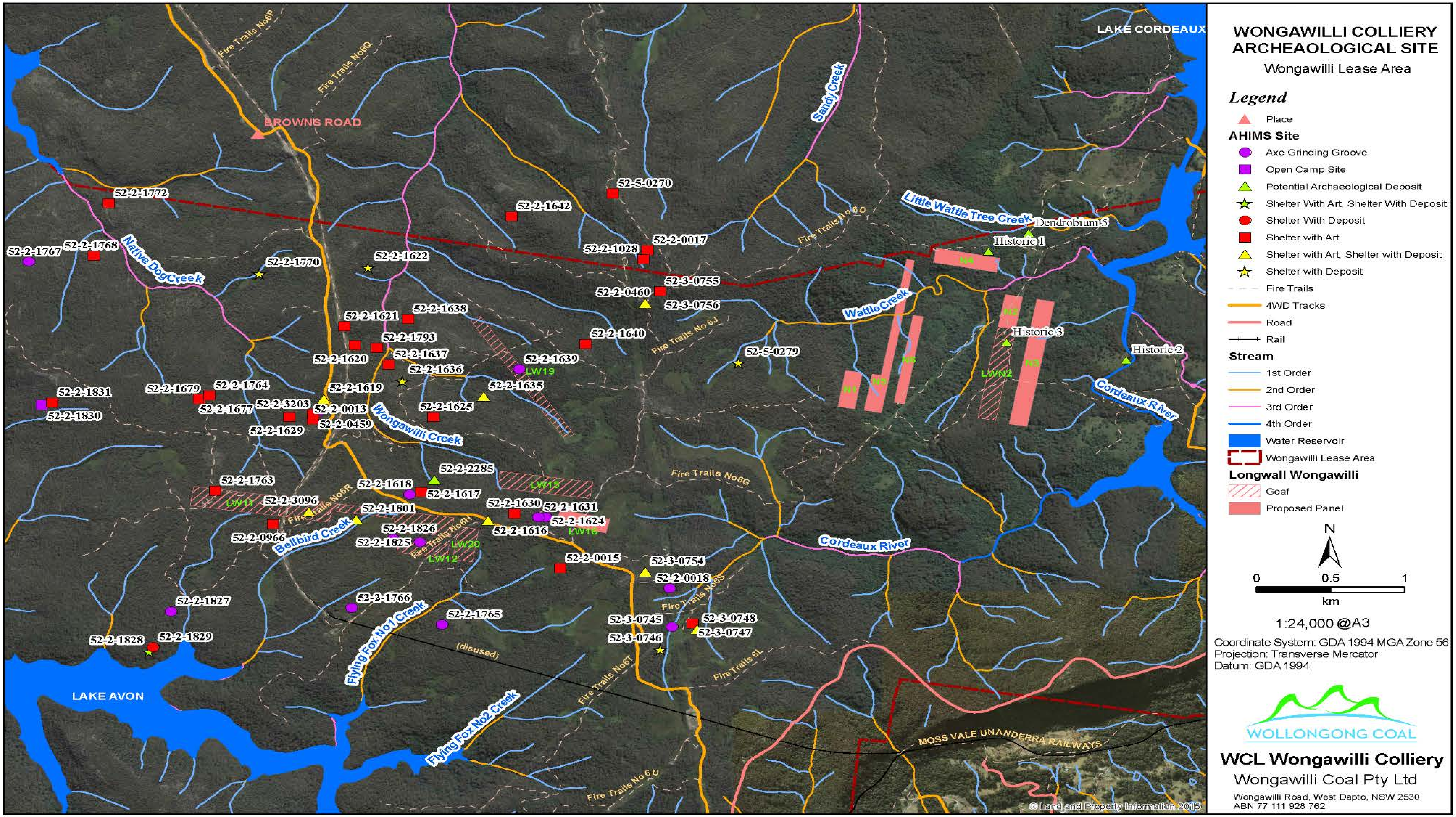
Avondale Pit Top

There has been no activity at the Avondale pit top and hence no impact on Aboriginal Heritage.

SMP and Catchment Lease Areas

Aboriginal heritage monitoring is undertaken in mining and catchment lease areas of Nebo N1-N6 in accordance with SMP and EP approval requirements as shown in **Figure 5.9**.

Figure 5.9: Wongawilli Colliery - Heritage Monitoring



Environmental Performance

Wongawilli Colliery Pit Top

No construction activities have been undertaken and thus there has been no potential disturbance to Aboriginal heritage.

Avondale Pit Top

There has been no activity at the Avondale pit top in this reporting period.

SMP and Catchment Lease Areas

There has been no subsidence impacts observed to the Aboriginal heritage site.

5.12 Spontaneous Combustion

In the past there has been occurrences of low levels of oxidisation of coal, however, there has never been instances of spontaneous combustion events recorded at Wongawilli Colliery.

5.13 Bushfire

Environmental Management

Wongawilli Colliery Pit Top

A Bushfire Management Plan was developed and submitted to DPE for approval as required by the project approval (MP 09_0161).

Physical weed reduction has been undertaken around site infrastructure during the reporting period to help reduce the risk of bushfires affecting the operational areas of the mine surface.

A firefighting water main is also provided on the mine site, which is boosted by a pressure pump, to provide the means to manually fight any bushfire that may threaten the site. The road verges of the Pit Top Access Road is periodically slashed to ensure the emergency evacuation route remains safe. Wongawilli Colliery has a designated fire officer who liaises closely with local RFDS Brigade. Personnel are trained in firefighting and the practical use of fire extinguishers is conducted during site inductions. There is also a large supply of readily available water and firefighting equipment throughout the site.

Avondale Pit Top

There are no mining activity happening on the site that may ignite a fire and no infrastructure that can be impacted by a bushfire.

SMP and Catchment Lease Areas

A firebreak that has been cleared around the site perimeter fence line of the main ventilation shaft site provides an asset protection zone and catchment bushfire protection. Vegetation inside perimeter fences are maintained and kept low.

Environmental Performance

Wongawilli Colliery Pit Top

There has been no monitoring of the effectiveness of the bushfire management activities.

Avondale Pit Top

There has been no monitoring of the effectiveness of the bushfire management activities.

5.14 Mine Subsidence

Environmental Management

SMP and Catchment Lease Areas

Mine subsidence is an important consideration in the ongoing operations at Wongawilli Colliery.

The potential for subsidence impacts on natural and man made features has been assessed for areas which may potentially be affected by mine subsidence and a number of protection and monitoring measures have been implemented in these areas.

Wollongong Coal engaged Southern Cross Consulting Services to undertake subsidence monitoring of all monitoring points, FFM, NM1 line, NM2 line, NM3 line, NM4 line, D2000 line and Powerlines in the Catchment Area.

Elouera Area

Wongawilli Colliery had an approved SMP for extraction of the Elouera LW11-20 extraction panels. The only remaining area to be extracted in this area is N16 extraction panel. Currently, the ecological monitoring for Elouera LW11-20 extraction panels has ceased and the mining approvals for that project expired on the 31 December 2017.

The SMP also included an approved subsidence monitoring and management plan. This plan covered:

Natural Features:

- Declared Special Metropolitan Catchment lands controlled and managed by WNSW;
- Creeks;

- Threatened and protected species; and
- Natural Vegetation.

Man-made features:

- Roads (particularly dirt roads and fire trails);
- Rail cuttings;
- Exploration boreholes; and
- Survey control marks.

Nebo Area

The Colliery has also developed and implemented both Extraction Plan (**EP**) and SMP for the Nebo domain (N2 to N6) as a requirement to receiving extraction approval from DPIE and DRG respectively.

The EP demonstrates the Colliery's management strategies to minimise potential subsidence impacts from the extraction of N2-N6 consistent with government policies and community expectations. The subsidence report prepared by consultants Mine Subsidence Engineering Consultants Pty Ltd (MSEC), for MP 09_0161 contains a full list of all surface and subsurface features that have been considered as part of that Application.

Particular reference is made within this report to those key natural and man-made surface and sub–surface features of specific relevance to the application area. There are no significant rivers, cliff lines or valley infill swamps within the potential subsidence footprint. Impacts to natural and man-made features are not likely.

Natural Features:

- Declared Special Metropolitan Catchment lands controlled and managed by WaterNSW;
- Creeks;
- Threatened and protected species; and
- Natural Vegetation.

Man-made Features:

- Roads (particularly dirt roads and fire trails;
- Electricity transmission lines;
- Exploration boreholes; and
- Survey control marks.

Both Elouera and Nebo areas are not within a declared Mine Subsidence District. Also as the surface lands are in the Metropolitan Special Area controlled by WaterNSW, there are no known development proposals within the application area.

Fire trails/dirt roads, rail cuttings and electricity transmission lines are the only features that have been identified as posing potential risks to people in both areas. Reference is made to those areas that have been predicted to be affected by mining related activities in the approved SMP and Extraction Plan.

Environmental Performance

Wollongong Coal engaged Southern Cross Consulting Services to undertake subsidence monitoring of all monitoring points, FFM, NM1 line, NM2 line, NM3 line, NM4 line, D2000 line and Powerlines in the Catchment Area. End of Panel Subsidence Reports for N1, N3 and N5 were prepared by SCT (**Appendix G & H**).

Subsidence monitoring above the Longwall N2 (SCT2014) confirmed the previously observed bridging capacity of the Cordeaux Crinanite, a dolerite sill intrusion within the overburden sequence over the approved panel geometries in the Nebo area. This bridging capacity limited the magnitude of the maximum subsidence and associated parameters to levels that are imperceptible for all practical purposes about Longwall N2. Although not directly measured, similar overburden behaviour is likely to have occurred above the N1, N3 and N5 Panels.

The maximum subsidence parameters observed above the N1 and N5 panels are:

- Vertical subsidence is approximately 210mm (measured) and 360mm (estimated);
- Tilt is less than 2.4 ± 0.7mm/m; and
- Strains less than 0.9 ± 0.7mm/m.

Based on site inspections and the low levels of ground movement expected, there is considered to be no potential for significant impacts to man-made features such as power lines, access roads and heritage sites, or any natural features including watercourses, cliffs and steep slopes in the vicinity of the N1 and N5 Panels (**Appendix G**).

The maximum subsidence parameters observed above the N3 panel are:

- Vertical subsidence is approximately 150mm;
- Tilt is less than 2 mm/m;
- Strains less than 1mm/m; and
- Horizontal movement of less than 50mm.

Based on site inspections and the low levels of ground movement, there is considered to be no potential for significant impacts to man-made features such as power lines, access roads and heritage sites, or any natural features including watercourses, cliffs and steep slopes in the vicinity of the N3 Panel (**Appendix H**).

The subsidence impacts and consequences from the mining of N1, N3 and N5 Panels were compliant with the subsidence impact performance measures in Project Approval 09_0161

for water resources, watercourses, land, biodiversity, heritage features, built features and public safety.

5.15 Hydrocarbon Contamination

Environmental Management

Wongawilli Colliery Pit Top

All potential contaminating substances are stored in bunded areas to prevent the potential for leakage to contaminate soil or water. There are absorbent materials, booms and other control materials stored in a variety of high activity areas around site to allow rapid response to small and large hydrocarbon spills.

Oil and grease drums are stored within secondary containment. The majority of oils are stored in the surface hydrocarbon storage facility within bunded trays under permanent cover.

Avondale Pit Top

There are no hydrocarbons stored at Avondale Pit Top.

SMP and Catchment Lease Areas

There are small quantities of hydrocarbons (diesel) stored at No.4 Shaft site in the catchment areas. These are stored on a bunded pallet inside the fan shed.

Also vehicles that access the site for purposes such as servicing shafts, for exploration related activities or SMP monitoring contain oil, diesel, petrol and/or other hydrocarbons which could potentially contaminate soil and water.

Environmental Performance

Wongawilli Colliery Pit Top

Hydrocarbon management is under constant review by operational staff.

The following work has been undertaken to improve hydrocarbon management at the site:

- Engagement of Nationwide Oils to remove waste oils and miscellaneous oils that are no longer required.
- Unwanted drums of oil from around the pit top were emptied out and removed as waste oil. There was 9,500lt of waste oil was removed from site this reporting period.
- The old petrotac bund is now being used to drain drums before disposal (**Figure 5.10**).
- The surface hydrocarbon storage area was cleaned out and is maintained in a neat and tidy state (**Figure 5.11**).

5.10: Drum Draining Area

5.11: Surface Oil Storage Facility

Avondale Pit Top

There are no hydrocarbons at Avondale Colliery.

SMP and Catchment Lease Areas

Environmental workplace inspections are conducted on WWC infrastructure in the catchment and hydrocarbon management on these sites are part of site compliance.

5.16 Energy, Greenhouse Gases, Methane Drainage & Ventilation

Ventilation via the fan at No.4 Shaft provides the methane drainage mechanism for the mine. There has been no change to this facility or the management of ventilation during the period.

A Ventilation Control Plan is in use at Wongawilli Colliery. The Ventilation Control Plan has the prime objectives of ensuring critical safety risks posed by gas emissions and other hazards related to ventilation at Wongawilli Colliery can be effectively controlled.

Associated management positions and accountabilities are contained in the Plan with resources allocated to ensure such Plan is current and fully implemented.

The highest desorbable gas content recorded for the Wongawilli Coal Seam, from exploration samples is approximately 12m^3/tonne (at 20°C, 101.3kpa). The gas is generally composed of 70% Methane and 30% Carbon Dioxide. The monitoring of gas and triggers for actions are detailed in the mine's Ventilation Control Plan.

In current mining areas, based upon typically low gas content information from exploration boreholes, of approximately 2 - 4m^3/tonne, methane drainage is not currently considered warranted. There has been no change to this facility or the management of ventilation during the period.

5.17 Public Safety

Environmental Management

Wongawilli Colliery Pit Top

Wongawilli Colliery pit top sites have established perimeter fencing with entry gates that are locked during periods of non-operation to secure the sites against unauthorised access and the consequential risk to public safety.

Surveillance cameras are installed around site that covers the main operational areas and infrastructure at the mine. The footage from the cameras is streamed directly to the Colliery Control Room.

Signage is in place that identifies:

- Mine site entry gates;
- The type and nature of chemicals stored or used;
- The voltage level of electrical equipment within protected enclosures;
- Personal protective equipment requirements;
- Authorised access areas; and
- Contents of pipelines e.g.: gases, water compressed air etc.

Avondale Pit Top

The site is maintained in a safe and stable condition, with existing portals secured to prevent unauthorised access.

SMP and Catchment Lease Areas

The plateau land above the underground workings is primarily natural bushland environment with access restricted to authorised persons only. The land is covered by the Metropolitan Special Area, a WaterNSW Catchment Schedule 1 Area. Mining activities on the plateau have negligible implications for public safety over the present and proposed underground workings or in the areas where mine infrastructure is established.

Access into the WaterNSW Catchment Area is via locked gates. Areas on catchment land and on the mine site that have individual security and controlled access include:

- Fan sites;
- Hazardous materials storage compounds;
- Compressed gases storage compounds;
- Rooms, compounds and enclosures containing electrical equipment;
- All electricity substations; and
- Gates accessing the Catchment area.

Monitoring of public safety issues in relation to mine subsidence is as follows:

- Regular visual inspection of cliffs and steep slopes, fire roads, 4WD tracks, rocky outcrops and cuttings during extraction; and
- Regular visual inspection of cliffs and steep slopes, fire roads, 4WD tracks, rocky outcrops and cuttings for six months following the completion of extraction of the longwalls (which is now Pillar Extraction).

Environmental Performance

Wongawilli Colliery Pit Top

There have been no observed public safety incidents during the reporting period. Security guards ensure unauthorised access is kept to a minimum.

Avondale Pit Top

There have been no observed public safety incidents during the reporting period at Avondale Pit Top.

SMP and Catchment Lease Areas

There have been no observed public safety incidents during the 2018-2019 reporting period.

6 WATER MANAGEMENT

Wongawilli Colliery have had a number of licensed discharge points under Section 55 of the *Protection of the Environment Operations Act 1997*. They are:

- LDP1 – Secondary Stabilisation Lagoon (bathhouse water);
- LDP2 – Underground mine water discharge from Wongawilli Colliery;
- LDP3 – Underflow from Filter Lagoon;
- LDP4 – Overflow from the stockpile sand Filter Lagoon; and
- LDP7 – Underground mine water discharge at N6 Forest 11 entry (Eastern Portal).
- LDP8 – N7 Forest 11 entry (Western Portal)

Refer to **Figure 2.4** and **Figure 2.5** show these discharge points. The monitoring results for these points are available on WCL website.

6.1 Water Supply and Use

There are two separate supplies of water for Wongawilli Colliery, being potable water and groundwater. The town water supply feeds into the surface water tanks and is supplied for office and bathhouse facilities.

All water that is used for underground mining operations is recycled within the underground environment. Mine de-watering is undertaken as required to ensure access and ventilation is maintained. Discharge water is via LDP2 which is located near the Timber Yard laydown area.

The mine water is moderately alkaline and the dissolved solids content is predominantly in the form of sodium bicarbonate. This is characteristic of the groundwater quality in the underground mines in the Illawarra. Wongawilli Colliery mine water quality is not expected to vary significantly because the water quality is primarily determined by the hydrogeology of the region rather than the activities of the mine.

6.2 Surface Water Management

Environmental Management

Wongawilli Colliery Pit Top

Surface water is managed in accordance with the approved Surface Water Management Plan. A system of cut-off drains are established up-slope (west) of the mine site facilities to capture stormwater run-off from the escarpment and divert it away from the operational areas of the mine site and into local watercourses. The clean water drains on the site are generally open channels that are grassed or concrete lined. The system carries the water from the mine site to discharge through areas of bushland and via unnamed watercourses into tributaries of Robins Creek.

Dirty water drainage systems are provided on the mine site where the potential exists for run-off water to be contaminated by surface operations. Operations that normally contribute to contaminated water run-off include coal handling and stockpiling, rail loading, workshops, store yard areas and associated operational roads etc. The drainage systems have been constructed to minimise erosional impacts. The control measures in place include grass or concrete lining of open drains and concrete sub-surface pipes and pits.

The dirty water drainage system at Wongawilli Colliery includes a number of settling ponds and sumps to capture sediment and provide retention of dirty water to allow soil particles to settle as the dirty water moves through the system. Each pond or sump is provided with access for the removal of silt by mobile equipment. The sumps are located toward the bottom of the decline corridor, at the foot of the decline east of the elevator building, adjacent to the coal storage bins and southeast of the ROM coal stockpile.

Cleaning of these ponds and sumps is undertaken as required to maintain the efficiency of the water treatment facilities.

Runoff from the conveyor decline flows down the slope in an open unlined channel and into a large settling and sediment retention basin located near the bottom of the decline slope. This water then flows into further settling basins located on the north-western end of the stockpile area.

Dirty water runoff from the stockpile area and the settling basin on the north-western end of the stockpile enters two filter fabric lined gabion wall sediment ponds in series and a sand bed Filter Lagoon. Overflow from the lagoon may enter Robins Creek via LDP4 in accordance with EPL 1087 licence conditions.

Once the water level in this lagoon is greater than 30% it is transferred to the Retention Dam in the emplacement area where further settling can occur. Water from the Retention dam may then be used for spray irrigation and/or dust suppression or may discharge via Pond A weir.

An estimate of the volume of dirty water stored on site at the end of the reporting period is provided in Table 6.1.

Table 6.1: Wongawilli Colliery Stored Water

	Volumes Held (ML)		
	Start of Reporting Period	At End of Reporting Period	Storage Capacity
Water Storage			
Secondary Sediment Pond	1.2	0.5	1.2
Filter Lagoon	0.1	0.0	5.8
Pond C	0.4	1.5	2.2
Retention Dam	20	20.5	29.2
Pond A	3.2	2.5	3.2
Mine Dam	3.1	2.0	3.1
Primary Stabilisation Lagoon	0.2	0.0	3.2
Secondary Stabilisation Lagoon	0	0	3.4

Note: Storages that make up a relatively small contribution to onsite stored water volumes of less than 1 ML have not been included. This includes the Decline Dam, Surcharge Dam, Rail Sedimentation Pond and Primary Sediment Pond.

Avondale Pit Top

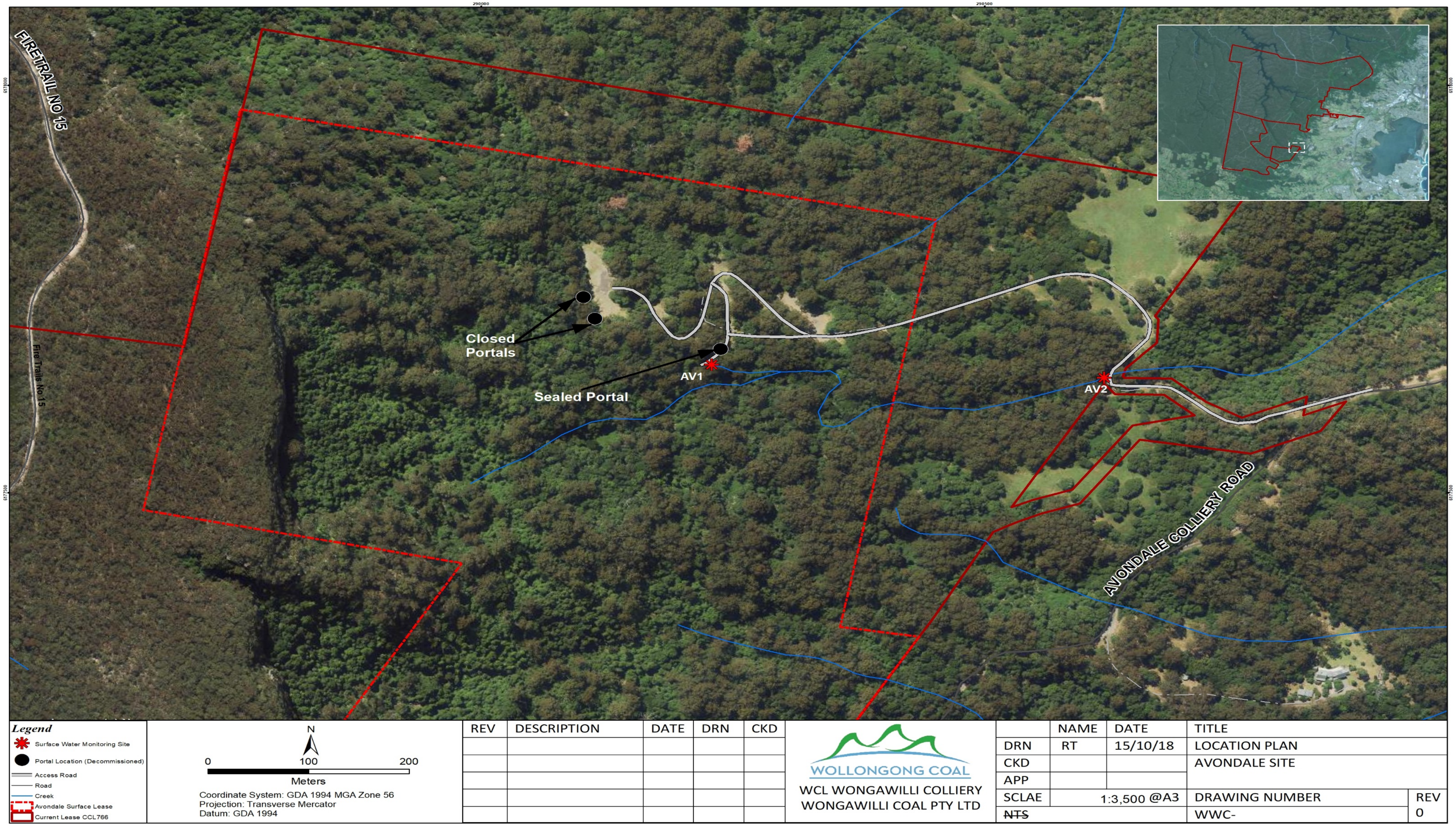
There is one licensed discharge point, LDP1, identified in EPL 12442. There is no requirement in the licence to monitor this discharge point. During a site inspection visit, mine water was seen discharging from LDP1 and while there is no requirement to monitor water from this point, WCL has recommenced water monitoring at two locations on site and if water is being discharged from the mine water samples are taken. Figure 6.1 shows the location of these monitoring sites, and when results are received they are uploaded on the WCL website.

SMP and Catchment Lease Areas

Surface water quality monitoring is undertaken in the LW11-20 extraction area and Nebo N1-6 extraction area on a regular basis and in accordance with SMP and EP approval requirements to determine the impacts on surface water quality from previous mining. Baseline surface water quality monitoring is also undertaken in the proposed future Wonga South extraction area.

Geoterra Ground and Surface water EoP reports for the N1, N3 & N5 panels are attached as **Appendices F, G and H**.

Figure 6.1: Water Monitoring Map (Avondale)



Environmental Management

Wongawilli Colliery Pit Top

Under EPL 1089 surface water is analysed at LDP1 and LDP7 only when water is being discharged. There has been no discharge from LDP1 or LDP7 during this period. Some housekeeping measures here include regular visual inspections of ponds, sumps, dams and dirty water transfer systems and regular services of pumps.

Mine water discharge via LDP2 in the reporting year is summarised in **Table 6.2.** Under EPL 1087, surface water is analysed at LDP2 and monitoring is required for pH, total suspended solids and Oil and Grease, which is summarised in **Table 6.3**.

Table 6.2: LDP2 Discharge Volumes (2018-2019)

Month	Total Amount Discharged (ML)	Daily Discharged (ML)
July 2018	84,358	2.72
August 2018	56,574	1.82
September 2018	23,612	0.787
October 2018	20,178	0.650
November 2018	23,008	0.766
December 2018	19,308	0.622
January 2019	7.7	0.247
February 2019	7.9	0.281
March 2019	3.5	0.112
April 2019	0.11	0.003
May 2019	804	0.025
June 2019	0	0
Yearly Total	**227,861**	**0.669**

Table 6.3: LDP2 Water Quality Monitoring Results (2018-2019)

Month	Pollutant	Result
July 2018	Oil and Grease(mg/L)	<5
	pH	7.4
	Total Suspended Solids(mg/L)	<5
August 2018	Oil and Grease(mg/L)	<5
	pH	7.3
	Total Suspended Solids(mg/L)	89*
September 2018	Oil and Grease(mg/L)	<5
	pH	8.45
	Total Suspended Solids(mg/L)	12
October 2018	Oil and Grease(mg/L)	<5
	pH	7.4
	Total Suspended Solids(mg/L)	9
November 2018	Oil and Grease(mg/L)	<5
	pH	7.4
	Total Suspended Solids(mg/L)	<5
December 2018	Oil and Grease(mg/L)	<5
	pH	7.5
	Total Suspended Solids(mg/L)	<5
January 2019	Oil and Grease(mg/L)	<5
	pH	7.9

Month	Pollutant	Result
	Total Suspended Solids(mg/L)	8
February 2019	Oil and Grease(mg/L)	<5
	pH	7.7
	Total Suspended Solids(mg/L)	27
March 2019	Oil and Grease(mg/L)	<5
	pH	7.6
	Total Suspended Solids(mg/L)	29
April 2019	Oil and Grease(mg/L)	**
	pH	**
	Total Suspended Solids(mg/L)	**
May 2019	Oil and Grease(mg/L)	**
	pH	**
	Total Suspended Solids(mg/L)	**
June 2019	Oil and Grease(mg/L)	**
	pH	**
	Total Suspended Solids(mg/L)	**

***TSS result higher than the EPL 100 Percentile Concentration limits. No visual analysis of the sample was completed, however, the lab analysis of the sample taken at the point where the discharge leaves site (mine dam) was recorded as 12mg/L.*
***** *Unable to sample as the site was dry. Due to the mine not operating since March 2019, mine-water discharge has been very low to nil.*

There was one non-compliances result identified at Wongawilli Colliery at the LDP2 sampling point during the reporting period. Refer to * comment above. This will be reported in the EPA Annual Return.

Avondale Pit Top

There have been no surface water pollution incidents at Avondale Pit top during the reporting period.

SMP and Catchment Lease Areas

There has been no identified impacts on surface water quality due to mining activities during the reporting period. The extraction of the N1 panel was completed during September 2018 and mining in the N3 panel was completed in March 2019.

6.3 Groundwater Management

Environmental Management

Wongawilli Colliery Pit Top

Groundwater is managed in accordance with the approved Surface Water Management Plan. Groundwater is collected in pits and sumps underground and is used in mining activities as much as possible. The primary use of captured groundwater is dust suppression at the operating coal face or on transport roadways and conveyor systems.

Groundwater inflow to the mine creates issues for the coal face operations during mining and causes mine roadway deterioration. Added to this, are the problems arising from over-wetted coal being transported by conveyor systems through the mine to the surface stockpile/coal bins.

The groundwater inflow to the mine is approximately 50 to 60 L/second during normal conditions with increases to approximately 120 L/second during prolonged periods of substantial regional rainfall. Mine de-watering can occur at an average rate of approximately 4.2 ML/day during normal mining operations.

Groundwater that is discharged from the mine is pumped to the surface and flows into the Mine Dam via LDP2. During the 2018 – 2019 reporting period the daily average amount of water that was dewatered from the mine through LDP2 was 0.67ML.

Some of the water from the Mine Dam is used for dust suppression in the stockpile area and overflow from the Mine Dam discharges to Robins Creek. LDP7 is another point from which excess groundwater may be discharged. This is only used in times of very high flow. No water was discharged through LDP7 during the reporting period. An inspection of LDP7 was conducted in October 2018 and no water has been discharging from this location. Groundwater will continue to be managed in this manner during the next reporting period.

Avondale Pit Top

During a site visit, mine water was seen discharging from a pipe that comes from the underground mine. While there is no requirement in the licence to monitor this discharge point, WCL has commenced water monitoring at two points on site. One is at the discharge point and one is further down the creek where it was indicated by a former Avondale staff member that is was once sampled at this spot.

SMP and Catchment Lease Areas

Ground Water monitoring is undertaken in SMP and catchment lease areas of Wongawilli Colliery on a regular basis and in accordance with SMP and EP approval requirements.

Environmental Performance

Wongawilli Colliery Pit Top

There has been no monitoring of groundwater impacts at Wongawilli Colliery Pit Top during the reporting period.

Avondale Pit Top

There has been no monitoring of groundwater impacts at Avondale Pit Top during the reporting period.

SMP and Catchment Lease Areas

Monitoring of groundwater within SMP area has identified no impacts as result of mining activities in the reporting period.

6.4 Sewage Treatment / Disposal

Greywater from sinks and showers on the upper pit top flows through a PVC pipe down the decline to the Primary Stabilisation Lagoon which when full flows into the Secondary Stabilisation Lagoon. Allowance has been made in EPL 1087 for discharge from the Secondary Stabilisation Lagoons which is via LDP1. There has been no discharge from LDP1 during the reporting period.

Blackwater from toilets and urinals on the upper pit top is directed to three septic tanks which are regularly pumped out by licensed contractors. Port-a-loos from the underground workings are routinely serviced by a licensed contractor for disposal at an approved facility.

The contractor's area toilet, located adjacent to the main access road close to the site entrance, has an in-ground concrete septic pit and an absorption trench system. This is pumped out as required by a licensed contractor for disposal at an approved facility.

7 REHABILITATION

7.1 Buildings

There have been no buildings demolished or rehabilitated during the period.

7.2 Rehabilitation of Disturbed Land

There has been no rehabilitation activity undertaken during the reporting period at Wongawilli Colliery. The summary and current status of disturbed areas and proposed rehabilitation is detailed in **Table 7.1** and **Table 7.2**.

Table 7.1: Rehabilitation Summary

	Cumulative Area Affected (hectares)		
	To date	Last report	Next Report (estimated)
A: Mine Lease Area			
A1 Mine Lease (s) Area	14,767ha	14,767ha	14,767ha
B: Disturbed Areas			
B1 Infrastructure area (other disturbed areas to be rehabilitated at closure including facilities, roads)	36.85ha	36.85ha	36.85ha
B2 Active Mining Area (excluding items B3 – B5 below)	0	0	0
B3 Waste emplacements, (active/unshaped/in or out-of-pit)	0	0	0
B4 Tailings emplacements,(active/unshaped/uncapped)	0	0	0
B5 Shaped waste emplacement (awaits final vegetation).	0	0	0
All Disturbed Areas	36.85ha	36.85ha	36.85ha
C: Rehabilitation Progress			
C1 Total Rehabilitated area (except for maintenance).	14ha	14ha	14ha
D: Rehabilitation On Slopes			

D1 10 to 18 degrees	0	0	0
D2 Greater than 18 degrees	0	0	0
E: Surface Of Rehabilitated Land			
E1 Pasture and grasses	0	0	0
E2 Native forest/ecosystems	14	14	14
E3 Plantation and crops	0	0	0
E4 Other (include non-vegetative outcomes)	0	0	0

Table 7.2: Maintenance Activities on Rehabilitated Land

Nature Of Treatment	Area Treated (Ha)		Comment/Control Strategies/ Treatment Detail
	Report Period	Next Period	
Additional erosion control works (drains re-contouring, rock protection)	0	0	See Section 5.3
Re-covering (detail – further topsoil, subsoil sealing etc)	0	0	See Section 5.3
Soil treatment (detail – fertilizer, lime, gypsum etc)	0	0	N/A
Treatment/Management (detail – grazing, cropping, slashing etc)	0	0	N/A
Adversely Affected by Weeds (detail – type and treatment)	See Section 5.6	See Section 5.6	See Section 5.7
Feral animal control (detail – additional fencing, trapping, baiting etc)	32.6ha	32.6ha	See Table 5.4 Section 5

In the past, rehabilitation completed within Wongawilli lease holdings has been limited to areas at both the Avondale Colliery Pit Top and Nebo Pit Top.

14ha located at the Avondale Colliery was rehabilitated by Huntley Heritage as previous operators of the Avondale Colliery.

7.3 Other Infrastructure

There was no rehabilitation of other infrastructure undertaken during the reporting period.

The only infrastructure remaining at the Avondale Colliery is two portals, an access track and associated gates and fencing. There are no current plans to utilise the Avondale Colliery as an active area.

Currently, the remaining portals are fenced off to restrict access by unauthorised persons into the old workings. The remaining portals may be utilised in the future to provide ventilation to new workings. The access track will be maintained to achieve access to the remaining portals and fencing and gates will remain for security purposes.

7.4 Rehabilitation Trials & Research

There have been no rehabilitation trials or research undertaken during the period.

7.5 Final Rehabilitation Plan

An assessment of rehabilitation issues has previously been undertaken as part of the Major Development application MP 09-0161.

Pursuant to Condition 3 of ML1596, Condition 2 of ML1565 and Condition 2 of CCL766, the Mining Operation Plan (MOP) was prepared and submitted on 27 July 2017. The MOP is approved until 31 December 2020.

8 COMMUNITY RELATIONS

8.1 Complaints Procedure

All complaints received are recorded and documented in accordance with the EPL conditions.

8.2 Environmental Complaints

All environmental complaints are summarised in the **Table 8.1**. The complaints register is publicly available on the WCL website.

Table 8.1: Environmental Complaints Summary

Date	Complainant	Nature of Complaint	Investigation/Action Taken/Follow - up
September 2018	CCC member	Phone to regulators regarding WCL website missing information.	Issue was raised in a CCC meeting. Monitoring report had an incorrect date and train movements for 2017 were not displayed.
February 2019	Resident	Email was sent to WWC regarding a strong vibration being felt inside their house	Due to the large amount of wet coal being loaded out from the underground bins the Sytron was in wet coal mode continuously to prevent any slumps from occurring. This is part of normal operations if wet coal is present. Inspection was organised to inspect and adjust vibrator and check if Syntron was still in range.
February 2019	Resident	Safety concern raised about a machine parked on the side of the road	While this machine was parked on private property WWC moved the machine back to the pit top workshop.

8.3 Community Consultation

WCL has established a Community Consultative Committee (CCC) in accordance with the requirements of the Condition 5 of Schedule 6 of the Approved Project (MP09_0161) which has the following objectives:

- To develop this CCC with its community;
- To outline what is planned for WCL and its mine sites; and
- To share information with the CCC to date.

Four CCC meetings were held during the reporting period on 5 September 2018, 5 December 2018, 6 March 2019 and 5 June 2019. There were two new members added to the CCC. The key outcomes of the meetings are included into meeting minutes. The CCC meeting minutes are publicly available on the WCL website.

8.4 Agency Consultation

Consultation with key NSW State Government agencies in relation to Wongawilli Colliery will continue as required.

Generally, WCL's consultation is undertaken to ensure that all aspects of the proposed project are conveyed and any issues identified are addressed. Mitigation, monitoring and management measures can also be discussed and included in detail within the respective plans of management and Trigger Action Response Plans (TARPs) accordingly.

9 INDEPENDENT AUDIT

In accordance with the Wongawilli Colliery Project Approval, an Independent Environmental Audit (**IEA**) is also required to be conducted every 3 years in accordance with the NSW Government Independent Audit Guideline (NSW Government, 2015).

Wolfpeak Pty Ltd have been engaged to conduct the next Independent Environmental Monitoring Audit for the period 1 July 2016 and 30 June 2019.

10 INCIDENTS AND NON-COMPLIANCES

The reportable incidents and non-compliances identified with the Project Approval and other relevant environmental approvals and licences are detailed in Sections 10.1 and 10.2.

10.1 Incidents

There were no reportable incidents for the 2018-2019 reporting period.

10.2 Non-compliances

The non-compliances identified with the Project Approval and other relevant environmental approvals and licences during the reporting period are detailed below in **Table 10.1**, **Table 10.2** and **Table 10.3**.

Table 10.1: Non Compliances with Project Approval (09_161)

Condition	Non-Compliance	Risk Level
Schedule 2, Condition 1	Rubbish and loose material that has accumulated behind the perimeter bund in the Timber Yard has yet to be addressed.	**Medium**
Schedule 2, Condition 1	Surface water management in the Timber Yard has yet to be addressed.	**Medium**

Table 10.2: Non Compliances with EPL 1087

Condition	Non-Compliance	Risk Level
O1.1 (b)	Rubbish and loose material that has accumulated behind the perimeter bund in the Timber Yard has yet to be addressed.	**Medium**
L1.1	Surface water management in the Timber Yard has yet to be addressed. Repairs were undertaken with a backhoe to repair the breached bund identified in past inspections.	**Medium**
E1.1 (1)	Develop an Environmental Management Plan that describes how environmental risks related to the operation of the land farm will be managed.	**Low**
U1 (2) Medium Term)	The licensee must provide written reports to EPA describing inspections and maintenance activities in the previous 6 months on 30 June 2018, 30 December 2018.	**Low**

Table 10.3: Non Compliances with EPL 12442

Lease	Non-Compliance	Risk Level
Avondale	Nil	

11 ACTIVITES PROPOSED IN THE NEXT REPORTING PERIOD

11.1 Activities Proposed

Activities proposed during the next reporting period are outlined in **Table 11.1**.

Table 11.1: Activities Proposed during the next Reporting Period

Activity	Details	Proposed Timing
Management Plans Review	Review of existing approved management plans	Within the 3 months after AEMR submission.
Waste management	Removal of a large amount of scrap steel from site	During Q4 2019 through to Q1 2020.
Relocation of mining equipment	Remove mining equipment from site and relocate to Russell Vale Colliery.	During Q3 2019 through to Q1 2020.
Pit Top clean up	Clean up all surface areas of WWC	During Q4 2019 through to Q1 2020.
Decline erosion gully	Erosion issues with decline drain. Looking into options to reduce impacts on the upper levels of the decline	Q4 2019 through to Q1 2020
Timber Yard batter repairs.	Excess coal reject material and rubbish accumulating behind the bund.	Q4 2019 through to Q1 2020
Independent Environmental Audit	Source suitable auditor and conduct environmental audit which covers 2016-2019 period.	Q3-Q4 2019
Management of old mine portals	Commence program of sealing access to old mining portals.	Start during Q4 2019.

12 REFERENCES

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13 CONTROL AND REVISION HISTORY

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Appendix A – Combined Terrestrial & Aquatic Ecology Report

Nebo ecological monitoring program: Combined annual report for 2018

FINAL REPORT

Prepared for Wollongong Coal Ltd

18 October 2019

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- Paul Price, Bianca Klein, Byron Dale, James Lidsey, Kayla Asplet and Adam Baus (assistance in the field)
- Heather Lee-Kiorgaard, Adam Baus and James Lidsey (data analysis)
- Anne Murray (mapping)

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Summary

This document reports on the terrestrial flora and fauna-monitoring program, and aquatic ecological monitoring program for the Nebo Area during the 2018 monitoring period. This annual report incorporates data collected between spring 2010 to autumn 2019.

Baseline monitoring of impact sites within the Nebo Area commenced in spring 2010 and monitoring at paired control sites commenced as early as autumn 2011. Following the completion of Longwall N2 in February 2014, Wongawilli Coal discontinued mining in the Nebo Area. Subsequently, all related terrestrial ecological monitoring ceased, on the condition from the regulator that baseline monitoring was to restart six months prior to the recommencement of mining. In addition, data analysis should not show a significant change in condition over the intervening period. Baseline monitoring within the Nebo Area recommenced in spring 2015, ahead of the proposed extraction of Longwall N4, which commenced in August 2016. Data collected and presented herein represents the findings of the monitoring undertaken in 2018, which is compared to previous years of monitoring and represent post/during mining findings at impact sites.

Baseline data collected and analysed indicates that all Nebo vegetation sites have a small, but statistically significant, increasing trend in total species richness (TSR). When compared to their paired control sites TSR at impact sites is higher, however this is a continuation of a pre-mining trend that must be taken into consideration when analysing data following mining. Vegetation species composition within all sites was found to be changing over time, and is most likely due to natural fluctuations, given no statistically significant effect from mining treatment was identified. Creek-inhabiting frog data continues to be highly variable with a low number of species recorded, in line with previous years of monitoring.

The findings of the aquatic ecological monitoring program identified a variable but generally high level of taxonomic diversity with the aquatic ecological communities occurring within the Nebo Area, across all creeks surveyed. Water quality among impact sites ranged between poor and fair across the 2018 monitoring period, demonstrating broad consistency with previous monitoring results. Minor variations observed in the data are attributed to environmental variability at the time of sampling, not underground coal mining, given the results are within the range of results previously recorded for the sites. Further, no leachate or changes in flow regime were observed during the monitoring period at any of the sites.

The trends identified in 2018, and in previous iterations of the terrestrial and aquatic ecological monitoring programs are consistent with those observed during the recommencement of mining in the Nebo Area.

1 Introduction

1.1 Nebo area

The mining domain of the Nebo Area is located within the Metropolitan Special Area and Southern Coalfield of New South Wales (Appendix 1). On 16 July 2009 Wongawilli Coal (previously Gujurat NRE – Wonga Pty Ltd) received Project Approval from the *NSW Department of Planning and Infrastructure* under Part 3A of the *Environmental Planning and Assessment Act 1979* (EP&A Act) to extract coal from the Wongawilli seam (MP09_0161). A variation to include mining of Longwalls N1 to N6 within Nebo Colliery (hereafter referred to as the Nebo Area) was approved on 2 November 2011. An Extraction Plan was developed to satisfy the requirements of Schedule 3, Condition 7 (h) and (i) of the Project Approval. This plan, includes a Subsidence Management Plan (SMP) required by the Division of Resources and Energy (DRE), NSW Trade & Investment that addresses Schedule 3 Condition 7 (e) and (f) of the project approval for the ecological monitoring programs.

The Nebo Area includes natural features located above Longwalls N1 through to N6 (Appendix 1). The mine complex at Nebo includes longwalls (N1, N2, N3, N4, N5 and N6) that are situated beneath the catchments of Wattle Creek and Little Wattle Tree Creek within the greater catchment of Lake Cordeaux. Extraction of coal has begun at the following longwalls:

- Longwall N1 commenced on 22 May 2017 and was completed on 16 September 2018.
- Longwall N2 commenced June 2013 and was completed in February 2014.
- Longwall N3 commenced 4 October 2016 and was completed on 13 March 2019.
- Longwall N4 commenced August 2016 and was completed in May 2017.
- Longwall N5 commenced 20 March 2017 and was completed on 26 January 2019.

1.2 Ecological monitoring

Natural features with Risk Management Zone (RMZ's) located within the subsidence impact footprint of the Nebo Area require monitoring for a minimum of two years prior to the start of longwall mining (the 'impact' event). Monitoring focusses on ecological features that are sensitive to geological changes to the landscape, including: valley closure, upsidence, strains and fracturing. This is in accordance with recommendations made by the Department of Planning (DoP 2008). Mining beneath watercourses in steep valleys can result in localised water losses from creek lines immediately above the mine due to water permeating into fractures within the bedrock (DPI 2006). The water usually returns to the surface further downstream, but may be altered chemically by leaching of the newly exposed minerals from within the rock strata (DPI 2006). Sites are referred to as pre-impact, until the closest point of secondary extraction is located within RMZ of the ecological feature, then are referred to as post-mining impact sites.

Baseline terrestrial ecological monitoring of impact sites within the Nebo Area commenced in spring 2010 and monitoring at paired control sites commenced as early as autumn 2011. Aquatic ecological monitoring in the Nebo lease area commenced in autumn 2011 to collect pre-mining monitoring data, which also included the assessment of four control sites. Following the completion of Longwall N2 in February 2014, Wongawilli Coal discontinued mining in the Nebo Area. Subsequently, all related terrestrial ecological monitoring ceased, on the condition from the regulator, that baseline monitoring was to restart six months prior to the recommencement of mining. In addition, data analysis should not show a significant change in condition over

the intervening period. Baseline monitoring within the Nebo Area recommenced in spring 2015, ahead of the proposed extraction of longwall N4.

The adopted Trigger Action Response Plans (TARPs) (Niche 2012) for the Nebo Area require monitoring and impact assessment to be undertaken for a minimum of one year following the completion of mining activities. If an impact is detected, post-mining monitoring may be required to be collected for a period determined to be satisfactory by WaterNSW and the Office of Environment & Heritage (now Environment, Energy and Science).

To determine whether subsidence related effects associated with longwall mining result in impacts to terrestrial flora and fauna features located above the longwalls, Biosis has designed and implemented a Before-After Control-Impact (BACI) experimental design, looking at how sites that have been mined beneath change over time (Before-After) and comparing this to control sites that have not been mined beneath (Control-Impact).

Terrestrial ecology

The Extraction Plan for longwalls within the Nebo Area, developed in May 2012 (Niche 2012) identified that the extraction of Longwalls N4, N5 and N6 will result in a subsidence footprint that occurs within the RMZ for sensitive ecological features. Ecological features at greatest risk of impact from subsidence effects are considered to be those features reliant on groundwater or surface water. The ecological features which are relevant (Niche 2012) and currently being monitored prior to the recommencement of mining and since mining recommenced in August 2016 in Nebo include plant communities (species) and frogs (presence/absence) along two creeks.

The Nebo Terrestrial Ecological Monitoring program was developed using protocols established for the Southern Coalfield in 2003, consultation with Wongawilli Coal and the outlined Chapter 3 Subsidence Management Measures in the Nebo Longwalls N1-N6 Extraction Plan (Niche 2012).

Aquatic ecology

The aim of Nebo Aquatic Ecological Monitoring Program is to identify any changes in the relative condition of aquatic ecological values during mining activity. The aquatic ecological monitoring program presented herein is a component of the biodiversity monitoring activities that conform to the instrument of approval within the Nebo Longwalls N1-N6 Subsidence Management Plan Approval (DTIRIS, 2013) and NRE Wongawilli Colliery – Nebo Area Project Approval (MP09_0161). The Project Approval contains Conditions of Approval (CoA), which specify activities that need to be undertaken by Wongawilli Coal to continue mining in the Nebo Area.

Previous aquatic surveys of the study area had been conducted by another consultancy in spring 2009 and autumn 2010. These surveys involved sampling at two 'impact' reaches within the Application Area (both on Wattle Creek) and four 'control' reaches on nearby waterways (Kentish Creek and the upper Cordeaux River) that are not expected to be undermined in the near future. This original study design was considered unsuitable due to the small number of impact reaches monitored within the Application Area. Biosis was commissioned to develop an alternative monitoring program with an appropriate number of monitoring reaches commensurate with the size of the Application Area. Biosis established six additional monitoring reaches within the Application Area and the inclusion of four control monitoring reaches on Moran's Gully, Meemi Creeks, Kentish Creek and a tributary of Kentish Creek.

1.3 Aims of this report

This report provides a summary of the results of the 2018 calendar year of the Nebo terrestrial and aquatic monitoring programs. The aims of this monitoring report are to:

- Describe ecological monitoring undertaken in the Nebo area up to and including the 2018 calendar year of the monitoring program.
- Present the monitoring results recorded during 2018 in the context of the results of the program since its inception.
- Examine the potential impacts of subsidence on riparian vegetation and frogs in creek environments in the Nebo Area.
- Examine the potential impacts of subsidence on stream health and aquatic ecological communities in the Nebo Area.
- Relate the ecological monitoring results to the TARPs (Niche 2012) for Longwalls N1-N6 (Appendix 2).
- Describe the requirements of future ecological monitoring to be undertaken in the Nebo area.

2 Methods

2.1 Survey sites and monitoring periods

A summary of the monitoring sites is provided in Table 1. This table details impact and control site pairing and monitoring periods. All components of the ecological monitoring programs are to be undertaken in both spring and autumn of each year. However monitoring was only completed in one season for the 2018 period, shown in Table 1 and Appendix 3. All impact sites are considered to be in a 'post mining' (within RMZ) condition during the 2018 monitoring period. The locations of the impact and control monitoring sites for each monitoring program are displayed in Appendix 1.

Table 1 Monitroing sites and periods

Area	Site	Monitoring period	Control sites
Vegetation monitoring			
Nebo	Wattle Creek (WTC)	Spring 2010 to Autumn 2014 Spring 2015 to Spring 2017 Spring 2018 to Autumn 2019	Moran's Gully (MG) Flying Fox Creek No. 3 (FFC)
	Little Wattle Tree Creek (LWTC)	Spring 2010 to Autumn 2014 Spring 2015 to Spring 2017 Spring 2018 to Autumn 2019	Moran's Gully (MG) Flying Fox Creek No. 3 (FFC)
Frog species monitoring			
Nebo	Wattle Creek (WTC)	Spring 2010 to Autumn 2014 Spring 2015 to Autumn 2018 Autumn 2019	Moran's Gully (MG) Flying Fox Creek No. 3 (FFC)
	Little Wattle Tree Creek (LWTC)	Spring 2010 to Autumn 2014 Spring 2015 to Autumn 2018 Autumn 2019	Moran's Gully (MG) Flying Fox Creek (FFC)
Aquatic monitoring			
Nebo	Wattle Creek (WTC)	Autumn 2011 to Autumn 2018 Autumn 2019	Moran's Gully (MG) Meemi Creek (MEC) Kentish Creek (KEC) Kentish Creek Tributary (KCT)
	Little Wattle Tree Creek (LWTC)	Autumn 2011 to Autumn 2018 Autumn 2019	Moran's Gully (MG) Meemi Creek (MEC) Kentish Creek (KEC) Kentish Creek Tributary (KCT)

Trends or changes in the ecological metrics used to record and interpret the data for vegetation and frog species monitoring may be due to mining impacts or unrelated landscape effects. For example local climate changes or bushfire. As such a BACI (Underwood 1991) experimental design has been employed to increase confidence in the interpretation of observed changes.

Each site is analysed based on the following impact treatments:

- Control: sites not mined beneath and not at risk of mining related impacts.
- Impact: the 400 metre risk management zone will experience mining of Nebo Panels and the site is considered to potentially be at risk of mining related impacts.

Control sites selected for analysis were chosen for impact sites based on ecological and structural similarity to impact sites in the field, and their geographical location. These sites were then compared using exploratory data analysis to confirm that the data were statistically suitable and available for the same period of time as impact sites.

2.2 Terrestrial ecological monitoring program

2.2.1 Riparian vegetation monitoring

Field data collection

Vegetation surveys within creeks are undertaken at three 20 by 20 metre (400 square metre) quadrats per creek (Appendix 1). These three quadrats per creek are considered to be a single monitoring site and are analysed as a group. Within each quadrat, subjective cover and abundance scores are given to each species occurring within the quadrat using a modified Braun-Blanquet scale.

Data analysis

The Analytical Edge Statistical Consulting Pty Ltd has been commissioned by Biosis to undertake statistical analyses of flora data collected at creek sites and has refined the statistical analysis design methods used in the monitoring program (The Analytical Edge 2019). Austral Research and Consulting (2019) has undertaken the statistical analysis for the 2018 and 2019 monitoring period data. The analysis provides a statistical comparison of impact and control sites with the aim to identify, understand and manage any mining impacts.

Impacts to vegetation may be manifested as a change in the number of species at different sites, or an overall change in the species composition (as some species may be more or less affected than other species to impacts associated with mining). In affected areas, these impacts are likely to be manifested and detectable through statistical analysis the following ways:

- Change in floristic total species richness (TSR): the number of individual species present.
- Changes in the floristic species composition: the assemblage or identity of different individual plant species that make up a vegetation community.

A change in TSR or species composition following mining at a potential impact site that does not occur at a control site may indicate an impact. In order to detect changes in indicator variables, particular trends must be identified. These trends may occur suddenly, as a pulse event, or more likely, gradually over time.

Statistical methods

To avoid the Braun-Blanquet categories resulting in an inappropriate weighting of species abundance, the data utilised in the statistical analysis was transformed to presence-absence data. Here-in all vegetation data refers to presence-absence data only.

TSR data were plotted by year and treatment (control or impact), pooled across all quadrats and creeks surveyed within a year (autumn and spring data combined), and also for each creek line surveyed. TSR data was graphically displayed using box plots to enable a visual comparison of flora data between sites and years. Box plots allow for a detailed visual presentation of the median distribution including the underlying

variability and distribution of the metrics. The box of a box plot contains the central 50 per cent of the distribution; from the first quartile to the third quartile (quartiles split the distribution into four parts, each containing one quarter, 25 per cent). Lines extending from the boxes represent the rest of the data and any points beyond these are considered outliers.

To formally quantify whether trends detected visually represent actual changes in TSR, generalised linear mixed models (Bolker et al. 2009) were tested for all sites. The models tested the influence of season, year and mining status (pre, post or mined beneath) on TSR. Season allows us to look for any cyclical trends; calendar year allows us to look for trends in time across all sites, while mining status allows us to see if observed trends are different at mining and non-mining sites. Analysis of variance (ANOVA) was used to formally test the significance of explanatory variables (i.e., 'year', 'season' and mining status) on species composition. If the mining status explanatory variable was found to be significant, univariate or other tests were completed to determine which individual species were driving the change in flora community composition.

Assumptions and models

An assumption of generalised linear mixed models is that observations are independent, which here is clearly violated both temporally (since sites are visited multiple times) and spatially (since some sites within regions are closer together). That is, it would be expected that observations collected at the same creek, regardless of year or season, would be more correlated than observations collected at different creeks; and similarly, observations collected at creeks near each other would be more similar to observations collected at creeks further away. To account for this correlation within sites and the nesting of sample points within the area, a random-effect term was included. Akiake's Information Criteria (AIC) was used to select between competing models, whereby the model with the lowest AIC was considered the 'best' of all models fitted, and models that had an AIC less than or equal to two from the AIC of the best model were considered equivalent. Each model is identified below:

- M1 – treatment effects (control and impact).
- M2 – yearly effects.
- M3 – season effect.
- M4 – treatment and additive yearly effects.
- M5 – treatment and additive season effects.
- M6 – year and additive season effects.
- M7 – treatment and additive year and season effects.
- M8 – interaction between treatment and year effects.
- M9 – interaction between treatment, year and season effects.
- M10 – mining effect (33 observations are post-impact).

All modelling and the creation of graphs were completed in the statistical software program R, by Austral Research and Consulting (2019). Generalised linear mixed models of TSR were fitted using the 'glmer' function in the 'lme4' package. The 'manyglm' function in the 'mvabund' package (in the program R), were used to fit presence-absence models to each detected species. These models correct the correlation between species (thus violating an assumption of standard generalised linear models) by using generalized estimating equations.

2.2.2 Amphibian monitoring

Field data collection

Frog surveys along the identified creek lines are conducted along three 50 metre transects within each creek (Appendix 1). These three transects per creek are referred to collectively as a monitoring site and are analysed as a group. An initial five minute listening period is followed by active searching of all natural features including rocks, vegetation and leaf litter within the transect for an additional 25 person minutes. The presence and abundance of all frog species within each transect is recorded. Additional physical data is also collected to describe the transects at the time of survey. The survey occurs twice during both autumn and spring, a total of four nights of survey per site each year.

Data analysis

The mean number of frog species observed was calculated and plotted on line graphs by year and treatment for each site surveyed. The plotted data were then visually assessed to identify any trends in increasing or decreasing observations of frog species. This analysis is supported by the visual observations of changes in habitat features (e.g. water level or vegetation change) that may drive change in the species of frog detected over time.

Impacts to frog populations are likely to occur as declines in population numbers or disruption of species breeding cycle following changes to key breeding habitat features. This may in turn be manifested as a change in the number of individuals for a creek frog species present and / or a change in the composition of species found at a site if some species are more sensitive to habitat change than others. Given the inherent variability in fauna data, particularly frog detection, the analysis focuses on comparisons of the average number of species detected at each site to identify any changes in the frog species assemblage within each creek. This is considered to be the more reliable indicator, although any significant changes in frog abundance are reported and discussed.

2.3 Aquatic ecological monitoring program

HABSCORE assessments

HABSCORES were completed at each site to provide a relative measure of aquatic habitat health when the site is dry and no AUSRIVAS assessment can be completed. HABSCORE is a visually based habitat assessment that 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).

HABSCORES range from Poor to Optimal condition and generally reflect the current category condition of the water resource. Categories are derived from the sum of scores divided by the sum of the characters assessed. This provides an ecological indicator that produces information on the water resource when conditions preclude AUSRIVAS and Signal scores (i.e. dry conditions). HABSCORE assessments are based on the presence and condition of the following features:

- Pool substrate characterisation
- Pool variability
- Channel flow status
- Bank vegetation (score for each bank)
- Bank stability (score for each bank)

- Width of riparian zone (score for each bank)
- Epifaunal substrate / available cover

The aquatic habitat within the study area was described in terms of four category types (Barbour et al. 1999). The four categories used to evaluate habitat value were Optimal, Suboptimal, Marginal or Poor, as detailed below:

Optimal: Watercourses that contain numerous large, permanent pools and generally have flow connectivity except during prolonged drought. They provide extensive and diverse aquatic habitat for aquatic flora and fauna.

Suboptimal: Watercourses that contain some larger permanent and semi-permanent refuge pools, which would persist through prolonged drought although, become greatly reduced in extent. These watercourses should support a relatively diverse array of aquatic biota including some fish, freshwater crayfish and aquatic macroinvertebrates. There may also be some aquatic plant species present.

Marginal: Watercourses that contain some small semi-permanent refuge pools which are unlikely to persist through prolonged drought. Flow connectivity would only occur during and following significant rainfall. These pools may provide habitat for some aquatic species including aquatic macroinvertebrates and freshwater crayfish.

Poor: Watercourses or drainages that only flow during and immediately after significant rainfall. Permanent or semi-permanent pools that could provide refuge for aquatic biota during prolonged dry weather are absent.

Water quality measurements

Physicochemical water quality variables were measured at each reach, approximately 30 centimetres (cm) below the surface, using a Horiba Multiparameter Water Quality Meter. Variables measured included pH, dissolved oxygen (DO), temperature, turbidity and electrical conductivity (EC). Alkalinity was measured using a Hach Alkalinity Kit. Water quality measurements are compared against guidelines recommended by ANZECC (2000) for the protection of aquatic systems in South-eastern Australia. As the project falls within the area controlled by the Water NSW (previously controlled by the Sydney Catchment Authority), water quality objectives set by the SCA apply and are also referred to within the report. Water quality data is collected to support macroinvertebrate and habitat assessments and is not a stand-alone record of long term water quality monitoring.

Aquatic macroinvertebrates

Aquatic macroinvertebrate samples were collected at each monitoring reach where water is present, according to the techniques described in the NSW AUSRIVAS Rapid Assessment Method developed by the NSW Environment Protection Authority (Turak et al. 2004). This method involves the collection of samples from two types of aquatic habitats (where possible) within a monitoring reach using two sampling techniques: slow-flowing river edges (dip-net technique) and fast-flowing riffles (kick-net technique). In this study only sufficient edge habitat was available for sampling according to the AUSRIVAS methodology.

Macroinvertebrates were live-picked from the samples while in the field, preserved in 70% ethanol and later identified in the lab. Macroinvertebrates were identified to family level with the exception of Oligochaeta (to class), Polychaeta (to class), Ostracoda (to subclass), Nematoda (to phylum), Nemertea (to phylum), Acarina (to order) and Chironomidae (to subfamily) as outlined in the NSW AUSRIVAS Sampling and Processing Manual (Turak et al. 2004). All macroinvertebrates were identified using the taxonomic keys and names listed in Hawking (2000).

The results were then analysed using the AUSRIVAS software package, which contains predictive models that assess the ecological health of a monitoring reach by comparing its macroinvertebrate community with those of similar 'reference' reaches within the model. The macroinvertebrates recorded at these reference reaches are considered to be a strong representation of what macroinvertebrate communities would be expected to occur at a study reach if it is in a 'reference' or undisturbed condition. If a reach does not contain the taxa expected by the model, then its condition is described as being 'lower than reference'. This is described in more detail below. Due to the timing and conditions at the time of the spring 2017 sample, the results were analysed using the un-weighted Signal2 methodology outlined by Chessman (2003).

The defined seasonal dates for macroinvertebrate sampling are autumn: 15 March to 15 June and spring: 15 September to 15 December (Turak et al. 2004). AUSRIVAS sampling may occur outside of the AUSRIVAS defined seasonal dates where weather for the season falls within acceptable conditions to allow the samples to be representative of the season (pers comm Jan Miller OEH). Where weather conditions are not representative of appropriate seasonal conditions AUSRIVAS analyses are not conducted and OE50 scores and Band ratings are therefore not reported for those seasons. In these seasons the stream health analysis relies on the un-weighted Signal2 methodology outlined by Chessman (2003) and number of taxa scores, as these indices are not seasonally dependent.

OE50 score

The AUSRIVAS model provides several outputs, including a ratio of the macroinvertebrates recorded at a study reach versus those recorded in the model. This is a ratio of observed taxa versus expected taxa and is called an 'O/E score' (Observed/Expected). Many macroinvertebrates are very rare, so the full list of expected taxa will often contain animals that have only been recorded once, and typically at only one reference reach. If these were expected by the model to be present at a study reach, the result would often be very low O/E scores. So, the most commonly used ratio is the 'O/E 50' score which only gives the ratio of observed/expected taxa that have a greater than 50% chance of occurring at a monitoring reach (i.e. the taxa which were recorded at more than 50% of matching reference reaches within the model).

Band rating

The second output from the model is a 'BAND' rating of each study site. BAND ratings are a simple description of stream condition and are described as follows:

- X – The site is richer than reference condition
- A – The site is equivalent to reference condition
- B – The site is in moderately impaired condition
- C – The site is in significantly impaired condition
- D – The site is in extremely impaired condition

Signal2 index

The Signal2 (Stream Invertebrate Grade Number Average Level) biotic index score (Chessman 2003) applies a revised sensitivity grade to macroinvertebrate families and, based upon the original Signal grade (Chessman 1995) and is considered a more accurate grading. The Signal2 index describes the tolerance of macroinvertebrate taxonomic families to pollution. The index provides a comprehensive ecological indicator that produces an average Signal2 score (Table 2) for each monitoring reach as an indication of the macroinvertebrate community's overall tolerance to pollution or disturbance.

The AUSRIVAS predictive model software provides a Signal2 score for each site analysed in the form of the O0Signal output, which has been used throughout the Nebo stream health monitoring program. Where it is not possible appropriate to run the AUSRIVAS models due to seasonal conditions, the un-weighted Signal2 scores for this data have been calculated following Chessman (2003). Minor differences do occur between the manually calculated Signal2 output and the O0Signal output of the AUSRIVAS model, due to some taxa being automatically removed by the model, to produce other outputs. However, this is not considered to be a significant limitation to the data analyses or interpretation.

Table 2 Signal2 biotic index classification scheme

Signal2 Score	Impairment	Water Quality Status
Greater than 7	Unimpaired & rich in sensitive taxa	Excellent water quality
6 - 7	Unimpaired	Good water quality
5 - 6	Mildly impaired	Fair quality, possible mild pollution
4 - 5	Moderately impaired	Poor quality
Less than 4	Severely impaired	Very poor water quality

Trigger values

Impacts to waterways arising from longwall mining result in distinct changes to aquatic environments resulting in introduction of leachates, smothering of habitat or distinct reduction in water level. The trigger values for macroinvertebrates have been developed considering this level of impact and the highly variable before and control site results. The trigger values, for initiating immediate supplementary investigations, for macroinvertebrate data analysis are Signal scores (Chessman 1995) less than four and a number of taxa at a monitoring reach below 10.

2.4 Limitations

Ecological monitoring surveys should be undertaken during the programmed seasons and be consistent across years. Biosis has undertaken monitoring surveys as part of this monitoring program following the approval by Wollongong Coal. Survey dates for all monitoring periods are provided in Appendix 3. Interpretations of data that have been collected substantially outside the monitoring period must be treated with caution. As these data are likely to have been collected under considerably different seasonal conditions to the programmed seasons they are intended to represent. As such, these data may not be directly comparable to previous seasons data or representative of the ecological biota that would be present during the programmed season. A considerable number of seasons of baseline data have been collected providing a comprehensive basis to interpret data that has been collected outside of the prescribed season. Interpretations are further supported by the use of observations regarding any impacts associated with mining, such as surface deformation, cracking, surface water loss or leachate.

Given the complexity that arises with cryptic flora species, such as those that are inconspicuous unless flowering or in fruit, or located high in the vegetation canopy; plant species complexes have been developed that link plant species that are known to be easily confused in the field. These linked species have been treated as one species complex in the data as they represent sympatric species and occupy a similar ecological niche. Species complexes have been developed based on site specific experience over many years.

Like many fauna surveys, the frog species dataset is not normally distributed and is skewed by a high number of zero counts. It is not possible to sufficiently estimate a measure of detectability for the frog species monitoring. Therefore the difference between a true absence record (i.e. the species does not occur at the site) and a false absence record (i.e. the species does occur at the site but was not detected) cannot be established, a common feature of such monitoring programs. Therefore, the amphibian monitoring data has been transformed to presence-absence data. Two rounds of survey are completed in each season to increase confidence in the data, given the high degree of variability encountered in the monitoring of amphibians.

The aquatic ecological monitoring program is not considered subject to any significant limitations. The survey effort, combined with information available from other sources, is considered suitable to assess the overall aquatic ecological values of the sites. The physiochemical water quality parameters measured provide a snapshot of conditions at the time of sampling. Some of these parameters typically exhibit a high degree of temporal variation and can change substantially over short periods of time, particularly in response to significant rainfall events. These parameters are used to inform the macroinvertebrate analyses only.

Ecological monitoring programs may be confounded by varying responses of ecological communities or populations responding to impacts or environmental conditions in differing ways. Therefore, monitoring and interpretation of data with a 'one size fits all' approach must be treated with caution. As such, a number of parameters including both qualitative and quantitative metrics are recorded to establish multiple lines of evidence to inform the interpretation of results. Biosis is committed to the continual review of our programs to provide options for improvement.

3 Results

One season of data was collected for each monitoring component (flora, amphibian and aquatic) of the ecological monitoring programs during 2018 and were collected outside of the programmed survey periods (Appendix 3). For this reason, data collected from previous years and the autumn 2019 monitoring season has been included in this report in order to increase the confidence in the interpretation of results and assessment of any impacts against the relevant TARPs.

3.1 Terrestrial ecological monitoring

3.1.1 Vegetation monitoring

Riparian floristic data for 2018 was collected for the spring season only and collected under conditions more representative of summer than spring.

Total species richness

The results of exploratory analysis of the pooled TSR data collected at each control and impact site is presented in Figure 1. The solid line within the boxes of Figure 2 is the median (i.e., the 50th percentile), the margins of the box are the interquartile ranges (i.e., the 25th and 75th percentile) and the whiskers of the boxplot show the range of the data. The control monitoring sites are shaded white, pre-mining impact monitoring sites grey and post mining - within RMZ blue. Solid black points are the observations.

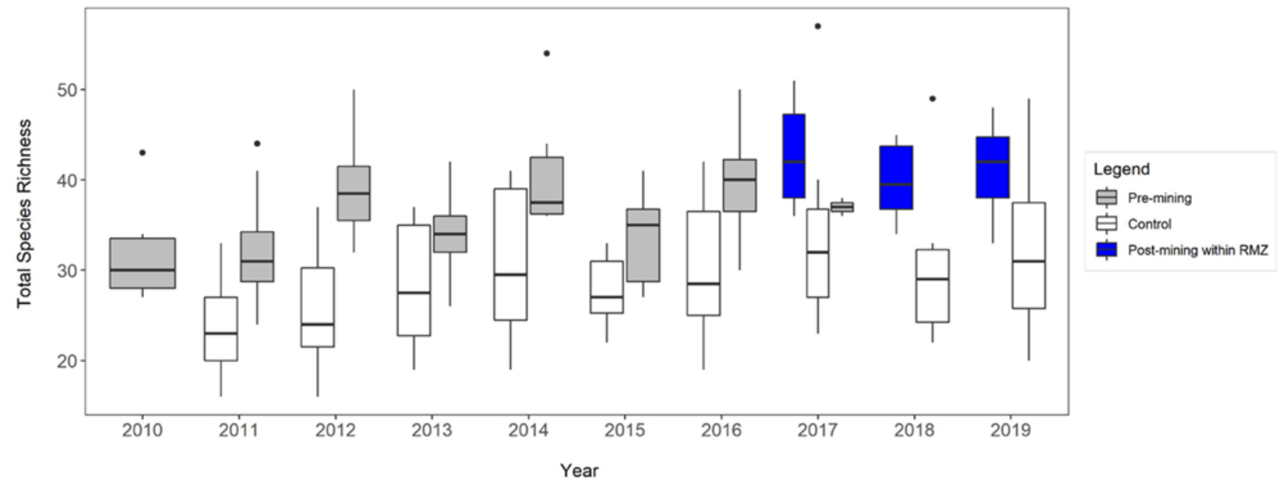

Figure 1 Boxplot showing pooled Total Species Richness for all monitoring sites over all monitoring periods: split by mining or control status

The pooled data for the control, pre-mining and post mining monitoring sites demonstrate a high degree of variability in TSR from year to year. Both the control and impact sites appear to follow the same broad pattern of change over time. With TSR being generally higher at impact sites than control sites, particularly at the post-mining sites, and this pattern has continued through autumn 2018 and autumn 2019. The TSR results for the impact sites recorded in the autumn 2018 and autumn 2019 monitoring period are within the range of variability recorded during the pre-mining data collection period (2010 to 2016).

The TSR results for individual control and impact monitoring sites across all monitoring periods are presented in Figure 2. The sites show a broad trend of increasing TSR over time, with Flying Fox Creek and Little Wattle Tree Creek both showing a plateau and slight decline in 2018 and 2019. Changes in the variability of results are more marked in the 2018 and 2019 years, this attributed to these years being represented by a single autumn season of monitoring only. Little Wattle Tree Creek displays the highest TSR, with the overall pattern of change closely mirrored in Flying Fox Creek. With Flying Fox Creek showing a lower TSR than any other monitoring site. Wattle Creek and Morans Gully show very similar increases in TSR over time and comparatively similar TSR values.

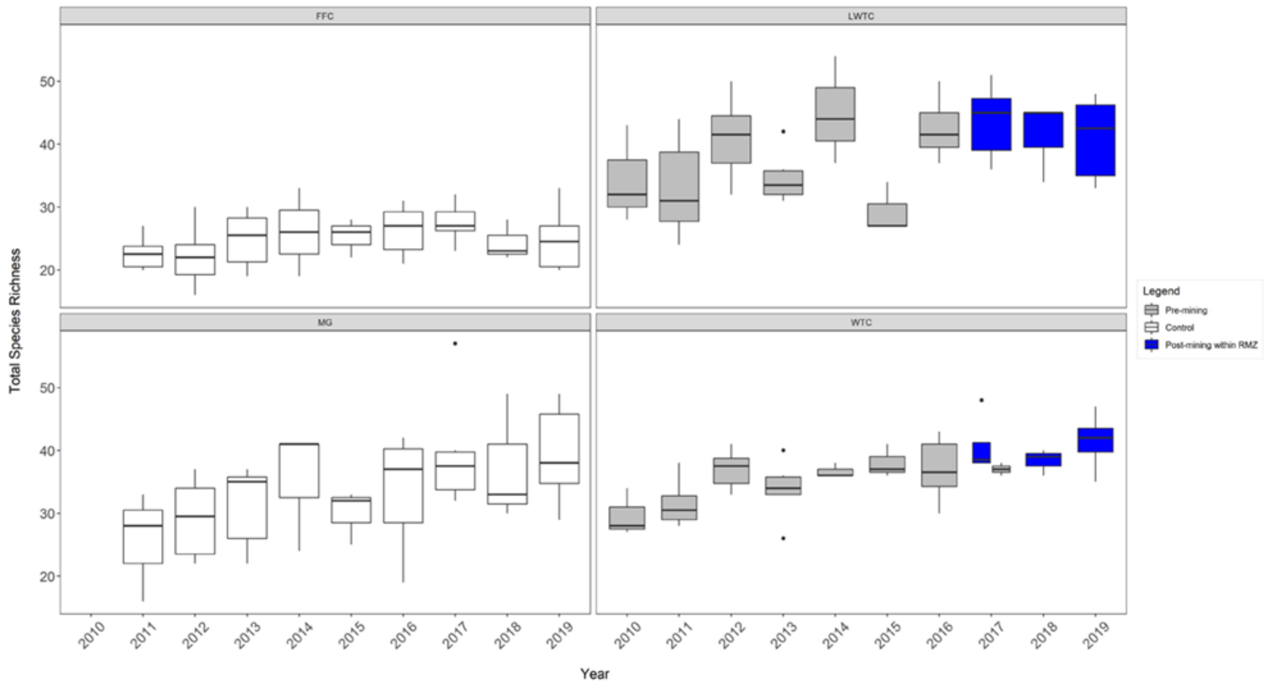

Figure 2 Boxplots of total species richness for each impact site, over time

The results of generalised linear mixed models (GLMMs), which were fit to the TSR data for sites within the Nebo Area are presented in Table 3. AIC is the Akiake's Information Criteria, and dAIC is the difference in AIC when compared to the model with the lowest AIC. The model with the lowest AIC is the model best fit to the data.

Table 3 Model results for the GLMM fit to the TSR data

Model	Df	AIC	dAIC
M4	4	1118.0	0
M7	6	1118.2	0.2
M8	5	1119.6	1.5
M9	11	1122.3	4.2
M2	3	1122.6	4.5
M6	5	1122.6	4.5
M10	3	1145.8	27.7
M5	5	1153.9	35.8
M1	3	1154.4	36.3
M3	4	1157.9	39.8
M0	2	1158.4	40.3

The Treatment and Year model (M4) was the best fit for the data (lowest AIC). These results suggest that the yearly increase in TSR across all sites surveyed is small but statistically significant (estimate = 0.03, standard error = 0.002, $p < 0.001$). Also that TSR at impact sites were statistically significantly higher than control sites (estimate = 0.28, standard error = 0.095, $p = 0.003$). However, there was moderate model selection uncertainty, as the next best fitting models (M7 - additive effects of Treatment, Year and Season and M8 - interaction between Treatment and Year effects) are within three AIC of model M4, suggesting these models are essentially equivalent (Burnham and Anderson, 2003). These results are consistent with the results of previous monitoring (Biosis 2019).

Species composition

No clear difference in floral species assemblage was identified between impact and control sites. A moderate number of unique species were detected at each creek during the monitoring period, the lowest being 10 (impact site WTC) up to 32 (Control site MG). These results are low when compared to the 2017 monitoring year and may be influenced by single season of data representing the 2018 monitoring year (Biosis 2019). However, the percentage of species that were detected only once are highly similar to the 2017 monitoring period (Biosis 2019), consistent with previous results. When expressed as a proportion of the total number of species detected at each site, was lower at the impact sites (10% at WTC and 21% at LWTC) and slightly higher at the control sites (12% at FFC and 18% at MG).

No statistically significant mining status effect was detected at the impact sites. A yearly-trend was statistically significant at all creeks, regardless of whether it was a Control or Impact site (all p-values < 0.05). This is not surprising, as it is reasonable to expect some natural turnover of species at sites each season and across years.

3.1.2 Amphibian monitoring

Amphibian monitoring data for 2018 was collected for the autumn season only and collected under conditions more representative of winter. Annual analysis and comparisons of the amphibian monitoring data focusses on the mean number of frog species detected each year. Given that only one season of amphibian monitoring data was been collected during 2018, the results for the most recent autumn monitoring seasons are presented below and discussed in the context of recent years of monitoring. Annual totals (combining autumn and spring) will be presented in the 2019 monitoring report.

Figure 3 presents the mean number of frog species detected at the impact and paired control monitoring sites, during each autumn from 2016 to 2017. The number of frog species detected at both impact sites is seen to decline between 2016 to 2018, before increasing in 2019. This pattern is also seen in the paired control sites, indicating the driving factors behind these changes are catchment scale processes rather than any impacts associated with mining. The lowest numbers of frogs detected were recorded in 2018. It should be noted that this round of monitoring was conducted in winter, when many frog species are expected to be less active and therefore less detectable. The frog species detected at the monitoring sites in 2018 are common species that are repeatedly recorded as part of this program and are typical of the rocky creek and riparian habitats in the region. With the Common Eastern Froglet *Crinia signifera*, Southern Stony-creek Frog *Litoria lesueuri* and species from the *Litoria nudidigita* / *Litoria phyllochroa* species complex most commonly encountered.

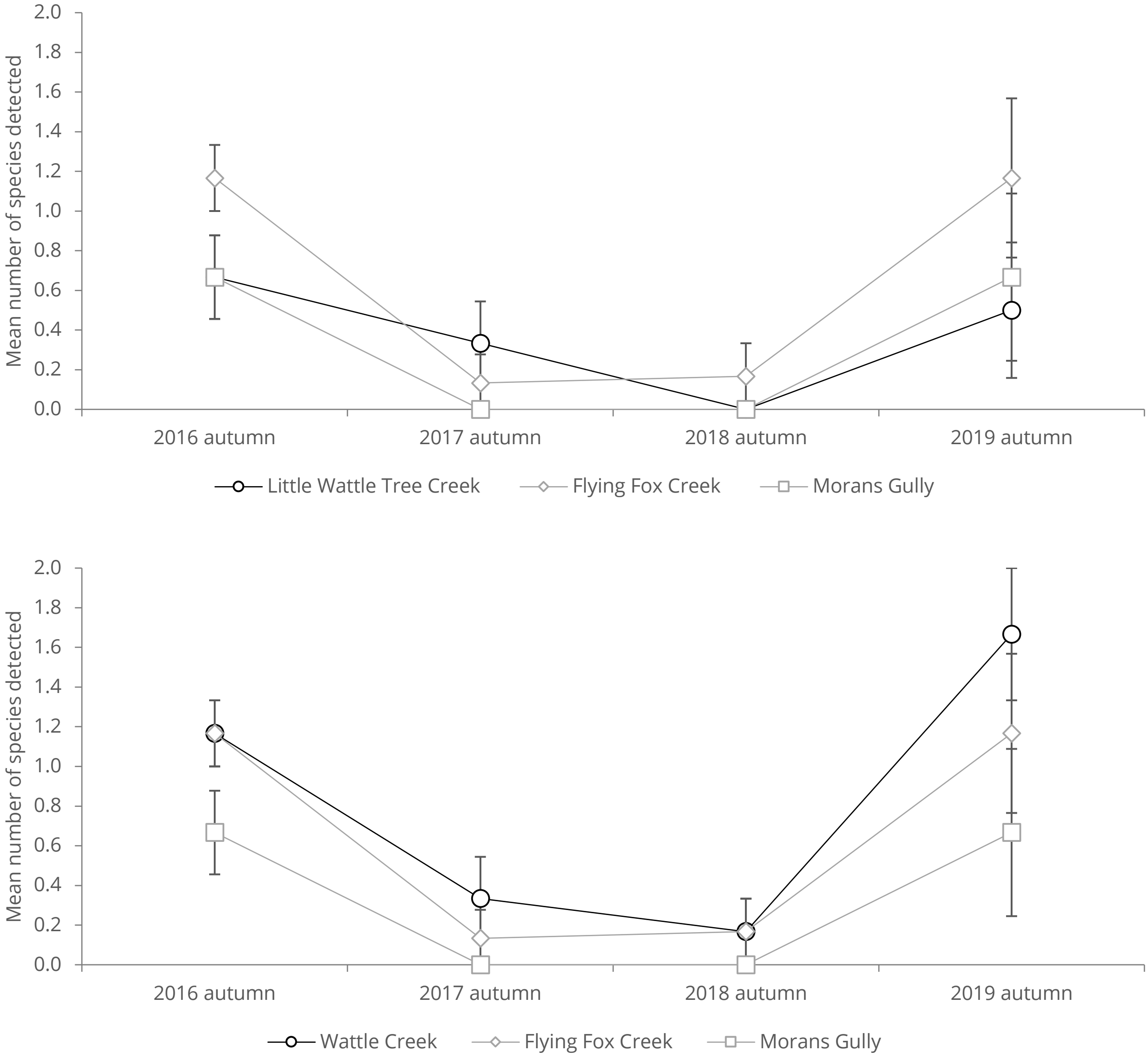

Figure 3 **Mean number of frog species detected at control and impact sites. Error bars show standard error of the mean**

The data recorded at the impact monitoring sites during these monitoring periods are consistent with the previously collected data. With the number of species detected at Wattle Creek being generally between, or just above the two control sites and Little Wattle Tree Creek being generally at or below the mean number of frogs at the control sites. Comparatively low mean numbers of frog species have been detected at site Little Wattle Tree Creek during the 2017 and 2018 monitoring periods. Frog detection data is highly variable and may change substantially in response to subtle changes in conditions, and such results are not unexpected. Site observations indicate a reduction in water availability at all three monitoring transects along this site, also observed in the aquatic monitoring program (section 3.2.4), reducing the condition and availability of habitat. Based on site observations, it is considered likely that this section of Little Wattle Tree Creek receives proportionally less inputs from groundwater than the other creeklines and the overall reduction in water availability at this site is a result of the prolonged period of drought throughout this monitoring period. No observations of mining impacts have been recorded along the monitoring sections of Little Wattle Tree Creek by Biosis, e.g. surface cracking or deformation, leachate or vegetation dieback.

3.2 Aquatic ecological monitoring

Aquatic ecological data for 2018 was collected for the autumn season only and collected under conditions more representative of winter than autumn.

3.2.1 Water quality measurements

The water quality readings are compared with ANZECC (2000) guidelines for upland streams (altitude ≥150 m) in southeastern Australia and guidelines defined by the SCA (now WaterNSW), for raw water supplied at the Nepean Water Filtration Plant (WFP) (Table 4). The Nepean WFP receives raw water from the Cataract, Cordeaux, Avon and Nepean dams for which the water quality limits of the area are defined. SCA water quality guideline benchmarks are used for pH and alkalinity, with the remainder measured against ANZECC values.

Table 4 Water quality guidelines of AZECC (2000) and the SCA (now WaterNSW)

Water quality variable	ANZECC Guidelines	SCA Guidelines
pH	6.5 – 7.5	4.8 – 7.7
Electrical Conductivity (μS/cm)	30 - 350	-
Dissolved Oxygen (%)	90 – 110	-

The physicochemical water quality results from the 2018 survey are presented in Table 5. Readings outside of the guideline values are highlighted in red. Water quality measurements were generally within the prescribed benchmarks for all parameters, with dissolved oxygen being the exception. Dissolved oxygen fluctuates throughout diurnal periods with measurements collected herein providing a single point in time measurement. These lower than prescribed readings do not indicate abnormal or deleterious results and are in line with the range of values previously recorded at these sites.

Table 5 Water quality readings collected during autumn 2018

Parameter	pH	Conductivity (μS/cm)	D.O. Saturation (%)
COR-AQ1	7.53	103	68.5
KEC-AQ1	7.15	115	51.3
KCT-AQ1	7.19	115	55.1
LWC-AQ1	6.97	178	40.2
LWC-AQ2	Dry	Dry	Dry
MEC-AQ1	6.91	215	2.7
MGC-AQ1	7.06	210	18.0
WAC-AQ1	7.00	96	60.0
WAC-AQ2	7.57	145	58.9
WAC-AQ3	7.55	149	63.7
WAC-AQ4	Dry	Dry	Dry
WAC-AQ5	7.44	132	61.1
WAC-AQ6	7.50	132	54.7

3.2.2 Macroinvertebrate results

The results of macroinvertebrate analysis for the autumn 2017 to autumn 2019 period are provided in Table 6 below. Results for all monitoring periods are provided in Appendix 4.

Table 6 Summary of impact site stream health analysis results, autumn 2017 to autumn 2019

Site	Indices	2017		2018		2019
		Autumn	Spring	Autumn	Spring	Autumn
COR-AQ1	Signal2	4.77	6.10*	4.40*	-	4.36
	OE50	0.92	-	-	-	0.88
	Band	A	-	-	-	A
	No. Taxa	26	21	15	-	27
WAC-AQ1	Signal2	5.18	6.31*	5.33*	-	5.18
	OE50	0.29	-	-	-	0.37
	Band	C	-	-	-	C
	No. Taxa	11	14	12	-	17
WAC-AQ2	Signal2	5.88	6.00*	5.50*	-	5.10
	OE50	0.29	-	-	-	0.51
	Band	C	-	-	-	B
	No. Taxa	17	18	17	-	19
WAC-AQ3	Signal2	5.60	6.77*	5.18*	-	5.67
	OE50	0.29	-	-	-	0.39
	Band	C	-	-	-	C
	No. Taxa	15	14	11	-	9
WAC-AQ4	Signal2	5.92	5.83*	Dry	-	Dry
	OE50	0.37	-		-	
	Band	C	-		-	
	No. Taxa	13	7		-	
WAC-AQ5	Signal2	5.25	6.12*	4.63*	-	5.40
	OE50	0.44	-	-	-	0.48
	Band	C	-	-	-	B
	No. Taxa	16	18	15	-	10
WAC-AQ6	Signal2	5.73	5.94*	4.40*	-	5.14
	OE50	0.37	-	-	-	0.58
	Band	C	-	-	-	B
	No. Taxa	11	18	18	-	20
LWC-AQ1	Signal2	Dry	6.29*	5.30*	-	4.13
	OE50		-	-	-	0.65
	Band		-	-	-	B
	No. Taxa		18	7	-	15
LWC-AQ2	Signal2	Dry	Dry	Dry	-	Dry
	OE50				-	
	Band				-	
	No. Taxa				-	

Table 7 Summary of control site stream health analysis results, autumn 2017 to autumn 2019

Site	Indices	2017		2018		2019
		Autumn	Spring	Autumn	Spring	Autumn
KCT-AQ1	Signal2	4.25	6.38*	5.14*	-	4.76
	OE50	0.45	-	-	-	0.66
	Band	C	-	-	-	B
	No. Taxa	8	22	14	-	17
KEC-AQ1	Signal2	6.33	5.87*	5.00*	-	5.86
	OE50	0.36	-	-	-	0.44
	Band	C	-	-	-	C
	No. Taxa	9	16	13	-	14
MGC-AQ1	Signal2	5.23	5.62*	4.90*	-	4.83
	OE50	0.37	-	-	-	0.44
	Band	C	-	-	-	C
	No. Taxa	12	14	13	-	12
MEC-AQ1	Signal2	5.30	5.47*	5.10*	-	4.53
	OE50	0.44	-	-	-	0.59
	Band	C	-	-	-	B
	No. Taxa	10	18	14	-	19

The observed macroinvertebrate communities were all impoverished when compared to reference conditions, with the water quality results typically poor to fair at all impact and control monitoring reaches through the autumn 2017 to autumn 2019 monitoring period. The number of taxa recorded at each site are typically consistent across the autumn 2017 to autumn 2019 monitoring period and previous monitoring surveys, despite some surveys being conducted out of season. Considering all stream health results together, no major changes in comparison to previous monitoring results were detected at any reach and no areas of concern have been identified. Comparisons to the results of key analyses across all monitoring seasons are provided below.

Signal2 scores

Figure 4 highlights the observed changes in the Signal2 scores over all sampling years. While the water quality results were generally slightly lower in autumn 2018 than in recent monitoring periods, the scores were within the range of values previously recorded since 2011. A number of sites were found to have increased Signal2 scores in autumn 2019, also exhibiting a greater distribution of scores. Typically the results indicate moderate up to mild levels of stream health impairment across all monitoring sites. The results from the impact sites are consistent with the results for the control sites, indicating that broader scale environmental influences are responsible for relative fluctuations in water quality.

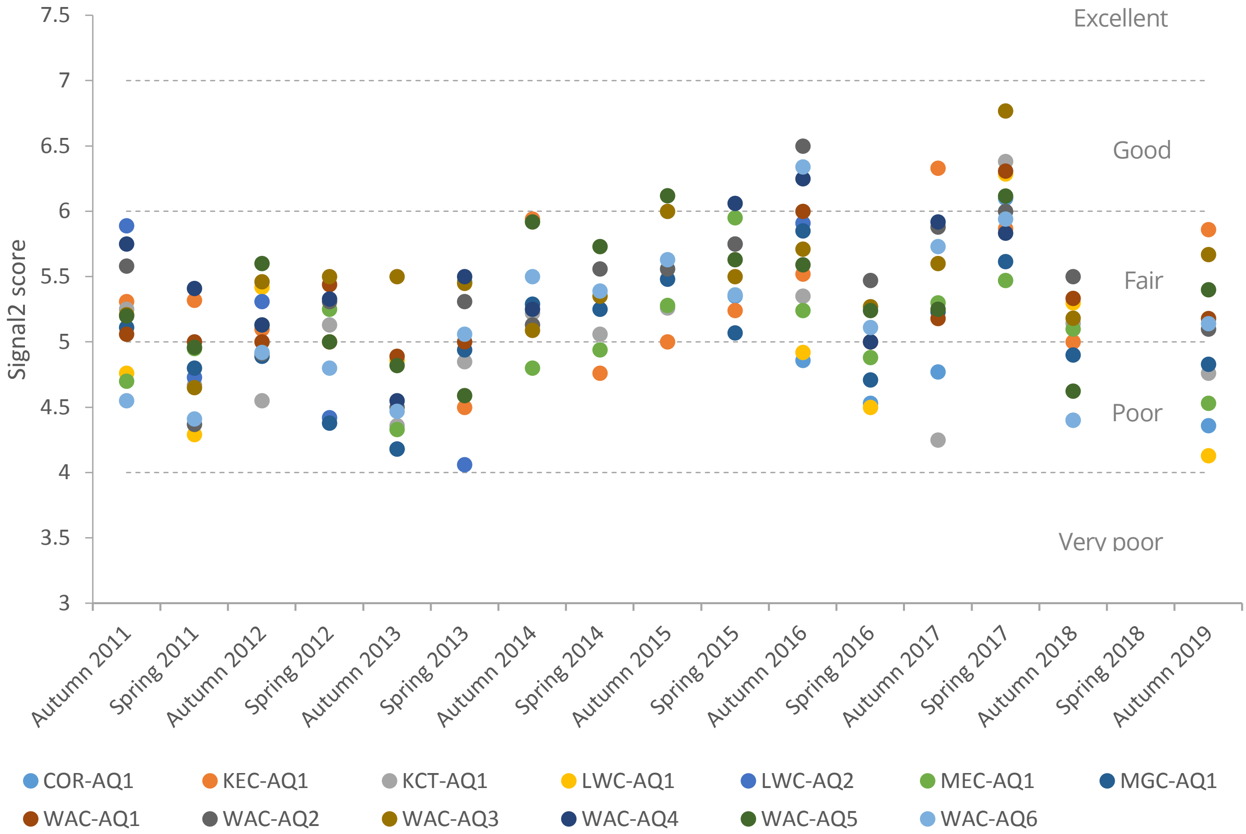

Figure 4 Signal2 scores for all monitoring periods

OE50 scores

Figure 5 highlights the observed changes in the OE50 scores across all sampling periods. OE50 scores may only be calculated for data collected within the prescribed AUSRIVAS monitoring periods (Turak et al. 2004), or under similar conditions. Hence, OE50 scores have not been calculated for the spring 2017 and autumn 2018 monitoring seasons, with no data collected in spring 2018. The OE50 scores, which indicate the diversity of macroinvertebrate communities, were generally below the average recorded across all years in autumn 2017 and 2019, although within the range of scores previously recorded. Autumn OE50 results tend to be somewhat lower than spring results, as seen in the results across all monitoring sites going back to 2011. The autumn 2017 results appear to be more concentrated and exhibit somewhat lower results than those recorded in previous years. However, the results from the control sites were consistent with the results for the impacts sites, indicating the lower results were due to broader environmental influences rather than any effects from mining operations in 2017. A similar trend is seen in the autumn 2019 data, however the scores are less concentrated, with the distribution more representative of the results typically seen within the previous monitoring seasons.

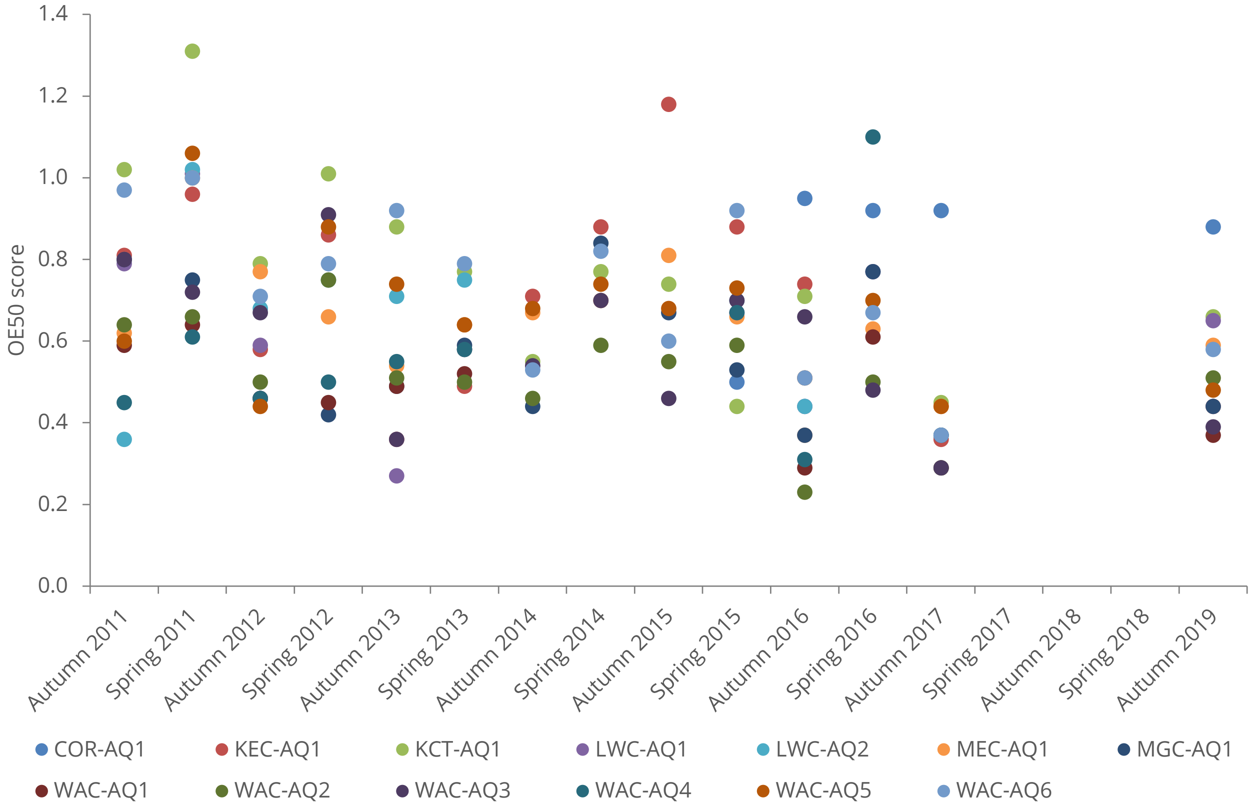

Figure 5 OE50 scores for all monitoring periods

3.2.3 Trigger values

Figure 6 shows that the majority of monitoring reaches are within the trigger values set out in this monitoring report for autumn 2018 and autumn 2019. A total of two sites were identified to be below the number of taxa trigger value during these monitoring periods, these sites were WAC-AQ3 in autumn 2019 and LWC-AQ1 in autumn 2018. Both of these sites recorded corresponding Signal2 scores above the Signal2 trigger value level. These scores were also above the average Signal2 score recorded for these sites. This indicates a relatively abundant presence of pollution sensitive taxa at these sites during the monitoring periods and therefore no indication of impacts to water quality beyond any catchment scale environmental influences experienced by all sites. LWC-AQ1 and WAC-AQ3 have only recorded a number of taxa score below ten on one other occasion since the monitoring program began in 2011. As such, no indications of decreasing stream health have been identified at these sites and no immediate supplementary investigations are required. The results at these sites should be reviewed in the 2019 monitoring program report to identify if the reduced number of taxa are part of a trend.

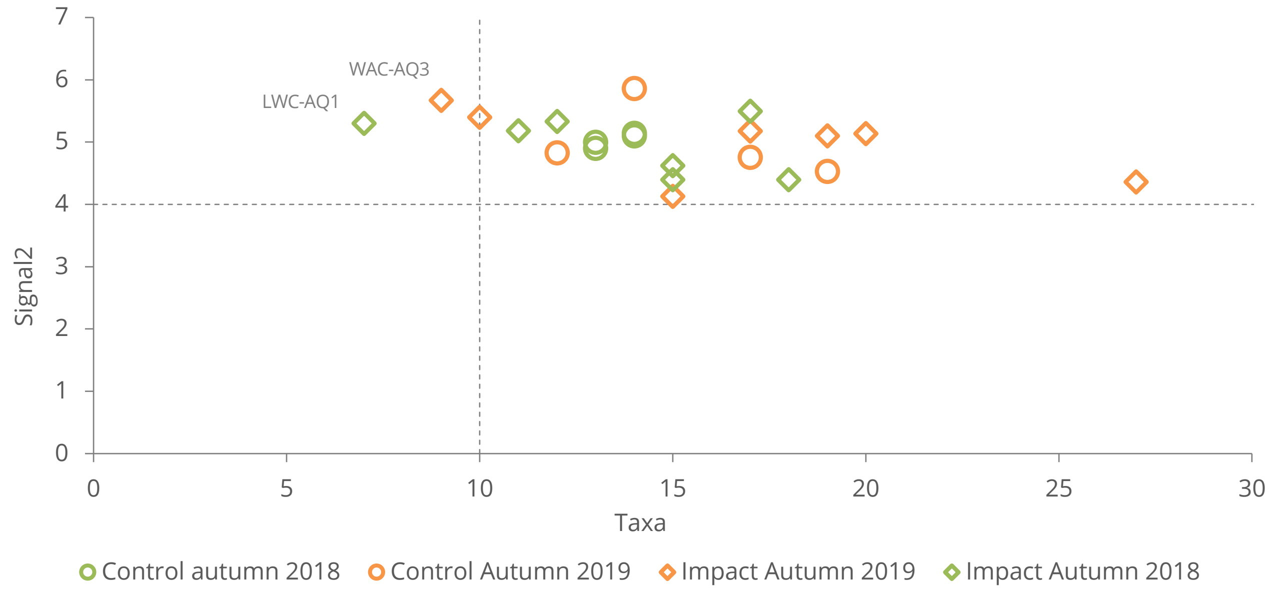

Figure 6 Trigger value biplot for the autumn 2018 and autumn 2019 monitoring periods

3.2.4 HABSCORE assessments

The HABSCORE assessments for each aquatic ecological monitoring season are presented in Figure 7. The results for autumn 2018 and autumn 2019 show a clear degree of consistency across the monitoring period and are within the range of values previously recorded across previous monitoring seasons. The majority of monitoring reaches recorded habitat grades of 'Suboptimal' during the autumn 2018 and autumn 2019 monitoring periods. Three sites recorded 'Marginal' grades in autumn 2018, due to these sites being dry and receiving low scores for water availability and flow status. No 'Optimal' scores were recorded during autumn 2018, likely a result of the highly reduced rainfall recorded during this period. Reduced rainfall will result in lower scores for both water availability and flow status. In actual habitat terms the reduced flows and rainfall inputs reduce the availability of habitat as the wetted perimeters of these waterways decrease, are reduced to refuge pools, or are completely dry where no groundwater inputs are present to maintain a baseflow through the waterway without rainfall. As is the case at Little Wattle Tree Creek which has recorded a number of dry seasons throughout the monitoring program and in autumn of 2018. The lack of flows also reduces habitat renewal with associated reduction in coarse and fine organic matter inputs from both longitudinal (upstream) and latitudinal (bank/floodplain) sources. In consideration of these factors, the HABSCORE results are within the range of values expected and are indicative of the prevailing catchment scale environmental conditions during the monitoring period.

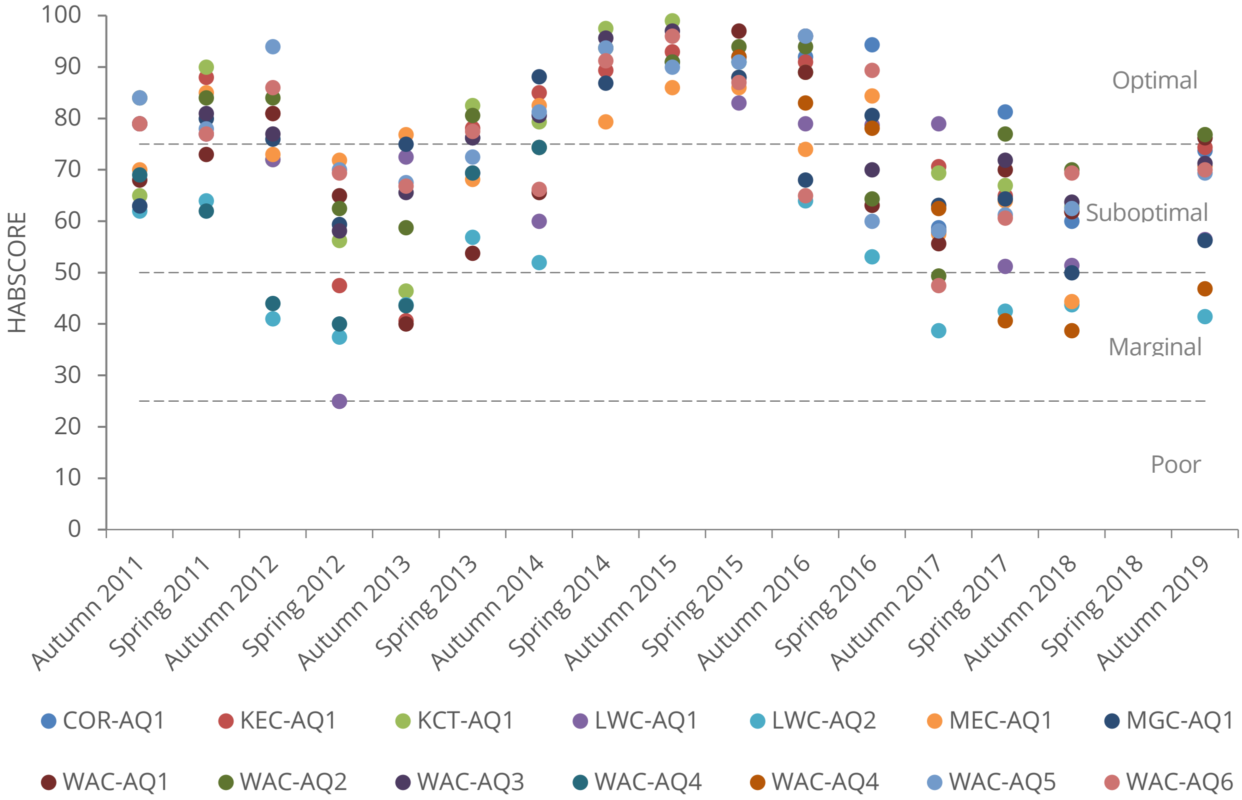

Figure 7 HABSCORE results for all montiroing periods

4 Discussion

The data collected in autumn of 2018 and 2019 adds to the existing baseline dataset to provide a total of 15 seasons of terrestrial monitoring data and 17 seasons of aquatic monitoring data between 2010 to 2019. The trends identified in previous iterations of the terrestrial ecological monitoring program are consistent with those observed during the recommencement of mining in the Nebo Area, continuing through the 2018 monitoring period.

Riparian vegetation

Assessment of site-based vegetation monitoring TSR data indicates that the monitoring results for autumn 2018 and 2019 are within the range of pre-mining data collected at the impact sites, and are comparable to the results of the paired controls. Although TSR was found to generally be increasing over time, this trend was observed across all sites (both impact and control), and thus is not likely to be a result of impacts due to mining. TSR was found to be higher at impact sites than control sites. However, this difference has been present since before mining occurred, and has remained consistent, indicating that this is a natural trend unrelated to mining.

Further analysis of vegetation data did not identify any statistically significant change in species composition based on mining effect at the impact sites. The species composition analysis indicated that there have been small changes to species composition at both impact and control sites over time. As this trend was not limited to sites that had been mined, the result is most likely due to natural fluctuations in species composition, which may have been caused by weather, species interactions or other natural processes.

Amphibian monitoring

The assessment of the mean number of frog species detected in the frog species monitoring data indicates that the data collected during the autumn 2018 period was generally lower than typically recorded. However, this pattern is also evident in the control sites and is attributed to the data being collected under winter conditions. In autumn 2019 the numbers of species detected at each site increased to the typical range of values recorded previously. In summary, no impacts associated with mining during the 2018 calendar year are identified through a visual inspection of the monitoring data.

Data collected illustrates a high level of seasonal and annual variation and includes a high proportion of monitoring events that record either one species or no species of frogs. Comparatively low mean numbers of frog species have been detected at the Little Wattle Tree Creek site during the 2017 to 2019 monitoring periods. Site observations indicate a reduction in water availability at all three monitoring transects along this site, also observed in the aquatic monitoring program (section 3.2.4), reducing the amount and condition of habitat suitable for frog species. No observations of mining impacts were recorded in this area by Biosis, such as surface cracking or deformation, flocculant, vegetation dieback or downstream impacts to water quality (section 3.2.2). The decline in frog species detected is seen to rebound in autumn 2019 and therefore the low numbers at this site in autumn 2018 are attributed to survey timing and seasonal conditions rather than impacts associated with mining.

Aquatic ecological monitoring

The findings of the previous monitoring reports have been used as an indicative baseline or benchmark, to which the monitoring results for autumn 2018 and autumn 2019 have been compared to.

The findings of the aquatic ecological monitoring program identified a variable but generally high level of taxonomic diversity with the aquatic ecological communities occurring within the Nebo Area, across all creeks surveyed. Water quality among impact sites ranged between poor and fair across the 2018 monitoring period. Some variation in water quality among control and impact sites were observed among during the 2018 monitoring period. These variations to be attributed to environmental variability not underground coal mining, since the results are within the range of results previously recorded for the sites. Further, no leachate or changes in flow regime beyond that expected due to the reduced flow conditions encountered during the monitoring period were observed at any of the sites.

The Signal2 scores were generally reduced in comparison to recent previous monitoring results, but were within the range of scores previously recorded across the monitoring sites. This indicates broad consistency with previous years and reflects the prevailing climatic and catchment scale environmental conditions at the time of survey. The OE50 scores at both impact and control monitoring reaches in autumn 2017 were generally lower than those previously recorded during the monitoring program, but were found to increase in autumn 2019 to values more typical of those recorded in previous rounds of monitoring.

TARPs

The TARPs developed for Longwalls N1-N6 (Niche 2012) are provided in Appendix 2. No impacts associated with mining have been identified as part of the terrestrial or aquatic monitoring program for the 2018 monitoring period. With no changes as compared to baseline observed in the 2018 data for each component of the ecological monitoring programs (riparian vegetation, amphibians and aquatic). As such no TARP levels have been triggered and monitoring should continue.

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Appendix 1 – Figures

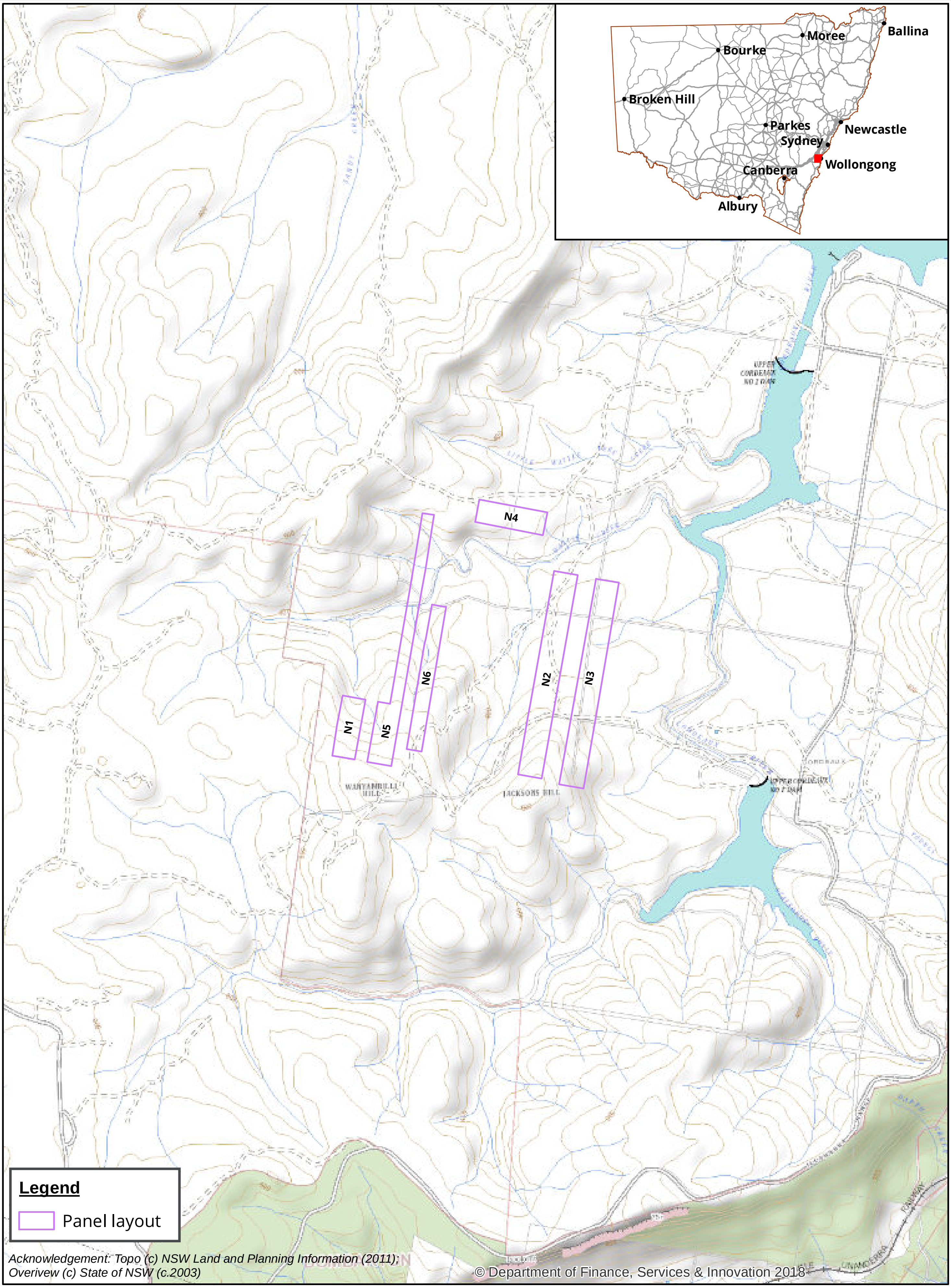

Figure 1 Location of the study area in a regional context

Matter: 30270
Date: 24 September 2019,
Checked by: LS, Drawn by: AEDM, Last edited by: amurray
Location:P:\30200s\30270\Mapping\

Biosis Pty Ltd
Albury, Ballarat, Melbourne,
Newcastle, Sydney, Wangaratta & Wollongong

0 200 400 600 800 1,000
Metres
N
Scale 1:25,000 @ A4, GDA 1994 MGA Zone 56

Legend

- Flora creek impact site
- Fauna creek impact site

Survey area

- Panel layout

Figure 2 Location of impact terrestrial monitoring sites in the Nebo Area

0 100 200 300 400

Metres

Scale: 1:7,500 @ A3

Coordinate System: GDA 1994 MGA Zone 56

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Matter: 30270
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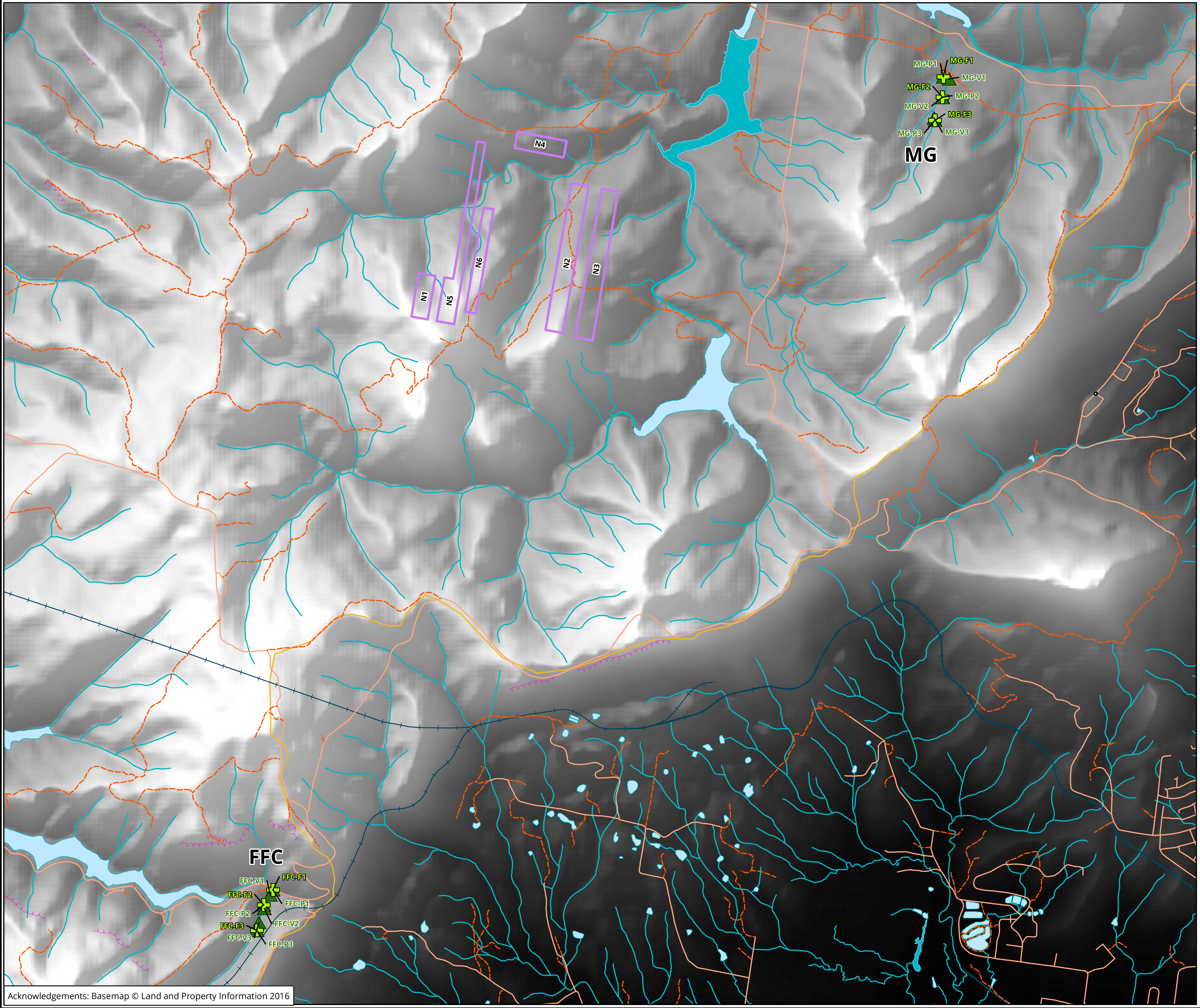

Legend

- Flora creek control site
- Fauna creek control site

Survey area

- Panel layout

Figure 3 Location of control terrestrial monitoring sites in the Nebo Area

0 200 400 600 800 1,000

Metres

Scale: 1:25,000 @ A3

Coordinate System: GDA 1994 MGA Zone 56

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Matter: 30270
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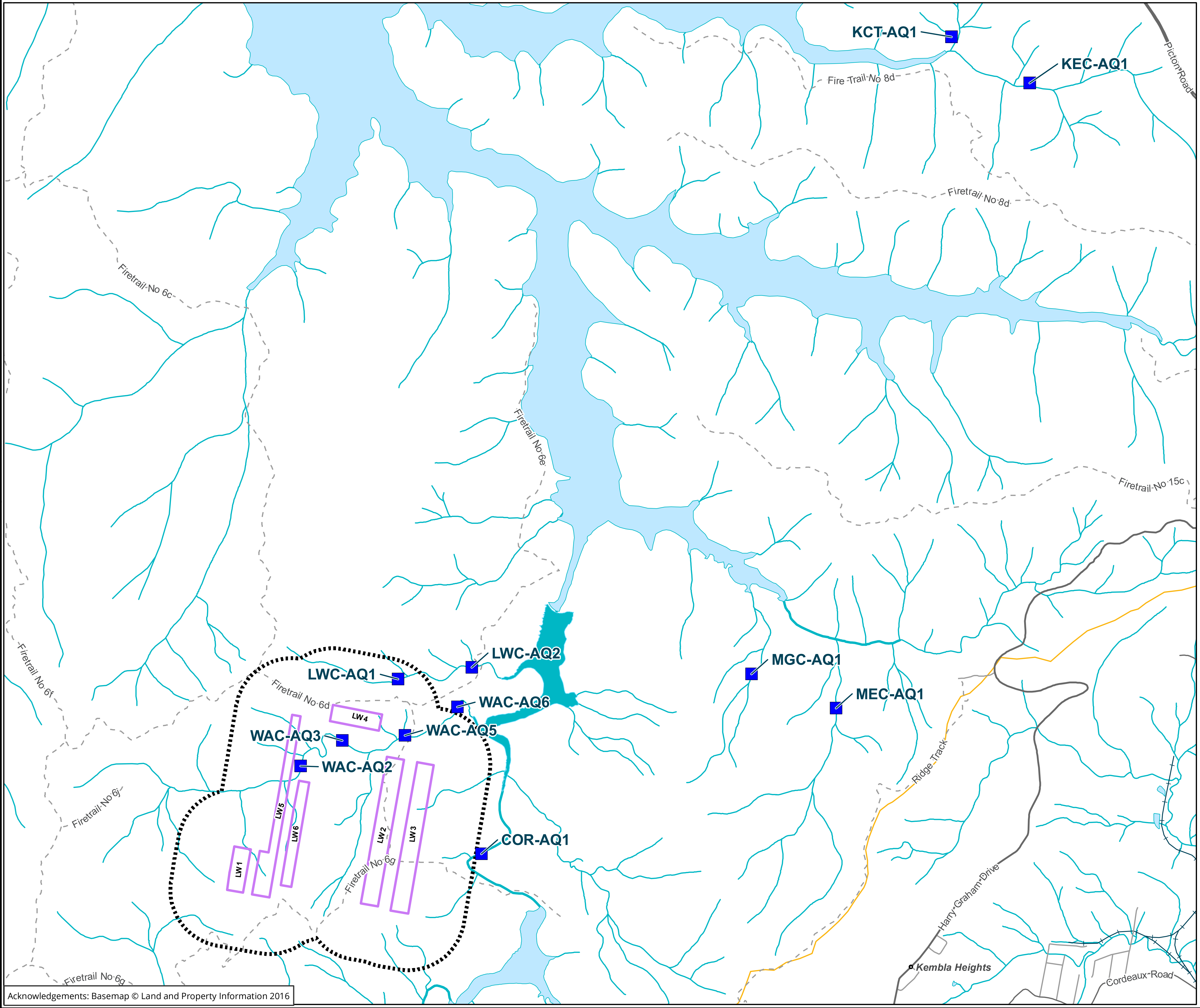

Acknowledgements: Basemap © Land and Property Information 2016

Figure 4 Aquatic monitoring sites

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Matter: 30270
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30270_F4_AqMonitoring

Appendix 2 - Trigger Action Response Plans

Table 8 –Trigger Action Response Plan (TARP) table for Longwalls N1-N6 (Niche 2012)

Feature	Monitoring Program			TARPs	
	Prior to Mining	During Mining	Post mining and Future Monitoring	Trigger	Response
Riparian vegetation					
3 Monitoring sites on Wattle 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).	Species inventory and modified Braun Blanquette cover - Abundance for each species. Autumn and spring during entire extraction period. Started for LWTC, not started for WTC.	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.	**NORMAL** No change as compared to baseline observed **WITHIN PREDICTIONS** Survey results within baseline variability **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	Continue monitoring Report in end of panel report Continue monitoring Report in end of panel report 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

Feature	Monitoring Program			TARPs	
	Prior to Mining	During Mining	Post mining and Future Monitoring	Trigger	Response
Amphibians					
3 Monitoring sites on Wattle 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 Creek and Little Wattle Tree Creek conducted Autumn and Spring. Baseline monitoring completed LWTC, ongoing WTC. Targeted Threatened Amphibian searches each Winter along Wattle Creek and Little Wattle Tree Creek.	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. Completed LWTC, not started WTC. Targeted Threatened Amphibian searches each Winter along Wattle 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.	**NORMAL** No change as compared to baseline observed **WITHIN PREDICTIONS** Survey results within baseline variability **EXCEEDS PREDICTIONS** Observed physical impacts to habitat. Statistically significant decrease in population numbers and/or species composition 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 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

Feature	Monitoring Program			TARPs	
	Prior to Mining	During Mining	Post mining and Future Monitoring	Trigger	Response
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 N4, 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).	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 N4. 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).	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 N4. 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).	**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.

Appendix 3 - Monitoring survey periods and survey dates

Table 9 –Monitoring survey periods and monitoring survey dates

Period	Vegetation	Amphibian	Aquatic
Spring 2010	01/10/10 (spring)	07/12/10 – 08/12/10 (spring - summer)	-
Autumn 2011	01/04/11 (autumn)	07/03/11 – 19/05/11 (autumn)	10/05/11 – 10/06/11 (autumn)
Spring 2011	01/10/11 (spring)	01/10/11 – 06/12/11 (spring – summer)	19/10/11 – 18/11/11 (spring)
Autumn 2012	01/04/12 (autumn)	26/03/12 – 23/05/12 (autumn)	29/05/12 – 31/05/12 (autumn)
Spring 2012	09/11/12 – 14/11/12 (spring)	04/10/12 – 22/11/12 (spring)	22/10/12 – 26/10/12 (spring)
Autumn 2013	12/04/13 – 07/06/13 (autumn)	14/03/13 – 20/05/13 (autumn)	18/03/13 – 22/03/13 (autumn)
Spring 2013	03/12/13 – 12/12/13 (spring – summer)	20/05/13 – 03/12/13 (spring – summer)	02/12/13 – 05/12/18 (spring – summer)
Autumn 2014	05/05/14 – 06/05/14 (autumn)	17/03/14 – 06/05/14 (autumn)	18/03/14 – 21/03/14 (autumn)
Spring 2014	-	-	07/10/14 – 10/10/14 (spring)
Autumn 2015	-	-	23/03/15 – 05/06/15 (autumn)
Spring 2015	02/10/15 – 14/10/15 (spring)	15/10/15 – 26/11/15 (spring)	22/09/15 – 25/09/15 (spring)
Autumn 2016	17/03/16 – 18/03/16 (autumn)	16/03/16 – 23/03/16 (autumn)	15/06/16 – 17/06/16 (autumn)
Spring 2016	23/01/17 – 27/01/17 (summer)	21/12/16 – 13/01/17 (summer)	22/12/16 – 23/12/16 (summer)
Autumn 2017	25/05/17 – 26/05/17 (autumn)	25/05/17 – 30/05/17 (autumn)	24/07/2017 – 27/07/17 (winter)
Spring 2017	10/01/18 - 18/01/18 (summer)	23/01/18 – 25/01/18 (summer)	17/01/18 – 01/02/18 (summer)
Autumn 2018	-	23/07/19 – 26/07/19 (winter)	06/08/18 – 08/08/18 (winter)

Period	Vegetation	Amphibian	Aquatic
Spring 2018	29/01/19 – 01/02/19 (summer)	-	-
Autumn 2019	17/04/19 – 30/04/19 (autumn)	11/06/19 – 13/06/19 (autumn – winter)	21/05/19 – 22/07/19 (autumn – winter)

Appendix 4 - Aquatic macroinvertebrate results

Table 10 –Aquatic macroinvertebrate results 2011 - 2019

Site	Indices	2011		2012		2013		2014		2015		2016		2017		2018		2019
		Aut	Spr	Aut	Spr	Aut	Spr	Aut	Spr	Aut	Spr	Aut	Spr	Aut	Spr	Aut	Spr	Aut
KCT-AQ1	Signal2	5.25	4.67	4.55	4.44	4.30	5.13	5.22	5.06	5.26	5.75	5.35	-	4.25	6.38	5.14	-	4.76
	OE50	1.02	1.31	0.79	1.01	0.88	0.88	0.55	0.77	0.74	0.44	0.71	-	0.45	-	-	-	0.66
	Band	A	X	B	A	A	A	B	B	B	C	B	-	C	-	-	-	B
	Taxa	17	24	11	17	11	15	9	16	19	18	19	-	8	22	14	-	17
KEC-AQ1	Signal2	5.31	5.32	5.10	4.35	4.67	4.55	5.94	4.76	5.00	5.24	5.52	-	6.33	5.87	5.00	-	5.86
	OE50	0.81	0.96	0.58	0.86	0.36	0.47	0.71	0.88	1.07	0.88	0.74	-	0.36	-	-	-	0.44
	Band	B	A	B	A	C	C	B	A	A	A	B	-	C	-	-	-	C
	Taxa	17	25	10	14	9	11	16	18	25	24	27	-	9	16	13	-	14
WAC-AQ1	Signal2	5.06	5.00	5.00	4.48	4.47	5.44	-	-	-	5.40	6.00	5.00	5.18	6.31	5.33	-	5.18
	OE50	0.59	0.64	0.46	0.45	0.49	0.49	-	-	-	0.48	0.29	0.61	0.29	-	-	-	0.37
	Band	B	B	C	C	B	C	-	-	-	C	C	B	C	-	-	-	C
	Taxa	16	16	7	10	10	9	-	-	-	11	11	13	11	14	12	-	17
WAC-AQ2	Signal2	5.58	4.37	4.91	4.45	4.35	5.24	5.13	5.56	5.56	5.75	6.50	5.47	5.88	6.00	5.50	-	5.10
	OE50	0.64	0.66	0.50	0.75	0.51	0.50	0.46	0.59	0.44	0.59	0.23	0.50	0.29	-	-	-	0.51
	Band	B	B	B	B	B	C	C	B	C	B	C	C	C	-	-	-	B
	Taxa	12	19	11	14	9	17	9	21	16	19	16	17	17	18	17	-	19
WAC-AQ3	Signal2	5.21	4.65	5.46	4.36	4.65	5.71	5.09	5.35	6.00	5.50	5.71	5.27	5.60	6.77	5.18	-	5.67
	OE50	0.80	0.72	0.67	0.91	0.36	0.55	0.54	0.70	0.37	0.70	0.66	0.48	0.29	-	-	-	0.39
	Band	B	B	B	A	C	B	B	B	C	B	B	C	C	-	-	-	C
	Taxa	15	21	13	15	7	13	11	20	11	20	21	16	15	14	11	-	9
WAC-AQ4	Signal2	5.75	5.41	5.13	4.44	4.42	5.14	5.25	-	-	6.06	6.25	5.00	5.92	5.83	-	-	-

Site	Indices	2011		2012		2013		2014		2015		2016		2017		2018		2019
		Aut	Spr	Aut	Spr	Aut	Spr	Aut	Spr	Aut	Spr	Aut	Spr	Aut	Spr	Aut	Spr	Aut
	OE50	0.45	0.61	0.46	0.50	0.55	0.56	0.49	-	-	0.67	0.31	1.10	0.37	-	-	-	-
	Band	C	B	C	C	B	B	B	-	-	B	C	B	C	-	-	-	-
	Taxa	12	17	9	10	12	14	16	-	-	17	12	12	13	7	-	-	-
WAC-AQ5	**Signal2**	5.20	4.96	5.60	4.35	4.64	4.63	5.92	5.73	6.12	5.63	5.59	5.24	5.25	6.12	4.63	-	5.40
	OE50	0.60	1.06	0.44	0.88	0.74	0.71	0.68	0.74	0.58	0.73	1.03	0.70	0.44	-	-	-	0.48
	Band	B	A	C	A	B	B	B	B	B	B	B	B	C	-	-	-	B
	Taxa	15	26	10	18	18	18	12	23	25	31	17	18	16	18	15	-	10
WAC-AQ6	**Signal2**	4.55	4.41	4.92	4.58	4.58	5.05	5.50	5.39	5.63	5.35	6.34	5.11	5.73	5.94	4.40	-	5.14
	OE50	0.97	1.00	0.71	0.79	0.92	0.77	0.53	0.82	0.51	0.92	0.51	0.67	0.37	-	-	-	0.58
	Band	A	A	B	B	A	B	B	B	B	A	B	B	C	-	-	-	B
	Taxa	20	27	14	16	21	19	13	22	16	22	29	21	11	18	18	-	20
LWC-AQ1	**Signal2**	4.76	4.29	5.42	-	4.46	4.67	-	-	-	5.75	4.92	4.50	-	6.29	5.30	-	4.13
	OE50	0.79	1.01	0.59	-	0.27	0.71	-	-	-	0.67	0.44	0.77	-	-	-	-	0.65
	Band	B	A	B	-	C	B	-	-	-	B	C	B	-	-	-	-	B
	Taxa	18	17	13	-	8	12	-	-	-	16	12	17	-	18	7	-	15
LWC-AQ2	**Signal2**	5.89	4.73	5.31	4.43	4.68	4.06	-	-	-	5.26	5.91	-	-	-	-	-	-
	OE50	0.36	1.02	0.68	0.75	0.71	0.75	-	-	-	0.70	0.44	-	-	-	-	-	-
	Band	C	A	B	B	B	B	-	-	-	B	C	-	-	-	-	-	-
	Taxa	9	26	14	13	18	17	-	-	-	19	23	-	-	-	-	-	-
MGC-AQ1	**Signal2**	5.11	4.80	4.89	4.58	4.45	5.18	5.29	5.25	5.48	5.07	5.85	4.71	5.23	5.62	4.90	-	4.83
	OE50	0.80	0.75	0.46	0.42	0.49	0.59	0.44	0.84	0.62	0.53	0.37	0.77	0.37	-	-	-	0.44
	Band	B	B	C	C	B	B	C	A	B	B	C	B	C	-	-	-	C
	Taxa	18	15	10	8	13	17	14	23	21	17	19	16	12	14	13	-	12
MEC-AQ1	**Signal2**	4.70	4.95	5.13	4.35	4.43	5.43	4.80	4.94	5.28	5.95	5.24	4.88	5.30	5.47	5.10	-	4.53
	OE50	0.62	1.00	0.77	0.66	0.54	0.63	0.67	0.70	0.73	0.66	0.37	0.63	0.44	-	-	-	0.59
	Band	B	A	B	B	B	B	B	B	B	B	C	B	C	-	-	-	B

Site	Indices	2011		2012		2013		2014		2015		2016		2017		2018		2019
		Aut	Spr	Aut	Spr	Aut	Spr	Aut	Spr	Aut	Spr	Aut	Spr	Aut	Spr	Aut	Spr	Aut
	Taxa	10	20	17	17	17	14	16	19	25	21	16	17	10	18	14	-	19
COR-AQ1	**Signal2**	-	-	-	-	-	-	-	-	-	5.35	4.86	4.53	4.77	6.10	4.40	-	4.36
	OE50	-	-	-	-	-	-	-	-	-	0.50	0.95	0.92	0.92	-	-	-	0.88
	Band	-	-	-	-	-	-	-	-	-	C	A	A	A	-	-	-	A
	Taxa	-	-	-	-	-	-	-	-	-	21	21	20	26	21	15	-	27

Appendix B – Biosis NEBO LWN1 EoP Report

Nebo Area – Longwall N1: End of Panel Report (Ecology)

FINAL REPORT

Prepared for Wollongong Coal Pty Ltd

15 October 2019

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- Wollongong Coal: Robert Faddy-Vrouwe and Sasa Cugalj

Biosis staff involved in this project were:

- Anne Murray (mapping)

Contents

Tables

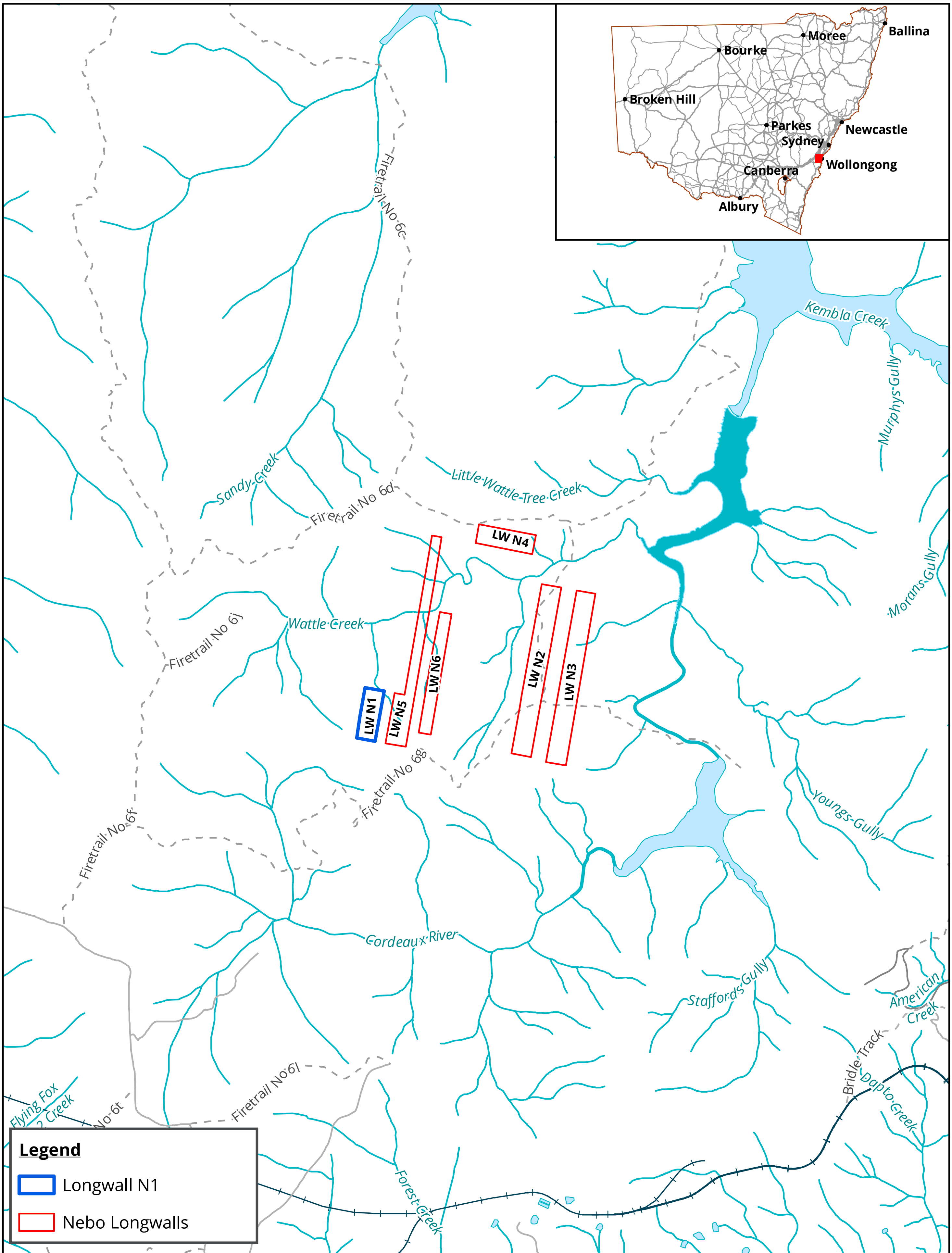
Figures

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 N1 in the Nebo Area at Wongawilli Colliery. This report assesses the post mining conditions of sensitive terrestrial and aquatic ecological features with associated Risk Management Zones (RMZ) (DoP 2008) that will potentially be impacted upon by the extraction of Longwall N1 (Figure 1). Extraction of Longwall N1 started on 22 May 2017 and extraction of the full panel was completed on 16 September 2018.

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 N1, 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)

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Figure 1 Longwall N1, Nebo Area

Matter: 29884
Date: 24 September 2019,
Checked by: AJB, Drawn by: AEDM, Last edited by: amurray
Location:P:\29800s\29884\Mapping\

0 200 400 600 800 1,000
Metres
N
Scale 1:30,000 @ A4, GDA 1994 MGA Zone 56

2 Monitoring programs

The ecological monitoring programs for the Nebo Area are detailed within the Nebo Longwalls N1-N6 Subsidence Monitoring Plan (SMP) (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 summarised 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 conducts annual surveys at impact and control sites shown in Figure 2 and Figure 3, including:

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

There are no significant swamps, threatened frog habitat (Biosis 2014) or ridgeline features in the vicinity of Longwall N1.

The terrestrial 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 terrestrial ecology monitoring program employs a Before-After Control-Impact (BACI) design. This design compares monitoring sites pre- and post-mining and compares impact sites to control sites. Impact sites are those positioned to detect possible changes to sensitive ecological features that have the subsidence footprint of the longwall occurring within their associated RMZ. Control sites are those that have not had the subsidence footprint of the longwall occurring within their associated RMZ. Control sites were selected based on their geographical, ecological and structural similarity to the impact sites.

While both Wattle Creek and Little Wattle Tree Creek have been identified as sensitive ecological features in the Nebo mining area the subsidence footprint of Longwall N1 extends into the RMZ of Wattle Creek only and not Little Wattle Tree Creek. Therefore this EoP addresses only data collected from Wattle Creek sites, identified in Table 1.

2.1.1 Monitoring to date

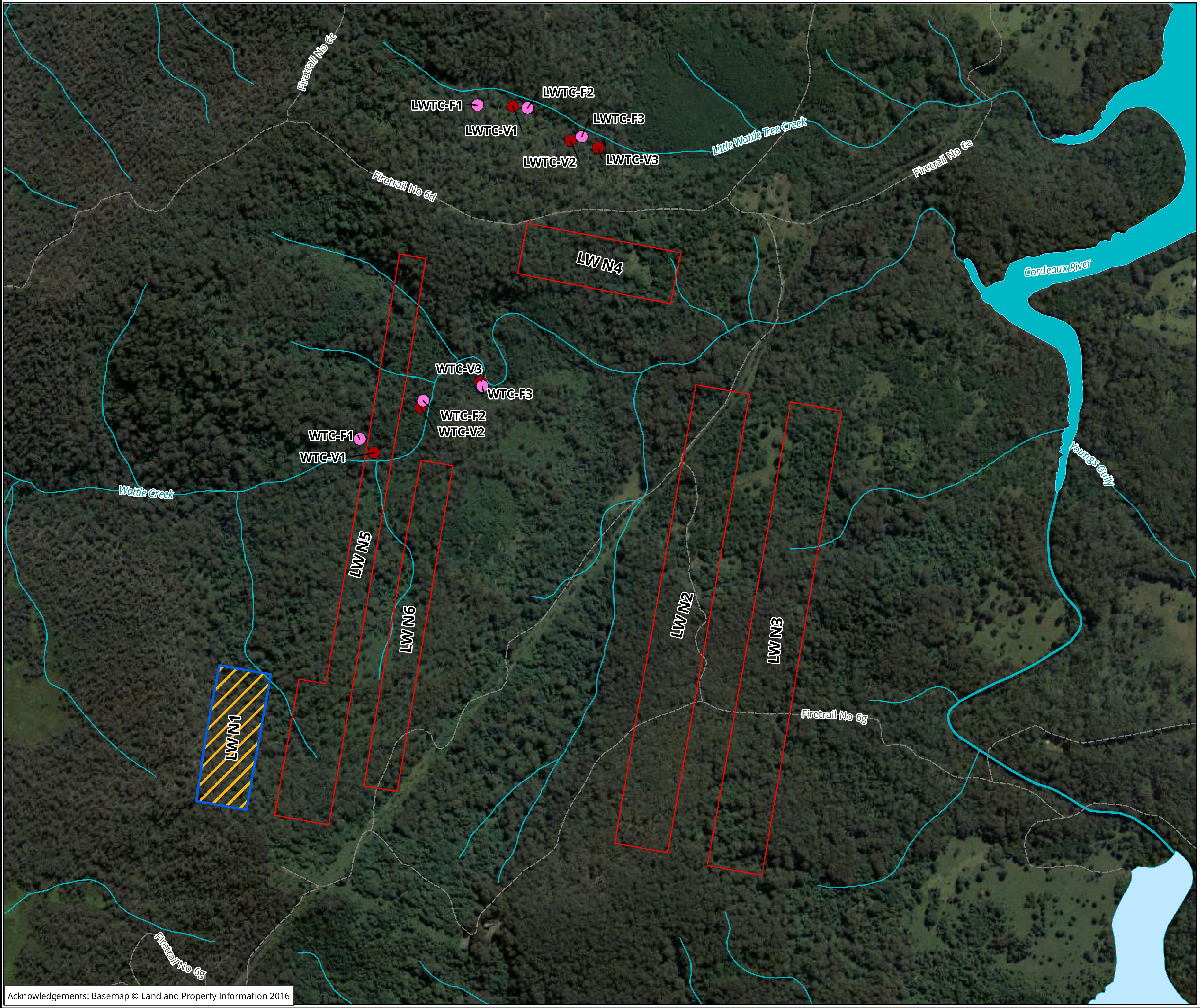
Baseline terrestrial monitoring of impact sites within the Nebo area commenced with the spring 2010 monitoring period and monitoring of paired controlled sites commenced with the autumn 2011 monitoring period. This monitoring was undertaken until autumn 2014 and was then suspended after mining of Longwall

N2 was completed in February 2014. Baseline terrestrial monitoring recommenced in spring 2015 before the proposed extraction of Longwall N4. Excluding flora monitoring in autumn 2018 and fauna monitoring in spring 2018, terrestrial ecology monitoring has been completed for both autumn and spring periods up to autumn 2019.

The terrestrial monitoring program, including monitoring type, sites, site type and methodology, is summarised in Table 1. Full survey methodologies are reported in Biosis (2019).

Table 1 Terrestrial ecology monitoring program

Monitoring	Impact sites (Figure 2)	Control sites (Figure 3)	Methodology
Riparian Vegetation	Wattle Creek	Flying Fox Creek No. 3 Morans Gully	Vegetation surveys within creeks are undertaken at three 20 m x 20 m (400 m^2) quadrats per creek located at least 150 m apart. Within each quadrat, subjective cover abundance scores are given to each species occurring within the quadrat using a modified Braun-Blanquet scale. Surveys are undertaken once in spring and once in autumn each year.
Amphibians	Wattle Creek	Flying Fox Creek No. 3 Morans Gully	Nocturnal frog surveys within creeks are undertaken at three 50 m 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

Nebo Longwalls

Longwall N1

Extent mined

Figure 2 Terrestrial ecology monitoring impact sites

0 100 200 300 400

Metres

Scale: 1:8,000 @ A3

Coordinate System: GDA 1994 MGA Zone 56

N

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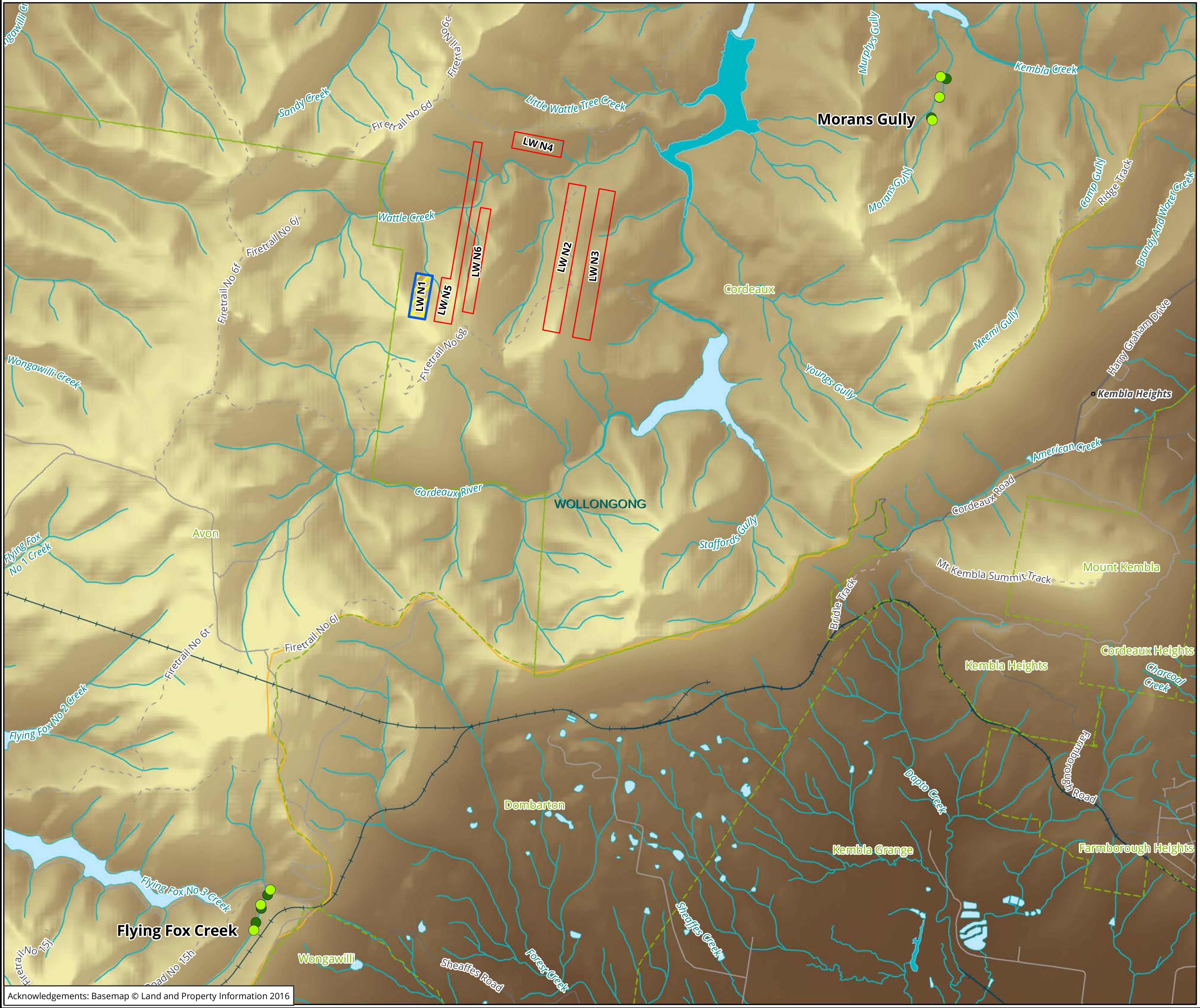
Matter: 29884
Date: 24 September 2019,
Checked by: AJB, Drawn by: AEDM, Last edited by: amurray
Location:P:\29800s\29884\Mapping
29884_F2_EcoImpactMonitoring



Legend

Flora Monitoring

- Flora creek control site

Fauna Monitoring

- Fauna creek control site

Survey Area

- Nebo Longwalls
- Longwall N1
- Extent mined

Figure 3 Terrestrial ecology monitoring control sites

0 200 400 600 800 1,000

Metres

Scale: 1:25,000 @ A3

Coordinate System: GDA 1994 MGA Zone 56

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Matter: 29884
Date: 24 September 2019,
Checked by: AJB, Drawn by: AEDM, Last edited by: lstone
Location:\\bio-data-01\matters$\29800s\29884\Mapping\29884_F3_EcoControlMonitoring

2.2 Aquatic ecology monitoring program

The aquatic ecology monitoring program aims to identify changes in the relative condition of aquatic ecology values during mining activity. Aquatic monitoring for Longwalls N1-6 is undertaken at eight impact sites and four control sites, monitored during spring and autumn (Figure 4), including:

- Aquatic habitat monitoring, including surface water quality monitoring.
- Monitoring of aquatic macroinvertebrates (following the NSW AUSRIVAS methodology).
- Photo point monitoring.

The aquatic ecology monitoring program is required to be conducted for a minimum of two year's pre-mining, during mining and a minimum of one year post mining.

The aquatic ecological monitoring programs employ a Before-After Control-Impact (BACI) design, comparing sites pre- and post- mining and comparing impact sites with control sites. While both Wattle Creek and Little Wattle Tree Creek have been identified as key ecological features in the Nebo mining area the subsidence footprint of Longwall N1 extends into the RMZ of Wattle Creek only. Therefore, only impact sites associated with Wattle Creek will be able to detect potential subsidence impacts from Longwall N1, as indicated in Table 2.

2.2.1 Monitoring to date

The Nebo area includes longwalls (N1, N2, N3, N4, N5 and N6) with subsidence footprints that may impact upon the catchments of Wattle Creek and Little Wattle Tree Creek within the greater catchment of Lake Cordeaux. Mining operations in the Nebo lease area first commenced with Longwall N2 in June 2013 and ceased in February 2014. Mining and associated aquatic ecology monitoring recommenced with the extraction of Longwall N4. Excluding monitoring in spring 2018 and aquatic terrestrial ecology monitoring has been completed for both autumn and spring periods up to autumn 2019.

Previous aquatic surveys of the study area had been conducted by another consultancy in spring 2009 and autumn 2010. These surveys involved sampling at two 'impact' reaches within the Application Area (both on Wattle Creek) and four 'control' reaches on nearby waterways (Kentish Creek and the upper Cordeaux River) that are not expected to be undermined in the near future. This original study design was considered unsuitable due to the small number of impact reaches monitored within the Application Area. Biosis was commissioned to develop an alternative monitoring program with an appropriate number of monitoring reaches commensurate with the size of the Application Area. Biosis established six additional monitoring reaches within the Application Area and the inclusion of four control monitoring reaches on Moran's Gully, Meemi Creeks, Kentish Creek and a tributary of Kentish Creek.

Details of the aquatic monitoring program, including monitoring type, monitoring reaches, and methodology, area provided in Table 2.

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-AQ1 WAC-AQ2 WAC-AQ3 WAC-AQ5 WAC-AQ6	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.
Aquatic macroinvertebrate monitoring	WAC-AQ1 WAC AQ2 WAC-AQ3 WAC-AQ5 WAC-AQ6	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-AQ1 WAC AQ2 WAC-AQ3 WAC-AQ5 WAC-AQ6	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.

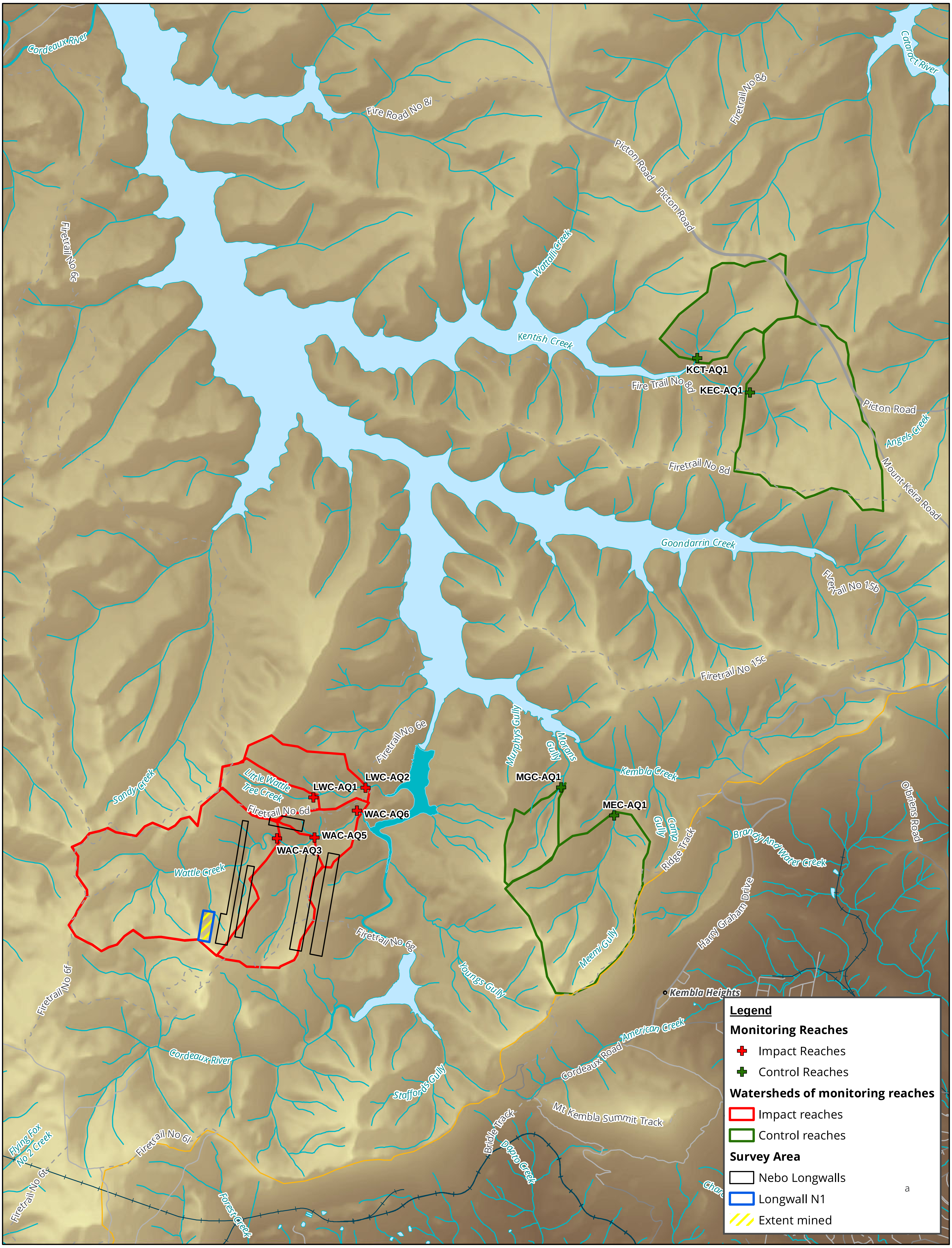

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Figure 4 Aquatic monitoring sites

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

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3 Impact assessment

3.1 Results of monitoring programs

3.1.1 Terrestrial ecology

No subsidence effects on either riparian vegetation or amphibian ecological values in the Wattle Creek catchment has been detected as a result of the extraction of Longwall N1. Detailed results of the terrestrial monitoring program are presented in the annual monitoring reports, most recently Biosis (2019). The existing field survey results indicates that vegetation has not changed as a result of mining and baseline sites remain comparable with control sites. Changes in vegetation community species composition have not deviated from those predicted and have been observed at both impact and control sites indicating that any small changes observed are most likely natural fluctuations and not mining related.

3.1.2 Aquatic ecology

Existing results from aquatic monitoring have not detected any subsidence effects on aquatic ecological values in the Wattle Creek catchments resulting from Longwall N1. Detailed results of the aquatic ecology monitoring program are presented in the annual monitoring reports, most recently Biosis (2019). Existing aquatic survey results indicate that aquatic ecological values have not deviated from baseline values and remain comparable with the control sites indicating that any small changes observed are most likely natural fluctuations and not mining related.

3.2 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 250 mm 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 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 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.	No observable changes to vegetation composition in Wattle Tree Creek or Little Wattle Tree Creek.	Yes
Upland swamps	Low – Swamp No.22 and Swamp No.39 are at least 40 m from the predicted subsidence footprint and over 400 m 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 N1.	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 N1.	N/A

3.3 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 N1.

A TARP assessment (Appendix 1) is provided in Table 4 (riparian vegetation), Table 5 (amphibians), and Table 6 (aquatic ecology).

3.3.1 Longwall N1

Monitoring in the Nebo Area to date has not identified any impacts to flora and fauna, and aquatic ecology sites as a result of subsidence associated with mining of Longwall N1. No other management actions have been triggered under the TARP (Table 4, Table 5 and Table 6).

3.3.2 Cumulative Impacts within the Nebo Mining Domain

Longwall N1 which commenced on 22 May 2017 and was completed on 16 September 2018, is the third longwall extraction completed within the Nebo Area. Longwall N2 commenced in June 2013 and ceased in February 2014. Longwall 4 was completed between August 2016 and May 2017.

No cumulative impacts have been recorded following the completions of any longwall.

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 N1, and compares these observed impacts to impacts predicted to occur.

Using the most recently analysed data, observed impacts are within predictions and significant impacts to ecological values have not resulted from the extraction of Longwall N1. No management actions under the TARP have been triggered. No cumulative impacts have resulted from the extraction of both longwalls in the Nebo area.

It is recommended that monitoring of all natural features above Longwall N1 be conducted for one year post-mining. If no impacts are observed during this time monitoring should cease, as per the Biodiversity Management Plan (Niche 2012).

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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 SMP (NRE 2014) 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 N1
Riparian vegetation 3 Monitoring sites on Wattle 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 completed to LWTC, ongoing for WTC.	Species inventory and modified Braun Blanquette cover - Abundance for each species. Autumn and spring during entire extraction period. During mining monitoring completed for Longwall N1.	Species inventory and modified Braun Blanquette cover - Abundance for each species. Autumn and Spring for a minimum of one year post-mining. Monitoring ongoing for this stage as it relates to N1. Completion of spring 2019 post mining monitoring required	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. **WITHIN PREDICTIONS** Survey results within baseline variability. **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	• Continue monitoring • Report in end of panel report • Continue monitoring • Report in end of panel report • 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	No management action/s required. No change to flora species or vegetation communities was observed when compared to baseline and control sites.

Table 5 Trigger Action Response Plan (TARP) Table, amphibians, including assessment of actions required by the Subsidence Monitoring Plan (NRE 2014) 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 N1
Amphibians 3 Monitoring sites on Wattle 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 Creek and Little Wattle Tree Creek conducted Autumn and Spring. Baseline monitoring completed LWTC, ongoing WTC. Targeted Threatened Amphibian searches each Winter along Wattle 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. Completed LWTC, not started WTC. Targeted Threatened Amphibian searches each winter along Wattle 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. **WITHIN PREDICTIONS** Survey results within baseline variability. **EXCEEDS PREDICTIONS** Observed physical impacts to habitat. Statistically significant decrease in population numbers and/or species composition 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 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	No management action/s required. No changes in amphibian populations or habitats were observed when compared to baseline and control sites.

Table 6 Trigger Action Response Plan (TARP) Table, aquatic ecology, including assessment of actions required by the Subsidence Monitoring Plan (NRE 2014) 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 N1
Aquatic ecology 6 Monitoring sites on Wattle 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 N1, 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 N1, 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 N1. 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 N1.	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 N1 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 N1.	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.

Appendix C – Biosis NEBO N3 & N5 EoP Report

Nebo Area – Longwalls N3 and N5: End of Panel Report (Ecology)

FINAL REPORT

Prepared for Wollongong Coal Pty Ltd

27 September 2019

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Document control

Version	Internal reviewer	Date issued
Draft version 01	Luke Stone	27/09/19
Final version 01	Tony Cable	18/10/19

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- Wollongong Coal: Robert Faddy-Vrouwe and Sasa Cugalj

Biosis staff involved in this project were:

- Anne Murray (mapping)

Contents

Tables

Figures

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 Longwalls N3 and N5 in the Nebo Area at Wongawilli Colliery. This report assesses the post mining conditions of sensitive terrestrial and aquatic ecological features with associated Risk Management Zones (RMZ; DoP 2008) that will potentially be impacted upon by the extraction of Longwalls N3 and N5 (Figure 1). Extraction of Longwall N3 started on 4 October 2016 and was completed on 13 March 2019. Extraction of Longwall N5 started on 20 March 2017 and was completed on 26 January 2019. The full longwall panel length was extracted for both longwalls.

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 Longwalls N3 and N5, as well as cumulative impacts from longwall mining in the Nebo Area.

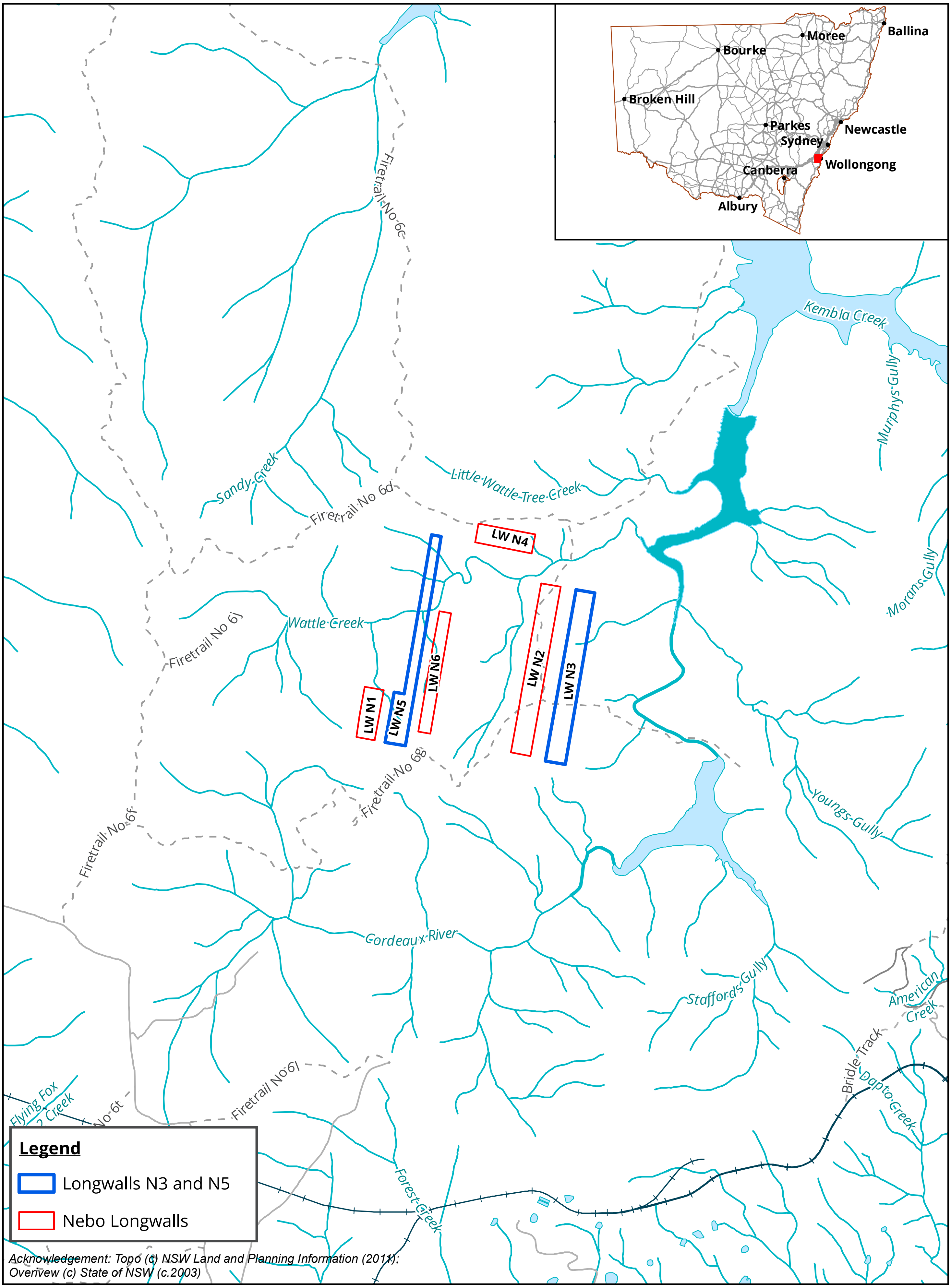

Figure 1 Longwalls N3 and N5, Nebo Area

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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 conducts annual surveys at impact and control sites shown in Figure 2 and Figure 3, including:

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

There are no significant swamps, threatened frog habitat (Biosis 2014) or ridgeline features in the vicinity of Longwalls N3 and N5.

The terrestrial 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 program employs a Before-After Control-Impact (BACI) design. This design compares monitoring sites pre- and post-mining and compares impact sites to control sites. Impact sites are those positioned to detect possible changes to ecological features that have the subsidence footprint of the longwall occurring within their associated RMZ. Control sites are those that have not had the subsidence footprint of the longwall occurring within their associated RMZ. Control sites were selected based on their geographical, ecological and structural similarity to the impact sites.

While both Wattle Creek and Little Wattle Tree Creek have been identified as sensitive ecological features in the Nebo mining area the subsidence footprints of Longwalls N3 and N5 extends into the RMZ of Wattle Creek only and not Little Wattle Tree Creek. Therefore this EoP addresses only data collected from Wattle Creek sites, identified in Table 1.

2.1.1 Monitoring to Date

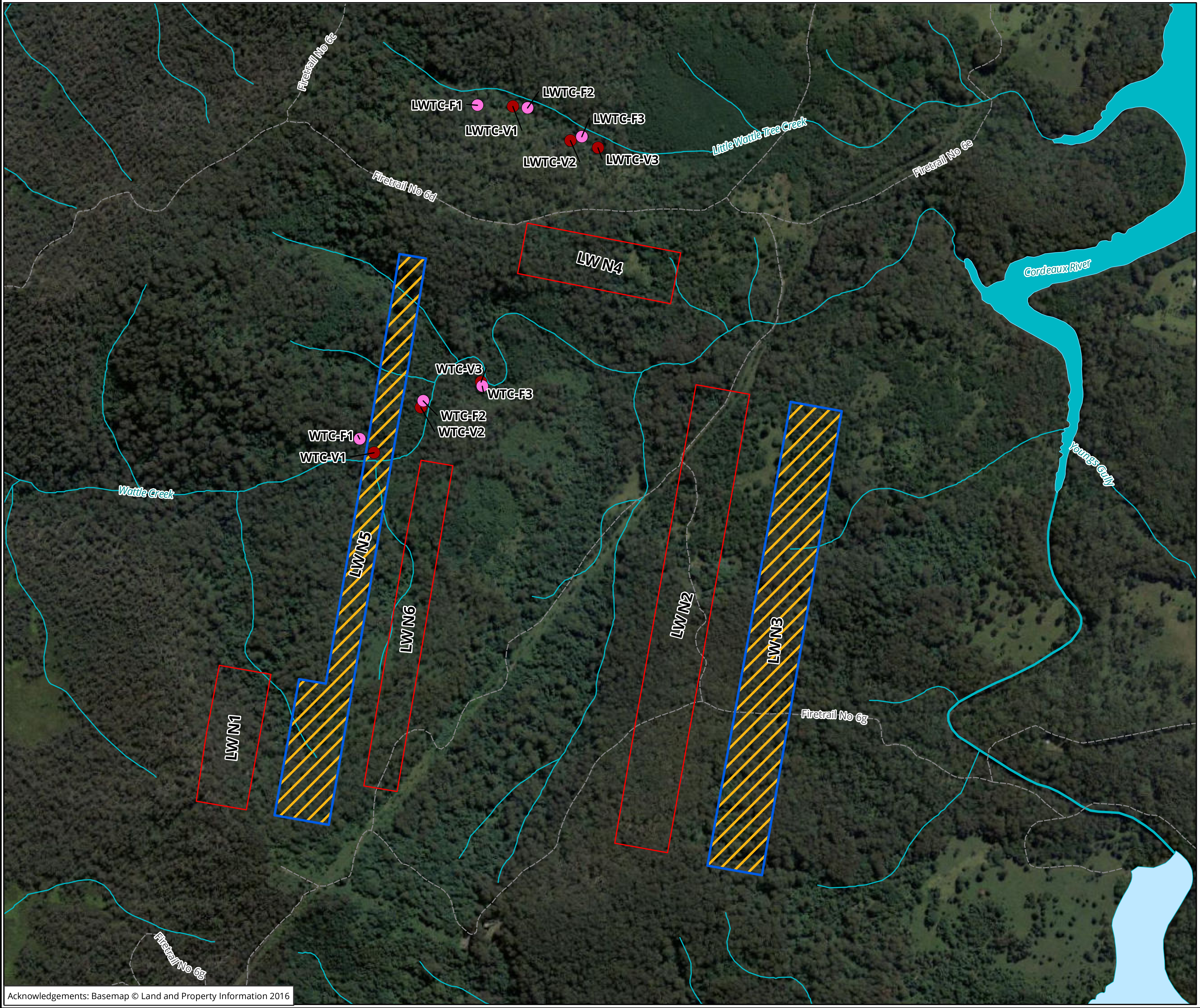
Baseline terrestrial monitoring of impact sites within the Nebo area commenced with the spring 2010 monitoring period and monitoring of paired controlled sites commenced with the autumn 2011 monitoring period. This monitoring was undertaken until the completion of the autumn 2014 period and then suspended after mining of Longwall N2 was completed in February 2014. Baseline terrestrial monitoring recommenced in spring 2015 before the proposed extraction of Longwall N4. Excluding flora monitoring in autumn 2018

and fauna monitoring in spring 2018, terrestrial ecology monitoring has been completed for both autumn and spring periods up to autumn 2019.

The terrestrial monitoring program, including monitoring type, sites, site type and methodology, is outlined in Table 1.

Table 1 Terrestrial ecology monitoring program

Monitoring	Impact sites (Figure 2)	Control sites (Figure 3)	Methodology
Riparian Vegetation	Wattle Creek	Flying Fox Creek No. 3 Morans Gully	Vegetation surveys within creeks are undertaken at three 20 m x 20 m (400 m^2) quadrats per creek located at least 150 m apart. Within each quadrat, subjective cover abundance scores are given to each species occurring within the quadrat using a modified Braun-Blanquet scale. Surveys are undertaken once in spring and once in autumn each year.
Frogs – Point Surveys	Wattle Creek	Flying Fox Creek No. 3 Morans Gully	Nocturnal frog surveys within creeks are undertaken at three 50 m long transects per creek located at least 150 m 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

Nebo Longwalls

Longwalls N3 and N5

Extent mined

Figure 2 Terrestrial ecology monitoring impact sites

0 100 200 300 400

Metres

Scale: 1:8,000 @ A3

Coordinate System: GDA 1994 MGA Zone 56

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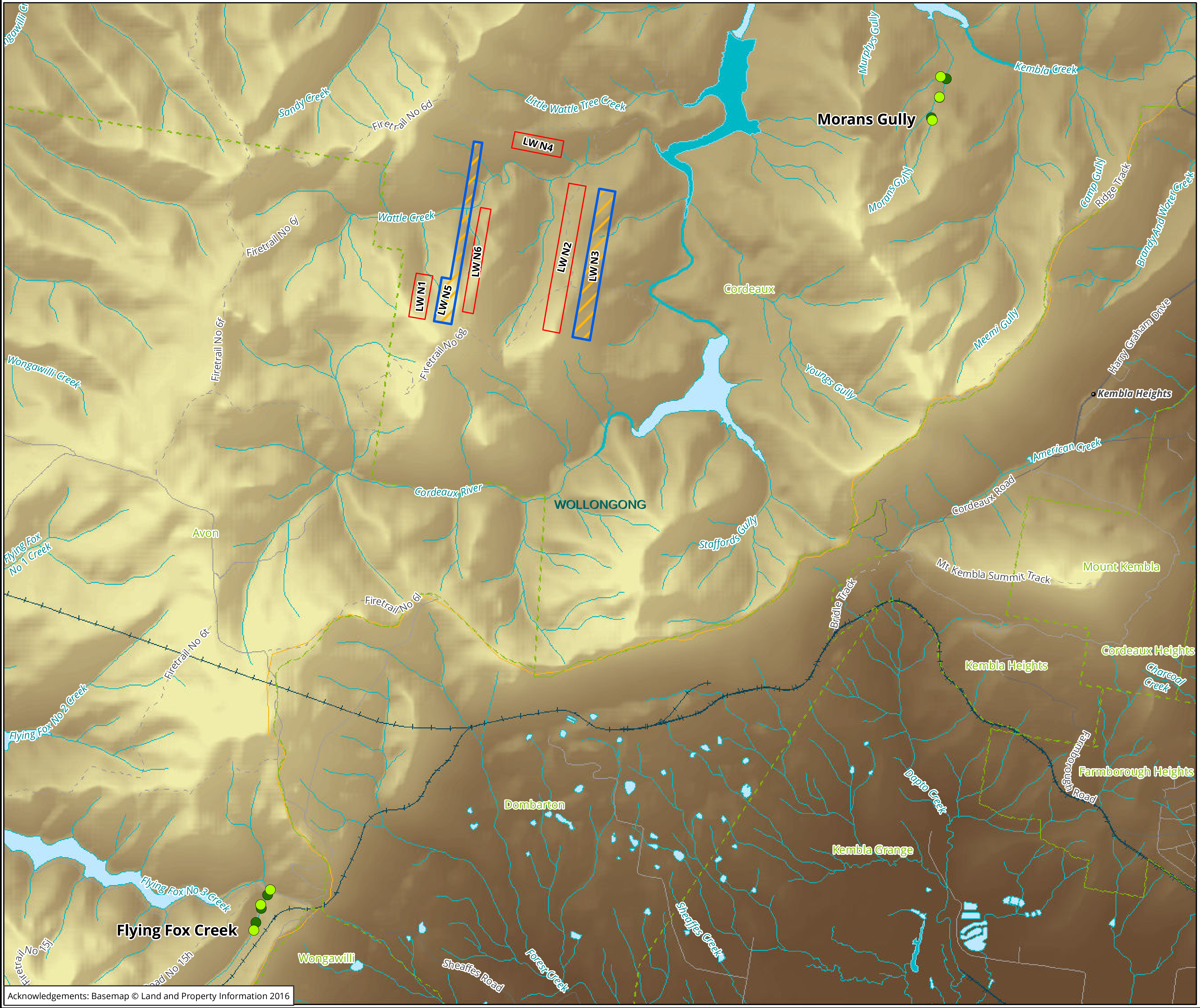

Legend

Flora Monitoring

- Flora creek control site

Fauna Monitoring

- Fauna creek control site

Survey Area

- Nebo Longwalls
- Longwalls N3 and N5
- Extent mined

Figure 3 Terrestrial ecology monitoring control sites

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Metres

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Acknowledgements: Basemap © Land and Property Information 2016

2.2 Aquatic ecology monitoring program

The aquatic ecology monitoring program for Longwalls N1-6 is undertaken at eight impact sites and four control sites, monitored during spring and autumn (Figure 4), including:

- Aquatic habitat monitoring, including surface water quality monitoring.
- Monitoring of aquatic macroinvertebrates (AUSRIVAS).
- Photo point monitoring.

The aquatic ecology monitoring program is required to be conducted for a minimum of two year's pre-mining, during mining and a minimum of one year post mining.

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). While both Wattle Creek and Little Wattle Tree Creek have been identified as key ecological features in the Nebo mining area the subsidence footprints of Longwalls N3 and N5 extend into the RMZ of Wattle Creek only. Therefore, only impact sites associated with Wattle Creek will be able to detect potential subsidence impacts from Longwalls N3 and N5, as indicated inTable 2.

2.2.1 Monitoring to Date

The Nebo area includes longwalls (N1, N2, N3, N4, N5 and N6) with subsidence footprints that may impact upon the catchments of Wattle Creek and Little Wattle Tree Creek within the greater catchment of Lake Cordeaux. Mining operations in the Nebo lease area first commenced with Longwall N2 in June 2013 and ceased in February 2014. Mining and associated aquatic ecology monitoring recommenced with the extraction of Longwall N4. Excluding monitoring in spring 2018, the aquatic terrestrial ecology monitoring has been completed for both autumn and spring periods up to autumn 2019.

Previous aquatic surveys of the study area had been conducted by another consultancy in spring 2009 and autumn 2010. These surveys involved sampling at two 'impact' reaches within the Application Area (both on Wattle Creek) and four 'control' reaches on nearby waterways (Kentish Creek and the upper Cordeaux River) that are not expected to be undermined in the near future. This original study design was considered unsuitable due to the small number of impact reaches monitored within the Application Area. Biosis was commissioned to develop an alternative monitoring program with an appropriate number of monitoring reaches commensurate with the size of the Application Area. Biosis established six additional monitoring reaches within the Application Area and the inclusion of four control monitoring reaches on Moran's Gully, Meemi Creeks, Kentish Creek and a tributary of Kentish Creek.

Details of the aquatic monitoring program, including monitoring type, monitoring reaches, and methodology, area provided in Table 2.

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-AQ1 WAC-AQ2 WAC-AQ3 WAC-AQ5 WAC-AQ6	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. Physio-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.
Aquatic Macroinvertebrate Monitoring	WAC-AQ1 WAC-AQ2 WAC-AQ3 WAC-AQ5 WAC-AQ6	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-AQ1 WAC-AQ2 WAC-AQ3 WAC-AQ5 WAC-AQ6	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 the spring monitoring period and once in the autumn monitoring period each year.

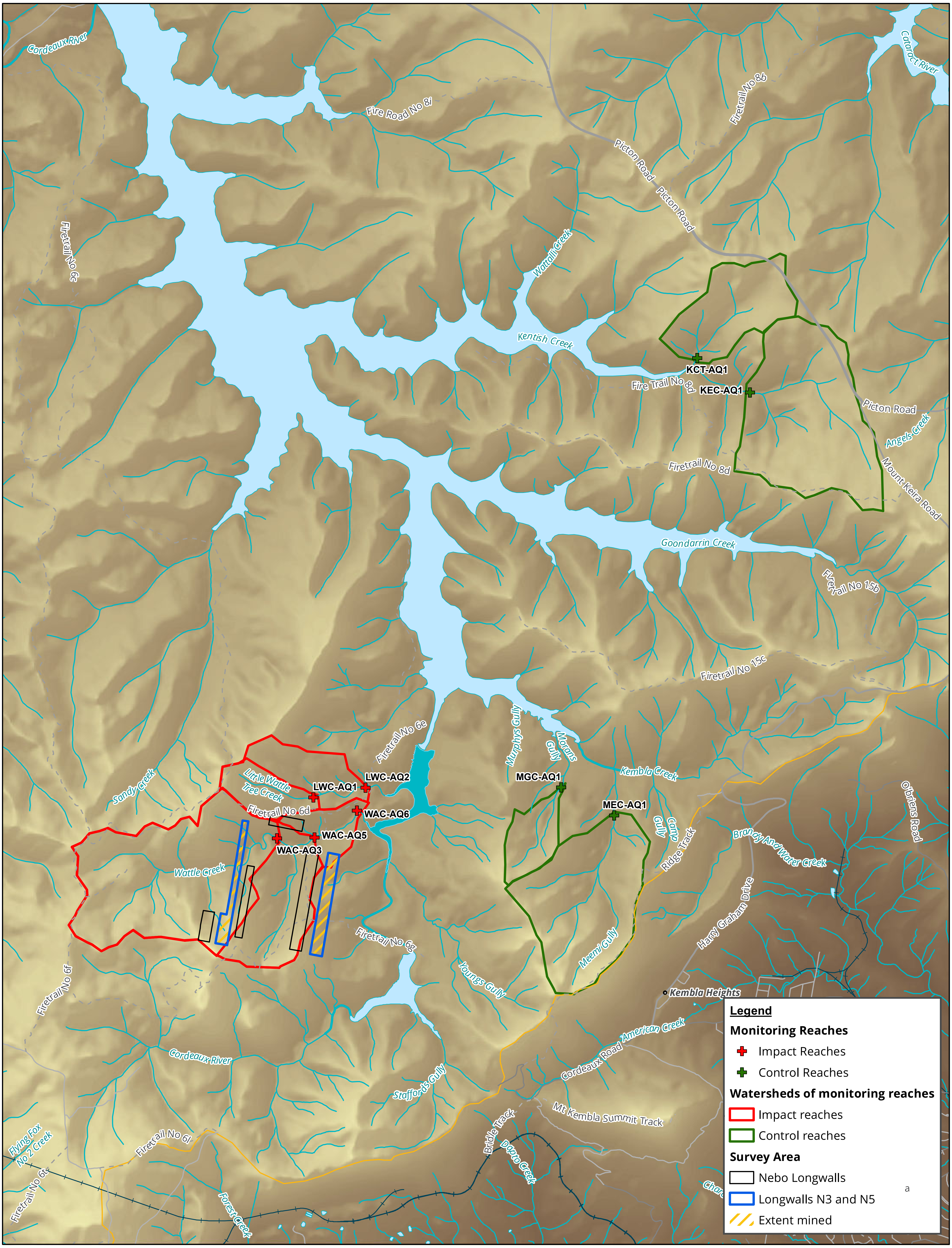

Figure 4 Aquatic monitoring sites

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Date: 24 September 2019,
Checked by: AJB, Drawn by: AEDM, Last edited by: amurray
Location:P:\30300s\30380\Mapping\30380_F4_AquaticMonitoring

0 500 1,000 1,500
Metres
Scale 1:35,000 @ A3
Coordinate System: GDA 1994 MGA Zone 56

N

3 Impact assessment

3.1 Results of monitoring programs

3.1.1 Terrestrial ecology

To date, results from terrestrial ecology monitoring of both vegetation and amphibians in Wattle Creek catchment has not detected any subsidence effects on aquatic ecological values as a result of the extraction of Longwalls N3 or N5. Detailed results of the terrestrial monitoring program are presented in the annual monitoring reports (Biosis 2019). Any changes and differences in terrestrial ecology have been observed during baseline surveys and at both control and impact sites. This indicates that vegetation has not deviated from expected natural trends and remains within in predictions.

3.1.2 Aquatic ecology

To date, results from aquatic monitoring have not detected any subsidence effects on aquatic ecological values in the Wattle Tree catchment resulting from Longwalls N3 and N5. Detailed results of the aquatic ecology monitoring program are presented in the annual monitoring reports (Biosis 2019). The aquatic survey data collected indicates that aquatic ecological values have not deviated from baseline values and remain comparable with the control sites.

3.2 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 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.	No observable changes to vegetation composition in Wattle Tree Creek or Little Wattle Tree Creek.	Yes
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 Longwalls N3 and N5.	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 Longwalls N3 and N5	N/A

3.3 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 Longwalls N3 and N5.

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

3.3.1 Longwalls N3 and N5

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 N4. No other management actions have been triggered under the TARP (Table 4, Table 5 and Table 6).

3.3.2 Cumulative Impacts within the Nebo Mining Domain

Longwall N3 which was extracted from 4 October 2016 to 13 March 2019 is the fourth to be completed within the Nebo Area. Longwall N5 which was extracted from 20 March 2017 to 26 January 2019 is fifth longwall to be completed within the Nebo Area. Longwall N2 commenced in June 2013 and ceased in February 2014, Longwall 4 was extracted between August 2016 and May 2017 and extraction of Longwall N1 was completed on 16 September 2018.

No cumulative impacts have been recorded following the completions of any longwall.

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 Longwalls N3 and N5, 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 Longwalls N3 and N5. No management actions under the TARP have been triggered. No cumulative impacts have resulted from the extraction of both longwalls in the Nebo area.

It is recommended that monitoring of all natural features above Longwalls N3 and N5 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).

References

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DTIRIS 2013. Subsidence Management Plan Approval – NRE Wongawilli Colliery Nebo Longwalls N1-N6, (dated 25 January 2013, file no. 09/5341).

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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 SMP (Gujarat NRE 2014) 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 s N3 and N5
Riparian vegetation 3 Monitoring sites on Wattle 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 completed to LWTC, ongoing for WTC.	Species inventory and modified Braun Blanquette cover - Abundance for each species. Autumn and spring during entire extraction period. During mining monitoring completed for Longwall N1.	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. Monitoring ongoing for this stage as it relates to N3 and N5. Completion of spring 2019 post mining monitoring required	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. **WITHIN PREDICTIONS** Survey results within baseline variability. **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.	• Continue monitoring • Report in end of panel report • Continue monitoring • Report in end of panel report • 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	No management action/s required. No change to flora species or vegetation communities was observed when compared to baseline and control sites.

Table 5 Trigger Action Response Plan (TARP) Table, amphibians, including assessment of actions required by the SMP (NRE 2014) 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 Longwalls N3 and N5
Amphibians 3 Monitoring sites on Wattle 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 150-200 m apart along Wattle Tree Creek and Little Wattle Tree Creek conducted Autumn and Spring. Baseline monitoring completed LWTC, ongoing WTC. 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 150-200 m apart along Wattle Creek and Little Wattle Tree Creek conducted Autumn and Spring during entire extraction period. Completed LWTC, not started WTC. 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. **WITHIN PREDICTIONS** Survey results within baseline variability. **EXCEEDS PREDICTIONS** Observed physical impacts to habitat. Statistically significant decrease in population numbers and/or species composition 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 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	No management action/s required. No changes in amphibian populations or habitats were observed when compared to baseline and control sites.

Table 6 Trigger Action Response Plan (TARP) Table, aquatic ecology, including assessment of actions required by the SMP (NRE 2014) 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 s N3 and N5
Aquatic ecology 6 Monitoring sites on Wattle 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 Longwalls N3 and N5, 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 N4, 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 Longwalls N3 and N4. 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 Longwalls N3 and N4.	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 Longwalls N3 and N5. 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 Longwalls N3 and N5.	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.

Appendices D – Geoterra Ground & Surface Water NEBO N1 EoP Report

WOLLONGONG COAL LTD

WONGAWILLI COLLIERY
END OF PANEL N1
SURFACE WATER AND GROUNDWATER REPORT

Wollongong, NSW

NEB6-R1A

7 November, 2019

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Date	Rev	Comments
31/10/2019		Initial Report
7/11/2019	A	Incorporate review comments

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DRAWINGS

1. INTRODUCTION

This document outlines observation of the groundwater and surface water systems in the Nebo Area within the Wollongong Coal Limited (WCL) operated Wongawilli Colliery lease area.

Extraction of the Wongawilli Seam in Panel N1, N3 and N5 was conducted as shown in **Table 1** by secondary pillar extraction with a continuous miner.

Table 1 Panel Extraction Dates and % Recovery

Panel	Start	Finish
N1	13/05/2017	21/09/2018
N3	04/10/2016	13/03/2019
N5	19/09/2018	26/01/2019

1.1 Site Description

The study area is located 13km west of Wollongong in the upper reaches of the Cordeaux River valley within the Sydney Water Catchment Metropolitan Special Area.

The area is within undeveloped bushland comprising native vegetation and other regeneration areas.

Panel N1 is located below the peak of Wanyambilli Hill between Wattle Creek and Jackson's Creek Wattle Creek.

Panel N3 is located between the Cordeaux River and Jackson's Creek, to the east of Panel N2 and underneath the eastern flank of Jackson's Hill.

Panel N5 extends from beneath the peak of Wanyambilli Hill to Little Wattle Tree Creek.

All three panels are outside the Dams Safety Committee Notification Area for the Cordeaux Storage Reservoir, except for the northern portion of N3.

2. SCOPE OF WORK

GeoTerra were commissioned by WCL to report on any observed groundwater system changes resulting from extraction of Panels N1, N3 and N5 in accordance with the:

- Nebo Longwalls N1-N6 Extraction Plan (Niche, 2011),
- Extraction Plan (EP) subsidence predictions (MSEC 2010), and the;
- Subsidence Management Plan (SMP) (Niche 2012), which was based on the Part 3A Application for the Nebo Area Project (09_0161).

This report presents the results of our review and analysis in accordance with Condition 18 of SMP Approval 09/5341and Extraction Plan requirements of Condition 7 in schedule 3 of Project Approval 09_0161.

3. OVERBURDEN GEOLOGY

The Nebo Study Area is predominantly covered by shallow hillslope-based colluvium developed directly over the Cordeaux Crinanite, with very thin to absent alluvial sedimentary deposits in the valley floors.

The colluvial soil ranges up to 6.5m thick and comprises ferruginous clays overlying the thin weathered mantle of the crinanite, or where the crinanite is absent, as in over the south western section of Panel N1, thin sandy soils developed on Hawkesbury Sandstone or the Bulgo Sandstone are present.

The crinanite has intruded into the basement between the Hawkesbury Sandstone and the Bulli Seam and dominates the sub-cropping and outcropping geology at Nebo. Where the crinanite is absent in the western mostly higher elevation portion, such as over the south western corner of N1, thin sandy colluvial soil overlies the Hawkesbury Sandstone, Narrabeen Group and Illawarra Coal Measures stratigraphy.

The crinanite outcrops at surface and ranges from 0 - 70m thick over the N1, N3 and N5 panels, with the base of the sill located approximately 50 - 60m above the extracted panels.

Previous exploratory work (SCT 2010) showed that a 65m thick 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.

No known major faults outcrop at surface as the Cordeaux Crinanite has overprinted any structures that may have been present in the sedimentary overburden.

4. PANEL EXTRACTION AND SUBSIDENCE

4.1 Mining Layout

Extraction of N1, N3 and N5 Panels occurred as shown in **Table 2**.

Table 2 Panel Extraction Dates and % Recovery

Panel	Length (m)	Width (m)	Mining Height (m)	Depth of Cover (m)	Extraction (%)
N1	310	120	3.2	240 - 350	73
N3	850	125	3.2	120 - 260	57
N5	1670	65 - 125	3.2	160 - 360	56

4.2 Subsidence

Subsidence behaviour above the panels is significantly influenced by the presence of the intruded crinanite sill.

The subsidence movements are of very low magnitude. However, these need to be considered in the context of the expected survey tolerances and Trigger Action Response Plans (TARPS) outlined in the Nebo Longwalls 1 - 6 Subsidence Monitoring Plan.

Accuracy expectations for regional points are ±25mm for position and ±35mm for height.

The maximum subsidence values along subsidence lines associated with Panels N1, N3 and N5 are shown in **Table 3**.

Table 3 Subsidence Monitoring

Panel	Subsidence (mm)	Tilt (mm/m)	Strain (mm/m) Compression	Strain (mm/m) Tension
N1	n/a	n/a	n/a	n/a
N3	<150	<2mm/m	<1mm/m	<1mm/m
N5	n/a	n/a	n/a	n/a

NOTE: n/a survey data not yet available

Overall, subsidence observed in the vicinity of Panels N1, N3 and N5 are considered (or expected) to be less than or consistent with the predictions made in the EP/SMP and Part 3A Application (SCT Operations, 2017).

Monitoring confirmed the bridging capacity of the crinanite, which has limited the maximum subsidence and associated parameters to levels that are imperceptible for all practical purposes (SCT Operations, 2019).

5. SURFACE WATER

Wattle Creek and Little Wattle Tree Creek are "connected - gaining streams" where the soil and, potentially to a lesser degree, the shallow crinanite groundwater, seeps into the creeks and maintains a baseflow during and after extended wet periods.

Variable seepage from the soil and crinanite enters the creeks and has been observed to maintain a continuous flow in the 3rd order channel of Wattle Creek, with the volume depending on the interaction between rainfall runoff, recharge and groundwater seepage applying at any one time.

The 2nd order channel of Little Wattle Tree Creek does not have a permanent stream flow.

Three channel types are present in the area:

- Channels incised into the crinanite with accumulated crinanite cobbles and boulders, with little to no channel sediment. These "v" shaped channels are usually bound by crinanite outcrop;
- Isolated rock platforms of variable width which are usually smooth except for minor depressions on the vertical, polygonally jointed crinanate. These platforms normally transgress into the pool / riffle sequence described above, and;
- Channels incised into crinanite boulder / cobble substrate in the lower catchment of Jacksons Creek, which is the 2nd order tributary of Wattle Creek draining to the north from Jacksons Hill and Wanyambilli Hill.

Three pool types are also present:

- Shallow, linear, small pools located in depressions formed by erosion of the columnar jointed crinanite where the downstream end is usually associated with a low rockbar outcrop,
- Larger pools constrained by a rockbar on the downstream end, or;
- Small pools upstream of a crinanite cobble / boulder accumulation.

5.1 Wattle Creek

Wattle Creek flows in a north easterly, then easterly direction and overlies the middle, narrowed section of LWN5, as well as the creeks catchment within the 20mm subsidence zone as shown in **Drawing 1**.

The creek is a perennial Schedule 2, 3rd order stream (DIPNR, 2005) downgradient of LWN5 and to the north of LWN2 and LWN3, with ephemeral 1st and 2nd order tributaries upstream of the WC1 and WC2 junction.

No workings underlie any 3rd order channel of Wattle Creek.

The 2nd order north flowing tributary (Jacksons Creek) drains into Wattle Creek at Site WC1.

Wattle Creek drains into the Upper Cordeaux No.2 reservoir to the east, and approximately 320m outside of, the 20mm subsidence zone, whilst its headwaters are predominantly contained within the 20mm subsidence envelope.

The creek is not regulated by any dams or weirs and there are no major waterfalls.

Wattle Creek stream monitoring site details are shown in **Table 4**.

Table 4 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	292915	6189490	1st order channel upstream of the extraction area

Wattle Creek is predominantly characterised by interspersed pools which are located over exposed crinanite or are upstream of crinanite boulder / cobble accumulations.

Generally small pools develop upstream of elevated rock bars or boulder / cobble accumulations, often with less than 0.5m drop between the pools. The pools are generally small due to the steep gradient of the creek bed.

The stream banks in the section upstream of Site WC3 are generally steep, although laid back, and can be over 20m high within a well defined channel with well developed rainforest vegetation along the banks and no apparent erosion or bank instability.

Downstream of WC3, the stream gradient reduces, although the well defined channel and rainforest vegetation is still present, albeit with lower banks.

5.1.1 Stream Chemistry

Water quality monitoring in Wattle Creek commenced in June 2009 as shown in **Figure 1**.

The creek at and downstream of WC2 has had a perennial flow, whilst the north flowing 2nd order tributary (Jacksons Creek) draining off Jacksons Hill and Wanyambilli Hill is often dry.

Wattle Creek's pH ranges from 5.7 to 7.5, which is occasionally below the pH 6.5 ANZECC 2000 South Eastern Australia Upland Stream criteria. The creek's salinity ranges from 117 - 185µS/cm, and generally rises after prolonged dry periods with less recharge to the stream.

Iron levels are generally low and there are no significant orange coloured iron oxyhydroxide precipitation areas. Sulfate levels are generally low (3 – 11mg/L) with no indicated dissolution of sulfuric acid after iron sulfide weathering in the crinanite.

Wattle Creek is within the acceptable range for potable water, however it can exceed the ANZECC 2000 95% Species Protection Level for Freshwater Aquatic Ecosystem Guidelines for the following parameters, depending on the flow conditions at the time of sampling;

- filtered copper and / or zinc very occasionally at all sites, and
- total nitrogen as well as total phosphorous at all sites, occasionally, with no regular pattern.

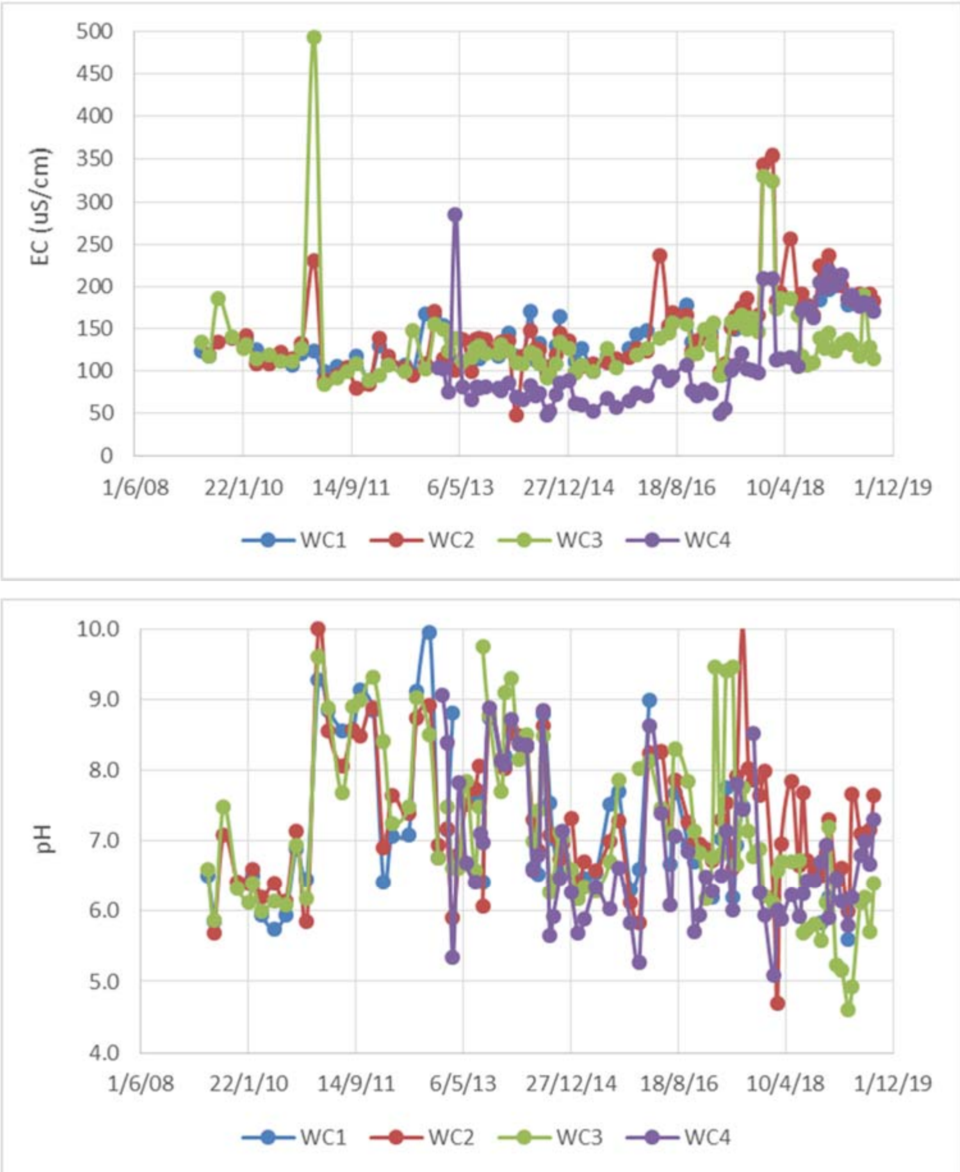


Figure 1 Wattle Creek Field Chemistry

5.1.2 Stream Flow

Stream flow in Wattle Creek, as measured by water depth monitoring, commenced in June 2009 as shown in **Figure 2**.

A correlation is evident between the major rainfall deficit period that started in late April 2017 and the lack of stream flow (as represented by water depth) in the Wattle Creek monitoring locations.

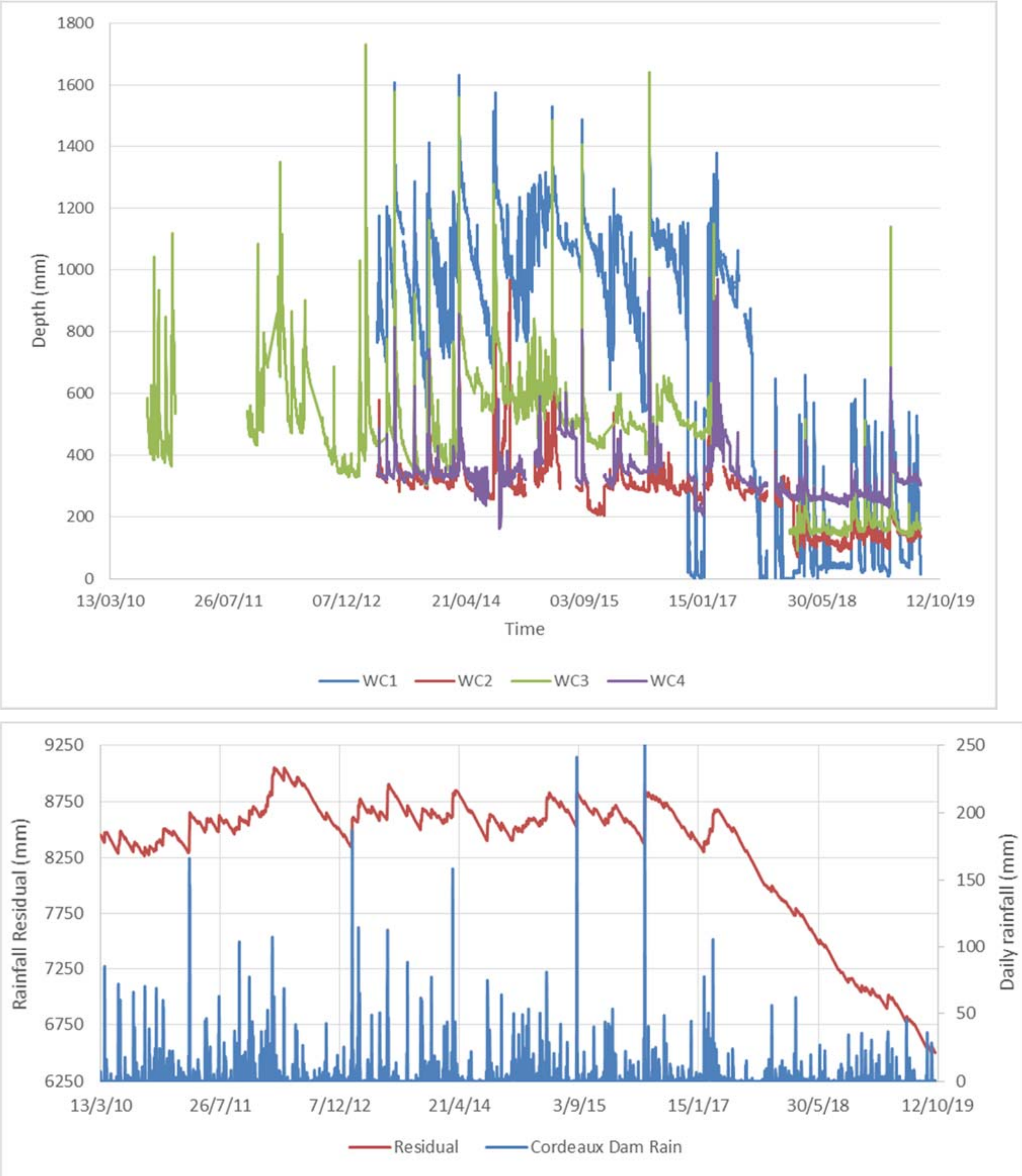


Figure 2 Wattle Creek Stream Water Levels and Rainfall

5.2 Little Wattle Tree Creek

Little Wattle Tree Creek flows in an easterly direction over the northern end of LWN5 and the adjacent catchment as shown in **Drawing 1**.

The main channel over LWN5 is a 1st order creek (DIPNR, 2005), which becomes a 2nd order stream upstream of the LWTC1 monitoring site.

Little Wattle Tree Creek drains into the Upper Cordeaux No.2 reservoir approximately 1250m to the east of LWN5, whilst its headwaters are located within the 20mm subsidence zone.

The channel of Little Wattle Tree Creek has not been undermined by any of the previous or proposed panels

The creek is not regulated by any dams or weirs and there are no waterfalls. Stream monitoring site details are shown in **Table 5**.

Table 5 Little Wattle Tree Creek Stream Monitoring Sites

SITE	E (MGA)	N (MGA)	DESCRIPTION
LWTC1	294920	6190020	At Fire Road 6 crossing

Little Wattle Tree Creek is characterised by a series of small boulder and cobble based pools as well as small pools developed on exposed columnar jointed crinanite, often with less than a 0.5m drop between the pools.

The stream is well defined with steeply sloping banks up to 10m high with a well developed rainforest and no apparent erosion or bank instability.

5.2.1 Stream Chemistry

Water quality monitoring in Little Wattle Tree Creek commenced in June 2009 as shown in **Figure 2**.

The LWTC1 site is generally dry, or ponded but not flowing. The creek's pH ranges from 5.5 to 6.6, which is generally marginally more acidic than Wattle Creek, and is predominantly below the pH 6.5 – 7.5 ANZECC 2000 South Eastern Australia Upland Stream criteria.

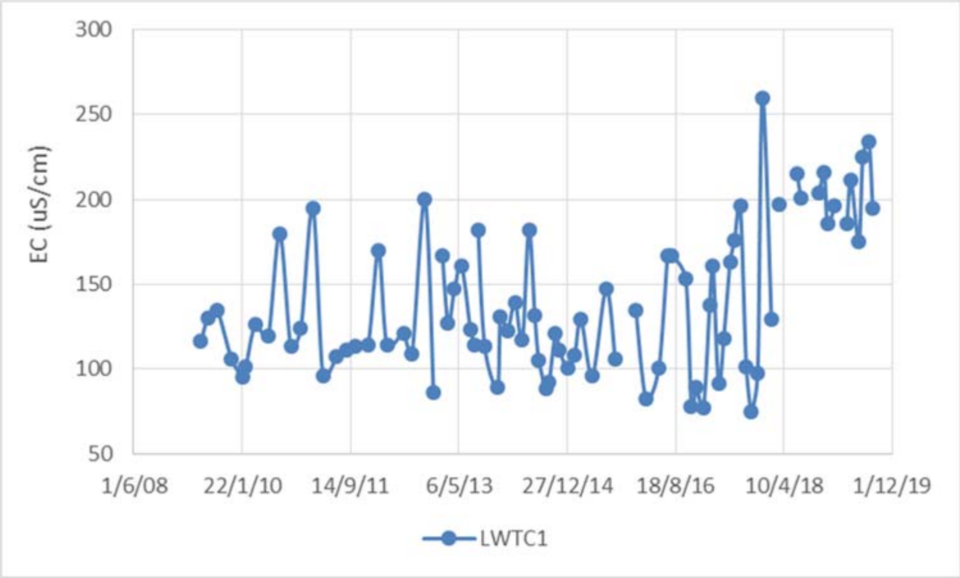
The creek's salinity ranges from 95 - 134µS/cm, which is generally less saline than Wattle Creek, and rises after prolonged dry periods.

Iron levels in the creek are generally low with some minor orange coloured iron oxyhydroxide precipitation seepage locations.

Sulfate levels are generally low (2 – 7mg/L) indicating no distinctive dissolution of sulfuric acid after iron sulfide weathering in the crinanite.

The creek is within the acceptable range for potable water, however it can exceed the ANZECC 2000 95% Species Protection Level for Freshwater Aquatic Ecosystem Guidelines for the following parameters, depending on the flow conditions at the time of sampling;

- filtered zinc very occasionally at all sites,
- total nitrogen, in all samples to date, and;
- total phosphorous, infrequently.



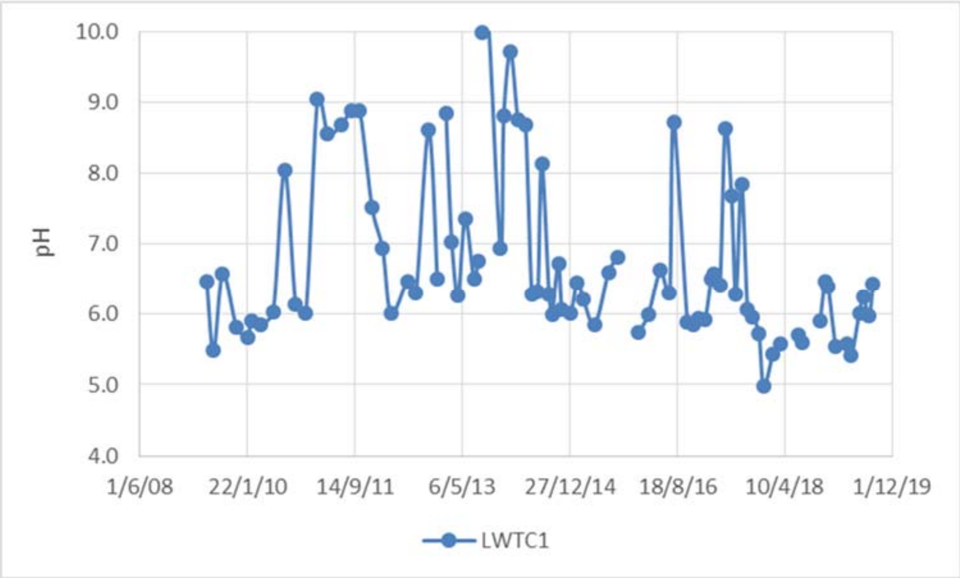


Figure 3 Little Wattle Tree Creek (LWTC1) Field Chemistry

5.2.2 Stream Flow

Stream flow in Little Wattle Tree Creek has not been measured during the monitoring period.

6. PREDICTED AND OBSERVED SURFACE WATER IMPACTS

6.1 Creek Subsidence

6.1.1 Potential Impacts

Maximum subsidence of;

- 50 - 100mm in Wattle Creek;
- <20mm in Little Wattle Tree Creek

6.1.2 Creek Subsidence Observations

No direct subsidence measurements have been conducted in Wattle Creek or Little Wattle Tree Creek, however extrapolation from adjacent monitoring lines indicate there has been no perceptible impacts on either creek due to extraction of Panels N1, N3 or N5.

No stream flow related TARP trigger levels have been reached or exceeded and no ameliorative actions are required due to extraction of Panel N1.

6.2 Stream Water Quality

6.2.1 Potential Impacts

- increased iron hydroxide precipitation, and;
- lowering (acidification) of pH.

6.2.2 Wattle and Little Wattle Tree Creek Observations

No observable water quality changes occurred in Wattle Creek or Little Wattle Tree Creek due to extraction of Panels N1, N3 or N5.

No stream water quality related TARP trigger levels have been reached or exceeded and no ameliorative actions are required due to extraction of Panel N1.

6.3 Stream Flow

6.3.1 Potential Impacts

- No anticipated adverse effect on stream flow in Wattle Creek or Little Wattle Tree Creek.

6.3.2 Stream Flow Observations

There has been no observed adverse effect on stream flow in Wattle Creek or Little Wattle Tree Creek due to extraction of Panels N1, N3 or N5.

No stream flow related TARP trigger levels have been reached or exceeded and no ameliorative actions are required due to extraction of Panel N1.

6.4 Stream Bed and Bank Stability

6.4.1 Potential Impacts

- no anticipated adverse effect on stream bed or bank instability or cracking of the stream bed is anticipated in Wattle Creek or Little Wattle Tree Creek resulting from extraction of Panels N1, N3 or N5.

6.4.2 Observed Impacts

No adverse effect has been observed on stream bed or bank instability or cracking of the stream bed in Wattle Creek or Little Wattle Tree Creek.

No stream bed or bank stability related TARP trigger levels have been reached or exceeded and no ameliorative actions are required due to extraction of Panel N1.

7. GROUNDWATER

The hydrogeology of the Nebo area is distinctly different to all other underground coal mines in the Southern Coalfield due to the presence of the up to 97.5m thick (as drilled) crinanite with its very low permeability, low storativity and its “aquitard” nature both pre and post subsidence (GeoTerra, 2010).

The crinanite is located at the top of the overburden stratigraphic profile and outcrops over approximately 95% of the Nebo area workings as a flat lying to bowl shaped igneous intrusion.

The presence of the crinanite is very significant, in that it acts as an aquitard over the Narrabeen Group and Permian Coal Measures. It separates the shallow soil groundwater system and connected streams at surface from the underlying Narrabeen Group and Permian Coal Measures.

The crinanite differentiates Nebo from all other coal mining areas in the Southern Coalfield and provides a unique hydrogeological and hydrological setting in which to assess and predict coal extraction subsidence effects on surface water and groundwater systems overlying the proposed workings.

Aquifers present that can interact with the local streams are;

- shallow, perched ephemeral aquifers in the up to 6.5m deep soil profile, and, if present
- low flow, short duration seeps from the crinanite or interface drainage originating between the crinanite and the limited exposures of the Narrabeen Group or Hawkesbury Sandstone along the western ridge.

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.

Geotechnical studies (SCT Operations, 2019) indicate that even after extraction where the Illawarra Coal Measures and Narrabeen Group (or Hawkesbury Sandstone if present) overburden is subsided and fractured, the Cordeaux Crinanite is anticipated to maintain its aquitard status where it is greater than 30m thick. This conservative value is an interpreted thickness under which the aquitard properties of the crinanite is likely to remain intact.

Due to the steep topography and the above mentioned factors, as well as depressurisation in subsided and fractured areas over and within the previous workings at Eloura / Nebo, there is anticipated to be essentially no notable remnant groundwater bearing strata in the Illawarra Coal Measures or Narrabeen Group sedimentary units underneath the crinanite.

No DPI-W registered private bores are located within the Nebo area as it is within a restricted access water catchment area administered by Water NSW.

7.1 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 6** and shown in **Drawing 2**.

Each piezometer was installed with a pressure transducer reading water pressure (levels) at least twice per day.

Table 6 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

7.2 Vibrating Wire Piezometers

Four vibrating wire piezometer arrays were installed between December 2009 and January 2010 as outlined in **Table 7** and shown in **Drawing 2.**

Table 7 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

8. PREDICTED AND OBSERVED GROUNDWATER IMPACTS

8.1 Aquifer / Aquitard Interconnection

8.1.1 Potential Impacts

- no adverse interconnection of aquifers and aquitards is 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.

8.1.2 Aquifer / Aquitard Interconnection Observations

No adverse aquitard / aquifer interconnection or increased recharge has been observed in the vicinity of, or resulting from, extraction of Panels N1, N3 or N5.

No aquifer / aquitard interconnection related TARP trigger levels have been reached or exceeded and no ameliorative actions are required due to extraction of Panel N1.

8.2 Groundwater Levels

8.2.1 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.

8.2.2 Groundwater Level Observations

Neither of the shallow soil, alluvium or colluvium piezometers (Nebo1S or Nebo2S) overlie Panel N4, and both have varied in response to rainfall in the catchment as shown in **Figure 4**, with no influence from N4 during its period of extraction.

Neither of the crinanite piezometers Nebo2D or Nebo3 overlie N4, and both have varied in response to rainfall in the catchment as shown in **Figure 5**, with no apparent diversion from the natural water level trends from N4 during its period of extraction.

Piezometer Nebo1D was installed in the Narrabeen Group, although is also not in close proximity to, and did not show a response to extraction of N4 as shown in **Figure 6**.

Piezometer Nebo4, which was installed in the Bulli Seam, to the north of N4, showed a rising water level during extraction of LWN2, albeit with short term drops and recoveries following water extraction sampling events, along with a 2.1m decline in water level during extraction of Panel N4, and a subsequent total drying out as shown in **Figure 7**.

No groundwater level related TARP trigger levels have been reached or exceeded and no ameliorative actions are required due to extraction of Panel N1.

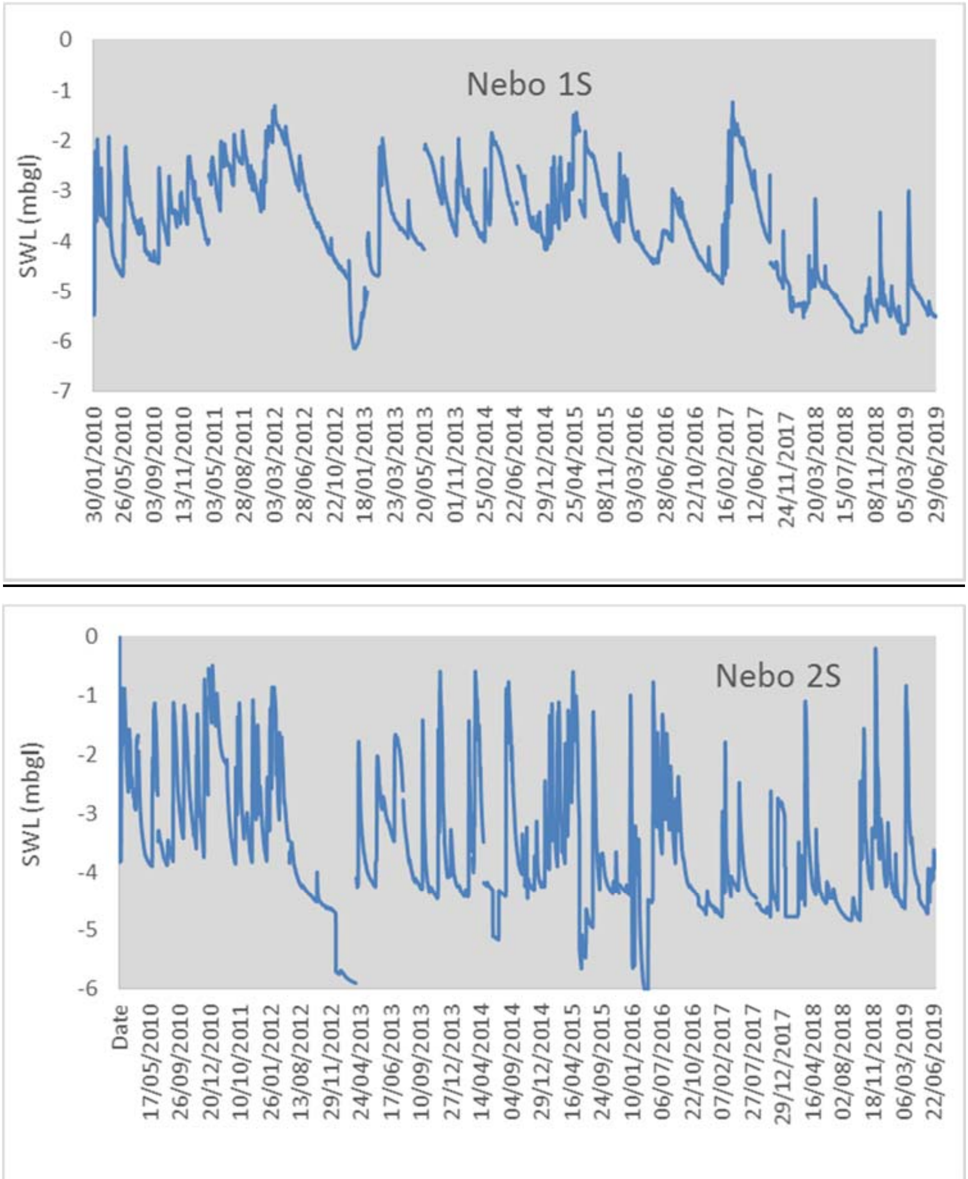


Figure 4 Alluvium / Colluvium Groundwater Levels

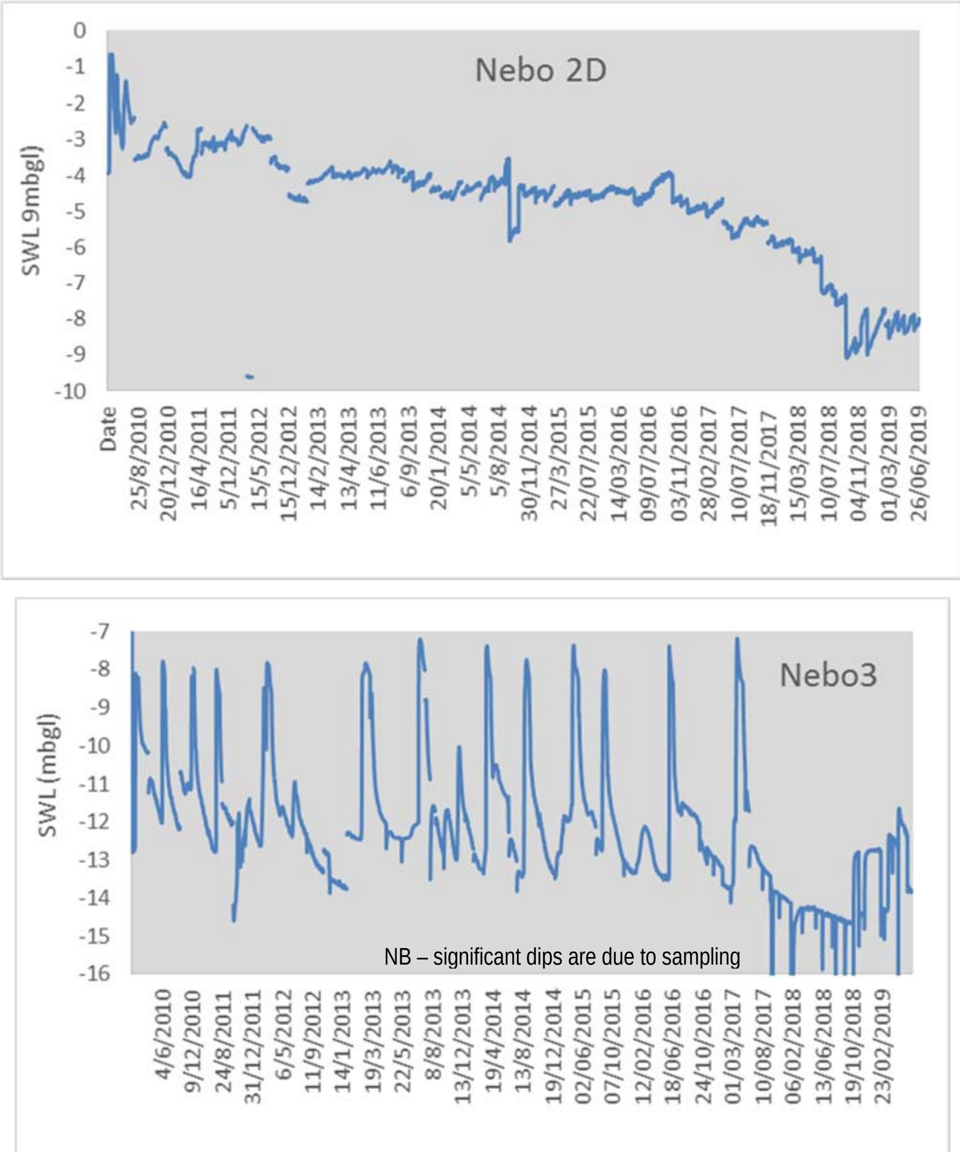


Figure 5 Crinanite Groundwater Levels

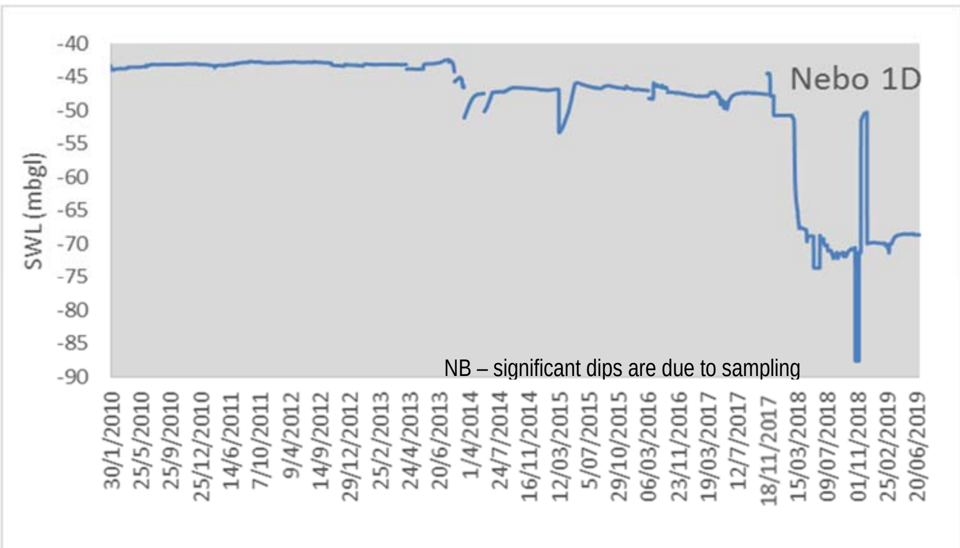


Figure 6 Narrabeen Group Groundwater Level

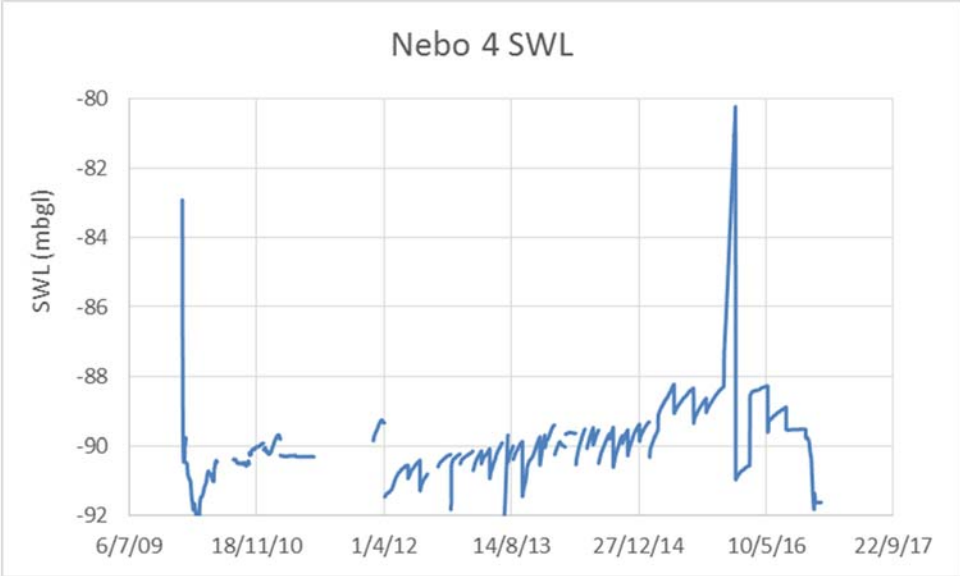


Figure 7 Bulli Seam Groundwater Level

The vibrating wire arrays installed in Nebo6, Nebo 7, Nebo 8 and Nebo8A demonstrated no response to Panels N1, N3 or N5 extraction, which indicates no mining subsidence effect in the crinanite.

In addition, no correlation with the water level of Cordeaux dam and the VWP intakes is apparent.

Water levels in the four VWP arrays are shown in **Figures 8** to **11**.

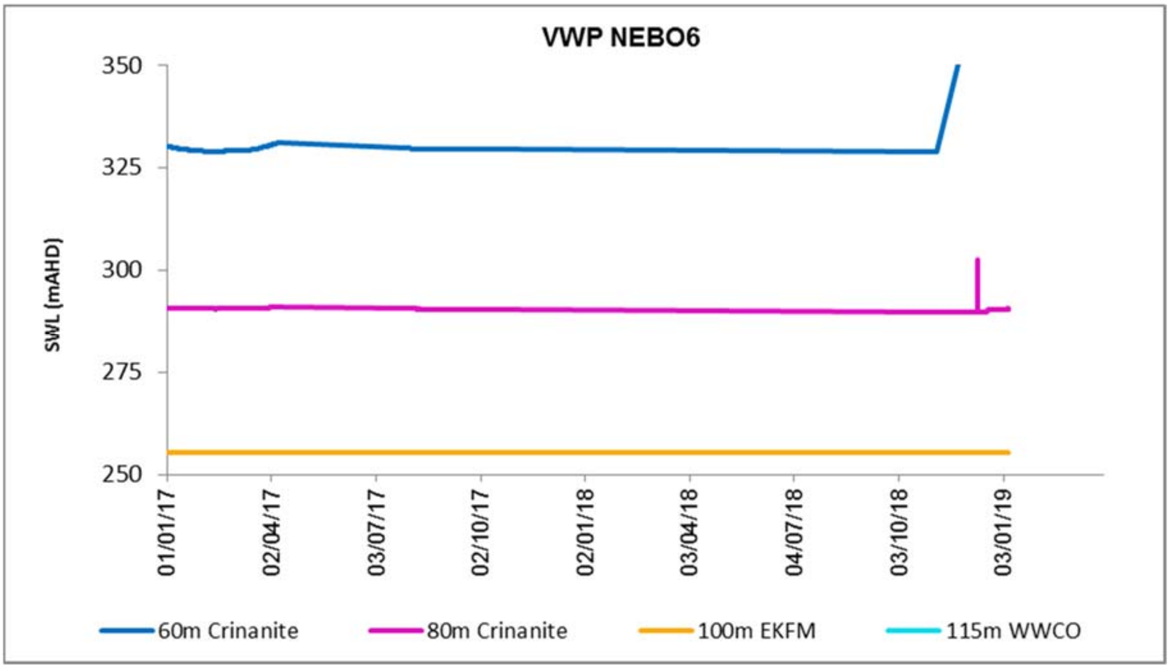


Figure 8 Nebo 6 VWP

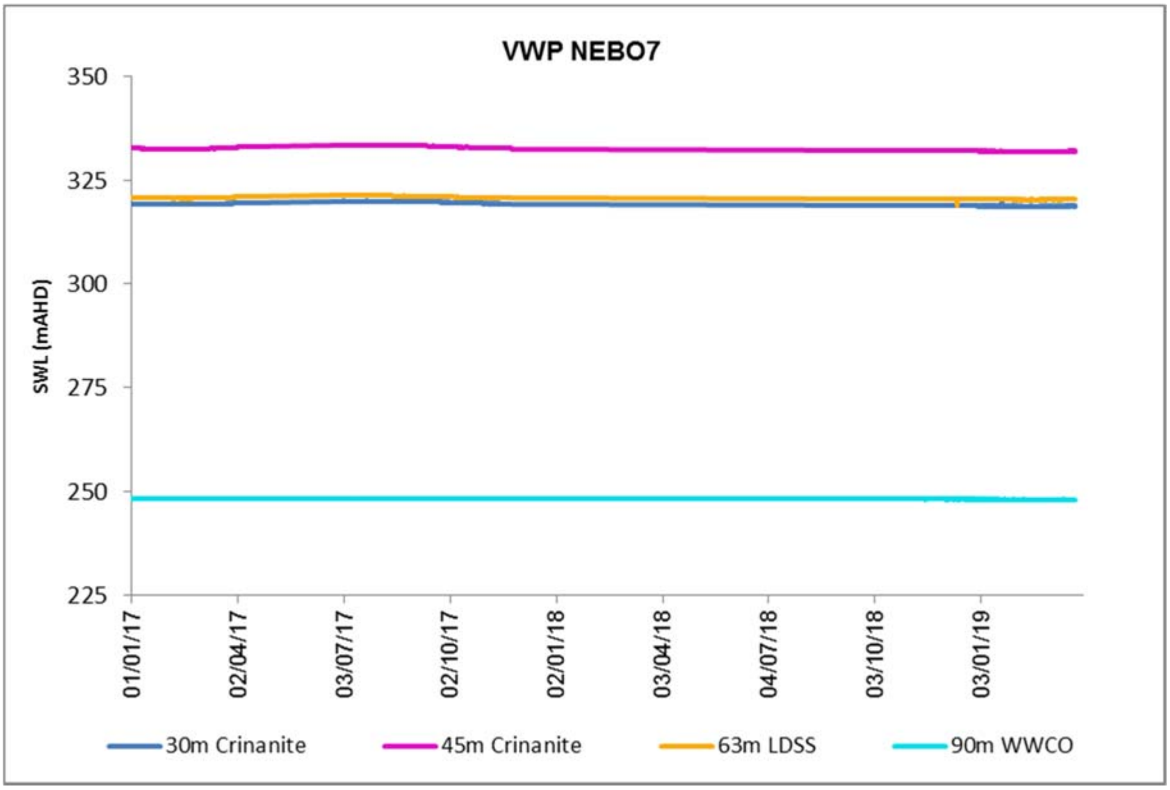


Figure 9 Nebo 7 VWP

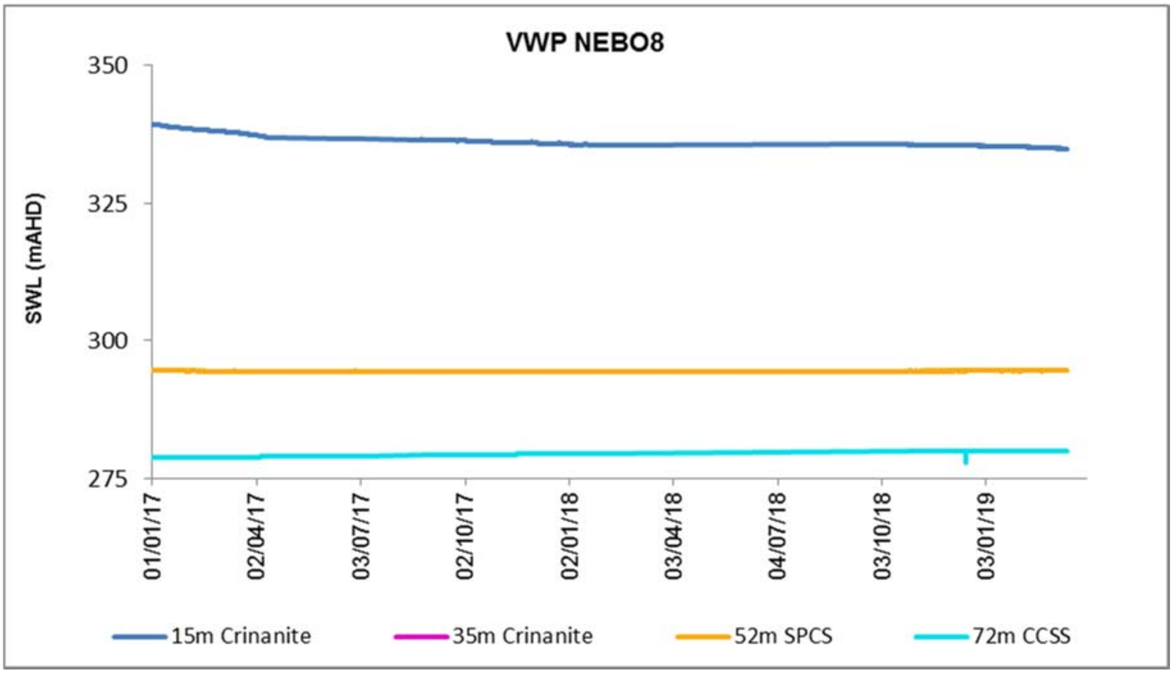


Figure 10 Nebo 8 VWP

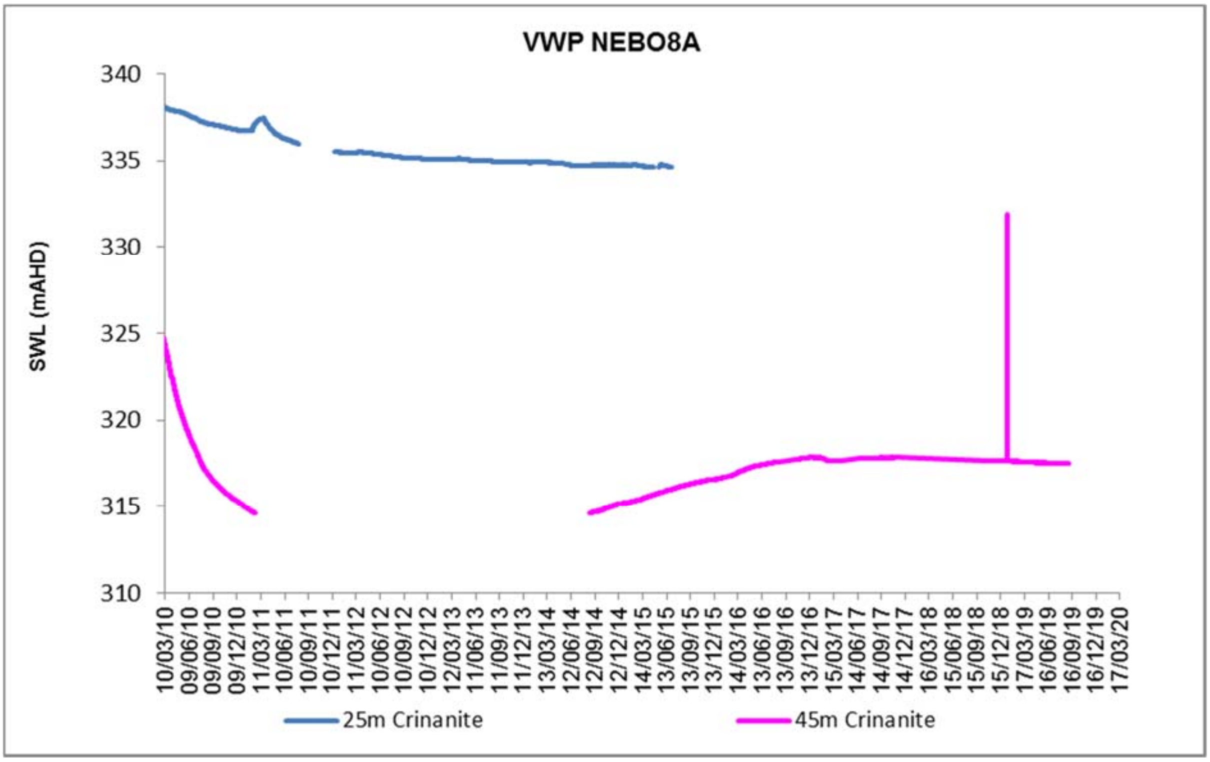


Figure 11 Nebo 8A VWP

4.5 Groundwater Quality

Groundwater in the Nebo study area has generally fresh to brackish salinity (39-2,965µS/cm) with acidic to circum-neutral pH (3.3 – 7.5) as summarised in **Table 5** and shown in **Figures 12** to **15**.

However, cement used to seal the piezometers during installation has had a definitive increase in alkalinity (up to pH 14) and salinity (up to 14500µS/cm) in Nebo 1D, 2D and 4, which means they do not represent the actual formation water chemistry.

Piezometers 1S, 2S and 3 appear to be unaffected by cement and better represent the formation water chemistry, although a cement influence is present.

Table 8 Nebo Field Groundwater Quality

Formation	Piezometers	EC (µS/cm)	pH
Shallow	1S, 2S	32 – 1,071	3.3 – 9.3
Crinanite	2D, 3	230 -2,950	6.7 – 9.8
Narrabeen	1D	123 – 2,965	7.5 – 10.5
Bulli Seam	4	798 – 14,440	10.9 – 13.9

Note: Nebo 1D, 2D and 4 are strongly affected by cement, 1S, 2S and 3 better represent actual formation water chemistry

Laboratory analyses indicate that the monitored groundwater is outside ANZECC 2000 criteria (default trigger values for physical & chemical stressors in SE Aust Upland Rivers / 95% protection of freshwater species / livestock / irrigation) for:

- Total nitrogen;
- Total phosphorous
- Copper
- Lead
- Zinc;
- Nickel, and
- Aluminium

Note that the water chemistry of Nebo 1D, 2D and 4 are strongly affected by cement used to seal the piezometer intake and do not therefore represent the actual formation water quality.

The exceedance varies depending on the applicable guideline applied for the end use of the water.

Groundwater in the Nebo area is suitable for selected livestock and limited irrigation use, but not for potable water.

No adverse change to groundwater quality in the Nebo piezometers has been observed, along with no distinctive increase in salinity, nutrients or metals.

No groundwater quality related TARP trigger levels have been reached or exceeded and no ameliorative actions are required due to extraction of Panel N1.

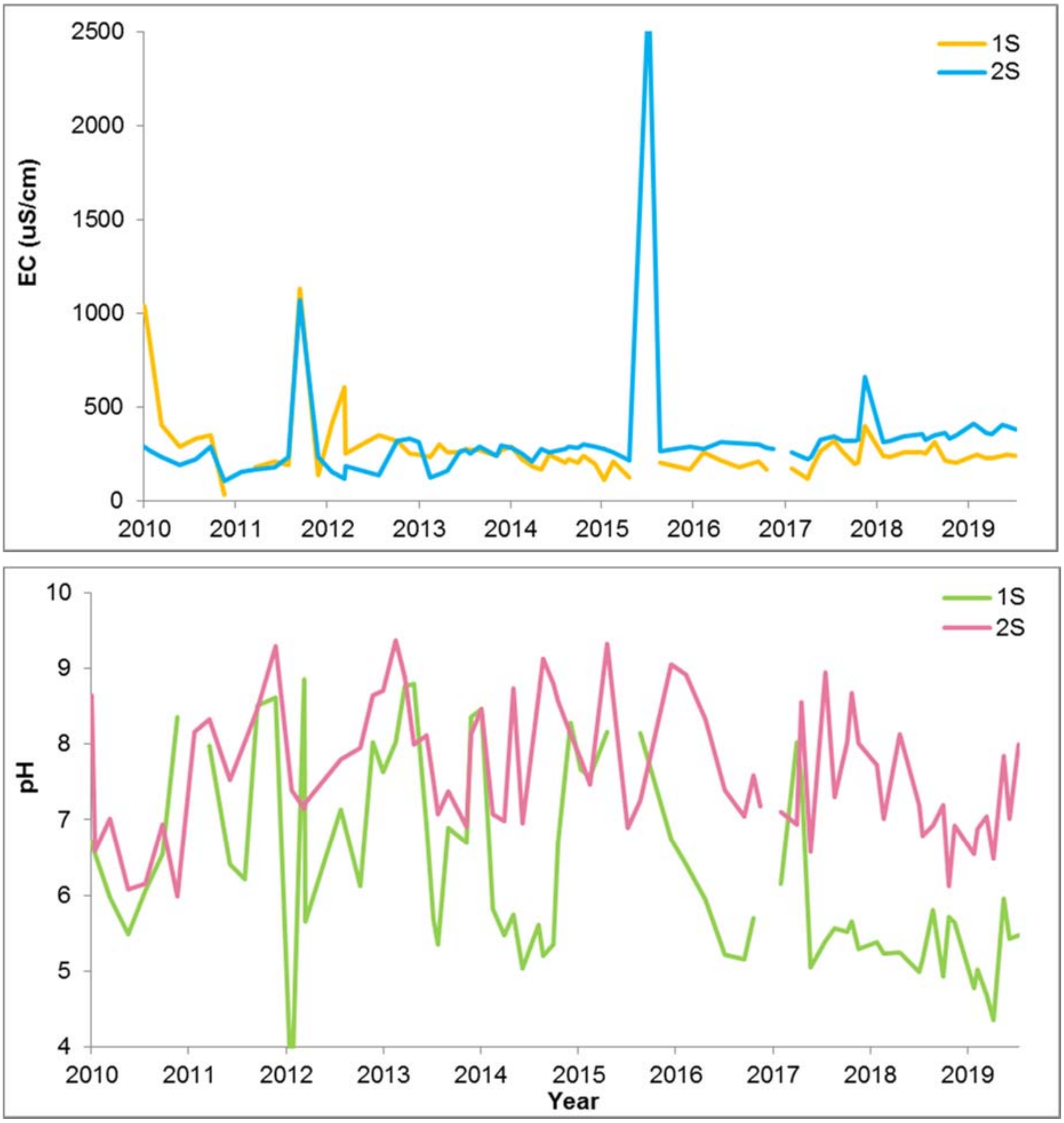


Figure 12 Soil and Shallow Field Groundwater Quality

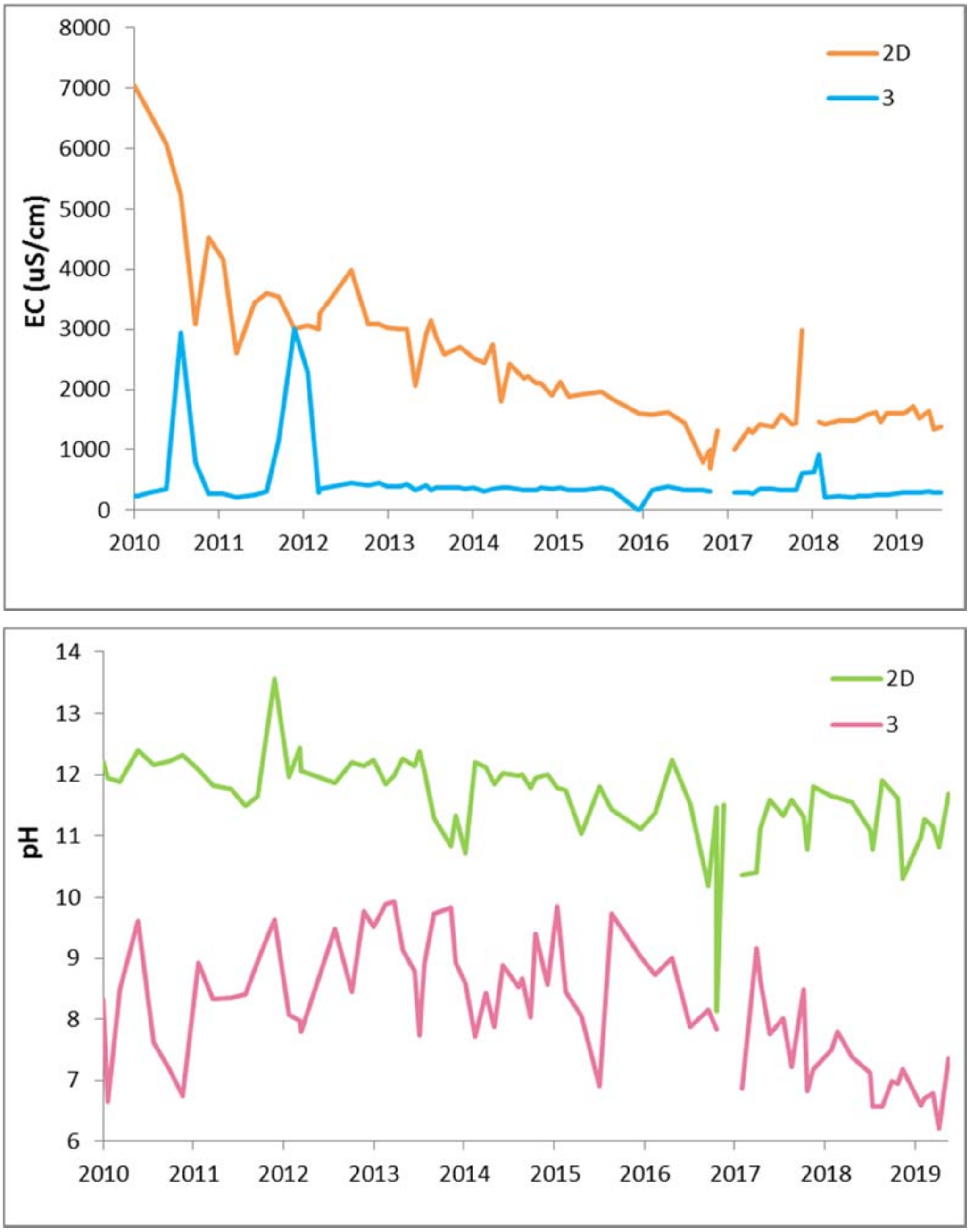
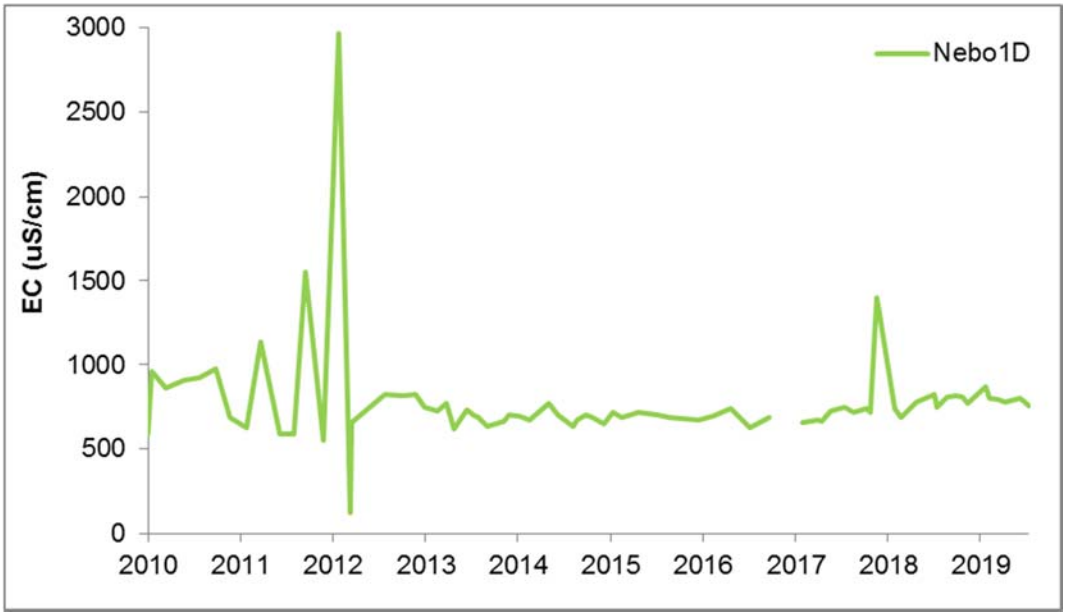


Figure 13 Crinanite Field Groundwater Quality



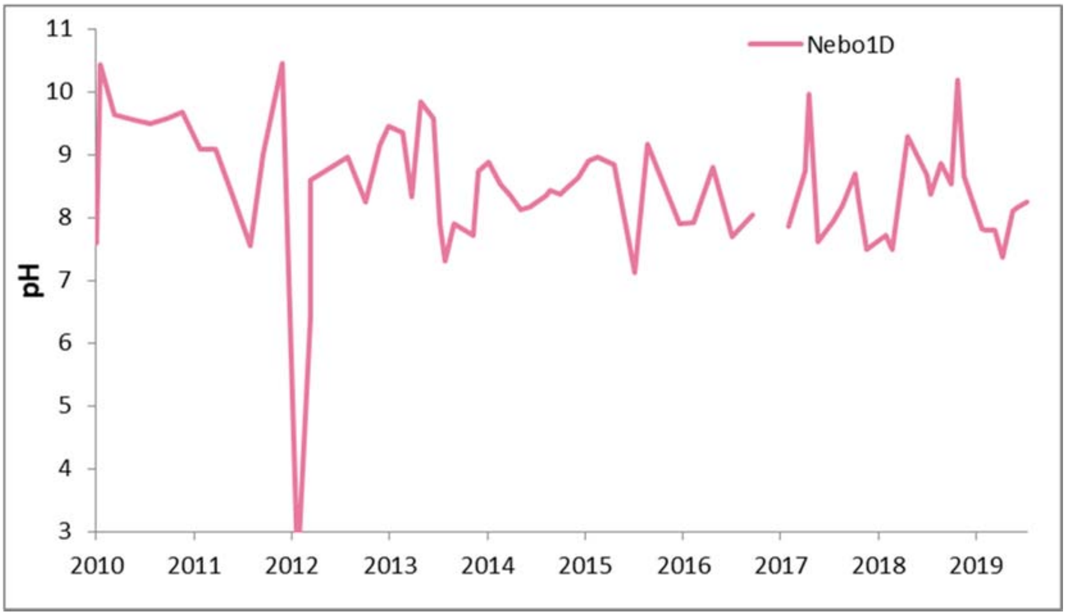


Figure 14 Narrabeen Formation Field Groundwater Quality

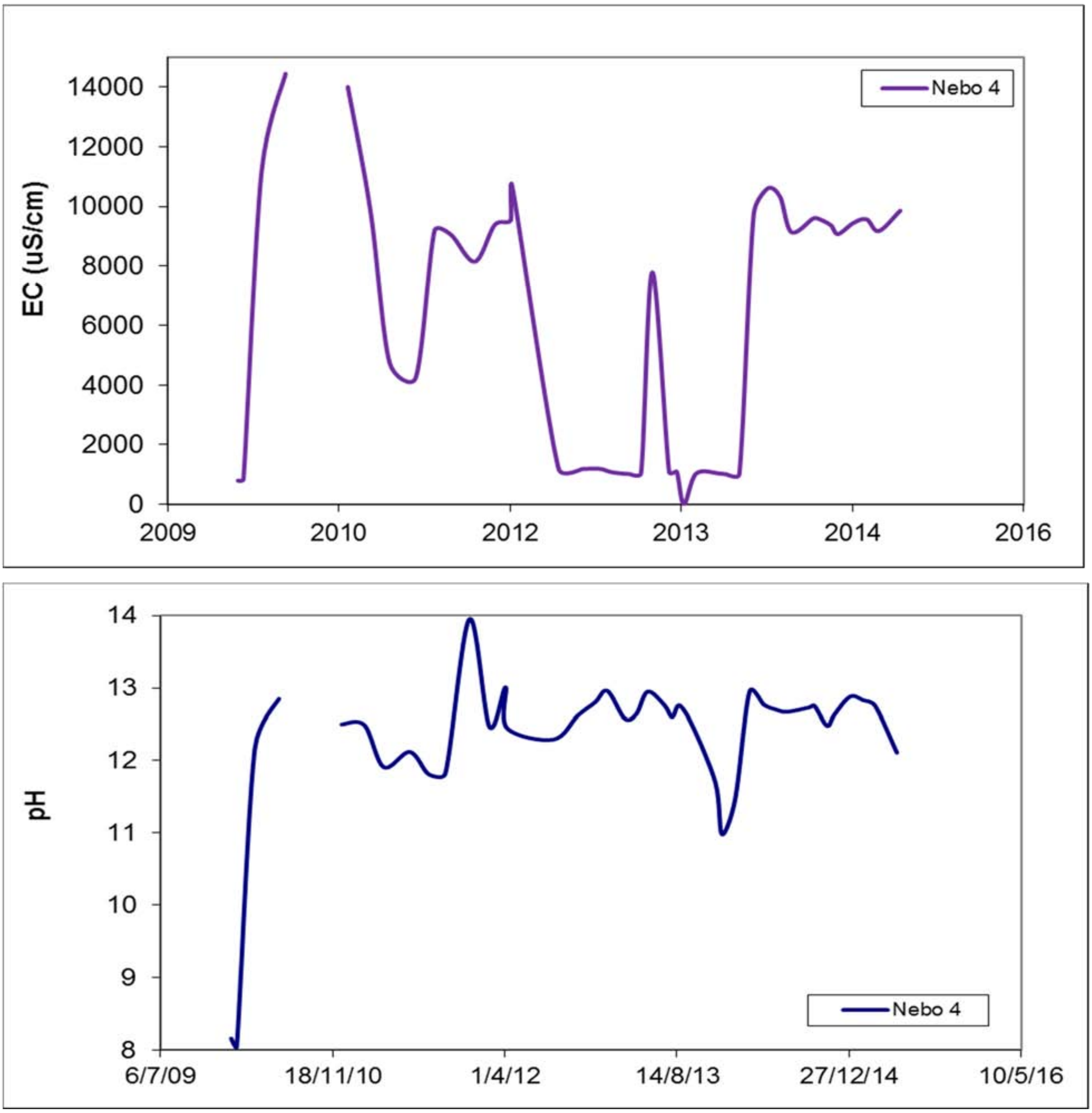


Figure 15 Bulli Seam Field Groundwater Quality

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

There was no groundwater make from the Panel N1, N3 and N5 during and after extraction of the panels, (Pers comm. - Paul Coxhead - Mining Engineering Manager).

No mine water discharge related TARP trigger levels have been reached or exceeded and no ameliorative actions are required due to extraction of Panel N1.

5 SUMMARY OF RESULTS

Although the subsidence movements along the axis or across the whole panel were not directly measured, the subsidence observed in the vicinity of Panels N1, N3 and N5 was less than or consistent with the predictions made in the EP/SMP and Part 3A Application.

Subsidence monitoring (SCT 2019) has confirmed the bridging capacity of the Cordeaux Crinanite (dolerite) sill within the overburden sequence for the approved panel geometries in the Nebo area.

This bridging has limited the magnitude of the maximum subsidence and associated parameters to levels that are imperceptible for all practical purposes.

The maximum subsidence parameters measured to date in the vicinity of Panels N1, N3 and N5 are:

- subsidence 150 mm
- tilt 2.0 mm/m
- strain 1mm/m (compression and tension)

Based on the low levels of ground movement observed as a result of Panel N1, N3 and N5 extraction, there have been no adverse or unexpected impacts on the groundwater or surface water systems at Nebo.

Piezometer Nebo 4, which is screened adjacent to Panel N4 within the Bulli Seam, became fully dewatered during extraction of N4. This impact was within the predicted impacts and was expected to happen due to the coal extraction and transmitted effect from creating an atmospheric pressure void within the seam due to mining Panel N4.

The subsidence impacts and consequences from the extraction of Panels N5 are within the predicted impacts and comply with the subsidence impact performance measures in Project Approval 09_0161 for surface water and groundwater systems at Nebo.

6 REFERENCES

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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

SCT Operations, 2017 Wongawilli Colliery N4 End of Panel Subsidence Report

SCT Operations, 2019 Wongawilli Colliery N3 End of Panel Subsidence Report

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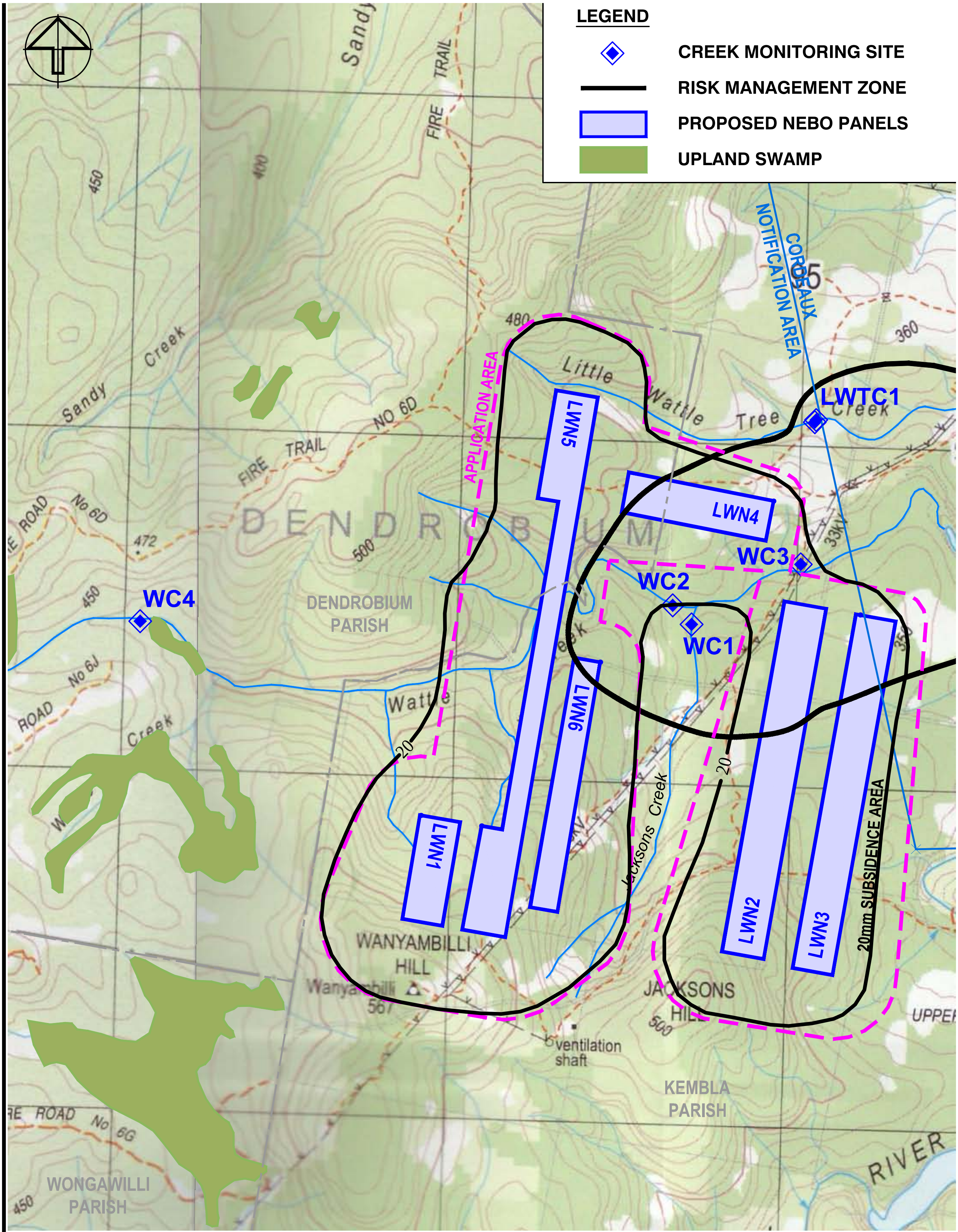

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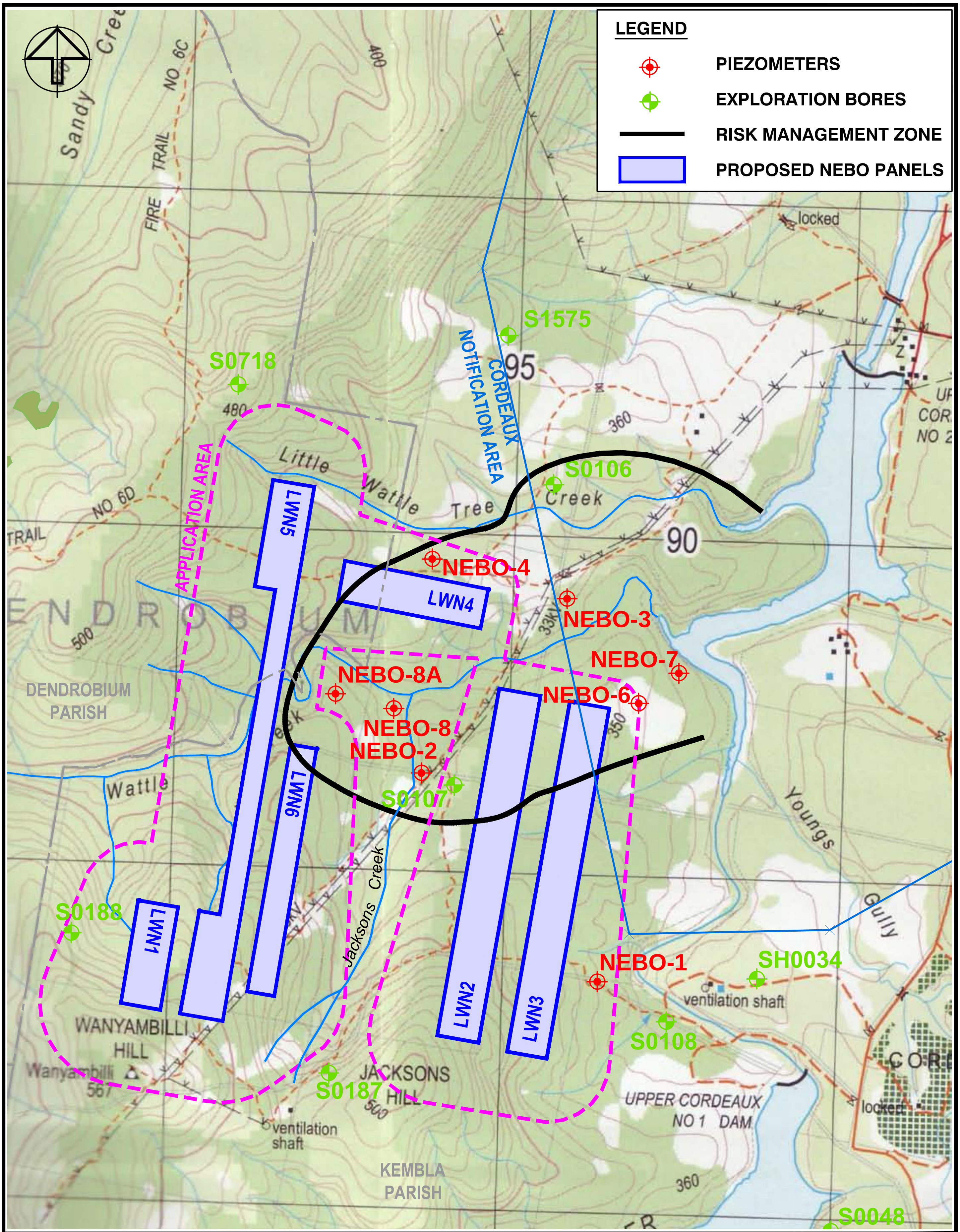
DATE:	28 May 2010		
SCALE:	1:15 000		



PROJECT:	NEB4-R1	WOLLONGONG COAL pTY LTD NEBO LONGWALL LWN2 PIEZOMETER LOCATIONS	GeoTerra
DRAWN:	A. DAWKINS		
DATE:	1 Sep 2014		DRAWING 2
SCALE:	1:15 000		

Appendices E – Geoterra Ground and Surface Water NEBO N3 EoP Report

GeoTerra

WOLLONGONG COAL LTD

WONGAWILLI COLLIERY END OF PANEL N3 SURFACE WATER AND GROUNDWATER REPORT

Wollongong, NSW

NEB6-R1A

7 November, 2019

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Date	Rev	Comments
31/10/2019		Initial Report
7/11/2019	A	Incorporate review comments

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DRAWINGS

1. INTRODUCTION

This document outlines observation of the groundwater and surface water systems in the Nebo Area within the Wollongong Coal Limited (WCL) operated Wongawilli Colliery lease area.

Extraction of the Wongawilli Seam in Panels N1, N3 and N5 was conducted as shown in **Table 1** by secondary pillar extraction with a continuous miner.

Table 1 Panel Extraction Dates and % Recovery

Panel	Start	Finish
N1	13/05/2017	21/09/2018
N3	04/10/2016	13/03/2019
N5	19/09/2018	26/01/2019

1.1 Site Description

The study area is located 13km west of Wollongong in the upper reaches of the Cordeaux River valley within the Sydney Water Catchment Metropolitan Special Area.

The area is within undeveloped bushland comprising native vegetation and other regeneration areas.

Panel N1 is located below the peak of Wanyambilli Hill between Wattle Creek and Jackson's Creek Wattle Creek.

Panel N3 is located between the Cordeaux River and Jackson's Creek, to the east of Panel N2 and underneath the eastern flank of Jackson's Hill.

Panel N5 extends from beneath the peak of Wanyambilli Hill to Little Wattle Tree Creek.

All three panels are outside the Dams Safety Committee Notification Area for the Cordeaux Storage Reservoir, except for the northern portion of N3.

2. SCOPE OF WORK

GeoTerra were commissioned by WCL to report on any observed groundwater system changes resulting from extraction of Panels N1, N3 and N5 in accordance with the:

- Nebo Longwalls N1-N6 Extraction Plan (Niche, 2011),
- Extraction Plan (EP) subsidence predictions (MSEC 2010), and the;
- Subsidence Management Plan (SMP) (Niche 2012), which was based on the Part 3A Application for the Nebo Area Project (09_0161).

This report presents the results of our review and analysis in accordance with Condition 18 of SMP Approval 09/5341and Extraction Plan requirements of Condition 7 in schedule 3 of Project Approval 09_0161.

3. OVERBURDEN GEOLOGY

The Nebo Study Area is predominantly covered by shallow hillslope-based colluvium developed directly over the Cordeaux Crinanite, with very thin to absent alluvial sedimentary deposits in the valley floors.

The colluvial soil ranges up to 6.5m thick and comprises ferruginous clays overlying the thin weathered mantle of the crinanite, or where the crinanite is absent, as in over the south western section of Panel N1, thin sandy soils developed on Hawkesbury Sandstone or the Bulgo Sandstone are present.

The crinanite has intruded into the basement between the Hawkesbury Sandstone and the Bulli Seam and dominates the sub-cropping and outcropping geology at Nebo. Where the crinanite is absent in the western mostly higher elevation portion, such as over the south western corner of N1, thin sandy colluvial soil overlies the Hawkesbury Sandstone, Narrabeen Group and Illawarra Coal Measures stratigraphy.

The crinanite outcrops at surface and ranges from 0 - 70m thick over the N1, N3 and N5 panels, with the base of the sill located approximately 50 - 60m above the extracted panels.

Previous exploratory work (SCT 2010) showed that a 65m thick 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.

No known major faults outcrop at surface as the Cordeaux Crinanite has overprinted any structures that may have been present in the sedimentary overburden.

4. PANEL EXTRACTION AND SUBSIDENCE

4.1 Mining Layout

Extraction of N1, N3 and N5 Panels occurred as shown in **Table 2**.

Table 2 Panel Extraction Dates and % Recovery

Panel	Length (m)	Width (m)	Mining Height (m)	Depth of Cover (m)	Extraction (%)
N1	310	120	3.2	240 - 350	73
N3	850	125	3.2	120 - 260	57
N5	1670	65 - 125	3.2	160 - 360	56

4.2 Subsidence

Subsidence behaviour above the panels is significantly influenced by the presence of the intruded crinanite sill.

The subsidence movements are of very low magnitude. However, these need to be considered in the context of the expected survey tolerances and Trigger Action Response Plans (TARPS) outlined in the Nebo Longwalls 1 - 6 Subsidence Monitoring Plan.

Accuracy expectations for regional points are ±25mm for position and ±35mm for height.

The maximum subsidence values along subsidence lines associated with Panels N1, N3 and N5 are shown in **Table 3**.

Table 3 Subsidence Monitoring

Panel	Subsidence (mm)	Tilt (mm/m)	Strain (mm/m) Compression	Strain (mm/m) Tension
N1	n/a	n/a	n/a	n/a
N3	<150	<2mm/m	<1mm/m	<1mm/m
N5	n/a	n/a	n/a	n/a

NOTE: n/a survey data not yet available

Overall, subsidence observed in the vicinity of Panels N1, N3 and N5 are considered (or expected) to be less than or consistent with the predictions made in the EP/SMP and Part 3A Application (SCT Operations, 2017).

Monitoring confirmed the bridging capacity of the crinanite, which has limited the maximum subsidence and associated parameters to levels that are imperceptible for all practical purposes (SCT Operations, 2019).

5. SURFACE WATER

Wattle Creek and Little Wattle Tree Creek are "connected - gaining streams" where the soil and, potentially to a lesser degree, the shallow crinanite groundwater, seeps into the creeks and maintains a baseflow during and after extended wet periods.

Variable seepage from the soil and crinanite enters the creeks and has been observed to maintain a continuous flow in the 3rd order channel of Wattle Creek, with the volume depending on the interaction between rainfall runoff, recharge and groundwater seepage applying at any one time.

The 2nd order channel of Little Wattle Tree Creek does not have a permanent stream flow.

Three channel types are present in the area:

- Channels incised into the crinanite with accumulated crinanite cobbles and boulders, with little to no channel sediment. These "v" shaped channels are usually bound by crinanite outcrop;
- Isolated rock platforms of variable width which are usually smooth except for minor depressions on the vertical, polygonally jointed crinanate. These platforms normally transgress into the pool / riffle sequence described above, and;
- Channels incised into crinanite boulder / cobble substrate in the lower catchment of Jacksons Creek, which is the 2nd order tributary of Wattle Creek draining to the north from Jacksons Hill and Wanyambilli Hill.

Three pool types are also present:

- Shallow, linear, small pools located in depressions formed by erosion of the columnar jointed crinanite where the downstream end is usually associated with a low rockbar outcrop,
- Larger pools constrained by a rockbar on the downstream end, or;
- Small pools upstream of a crinanite cobble / boulder accumulation.

5.1 Wattle Creek

Wattle Creek flows in a north easterly, then easterly direction and overlies the middle, narrowed section of LWN5, as well as the creeks catchment within the 20mm subsidence zone as shown in **Drawing 1**.

The creek is a perennial Schedule 2, 3rd order stream (DIPNR, 2005) downgradient of LWN5 and to the north of LWN2 and LWN3, with ephemeral 1st and 2nd order tributaries upstream of the WC1 and WC2 junction.

No workings underlie any 3rd order channel of Wattle Creek.

The 2nd order north flowing tributary (Jacksons Creek) drains into Wattle Creek at Site WC1.

Wattle Creek drains into the Upper Cordeaux No.2 reservoir to the east, and approximately 320m outside of, the 20mm subsidence zone, whilst its headwaters are predominantly contained within the 20mm subsidence envelope.

The creek is not regulated by any dams or weirs and there are no major waterfalls.

Wattle Creek stream monitoring site details are shown in **Table 4**.

Table 4 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	292915	6189490	1st order channel upstream of the extraction area

Wattle Creek is predominantly characterised by interspersed pools which are located over exposed crinanite or are upstream of crinanite boulder / cobble accumulations.

Generally small pools develop upstream of elevated rock bars or boulder / cobble accumulations, often with less than 0.5m drop between the pools. The pools are generally small due to the steep gradient of the creek bed.

The stream banks in the section upstream of Site WC3 are generally steep, although laid back, and can be over 20m high within a well defined channel with well developed rainforest vegetation along the banks and no apparent erosion or bank instability.

Downstream of WC3, the stream gradient reduces, although the well defined channel and rainforest vegetation is still present, albeit with lower banks.

5.1.1 Stream Chemistry

Water quality monitoring in Wattle Creek commenced in June 2009 as shown in **Figure 1**.

The creek at and downstream of WC2 has had a perennial flow, whilst the north flowing 2nd order tributary (Jacksons Creek) draining off Jacksons Hill and Wanyambilli Hill is often dry.

Wattle Creek's pH ranges from 5.7 to 7.5, which is occasionally below the pH 6.5 ANZECC 2000 South Eastern Australia Upland Stream criteria. The creek's salinity ranges from 117 - 185µS/cm, and generally rises after prolonged dry periods with less recharge to the stream.

Iron levels are generally low and there are no significant orange coloured iron oxyhydroxide precipitation areas. Sulfate levels are generally low (3 – 11mg/L) with no indicated dissolution of sulfuric acid after iron sulfide weathering in the crinanite.

Wattle Creek is within the acceptable range for potable water, however it can exceed the ANZECC 2000 95% Species Protection Level for Freshwater Aquatic Ecosystem Guidelines for the following parameters, depending on the flow conditions at the time of sampling;

- filtered copper and / or zinc very occasionally at all sites, and
- total nitrogen as well as total phosphorous at all sites, occasionally, with no regular pattern.

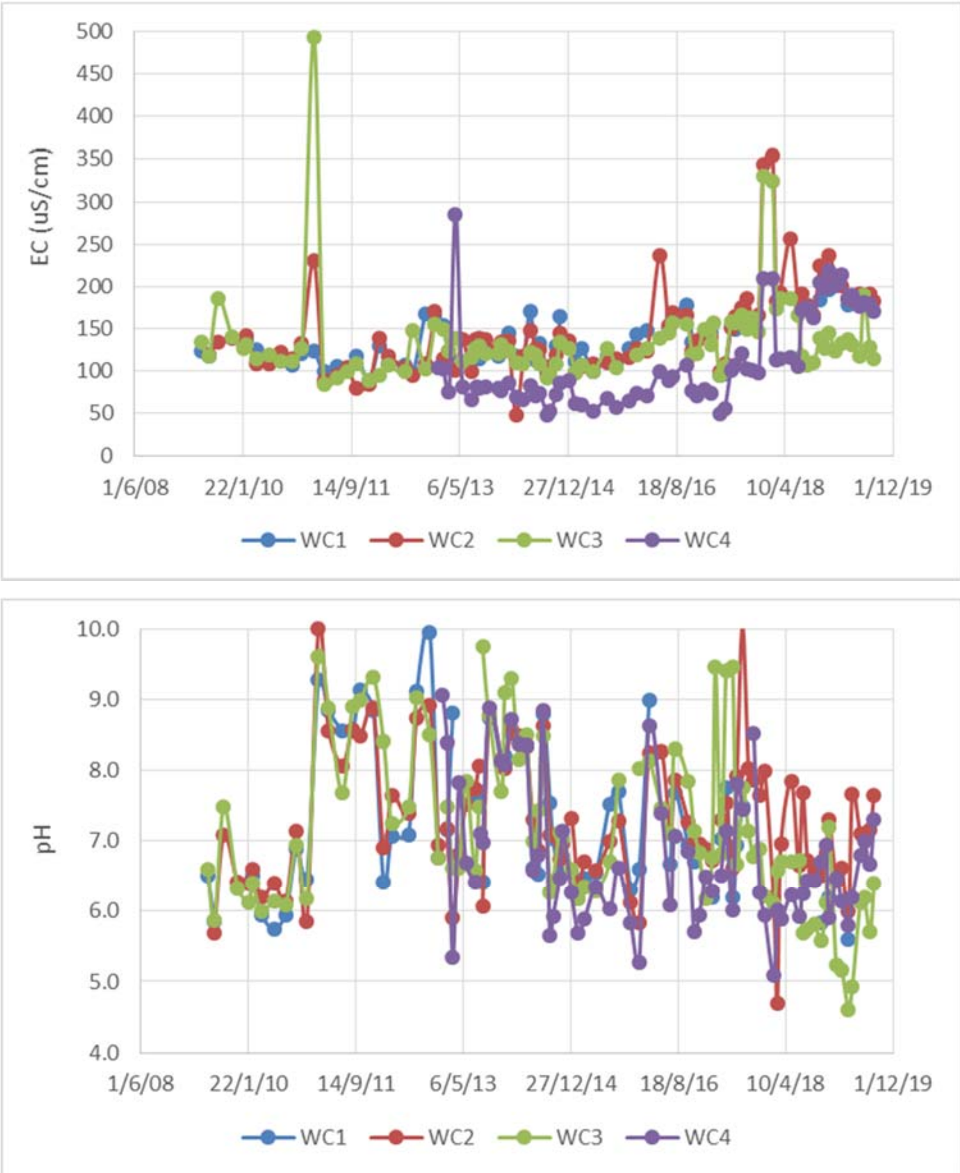

Figure 1 Wattle Creek Field Chemistry

5.1.2 Stream Flow

Stream flow in Wattle Creek, as measured by water depth monitoring, commenced in June 2009 as shown in **Figure 2**.

A correlation is evident between the major rainfall deficit period that started in late April 2017 and the lack of stream flow (as represented by water depth) in the Wattle Creek monitoring locations.

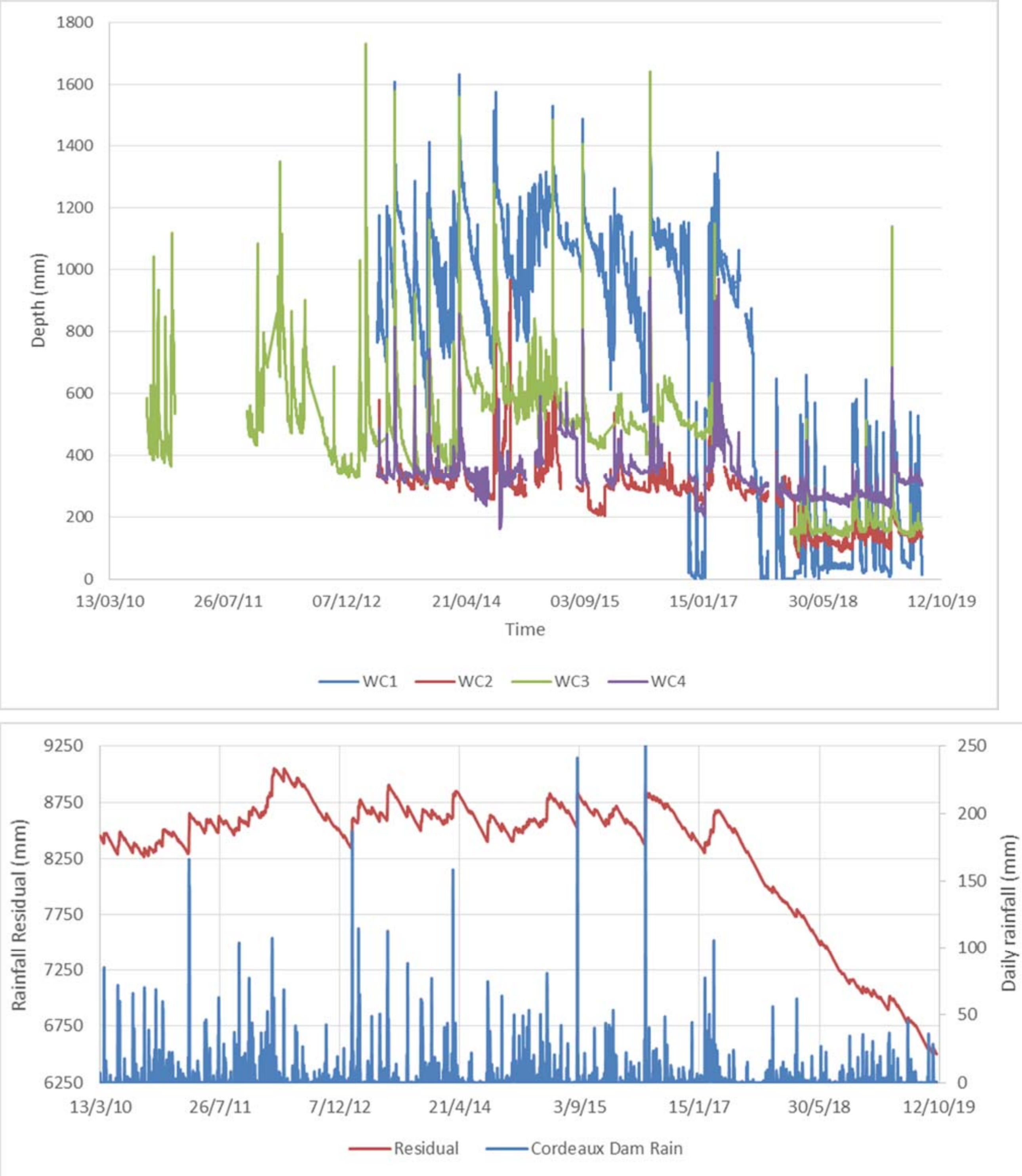

Figure 2 Wattle Creek Stream Water Levels and Rainfall

5.2 Little Wattle Tree Creek

Little Wattle Tree Creek flows in an easterly direction over the northern end of LWN5 and the adjacent catchment as shown in **Drawing 1**.

The main channel over LWN5 is a 1st order creek (DIPNR, 2005), which becomes a 2nd order stream upstream of the LWTC1 monitoring site.

Little Wattle Tree Creek drains into the Upper Cordeaux No.2 reservoir approximately 1250m to the east of LWN5, whilst its headwaters are located within the 20mm subsidence zone.

The channel of Little Wattle Tree Creek has not been undermined by any of the previous or proposed panels

The creek is not regulated by any dams or weirs and there are no waterfalls. Stream monitoring site details are shown in **Table 5**.

Table 5 Little Wattle Tree Creek Stream Monitoring Sites

SITE	E (MGA)	N (MGA)	DESCRIPTION
LWTC1	294920	6190020	At Fire Road 6 crossing

Little Wattle Tree Creek is characterised by a series of small boulder and cobble based pools as well as small pools developed on exposed columnar jointed crinanite, often with less than a 0.5m drop between the pools.

The stream is well defined with steeply sloping banks up to 10m high with a well developed rainforest and no apparent erosion or bank instability.

5.2.1 Stream Chemistry

Water quality monitoring in Little Wattle Tree Creek commenced in June 2009 as shown in **Figure 2**.

The LWTC1 site is generally dry, or ponded but not flowing. The creek's pH ranges from 5.5 to 6.6, which is generally marginally more acidic than Wattle Creek, and is predominantly below the pH 6.5 – 7.5 ANZECC 2000 South Eastern Australia Upland Stream criteria.

The creek's salinity ranges from 95 - 134µS/cm, which is generally less saline than Wattle Creek, and rises after prolonged dry periods.

Iron levels in the creek are generally low with some minor orange coloured iron oxyhydroxide precipitation seepage locations.

Sulfate levels are generally low (2 – 7mg/L) indicating no distinctive dissolution of sulfuric acid after iron sulfide weathering in the crinanite.

The creek is within the acceptable range for potable water, however it can exceed the ANZECC 2000 95% Species Protection Level for Freshwater Aquatic Ecosystem Guidelines for the following parameters, depending on the flow conditions at the time of sampling;

- filtered zinc very occasionally at all sites,
- total nitrogen, in all samples to date, and;
- total phosphorous, infrequently.

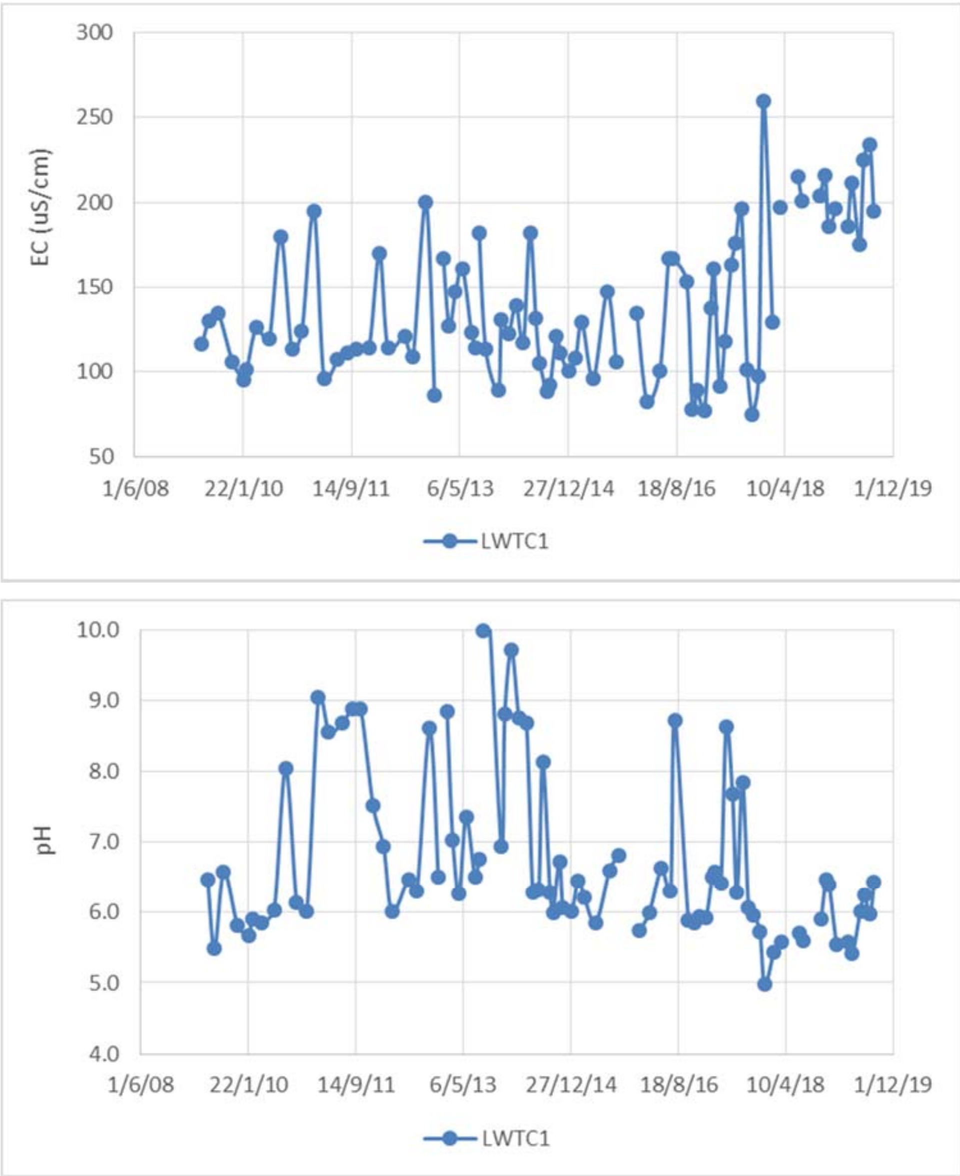

Figure 3 Little Wattle Tree Creek (LWTC1) Field Chemistry

5.2.2 Stream Flow

Stream flow in Little Wattle Tree Creek has not been measured during the monitoring period.

6. PREDICTED AND OBSERVED SURFACE WATER IMPACTS

6.1 Creek Subsidence

6.1.1 Potential Impacts

Maximum subsidence of;

- 50 - 100mm in Wattle Creek;
- <20mm in Little Wattle Tree Creek

6.1.2 Creek Subsidence Observations

No direct subsidence measurements have been conducted in Wattle Creek or Little Wattle Tree Creek, however extrapolation from adjacent monitoring lines indicate there has been no perceptible impacts on either creek due to extraction of Panels N1, N3 or N5.

No stream flow related TARP trigger levels have been reached or exceeded and no ameliorative actions are required due to extraction of Panel N3.

6.2 Stream Water Quality

6.2.1 Potential Impacts

- increased iron hydroxide precipitation, and;
- lowering (acidification) of pH.

6.2.2 Wattle and Little Wattle Tree Creek Observations

No observable water quality changes occurred in Wattle Creek or Little Wattle Tree Creek due to extraction of Panels N1, N3 or N5.

No stream water quality related TARP trigger levels have been reached or exceeded and no ameliorative actions are required due to extraction of Panel N3.

6.3 Stream Flow

6.3.1 Potential Impacts

- No anticipated adverse effect on stream flow in Wattle Creek or Little Wattle Tree Creek.

6.3.2 Stream Flow Observations

There has been no observed adverse effect on stream flow in Wattle Creek or Little Wattle Tree Creek due to extraction of Panels N1, N3 or N5.

No stream flow related TARP trigger levels have been reached or exceeded and no ameliorative actions are required due to extraction of Panel N3.

6.4 Stream Bed and Bank Stability

6.4.1 Potential Impacts

- no anticipated adverse effect on stream bed or bank instability or cracking of the stream bed is anticipated in Wattle Creek or Little Wattle Tree Creek resulting from extraction of Panels N1, N3 or N5.

6.4.2 Observed Impacts

No adverse effect has been observed on stream bed or bank instability or cracking of the stream bed in Wattle Creek or Little Wattle Tree Creek.

No stream bed or bank stability related TARP trigger levels have been reached or exceeded and no ameliorative actions are required due to extraction of Panel N3.

7. GROUNDWATER

The hydrogeology of the Nebo area is distinctly different to all other underground coal mines in the Southern Coalfield due to the presence of the up to 97.5m thick (as drilled) crinanite with its very low permeability, low storativity and its "aquitard" nature both pre and post subsidence (GeoTerra, 2010).

The crinanite is located at the top of the overburden stratigraphic profile and outcrops over approximately 95% of the Nebo area workings as a flat lying to bowl shaped igneous intrusion.

The presence of the crinanite is very significant, in that it acts as an aquitard over the Narrabeen Group and Permian Coal Measures. It separates the shallow soil groundwater system and connected streams at surface from the underlying Narrabeen Group and Permian Coal Measures.

The crinanite differentiates Nebo from all other coal mining areas in the Southern Coalfield and provides a unique hydrogeological and hydrological setting in which to assess and predict coal extraction subsidence effects on surface water and groundwater systems overlying the proposed workings.

Aquifers present that can interact with the local streams are;

- shallow, perched ephemeral aquifers in the up to 6.5m deep soil profile, and, if present
- low flow, short duration seeps from the crinanite or interface drainage originating between the crinanite and the limited exposures of the Narrabeen Group or Hawkesbury Sandstone along the western ridge.

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.

Geotechnical studies (SCT Operations, 2019) indicate that even after extraction where the Illawarra Coal Measures and Narrabeen Group (or Hawkesbury Sandstone if present) overburden is subsided and fractured, the Cordeaux Crinanite is anticipated to maintain its aquitard status where it is greater than 30m thick. This conservative value is an interpreted thickness under which the aquitard properties of the crinanite is likely to remain intact.

Due to the steep topography and the above mentioned factors, as well as depressurisation in subsided and fractured areas over and within the previous workings at Eloura / Nebo, there is anticipated to be essentially no notable remnant groundwater bearing strata in the Illawarra Coal Measures or Narrabeen Group sedimentary units underneath the crinanite.

No DPI-W registered private bores are located within the Nebo area as it is within a restricted access water catchment area administered by Water NSW.

7.1 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 6** and shown in **Drawing 2**.

Each piezometer was installed with a pressure transducer reading water pressure (levels) at least twice per day.

Table 6 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

7.2 Vibrating Wire Piezometers

Four vibrating wire piezometer arrays were installed between December 2009 and January 2010 as outlined in **Table 7** and shown in **Drawing 2.**

Table 7 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

8. PREDICTED AND OBSERVED GROUNDWATER IMPACTS

8.1 Aquifer / Aquitard Interconnection

8.1.1 Potential Impacts

- no adverse interconnection of aquifers and aquitards is 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.

8.1.2 Aquifer / Aquitard Interconnection Observations

No adverse aquitard / aquifer interconnection or increased recharge has been observed in the vicinity of, or resulting from, extraction of Panels N1, N3 or N5.

No aquifer / aquitard interconnection related TARP trigger levels have been reached or exceeded and no ameliorative actions are required due to extraction of Panel N3.

8.2 Groundwater Levels

8.2.1 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.

8.2.2 Groundwater Level Observations

Neither of the shallow soil, alluvium or colluvium piezometers (Nebo1S or Nebo2S) overlie Panel N4, and both have varied in response to rainfall in the catchment as shown in **Figure 4**, with no influence from N4 during its period of extraction.

Neither of the crinanite piezometers Nebo2D or Nebo3 overlie N4, and both have varied in response to rainfall in the catchment as shown in **Figure 5**, with no apparent diversion from the natural water level trends from N4 during its period of extraction.

Piezometer Nebo1D was installed in the Narrabeen Group, although is also not in close proximity to, and did not show a response to extraction of N4 as shown in **Figure 6**.

Piezometer Nebo4, which was installed in the Bulli Seam, to the north of N4, showed a rising water level during extraction of LWN2, albeit with short term drops and recoveries following water extraction sampling events, along with a 2.1m decline in water level during extraction of Panel N4, and a subsequent total drying out as shown in **Figure 7**.

No groundwater level related TARP trigger levels have been reached or exceeded and no ameliorative actions are required due to extraction of Panel N3.

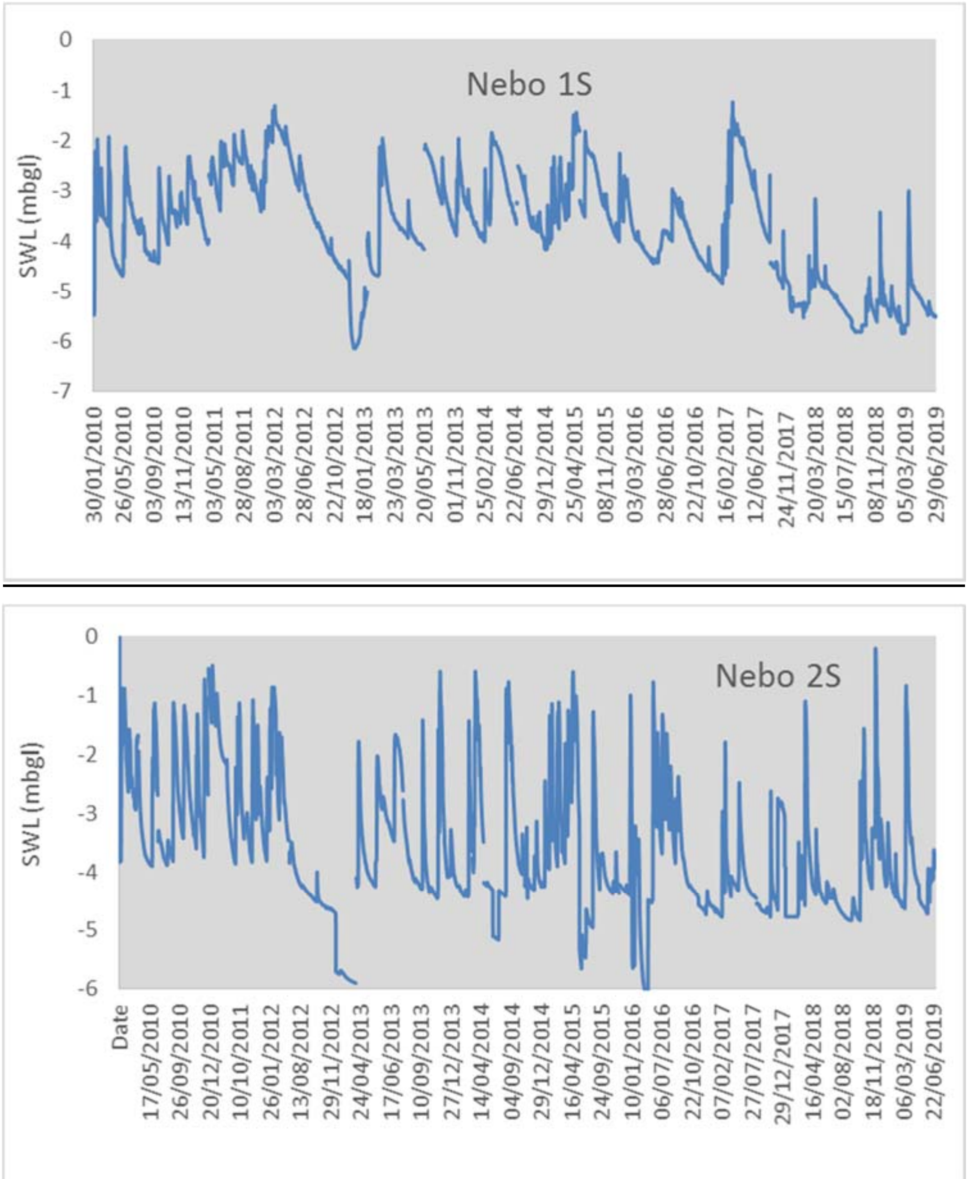

Figure 4 Alluvium / Colluvium Groundwater Levels

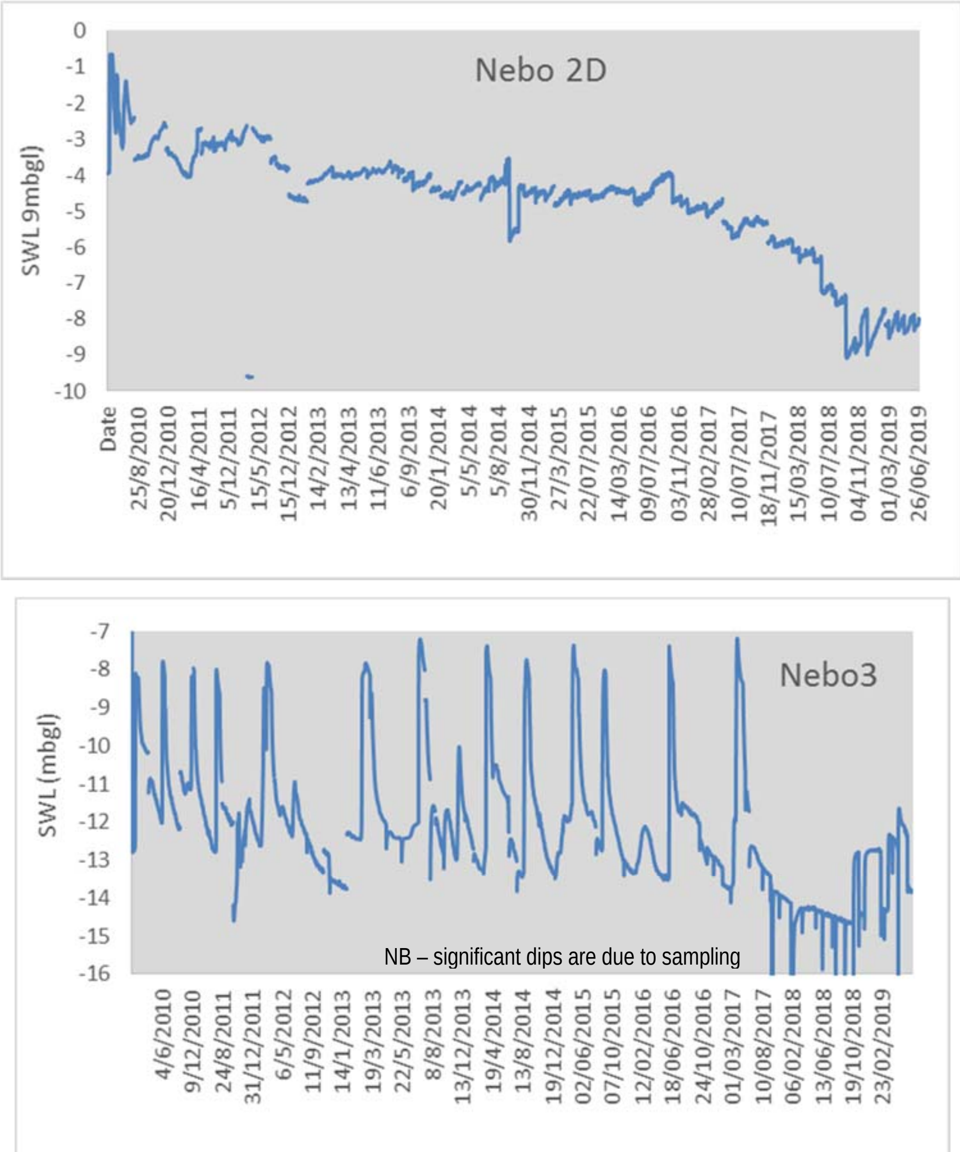

Figure 5 Crinanite Groundwater Levels

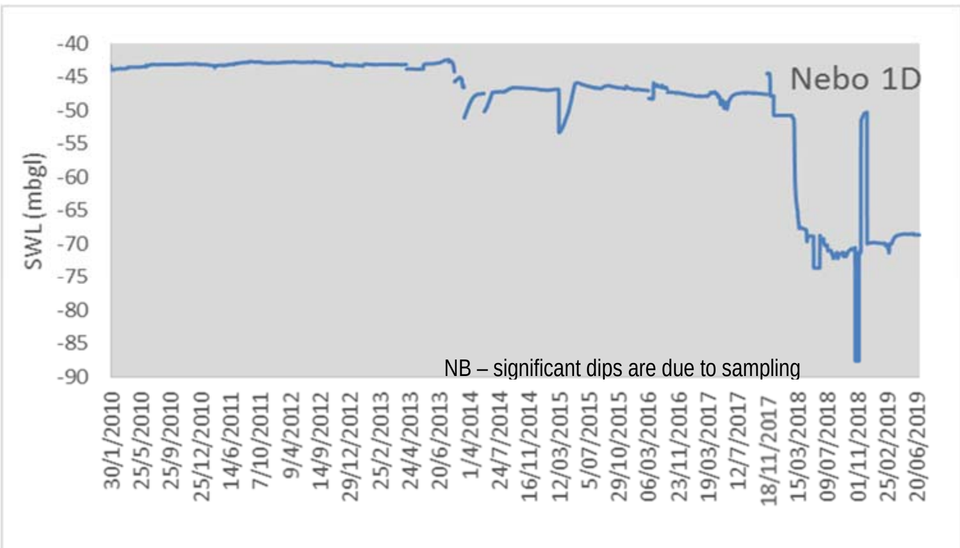

Figure 6 Narrabeen Group Groundwater Level

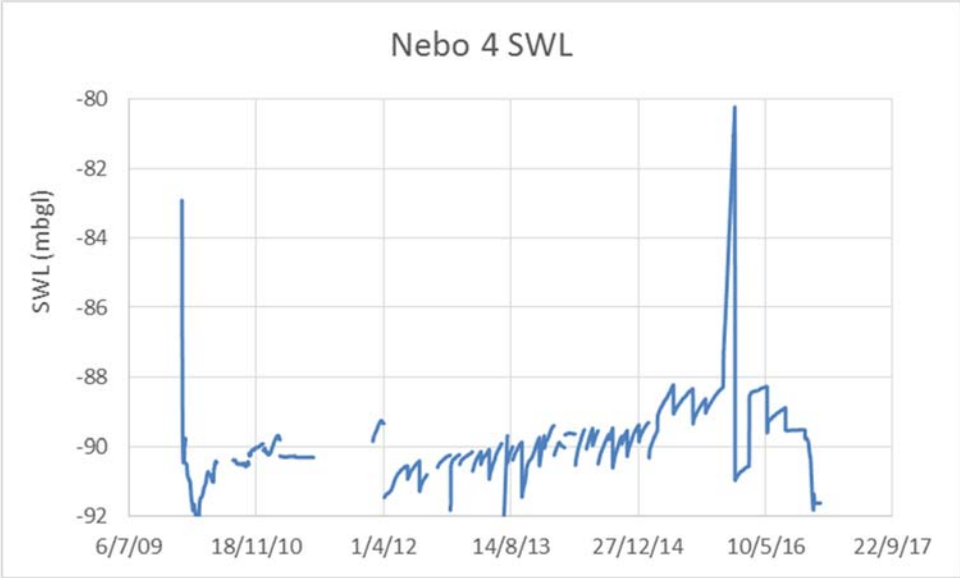

Figure 7 Bulli Seam Groundwater Level

The vibrating wire arrays installed in Nebo6, Nebo 7, Nebo 8 and Nebo8A demonstrated no response to Panels N1, N3 or N5 extraction, which indicates no mining subsidence effect in the crinanite.

In addition, no correlation with the water level of Cordeaux dam and the VWP intakes is apparent.

Water levels in the four VWP arrays are shown in **Figures 8** to **11**.

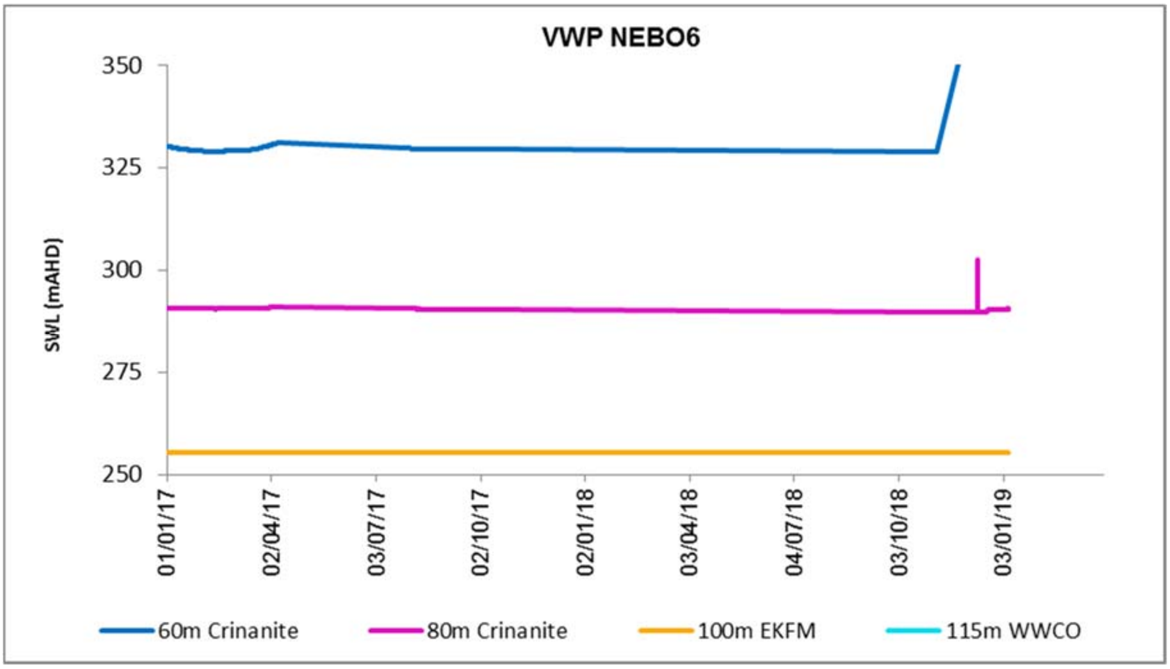

Figure 8 Nebo 6 VWP

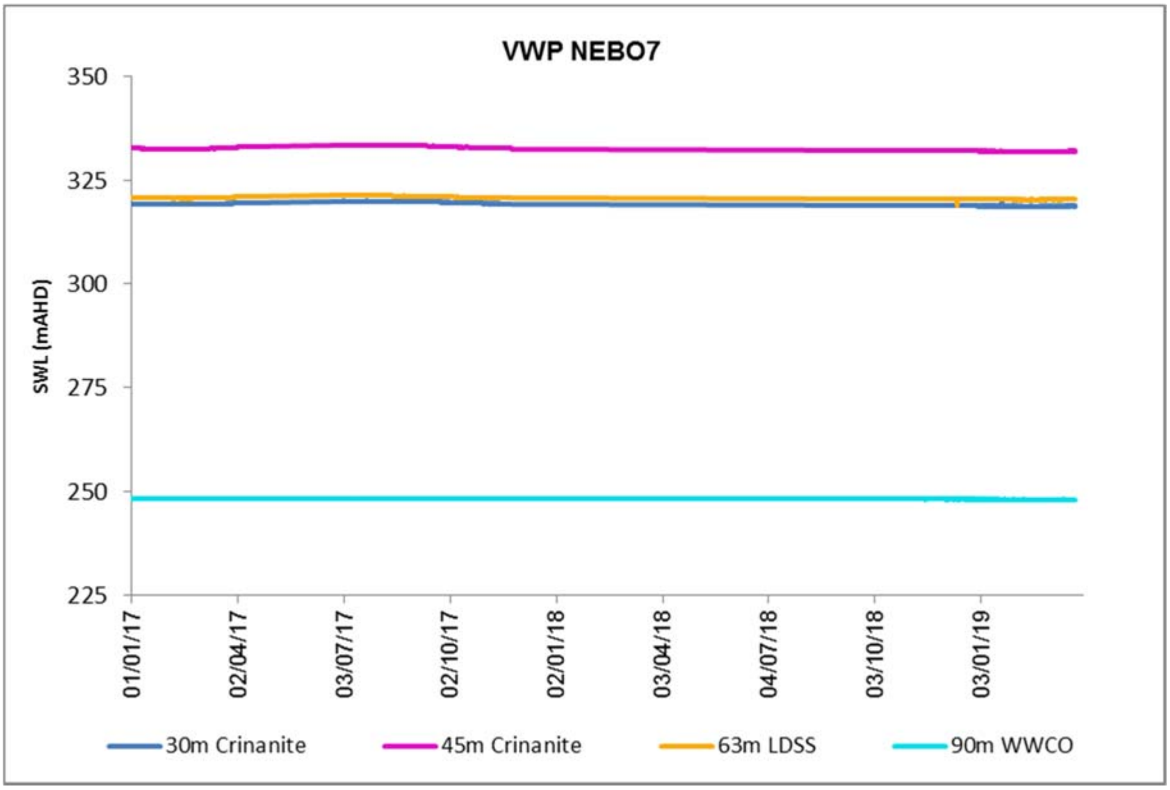

Figure 9 Nebo 7 VWP

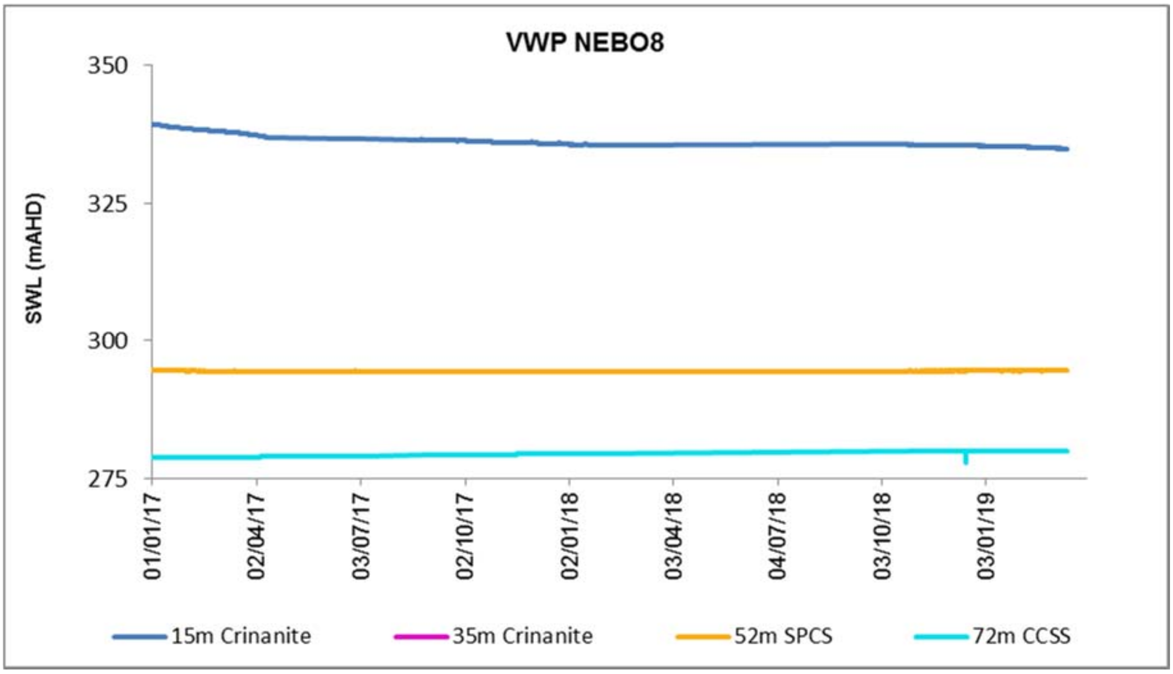

Figure 10 Nebo 8 VWP

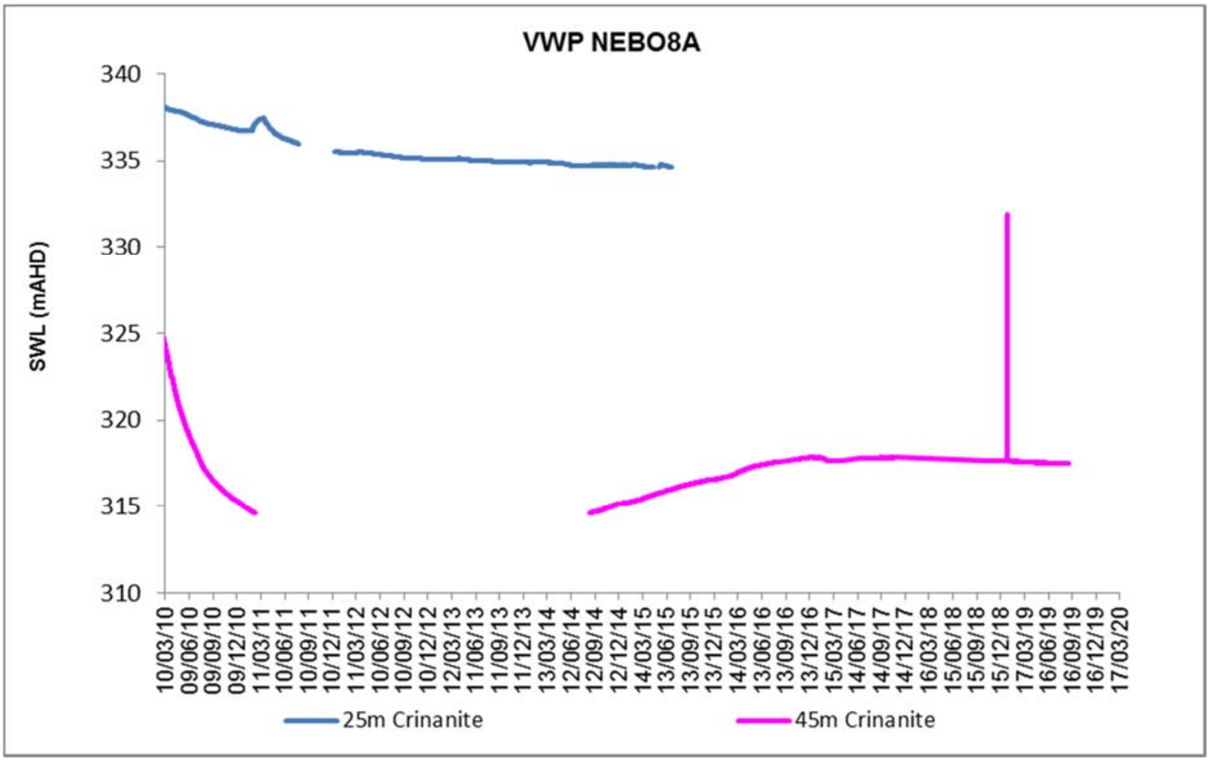

Figure 11 Nebo 8A VWP

4.5 Groundwater Quality

Groundwater in the Nebo study area has generally fresh to brackish salinity (39-2,965µS/cm) with acidic to circum-neutral pH (3.3 – 7.5) as summarised in **Table 5** and shown in **Figures 12** to **15**.

However, cement used to seal the piezometers during installation has had a definitive increase in alkalinity (up to pH 14) and salinity (up to 14500µS/cm) in Nebo 1D, 2D and 4, which means they do not represent the actual formation water chemistry.

Piezometers 1S, 2S and 3 appear to be unaffected by cement and better represent the formation water chemistry, although a cement influence is present.

Table 8 Nebo Field Groundwater Quality

Formation	Piezometers	EC (µS/cm)	pH
Shallow	1S, 2S	32 – 1,071	3.3 – 9.3
Crinanite	2D, 3	230 -2,950	6.7 – 9.8
Narrabeen	1D	123 – 2,965	7.5 – 10.5
Bulli Seam	4	798 – 14,440	10.9 – 13.9

Note: Nebo 1D, 2D and 4 are strongly affected by cement, 1S, 2S and 3 better represent actual formation water chemistry

Laboratory analyses indicate that the monitored groundwater is outside ANZECC 2000 criteria (default trigger values for physical & chemical stressors in SE Aust Upland Rivers / 95% protection of freshwater species / livestock / irrigation) for:

- Total nitrogen;
- Total phosphorous
- Copper
- Lead
- Zinc;
- Nickel, and
- Aluminium

Note that the water chemistry of Nebo 1D, 2D and 4 are strongly affected by cement used to seal the piezometer intake and do not therefore represent the actual formation water quality.

The exceedance varies depending on the applicable guideline applied for the end use of the water.

Groundwater in the Nebo area is suitable for selected livestock and limited irrigation use, but not for potable water.

No adverse change to groundwater quality in the Nebo piezometers has been observed, along with no distinctive increase in salinity, nutrients or metals.

No groundwater quality related TARP trigger levels have been reached or exceeded and no ameliorative actions are required due to extraction of Panel N3.

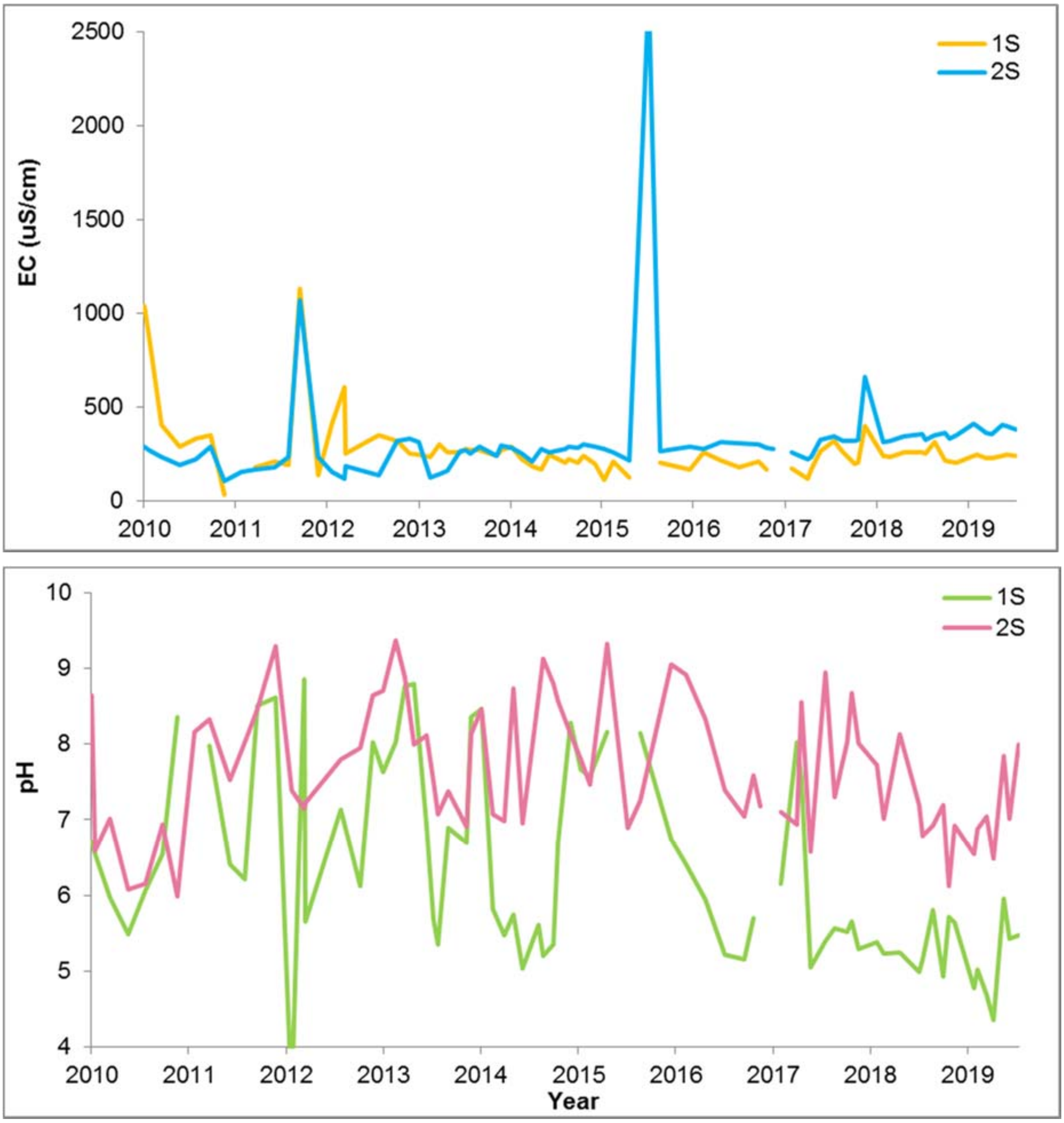

Figure 12 Soil and Shallow Field Groundwater Quality

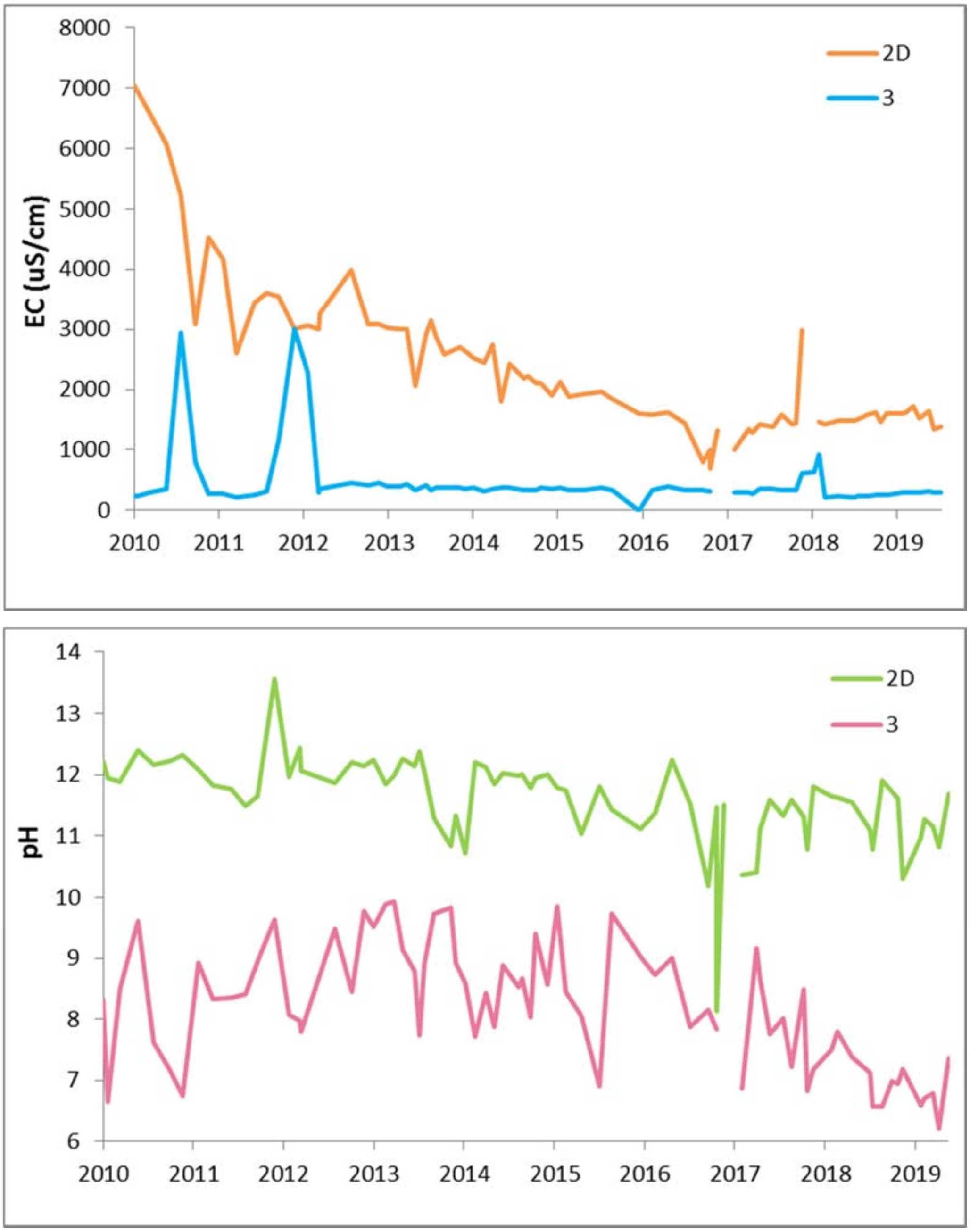

Figure 13 Crinanite Field Groundwater Quality

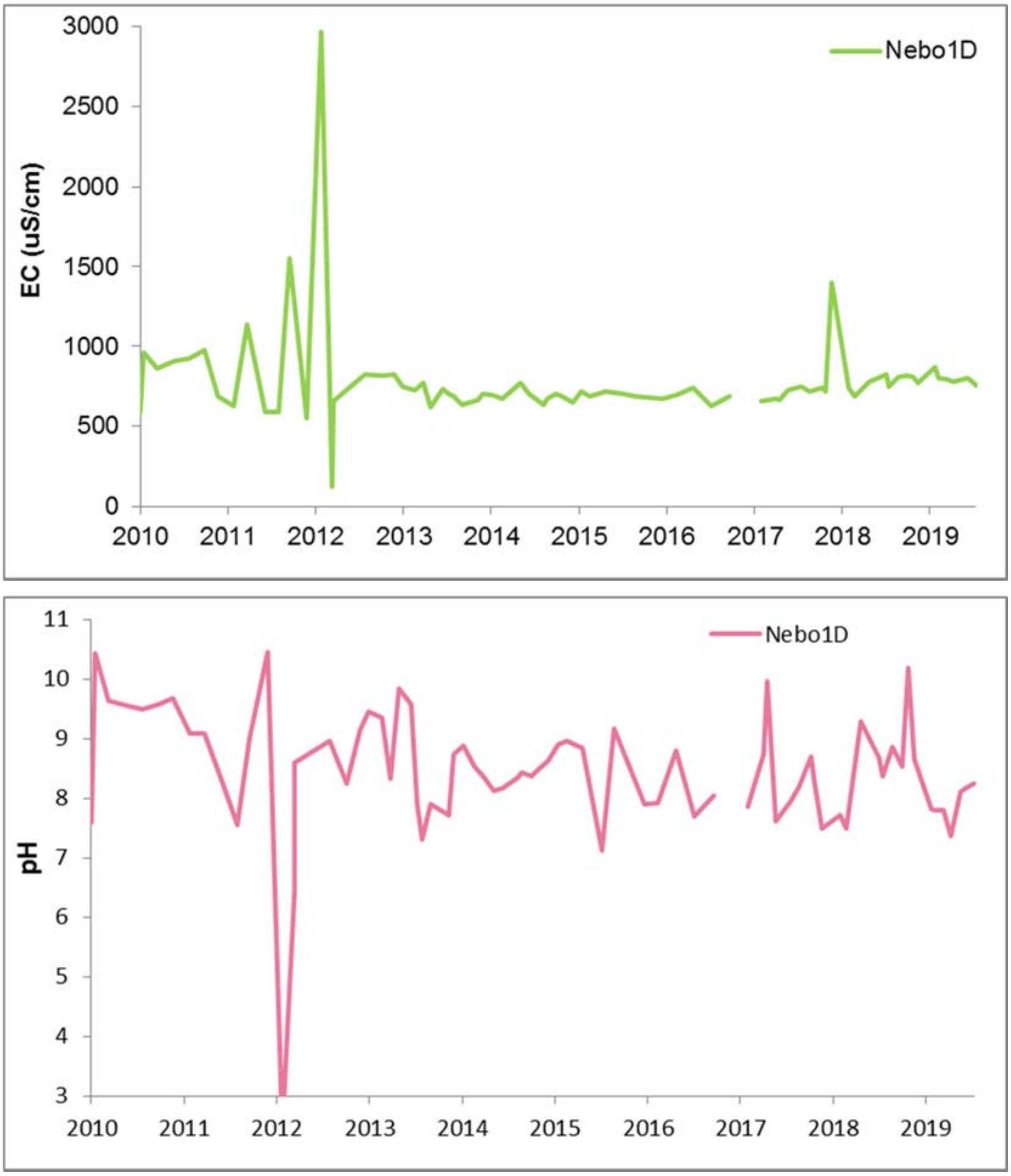

Figure 14 Narrabeen Formation Field Groundwater Quality

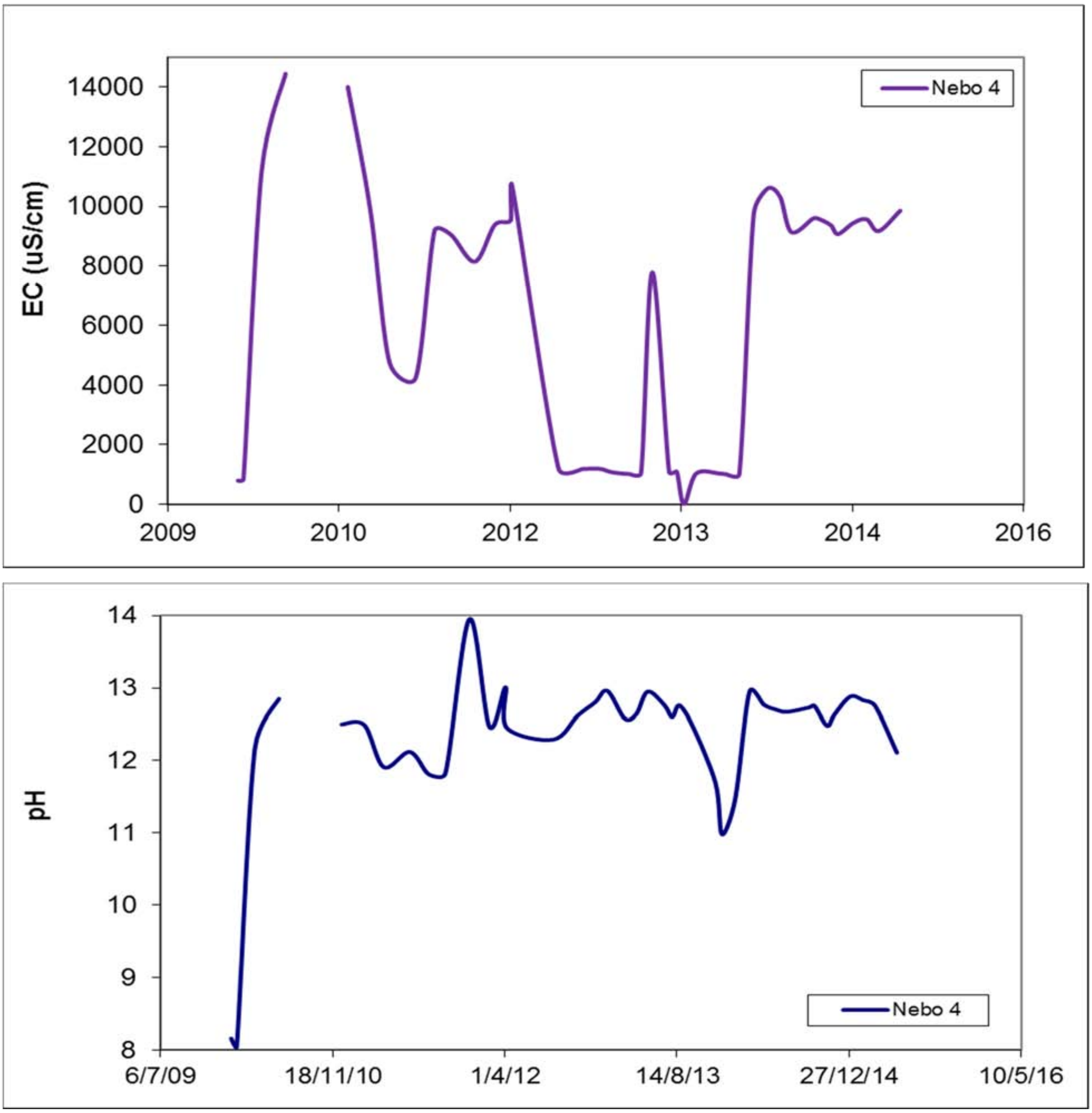

Figure 15 Bulli Seam Field Groundwater Quality

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

There was no groundwater make from the Panel N1, N3 and N5 during and after extraction of the panels, (Pers comm. - Paul Coxhead - Mining Engineering Manager).

No mine water discharge related TARP trigger levels have been reached or exceeded and no ameliorative actions are required due to extraction of Panel N3.

5 SUMMARY OF RESULTS

Although the subsidence movements along the axis or across the whole panel were not directly measured, the subsidence observed in the vicinity of Panels N1, N3 and N5 was less than or consistent with the predictions made in the EP/SMP and Part 3A Application.

Subsidence monitoring (SCT 2019) has confirmed the bridging capacity of the Cordeaux Crinanite (dolerite) sill within the overburden sequence for the approved panel geometries in the Nebo area.

This bridging has limited the magnitude of the maximum subsidence and associated parameters to levels that are imperceptible for all practical purposes.

The maximum subsidence parameters measured to date in the vicinity of Panels N1, N3 and N5 are:

- subsidence 150 mm
- tilt 2.0 mm/m
- strain 1mm/m (compression and tension)

Based on the low levels of ground movement observed as a result of Panel N1, N3 and N5 extraction, there have been no adverse or unexpected impacts on the groundwater or surface water systems at Nebo.

Piezometer Nebo 4, which is screened adjacent to Panel N4 within the Bulli Seam, became fully dewatered during extraction of N4. This impact was within the predicted impacts and was expected to happen due to the coal extraction and transmitted effect from creating an atmospheric pressure void within the seam due to mining Panel N4.

The subsidence impacts and consequences from the extraction of Panels N5 are within the predicted impacts and comply with the subsidence impact performance measures in Project Approval 09_0161 for surface water and groundwater systems at Nebo.

6 REFERENCES

ANZECC 2000 Australian and New Zealand Guidelines for Fresh and Marine Water Quality, Vol 1 & 2

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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

SCT Operations, 2017 Wongawilli Colliery N4 End of Panel Subsidence Report

SCT Operations, 2019 Wongawilli Colliery N3 End of Panel Subsidence Report

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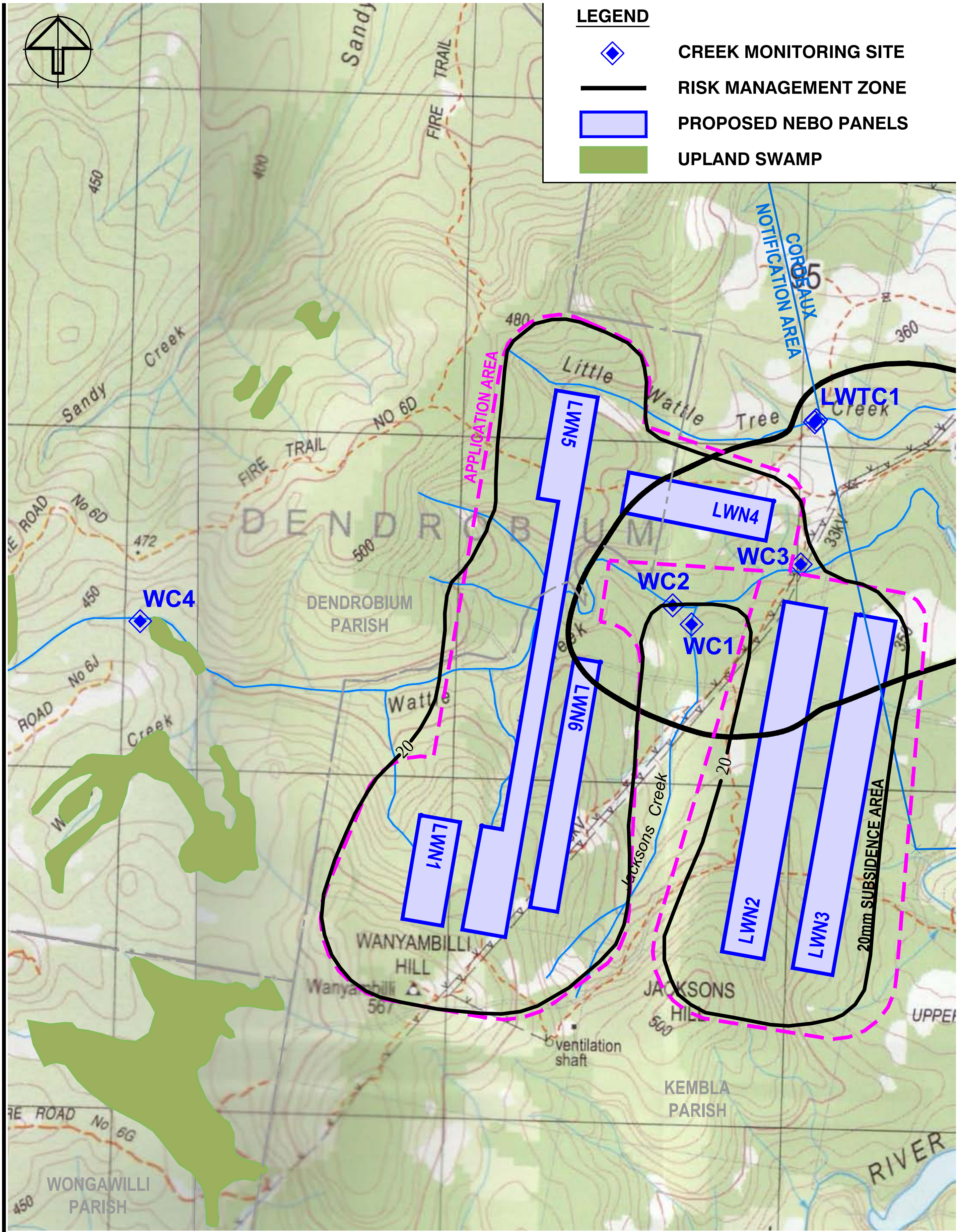
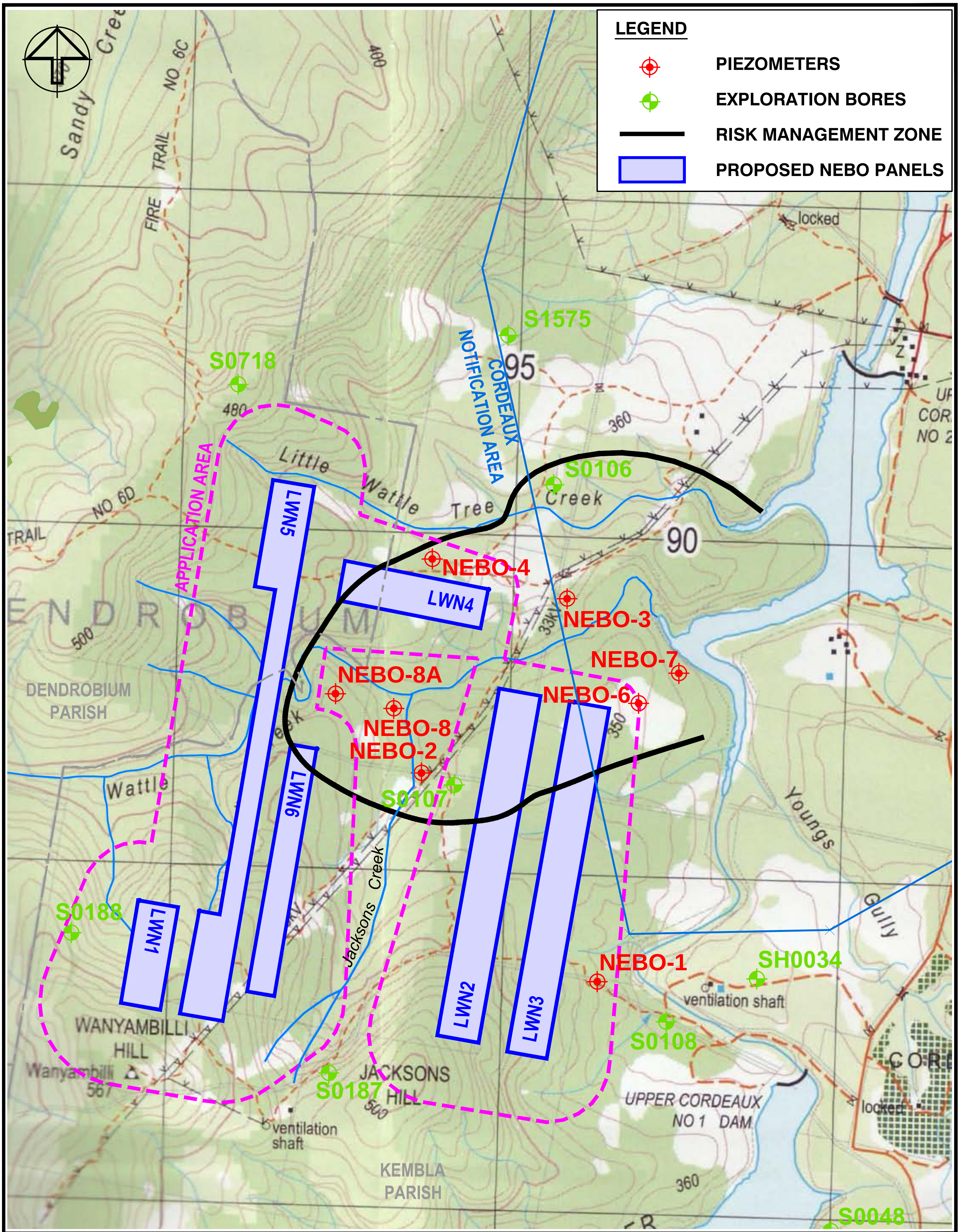


PROJECT:	NEB5	**WOLLONGONG COAL LTD** **NEBO** **SURFACE WATER** **MONITORING LOCATIONS**	**GeoTerra**
DRAWN:	A. DAWKINS		**DRAWING 1**
DATE:	28 May 2010		
SCALE:	1:15 000		



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

WOLLONGONG COAL pTY LTD
NEBO LONGWALL LWN2

PIEZOMETER LOCATIONS

GeoTerra

DRAWING 2

Appendix F – Geoterra Ground and Surface Water NEBO N5 EoP Report

GeoTerra

WOLLONGONG COAL LTD

WONGAWILLI COLLIERY END OF PANEL N5 SURFACE WATER AND GROUNDWATER REPORT

Wollongong, NSW

NEB6-R1A

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Date	Rev	Comments
31/10/2019		Initial Report
7/11/2019	A	Incorporate review comments

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1. INTRODUCTION

This document outlines observation of the groundwater and surface water systems in the Nebo Area within the Wollongong Coal Limited (WCL) operated Wongawilli Colliery lease area.

Extraction of the Wongawilli Seam in Panels N1, N3 and N5 was conducted as shown in **Table 1** by secondary pillar extraction with a continuous miner.

Table 1 Panel Extraction Dates and % Recovery

Panel	Start	Finish
N1	13/05/2017	21/09/2018
N3	04/10/2016	13/03/2019
N5	19/09/2018	26/01/2019

1.1 Site Description

The study area is located 13km west of Wollongong in the upper reaches of the Cordeaux River valley within the Sydney Water Catchment Metropolitan Special Area.

The area is within undeveloped bushland comprising native vegetation and other regeneration areas.

Panel N1 is located below the peak of Wanyambilli Hill between Wattle Creek and Jackson's Creek Wattle Creek.

Panel N3 is located between the Cordeaux River and Jackson's Creek, to the east of Panel N2 and underneath the eastern flank of Jackson's Hill.

Panel N5 extends from beneath the peak of Wanyambilli Hill to Little Wattle Tree Creek.

All three panels are outside the Dams Safety Committee Notification Area for the Cordeaux Storage Reservoir, except for the northern portion of N3.

2. SCOPE OF WORK

GeoTerra were commissioned by WCL to report on any observed groundwater system changes resulting from extraction of Panels N1, N3 and N5 in accordance with the:

- Nebo Longwalls N1-N6 Extraction Plan (Niche, 2011),
- Extraction Plan (EP) subsidence predictions (MSEC 2010), and the;
- Subsidence Management Plan (SMP) (Niche 2012), which was based on the Part 3A Application for the Nebo Area Project (09_0161).

This report presents the results of our review and analysis in accordance with Condition 18 of SMP Approval 09/5341and Extraction Plan requirements of Condition 7 in schedule 3 of Project Approval 09_0161.

3. OVERBURDEN GEOLOGY

The Nebo Study Area is predominantly covered by shallow hillslope-based colluvium developed directly over the Cordeaux Crinanite, with very thin to absent alluvial sedimentary deposits in the valley floors.

The colluvial soil ranges up to 6.5m thick and comprises ferruginous clays overlying the thin weathered mantle of the crinanite, or where the crinanite is absent, as in over the south western section of Panel N1, thin sandy soils developed on Hawkesbury Sandstone or the Bulgo Sandstone are present.

The crinanite has intruded into the basement between the Hawkesbury Sandstone and the Bulli Seam and dominates the sub-cropping and outcropping geology at Nebo. Where the crinanite is absent in the western mostly higher elevation portion, such as over the south western corner of N1, thin sandy colluvial soil overlies the Hawkesbury Sandstone, Narrabeen Group and Illawarra Coal Measures stratigraphy.

The crinanite outcrops at surface and ranges from 0 - 70m thick over the N1, N3 and N5 panels, with the base of the sill located approximately 50 - 60m above the extracted panels.

Previous exploratory work (SCT 2010) showed that a 65m thick 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.

No known major faults outcrop at surface as the Cordeaux Crinanite has overprinted any structures that may have been present in the sedimentary overburden.

4. PANEL EXTRACTION AND SUBSIDENCE

4.1 Mining Layout

Extraction of N1, N3 and N5 Panels occurred as shown in **Table 2**.

Table 2 Panel Extraction Dates and % Recovery

Panel	Length (m)	Width (m)	Mining Height (m)	Depth of Cover (m)	Extraction (%)
N1	310	120	3.2	240 - 350	73
N3	850	125	3.2	120 - 260	57
N5	1670	65 - 125	3.2	160 - 360	56

4.2 Subsidence

Subsidence behaviour above the panels is significantly influenced by the presence of the intruded crinanite sill.

The subsidence movements are of very low magnitude. However, these need to be considered in the context of the expected survey tolerances and Trigger Action Response Plans (TARPS) outlined in the Nebo Longwalls 1 - 6 Subsidence Monitoring Plan.

Accuracy expectations for regional points are ±25mm for position and ±35mm for height.

The maximum subsidence values along subsidence lines associated with Panels N1, N3 and N5 are shown in **Table 3**.

Table 3 Subsidence Monitoring

Panel	Subsidence (mm)	Tilt (mm/m)	Strain (mm/m) Compression	Strain (mm/m) Tension
N1	n/a	n/a	n/a	n/a
N3	<150	<2mm/m	<1mm/m	<1mm/m
N5	n/a	n/a	n/a	n/a

NOTE: n/a survey data not yet available

Overall, subsidence observed in the vicinity of Panels N1, N3 and N5 are considered (or expected) to be less than or consistent with the predictions made in the EP/SMP and Part 3A Application (SCT Operations, 2017).

Monitoring confirmed the bridging capacity of the crinanite, which has limited the maximum subsidence and associated parameters to levels that are imperceptible for all practical purposes (SCT Operations, 2019).

5. SURFACE WATER

Wattle Creek and Little Wattle Tree Creek are "connected - gaining streams" where the soil and, potentially to a lesser degree, the shallow crinanite groundwater, seeps into the creeks and maintains a baseflow during and after extended wet periods.

Variable seepage from the soil and crinanite enters the creeks and has been observed to maintain a continuous flow in the 3rd order channel of Wattle Creek, with the volume depending on the interaction between rainfall runoff, recharge and groundwater seepage applying at any one time.

The 2nd order channel of Little Wattle Tree Creek does not have a permanent stream flow.

Three channel types are present in the area:

- Channels incised into the crinanite with accumulated crinanite cobbles and boulders, with little to no channel sediment. These "v" shaped channels are usually bound by crinanite outcrop;
- Isolated rock platforms of variable width which are usually smooth except for minor depressions on the vertical, polygonally jointed crinanate. These platforms normally transgress into the pool / riffle sequence described above, and;
- Channels incised into crinanite boulder / cobble substrate in the lower catchment of Jacksons Creek, which is the 2nd order tributary of Wattle Creek draining to the north from Jacksons Hill and Wanyambilli Hill.

Three pool types are also present:

- Shallow, linear, small pools located in depressions formed by erosion of the columnar jointed crinanite where the downstream end is usually associated with a low rockbar outcrop,
- Larger pools constrained by a rockbar on the downstream end, or;
- Small pools upstream of a crinanite cobble / boulder accumulation.

5.1 Wattle Creek

Wattle Creek flows in a north easterly, then easterly direction and overlies the middle, narrowed section of LWN5, as well as the creeks catchment within the 20mm subsidence zone as shown in **Drawing 1**.

The creek is a perennial Schedule 2, 3rd order stream (DIPNR, 2005) downgradient of LWN5 and to the north of LWN2 and LWN3, with ephemeral 1st and 2nd order tributaries upstream of the WC1 and WC2 junction.

No workings underlie any 3rd order channel of Wattle Creek.

The 2nd order north flowing tributary (Jacksons Creek) drains into Wattle Creek at Site WC1.

Wattle Creek drains into the Upper Cordeaux No.2 reservoir to the east, and approximately 320m outside of, the 20mm subsidence zone, whilst its headwaters are predominantly contained within the 20mm subsidence envelope.

The creek is not regulated by any dams or weirs and there are no major waterfalls.

Wattle Creek stream monitoring site details are shown in **Table 4**.

Table 4 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	292915	6189490	1st order channel upstream of the extraction area

Wattle Creek is predominantly characterised by interspersed pools which are located over exposed crinanite or are upstream of crinanite boulder / cobble accumulations.

Generally small pools develop upstream of elevated rock bars or boulder / cobble accumulations, often with less than 0.5m drop between the pools. The pools are generally small due to the steep gradient of the creek bed.

The stream banks in the section upstream of Site WC3 are generally steep, although laid back, and can be over 20m high within a well defined channel with well developed rainforest vegetation along the banks and no apparent erosion or bank instability.

Downstream of WC3, the stream gradient reduces, although the well defined channel and rainforest vegetation is still present, albeit with lower banks.

5.1.1 Stream Chemistry

Water quality monitoring in Wattle Creek commenced in June 2009 as shown in **Figure 1**.

The creek at and downstream of WC2 has had a perennial flow, whilst the north flowing 2nd order tributary (Jacksons Creek) draining off Jacksons Hill and Wanyambilli Hill is often dry.

Wattle Creek's pH ranges from 5.7 to 7.5, which is occasionally below the pH 6.5 ANZECC 2000 South Eastern Australia Upland Stream criteria. The creek's salinity ranges from 117 - 185µS/cm, and generally rises after prolonged dry periods with less recharge to the stream.

Iron levels are generally low and there are no significant orange coloured iron oxyhydroxide precipitation areas. Sulfate levels are generally low (3 – 11mg/L) with no indicated dissolution of sulfuric acid after iron sulfide weathering in the crinanite.

Wattle Creek is within the acceptable range for potable water, however it can exceed the ANZECC 2000 95% Species Protection Level for Freshwater Aquatic Ecosystem Guidelines for the following parameters, depending on the flow conditions at the time of sampling;

- filtered copper and / or zinc very occasionally at all sites, and
- total nitrogen as well as total phosphorous at all sites, occasionally, with no regular pattern.

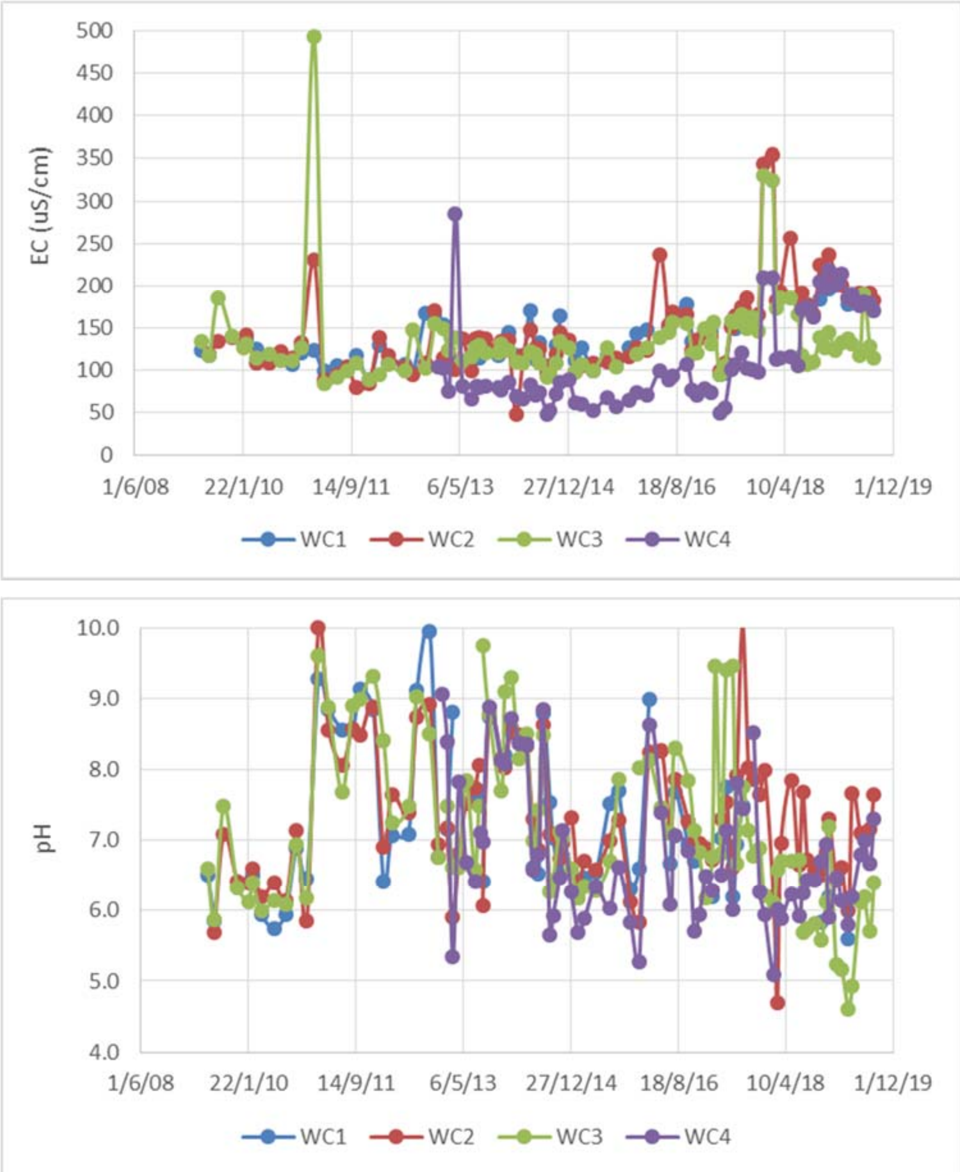
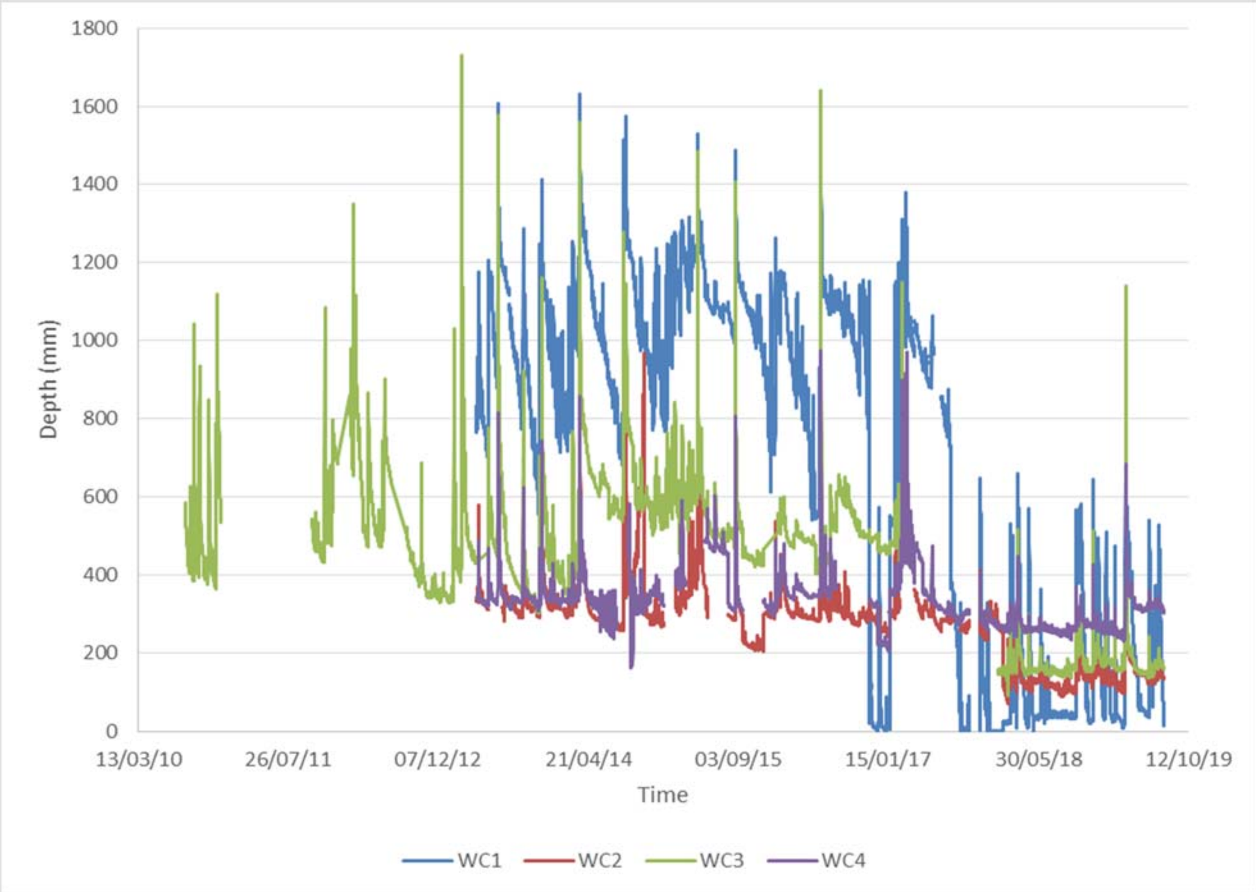


Figure 1 Wattle Creek Field Chemistry

5.1.2 Stream Flow

Stream flow in Wattle Creek, as measured by water depth monitoring, commenced in June 2009 as shown in **Figure 2**.

A correlation is evident between the major rainfall deficit period that started in late April 2017 and the lack of stream flow (as represented by water depth) in the Wattle Creek monitoring locations.



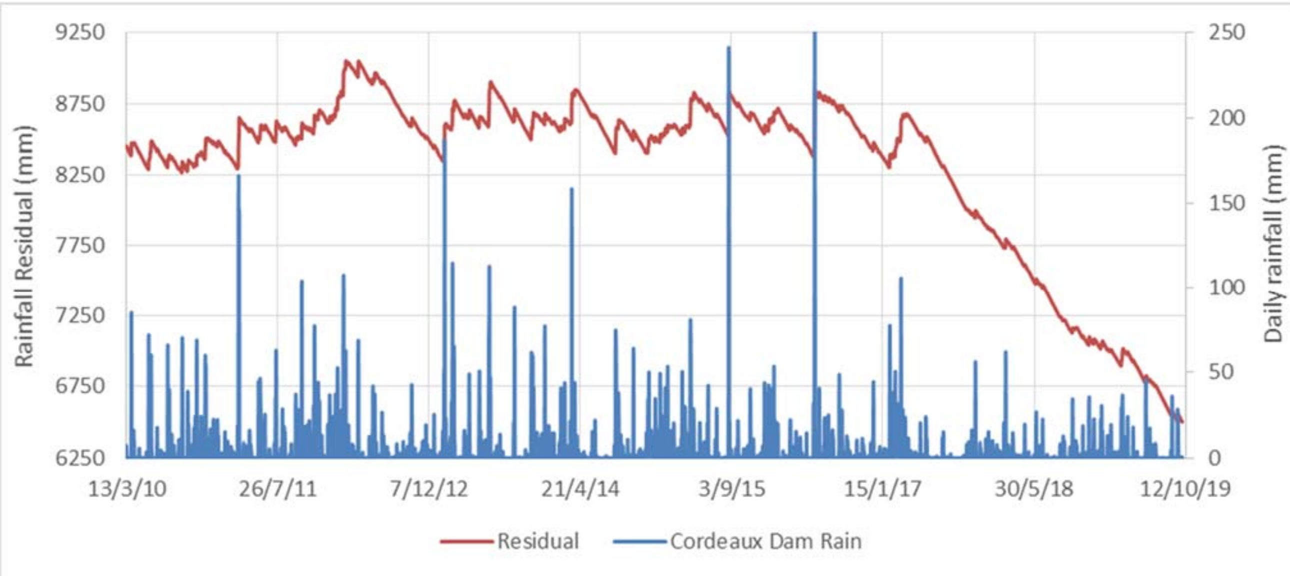


Figure 2 Wattle Creek Stream Water Levels and Rainfall

5.2 Little Wattle Tree Creek

Little Wattle Tree Creek flows in an easterly direction over the northern end of LWN5 and the adjacent catchment as shown in **Drawing 1**.

The main channel over LWN5 is a 1st order creek (DIPNR, 2005), which becomes a 2nd order stream upstream of the LWTC1 monitoring site.

Little Wattle Tree Creek drains into the Upper Cordeaux No.2 reservoir approximately 1250m to the east of LWN5, whilst its headwaters are located within the 20mm subsidence zone.

The channel of Little Wattle Tree Creek has not been undermined by any of the previous or proposed panels

The creek is not regulated by any dams or weirs and there are no waterfalls. Stream monitoring site details are shown in **Table 5**.

Table 5 Little Wattle Tree Creek Stream Monitoring Sites

SITE	E (MGA)	N (MGA)	DESCRIPTION
LWTC1	294920	6190020	At Fire Road 6 crossing

Little Wattle Tree Creek is characterised by a series of small boulder and cobble based pools as well as small pools developed on exposed columnar jointed crinanite, often with less than a 0.5m drop between the pools.

The stream is well defined with steeply sloping banks up to 10m high with a well developed rainforest and no apparent erosion or bank instability.

5.2.1 Stream Chemistry

Water quality monitoring in Little Wattle Tree Creek commenced in June 2009 as shown in **Figure 2**.

The LWTC1 site is generally dry, or ponded but not flowing. The creek's pH ranges from 5.5 to 6.6, which is generally marginally more acidic than Wattle Creek, and is predominantly below the pH 6.5 – 7.5 ANZECC 2000 South Eastern Australia Upland Stream criteria.

The creek's salinity ranges from 95 - 134µS/cm, which is generally less saline than Wattle Creek, and rises after prolonged dry periods.

Iron levels in the creek are generally low with some minor orange coloured iron oxyhydroxide precipitation seepage locations.

Sulfate levels are generally low (2 – 7mg/L) indicating no distinctive dissolution of sulfuric acid after iron sulfide weathering in the crinanite.

The creek is within the acceptable range for potable water, however it can exceed the ANZECC 2000 95% Species Protection Level for Freshwater Aquatic Ecosystem Guidelines for the following parameters, depending on the flow conditions at the time of sampling;

- filtered zinc very occasionally at all sites,
- total nitrogen, in all samples to date, and;
- total phosphorous, infrequently.

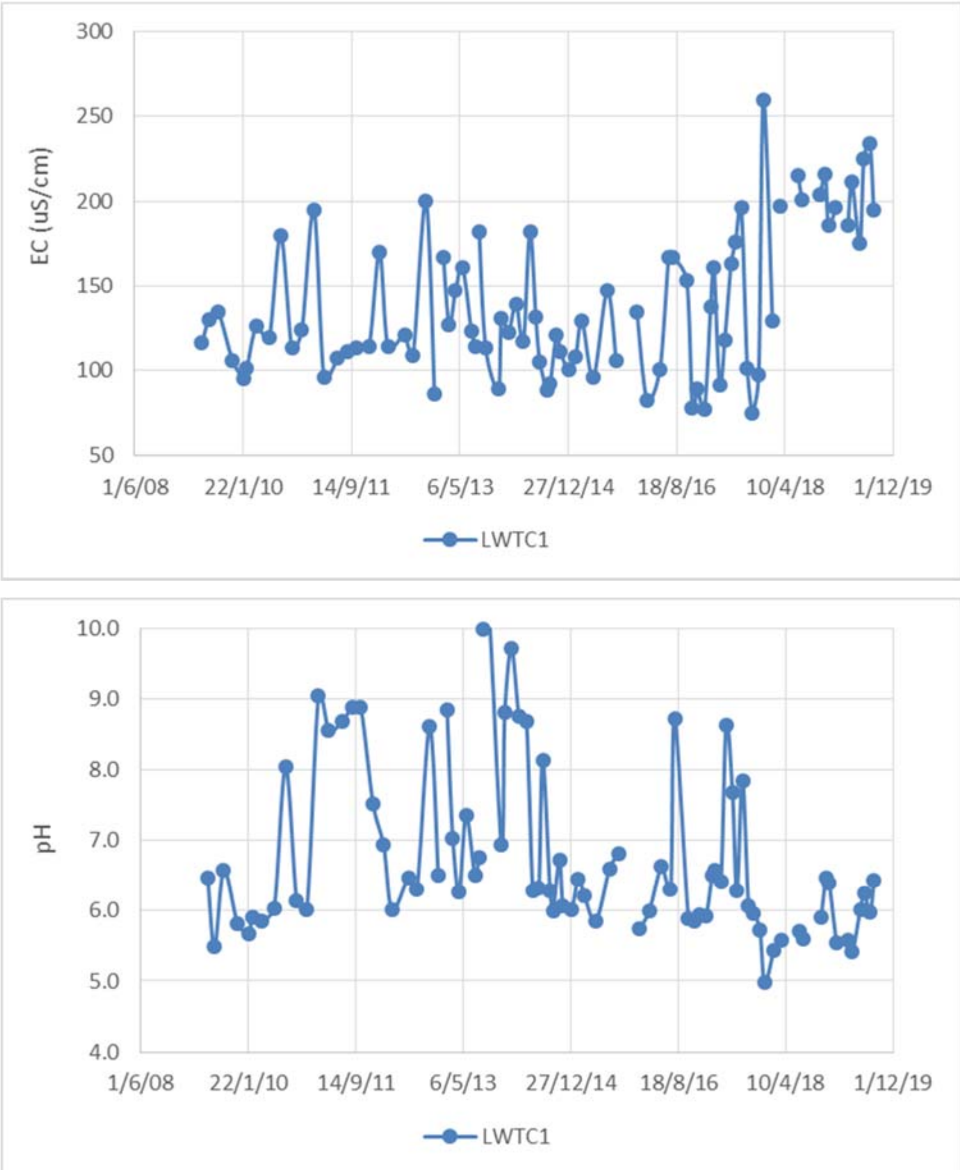


Figure 3 Little Wattle Tree Creek (LWTC1) Field Chemistry

5.2.2 Stream Flow

Stream flow in Little Wattle Tree Creek has not been measured during the monitoring period.

6. PREDICTED AND OBSERVED SURFACE WATER IMPACTS

6.1 Creek Subsidence

6.1.1 Potential Impacts

Maximum subsidence of;

- 50 - 100mm in Wattle Creek;
- <20mm in Little Wattle Tree Creek

6.1.2 Creek Subsidence Observations

No direct subsidence measurements have been conducted in Wattle Creek or Little Wattle Tree Creek, however extrapolation from adjacent monitoring lines indicate there has been no perceptible impacts on either creek due to extraction of Panels N1, N3 or N5.

<u>*No stream flow related TARP trigger levels have been reached or exceeded and no ameliorative actions are required due to extraction of Panel N5.*</u>

6.2 Stream Water Quality

6.2.1 Potential Impacts

- increased iron hydroxide precipitation, and;
- lowering (acidification) of pH.

6.2.2 Wattle and Little Wattle Tree Creek Observations

No observable water quality changes occurred in Wattle Creek or Little Wattle Tree Creek due to extraction of Panels N1, N3 or N5.

<u>*No stream water quality related TARP trigger levels have been reached or exceeded and no ameliorative actions are required due to extraction of Panel N5.*</u>

6.3 Stream Flow

6.3.1 Potential Impacts

- No anticipated adverse effect on stream flow in Wattle Creek or Little Wattle Tree Creek.

6.3.2 Stream Flow Observations

There has been no observed adverse effect on stream flow in Wattle Creek or Little Wattle Tree Creek due to extraction of Panels N1, N3 or N5.

<u>*No stream flow related TARP trigger levels have been reached or exceeded and no ameliorative actions are required due to extraction of Panel N5.*</u>

6.4 Stream Bed and Bank Stability

6.4.1 Potential Impacts

- no anticipated adverse effect on stream bed or bank instability or cracking of the stream bed is anticipated in Wattle Creek or Little Wattle Tree Creek resulting from extraction of Panels N1, N3 or N5.

6.4.2 Observed Impacts

No adverse effect has been observed on stream bed or bank instability or cracking of the stream bed in Wattle Creek or Little Wattle Tree Creek.

No stream bed or bank stability related TARP trigger levels have been reached or exceeded and no ameliorative actions are required due to extraction of Panel N5.

7. GROUNDWATER

The hydrogeology of the Nebo area is distinctly different to all other underground coal mines in the Southern Coalfield due to the presence of the up to 97.5m thick (as drilled) crinanite with its very low permeability, low storativity and its “aquitard” nature both pre and post subsidence (GeoTerra, 2010).

The crinanite is located at the top of the overburden stratigraphic profile and outcrops over approximately 95% of the Nebo area workings as a flat lying to bowl shaped igneous intrusion.

The presence of the crinanite is very significant, in that it acts as an aquitard over the Narrabeen Group and Permian Coal Measures. It separates the shallow soil groundwater system and connected streams at surface from the underlying Narrabeen Group and Permian Coal Measures.

The crinanite differentiates Nebo from all other coal mining areas in the Southern Coalfield and provides a unique hydrogeological and hydrological setting in which to assess and predict coal extraction subsidence effects on surface water and groundwater systems overlying the proposed workings.

Aquifers present that can interact with the local streams are;

- shallow, perched ephemeral aquifers in the up to 6.5m deep soil profile, and, if present
- low flow, short duration seeps from the crinanite or interface drainage originating between the crinanite and the limited exposures of the Narrabeen Group or Hawkesbury Sandstone along the western ridge.

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.

Geotechnical studies (SCT Operations, 2019) indicate that even after extraction where the Illawarra Coal Measures and Narrabeen Group (or Hawkesbury Sandstone if present) overburden is subsided and fractured, the Cordeaux Crinanite is anticipated to maintain its aquitard status where it is greater than 30m thick. This conservative value is an interpreted thickness under which the aquitard properties of the crinanite is likely to remain intact.

Due to the steep topography and the above mentioned factors, as well as depressurisation in subsided and fractured areas over and within the previous workings at Eloura / Nebo, there is anticipated to be essentially no notable remnant groundwater bearing strata in the Illawarra Coal Measures or Narrabeen Group sedimentary units underneath the crinanite.

No DPI-W registered private bores are located within the Nebo area as it is within a restricted access water catchment area administered by Water NSW.

7.1 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 6** and shown in **Drawing 2**.

Each piezometer was installed with a pressure transducer reading water pressure (levels) at least twice per day.

Table 6 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

7.2 Vibrating Wire Piezometers

Four vibrating wire piezometer arrays were installed between December 2009 and January 2010 as outlined in **Table 7** and shown in **Drawing 2.**

Table 7 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

8. PREDICTED AND OBSERVED GROUNDWATER IMPACTS

8.1 Aquifer / Aquitard Interconnection

8.1.1 Potential Impacts

- no adverse interconnection of aquifers and aquitards is 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.

8.1.2 Aquifer / Aquitard Interconnection Observations

No adverse aquitard / aquifer interconnection or increased recharge has been observed in the vicinity of, or resulting from, extraction of Panels N1, N3 or N5.

No aquifer / aquitard interconnection related TARP trigger levels have been reached or exceeded and no ameliorative actions are required due to extraction of Panel N5.

8.2 Groundwater Levels

8.2.1 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.

8.2.2 Groundwater Level Observations

Neither of the shallow soil, alluvium or colluvium piezometers (Nebo1S or Nebo2S) overlie Panel N4, and both have varied in response to rainfall in the catchment as shown in **Figure 4**, with no influence from N4 during its period of extraction.

Neither of the crinanite piezometers Nebo2D or Nebo3 overlie N4, and both have varied in response to rainfall in the catchment as shown in **Figure 5**, with no apparent diversion from the natural water level trends from N4 during its period of extraction.

Piezometer Nebo1D was installed in the Narrabeen Group, although is also not in close proximity to, and did not show a response to extraction of N4 as shown in **Figure 6**.

Piezometer Nebo4, which was installed in the Bulli Seam, to the north of N4, showed a rising water level during extraction of LWN2, albeit with short term drops and recoveries following water extraction sampling events, along with a 2.1m decline in water level during extraction of Panel N4, and a subsequent total drying out as shown in **Figure 7**.

No groundwater level related TARP trigger levels have been reached or exceeded and no ameliorative actions are required due to extraction of Panel N5.

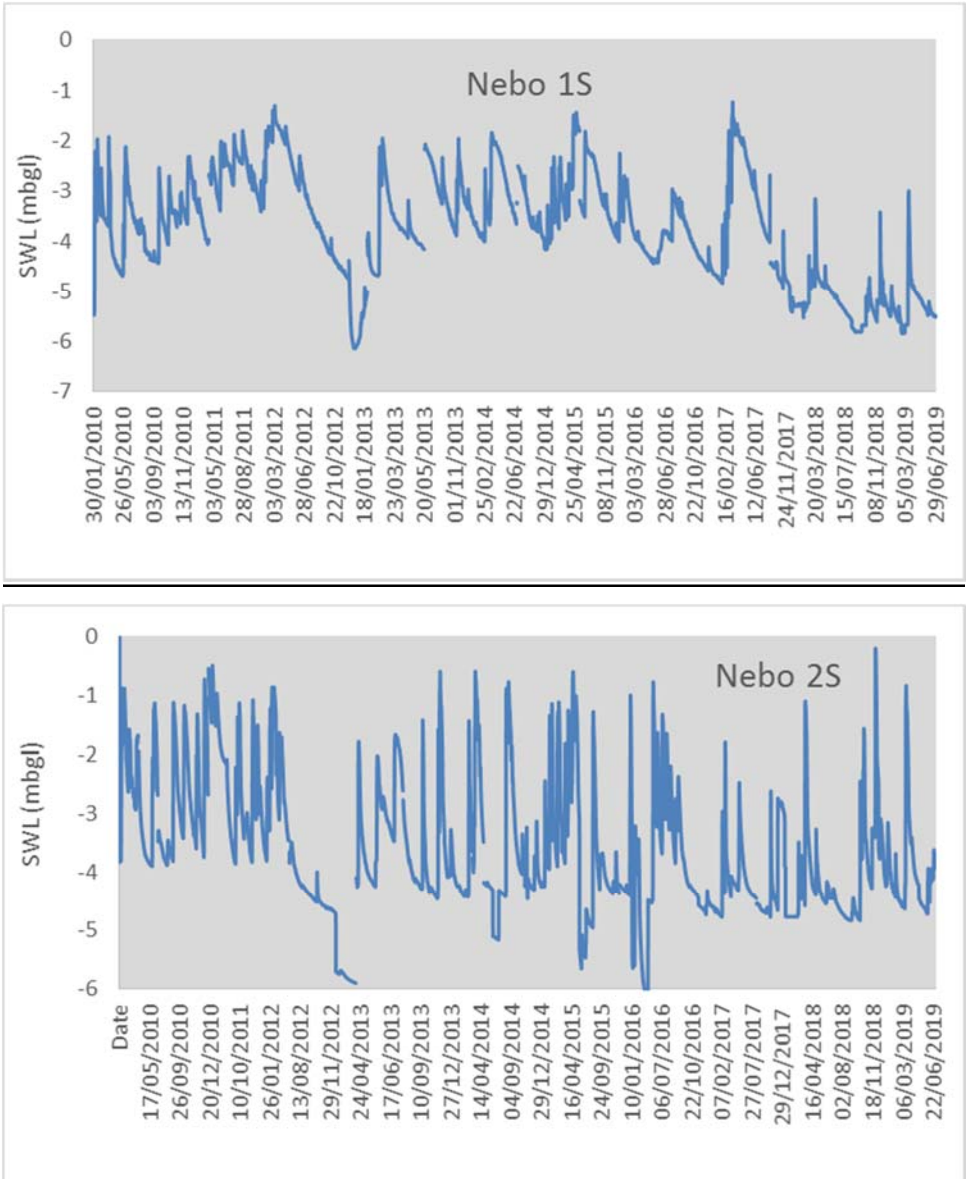


Figure 4 Alluvium / Colluvium Groundwater Levels

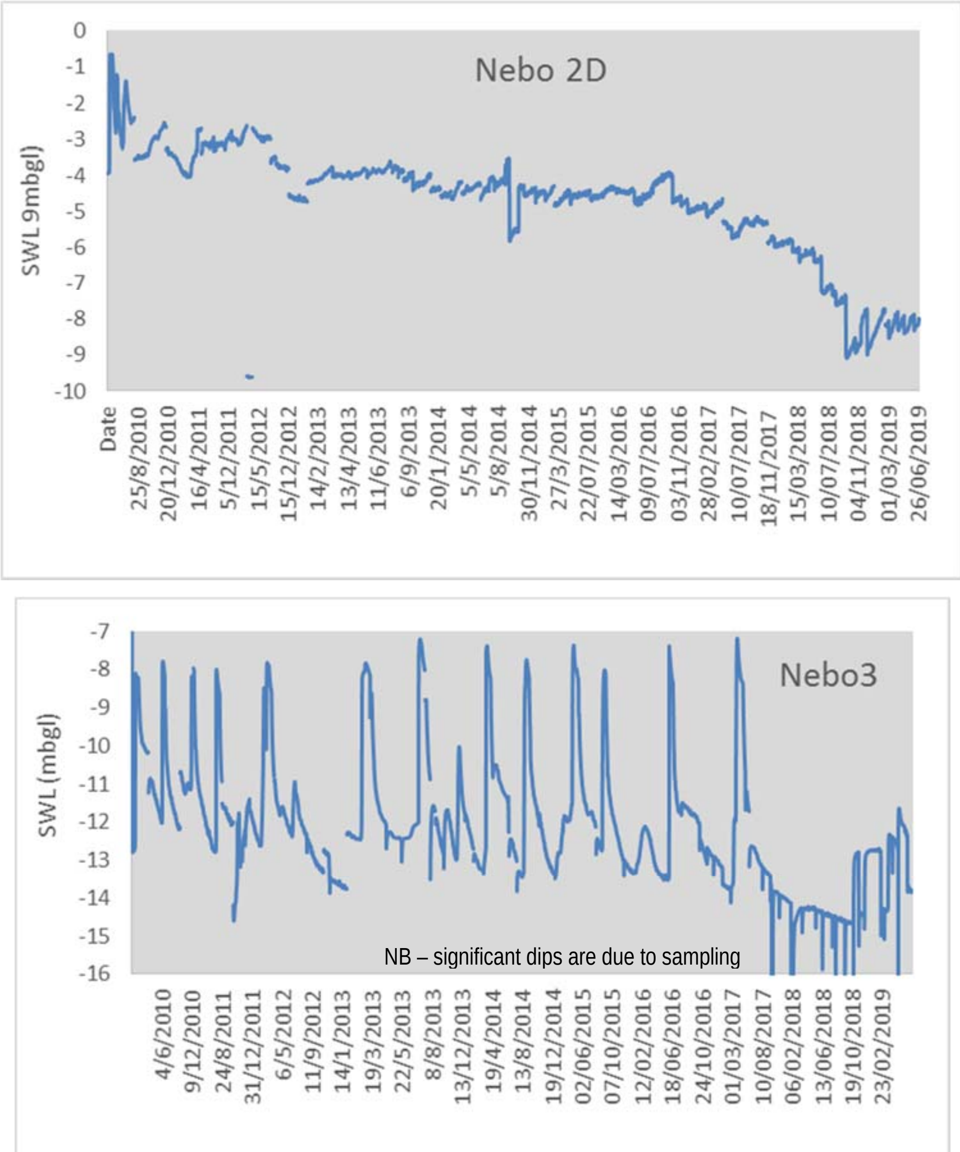


Figure 5 Crinanite Groundwater Levels

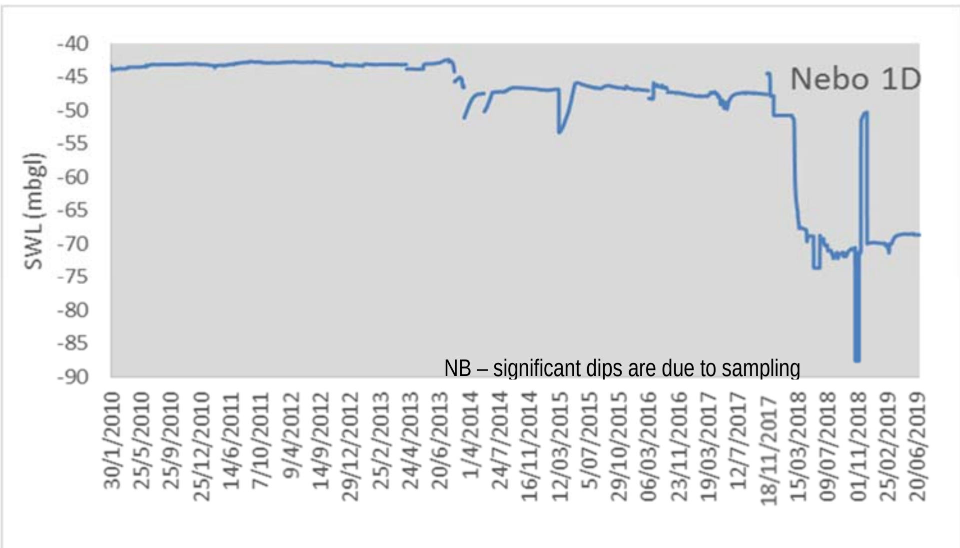


Figure 6 Narrabeen Group Groundwater Level

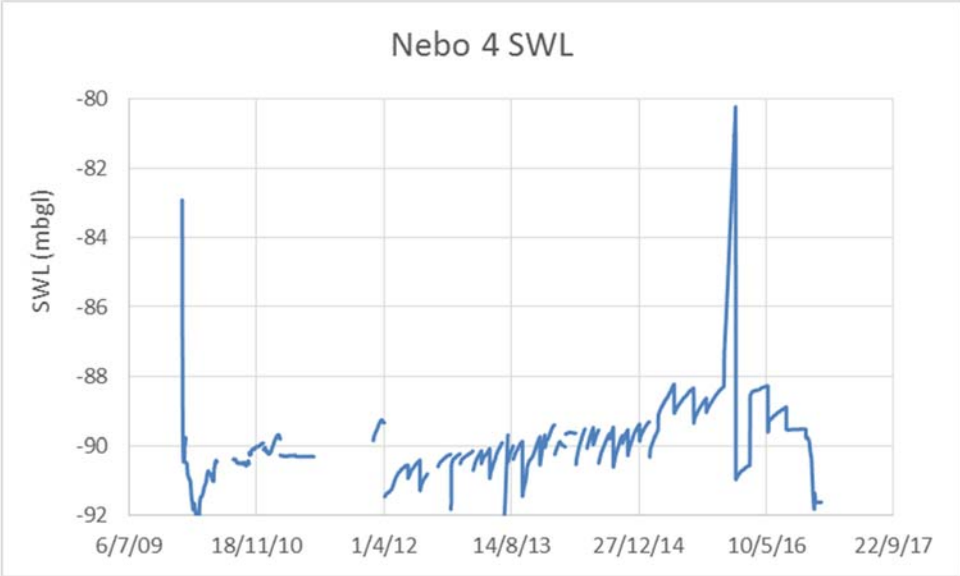


Figure 7 Bulli Seam Groundwater Level

The vibrating wire arrays installed in Nebo6, Nebo 7, Nebo 8 and Nebo8A demonstrated no response to Panels N1, N3 or N5 extraction, which indicates no mining subsidence effect in the crinanite.

In addition, no correlation with the water level of Cordeaux dam and the VWP intakes is apparent.

Water levels in the four VWP arrays are shown in **Figures 8** to **11**.

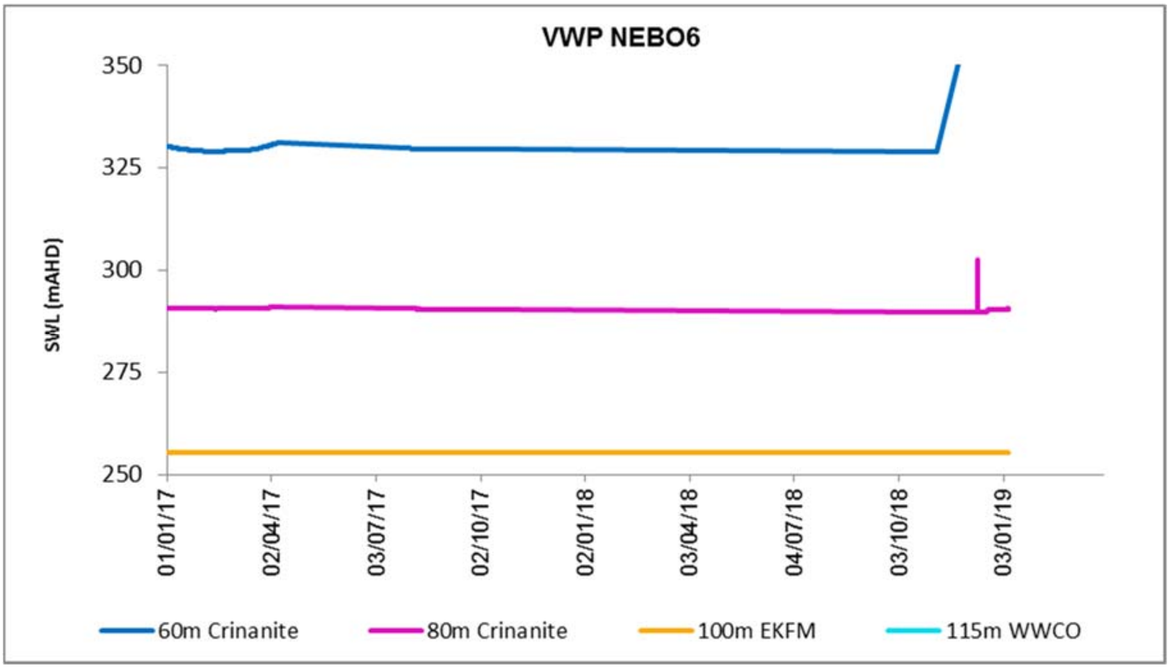


Figure 8 Nebo 6 VWP

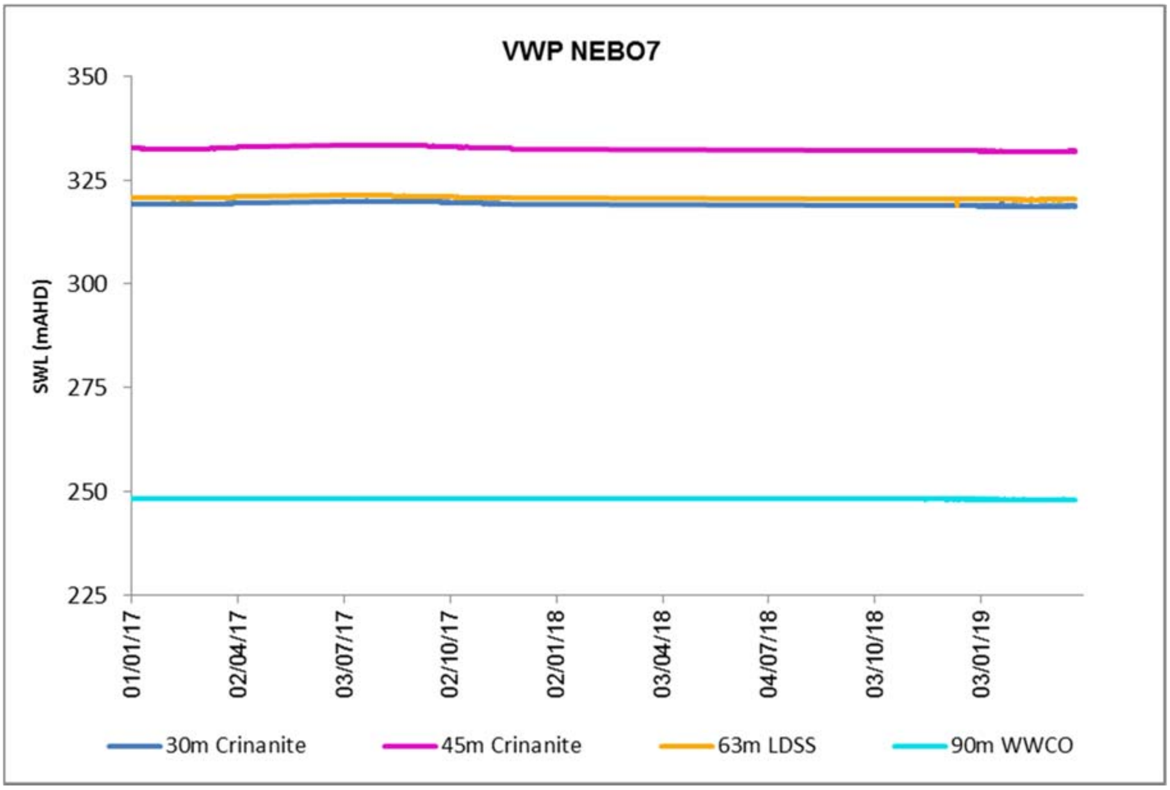


Figure 9 Nebo 7 VWP

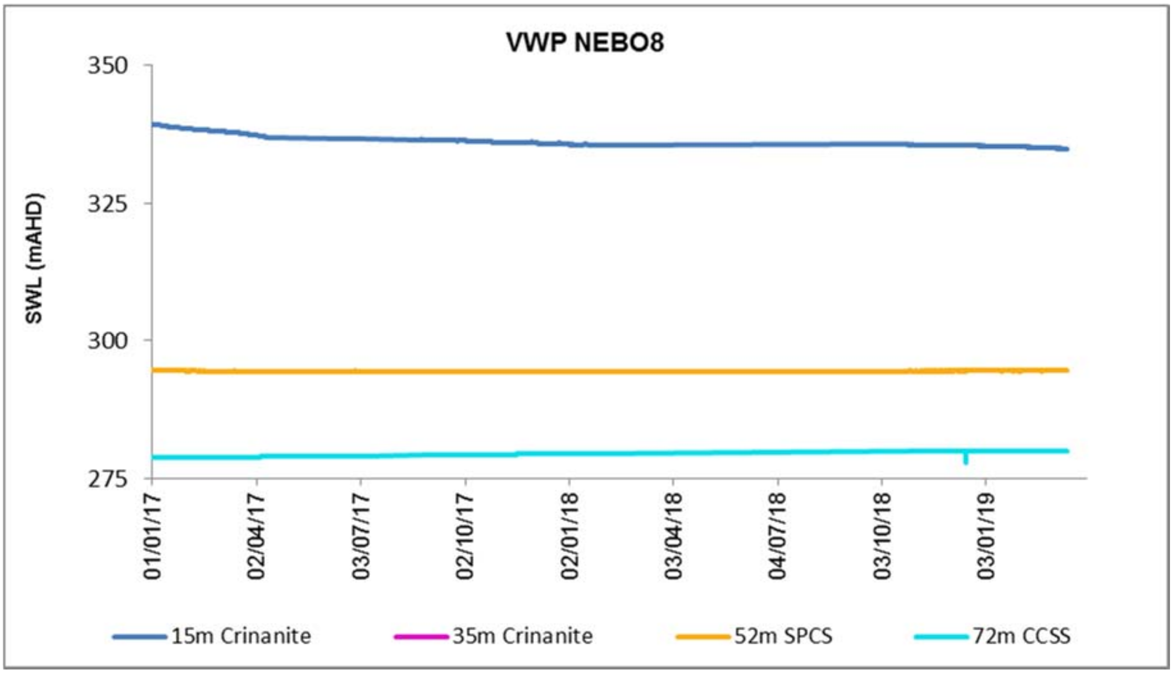


Figure 10 Nebo 8 VWP

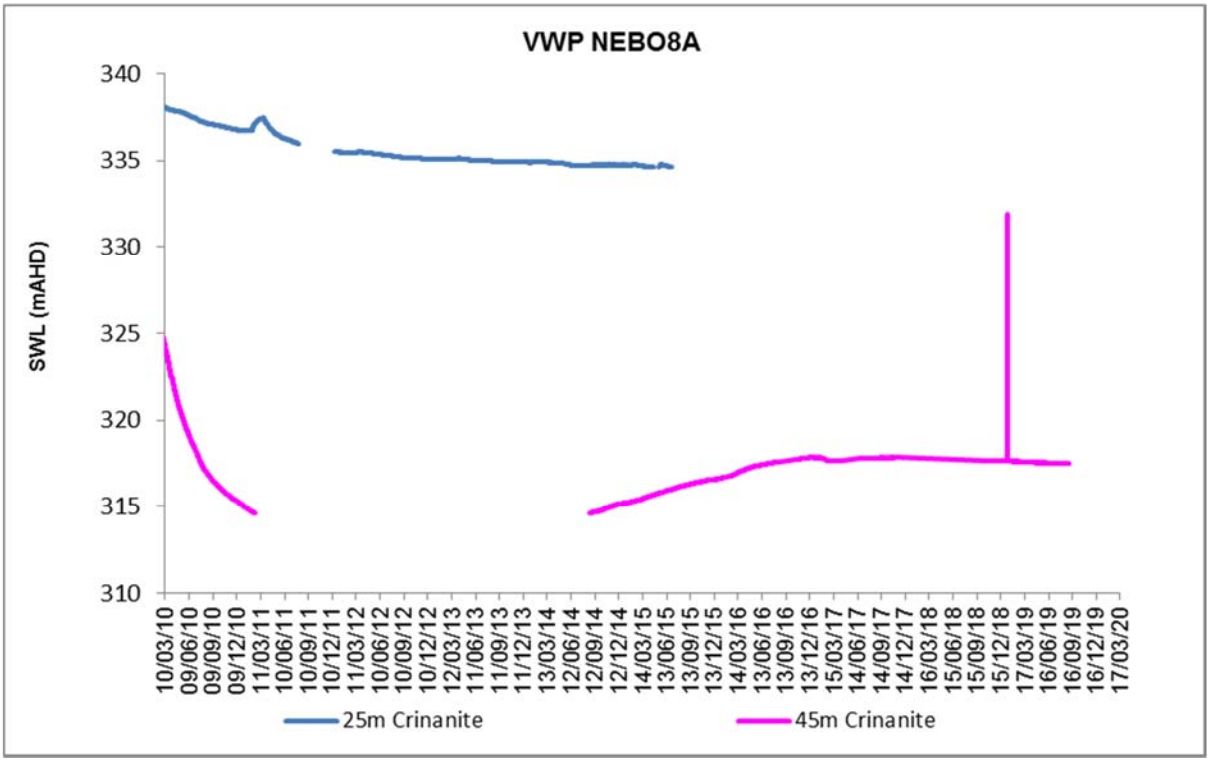


Figure 11 Nebo 8A VWP

4.5 Groundwater Quality

Groundwater in the Nebo study area has generally fresh to brackish salinity (39-2,965μS/cm) with acidic to circum-neutral pH (3.3 – 7.5) as summarised in **Table 5** and shown in **Figures 12** to **15**.

However, cement used to seal the piezometers during installation has had a definitive increase in alkalinity (up to pH 14) and salinity (up to 14500μS/cm) in Nebo 1D, 2D and 4, which means they do not represent the actual formation water chemistry.

Piezometers 1S, 2S and 3 appear to be unaffected by cement and better represent the formation water chemistry, although a cement influence is present.

Table 8 Nebo Field Groundwater Quality

Formation	Piezometers	EC (μS/cm)	pH
Shallow	1S, 2S	32 – 1,071	3.3 – 9.3
Crinanite	2D, 3	230 -2,950	6.7 – 9.8
Narrabeen	1D	123 – 2,965	7.5 – 10.5
Bulli Seam	4	798 – 14,440	10.9 – 13.9

Note: Nebo 1D, 2D and 4 are strongly affected by cement, 1S, 2S and 3 better represent actual formation water chemistry

Laboratory analyses indicate that the monitored groundwater is outside ANZECC 2000 criteria (default trigger values for physical & chemical stressors in SE Aust Upland Rivers / 95% protection of freshwater species / livestock / irrigation) for:

- Total nitrogen;
- Total phosphorous
- Copper
- Lead
- Zinc;
- Nickel, and
- Aluminium

Note that the water chemistry of Nebo 1D, 2D and 4 are strongly affected by cement used to seal the piezometer intake and do not therefore represent the actual formation water quality.

The exceedance varies depending on the applicable guideline applied for the end use of the water.

Groundwater in the Nebo area is suitable for selected livestock and limited irrigation use, but not for potable water.

No adverse change to groundwater quality in the Nebo piezometers has been observed, along with no distinctive increase in salinity, nutrients or metals.

No groundwater quality related TARP trigger levels have been reached or exceeded and no ameliorative actions are required due to extraction of Panel N5.

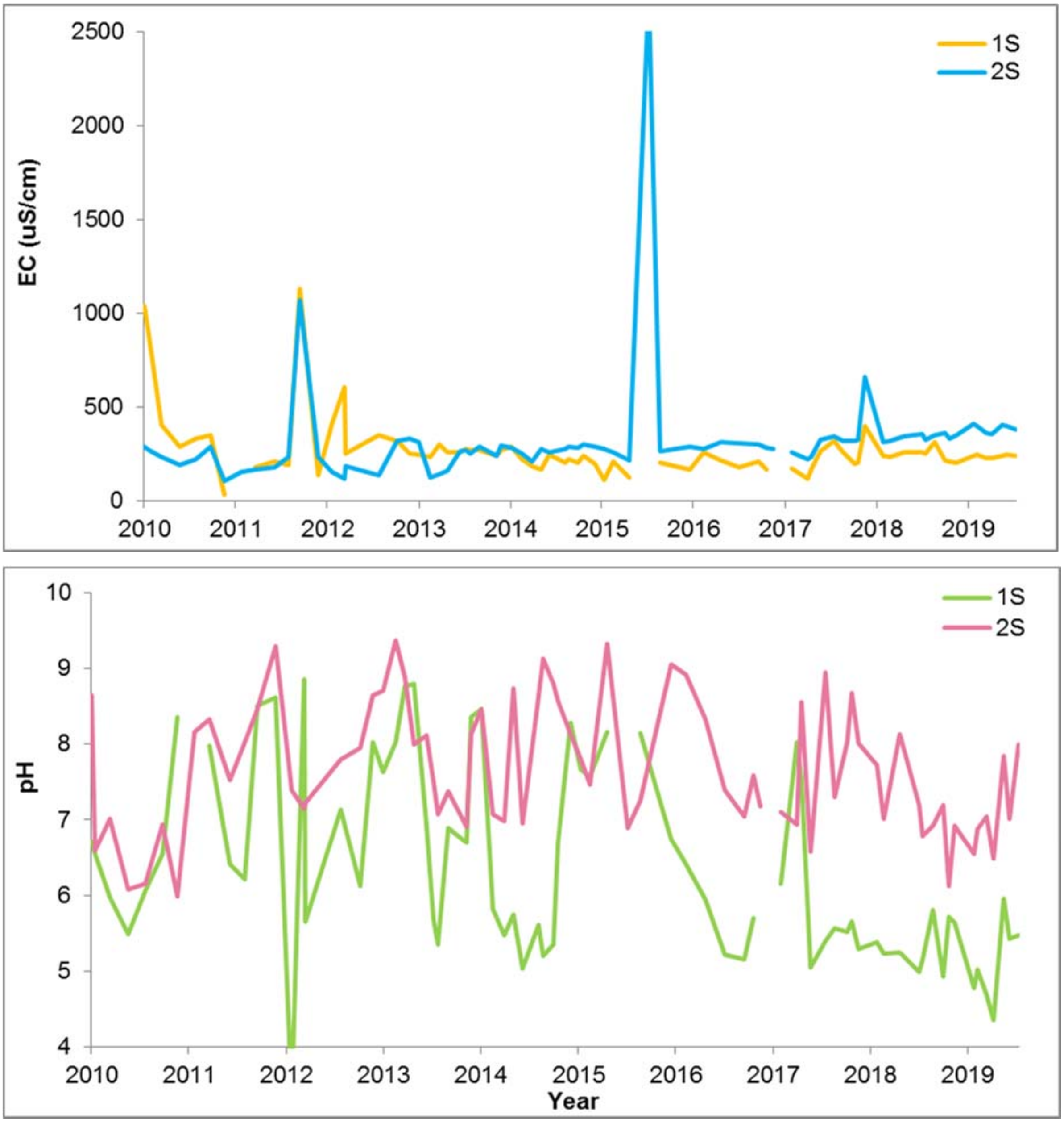


Figure 12 Soil and Shallow Field Groundwater Quality

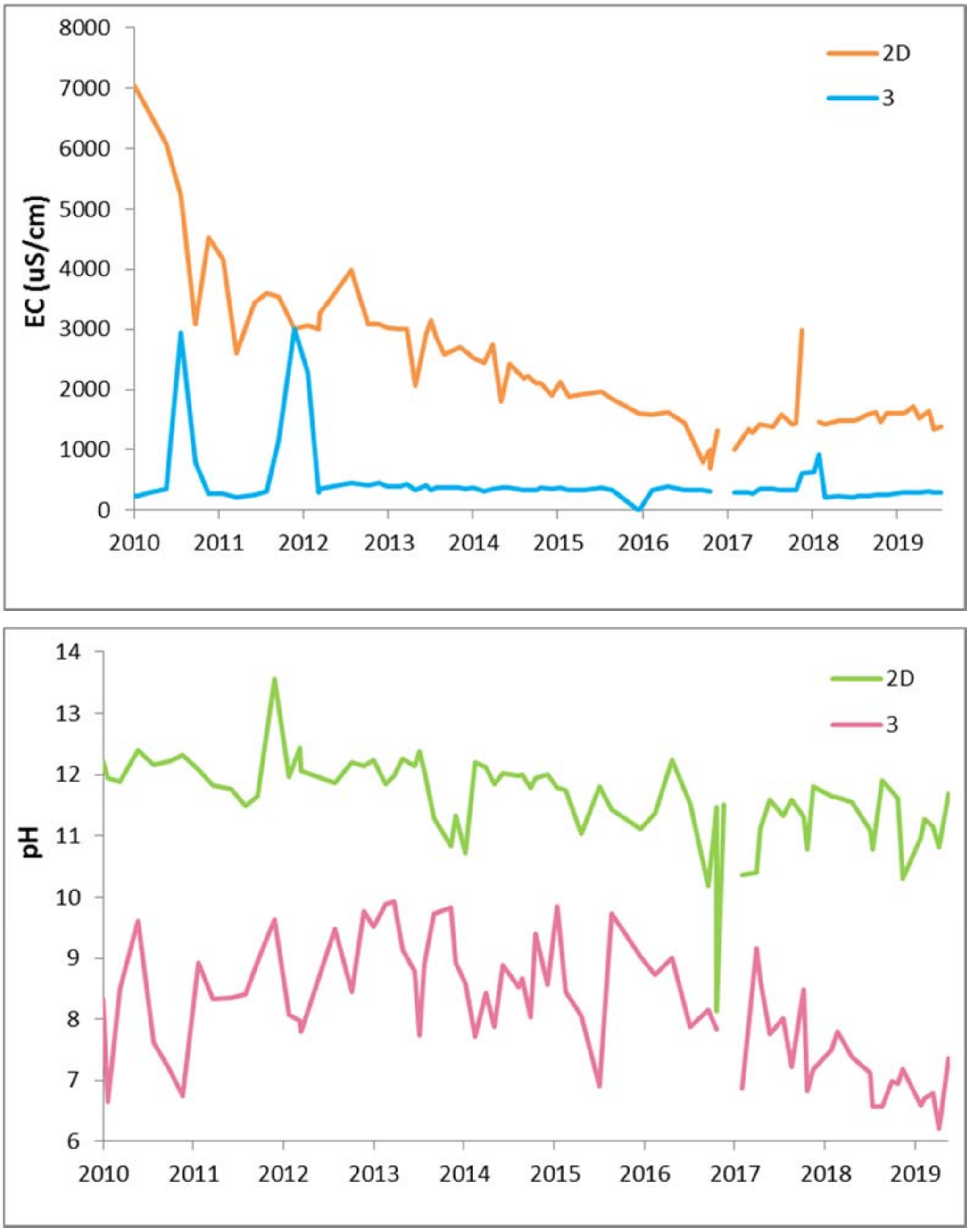


Figure 13 Crinanite Field Groundwater Quality

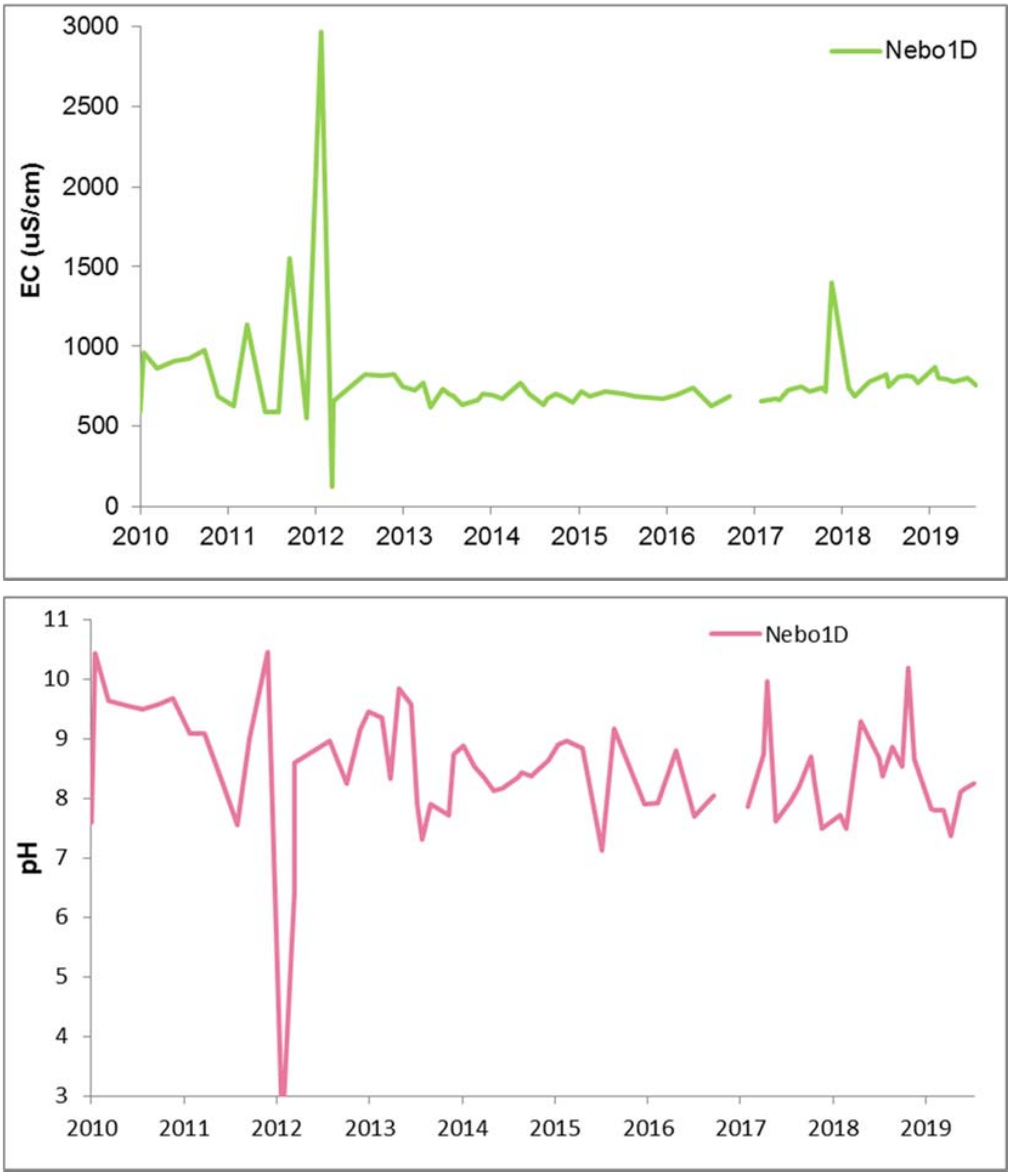
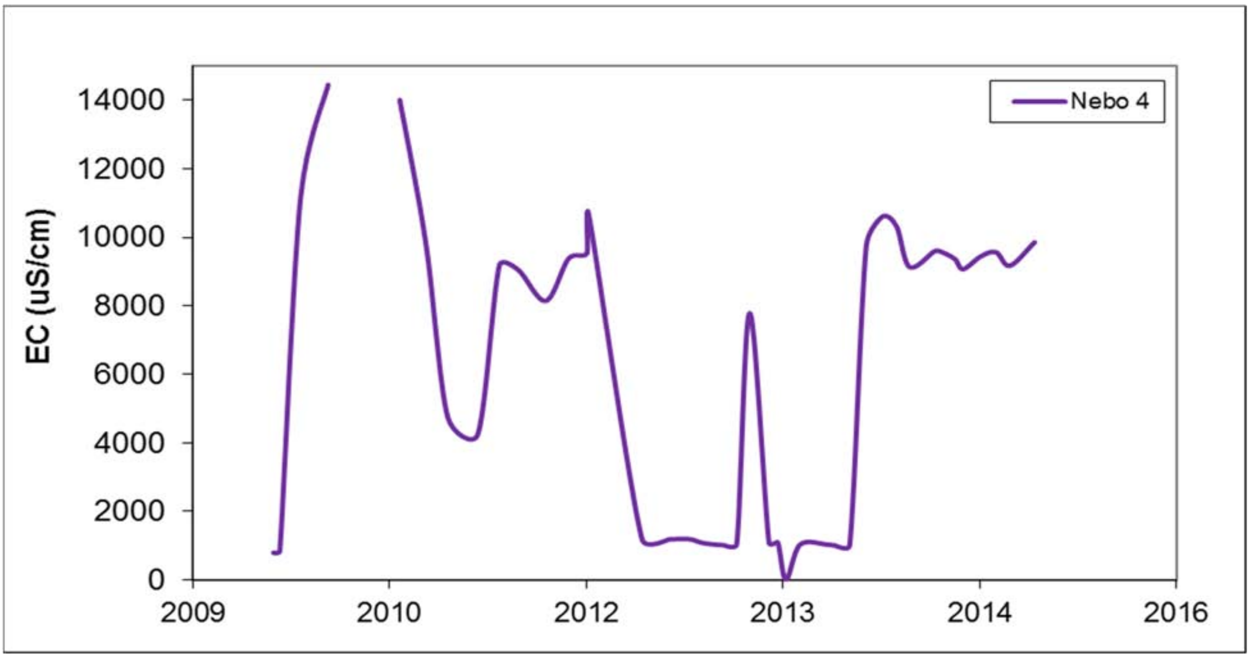


Figure 14 Narrabeen Formation Field Groundwater Quality



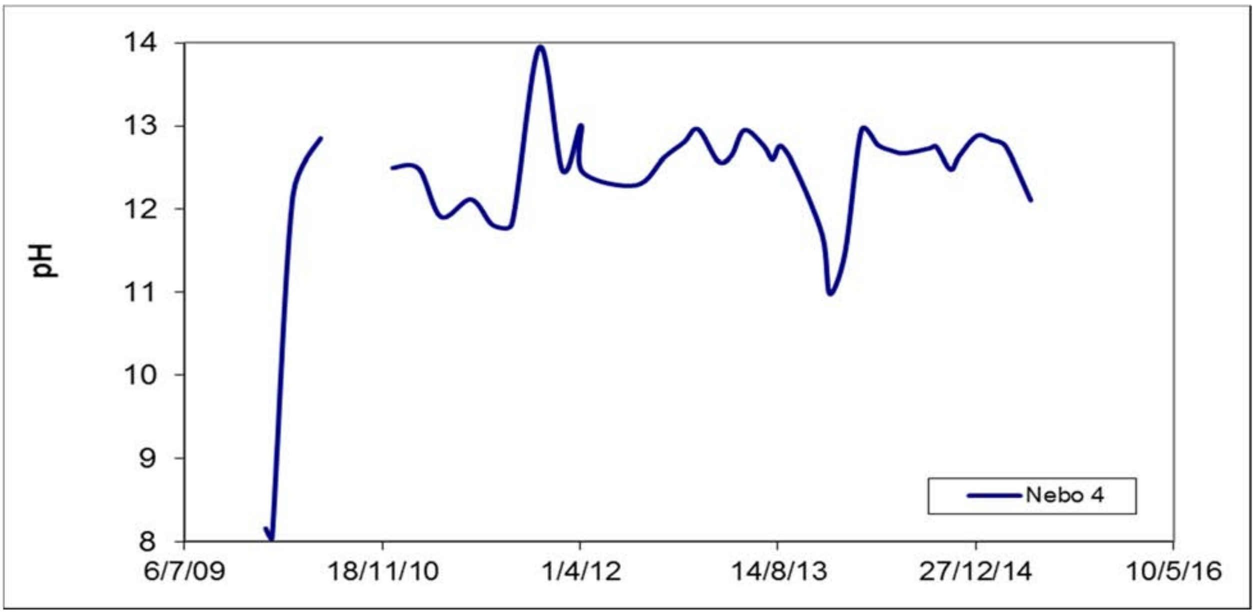


Figure 15 Bulli Seam Field Groundwater Quality

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

There was no groundwater make from the Panel N1, N3 and N5 during and after extraction of the panels, (Pers comm. - Paul Coxhead - Mining Engineering Manager).

No mine water discharge related TARP trigger levels have been reached or exceeded and no ameliorative actions are required due to extraction of Panel N5.

5 SUMMARY OF RESULTS

Although the subsidence movements along the axis or across the whole panel were not directly measured, the subsidence observed in the vicinity of Panels N1, N3 and N5 was less than or consistent with the predictions made in the EP/SMP and Part 3A Application.

Subsidence monitoring (SCT 2019) has confirmed the bridging capacity of the Cordeaux Crinanite (dolerite) sill within the overburden sequence for the approved panel geometries in the Nebo area.

This bridging has limited the magnitude of the maximum subsidence and associated parameters to levels that are imperceptible for all practical purposes.

The maximum subsidence parameters measured to date in the vicinity of Panels N1, N3 and N5 are:

- subsidence 150 mm
- tilt 2.0 mm/m
- strain 1mm/m (compression and tension)

Based on the low levels of ground movement observed as a result of Panel N1, N3 and N5 extraction, there have been no adverse or unexpected impacts on the groundwater or surface water systems at Nebo.

Piezometer Nebo 4, which is screened adjacent to Panel N4 within the Bulli Seam, became fully dewatered during extraction of N4. This impact was within the predicted impacts and was expected to happen due to the coal extraction and transmitted effect from creating an atmospheric pressure void within the seam due to mining Panel N4.

The subsidence impacts and consequences from the extraction of Panels N5 are within the predicted impacts and comply with the subsidence impact performance measures in Project Approval 09_0161 for surface water and groundwater systems at Nebo.

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SCT Operations, 2019 Wongawilli Colliery N3 End of Panel Subsidence Report

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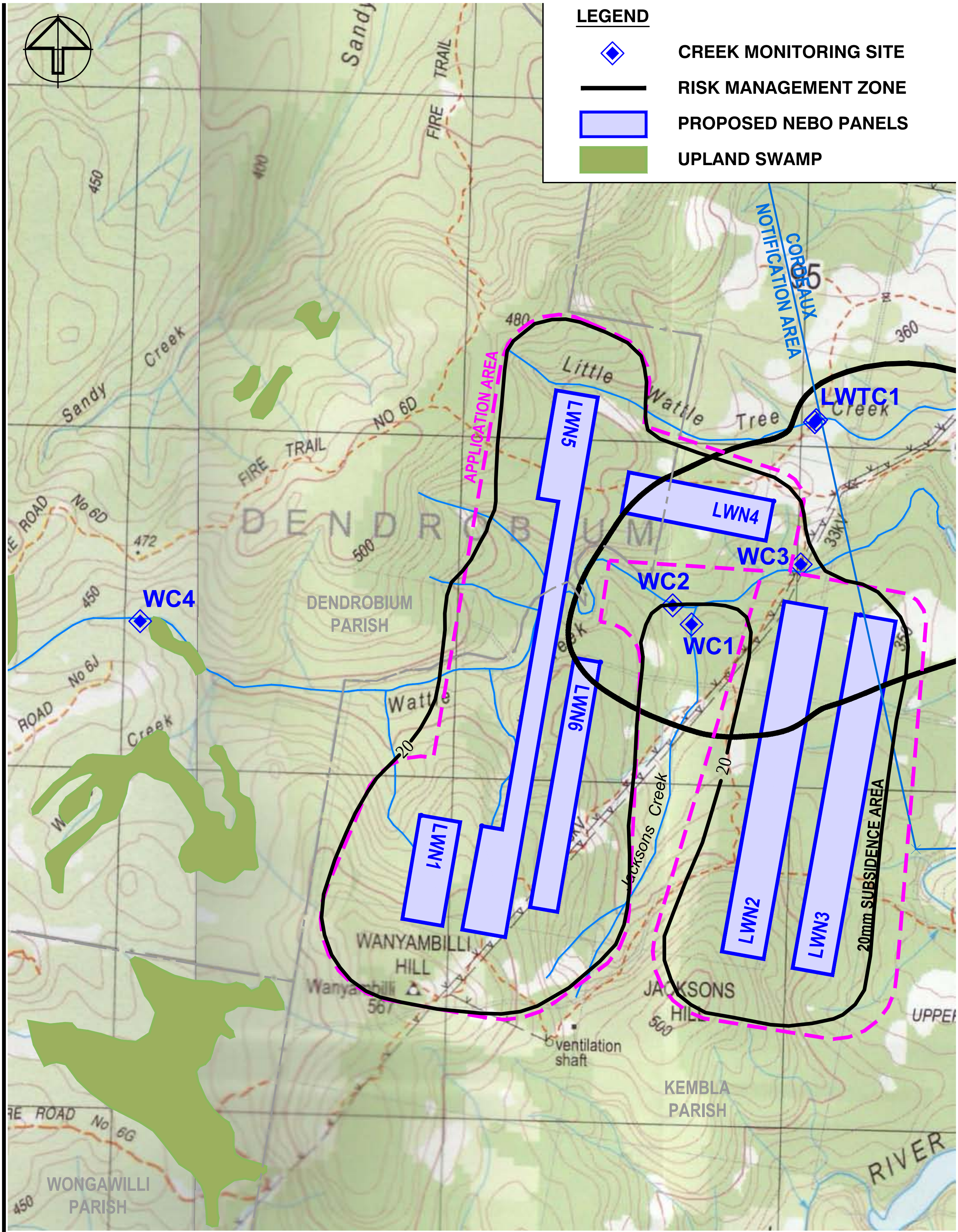
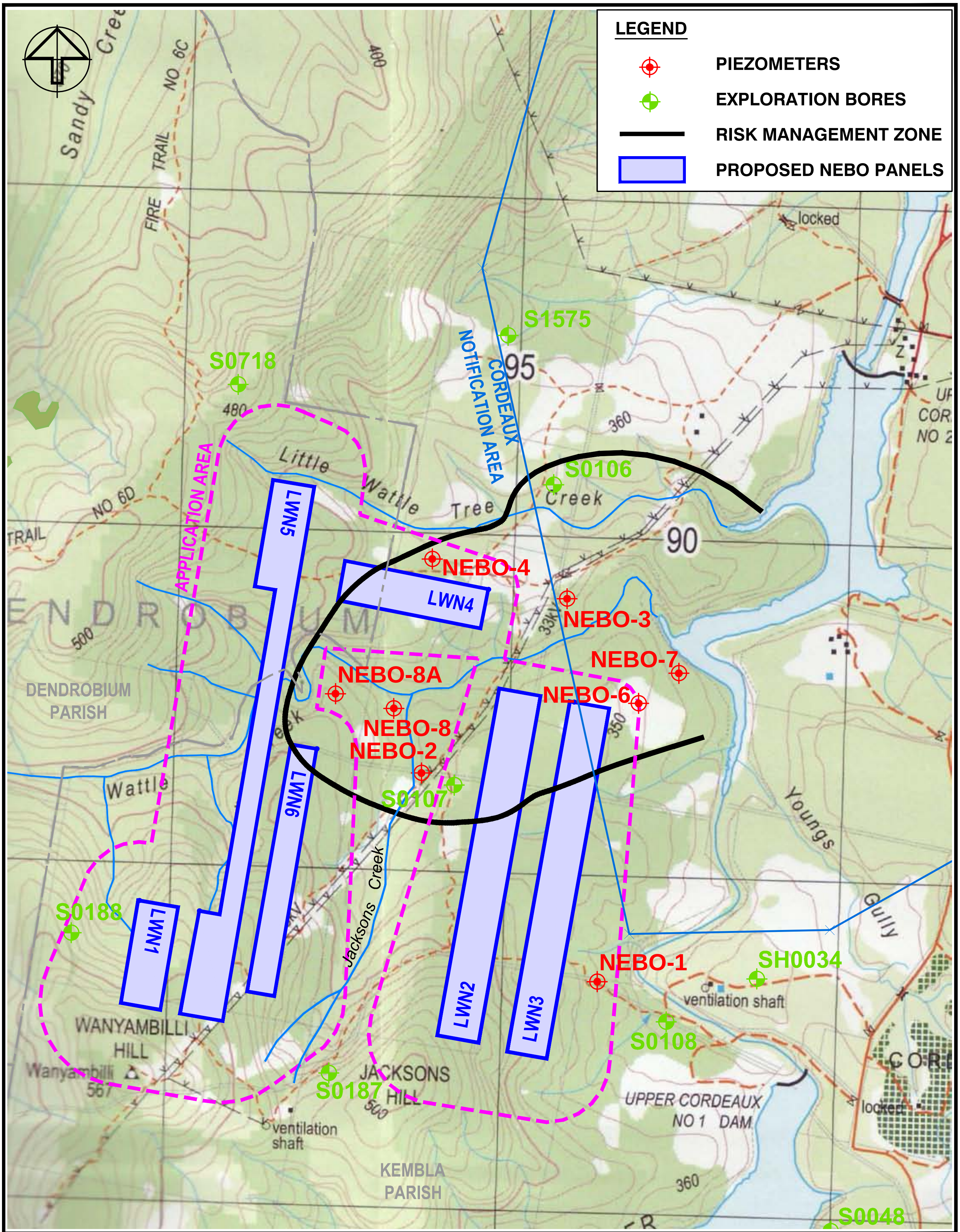


PROJECT:	NEB5
DRAWN:	A. DAWKINS
DATE:	28 May 2010
SCALE:	1:15 000

WOLLONGONG COAL LTD
NEBO
SURFACE WATER
MONITORING LOCATIONS

GeoTerra

DRAWING 1



PROJECT:	NEB4-R1	WOLLONGONG COAL pTY LTD NEBO LONGWALL LWN2 PIEZOMETER LOCATIONS	GeoTerra
DRAWN:	A. DAWKINS		
DATE:	1 Sep 2014		DRAWING 2
SCALE:	1:15 000		

Appendix G – SCT Nebo N1 and N5 End of Panel Subsidence Report

Strata Control Technology

WOLLONGONG COAL LIMITED

Wongawilli Colliery: Nebo N1 and N5
End of Panel Subsidence Report

WCWO4932

Mining Research and Consulting Group

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REPORT TO John Ross
Environment and Approvals Manager
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West Dapto, NSW 2530

TITLE Wongawilli Colliery: Nebo N1 and N5 End of Panel Subsidence Report

REPORT NO WCW04932

PREPARED BY Stephen Wilson

DATE 6 January 2020

Stephen Wilson
Mine Planner

Ken Mills
Principal Geotechnical Engineer

Report No	Version	Date
WCW04632	Draft	27 December 2019
WCW04632	Final	6 January 2020

SUMMARY

Wollongong Coal Limited (WCL) owns and operates Wongawilli Colliery southwest of Wollongong in NSW. Approval conditions for mining in the Nebo area require an end of panel subsidence report be prepared at the completion of mining in each panel. Following the recent completion of mining N1 and N5 Panels, WCL commissioned SCT Operations Pty Ltd (SCT) to analyse the subsidence monitoring conducted above these panels and prepare a report suitable to meet the end of panel reporting requirements detailed in SMP Approval 09/5341 and the Extraction Plan for the modified Nebo Area Project Approval 09_0161. This report presents our review and analysis of the available monitoring data and a summary of observations made during a site visit to the area in October 2019 to meet these reporting requirements.

Our review of available monitoring data indicates the measured subsidence effects for N1 and N5 Panels, including allowance for subsidence not measured, are so low as to be of no practical consequence or cause any perceptible surface impacts. No perceptible subsidence impacts were observed during the site visit or during regular inspections of the surface during the period of mining.

Subsidence behaviour is consistent with expectation, but the survey tolerance able to be achieved in steep terrain in a bushland environment has not been tight enough to confirm with confidence that measured maximum tilt and maximum strain are greater or less than the tilt and strain predicted. Maximum values of the primary subsidence parameters measured above N1 and N5 Panels are:

- Vertical subsidence of approximately 210mm (measured) and 360mm (estimated) compared to 400mm predicted.
- Tilt of 2.4±0.7mm/m measured compared to 2.2mm/m predicted.
- Strains of less than 0.9±0.7mm/m measured compared to 0.5mm/m predicted.

An additional 150mm of subsidence that was not measured due to the timing of surveys is estimated to have developed over N1 Panel giving maximum total subsidence of 360mm.

Surface impacts are expected to be compliant with the impact criteria in the SMP Approval conditions. Subsidence impacts and environmental consequences to features and items are also expected to be less than and compliant with the criteria in the subsidence impact performance measures of PA 09_0161 for water resources, watercourses, land, biodiversity, heritage features, built features and public safety, notwithstanding the input of other specialists or government agencies.

We recommend ongoing subsidence monitoring with detailed documentation of inspections to confirm current observations consistent with the NRE Wongawilli Colliery Nebo Longwalls N1-N6 Subsidence Monitoring Plan (NRE 2014).

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1. INTRODUCTION

Wollongong Coal Limited (WCL) has recently ceased mining in the Nebo N1 and N5 Panels at Wongawilli Colliery southwest of Wollongong in NSW. Although approved for longwall mining these two panels were developed simultaneously with secondary extraction of the pillars formed undertaken using continuous miners and breaker line supports. The mining conducted in N5 Panel represents only a small portion of the total area approved for this panel, but it is unlikely further mining will be undertaken in this area of the Wongawilli Seam within the current mining lease so an end of panel report has been prepared.

WCL commissioned SCT Operations Pty Ltd (SCT) to analyse the subsidence monitoring conducted for N1 and N5 Panels and prepare a report suitable to meet the end of panel or annual reporting requirements for subsidence as required by the Subsidence Management/Extraction Plan (SMP/EP) for Nebo Longwalls N1-N6. This report presents the results of our analysis and a review of the subsidence monitoring data for N1 and N5 Panels in accordance with conditions of SMP Approval 09/5341 and EP requirements of the modified Nebo Area Project Approval 09_0161.

The report includes comparisons of monitoring results with subsidence predictions made in the SMP / EP (Niche 2012). The comparisons are based on the Part 3A Application for the Nebo Area Project subsidence assessment (MSEC 2010) and assessment against relevant impact criteria including the subsidence impact performance measures of PA 09_0161 (MOD1). The results are also compared to the subsidence monitoring over previous panels as required by SMP Approval 09/5341.

Our assessment is based on the survey data supplied by WCL for monitoring points above and in proximity to N1 and N5 Panels, fortnightly visual inspections conducted by WCL environmental personnel and a site visit conducted by SCT on 18 October 2019 to inspect the surface above and in the vicinity of the areas mined by these panels.

The report is structured to provide:

- conclusions and recommendation from the review and analysis
- a site description
- a summary of the monitoring results
- observations of subsidence impacts
- comparison with:
    - predicted subsidence behaviour and impacts
    - subsidence effects and impacts from previous panels
- assessment of compliance with impact assessment criteria and subsidence impact performance measures.

2. CONCLUSIONS AND RECOMMENDATIONS

Our review of available monitoring data indicates that the measured subsidence effects for N1 and N5 Panels, including allowance for subsidence not measured, are so low as to be of no practical consequence or cause any perceptible surface impacts. No perceptible subsidence impacts were observed during the site visit or during regular inspections of the surface during the period of mining.

Subsidence behaviour is consistent with expectation, but the survey tolerance able to be achieved in steep terrain in a dense bushland environment has not been tight enough to confirm with confidence that measured maximum tilt and maximum strain are greater or less than the low levels of tilt and strain predicted. Maximum values of the primary subsidence parameters measured above N1 and N5 Panels are:

- Vertical subsidence of approximately 210mm (measured) and 360mm (estimated) compared to 400mm predicted.
- Tilt of 2.4±0.7mm/m measured compared to 2.2mm/m predicted.
- Strains of less than 0.9±0.7mm/m measured compared to 0.5mm/m predicted.

Subsidence effects from N1 and N5 Panels are slightly greater than those measured for Longwall N2, N3 and N4 Panels. These greater effects were predicted due to differences in the geological setting and mining geometry.

Measurements of subsidence effects and observations of subsidence impacts from regular monitoring and those made generally over the mining area and during the site visit by SCT, particularly along Line NM4, indicate that the effects from the mining in N1 and N5 Panels are consistent with expectations.

The impacts are expected to be compliant with the impact criteria in the SMP Approval conditions. Subsidence impacts and environmental consequences to features and items are also expected to be less than and compliant with the criteria in the subsidence impact performance measures of PA 09_0161 for water resources, watercourses, land, biodiversity, heritage features, built features and public safety. However, these expectations need to be confirmed by other specialists and government agencies.

Ongoing subsidence monitoring is recommended consistent with NRE (2014). Detailed documentation of inspection results to confirm current observations is also recommended. If further mining in the Nebo area is undertaken, a review of the current subsidence monitoring plan (program) is recommended.

3. SITE DESCRIPTION

Figure 1 shows a plan of the completed mining and approved layout in the Nebo area superimposed onto a 1:25,000 series topographic map.

The locations of subsidence monitoring lines and points (NM1, NM2, NM3, NM4 and PP) relative to panels are also shown. The main subsidence monitoring line for N1 and N5 Panels (NM4 - 400 Line) is installed in undeveloped bushland and aligned almost perpendicular to the mining direction.

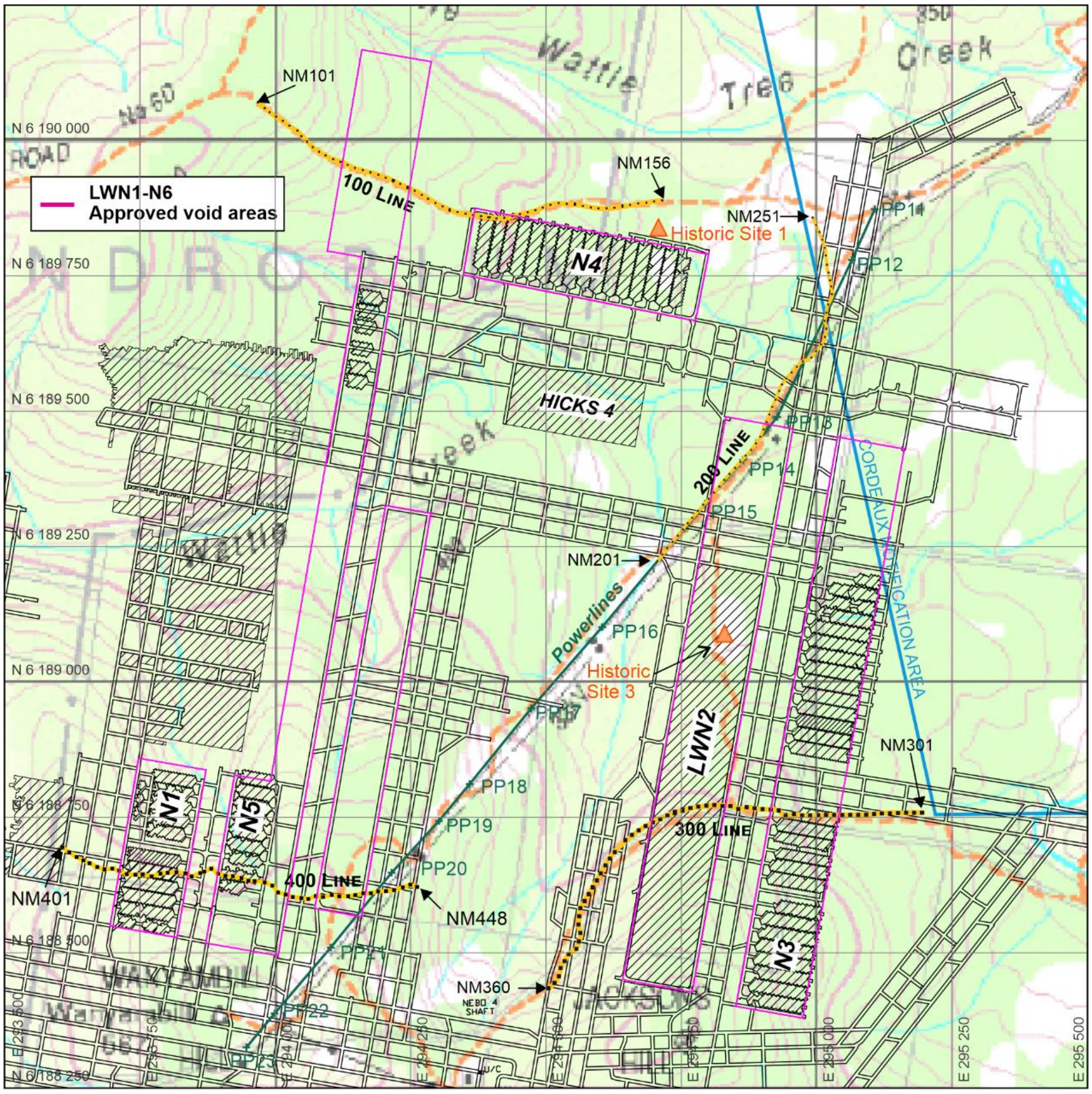

Figure: 1: Site plan showing location of N1 and N5 Panels plotted on 1:25,000 series topographic map with subsidence monitoring lines and power pole locations.

3.1 Surface Features

The Nebo area site is located approximately 13km west of Wollongong in the upper reaches of the Cordeaux River Valley within the Sydney Water Catchment Metropolitan Special Area. The surface above N1 and N5 Panels is located within thick undeveloped bushland on the northern slope of the regional topographic high point known as Wanyambilli Hill.

Most of the surface terrain over the areas mined by N1 and N5 Panels is defined in PA 09_0161 as a steep slope (i.e. a gradient between 18.3° and 63.4°) within the gully of an unnamed first order tributary of Wattle Creek. This tributary drains north into Wattle Creek, which in turn flows east into the Upper Cordeaux No 2 Dam. Rock outcrops are prominent near the top of the slope, more frequently above N1 Panel.

Other surface features in the proximity to N1 and N5 Panels are located to the east or south, remote from areas mined by secondary extraction in N1 and N5.

Built features include four-wheel drive access tracks (Fire Roads 6G and 6E), two parallel 33kV powerlines that traverse the Nebo mining area from the northeast to the southwest, and Wanyambilli trigonometrical survey station.

One powerline is owned by Integral Energy and supplies the Avon Dam pumping station. The other powerline is owned by the mine and supplies the Nebo No 4 shaft main ventilation fan installation and underground mine feeders. The poles that support the conductors of these two powerlines are located above pillars or larger areas of solid coal.

Wanyambilli trig station is located approximately 180m to the south of the secondary extraction area in N1 Panel.

There are no Archaeological heritage sites located in the vicinity of N1 and N5 Panels.

Mining in N1 and N5 Panels is remote from the Dams Safety Committee (DSC) Notification Area for the Cordeaux Storage Reservoirs.

There are no upland swamps within 35° angle of draw (0.7Depth) of N1 and N5 Panels.

3.2 Mining Geometry, Timing and Geology

Figure 2 shows the mined areas of N1 and N5 Panels adjacent to previous pillar extraction panels at Nebo Colliery. The areas approved for longwall mining and the approximate location of pegs on the subsidence monitoring line NM4 (400 Line) are also shown.

The area of N1 and the small portion of N5 were developed simultaneously using the same coal clearance (conveyor belts) and ventilation systems and then extracted in succession during the mining of N3 Panel.

N1 Panel mined an area 300m long by 125m wide within the panel boundary approved for Longwall N1. Some larger pillars, fenders and stooks of coal were left within the total extracted length. WCL calculate that the area of extraction was 73% of the total plan area of N1 Panel.

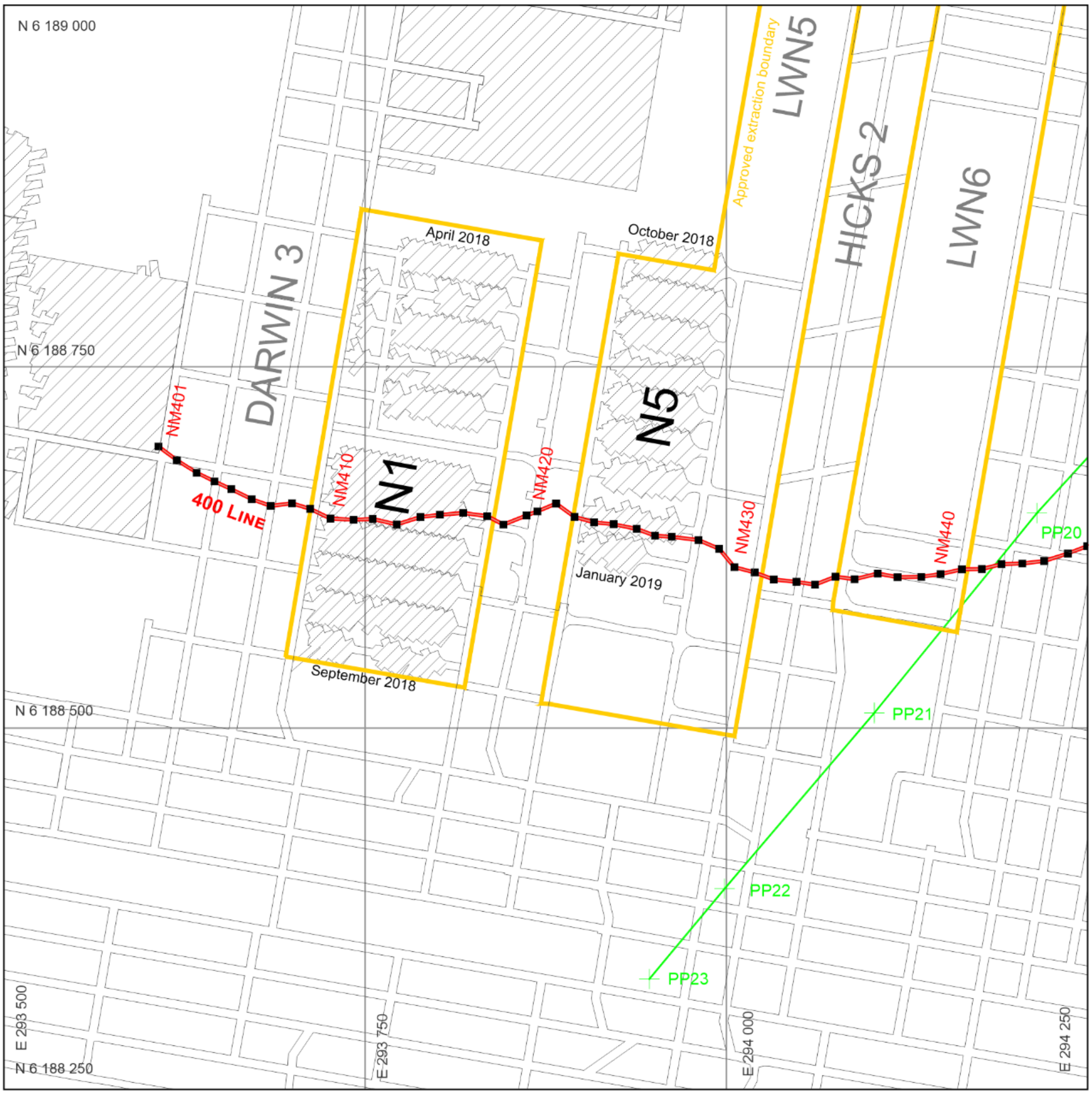

Figure 2: Details of areas mined in N1 and N5 Panels.

The approved void for Longwall N5 is 1675m long with variable widths of approximately 130m at the northern and southern ends and 65m in the central section of the panel. The southern secondary pillar extraction area of N5 Panel is 230m long and only 90m wide; 40m less than the 130m width approved for longwall mining. WCL report the mining height in both panels is 3.2m compared to the 3.6m extraction height approved for longwall mining.

Development of first workings roadways in the southern part of N1 and N5 Panels started in May 2017 with secondary extraction of the pillars in N1 Panel occurring between April 2018 to September 2018. Secondary extraction in N5 Panel commenced in October 2018 and stopped in January 2019. The outbye section of N5 Panel was not completed. All mining in the Nebo area was stopped in March 2019. The extraction direction was from north to south in both N1 and N5 Panels.

The overburden depth to the Wongawilli Seam mining horizon for N1 Panel varies from approximately 240m at the northern end of the panel to approximately 350m in the south. The overburden depth for N5 Panel ranges from 260m to 320m. The Wongawilli Seam dips at approximately 1 in 20 to the west at this location. The variation in overburden thickness is primarily a result of the steep surface terrain.

The sedimentary overburden sequence over most of the Nebo area was intruded by a crinanite (dolerite) sill known as the Cordeaux Crinanite. The overlying strata has subsequently been eroded away so that the crinanite is now located at or near the surface as shown in Figure 3.

Observations and interpretation from borehole investigations of the previous mining in Hicks 4 Panel indicate that where panels are narrow and there is substantial thickness of crinanite in the overburden, the caving and subsidence behaviour is significantly modified. In areas where the thickness of the crinanite is greater than 30-40m, the crinanite is observed to bridge across extracted panels up to 130m wide with caving being mainly confined to the underlying sedimentary strata. In this circumstance, subsidence is mainly due to elastic compression of the abutment coal and surrounding strata. Subsidence monitoring from Longwall N2, N3 and N4 Panels confirms this behaviour.

The western edge of the crinanite outcrops on the surface between N1 Panel and N5 Panel. No substantial thickness of crinanite is known to exist over N1 Panel. The crinanite is estimated to be 10m thick above the extracted area of N5 Panel. Subsidence behaviour above these panels is therefore not expected to be significantly modified by the crinanite.

Coal was extracted during March and April 2017 in a small area at the northern end of the narrow central section, approximately 1km north of NM4 Line. This extraction involved lifting off from six roadways within the approved area for Longwall N5. The overburden depth in this area ranges 160-180m and the crinanite is estimated to be 35-40m thick. Subsidence movements from this mining are expected to have been insignificant for all practical purposes given the limited extraction, the narrow geometries involved and the presence of the crinanite. Any movements that did occur are likely to have been at or below survey tolerance. The effects of this mining are not considered further.

3.3 Survey Accuracy Considerations

N1 Panel was already partly mined by the time that the base line survey for Line NM4 was completed. An additional 150mm of subsidence that was not measured due to the timing of the base line survey is estimated to have developed over N1 Panel giving maximum total subsidence of 360mm. This maximum subsidence is considered to be reasonable but is nevertheless an estimated of maximum subsidence rather than a surveyed measurement.

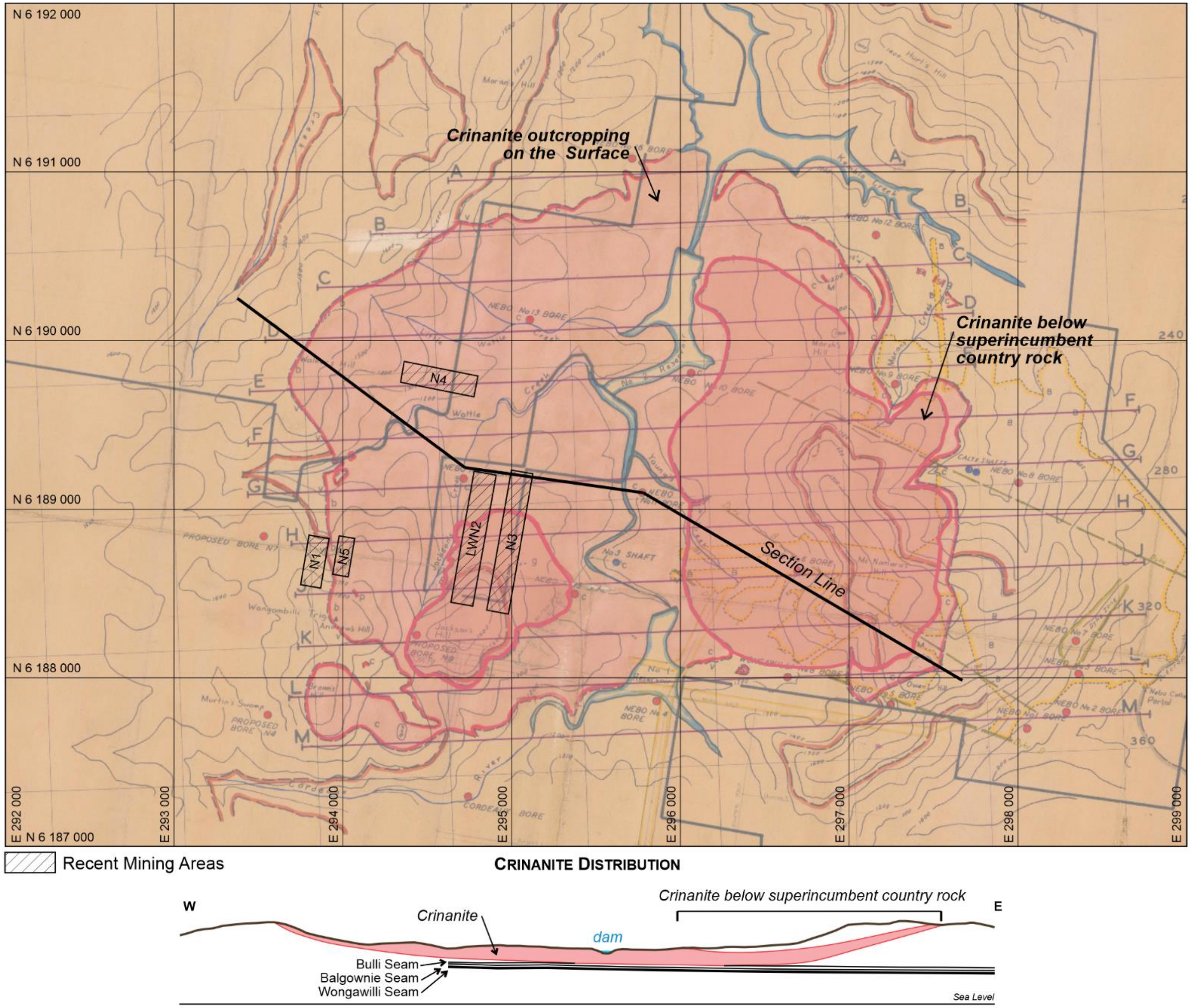

Figure 3: Crinanite distribution based on AIS Coal Geology Plan S3-64 *(accuracy is estimated to be generally better than 50m).*

For comparison with predictions, the measured and estimated parameters need to be considered in the context of the relative positions of the monitoring lines, prediction lines and mining geometry as well as survey tolerances and the overall magnitude of subsidence parameters.

Line NM4 is located nearer to the end of the panel than Prediction Line 1. In this location, subsidence values are likely to be slightly less than the maximum values that would have occurred at the location of Prediction Line 1.

Survey tolerances are detailed in the Trigger Action Response Plans (TARP) and other sections of the Nebo Longwalls 1-6 Subsidence Monitoring Plan (NRE 2014). The magnitudes of subsidence parameters are low relative to survey tolerance so high-confidence determination of compliance is not possible. The accuracy expectations in the TARPS for regional points are ±25mm for position and ±35mm for height. The survey accuracy expectations for individual pegs on subsidence lines are:

- ±5mm for level and relative position (NRE 2014 Appendix C).
- ±30mm for relative 3D accuracy.
- ±50mm for absolute 3D accuracy.

Given tilt and strain are measured across two pegs spaced nominally 15m apart, the accuracy expectations for tilt and are ±10mm/15m or ±0.7mm/m. The survey tolerances stated in the TARPS for tilt and strain are ±0.3mm/m, but the ±0.7mm/m accuracy expectations (±5mm 2D accuracy) indicated in Appendix C of NRE (2014) appear more realistic for the steep terrain and bushland environment where Line NM4 is located.

4. SUBSIDENCE EFFECTS MONITORING

An analysis and interpretation of the subsidence monitoring are presented in this section. The surveys considered include surveys of NM4 Line, regional 3D points (for far-field effects) and the 33kV powerline poles as outlined in NRE (2014).

4.1 NM4 (400) Line

The approximate locations of the individual pegs on NM4 Line are shown in Figures 1 and 2. This line traverses the steep terrain through uncleared bushland in an area almost perpendicular to the direction of extraction of N1 and N5 Panels. Figure 4 shows photographs of the surface along the NM4 subsidence line.

The overburden depth along NM4 Line varies from 290m over N5 Panel to 330m at the western edge of N1 Panel. Monitoring marks (pegs) are installed flush with the ground surface or on rock outcrops at approximately 15m intervals.

The two-dimensional (2D) baseline survey of NM4 Line was conducted at the end of August 2018 after N1 Panel had mined below the line during June and July 2018. Another 2D survey was conducted in November 2019, some 10 months after mining had ceased in January 2019. No three-dimensional (3D) surveys of NM4 Line were undertaken.

Incremental subsidence effects from the mining in N1 Panel were not measured due to the timing of surveys. However, an estimate of vertical subsidence from the mining in N1 Panel has been added to the profile measured after mining in N5 Panel for the purposes of compliance assessment.

Figure 5 shows a plot of the subsidence parameters able to be derived from the 2D measurements on NM4 Line above N1 and N5 Panels. These parameters are plotted perpendicular to the panel direction using the position of the goaf edge for the maximum approved LWN5 width as the zero distance. An estimate of additional vertical subsidence is included. This estimate is based on typical sedimentary behaviour considering the mined geometry, the position of the monitoring line, and the timing of surveys relative to mining.

The subsidence movements measured are of low magnitude. For compliance assessment, these movements need to be considered in the context of survey techniques, physical ground conditions and the expected survey tolerances outlined in Table 5.2 – Subsidence Monitoring and Management, Appendix A – Monitoring Program and Trigger Action Response Plans (TARPS), and Appendix C – Monitoring Methods and Accuracy of NRE (2014).

Maximum vertical subsidence of approximately 210mm was measured on Line NM4. An additional 150mm of subsidence is estimated to have occurred over N1 Panel prior to the first survey giving a total of 360mm. This additional subsidence is estimated following consideration of the sag and elastic compression components for the subcritical mining geometry.

The maximum vertical displacement profile is consistent with subsidence expected for the reduced extraction width of N5 Panel.

Horizontal subsidence movements were not able to be derived from the 2D surveys conducted.

Maximum tilt calculated between individual pegs along NM4 Line from the 2D data is 2.4mm/m. Maximum average tilt near the edges of the extracted voids is 1.4mm/m.

Maximum strains calculated between individual pegs along NM4 Line from the 2D data are 0.9mm/m in compression and 0.6mm/m in tension.

The angle of draw, to the 20mm vertical subsidence to the west of N1 Panel is estimated to be approximately 18°. In the east, the point of 20mm subsidence is located above the extracted void of N5 Panel due to reduced panel width and the low levels of subsidence over N5 Panel.

a) Looking west above N5 Panel.

b) Looking west above N1 Panel.

Figure 4: Examples of surface terrain along NM4 subsidence monitoring line.

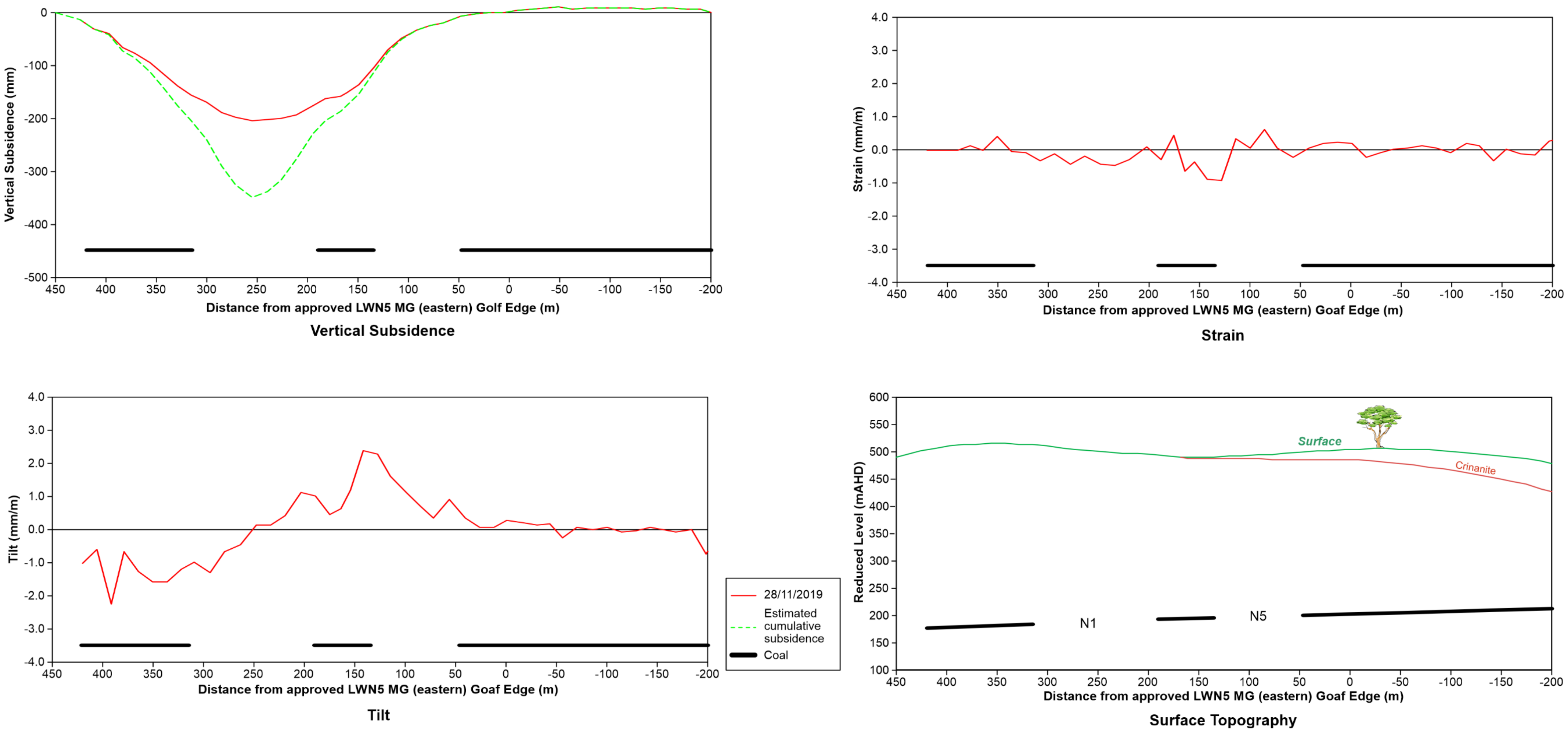

Figure 5: Summary of subsidence monitoring results along NM4 (400) Line after mining in N1 and N5 Panels.

4.2 Measurements on Power Poles

Measurements on the power poles located over the Nebo area indicate only low-level movements. No significant differences in tilt, vertical subsidence or horizontal movement were measured.

Figure 1 shows the position of 13 timber poles supporting the Integral Energy 33kV power line that crosses the surface above the Nebo mining area generally between Longwall N2 and N6 Panel. The poles were surveyed for tilt in both directions after the mining of Longwall N2, during the mining of N3 and N1 Panels and after all mining in the Nebo area stopped in March 2019.

PP21 and PP22 are the nearest power poles on this line to the areas of secondary extraction in N1 and N5 Panels. These two poles are located more than 130m horizontally to the southeast of N5 and are positioned above pillars or larger areas of solid coal. Figure 6 shows PP22 looking north, with the mine-owned 33kV powerline on the right.

Figure 6: Looking to North with Power Pole 22 on left.

From the baseline survey of March 2013, the poles were surveyed in July 2014 after Longwall N2, in September 2018 during the mining of N3 and N1 Panels and again in November 2019, some 10 months after mining in N5, and 8 months after all mining had finished.

4.3 Regional Ground Movements

An array of nine pegs located remote from the Nebo mining area on all sides of the panels were established and surveyed using GPS. The low-level ground movements observed appear to be a result of survey tolerance and are not consistent mining activity.

Figure 7 shows the locations of the points and the horizontal vectors of movement that were observed after the mining of Longwall N2 and during the secondary extraction in N3 and N1 Panels.

Figure 7: Far-field horizontal movements measured on distributed array of pegs.

There is no consistent pattern apparent. The movements observed are interpreted as random variations within survey tolerance rather than meaningful measurements of any systematic process. The low levels of far-field movements are consistent with the mining geometry and the low levels of horizontal ground movements observed from the mining in Longwall N2, N4, N3, and N1 Panels.

5. OBSERVATIONS OF SUBSIDENCE IMPACTS

Observations from fortnightly visual inspections by WCL environmental personnel during the mining of N1 and N5 Panels and from a walkover site visit by SCT conducted on 18 October 2019 are presented and discussed in this section. No perceptible impacts were observed.

Fortnightly inspections by WCL personnel were conducted during the period of active mining in N1 and N5 Panels and have continued post mining as required by the Nebo Longwalls 1-6 Subsidence Monitoring Plan. No subsidence impacts were reported during these inspections. The absence of reported impacts is consistent with the low magnitude subsidence effects measured and the predicted low magnitude of subsidence effects and impacts, particularly in a bushland environment.

No evidence of subsidence impacts or potential environmental consequences was observed in the vicinity of N1 and N5 Panels (or Longwall N2, N3 and N4 Panel) during the site visit by SCT. The site inspection included the fire roads (four-wheel drive tracks), steep slopes and rock outcrops above N3 Panel, Longwall N2, N5 and N1 Panels, along the 33kV powerlines alignment, as well as the heritage site known as Cordeaux River Historic Site 3.

No surface deformations (cracking, collapse or movement) were observed on the hard surfaces of the fire roads and no signs of slope instability or impacts to rock outcrops were observed in the vicinity to NM4 Line. Figure 8 shows a typical rock outcrop above N1 Panel with no perceptible impacts from mining.

No subsidence related impacts were observed to the 33kV powerlines or at Historic Site 3.

No situation was observed that could be construed as an additional risk to public safety, particularly given the controlled and limited access to the area.

In summary, no subsidence impacts from the mining in N1 and N5 Panels were observed.

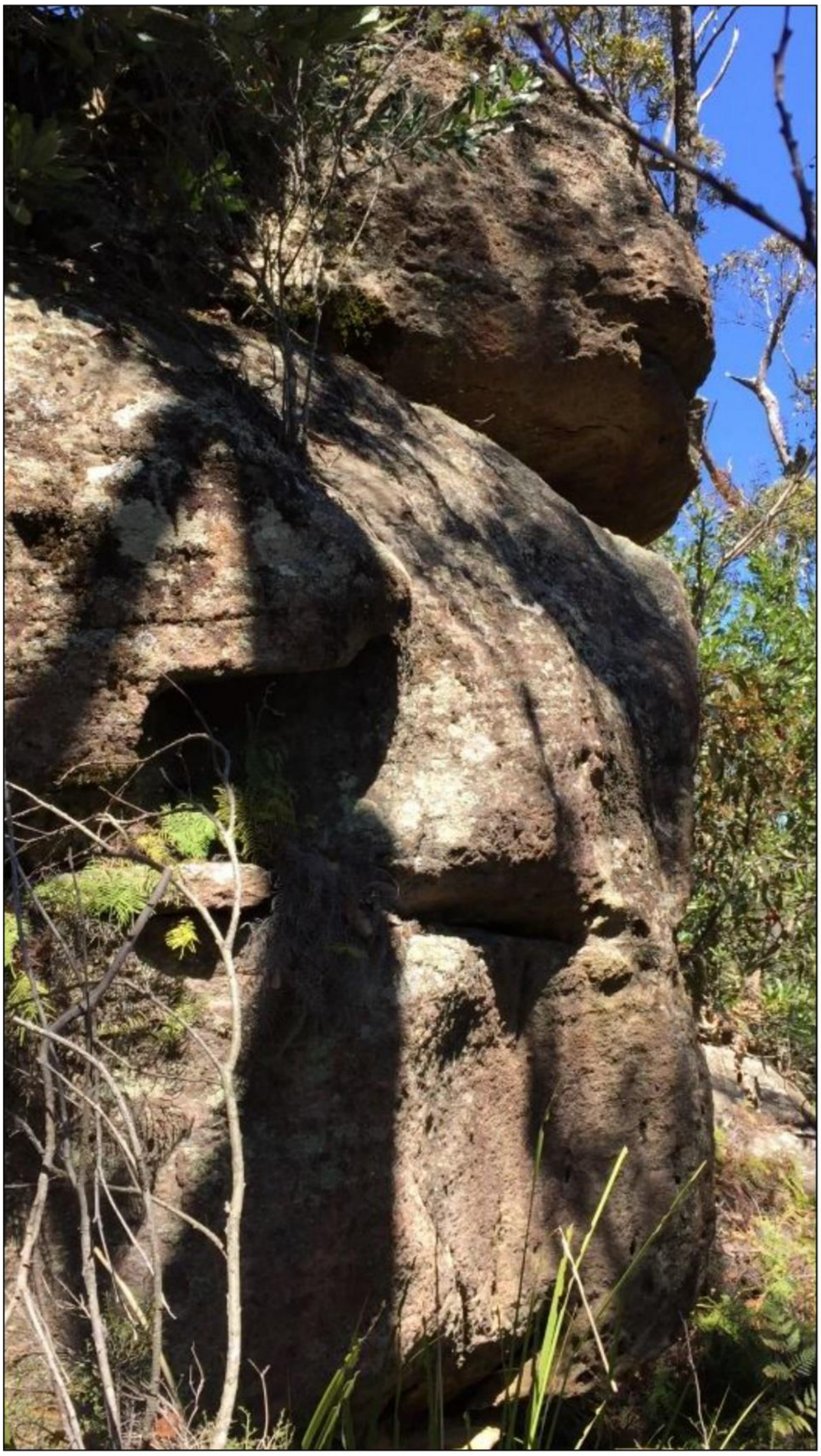

Figure 8: Typical rock outcrop near western edge of N1 Panel.

6. COMPARISON WITH PREDICTIONS AND PREVIOUS PANELS

Comparisons with predictions and the results of subsidence monitoring above previous panels are presented in this section.

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) as part of the environmental assessment (EA) for the Nebo Area Project (ERM 2010). These predictions were then used in the SMP / EP (Niche 2012) and associated management plans for these panels.

Figure 9 shows the predicted contours of vertical subsidence and locations of prediction lines for the approved Nebo Longwalls N1-N6 (after MSEC 2010). Prediction Line 1 is approximately 50m north of NM4 Line, but this prediction line includes the subsidence effects expected from the mining of Longwall N6.

Direct comparison between the subsidence measurements and predictions is not possible because of the changed geometries and practicalities of subsidence line location in dense bushland and steep terrain. However, the results can be compared with allowance for these factors.

The measured and estimated subsidence effects from mining N1 and N5 Panels are of low magnitude as expected. The effects are slightly greater than those measured for Longwall N2, N3 and N4 Panels because the bridging effect of the crinanite is not as strong over N1 and N5 Panels.

Maximum vertical subsidence of approximately 210mm was measured on Line NM4. An additional 150mm of subsidence is estimated to have occurred before the base line survey was conducted. Total subsidence is therefore estimated to be approximately 360mm. Both these values are less than the maximum 400mm predicted on Prediction Line 1 for the mining in Longwalls N1, N5 and N6. This level of maximum vertical subsidence compares with 90mm and 145mm from the mining of Longwall N2 and the combined effects of Longwall N2 and N3 Panel, respectively. The maximum subsidence movements for N4 Panel were not able to be measured on Line NM1 because this monitoring line is offset from the panel.

Maximum peg to peg tilt calculated along NM4 Line is 2.4mm/m. This measured tilt is slightly greater than the 2.2mm/m predicted by MSEC (2010), but within prediction allowing for survey tolerance of ±0.7mm/m. These values compare with tilts of 0.5mm/m from the mining of Longwall N2 and 1.5mm/m from the cumulative effects of Longwall N2 and N3 Panel.

The maximum peg to peg strains calculated along the NM4 Line are 0.9mm/m in compression and 0.6mm/m in tension. Table 4.2 in MSEC (2010) predicts strains on Prediction Line 1 of 0.3mm/m in compression and 0.5mm/m in tension. These values compare with strains of 0.2mm/m measured from the mining in Longwall N2 and 0.8mm/m in compression and 0.6mm/m in tension associated with mining Longwall N2 and N3 Panel.

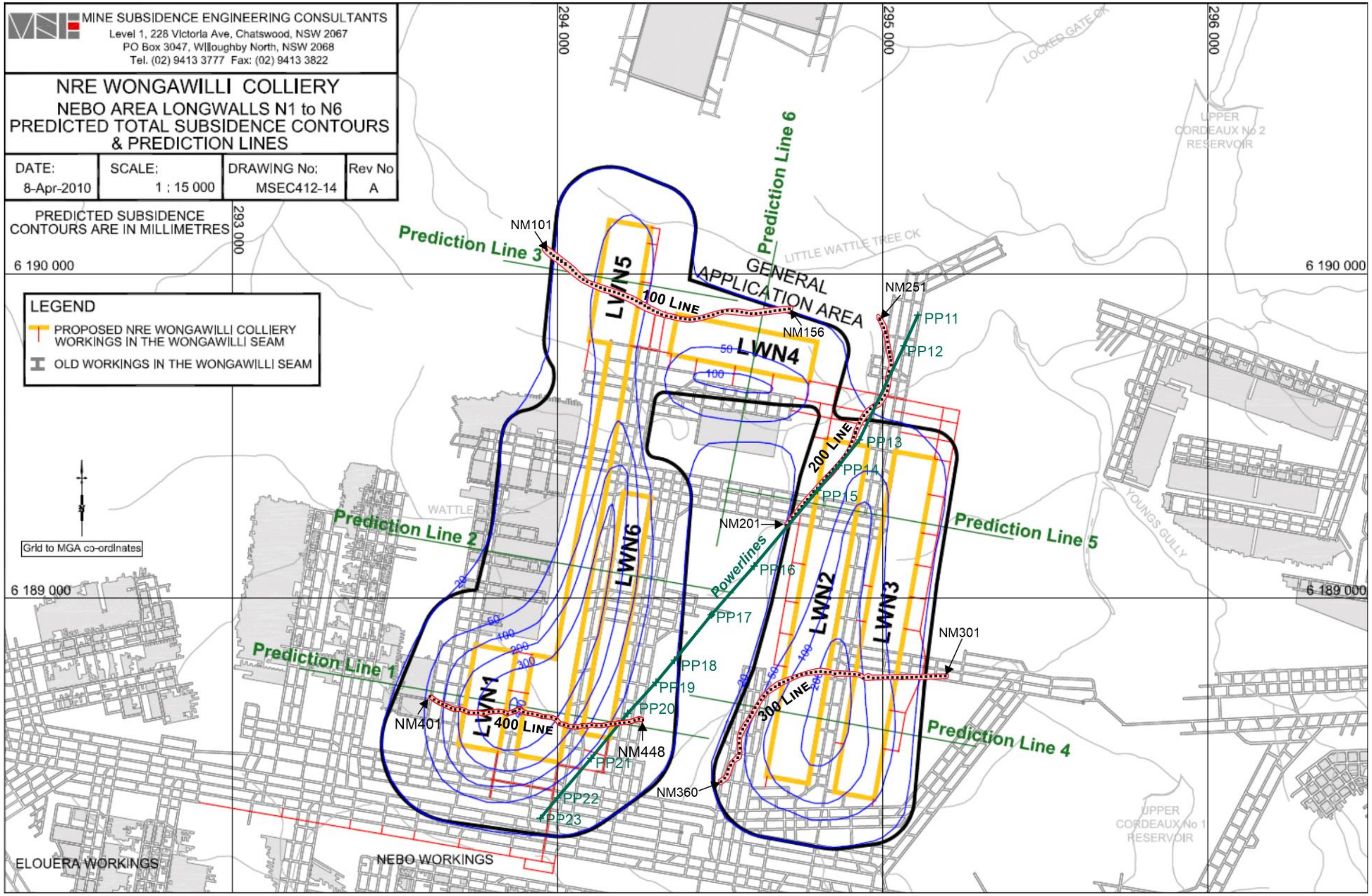

Figure 9: Vertical subsidence predicted in MSEC (2010) with subsidence monitoring lines superimposed.

7. ASSESSMENT OF COMPLIANCE WITH SUBSIDENCE IMPACT CRITERIA AND SUBSIDENCE IMPACT PERFORMANCE MEASURES

An assessment of compliance with subsidence impact performance measures of PA 09_0161 (MOD1) is presented in this section.

Based on the measured subsidence effects being of low level and no subsidence impacts being observed, the monitoring results from the mining of N1 and N5 Panels are expected to be compliant with the impact criteria for the SMP Approval.

Subsidence impacts and environmental consequences are also expected to be less than and compliant with the criteria in the subsidence impact performance measures of PA 09_0161 for water resources, watercourses, land, biodiversity, heritage features, built features and public safety. However, specific compliance for each of these items needs to be confirmed by other specialists or government agencies.

8. REFERENCES

ERM 2010 "NRE Wongawilli Colliery-Nebo Area-Environmental Assessment". ERM Report to Gujarat NRE FCGL Pty Ltd 0097271RP01. Final dated 18 October 2010.

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.

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NRE 2014 "NRE Wongawilli Colliery Nebo Longwalls N1-N6 Subsidence Monitoring Plan" NREN EMS MP002 Rev 3 – dated 14 February 2014.

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

SCT 2014 "Wongawilli Colliery – LWN2 End of Panel Subsidence Report". SCT Report WCW04319, dated 29 August 2014.

SCT 2017 "Wongawilli Colliery – Nebo N4 End of Panel Subsidence Report". SCT Report WCW04693, dated 8 December 2017

SCT 2019 "Wongawilli Colliery: Nebo N3 End of Panel Subsidence Report". SCT Report WCW05006-1, dated 12 December 2019

Appendix H – SCT Nebo N3 End of Panel Subsidence Report

Strata Control Technology

WOLLONGONG COAL LIMITED

Wongawilli Colliery: Nebo N3 End of Panel Subsidence Report

WCWO5006-1

Mining Research and Consulting Group

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REPORT TO John Ross
Environment and Approvals Manager
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TITLE Wongawilli Colliery: Nebo N3 End of Panel Subsidence Report

REPORT NO WCWO5006-1

PREPARED BY Stephen Wilson

DATE 12 December 2019

Stephen Wilson
Mine Planner

Ken Mills
Principal Geotechnical Engineer

Report No	Version	Date
WCWO5006-1	Draft	22 October 2019
WCWO5006-1	1	12 December 2019

SUMMARY

Wollongong Coal Limited (WCL) has recently ceased mining in the Nebo N3 Panel at Wongawilli Colliery southwest of Wollongong in NSW. Although the approved mining in this panel is not complete, it is unlikely further mining will be undertaken in this area of the Wongawilli Seam within the current mining lease. WCL commissioned SCT Operations Pty Ltd (SCT) to analyse the subsidence monitoring conducted for this shortened panel and to prepare a report suitable to meet the end of panel or annual reporting requirements for subsidence as required by the Subsidence Management/Extraction Plan (SMP/EP) for Nebo Longwalls N1-N6. This report presents the results of our analysis and review of the subsidence monitoring data for N3 Panel in accordance with conditions of SMP Approval 09/5341 and EP requirements of the modified Nebo Area Project Approval 09_0161.

Our review and analysis indicate measured subsidence effects for N3 Panel are less than or consistent with predictions and no subsidence impacts have been observed.

Incremental subsidence effects from N3 Panel are of low magnitude; similar to those measured for Longwall N2. Any subsidence impacts from N3 Panel are imperceptible for all practical purposes, the same subsidence outcome as for the mining in both Longwall N2 and N4 Panels.

The maximum subsidence parameters measured after N3 Panel are:

- Vertical subsidence of less than 150mm.
- Tilt of less than 2mm/m.
- Strains of generally less than 1mm/m.
- Horizontal movements of generally less than 50mm.

Measurements of subsidence effects and observations of subsidence impacts from regular monitoring and those made during a site visit by SCT indicate that the effects from the mining of N3 Panel are likely to be less than predicted and the impacts are expected to be compliant with the impact criteria in the SMP Approval conditions.

Subsidence impacts and environmental consequences to features and items are also expected to be less than and compliant with the criteria in the subsidence impact performance measures of PA 09_0161 for water resources, watercourses, land, biodiversity, heritage features, built features and public safety, notwithstanding the input of other specialists or government agencies.

Ongoing subsidence monitoring, consistent with the Nebo Longwalls N1-N6 Subsidence Monitoring Plan, with detailed documentation of inspection results is recommended. If further mining in the Nebo area is planned, a review of the current subsidence monitoring plan (program) is recommended.

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1. INTRODUCTION

Wollongong Coal Limited (WCL) has recently ceased mining in the Nebo N3 Panel at Wongawilli Colliery southwest of Wollongong in NSW. Although the approved mining in this panel is not complete, it is unlikely further mining will be undertaken in this area of the Wongawilli Seam within the current mining lease. This panel was initially approved to be mined using the longwall method, however the panel has been subsequently mined using secondary pillar extraction by continuous miners and breaker line supports. WCL commissioned SCT Operations Pty Ltd (SCT) to analyse the subsidence monitoring conducted for this shortened panel and to prepare a report suitable to meet the end of panel or annual reporting requirements for subsidence as required by the Subsidence Management/Extraction Plan (SMP/EP) for Nebo Longwalls N1-N6. This report presents the results of our analysis and review of the subsidence monitoring data for N3 Panel in accordance with conditions of SMP Approval 09/5341 and EP requirements of the modified Nebo Area Project Approval 09_0161.

The report includes comparisons of monitoring results with subsidence predictions made in the SMP / EP (Niche 2012). The comparisons are based on the Part 3A Application for the Nebo Area Project subsidence assessment (MSEC 2010), monitoring results from previous panels and assessment against relevant impact criteria including the subsidence impact performance measures of PA 09_0161 (MOD1).

Our assessment is based on the survey data supplied by WCL for monitoring points in proximity to N3 Panel, fortnightly visual inspections conducted by WCL environmental personnel and a site visit conducted on 18 October 2019 by SCT to inspect the surface in the vicinity of this panel.

The report is structured to provide:

- conclusions and recommendation from the review and analysis
- a site description
- a summary of the monitoring results
- comparison with:
    - predicted subsidence behaviour and impacts
    - subsidence effects and impacts from previous panels
    - assessment of compliance with impact assessment criteria and subsidence impact performance measures.

2. CONCLUSIONS AND RECOMMENDATIONS

Our review and analysis indicate measured subsidence effects for N3 Panel are less than or consistent with predictions. SCT is not aware of any perceptible subsidence impacts.

Subsidence behaviour as a result of the Cordeaux Crinanite in the overburden sequence is consistent with expectation such that any minor impacts from the mining of N3 Panel are imperceptible for all practical purposes.

Incremental subsidence effects from N3 Panel are similar to those measured for Longwall N2. Subsidence impacts from N3 Panel are imperceptible as they were for the mining Longwall N2 and N4 Panel in the same geological setting.

The maximum subsidence parameters measured after N3 Panel are:

- Vertical subsidence of less than 150mm.
- Tilt of less than 2mm/m.
- Strains of generally less than 1mm/m.
- Horizontal movements of generally less than 50mm.

These measured parameters need to be considered in the context of the position of the monitoring lines relative to the mining geometry and prediction lines, the stated survey tolerances and Trigger Action Response Plans (TARP) outlined in the Nebo Longwalls 1-6 Subsidence Monitoring Plan.

The monitoring line is located close to where remnant pillars were left in the panel. Vertical subsidence is likely to be reduced at the location of the monitoring line due to the presence of these pillars.

The accuracy expectations in the TARPS for regional points are ±25mm for position and ±35mm for height. The accuracy expectations for individual pegs on subsidence lines are:

- ±50mm for absolute position
- ±30mm for relative position
- ±5mm for level
- ±0.3mm/m for strain.

A consequence of these survey tolerances is that even if the subsidence lines were located in an area where maximum subsidence movements would be expected, the tolerance of the survey techniques used may be too high to measure the low values of the subsidence parameters predicted.

Nevertheless, measurements of subsidence effects and observations of subsidence impacts from regular monitoring, and those made during the site visit by SCT, indicate that the effects from the mining of N3 Panel are likely to be less than predicted and the impacts are expected to be compliant with the impact criteria in the SMP Approval conditions.

Subsidence impacts and environmental consequences to features and items are also expected to be less than and compliant with the criteria in the subsidence impact performance measures of PA 09_0161 for water resources, watercourses, land, biodiversity, heritage features, built features and public safety, notwithstanding the input of other specialists and government agencies.

Ongoing subsidence monitoring, consistent with the Nebo Longwalls N1-N6 Subsidence Monitoring Plan, with detailed documentation of inspection results is recommended. If further mining in the Nebo is planned, a review of the current subsidence monitoring plan (program) is also recommended.

3. SITE DESCRIPTION

Figure 1 shows a plan of the mining layout in the Nebo area superimposed onto a 1:25,000 series topographic map.

The locations of subsidence monitoring lines and points (NM1, NM2, NM3, NM4 and PP) are also shown. The main subsidence monitoring line (NM3 - 300 Line) for N3 Panel is located along Fire Road 6G above Longwall N2 and N3 Panel.

3.1 Surface Features

The site is located approximately 13km west of Wollongong in the upper reaches of the Cordeaux River Valley within the Sydney Water Catchment Metropolitan Special Area. The surface above N3 Panel is undeveloped bushland comprising sections of native vegetation and other areas regenerating from previous European settlement.

N3 Panel is positioned below the northern slope of a local topographic high point (Jacksons Hill) where the surface terrain drains east into the Cordeaux River between the Upper Cordeaux No1 and No2 dam walls. The northern section of N3 Panel has mined below an unnamed first order tributary of Cordeaux River.

Other surface features above or in the proximity to N3 Panel include four-wheel drive access tracks (Fire Roads 6G and 6E) and two parallel 33kV powerlines that traverse the Nebo mining area from the northeast to the southwest. One powerline is owned by Integral Energy and supplies the Avon Dam pumping station. The other powerline is owned by the mine and supplies the Nebo No4 shaft main ventilation fan installation and underground mine feeders. The poles that support the conductors of these two powerlines are located remote from N3 Panel above solid coal areas not extracted by Longwall N2.

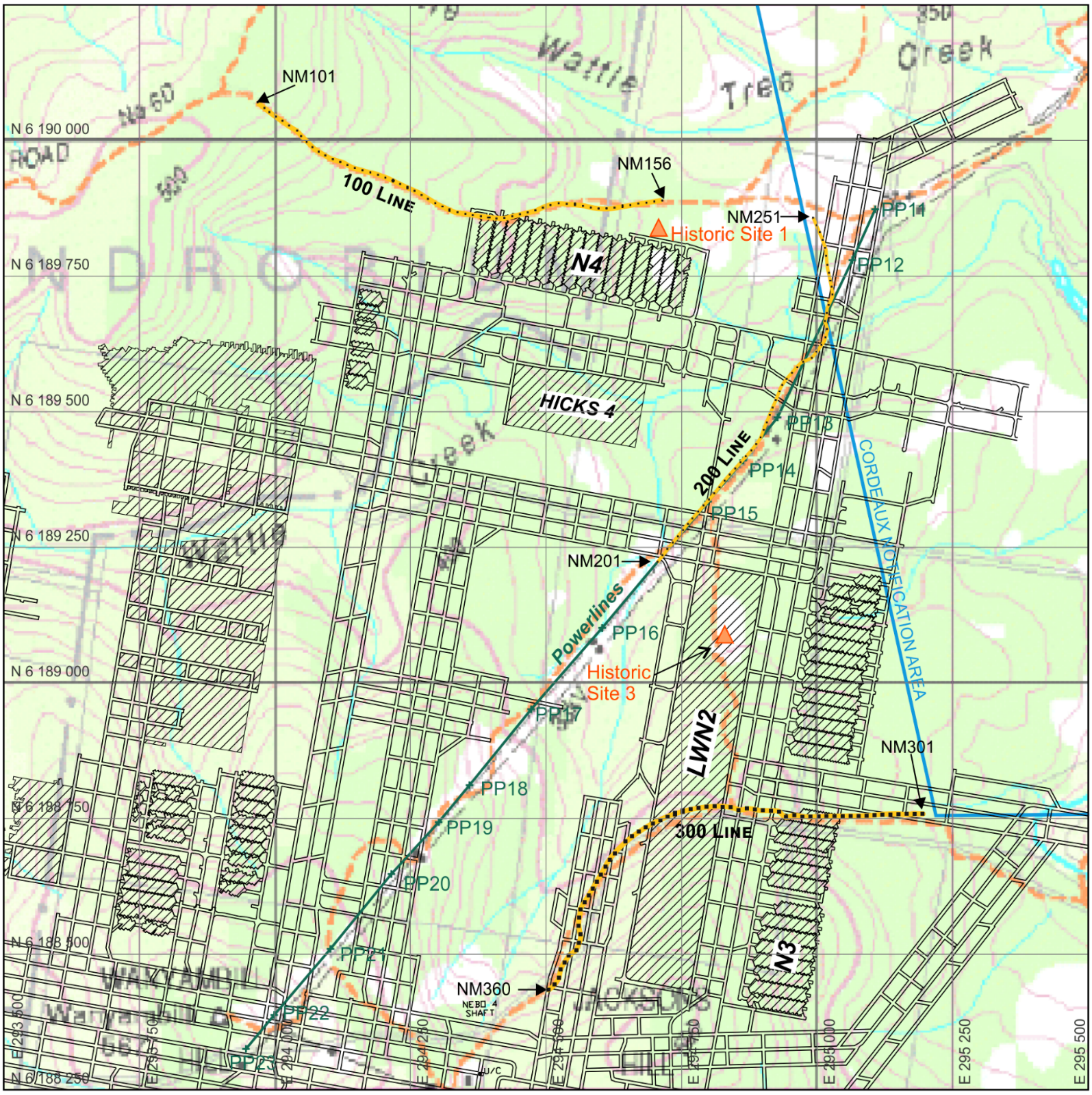


Figure: 1: Site plan showing location of N3 Panel plotted on 1:25,000 series topographic map and subsidence monitoring lines.

A heritage site (Cordeaux River Historic Site 3) is located adjacent to N3 Panel above the area mined by Longwall N2. This site contains scattered artefacts, building foundations and non-native floral species from earlier European habitation.

The secondary extraction area of N3 Panel has not mined within the Dams Safety Committee (DSC) Notification Area for the Cordeaux Storage Reservoirs.

3.2 Mining Geometry, Timing and Geology

The original mining layout for the Nebo area was developed as part of Nebo Colliery. The subsequent secondary extraction panel have been mined by WCL from Wongawilli Colliery.

N3 Panel is the third panel, after Longwall N2 and N4 Panel, to be mined within the approved mining plan for the Nebo area. N3 Panel is adjacent to Longwall N2 but separated by three rows of chain pillars. The panel was mined from south to north. Secondary pillar extraction commenced in February 2017 and production in this panel was stopped in March 2019.

The extraction of N3 Panel created two goaf areas that are around 125m wide with a total length of approximately 850m long. Some larger pillars of coal remain within the total extracted length. The total extracted area represents around 79% of the area approved for Longwall N3. The percentage extraction in plan area allowing for stooks and other remnant coal left as a result of the mining system is calculated by WCL to be 57% of the area approved for Longwall N3.

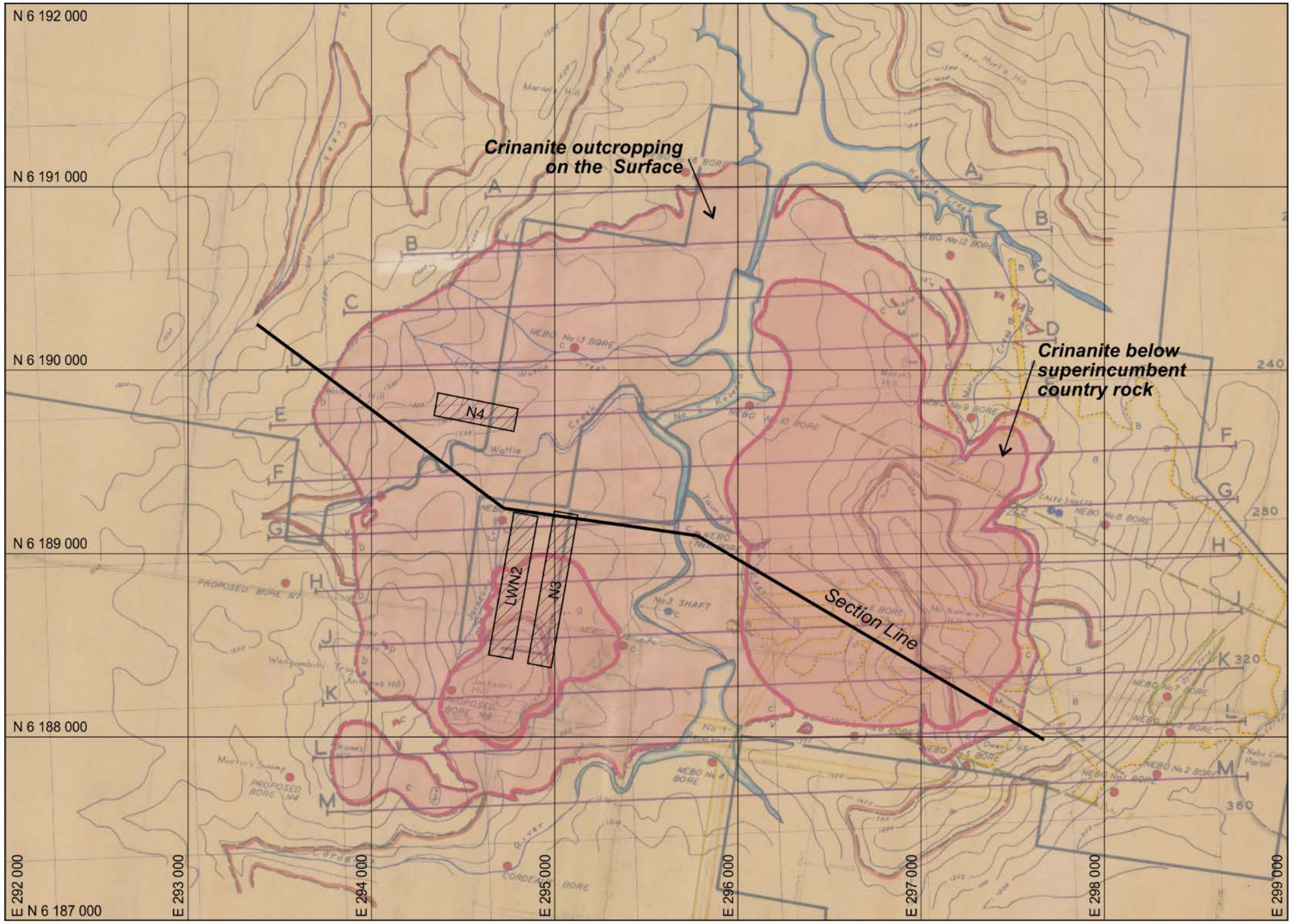
The mining height is reported as being 3.2m compared to the 3.6m extraction height approved for longwall mining. The depth to the Wongawilli Seam mining horizon ranges from about 260m at the start of the panel in the south to approximately 120m at the northern end of the panel.

The sedimentary overburden sequence over most of the Nebo Longwalls N1-N6 areas has been intruded by a crinanite (dolerite) sill known as the Cordeaux Crinanite at or near the surface as shown in Figure 2.

Based on nearby borehole intersections, this crinanite intrusion generally outcrops at the surface and ranges in thickness from 65-80m in the vicinity of the N3 Panel extraction area. The base of the crinanite sill is generally located more than 40-50m above the mining horizon over N3 Panel.

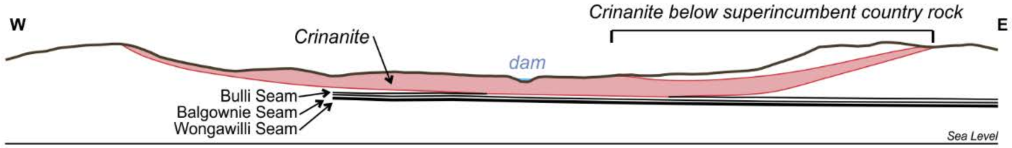
Although N3 Panel was approved for longwall mining with an extraction height of 3.6m, the panel was actually mined using a pillar extraction method with reduced dimensions. Typically, this change of mining method with reductions in the mining height and percentage of coal extracted would be expected to reduce subsidence effects. However, the changes in mining technique and geometry for N3 Panel are unlikely to have had any significant effect on the subsidence outcomes, as the width of extraction remained the same and no significant sag subsidence was originally anticipated.

The crinanite is expected to have substantially bridged across the panel with caving being mainly confined to the underlying sedimentary strata. In areas where the thickness of the crinanite is greater than 30-40m, the main subsidence component is expected to be elastic compression of the abutment coal and surrounding strata. The magnitude of elastic compression is expected to be insensitive to minor variations in mining height or the percentage of extraction at seam level.



Recent Mining Areas

CRINANITE DISTRIBUTION



SECTION *(natural scale)*

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

4. SUBSIDENCE EFFECTS MONITORING

An analysis and interpretation of subsidence monitoring measurements are presented in this section. The surveys considered include NM2 Line, NM3 Line, Regional 3D points (for far-field effects) and the 33kV powerline poles as outlined in the Subsidence Monitoring Plan for Nebo Longwalls N1-N6. The survey results are discussed in order of relevance to subsidence effects from the mining of N3 Panel.

4.1 NM3 (300) Line

The locations of the individual pegs on NM3 Line are shown in Figure 1. This line is sub-perpendicular to the N3 Panel extraction direction with marks positioned along the edge of a four-wheel drive access track known as Fire Road No 6G. Figure 3 shows photographs of the surface along the NM3 subsidence line.

The overburden depth along NM3 Line above the area extracted by N3 Panel varies from 160m on the east of the panel edge to 180m at the west. The crinanite is expected to be greater than 70m thick and more than 60m above the Wongawilli Seam in the vicinity of NM3 Line. Monitoring marks (pegs) are installed along the northern edge of Fire Road No 6G flush with the ground surface at approximately 15m centres.

The baseline survey of NM3 Line was conducted in 2013 before the mining of Longwall N2 and surveyed again in 2014 after mining in Longwall N2 was finished. The XYZ coordinate values of marks on NM3 Line were reset by a survey in 2015. Surveys for N3 Panel extraction were undertaken in August 2018, some four months after NM3 Line was mined under and again in November 2019, eight months after production in this panel was stopped.

Figure 4 shows a plot of the subsidence parameters measured on the NM3 Line above N3 Panel and the adjacent Longwall N2.

The components of subsidence movements are calculated from the three-dimensional (3D) survey data and resolved and plotted as if the line was perpendicular to the panels. The distances are relative to the western goaf edge of Longwall N2. Due to the resetting of the coordinate values for the survey marks on NM3 Line during the period between the mining of each panel, the incremental movements for each panel and the addition of both as cumulative effects, are plotted.

The subsidence movements measured are of low magnitude. However, these need to be considered in the context of survey techniques and the expected survey tolerances outlined in Table 5.2 – Subsidence Monitoring and Management, Appendix A – Monitoring Program and Trigger Action Response Plans (TARPS) and Appendix C – Monitoring Methods and Accuracy of the Nebo Longwalls 1-6 Subsidence Monitoring Plan.

a) Looking west above N3 Panel.

b) Looking north above LWN2-N3 chain pillars.
(Location of maximum subsidence)

Figure 3: Surface along NM3 subsidence monitoring line.

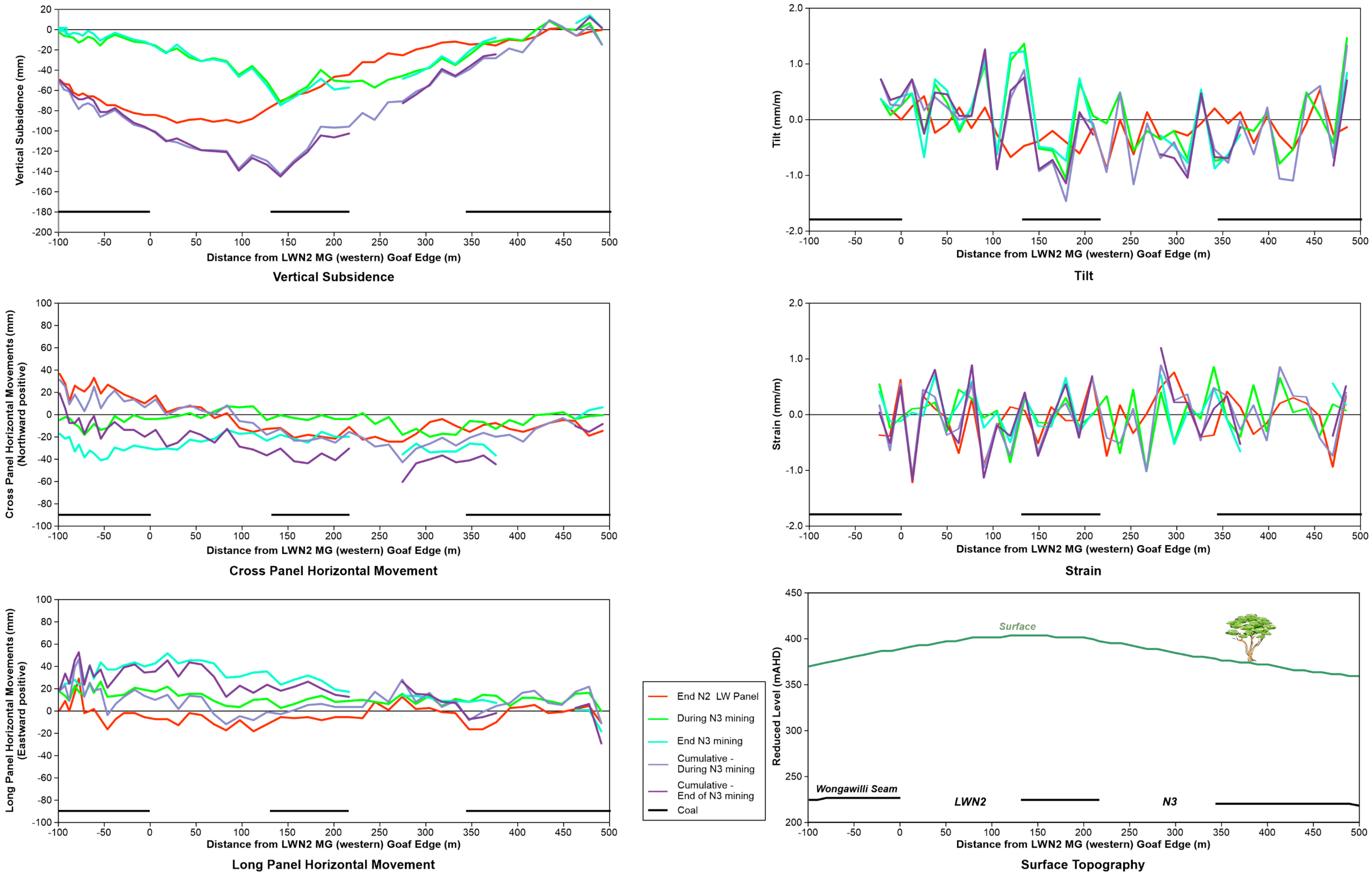


Figure 4: Summary of subsidence monitoring results along NM3 (300) Line after mining of N3 Panel.

One survey peg appears to have been damaged between the surveys after Longwall N2 and the survey during N3 Panel mining. Several survey pegs were also destroyed between the surveys during and after N3 Panel mining. The disturbances to these marks have been considered in the analysis of the data.

Maximum vertical subsidence measured for the mining in N3 Panel is approximately 75mm and when combined with previous subsidence from Longwall N2 the cumulative total is 145mm. However, it is recognised that slightly greater vertical subsidence is likely to have occurred further north along the panel where pillars of coal were not left, but the total subsidence is still expected to be less than the 230mm predicted by MSEC (2010).

The location of the maximum vertical displacement is as expected, above the coal abutments supporting the bridging spans of the crinanite. In this case, the chain pillars between Longwall N2 and N3 Panel that were designed to be left in place to control subsidence and limit movements to low magnitudes.

The horizontal movements measured on NM3 Line are much smaller than the vertical subsidence.

Horizontal movements across the panel from the mining of N3 Panel is generally less than 30mm and when combined with the horizontal movements from the mining of Longwall N2, total typically less than 50mm.

Long-panel horizontal movements are of similar magnitudes to the cross-panel movements. For N3 Panel these are generally less than 20mm and when combined, the cumulative movements are typically less than 40mm.

Maximum tilt calculated from the 3D data for surveys for N3 Panel is 1.5mm/m. Maximum cumulative tilt is also 1.5mm/m, but in the opposite sense.

Maximum strains calculated from the 3D data for surveys for N3 Panel are 1.0mm/m in compression and 0.9mm/m in tension. Cumulative effects are 1.2mm/m and 1.2mm/m respectively. The calculated strains from 2D measurements along the line are less than 0.8mm/m in compression and less than 0.6mm/m in tension.

For a maximum vertical subsidence of less than 150mm, the angle of draw (to the 20mm subsidence) to the east of N3 Panel is estimated to be approximately 22°.

4.2 NM2 (200) Line

The position of the pegs on NM2 Line are shown in Figure 1. These pegs are nominally spaced at 15m centres. The line now starts near the finish line of the shortened Longwall N2 and extends approximately 800m to the northeast. The line is installed along the powerline easement and four-wheel drive track (Fire Road No 6E) over the unmined section of Longwall N2 and first workings or solid coal.

The line is located more than 250m or beyond 0.7 times depth from the extracted area of N3 Panel. NM2 Line is considered too remote from N3 Panel to detect any significant subsidence movements from the mining in this panel.

The NM2 Line was originally established to monitor subsidence effects from the mining of Longwall N2. However, after the cessation of Longwall N2 mining, the line has been refurbished and resurveyed to rectify damage to several pegs sustained from maintenance activities for the surface powerline infrastructure. As a result of this refurbishment no meaningful correlation with previous surveys for Longwall N2 is possible.

Overburden depth varies along the line from 90-120m. The crinanite extends from the surface to a depth of approximately 50-70m. The base of the crinanite is typically 40-50m above the Wongawilli Seam in the vicinity of NM2 Line.

Surveys of the refurbished NM2 Line were conducted in January 2016 to establish a new baseline prior to secondary extraction of N4 Panel. A second survey was conducted in early September 2017 once mining in N4 Panel was finished. A survey during the mining of N3 Panel was undertaken in August 2018.

Analysis of the data for the 2017 and 2018 surveys indicates that the vertical and horizontal subsidence movements measured are generally within survey tolerance of ±20mm for vertical subsidence and ±30mm for horizontal movements. These measurements do not indicate any significant subsidence movements along NM2 Line from the mining of N4 Panel and the recent mining in N3 Panel.

4.3 Measurements on Power Poles

Figure 1 shows the position of 13 timber poles supporting the Integral Energy 33kV power line located to the west of Longwall N2. These poles were surveyed for tilt in both directions using an electronic protractor after the mining of Longwall N2 and during mining of N3 Panel. SCT understands the accuracy of this measurement device is ±0.5mm/m.

The nearest power poles on this line to Longwall N2 and N3 Panels are PP15, located 110m north of where the Longwall N2 stopped and PP16 located 150m to the west of Longwall N2. Both these locations are above solid coal. PP15 has been replaced since Longwall N2 finished as part of regular maintenance on this transmission line. Figure 5 shows the powerlines with PP15 and PP16 identified.

From the baseline survey of March 2013, the poles were surveyed in July 2014 after Longwall N2, in September 2018 during the mining of N3 Panel and again in November 2019. Although PP16 is expected to have experienced up to 30mm of horizontal and vertical subsidence, comparison of the surveys of all poles indicates only low-level movements within survey tolerance. No significant differences in tilt, vertical subsidence or horizontal movement were measured.

a) Looking north - PP15 in foreground on left.

b) Looking south from PP15 - PP16 in middle ground on right.

Figure 5: Surface along 33kV powerlines easement.

4.4 Regional Ground Movements

An array of nine pegs located remote from the Nebo mining area on all sides of the panels were surveyed using GPS to determine if any pattern of consistent far-field movements could be related to mining.

Figure 6 shows the locations of the points and the horizontal vectors of movement that were observed after the mining of Longwall N2 and during the extraction of N3 Panel. There is no consistent pattern apparent. This 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 mining geometry and the low levels of horizontal ground movements observed on NM3 Line.

Figure 6: Far-field horizontal movements measured on distributed array of pegs.

5. OBSERVATIONS OF SUBSIDENCE IMPACTS

Observations from fortnightly visual inspections by WCL environmental personnel during the mining of N3 Panel and from a walkover site visit by SCT conducted on 18 October 2019 are presented and discussed in this section.

Fortnightly inspections by WCL personnel were conducted during the period of active mining in N3 Panel and continued post mining as required by the Nebo Longwalls 1-6 Subsidence Monitoring Plan. No subsidence impacts were reported during these inspections. The absence of reported impacts is consistent with the low magnitude subsidence effects measured and the expectations of the low magnitude subsidence effects and impacts predicted.

The low-level subsidence movements were expected to be imperceptible for all practical purposes in the bushland terrain above the Nebo mining area.

No evidence of subsidence impacts or potential environmental consequences was observed in the vicinity of N3 Panel (or Longwall N2 and N4 Panel) during the site visit by SCT. The site inspection included the fire roads (four-wheel drive tracks), steep slopes and rock outcrops above N3 Panel, Longwall N2, N5 and N1 Panels, along the 33kV powerlines alignment, as well as the heritage site known as Cordeaux River Historic Site 3.

No surface deformations (cracking, collapse or movement) were observed on the hard surfaces of the fire roads and no signs of slope instability or impacts to rock outcrops were observed.

No subsidence related impacts were observed to the 33kV powerlines or at Historic Site 3.

No situation was observed that could be construed as an additional risk to public safety, particularly given the controlled and limited access to the area.

In summary, subsidence impacts from N3 Panel are considered to be imperceptible for all practical purposes.

6. COMPARISON WITH PREDICTIONS

Comparisons with predictions and expectation of compliance with subsidence impact performance measures of PA 09_0161 (MOD1) are presented in this section.

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) as part of the environmental assessment (EA) for the Nebo Area Project (ERM 2010). These predictions were then used in the SMP / EP (Niche 2012) and associated management plans for these panels.

Figure 7 shows the predicted contours of vertical subsidence and locations of prediction lines for the approved Nebo Longwalls N1-N6 (after MSEC 2010).

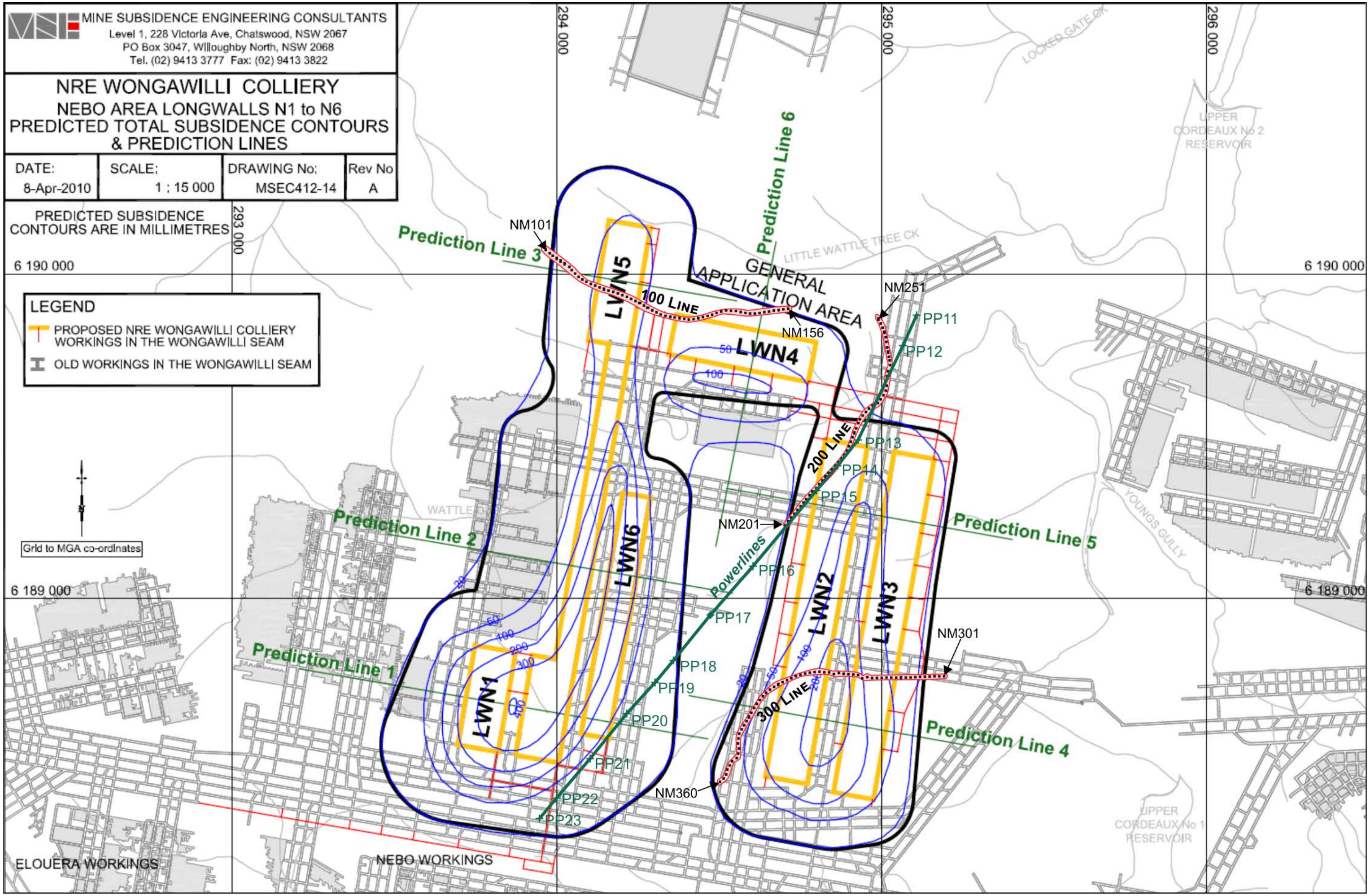


Figure 7: Vertical subsidence predicted in MSEC (2010) with subsidence monitoring lines superimposed.

Direct comparison between the subsidence measurements and predictions is not entirely possible due to the position of the monitoring lines relative to the prediction lines. Reasonable interpolation is nevertheless considered possible.

Incremental subsidence effects from N3 Panel are similar to those measured for Longwall N2.

Maximum vertical subsidence of approximately 140mm was measured on NM3 Line. This subsidence is less than the 230mm predicted nearby on Prediction Line 4 for the mining of both Longwalls N2 and N3. Vertical subsidence from N3 Panel was approximately 70mm compared to approximately 90mm from the mining of Longwall N2.

Combined cumulative horizontal movements are generally less than 40mm for both cross-panel and long-panel movements. These are similar but less than the 50mm predicted by MSEC (2010). The horizontal movements of 20-30mm are similar for both Longwall N2 and N3 Panel extraction

Maximum tilt calculated for N3 Panel is 1.5mm/m. This measured tilt is consistent with the 1.7mm/m predicted by MSEC (2010) after consideration of the stated survey tolerance. The maximum peg to peg tilt measured for N3 Panel is about twice that measured for Longwall N2, and although still at a low level this is likely to be an artefact of survey tolerance.

The maximum strains along the NM3 Line are less than 0.8mm/m in compression and less than 0.6mm/m in tension. These values are within survey tolerance of those predicted in MSEC (2010). The maximum peg to peg strains measured for N3 Panel are similar to those for Longwall N2.

7. ASSESSMENT OF COMPLIANCE WITH SUBSIDENCE IMPACT PERFORMANCE MEASURES

Based on the measured subsidence effects being less than or consistent with predictions and no subsidence impacts being observed, the monitoring results from the mining of N3 Panel are expected to be compliant with the impact criteria for the SMP Approval.

Subsidence impacts and environmental consequences are also expected to be less than and compliant with the criteria in the subsidence impact performance measures of PA 09_0161 for water resources, watercourses, land, biodiversity, heritage features, built features and public safety. Specific compliance in each of these items needs to be confirmed by other specialists or government agencies.

8. REFERENCES

ERM 2010. "NRE Wongawilli Colliery-Nebo Area-Environmental Assessment". ERM Report to Gujarat NRE FCGL Pty Ltd 0097271RP01. Final dated 18 October 2010.

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