Centennial Coal

Western Region Stygofauna Monitoring and Assessment Plan

Centennial Coal

Updated June 2018

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Glossary

Aquifer	An underground layer of permeable material from which groundwater can be usefully extracted.
Biota	All of the living organisms found in a given area.
Community	An assemblage of organisms occupying a specified location and time, usually interacting with one another.
Dissolved oxygen	A measure of the amount of oxygen that is dissolved in water.
Ecosystem	A dynamic complex of plant, animal and micro-organism communities and their non-living environment interacting as a functional unit.
Electrical conductivity	A measure of the concentration of dissolved salts or ions in water.
Endemism	Ecologically unique to a defined geographic area.
Groundwater	Water occurring naturally below ground level.
Guideline Value	A numerical concentration or narrative statement that provides appropriate guidance for a designated water use or impact.
pH	The value taken to represent the acidity or alkalinity of an aqueous solution. It is defined as the negative logarithm of the hydrogen ion concentration of the solution.
Phreatic	Relating to or denoting underground water in the zone of saturation (beneath the water table)
Stygofauna	Groundwater fauna, or stygofauna, comprise the animals that live in underground water. It is made up predominantly of many kinds of crustaceans but includes worms, snails, insects, other invertebrate groups, and, in Australia, two species of blind fish. Most species spend their entire lives in groundwater and are found nowhere else (Humphreys 2006)
Turbidity	A measure of clarity (turbidity) of water. Turbidity in excess of 5 NTU is just noticeable to the average person.

Abbreviations

AHD	Australian Height Datum
Centennial Coal	Centennial Coal Company Limited
DO	Dissolved oxygen
DPE	Department of Planning and Environment
DPI	Department of Primary Industries
EC	Electrical conductivity
EIS	Environmental impact statement
EP&A Act	*Environmental Planning and Assessment Act 1979*
EPA	Environment Protection Authority
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999*
FM Act	*Fisheries Management Act 1994*
GDE	Groundwater dependent ecosystem
GHD	GHD Pty Ltd
ha	Hectare
km	Kilometre
KTP	Key threatening process
kV	Kilovolt
L	Litre
m	Metre
m bgl	Metre below ground level
m btoc	Metre below top of casing
mg/L	Milligram per litre
MNES	Matters of National Environmental Significance
MPR	Marine Pollution Research
NOW	NSW Office of Water, now Department of Primary Industries = Water
NTU	Nephelometric turbidity unit
OEH	Office of Environment and Heritage
SWL	Standing water level
TSC Act	*Threatened Species Conservation Act 1995*
µm	Micrometre
µS/cm	Microsiemens per centimetre
WM Act	*Water Management Act 2000*
°C	Degree Celsius

1. Background

1.1 Updates to the document

This document has been updated in December 2016 following release of the Commonwealth Scientific and Industrial Research Organisation (CSIRO) published article funded by the Australian Coal Association Research Program (ACARP) titled Stygofauna in Australian Groundwater Systems: Extent of knowledge (Hose *et al*., 2015).

The research article details the most up to date knowledge on stygofauna presence in aquifers. The SMAP was originally developed using environmental preferences of stygofauna based on Hancock and Boulton (2008); WA EPA (2007) and unpublished data collected by GHD. The SMAP has been reviewed in light of the updated information provided within the CSIRO paper (Hose *et al*., 2015).

The review of the SMAP identified some small changes in the criteria for water quality preferences and lithology that were used within the Multi-Criteria Analysis Protocol that was used to rank each bore in the Centennial network according to likelihood of stygofauna presence. Re-running the Multi-Criteria Analysis with updated criteria did result in some changes to bore rankings, mostly of the low priority bores (those bores with low likelihood of containing stygofauna. The altered rankings did not change the 22 bores selected as part of the stygofauna monitoring program (see Table 4-2). This is because bores were selected for inclusion of the monitoring program on the basis of a number of criteria, only one of which was the ranking from the Multi-Criteria Analysis. High weighting was given to any bores where stygofauna or likely stygofauna have previously been collected and specific aquifers were targeted as required by consent conditions of the Springvale Mine Extension Project (see section 1.5). A more detailed description of the factors considered in selection of bores for the monitoring program is provided in section 3.4.

1.2 Introduction

The Stygofauna Monitoring and Assessment Plan (SMAP) has been developed on behalf of Centennial Coal (Centennial) in order to monitor and assess existing communities of aquatic subterranean fauna (stygofauna) across a number of Centennial sites located within the Western Coalfield.

Stygofauna monitoring commenced in February 2018 with and repeated in August 2017. Following the drilling of deep groundwater bores at Springvale in mid 2018, the final sampling rounds will be undertaken in March 2019 and July 2019. Following completion of the 2019 monitoring event, within 3 months this SMAP will be updated to incorporate the monitoring program outcomes, address conditions of development consent on the program outcomes and be undertaken in consultation with OEH. The revised SMAP will be submitted to the Department of Planning and Environment for Approval (DPE).

1.2.1 Stygofauna

Aquifers host a complex biodiversity of aquatic invertebrates called stygofauna. Stygofauna is a collective term for all groundwater animals (Hancock *et al*., 2005). Stygofauna can have varying levels of dependence on groundwater. A number of specific terms are used to differentiate the types of stygofauna:

- **Stygoxenes** and **stygophiles** are able to utilise groundwater during at least part of their lifecycle but are not reliant upon it.

- **Stygobites** are obligate groundwater species (Hancock *et al.*, 2005).
- **Phreatobites** are a type of stygobite that are specially adapted to live in the interstitial spaces of alluvial aquifers.
- **Troglofauna** are also subterranean animals but are distinct from stygofauna as they are not associated with groundwater (Humphreys, 2008).
- **Edaphobites** are terrestrial soil dwelling animals which can accidentally or opportunistically colonise subterranean environments.

Stygofauna are highly endemic, often have ancient lineages with Gondwana (350 million years ago) and typically have narrow environmental tolerance range (Serov, 2016). Because of the adaptation of stygofauna to the groundwater environment and limited connectivity between favourable habitats some obligate stygofauna species can have restricted distributions (short range endemism) (Humphreys, 2008).

Stygofauna are threatened by activities that change the quality or quantity of groundwater, that disrupt the connectivity between different aquifers or between aquifers and surface systems or remove soil pores. Disturbance of aquifers could potentially result in local population extinctions, loss of genetic diversity and even species extinctions (Cardno, 2014a).

In Australia, stygofauna research has increased greatly over the last two decades (Hancock and Boulton, 2008), particularly in Western Australia and Queensland, but also in South Australia and NSW. Large scale mining projects have provided the impetus to drive stygofaunal discoveries in Western Australia and Queensland, where specific guidelines or guidance documents have been developed in relation to stygofauna. This driving force is less strongly felt in NSW where many large mining leases are already established and stygofauna are only recognised in environmental impact assessment requirements for new projects. Comparatively, there has been relatively little research done on stygofauna in NSW.

Stygofauna monitoring has been undertaken by Centennial in parts of the Western Coalfield since 2013 (summarised in Section 2.5), however the presence and diversity of stygofauna across the region remains largely unknown.

1.2.2 Multi-Criteria Analysis Protocol

Centennial maintains 158 bores (including both operational and disused monitoring and exploration borehole) across the western region of Centennial's operations within various hydrogeological units (such as coal seams, sandstone layers and alluvium), which provides a multitude of potential stygofauna sampling locations. GHD Pty Ltd (GHD) has developed and implemented the Multi-Criteria Analysis Protocol as a bore prioritisation process which will allow for a targeted stygofauna survey.

The protocol uses key bore attribute data (including water quality, hydrogeological characteristics and bore construction details) to identify the bores with the highest likelihood of stygofauna occurrence.

Sampling will then be undertaken to establish presence and abundance of stygofauna on a regional scale across the western region.

1.3 Site background

Centennial owns and/or operates the following seven sites within the Western Coalfield, which can be divided into four main zones:

- Angus Place Colliery, Clarence Colliery, Springvale Mine.
- Neubeck, Lidsdale Siding, Western Coal Services.

- Airly Mine, Inglenook.
- Charbon Colliery.

The Centennial sites located within the Western Coalfield are shown in Figure 1-1.

Centennial, as part of consent conditions issued for the Springvale Mine Extension Project, are required to develop a regional SMAP. This is consistent with Centennial's regionalised environmental management approach for both their northern and western operations. A regionalised approach for stygofauna will:

- Allow Centennial to conduct a region-wide stygofauna survey that will fulfil monitoring requirements of all Centennial sites within the western region.
- Increase the likelihood of survey success by identifying bores with high potential for stygofauna presence.
- Reduce survey effort and cost by identifying a monitoring program with a regional focus rather than individual site surveys.
- Allow for assessment of the cumulative impact of Centennial sites, where applicable.

One area of operations has the potential to create a significant cumulative impact. This is the Newnes Plateau which includes Angus Place Colliery, Clarence Colliery and Springvale Mine. The geology of the Newnes Plateau is consistent and, as such, the extent of the underlying shallow and deep aquifer systems are consistent across the plateau. Movement of stygofauna within the aquifer, therefore, are expected to be largely unconfined.

Figure 1-1 Locality

1.4 SMAP objectives

The objectives of this plan are to:

- Communicate the results of the review of bore information and attributes across Centennial's western region sites.
- Provide a summary of stygofauna monitoring conducted across centennial's western region sites.
- Detail the bore prioritisation process.
- Provide the results of the Multi-Criteria Analysis Tool.
- Outline a monitoring program for the western region dictating methodology for stygofauna monitoring based on the outcomes of this prioritisation tool and previous monitoring.

Another key objective of the SMAP is to fulfil the consent conditions stipulated by the Director General (Department of Planning and Environment) in relation to the Springvale Mine Extension Project (see Table 1-1).

1.5 Approvals and licensing requirements

Aquatic ecosystems have been used for management and in legislation for surface water and groundwater resources in Australia and has been incorporated into Federal and State Government programs that recognise the importance of groundwater dependent ecosystems (GDEs).

1.5.1 Federal Government

Environmental Protection Biodiversity Conservation 1999

The *Environmental Protection and Biodiversity Conservation Act 1999* (EPBC Act) is the Australian Government's central piece of environmental legislation. The act is a legal framework to protect and manage ecological communities of national and international environmental significance including nationally threatened species and ecological communities, migratory species and wetlands.

1.5.2 State Government

NSW Aquifer Interference Policy 2012

The NSW Aquifer Interference Policy was finalised in September 2012 and clarifies the water licencing and approval requirements for aquifer interference activities in NSW, including the taking of water from an aquifer in the course of carrying out mining. Many aspects of this Policy will be given legal effect in the future through an Aquifer Interference Regulation. Stage 1 of the Aquifer Interference Regulation commenced on 30 June 2011.

The NSW Aquifer Interference Policy requires that potential impacts on groundwater sources including for GDEs be assessed against minimal impact considerations, outlined in Table 1 of the Policy. If the predicted impacts are less than the Level 1 minimal impact considerations, then these impacts will be considered as acceptable (DPI-Water, 2012).

The Level 1 minimal impact considerations for less productive groundwater sources are relevant to the groundwater sources at underground Centennial sites and are as follows:

- Water table: less than or equal to 10% cumulative variation in the water table, allowing for typical climatic 'post-water sharing plan' variations, 40 m from any high priority groundwater dependent ecosystem or high priority culturally significant site listed in the schedule of the relevant water sharing plan. A maximum of a 2 m decline cumulatively at any water supply work unless make good provisions should apply.
- Water pressure: a cumulative pressure head decline of not more than 40% of the 'post-water sharing plan' pressure head above the base of the water source to a maximum of a 2 m decline at any water supply work.
- Water quality: any change in the groundwater quality should not lower the beneficial use category of the groundwater source beyond 40 m from the activity. For alluvial water sources, there should be no increase of more than 1% per activity in the long-term average salinity in a highly connected surface water source at the nearest point to the activity.

Draft Groundwater Monitoring Guidelines 2003

The former NSW Department of Infrastructure, Planning and Natural Resources (DIPNR) developed the *Draft Groundwater Monitoring Guidelines for Mine Sites* in September 2003. This draft guideline is still used by the NSW Department of Primary Industries – Water (DPI-Water) as the benchmark for groundwater monitoring programs at mine sites (DPI-Water, 2012).

NSW State Groundwater Dependent Ecosystems Policy 2002

The *NSW State Groundwater Dependent Ecosystems Policy* (2002) protects ecosystems which rely on groundwater for survival. The policy provides a set of principles and management tool for management of GDEs in NSW, which is outlined in Sections 1.2 and 1.3 of the policy.

Water Management Act 2000

The *Water Management Act 2000* recognises the need to provide water for the environmental health of groundwater systems and includes objects and principals to specifically protect and restore water-dependent ecosystems. The act has provisions in place for water management in order to minimise any harm from developments to water sources.

NSW Groundwater Quality Protection Policy 1998

The *NSW Groundwater Quality Protection Policy* (1998) provides a set of policy principals for groundwater quality protection and guidance for resource managers. The policy objective includes applying the management principles for GDEs and where practical rehabilitate environmental degraded areas to restore ecosystem function.

Environmental Planning and Assessment Act 1979

The *Environmental Planning and Assessment Act 1979* institutes a system of environmental planning and assessment for the relevant planning authority to take into consideration the impacts to the environment. Most developments require a statement of environmental effects or an environmental impact statement (EIS), which allow consideration of environmental impacts from proposed development or land-use change.

The factors to be considered are specified in Section 5A of the act and constitute the Assessment of Significance. The factors relevant to consideration of effects on threatened species, for example, are:

- Whether the proposed action is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction.
- The extent to which the species habitat is likely to be removed or modified as a result of the action proposed, whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and whether the habitat to be removed, modified, fragmented or isolated is important to the long-term survival of the species in the locality.
- Whether the proposed action is likely to have an adverse effect on critical habitat (either directly or indirectly.
- Whether the proposed action is consistent with the objectives or actions of a recovery plan or threat abatement plan.
- Whether the action proposed constitutes or is part of a key threatening process.

NSW State Groundwater Policy 1997

The *NSW State Groundwater Policy Framework Document* manages groundwater resources for sustainable environmental users, including the relevant component for *NSW Groundwater Dependent Ecosystems Policy* (NSW Government, 1997).

This policy was designed to protect ecosystems which rely on groundwater for survival so that, wherever possible, the ecological processes and biodiversity of these dependent ecosystems are maintained or restored for the benefit of present and future generations.

Threatened Species Conservation Act 1995

The *Threatened Species Conservation Act 1995* relates to regulations and conservation of species, populations and ecological communities of significance. The act lists threatened species, populations and communities under schedules 1 and 2. The environmental assessment can determine whether a proposed development is likely to cause a significant impact on threatened biota.

Water Act 1912

The *Water Act 1912* provides conditions to granting or renewing a licence, permit, authority or group licence, which includes for the protection of the environment. Environmental protection conditions subject to the authority holder from their activities or water management include:

- Protect a water source from any adverse effects.
- Mitigate any adverse effects on a water source that have arisen.
- Prevent the wastage or pollution of water.

Development consent conditions

The Springvale Mine Extension Project received approval on the 21 September 2015 from the Planning Assessment Commission NSW for the extraction of 4.5 million tonnes per year of coal using longwall mining techniques, which involves dewatering.

Relevant approval conditions from Schedule 4 of the *Development Consent SSD 5594* (2015) for the Project have been outlined in Table 1-1.

Table 1-1 Springvale Mine Extension Project consent conditions

Condition	Where addressed
17. Prepare and Implement a regional Stygofauna Monitoring and Assessment Plan	This document
a) Be prepared in consultation with OEH and be submitted to the Secretary for approval within six months of the date of consent.	Section 1.2
b) Ongoing monitoring of at least one bore in each aquifer where stygofauna are known to occur.	Section 4
c) Monitor for the presence of stygofauna in the deep aquifer system (AQ1 to AQ3) at Springvale.	Section 4
d) Collate existing available information on groundwater bores, water quality and characteristics in Centennial's mines throughout the Western Coalfield.	Section 2.3, 2.4, 2.5 and 3.1 Appendix B
e) Develop a prioritisation list of likely areas for GDEs (fauna) to occur.	Section 3
f) Develop a prioritisation protocol to identify bores that can be sampled to provide data on the presence and significance of fauna both within and outside mine areas.	Section 3
g) Identify any stygofauna found to a minimum of Family level.	Section 2.5 and pending first round results
h) Advise on the significance of the findings.	Section 3.3
i) Examine relationship between bore characteristics and presence of stygofauna.	Section 3.3

Centennial has also committed to the following, as part of statement of commitments for the Springvale Mine Extension Project:

- Throughout the life of the Project, stygofauna will be monitored using standing water levels within at least one borehole in each aquifer where stygofauna are known to occur (i.e. AQ4 to AQ6). Monitoring the deep aquifer system, AQ1 to AQ3 is to be undertaken to establish the presence of stygofauna. Centennial will undertake a regional stygofauna assessment which will:

- Collate existing available information on groundwater bores, water quality and characteristics in Centennial's area of operations throughout the Western Coalfield.
- Use this information to form a prioritisation list of likely areas for GDE to occur.
- Use the prioritisation protocol to identify bores that can be sampled to provide data on the presence and significance of fauna both within and outside mine areas.
- Identify any stygofauna found to a minimum of Family level.
- Advise on the significance of the findings.
- Examine relationships between bore characteristics and presence of stygofauna.

This document can be applied to other Centennial developments in the Western Coalfield and the respective Conditions of Consent as they become approved by the Planning Assessment Commission NSW.

1.5.3 Industry standards and guidelines

The primary guideline in NSW is the *Risk Assessment Guidelines for Groundwater Dependent Ecosystems, Volume 1 – The Conceptual Framework* (Serov *et al*., 2012). This was developed by NOW and the OEH to:

- Define GDE types.
- Provide a method for determining the ecological value or an aquifer and associated GDEs.
- Provide a method for developing the risk of an activity to the ecological value of an aquifer and associated GDEs.
- Provide a method for developing management strategies for aquifers and identified GDEs using the risk matrix approach.
- Provide a method to identify the type and location of GDEs within an aquifer or defined area.
- Provide a method for inferring the groundwater dependency of identified ecosystems.
- Describe surface and subsurface activities that threaten aquifers and associated GDEs.

With respect to the appropriate sampling of stygofauna and the development of monitoring and assessment plans, there are no specific guidelines in NSW. Queensland currently adopts the criteria outlined in the Western Australian Environmental Protection Authority (EPA) guidelines, which are accepted as current industry best practice in Australia. These guidelines are:

- *Guidance for the Assessment of Environmental Factors: Sampling Methods and Survey Considerations for Subterranean Fauna in Western Australia* (WA EPA, 2007).
- *Environmental Assessment Guideline for Consideration of Subterranean Fauna in Environmental Impact Assessment in Western Australia* (WA EPA, 2013).

The guidelines provide information which the Western Australian EPA considers important when assessing proposals where subterranean fauna is considered a relevant environmental factor.

1.6 Consultation

The review of the draft Stygofauna Monitoring and Assessment Plan has been undertaken in consultation with OEH and the Department of Planning and Infrastructure (DPI). A summary of issues raised during this consultation process is provided in Appendix A.

1.7 Scope and assumptions

The scope of this document includes:

- Review of historical stygofauna investigations undertaken at Centennial's sites in the western region. This includes the review of documents completed by consultants RPS, GHD, Cardno and Marine Pollution Research that relate to stygofauna monitoring.
- Compilation of groundwater data and monitoring infrastructure (standpipes) from Centennial sites, including water quality and available hydrogeological information.
- Characterisation of the groundwater environment and the suitability of stygofauna habitat.
- Development and running of GHD's prioritisation tool to determine likely habitat and recommended sampling locations.
- Identification of stygofauna communities present (based on historical investigations and literature).
- Development of a regional stygofauna monitoring and assessment plan.

The following assumptions were made in the development of this monitoring and assessment plan:

- This work draws on experience from NSW, Queensland and Victoria to determine bore attributes favourable for the occurrence of stygofauna. In the absence of contrary data, it is assumed that these favourable attributes will predict the likely location of stygofauna communities of the western coalfield.
- Sampling methods described are based upon the WA EPA (2007) guidelines, published information regarding stygofauna in Australia and GHD's previous experience in NSW, Queensland and Victoria. It is assumed that these methods are appropriate for sampling stygofauna in the western region.
- Historic stygofauna sampling across Centennial's western region sites has been undertaken by GHD as well as other consulting companies. It is assumed that the results of these studies are comparable despite differences in sampling methodology.

2. Regional environment

2.1 Land use and topography

The Western Coalfield area lies on the western slopes of the north-south oriented sandstone ridgeline of the Great Dividing Range, to the west of the Wollemi and Blue Mountains National Parks. The area consists primarily of undulating hills and mountain tops, with some low lying areas.

The region is surrounded by state recognised forests and reserves, including the Turon State Forest and Winburndale Nature Reserve to the west, and the Wolgan State Forest and Newnes State Forest to the east. The region to the north consists primarily of forest and shrub. These low-lying areas have been cleared of natural vegetation for agricultural, commercial and industrial purposes, including coal and shale mining, forestry and power generation. Other surrounding land use includes the Mount Piper Power Station. Nearby residential areas include Lithgow and Wallerawang to the south and Portland and Cullen Bullen to the west.

The Newnes Plateau, a sedimentary sequence of sandstone, claystone and siltstone, forms a significant topographical feature in the area. The elevations of the plateau vary from 900 mAHD to 1,175 mAHD. Features of the plateau include cliffs and pagodas, narrow gorges and high undulating ridgelines (Golder Associates, 2014).

2.2 Geology

The Western Coalfield is geologically located on the western edge of the Sydney Basin. The stratigraphy of the region consists of material from the Tertiary, Triassic and Permian periods.

The Sydney Basin is characterised by coal, shale and sandstone sedimentary beds of Permo-Carboniferous age. These form the gently dipping beds of the Illawarra Coal Measures, capped by shale and sandstone from the Wiannamatta and Narabeen Group (Triassic Period) and Basalt from the Tertiary period.

Directly below the Illawarra Coal Measures lies the silty, coaly sedimentary rocks of the Nile Subgroup and sandy siltstone of the Berry Siltsone.

Basement rocks of western Sydney Basin are folded Palaeozoic metamorphosed rocks of the Lachlan Fold Belt, Late Carboniferous granites and Early Permian Rhylstone Volcanics.

There are seven identified coal seams within this region, listed in descending stratigraphical order as follows:

- Katoomba Seam.
- Middle River Seam.
- Moolarben Seam.
- Upper Irondale Seam.
- Irondale Seam.
- Lidsdale Seam.
- Lithgow Seam.

Seismic activity has been noted along the Coxs River Lineament Fault Zone, a 250 m wide, north-south trending graben structure which follows the valley of Coxs River.

2.2.1 Angus Place Colliery, Clarence Colliery and Springvale Mine

The Burralow Formation and the Banks Wall Sandstone of the Triassic Narrabeen Group outcrops in the vicinity of Angus Place Colliery and Springvale Mine, as shown in Figure 2-1. Clarence Colliery is geologically located down-dip of Angus Place Colliery and Springvale Mine. At Clarence Colliery there are some areas of outcrop of the Burralow Formation; however, the majority of the outcropping strata at is Banks Wall Sandstone, as shown in Figure 2-2. The Banks Wall Sandstone is underlain by Mount York Claystone (MYC), Burra Moko Head Sandstone and the Caley Formation. There are small areas of unconsolidated Quaternary Alluvium along creek lines.

The Permian Illawarra Coal Measures outcrop to the south and the west of Angus Place Colliery, Clarence Colliery and Springvale Mine. The Lithgow Seam is the target seam at Angus Place Colliery and Springvale Mine. The Katoomba Seam is the target seam at Clarence Colliery.

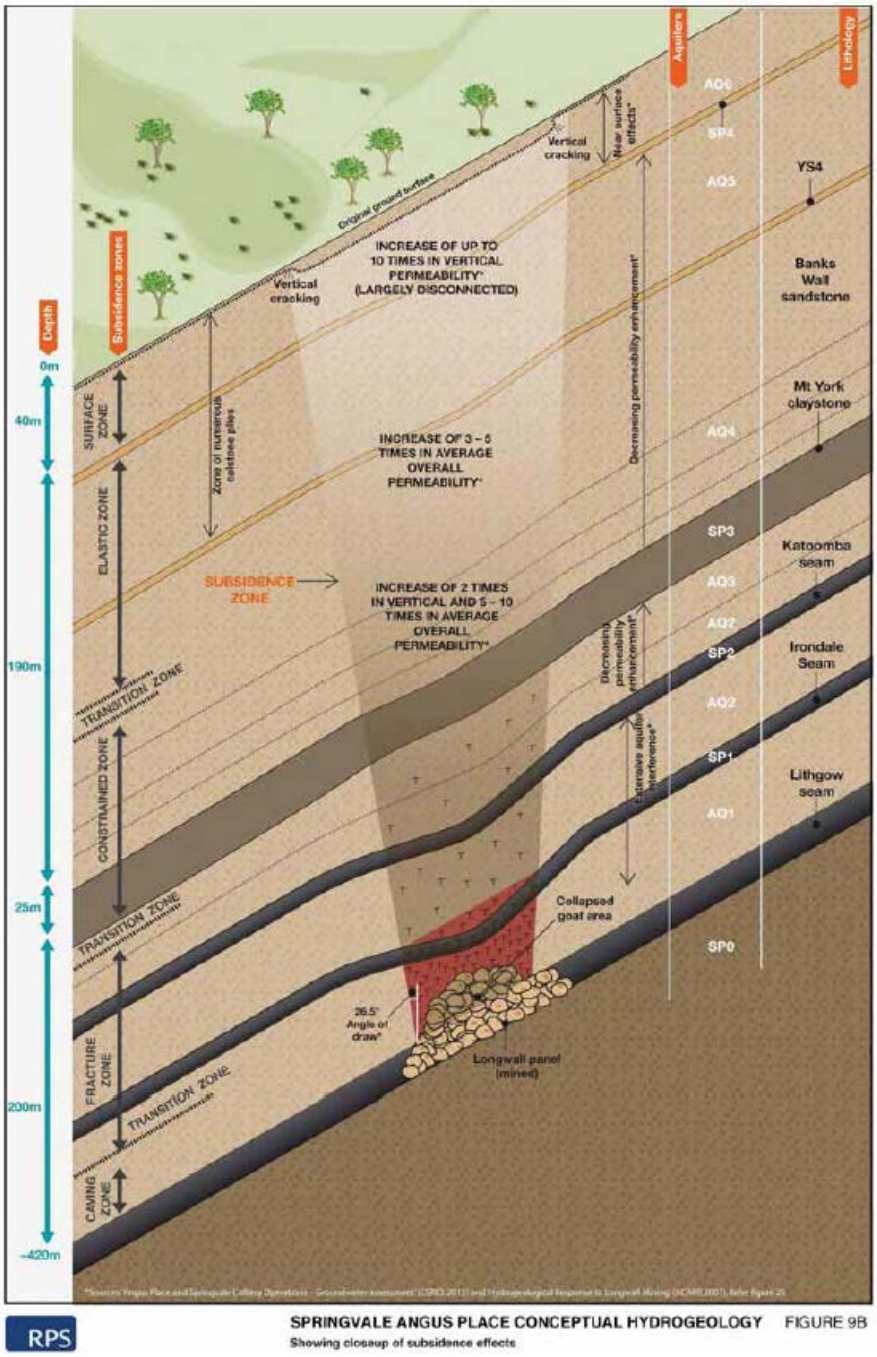


Figure 2-1 Geology of Angus Place Colliery and Springvale Mine (mining Lithgow Seam) (RPS, 2013)

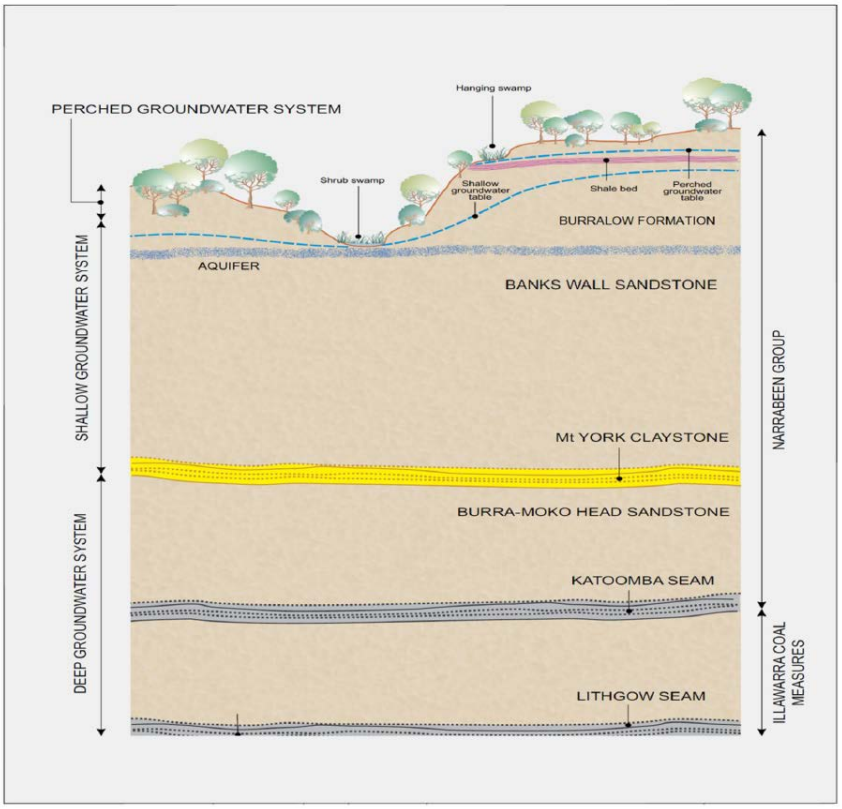


Figure 2-2 Clarence Geology (mining Katoomba Seam) (Aurecon, 2013)

2.2.2 Neubeck and Western Coal Services

The Neubeck and Western Coal Services site are located to the west of Angus Place Colliery, Clarence Colliery and Springvale Mine. The Permian Illawarra Coal Measures outcrop in the vicinity of the Neubeck and Western Coal Services site. The formations present are outlined in Table 2-1. The overlying sandstone unit at the Neubeck is considered to be similar to the Gap Sandstone identified at Springvale Mine while the mudstone units that separate the sandstone from the Irondale Seam are considered to be similar to the Denman Formation identified at Springvale Mine (GHD, 2011). The Lidsdale and Lithgow coal seams at the Neubeck site dip to the east and north east at a slope of approximately 1 degree.

To the south of Western Coal Services, the underlying Berry Siltstone of the Shoalhaven Group outcrops. To the north of Western Coal Services, the Illawarra Coal Measures are overlain by Narrabeen Sandstone. The Illawarra Coal Measures dip to the northeast at approximately 1.5 degrees. There are very limited alluvial sediments at Western Coal Services and Wangcol Creek as watercourses in these areas predominantly flow over bedrock. Table 2-1 provides an overview of the geological units at the Neubeck and Western Coal Services sites.

Table 2-1 Neubeck and Western Coal Services Geology (mining Lithgow, Lidsdale and Irondale Seams) (RPS, 2013)

Formation	Lithological unit
Katoomba Seam	Coal
Middle River Seam	Coal
Glen Davies Formation (Upper Irondale Seam)	Coal, shale, sandstone
Irondale Seam	Coal

Formation	Lithological unit
Long Swamp Formation	Shale and sandstone
Lidsdale Seam	Coal
Blackmans Flat	Conglomerate
Lithgow Seam	Coal
Marrangaroo Formation	Sandstone, conglomerate

2.2.1 Lidsdale Siding

Lidsdale Siding is underlain by a layer of colluvium/alluvium that is 2 m to 6 m thick (RPS, 2012). The alluvium is underlain by shale that is weathered in the top section (approximately 7 m) and fresh below this depth. The Shoalhaven Group outcrops to the south and west of Lidsdale Siding while the Permian Illawarra Coal Measures outcrop to the north and the east (RPS, 2012).

2.2.2 Airly Mine

The topology of Airly Mine is dominated by Mount Airly and Genowlan Mountain. The Grose sandstone of the Triassic Narrabeen Group outcrops throughout the plateau and cliffs of Mount Airly and Genowlan Mountain with small areas of Tertiary basalt outcrop at the higher elevations. The Triassic strata are up to 200 m thick.

The Permian Illawarra Coal Measures outcrop around the Triassic formations at lower elevations, including the zone between Mount Airly and Genowlan Mountain. The Lithgow Seam, within the lower Illawarra Coal Measures is the target coal seam at Airly Mine. The seam outcrops completely within the Project Application Area for the Airly Mine Extension Project and is therefore disconnected to the areas of occurrence of this seam located several kilometres to the south and northwest, as shown in Figure 2-3.

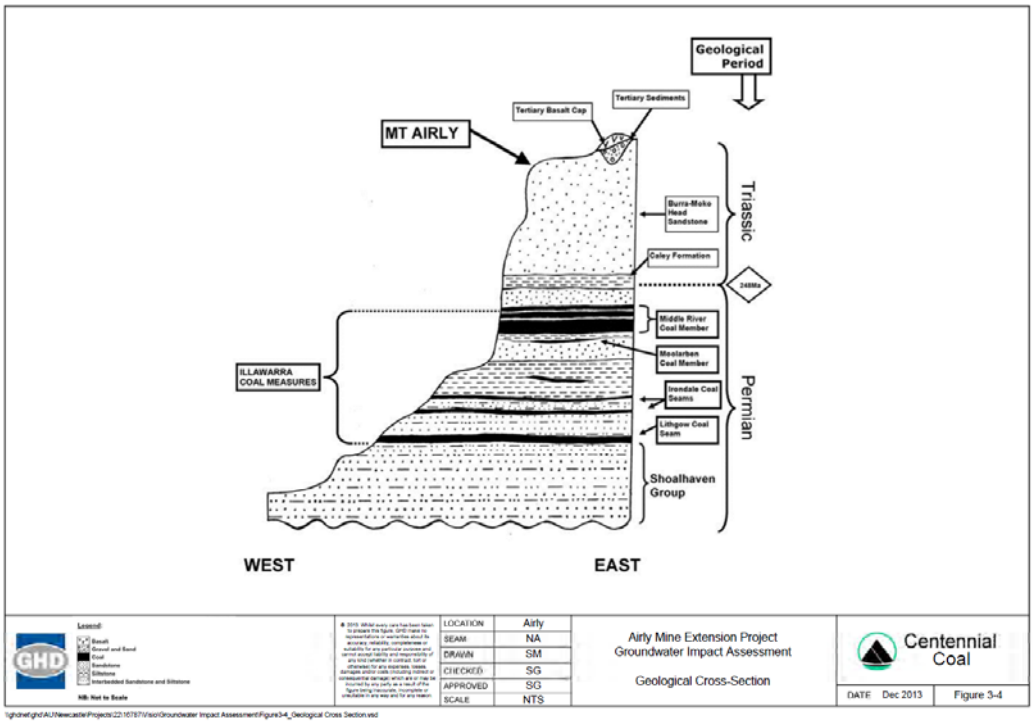


Figure 2-3 Geology of Airly Mine (GHD, 2013)

2.3 Hydrogeology

The geological conditions present in the Western Coalfield area create a range of aquifer systems associated with higher permeability sandstones and coal seams. These appear to be separated by lower permeability aquitards associated with mudstones, claystones and shale layers.

CSIRO (2013) identified a number of aquifers and semi permeable strata in the Western Coalfield based on the available geological information and piezometric levels. These aquifers and semi-permeable units are not present at all sites due to the variations in topology and the outcropping of various strata. In addition to this, the thickness of various strata varies between sites and therefore the hydrogeological connection between aquifers may vary from site to site. The aquifers and semi permeable strata identified by CSIRO (2013) and Centennial (2014), from deepest to shallowest, include:

- Weathered section – 10 m thick layer of weathered surficial material.
- Aquifer 1 (AQ1) – Includes the Lidsdale/Lithgow Coal Seam which is hydraulically connected with the laminated siltstone (Berry Siltstone) and sandstone of the Marrangaroo Formation underneath and the sandstone and siltstone of the Long Swamp Formation and Irondale Coal Seam above.
- Semi-permeable layer 1 –This unit is comprised of mudstone, siltstone and claystone (Baal Bone/Denman Formation).
- Aquifer 2 (AQ2) – Sandstone with laminated siltstone and Middle River Coal member.
- Semi-permeable layer 2 – Coal, siltstone and mudstone located just below the Katoomba Seam and occurs between AQ2 and AQ3.
- Aquifer 3 (AQ3) – Sandstone of the Burra Moko Head Formation and the Caley Formation located below the Mount York Claystone. It is hydraulically connected with the Katoomba Seam.

- Semi-permeable layer 3 – This is a semi-permeable siltstone/claystone (Mouth York Claystone) layer that separates aquifers AQ3 and AQ4.
- Aquifer 4 (AQ4) – This aquifer is located in the Banks Wall Sandstone. The Banks Wall Sandstone is interpreted to have two or three isolated aquifer systems that are hydraulically connected by lower permeability siltstones and claystones (CSIRO, 2010).
- Aquifer 5 (AQ5) – This aquifer is located in the Burralow Formation. This aquifer is separated from the underlying AQ4 by a thin semi-permeable claystone layer.
- Semi-permeable layer 4 – Thin semi-permeable layer located in the Burralow Formation and comprises claystone and sandstone/siltstone.
- Aquifer 6 (AQ6) – This aquifer is located in the upper part of the Narrabeen Group sandstone. It only appears at the top of the Newnes Plateau.

The properties of each of the groundwater systems are summarised in Table 2-2.

Table 2-2 Aquifer properties

Aquifer	Description
Quaternary Alluvium Aquifers	Saturated zones are laterally discontinuous and occur in isolated pockets. Perched groundwater present in unconsolidated sands, silts and peat. Generally isolated and of minimal thickness.
Triassic Overburden Sediment Aquifers	Water-bearing zones within the Narrabeen Group. Complex with perched water tables and semi-confined, separated by relatively impermeable claystone layers. Porosity: • Primary: Low flow inter-granular (<8–10 m/s). • Secondary: Higher flow, fractures, bedding partings and Fissures.
Permian Coal Measure Aquifers	Overburden/interburden sandstones, siltstones and mudstones (primarily coal seams). Porosity: • Primary: Limited primary porosity (tightly consolidated geological layers). • Secondary: greater due to jointing and localised faulting. Weathered profile. Largely unsaturated.

Aquifer	Description
Permian Marrangaroo Formation Aquifer	Thickness from 2 m to 6 m. Dominantly quartzose in composition grading from granular sandstone to pebble conglomerate. Likely hydraulic conductivity expected to range from 0.05 m/day to 0.5 m/day. Recharge through direct rainfall infiltration and local runoff into outcrop in low-lying areas. Flow north-east and discharges at outcrop areas.

2.3.1 Angus Place Colliery, Clarence Colliery and Springvale Mine

The hydrogeological environment at Angus Place Colliery, Clarence Colliery and Springvale Mine has been investigated by CSIRO (2013) and summarised by RPS (2013) in Figure 2-4. The Mount York Claystone has been identified as a major aquiclude separating the shallow (perched) and deeper (regional) groundwater systems.

Perched groundwater system

The perched groundwater systems comprise discontinuous, surficial systems which are hydraulically independent of the underlying regional groundwater system. The perched groundwater is generally located within the upper 100 m where the Burralow Formation is present. It is derived from excess rainfall which is largely prevented from infiltrating deeper down into the regional systems due to the presence of fine grained or less permeable claystone and siltstone horizons. The perched groundwater system is important for the establishment and survival of Newnes Plateau hanging swamps.

The Burralow Formation outcrops in the vicinity of Angus Place Colliery and Springvale Mine and is not as prevalent at Clarence Colliery.

Newnes Plateau swamps occur within the gus Place Colliery, Clarence Colliery and Springvale Mine lease areas. The Newnes Plateau swamps are Temperate Highland Peat Swamps on Sandstone (THPSS) and are listed as an endangered ecological community under the EPBC Act.

THPSS have been mapped as being shrub swamps or hanging swamps. Shrub swamps form at the base of valleys underlined by Narrabeen Group strata that are subject to temporary to permanent waterlogging from groundwater, surface runoff and rainfall. Hanging swamps form on the sides of valleys where perched groundwater discharges. Hanging swamps are subject to infrequent waterlogging from perched groundwater, surface runoff and rainfall.

Shallow groundwater system

The shallow groundwater system is located within the Banks Wall Sandstone.

Bish (1999) identified that the general flow direction in the shallow groundwater system is towards the northeast, in the general formation dip direction. Recharge potentially occurs in areas of outcrop/sub-crop to the west and southwest of the area. Discharge is inferred to occur to the north-east, where the units outcrop in the scarp of the plateau. The shallow groundwater system is underlain by the Mount York Claystone. This horizon comprises a low permeability layer that restricts infiltration downwards from the shallow groundwater system to the underlying deep groundwater system.

Deep groundwater system

The regional groundwater source includes the Burra-Moko Head Sandstone, the Caley Formation of the Triassic Narrabeen Group and the Permian Illawarra Coal Measures. The deep groundwater system is recharged in areas of outcrop to the west of Springvale Mine and via minimal inter-aquifer flow from overlying aquifers. Groundwater flow within the deep groundwater sources is expected to follow the dip of the strata towards the north east.

Each of these groundwater sources are separated by various layers of lower permeability siltstone and claystones which inhibit the hydraulic connectivity of these sources.

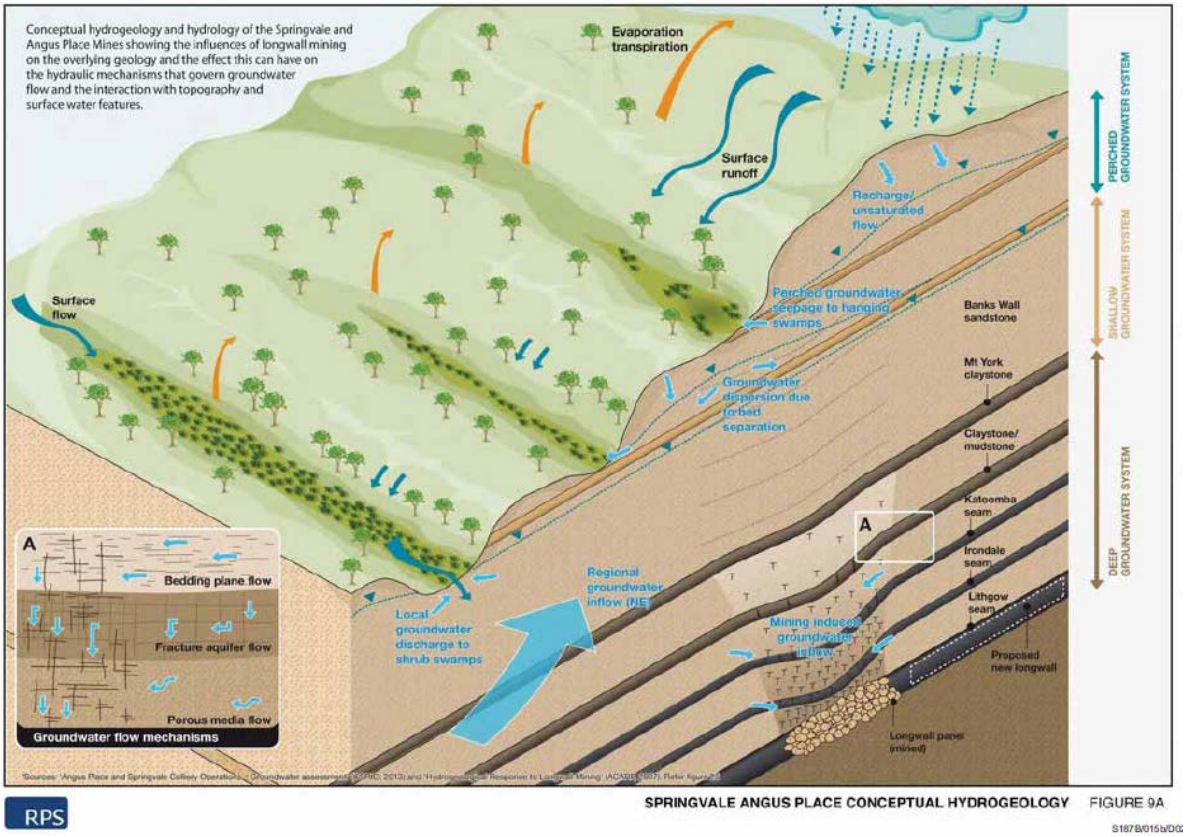


Figure 2-4 Angus Place Colliery and Springvale Mine Conceptual Groundwater Model (RPS, 2013)

2.3.2 Neubeck and Western Coal Services

Neubeck

The aquifers at Neubeck include the shallow alluvium, the overburden sandstone, Lidsdale Seam and Lithgow Seam.

Alluvium groundwater

Groundwater has been characterised within narrow zones of alluvium associated with Neubeck Creek. The alluvium is expected to be limited in extent and is not expected to represent a significant aquifer system as reported in the *Groundwater Impact Assessment* (GHD, 2014).

Overburden (sandstone) groundwater

There are two groundwater bores located in the sandstone overburden geology, including NGW07_s (NB4R) and NGW08_s (NB2R).

GHD (2014a) reported that the groundwater levels do not respond significantly to rainfall events, which is expected given the depth to groundwater, but could also suggest the presence of low vertical hydraulic conductivities through the shallow profile. The groundwater elevations were found to be similar to the elevations present in the alluvium suggesting that there may be some hydraulic connection between these units. The groundwater elevations are also above surface water elevations at the lower end of Neubecks Creek, suggesting that the groundwater may be discharging to the creek (GHD, 2014a).

Lidsdale Seam groundwater

There are two groundwater bores in the Lidsdale Seam, including NGW09_li (NBDW2R) and NGW06_li (NB3R). GHD (2014) found that the groundwater elevations do not respond significantly to individual rainfall events, which is expected given the depth to groundwater, however it may also suggest the presence of low vertical hydraulic conductivities through the shallow profile.

GHD (2014) also reported that the groundwater elevations are lower than in the alluvium and overlying sandstone aquifer systems by between 12 m and 20 m. This suggested that there is a strong downward vertical head gradient and that the vertical hydraulic connection is significantly reduced by the presence of low permeability units. The data also suggest a low potential for hydraulic connection with the alluvium aquifers (and surface water features at the site) and with the overlying sandstone aquifer system.

Lithgow Seam groundwater

There are six groundwater bores (five of which were surveyed) located in the Lithgow Seam, which intersect the historical Wallerawang and Huon underground mine workings. There are two groundwater bores at the northern part of the site located within the historical Wallerawang No. 3 Workings, NGW01_w (NBDW1) and NGW02_w (NBDW1-2). Three groundwater bores, NGW03_m (NBDB3-1), NGW04_m (NBDB3-2) and NGW05_m (NBDB3-3) are located in the Huon Workings.

The groundwater elevations remain stable within the Huon Workings, but have been found to be higher than in Neubecks Creek. Intuitively, this indicates the potential for groundwater associated with the Huon Workings to contribute to surface water flows in Neubecks Creek. However, it was recognised that this may not necessarily be the case as the wells surveyed are screened across multiple layers and therefore the groundwater elevations measured may represent elevations within shallower units (GHD, 2014a). In addition, fluorescence studies (GHD 2014a) investigating the level of connectivity between groundwater associated with the Huon Workings and Neubecks Creek and Wangcol Creek found little evidence to suggest connectivity between this groundwater source and surface water in these systems.

Other aquifer units

Other aquifer units are expected to exist in the vicinity of Neubeck (GHD, 2014), which include:

- The shallow sandstone aquifers which are predominant across the Neubeck area and are anticipated to be associated with the Gap and Ivanhoe Sandstone units. These aquifers are expected to be weathered in their near surface profile resulting in relatively high permeability with potential for a significant hydraulic connection with surface water features including Neubecks Creek and Wangcol Creek.
- The mudstone and siltstone units that are present between coals seams and sandstones throughout the profile that are suspected to significantly retard vertical flow between aquifer units.
- The Irondale Seam which is likely to form a higher permeability aquifer system, which outcrops in low lying areas at the site and may discharge to surfaces water features.

Due to the distance between Neubeck and Angus Place Colliery, Clarence Colliery and Springvale Mine and because the aquifers at Neubeck are assumed to discharge to Neubecks Creek; it is assumed that the groundwater system at Neubeck is unlikely to be connected to the groundwater systems at Angus Place Colliery, Clarence Colliery and Springvale Mine.

Western Coal Services

At Western Coal Services, the major groundwater sources are the coal seams and, to a lesser extent, the underlying strata, as shown in Figure 2-5. The Lithgow Seam has been mined by historical workings and the Lithgow Seam may be hydraulically connected to backfilled areas and surface water storages at Western Coal Services.

The Marrangaroo Formation subcrops over the Western Coal Services site. The quartz sandstone of the Marrangaroo Formation can be porous and water bearing (RPS, 2013). The Berry Siltstone of the Shoalhaven Group that outcrops to the south of the site. The Berry Siltstone is relatively fresh to highly weathered. The weathered Berry Siltstone forms a potential aquifer.

The Illawarra Coal Measures outcrop across Western Coal Services and Neubeck and hence these operations are located in a potential recharge area for the Illawarra Coal Measures.

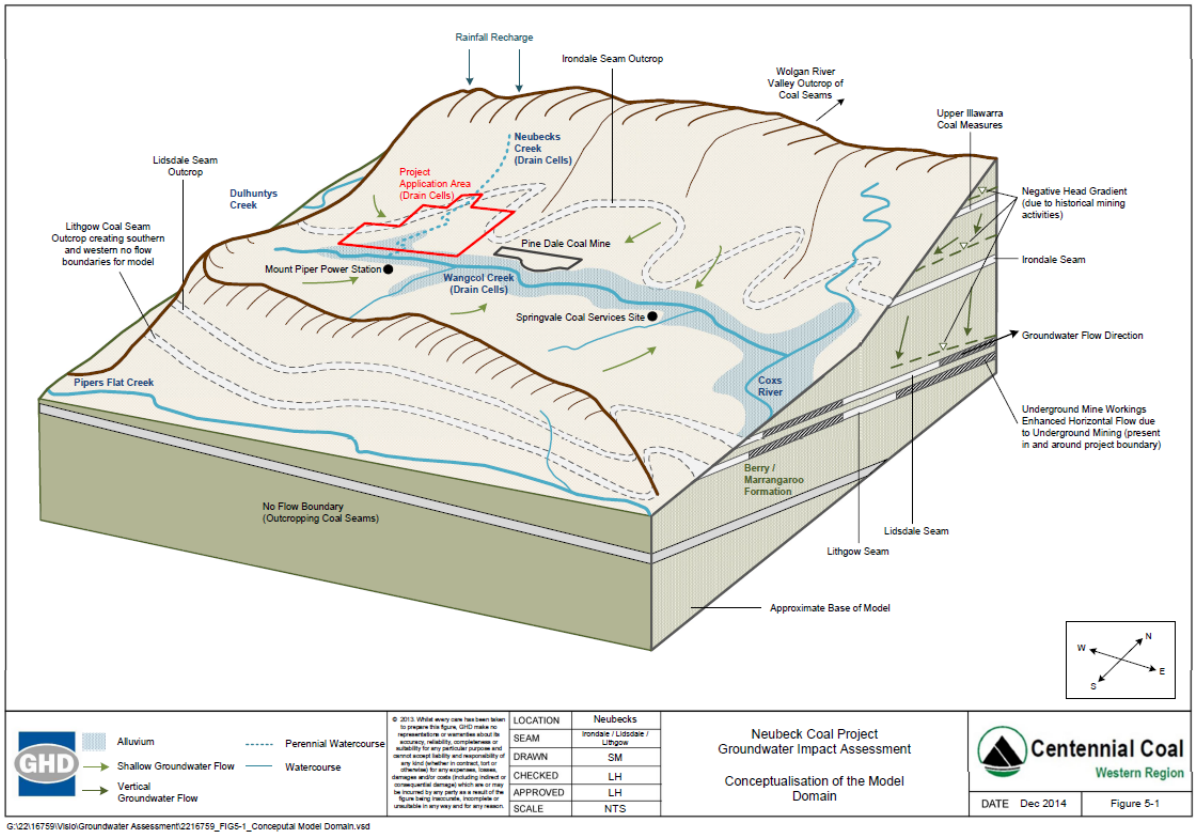
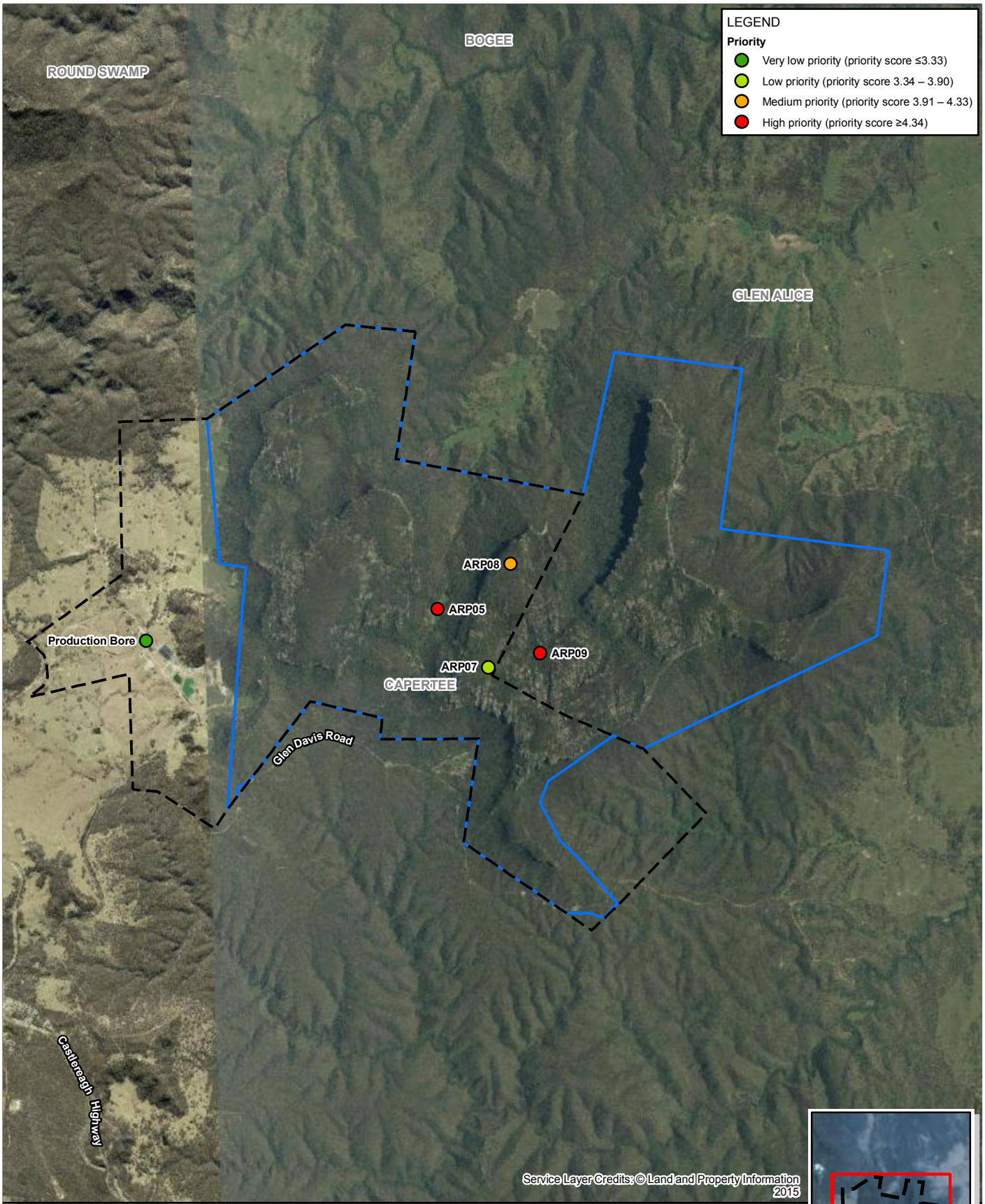


Figure 2-5 Neubeck, Western Coal Services, Western Coxs River Conceptual Groundwater Model (GHD, 2014b)

2.3.3 Airly Mine

As discussed in Section 2.2.1, the Narrabeen Sandstone and Permian Illawarra Coal Measures outcrop in the vicinity of Mount Airly and Genowlan Mountain and form a closed hydrogeological system that is separate from the occurrences of these seams located several kilometres to the south and northwest.



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Kilometres

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Horizontal Datum: Geodetic Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

LEGEND

ML1331 Boundary

A232 Boundary

LOCATION	-
SEAM	NA
DRAWN	T.Morton
CHECKED	L.H
APPROVED	S.G
SCALE	Refer to scalebar

Centennial Western Region Stygofauna Monitoring and Assessment Plan

Airly

Prioritised Monitoring Bores

Centennial Coal

DATE 23/08/2016

Figure 3-1

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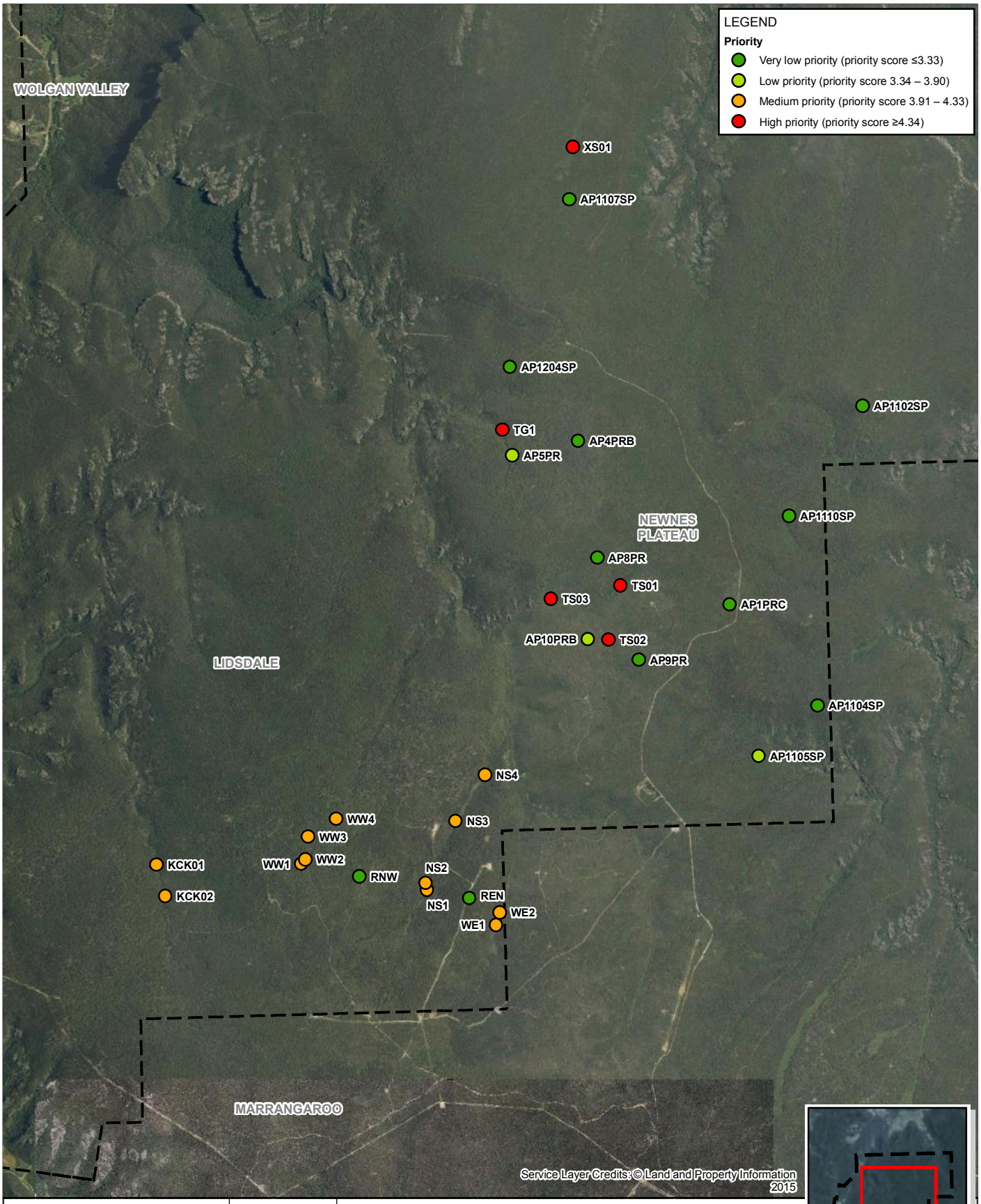

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Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geodetic Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

LEGEND

Colliery Holding Boundary

LOCATION	-
SEAM	NA
DRAWN	T.Morton
CHECKED	L.H
APPROVED	S.G
SCALE	Refer to scalebar

Centennial Western Region Stygofauna Monitoring and Assessment Plan

Angus Place - Part a Prioritised Monitoring Bores

Centennial Coal

DATE 23/08/2016

Figure 3-2a

GIS Filename: G:\22\0105001\GIS\Maps\Deliverables\Western\Regional\2218134\StygofaunaMonitoringandAssessmentPlan\2218134_SMA002_GWMonitoring_DDP_0.mxd

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0 0.09 0.18 0.27 0.36

Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geodetic Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

LEGEND

Colliery Holding Boundary

LOCATION	-
SEAM	NA
DRAWN	T.Morton
CHECKED	L.H
APPROVED	S.G
SCALE	Refer to scalebar

Centennial Western Region Stygofauna Monitoring and Assessment Plan

Angus Place - Part b

Prioritised Monitoring Bores

Centennial Coal

DATE 23/08/2016

Figure 3-2b

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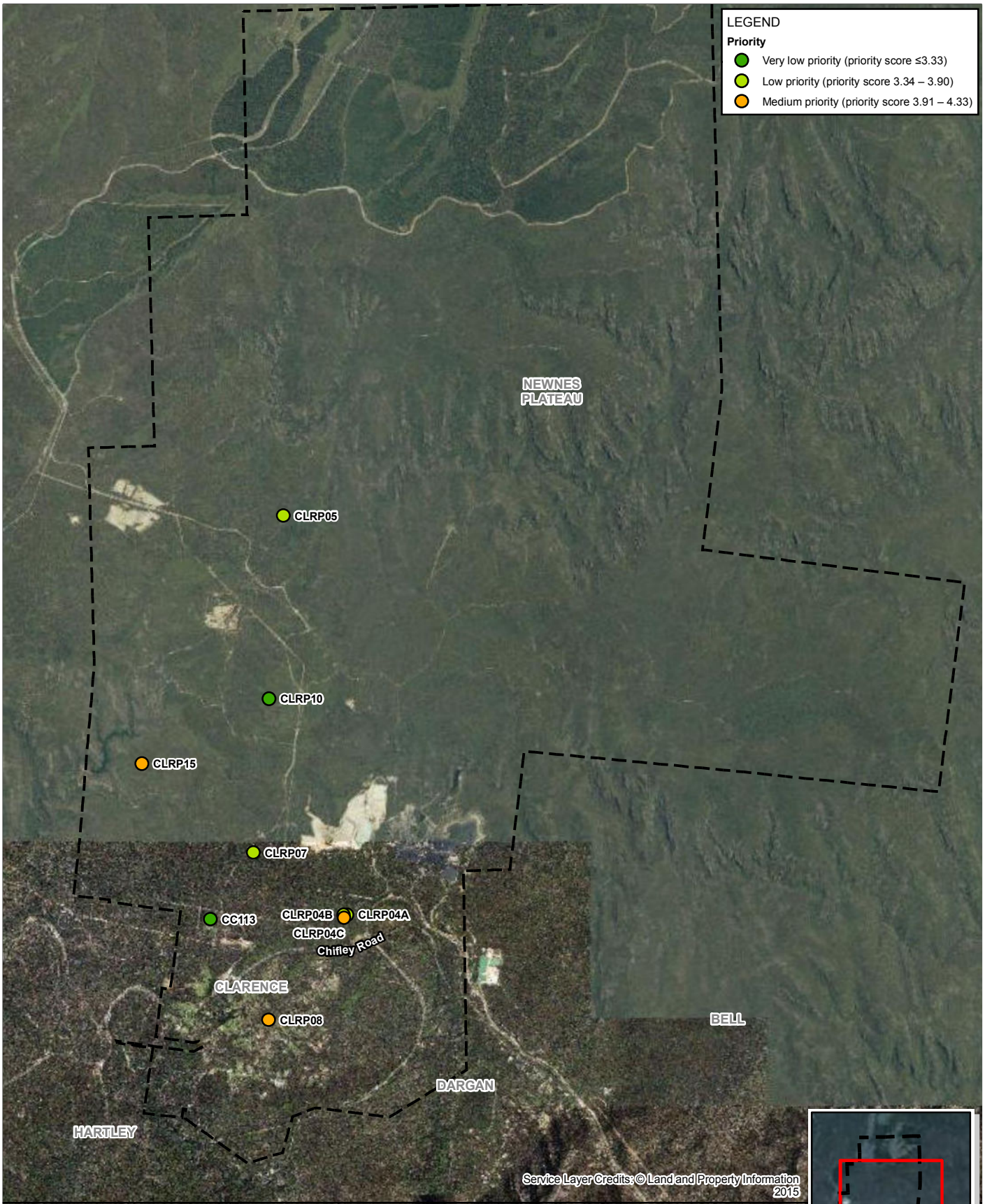

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Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geodetic Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

LEGEND

Colliery Holding Boundary

LOCATION	-
SEAM	NA
DRAWN	T.Morton
CHECKED	L.H
APPROVED	S.G
SCALE	Refer to scalebar

Centennial Western Region Stygofauna Monitoring and Assessment Plan

Clarence

Prioritised Monitoring Bores

Centennial Coal

DATE 23/08/2016

Figure 3-3

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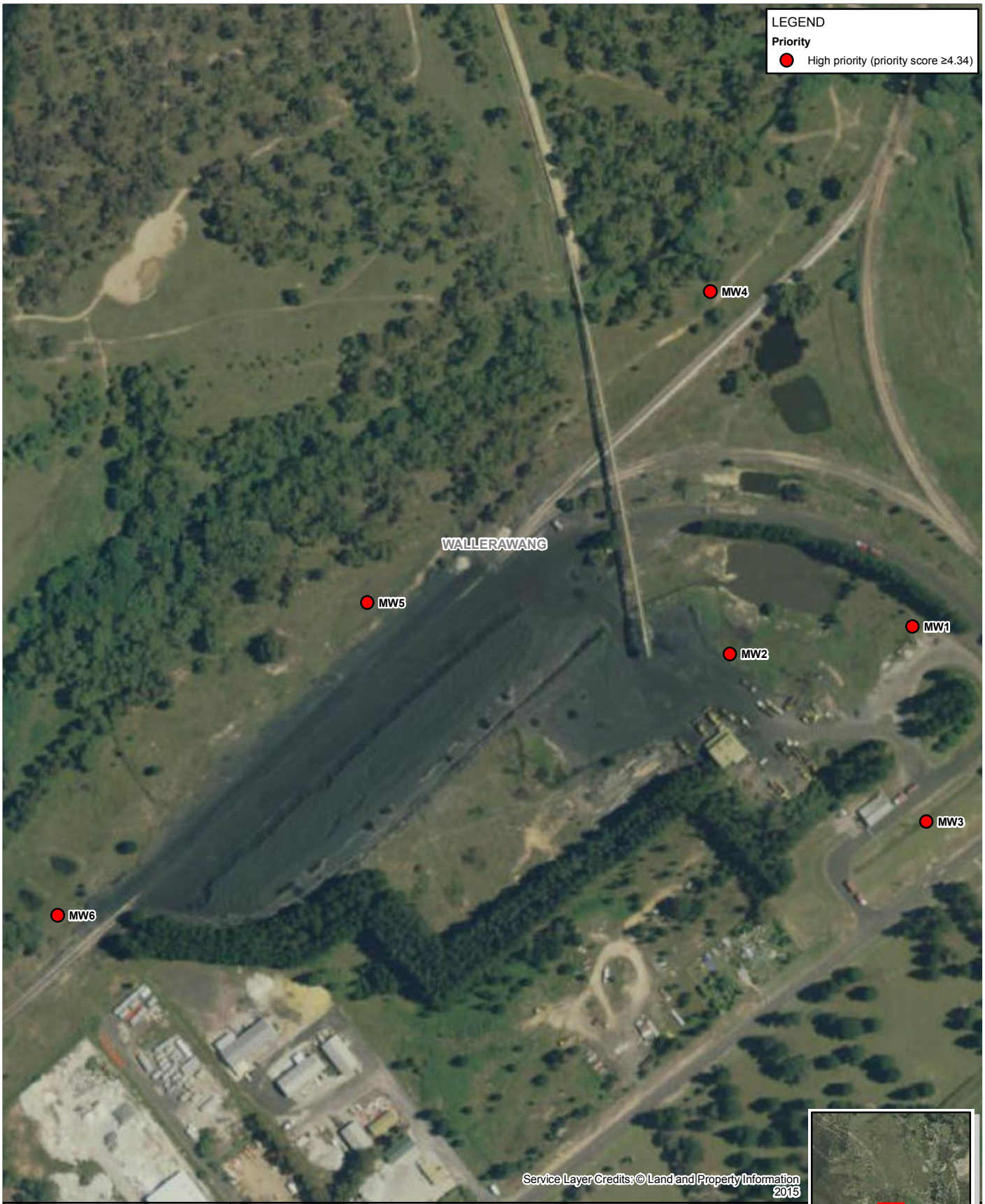

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Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geodetic Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

LEGEND

LOCATION	-
SEAM	NA
DRAWN	T.Morton
CHECKED	L.H
APPROVED	S.G
SCALE	Refer to scalebar

Centennial Western Region Stygofauna Monitoring and Assessment Plan

Lidsdale Siding

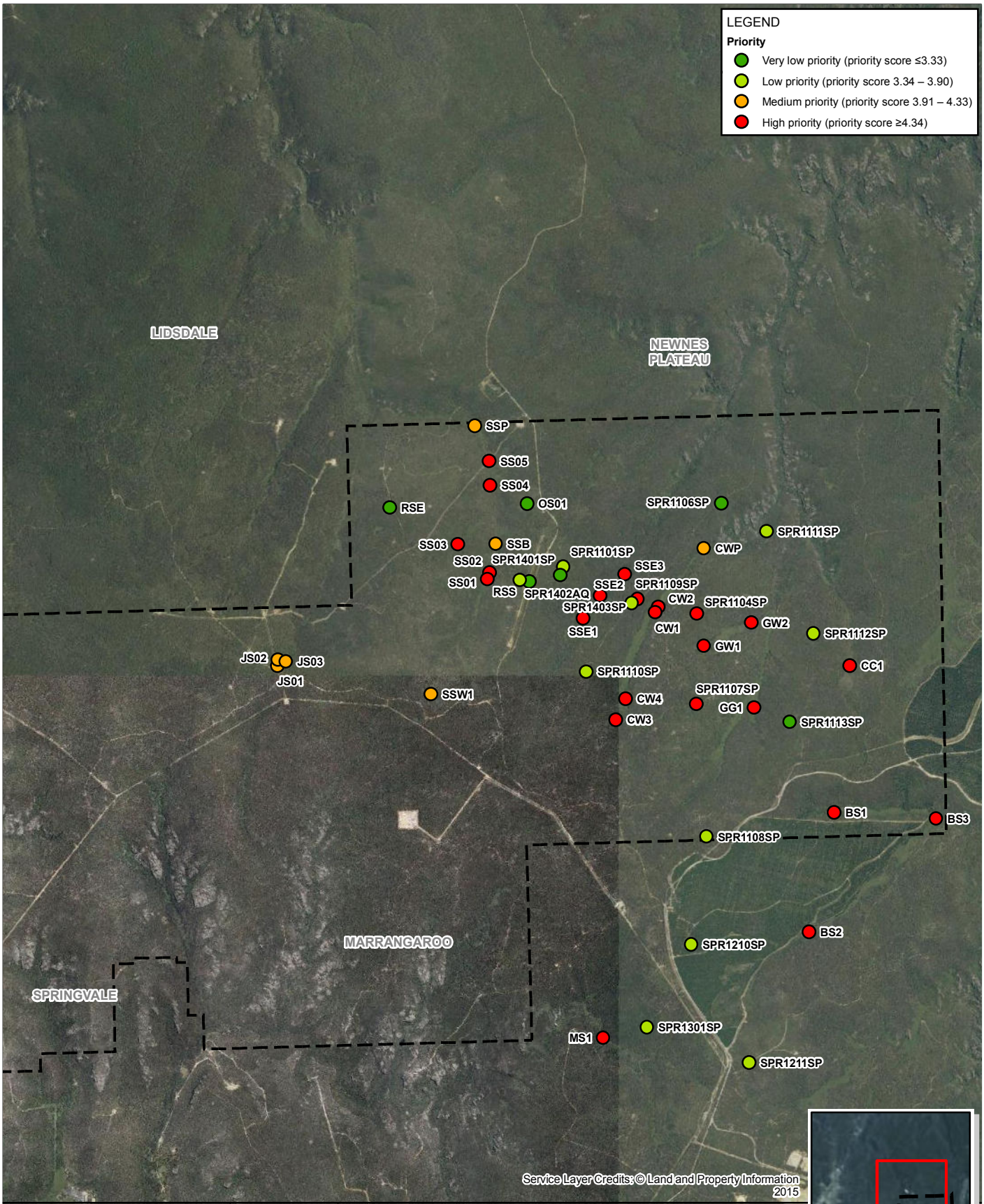
Prioritised Monitoring Bores

Centennial Coal

DATE 23/08/2016

Figure 3-4

GIS Filename: G:\22\0105001\GIS\Maps\Deliverables\Western\Regional\2218134\StygofaunaMonitoringandAssessmentPlan\2218134_SMA002_GWMonitoring_DDP_0.mxd



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Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geodetic Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

LEGEND

Colliery Holding Boundary

LOCATION	-
SEAM	NA
DRAWN	T.Morton
CHECKED	L.H
APPROVED	S.G
SCALE	Refer to scalebar

Centennial Western Region Stygofauna Monitoring and Assessment Plan

Springvale

Prioritised Monitoring Bores

Centennial Coal

DATE 23/08/2016

Figure 3-5

GIS Filename: G:\22\0105001\GIS\Maps\Deliverables\Western\Regional\2218134\StygofaunaMonitoringandAssessmentPlan\2218134_SMA002_GWMonitoring_DDP_0.mxd

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Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geodetic Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

LEGEND

Colliery Holding Boundary

LOCATION	-
SEAM	NA
DRAWN	T.Morton
CHECKED	L.H
APPROVED	S.G
SCALE	Refer to scalebar

Centennial Western Region Stygofauna Monitoring and Assessment Plan

Western Coal Services

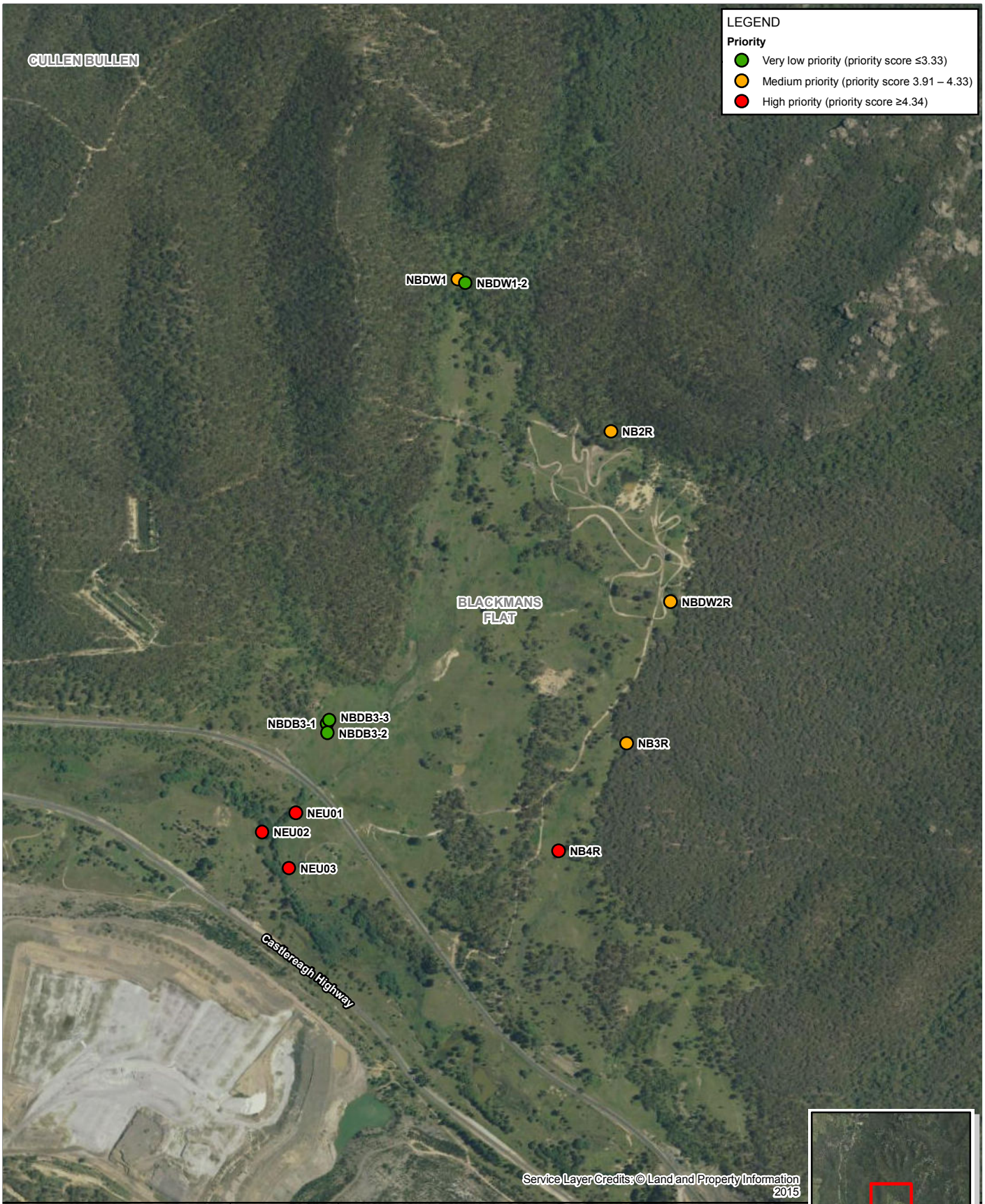
Prioritised Monitoring Bores

Centennial Coal

DATE 23/08/2016

Figure 3-6

GIS Filename: G:\22\0105001\GIS\Maps\Deliverables\Western\Regional\2218134\StygofaunaMonitoringandAssessmentPlan\2218134_SMA002_GWMonitoring_DDP_0.mxd



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Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geodetic Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

LEGEND

LOCATION	-
SEAM	NA
DRAWN	T.Morton
CHECKED	L.H
APPROVED	S.G
SCALE	Refer to scalebar

Centennial Western Region Stygofauna Monitoring and Assessment Plan

Neubeck - Part a

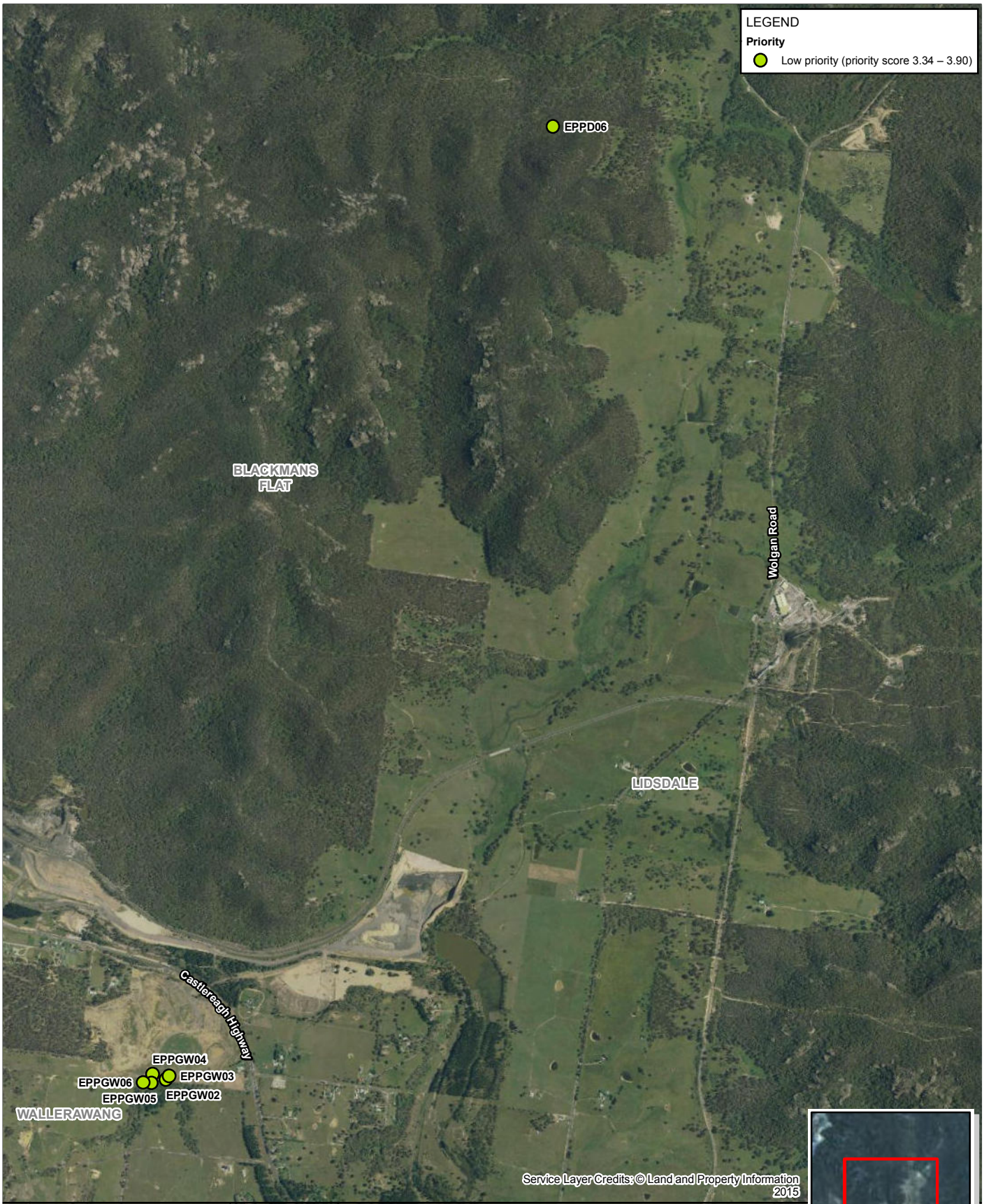
Prioritised Monitoring Bores

Centennial Coal

DATE 23/08/2016

Figure 3-7a

GIS Filename: G:\22\0105001\GIS\Maps\Deliverables\Western\Regional\2218134\StygofaunaMonitoringandAssessmentPlan\2218134_SMA002_GWMonitoring_DDP_0.mxd



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Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geodetic Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

LEGEND

LOCATION	-
SEAM	NA
DRAWN	T.Morton
CHECKED	L.H
APPROVED	S.G
SCALE	Refer to scalebar

Centennial Western Region Stygofauna Monitoring and Assessment Plan

Neubeck - Part b

Prioritised Monitoring Bores

Centennial Coal

DATE 23/08/2016

Figure 3-7b

GIS Filename: G:\22\0105001\GIS\Maps\Deliverables\Western\Regional\2218134\StygofaunaMonitoringandAssessmentPlan\2218134_SMA002_GWMonitoring_DDP_0.mxd

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Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geodetic Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

LEGEND

LOCATION	-
SEAM	NA
DRAWN	T.Morton
CHECKED	L.H
APPROVED	S.G
SCALE	Refer to scalebar

Centennial Western Region Stygofauna Monitoring and Assessment Plan

Inglenook

Prioritised Monitoring Bores

Centennial Coal

DATE 23/08/2016

Figure 3-8

GIS Filename: G:\22\0105001\GIS\Maps\Deliverables\Western\Regional\2218134\StygofaunaMonitoringandAssessmentPlan\2218134_SMA002_GWMonitoring_DDP_0.mxd

Local groundwater sources

At Airly Mine the local groundwater sources are low yielding and predominantly within the Quaternary alluvium, weathered and/or fractured sandstone and coal seams that occur within Mount Airly and Genowlan Mountain.

The alluvium at Airly Mine forms an unconfined shallow aquifer with groundwater ranging in depth from less than 1 m to over 5 m below ground level (bgl), and aquifer thickness generally less than 12 m.

The alluvium associated with Gap Creek and Genowlan Creek is generally a silty sand material and recharged from rainfall as well as inter-aquifer flow from adjacent (primarily Permian) strata. Alluvial groundwater discharges to connected streams.

The local porous and fractured rock groundwater sources include the Narrabeen Sandstone and coal seams of the Illawarra Coal Measures. These sources are recharged by rainfall via fractures within overlaying strata, and seep out of the side of the mountains or directly into watercourses. With the majority of discharge from these sources being to seepage areas, there is minimal inter-aquifer flow to underlying regional groundwater sources.

Regional groundwater sources

Regional groundwater sources occur within strata well below the coal measures and extend beyond the Airly Mine lease area.

The upper groundwater source occurs within siltstone and sandstone of the Shoalhaven Group. According to the Western Coalfield (Southern Part) Regional Geology 1:100,000 map, this rock formation was deposited in a marine environment and therefore the groundwater is highly brackish to saline. The existing production bore at the Airly Mine surface facilities area is installed within this groundwater source. The recharge area is predominantly to the west of Airly Mine where the Shoalhaven Group outcrops

The lower regional groundwater source occurs within Devonian metamorphic strata containing shale, sandstone and limestone. The groundwater is slightly brackish and therefore has a lower salt content than the Shoalhaven Group and it is less sulfate dominant. Recharge areas occur to the north, south and east of Airly Mine and groundwater flow is generally to the east.

It is considered that there would be minimal inter-aquifer hydraulic connection between the upper and lower regional groundwater sources, based on differences in groundwater chemistry discussed in GHD (2014c).

2.3.4 Lidsdale Siding

The production bore at Lidsdale Siding screens both the alluvium and the fractured rock aquifers. All monitoring bores at Lidsdale Siding screen the alluvial aquifer. In addition to the alluvial aquifer, the underlying weathered bedrock of the Shoalhaven Group also forms a shallow aquifer in the vicinity of Lidsdale Siding.

2.4 Centennial groundwater monitoring network

GHD have data for 151 bores (standpipes only) across the Centennial western region. Centennial have developed a database of groundwater monitoring resources which captures information about bores across the Centennial sites. This information includes any information recorded during drilling such as bore depth, bore diameter and the aquifer or genealogical seam intersected (where known). Bores considered for monitoring were purposed predominately for exploration however a number of bores are water extraction locations.

A summary of the number of bores recorded with and without Centennial aquifer references is shown in Table 2-3 and provided in Appendix B. A Centennial aquifer reference was not recorded for the five bores at Airly Mine. Angus Place Colliery bores are distributed across most aquifers (AQ1, AQ2, AQ4, AQ5 and AQ6). Springvale Mine bores are predominantly in the mid to shallower range of aquifers (AQ4, AQ5 and AQ6) with a lack of bores from AQ2 and AQ3. At Clarence Colliery, the bores are within the mid to deep Centennial aquifer reference range (AQ3 and AQ4). Neubeck, Western Coal Services and Inglenook bores are located mostly within the deeper aquifers (AQ1 and AQ2).

Table 2-3 Number of western region bores located in the Centennial Aquifer Reference

Site	Number of bores located in the Centennial Aquifer Reference:						Number of bores without Centennial aquifer reference	Total number of bores
	AQ1	AQ2	AQ3	AQ4	AQ5	AQ6		
Angus Place Colliery	8	1		3	9	8	17	46
Springvale Mine				3	11	3	29	46
Clarence Colliery			3	6				9
Western Coal Services	11	3					1	15
Neubeck	14	1					3	18
Airly Mine							5	5
Inglenook	1	2					3	6
Lidsdale Siding							6	6

Note: Centennial aquifer references ranges from deeper aquifer at AQ1 through to shallower aquifer at AQ6.

2.5 Historical stygofauna monitoring

Stygofauna monitoring undertaken since 2012 has been summarised for each of the western region sites. These summaries are aimed at providing regional context to stygofauna previously collected across Centennial's western region.

2.5.1 Neubeck (GHD, 2014a)

Subterranean aquatic ecosystems were assessed through the development of a pilot testing program which included the sampling of 12 groundwater bores across the Project Application Area interfacing with specific geological layers including coal seams, sandstone layers and alluvium. Additional stygofauna surveys were conducted in 2014.

Stygofauna within the Neubeck Project Application Area were represented by several obligate groundwater dependent taxa, albeit in low numbers. Based on the numbers of individuals collected during each survey, the abundance of stygofauna is either low or their distribution very patchy.

2.5.2 Springvale Mine (Cardno, 2014a; MPR, 2012)

Stygofauna sampling was conducted as part of the Springvale Mine Extension Project. Stygofauna were sampled by hand bailers from 11 sites in Sunnyside East, Gang Gang, Gang Gang West and Carne West Swamps. The swamp samples revealed 410 invertebrates, of which four likely and six possible stygofauna were identified. The likely stygofauna were cyclopoid copepods, harpacticoid copepods, copepod nauplii and the syncarid Bathynellidae, all of which are crustaceans. The possible stygofauna were Acarina (mites), Phreatoicidea (isopods), Nematoda (round worms), Oligochaeta (segmented worms), Rotifera (wheel animals) and Tardigrada (water bears).

In addition, samples were collected from four boreholes in the unconfined Banks Wall aquifer. These samples revealed 16 invertebrates, of which one cyclopoid copepod was identified as a likely stygofauna. One Acarina was identified as possible stygofauna.

2.5.3 Angus Place Colliery (Cardno, 2014b; MPR, 2012)

Stygofauna at were assessed at Angus Place Colliery as part of the Angus Place Extension Project stygofauna. In May 2012, MPR conducted a pilot survey of the invertebrates associated with boreholes targeting the groundwater system below individual swamps and the near-surface aquifer in the Banks Wall Sandstone. Sampling of eight bores was undertaken with hand bailers.

Samples collected from boreholes on Tri Star Swamp yielded two likely (Cyclopoid Copepoda and Ostracoda) and three possible stygofauna taxa (Acarina, Nematoda and Tardigrada). No animals were found in the Twin Gully Swamp samples. Samples from the unconfined aquifer yielded one likely (Bathynellid syncarid) and two possible stygofauna (Acarina and Nematoda). The other taxa recorded were either terrestrial or associated with saturated soils.

The samples collected from the ridge boreholes (AP4PR, AP5PR, AP9PR, and AP10PR) yielded a total of nine invertebrates, representing five taxa. Two likely (Bathynellidae and nematode) and one possible (Acarina) stygofauna were collected from this group of four bores.

2.5.4 Airly Mine (Cardno, 2014c)

Stygofauna samples were collected from three bores over three sampling events between May 2013 and December 2013 and an additional 3 bores sampled in June 2014 (Cardno, 2014c). Stygofauna were not recorded within the Airly Mine Project Application Area. Bores were sampled using bailers or pumping depending on the attributes of the bore. Sampling effort and the number of available bores was limited and, thus, the results of this monitoring program may not be representative of the current environment. The physical characteristics and the groundwater quality within the alluvial aquifer and the Narrabeen Group aquifer suggest the potential for stygofauna to be present.

2.5.5 Lidsdale Siding/Charbon Colliery/Clarence Colliery

No stygofauna monitoring has been undertaken to date at Lidsdale Siding, Charbon Colliery or Clarence Colliery.

3. Multi-Criteria Analysis Protocol

3.1 Bore information

All bores selected for evaluation by the Multi-Criteria Analysis Protocol have a bore diameter of greater than 50 mm and are vertically aligned (due to stygofauna sampling constraints). Bore use is observation for all bores except one production bore located at Airly Mine. The following bore characteristics were recorded for each site where available:

- Site ID.
- Bore ID.
- Coordinates.
- Mean electrical conductivity (EC) (µS/cm).
- Bore Depth (m).
- Monitored depth (m).
- Lithology.
- Centennial aquifer reference.
- pH.
- Bore use.
- Dissolved oxygen (DO) (mg/L).
- Bore diameter (m).
- Alignment.
- Lining.

3.2 Methodology

The Multi-Criteria Analysis Protocol draws on experience from previous stygofauna research to identify favourable locations for presence of stygofauna communities. GHD has previously employed this protocol for projects in NSW (Neubeck), Victoria and Queensland. The purpose of the Multi-Criteria Analysis Protocol is to identify bores that are most likely to contain stygofauna, based on a number of physical and chemical attributes. The parameters and favourable bore conditions have been defined by Hancock and Boulton (2008), the WA EPA (2007) and unpublished work conducted by GHD. The bore attributes and value ranges considered in the Multi-Criteria Analysis Protocol are summarised below in Table 3-1.

Table 3-1 Favourable bore attributes for stygofauna

Attribute	Favourable values
Lithology	Alluvial (sand and gravel)[1]
Bore depth	<50 m (max <200 m)[1]
Bore diameter	>50 mm (to permit sampling equipment)[1]
Bore construction	Preferably lined and slotted/screened through the water column[1]. Vertically aligned (not angled)1
Bore use	Observation/monitoring[1]
pH	6.5-8.5[1]
EC	<2,000 µS/cm (max <5,000 µS/cm)[1, 2]

Note: Preferences based on Hancock and Boulton (2008); WA EPA (2007) and unpublished data collected by GHD.

The Multi-Criteria Analysis Protocol ranks and weights each of these favourable bore attributes based on their importance. For example, lithology is thought to be more important for stygofauna occurrence than bore depth so was ranked higher and sand lithology is more favourable than clay lithology, so sand lithology is weighted higher.

The ranking and weighting process was completed using FME (Safe Software Inc.) and allowed a favourability score to be assigned to each bore attribute value. The product of these scores produced a final favourability score for each bore, where bores with the highest score had the most favourable conditions for stygofauna occurrence and were prioritised for sampling. Where groundwater bore data was deficient for a bore attribute the value for that attribute was treated as unfavourable. Bores were not included in the data set if there were a number of missing attributes. This was estimated at approximately 11% of the total number of bores assessed.

3.3 Outcomes

The scores calculated for the western region bores using the Multi-Criteria Analysis Protocol can be viewed in Appendix C. The five bores with the highest priority score are summarised in Table 3-2 along with the bore attributes. NEU01 and MW1 were identified as having the most favourable combination of bore attributes for the occurrence of stygofauna. Detection of stygofauna in this bore NEU01 and nearby supports the validity of GHD's prioritisation process.

However, some deficiencies were also evident. Some bores from which stygofauna have previously been collected, including NB4R and NBDW1 were given a relatively low rating. This is due to the greater depth of the bore and the fractured rock lithology when compared to the alluvium which has higher prospectus for stygofauna. Based on experience in NSW and Queensland, shallow alluvial aquifers are thought to be the most favourable for stygofauna occurrence and as such, these aquifers were targeted in the prioritisation process. Alluvium encompasses silt, sand and gravel, however only sand and gravel are thought to have interstitial spaces large enough to harbour stygofauna.

The accuracy of priority scores are also influenced by the amount of water quality data available. EC and pH were the most common parameters that were missing from the data set. Any further information that can be provided for these parameters will help improve the efficacy of the protocol. It is recognised that sampling is limited by the availability of bores.

Table 3-2 Five highest priority bores based on the Multi-Criteria Analysis Protocol

Centennial site	Bore ID	Bore use	Lithology	Bore depth (m)	pH	Mean EC (µS/cm)	Lining	Priority score (out of 6)
Neubeck	NEU01	observation	alluvium	2.2	6.66	391.8	lined screened	5.00
Lidsdale Siding	MW1	observation	alluvium	4.7	6.71	516.5	lined screened	5.00
Neubeck	NEU02	observation	alluvium	4.5	6.31	655.6	lined screened	4.90
Neubeck	NEU03	observation	alluvium	2.9	6.20	721.4	lined screened	4.90
Airly Mine	ARP05	observation	alluvium	15	5.9	138.0	lined screened	4.90

3.4 Validation of stygofauna prioritisation outcomes

3.4.1 Desktop validation

Some limitations of the prioritisation protocol were identified in Section 3.3 including the fact that some bores from which stygofauna have previously been collected were given a low priority score. To address this, the results of historic stygofauna sampling conducted at Centennial's western region sites were used to improve on the results of the prioritisation tool. The priority score of any bore where suspected stygofauna had previously been collected during stygofauna monitoring were scaled up.

The various historic studies have classified stygofauna differently. For the purposes of this exercise, stygofauna were deemed to be present in a bore if historic monitoring registered the collection of the following:

- Phreatobite.
- Stygobites.
- Likely stygofauna.
- Possible stygofauna.

The updated priority scores for each bore can be viewed in Appendix C. These updated priority scores were classified into the following four categories according to their score to allow for more easy interpretation of the results:

- High priority (priority score ≥4.34).
- Medium priority (priority score 3.91–4.33).
- Low priority (priority score 3.34–3.90).
- Very low priority (priority score ≤3.33).

High and medium priority bores are those bores with greater expectation of stygofauna habitation based on water quality, depth, lithology or other attributes discussed in Section 3.1.

A GIS layer was produced containing all bores within the western region and colour coded according to the stygofauna sampling priority. This GIS layer is mapped for the western region in Figure 3-1 to Figure 3-8.

Table 3-3 indicates the number of groundwater bores per operation within each priority category. High priority bores were observed at Angus Place Colliery, Springvale Mine, Neubeck, Airly Mine and Lidsdale Siding. Majority of Angus Place Colliery bores were of medium priority although a number of low and very low priority bores were observed. At Springvale Mine there was a large number of high priority bores due to the prevalence of shallow alluvium and swamp bores which generally are weighted more highly in the protocol. The bores at Clarence Colliery were designated as either medium, low or very low priority.

It is acknowledged that as previous collection of stygofauna has been weighted highly there is a bias towards western region sites where previous stygofauna monitoring has been conducted.

Table 3-3 Number of prioritised groundwater monitoring bores

Site	Number of groundwater bores			
Bore priority (score)	High priority (≥4.34)	Medium priority (3.91-4.33)	Low priority (3.34-3.90)	Very low priority (≤3.33)
Angus Place Colliery	5	17	13	11
Springvale Mine	23	7	7	9
Clarence Colliery	0	3	4	2
Western Coal Services	0	1	1	13
Neubeck	4	4	6	4
Airly Mine	1	2	1	1
Inglenook	0	2	4	0
Lidsdale Siding	6	0	0	0
Total	39	36	36	40

3.4.2 Validation sampling

The results of the Multi-Criteria Analysis Protocol and validation will need to be verified through stygofauna monitoring. See Section 4 for details on the proposed western region stygofauna monitoring program.

4. Stygofauna Monitoring and Assessment Plan

This monitoring program addresses key requirements as stipulated in the WA EPA Guidance Statement (WA EPA 2007) and forms the main part of Springvale Mine Extension Project consent condition 17, *prepare and implement a regional Stygofauna Monitoring and Assessment Plan* under *Development Consent SSD 5594*.

The SMAP will be reviewed following the initial regional stygofauna monitoring surveys. Some new bores need to be drilled in order to fulfil consent condition Schedule 4, Condition 17c, *Monitor for the presence of stygofauna in the deep aquifer system (AQ1 to AQ3) at Springvale*. The timing of stygofauna monitoring will be necessarily delayed until these new bores have been drilled and "seasoned" (see section 4.2).

The ongoing monitoring program (as required by consent condition Schedule 4, Condition 17b, *ongoing monitoring of at least one bore in each aquifer where stygofauna are known to occur*) will be determined following the review of the survey outcomes. The initial stygofauna monitoring program, including the survey of deep bores initially planned for autumn and spring 2017 has been delayed to mid 2018. (see section 4.2).

4.1 Number of bore samples

Geology can be heterogeneous and different assemblages of stygofauna species are likely to occur in the different geological formations. Additionally, uneven yield from bores may mean that the full range of species on the surrounding aquifer may require multiple rounds of sampling (WA EPA, 2007).

The consent conditions for the Springvale Mine Extension Project stipulated monitoring of at least one bore from aquifers where stygofauna have previously been collected. Additionally, it was required that the presence of stygofauna within the deep aquifer system (AQ1 to AQ3) be assessed.

The WA EPA (2007) recommends collection of 40 samples taken from at least 10 bores within the zone of impact (EPA, 2007) in order to adequately measure species diversity. These 40 samples can be collected across multiple sampling events.

The SMAP will involve a minimum of 40 samples, collected across two sampling events (i.e. 20 bores per event). This fulfils the recommendation of the WA EPA guidelines (2007) as well as the Springvale Mine Extension Project consent conditions.

4.2 Monitoring frequency and timing

To achieve a better understanding of the community level diversity, a multi-season sampling program must be undertaken (Hancock and Bolton, 2008). Sampling over multiple seasons will also enable a more confident determination of local species endemism and any regional distribution of the stygofauna community recorded. Surveys should be spaced at least 3 months apart to maximise stygofauna colonisation (WA EPA, 2007). At this time there is no information about preferred seasons for stygofauna, thus, the timing of sampling can be determined based on operational convenience. It is recommended that any newly drilled bores be left for a minimum of six months, if possible, prior to sampling (WA EPA, 2007).

Drilling of new bores in the vicinity of Airly Mine was completed inJanuary 2017. Drilling of new bores in the vicinity of Springvale Mine commenced in April 2018 and is to be completed in August 2018.,

The stygofauna monitoring program commenced in February 2017 and expanded to include the Airly bores in August 2018.

An additional two sampling events are planned Each bore selected for inclusion in the monitoring program (Table 4-2) will be monitored a minimum of two and a maximum of four times across the four stygofauna sampling events.

4.3 Bore selection

The Multi-Criteria Analysis Protocol identified the most prospective bores for stygofauna according to key physical and chemical attributes of the bore. Other important considerations in bore selection relevant for the western region SMAP are outlined in Table 4-1.

Table 4-1 Additional Considerations for Favourable Bore Selection

Attribute	Favourable values
Hydrogeology	Cover all hydrogeological units present[1] including the deep aquifer AQ1 to AQ3[2].
Bore location	Geographically spread across the western region and ideally include reference bores outside the potential zone of impact (i.e. water drawdown zone)[1].
Bore age	Be of varying age, in excess of six months old, and preferably undisturbed (i.e. not regularly pumped or purged)[1].

[1] WA EPA (2007).

[2] Requirement of the Springvale Mine Extension Project consent conditions.

The map containing the GIS layer of favourable bores for stygofauna sampling was compared to Centennial Coals areas of mining activities, management significance, estimated aquifer intersection and known GDEs.

One difficulty in bore selection to satisfy the consent conditions for Springvale is the requirement for monitoring of the deep aquifers (AQ1 to AQ3). Stygofauna sampling is difficult in deep bores due to the following practical constraints:

- Sampling nets and bailers are more likely to get stuck in the bore given the greater depth (and distance) that the net has to travel for each sample.
- The length of bailer cord and or pipe required can be cumbersome and heavy which makes water sampling difficult.
- There is greater likelihood of bore collapse in deeper (uncased) bores.

As specified in Table 3-1, deep bores (greater than 200 m deep) are also not considered to be prospective for stygofauna habitation. One way of addressing this issue in regards to AQ1 is to restrict sampling of this deepest aquifer to bores located at Angus Place Colliery. Due to differences in topography, the bores intersecting AQ1 at Springvale Mine are much deeper (up to 400 m) than the bores at Angus Place Colliery (approximately 30 m deep). These factors have been considered in selection of the bores to be included in the SMAP.

A total of 22 bores were selected which fulfil the requirements stipulated above (where possible). The bores proposed for the western region stygofauna monitoring program are outlined in Table 4-2 and Figure 4-1. The list of selected bores includes at least one bore from

all aquifers between AQ1 and AQ6, with priority given to bores where stygofauna have previously been collected and/or those bores given a high or medium priority by the Multi-Criteria Analysis Protocol. This fulfils Springvale Mine Extension Project consent conditions 17b and 17c (Table 1-1). A number of shallow alluvium or swamp bores have also been selected despite the fact that significant impacts to swamps due to the Springvale Mine Extension Project were determined to be “unlikely” (Golder Associates, 2014). WA EPA (2013) specifies that bores should encompass the full range of aquifer types present, with the more prospective habitats assigned significant sampling effort (e.g. alluvial aquifers).

Where new bores are proposed to increase the robustness of the monitoring program these have been proposed and highlighted in Table 4-2 with their location to be confirmed. The bores selected for monitoring may be revised prior to the commencement of sampling in 2017 if changes to operations or other factors mean that other bores are more suitable.

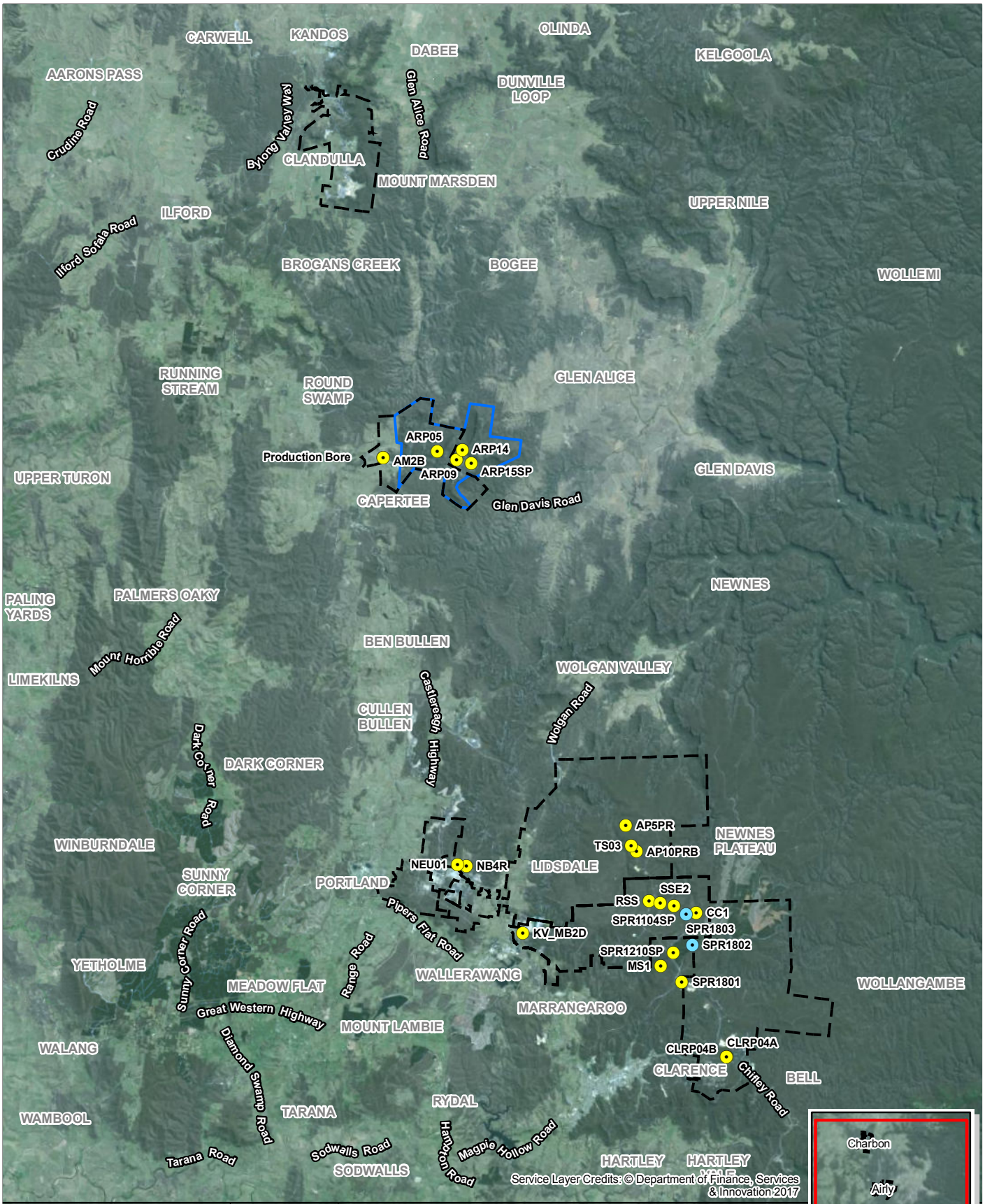
Table 4-2 Bores selected for stygofauna monitoring

Centennial site	Bore ID	Easting	Northing	Justification	Status*	Priority
Airly Mine	ARP05	224069	6333272	Shallow alluvium, baseline	Future mining	High
Airly Mine	ARP09	225330	6332729	Shallow alluvium, baseline	Future mining	High
Airly Mine	Production bore	220485	6332879	Monitoring of Shoalhaven Group	No mining	Very Low
Airly Mine	ARP14	225727	6333330	Shallow alluvium, baseline	Future mining	NA
Airly Mine	New AQ3 bore 1	NA	NA	AQ3, baseline	NA	NA
Airly Mine	ARP15SP	226317	6332484	AQ3, baseline, spatially separated from other AQ3 bores.	Future mining	NA
Angus Place Colliery	KV_MB2D	229718	6301382	AQ1 but shallower. Surrogate for AQ1 at Springvale	No mining	Low
Angus Place Colliery	AP5PR	236529	6308525	Stygofauna previously collected, deeper AQ1 bore	Future mining	Low
Angus Place Colliery	AP10PRB	237247	6306777	AQ4, stygofauna previously collected	Future mining	Low
Angus Place Colliery	TS03	236897	6307159	Swamp, stygofauna previously collected	Future mining	High
Clarence Colliery	CLRP04A/CLRP04B	243240	6293153	AQ3	Future mining	Very low
Neubeck	NB4R	225985	6305823	Stygofauna previously collected. AQ1 but	Future	High

Centennial site	Bore ID	Easting	Northing	Justification	Status*	Priority
				shallower. Surrogate for AQ1 at Springvale	mining	
Neubeck	NEU01	225388	6305910	Swamp, stygofauna previously collected, highest priority from tool	Future mining	High
Springvale Mine / Angus Place Colliery	SPR1801	240253	6298108	AQ1, baseline, spatially separated from other AQ1 bores.	Future mining	NA
Springvale Mine / Angus Place Colliery	SPR1802	240952	6300601	AQ2, baseline, spatially separated from other AQ2 bores.	Future mining	NA
Springvale Mine / Angus Place Colliery	SPR1803	240557	6302604	AQ3, baseline	Outside mine area	NA
Springvale Mine	SPR1210SP	239696	6300054	AQ4, highest priority in mine area	Future mining	Very low
Springvale Mine	SPR1104SP	239746	6303184	AQ5, stygofauna previously selected	Future mining	High
Springvale Mine	RSS	238072	6303500	AQ6	Mined	Low
Springvale Mine	CC1	241193	6302693	Swamp, reference	Outside mine area	High
Springvale Mine	MS1	238860	6299169	Swamp, different catchment	Future mining	High
Springvale Mine	SSE2	238831	6303352	Swamp, stygofauna previously collected, high priority	Future mining	High

*Future mining indicates a potential impact from future undermining.

Rows highlighted in yellow indicate a new bore to be drilled.



1:350,000 for A4

0 3 6 9 12

Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geodetic Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

LEGEND

- Colliery Holding Boundary
- A232 Boundary
- Existing bores
- Bores yet to be drilled

LOCATION	-
SEAM	NA
DRAWN	T.Morton
CHECKED	L.H
APPROVED	S.G
SCALE	Refer to scalebar

Centennial Western Region Stygofauna Monitoring and Assessment Plan

Selected bores for stygofauna monitoring

Centennial Coal

DATE 29/06/2018

Figure 4-1

GIS Filename: G:\22\0105001\GIS\Maps\Deliverables\Western\Regional\2218785\2218134_SMA004_StygoBores_0.mxd

4.4 Field methodology

The method of sample collection of stygofauna will be in accordance with the requirements for baseline surveys as defined by guidelines by WA EPA (2007; 2013). Any deviations from the protocols in these guideline documents will be detailed in the report following monitoring. Key aspects of the monitoring program have been outlined below to ensure the quality of the results of the SMAP and that the Springvale Mine Extension Project consent conditions are fulfilled.

4.4.1 *In situ* water quality

In situ physico-chemical water quality parameters will be measured at each of the sites using a multi-parameter water quality meter. The meter will be calibrated in accordance with quality system/quality assurance requirements and the manufacturer's specifications prior to its use in the field.

Groundwater quality measurements will be taken before the water column is disturbed by stygofauna sampling. Groundwater will be collected by lowering a plastic bailer tube down the bore until the water level is reached, then allowing the bailer to fill with water and sink into the water column. The full bailer will then be hauled out of the bore to the surface and decanted into a clean bucket or directly into the field meter vessel for measurement.

The following *in situ* water quality parameters will be recorded as a minimum for comparison to favourable stygofauna habitat conditions and water quality guidelines:

- Temperature.
- pH.
- EC.
- DO.
- Turbidity.
- Alkalinity.

4.4.2 Stygofauna sampling

For bores that were 50 mm in diameter, a 40 mm diameter net will be used for stygofauna sampling (GHD nets conform to WA EPA guideline [2007; 2013] specifications). For large bores (300 mm in diameter), a 150 mm diameter net will be used.

Nets are constructed of 50 µm nybolt mesh material, weighted at the bottom with a brass fixture with an attached plastic collecting jar. The net will be lowered to the bottom of the bore, agitated four times to dislodge resting animals and slowly retrieved. At the top of each haul, the collecting jar will be rinsed into a 50 µm mesh brass sieve and the net lowered again. In the event that the above mentioned method is not practical or feasible then an alternate methodology consistent with the WA EPA guideline (2007; 2013) specifications will be sought.

Sample effort will be standardised as much as possible to allow for comparison of results between sites and samples. However, it is noted that collapsed bores, tree roots can impede on sampling and limit the number of hauls from particular bores.

Six hauls will be completed for each bore, where possible, with all hauls reaching the bottom of the bore). The entire sieve contents were transferred to a labelled sample jar and preserved in 100% AR grade ethanol (to allow for future DNA analysis if required).

The use of a biological stain such Rose Bengal will be considered for addition to stygofauna samples to aid in sample processing.

4.4.3 Physical observations

The following will also be collected during the field survey on specialised field sheets:

- Photographs taken at each bore to aid in the assessment of surface land use and bore condition at the time of sampling and to act as a reference for future site visits.
- Measurements of standing water level (SWL) and bore depth of each bore using an electronic dip probe. The standing water level is the defined as the depth from the ground to the groundwater and is used to calculate the total depth of the water column.
- Recording of bore diameter, construction, purpose of bore, condition, GPS location and bore ID, presence of tree roots, surrounding land use, sampling date, time and sampling team.

4.5 Taxonomy

Stygofauna will be identified under a microscope to a minimum of family level and specimens preserved in a way that will allow for future genetic sequencing, if necessary. Family level identification is the requirement under the Springvale Mine Extension Project Development Consent (NSW Government, 2015).

An attachment of a digital camera to the microscope will be used to collect a photographic record representative of the stygofauna specimens collected. Examples of stygofauna collected by GHD are shown below in Figure 4-2 and Figure 4-3.

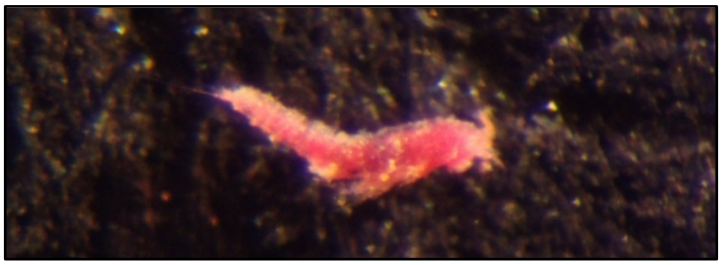


Figure 4-2 Phreatobitic Harpacticoid Copepod (Crustacea)

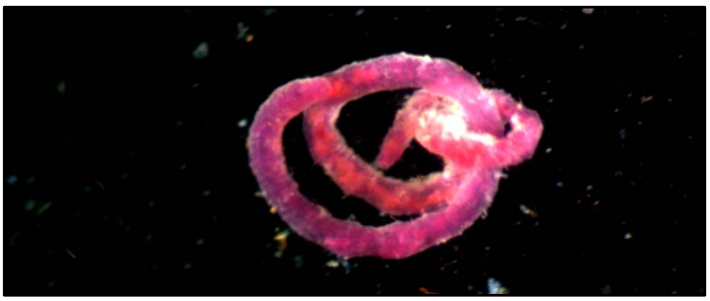


Figure 4-3 Phreatobitic Haplotaxid worm (Annelida)

The morphological identification of stygofauna requires highly experienced taxonomists. DNA analysis work on stygofauna samples may also need be considered to identify taxonomic level lower than the taxonomic level Family and determine endemicity, however this is not part of the current scope of work. Requirements for identification beyond family level will be determined following the review of SMAP results.

4.6 Reporting requirements

A report will be prepared at the completion of the second sampling event. The WA EPA (2007) suggests that reports on stygofauna should include details on the following:

- Background.

- Scope and objectives.
- Subterranean fauna habitat.
- Survey design and sampling methods.
- Survey and identification team.
- Limitations of the study.
- Results and discussion of species collected.
- Discussion of risk.
- Conclusions and recommendations.

In addition to the above, the following additional items will be addressed within the report:

- Comparison of in situ water quality data collected to the water quality guidelines (such as ANZECC, 2000), where appropriate.
- Examination of the relationship between stygofauna and the water quality and/or physical attributes of the bore.
- Discussion on significance of findings.
- Recommendations for further monitoring or actions.

This reporting structure will fulfil the requirements of the consent conditions for the Springvale Mine Extension Project.

5. Monitoring obligations

5.1 Responsibility of Centennial

As part of this assessment and monitoring program, the relevant Environmental and Community Coordinator is to engage a suitably qualified person to undertake the stygofauna monitoring program as stipulated in Section 4. The data obtained will be recorded in a centralised database of stygofauna monitoring results, which Centennial will develop. Storage of stygofauna data in a centralised database will ensure that:

- Stygofauna data can be easily shared across western region sites.
- The extent of past monitoring across the region can easily be identified.
- Data will be consistently formatted across all sites.
- Regionally relevant stygofauna information can be easily gathered for use in any EISs required as part of future capital expenditure projects.

5.2 Reporting (annual review)

Results from stygofauna monitoring should be summarised as part of the annual review for each site where stygofauna have been assessed. Reporting on monitoring results, whilst not specifically required, is an approach consistent with the conditions of consent outlined in Schedule 6, Condition 12b as part of SSD-5594.

5.3 Monitoring plan revisions

The monitoring plan should be revised in accordance with conditions of consent Schedule 6, Condition 6 of SSD-5594.

6. References

Aquaterra Consulting (2010) *Pine Dale Coal Mine Yarraboldy Extension: Groundwater Assessment*, Aquaterra Consulting Pty Ltd.

Australian Government (1999) *Environmental Protection and Biodiversity Conservation Act*, Department of Environment

Cardno (2014a) *Aquatic Ecology and Stygofauna Assessment*, Angus Place Mine Extension Project, prepared by Cardno for Centennial Angus Place Pty Ltd.

Cardno (2014b) Aquatic Ecology and Stygofauna Assessment, Springvale Mine Extension Project, prepared by Cardno for Springvale Coal Pty Ltd.

Cardno (2014c) *Aquatic Ecology and Stygofauna Assessment*, Airly Mine Extension Project, prepared by Cardno for Centennial Angus Place Pty Ltd.

Connell Wagner (2005) *Ivanhoe Mine Water Assessment*, prepared by Connell Wagner Pty Ltd for Centennial Coal.

DPI-Water (2012) *Aquifer Interference Policy,* Department of Primary Industries – Water, NSW Government

Eberhard, S.M., Halse, S.A., Williams, M.R., Scanlon, M.D., Cocking, J. and Barron, H.J (2009) *Exploring the relationship between sampling efficiency and short-range endemism for groundwater fauna in the Pilbara region*, Western Australia. Freshwater Biology 54, 885-901.

EPA (2007) *Guidance for the Assessment of Environmental Factors, Sampling Methods and Survey Considerations for Subterranean Fauna* (in accordance with the Environmental Protection Act 1986), Technical appendix to Guidance Statement No. 54, Environmental Protection Authority, Western Australia.

GHD (2011) *Springvale Colliery, Hydrogeology Impact Review*, Springvale Coal.

GHD (2014a) *Aquatic Ecology Impact Assessment*, Centennial Western Region, Neubeck Coal Project, prepared by GHD Pty Ltd for Centennial Angus Place Pty Ltd

GHD (2014b) *Western Coalfield Water and Salt Balance*, prepared by GHD Pty Ltd for Centennial Coal.

GHD (2014c) *Groundwater Impact Assessment,* Airly Mine Extension Project, prepared by GHD Pty Ltd for Centennial Airly Pty Limited.

GHD (2016) *Regional Water Management Plan (Northern)*, prepared by GHD Pty Ltd for Centennial Coal Company Limited.

Golder Associates (2014) Springvale Mine Extension Project, Environmental Impact Statement, prepared for Centennial Coal.

Hancock P.J., Boulton A.J. & Humphreys W.F. (2005) *Aquifers and hyporheic zones: Towards an ecological understanding of groundwater*. Hydrogeology Journal 13, 98-111.

Hancock, P.J. and Boulton, A.J. (2008) *Stygofauna biodiversity and endemism in four alluvial aquifers in eastern Australia*. Invertebrate Systematics 22, 117-126.

Hose, G.C., Sreekanth, J., Barron, O. and Pollino, C. (2015) Stygofauna in Australian Groundwater Systems: Extent of knowledge. CSIRO, Australia.

Humphreys, W. (2006) 'Groundwater fauna' paper prepared for the 2006 Australian State of the Environment Committee, Department of the Environment and Heritage, Canberra,

Humphreys, W.F (2008) Rising from Down Under: developments in subterranean biodiversity in Australia from a groundwater perspective. Invertebrate Systematics 22, 85-102.

MPR (2012). Aquatic Ecology Monitoring. Newnes Plateau Pilot Stygofauna Study Autumn 2012. Report prepared for Angus Place Colliery and Springvale Colliery.

NSW Government (2016) Angus Place Mine Extension Project, Planning and Environment, http://majorprojects.planning.nsw.gov.au/index.pl?action=view_job&job_id=5602 cited on 15 Jan 2016

NSW Government (2002) *State Groundwater Dependent Ecosystems Policy,* Department of Land and Water Conservation

NSW Government (2003) *Draft Groundwater Monitoring Guidelines for Mine Sites*, Department of Infrastructure, Planning and Natural Resources

NSW Government (2015) *Developments Consent*, Springvale Coal Mine Underground mine extension project, Department of Planning and Environment

NSW Government (2000) *Water Management Act*, No. 92, Parliamentary Counsel's Office

NSW Government (1997) *NSW State Groundwater Policy Framework Document*, Department of Land and Water Conservation

RPS (2012) *Groundwater Assessment,* Lidsdale Siding Upgrade Project, prepared by RPS Aquaterra.

RPS (2012a), *Lidsdale Siding Upgrade Project: Surface Water Impact & Water Balance Assessment*, RPS Aquaterra Pty Ltd.

RPS (2013) *Groundwater Assessment,* Centennial Western Coal Services Project, prepared by RPS Aquaterra for Springvale Coal Pty Ltd.

Serov P (2016) *http://www.stygoecologia.com.au/aquatic.php* (date accessed 14 January 2016)

Appendix A – Results of consultation

Table 6-1 Key comments raised through consultation and action taken

Requirement	How Addressed
NSW Office of Environment and Heritage 18 March 2016	
Reword sentence identifying requirement that the Management Plan is addressing OEH and NOW requirements, to consultation with OEH and NOW addressing DoPI	Changed wording as requested.
Request Hose (2008) be referenced in document	Hose reference has not been included. This report is not publicly available. Contact was made with Sydney Catchment Authority to access report however the report was not able to be provided.
Sunnyside East and Carne West should be sample repeated	Out of scope. The Springvale Mine Extension Project consent conditions require: Ongoing monitoring of at least one bore in each aquifer where stygofauna are known to occur and monitor for the presence of stygofauna in the deep aquifer system (AQ1 to AQ3) at Springvale. These conditions will be addressed through implementation of the Stygofauna Monitoring and Assessment Plan in its current form
The Stygofauna Monitoring and Assessment Plan should identify possibility of high numbers and diversity of stygofauna in swamps.	Out of scope. The Springvale Mine Extension Project consent conditions require: Ongoing monitoring of at least one bore in each aquifer where stygofauna are known to occur and monitor for the presence of stygofauna in the deep aquifer system (AQ1 to AQ3) at Springvale. These conditions will be addressed through implementation of the Stygofauna Monitoring and Assessment Plan in its current form.
Clearer definition of the timeframe of implementation of the Stygofauna Monitoring and Assessment Plan.	Section 1.1 and 4.2 of the Stygofauna Monitoring and Assessment Plan states the timeframe for the implementation of the Stygofauna Monitoring and Assessment Plan will be 12 months commencing in 2017.
Repeat stygofauna surveys are conducted in Sunnyside East and Carne West swamps to determine the status of these populations.	Out of scope. The Springvale Mine Extension Project consent conditions require: Ongoing monitoring of at least one bore in each aquifer where stygofauna are known to occur and monitor for the presence of stygofauna in the deep aquifer system (AQ1 to AQ3) at Springvale. These conditions will be addressed through implementation of the Stygofauna Monitoring and Assessment Plan in its current form.
NSW Department of Planning and Environment 8 August 2016	
P37 states new bores are proposed in the vicinity of Airly and Springvale and are scheduled to be drilled in 2016. Can the locations of the bores be finalised and the table updated?	P37, Table 4-2 and Figure 4-1 updated in accordance with bores installed to date. Revised schedule of completion of bores at Springvale is August 2018.

Table 4-2 includes SSE2. Figure 4-1 shows SSE1 would be used. Can you please clarify which SSE bore is included in the program and make the necessary changes.	
NSW Department of Planning and Environment 15 June 2018	
It is noted that monitoring was proposed for 2017 and 2018. On this basis the SMAP has been recommended for approval, providing that within 3 Months of completing the 2018 monitoring event, a revised SMAP is submitted for approval that also addresses the following:	Monitoring has been delayed from 2018 to 2019. Drilling at Springvale was delayed until April 2018 and will be finalised in August 2018. The final two sampling events will occur six months after the completion of drilling, and three months following the initial sample. The revised SMAP will be submitted to DPE for approval within 3 months of the final sampling event in accordance with the below requirements.
Section 4 be revised to remove passive language;	Section 4 has been reviewed to remove passive language.
The results of the monitoring program be incorporated into the SMAP;	The results of the monitoring program will be incorporated in the next revision of the SMAP.
Condition (17g, h and i) be address using the monitoring data; and	Springvale Mine Extension Project SSD- conditions of development consent 17g, h and I will be addressed in the next revision of the SMAP.
OEH are consulted on the revised SMAP.	OEH will be consulted and comments incorporated during the next revision of the SMAP.

Appendix B Groundwater bore information

Note: Blank cells in the following tables indicate no data.

Table B1 Airly bore characteristics

Site ID	Bore ID	X Coordinate	Y Coordinate	Mean EC (uS/cm)	Bore Depth (m)	Monitored depth (m)	Lithology	Centennial Aquifer Reference	pH	Bore usage	DO (mg/L)	Bore Diameter (mm)	Alignment	Lining
Airly	Production Bore	220485	6332879	5000.0	84.000		fractured rock	NA	6.50	production bore	6.7	>50mm	vertical	Lined unscreened
Airly	ARP05	224069	6333272	138.0	15.000		Alluvium		5.90	observation		>50mm	vertical	lined screened
Airly	ARP09	225330	6332729	117.4	6.200		Alluvium		5.57	observation		>50mm	vertical	lined screened
Airly	ARP07	224692	6332554		120		fractured rock	NA		observation		>50mm	vertical	lined screened
Airly	ARP08	224967	6333826		4.2		fractured rock	NA		observation		>50mm	vertical	lined screened

Table B2 Angus Place bore characteristics

Site ID	Bore ID	X Coordinate	Y Coordinate	Mean EC (uS/cm)	Bore Depth (m)	Monitored depth (m)	Lithology	Centennial Aquifer Reference	pH	Bore usage	DO (mg/L)	Bore Diameter (mm)	Alignment	Lining
Angus Place	KV_MB1S	229150	6303042		29.500	26.5-29.5m	fractured rock	AQ1		observation		>50mm	vertical	lined screened
Angus Place	KV_MB1D	229151	6303047		73.000	70-73m	fractured rock	AQ1		observation		>50mm	vertical	lined screened
Angus Place	KV_MB2D	229166	6301607		18.990	16-19m	fractured rock	AQ1		observation		>50mm	vertical	lined screened
Angus Place	KV_MB3S	229531	6301971		33.250	30.3-33.3m	fractured rock	AQ1		observation		>50mm	vertical	lined screened
Angus Place	KV_MB3D	229632	6302212		41.040	36-39m	fractured rock	AQ1		observation		>50mm	vertical	lined screened
Angus Place	KV_MB8A	229719	6301383		13.000	6-10m	fractured rock	AQ1		observation		>50mm	vertical	lined screened
Angus Place	AP8PR	229724	6302889		405.260	Cemented to 90m	fractured rock	AQ1		observation		>50mm	vertical	Lined unscreened
Angus Place	AP9PR	229730	6302889		399.520		fractured rock	AQ1		observation		>50mm	vertical	Lined unscreened
Angus Place	AP5PR	229983	6301783	18.7	333.340		fractured rock	AQ2	5.92	observation	4.95	>50mm	vertical	Lined unscreened
Angus Place	AP1102SP	229987	6301785		110.000		fractured rock	AQ4		observation		>50mm	vertical	Lined unscreened
Angus Place	REN	230238	6302344		55.080		fractured rock	AQ4		observation		>50mm	vertical	Lined unscreened
Angus Place	RNW	230277	6301743		50.460		fractured rock	AQ4		observation		>50mm	vertical	Lined unscreened
Angus Place	AP1104SP	230277	6301743		80.000		fractured rock	AQ5		observation		>50mm	vertical	Lined unscreened
Angus Place	AP1105SP	230600	6301290		75.000	Screened 60-75M	fractured rock	AQ5		observation		>50mm	vertical	lined screened
Angus Place	AP1107SP	230600	6301290		50.000		fractured rock	AQ5		observation		>50mm	vertical	Lined unscreened
Angus Place	AP1110SP	233152	6304633		110.000		fractured rock	AQ5		observation		>50mm	vertical	Lined unscreened

Site ID	Bore ID	X Coordinate	Y Coordinate	Mean EC (uS/cm)	Bore Depth (m)	Monitored depth (m)	Lithology	Centennial Aquifer Reference	pH	Bore usage	DO (mg/L)	Bore Diameter (mm)	Alignment	Lining
Angus Place	AP1204SP	233235	6304338		100.000		fractured rock	AQ5		observation		>50mm	vertical	Lined unscreened
Angus Place	AP1PRC	234527	6304641		54.000		fractured rock	AQ5		observation		>50mm	vertical	Lined unscreened
Angus Place	AP4PRB	234566	6304686	23.1	51.000		fractured rock	AQ5	5.27	observation	5.966667	>50mm	vertical	Lined unscreened
Angus Place	KV_MB10A	234591	6304901		59.000	54.5-57.5m	fractured rock	AQ5		observation		>50mm	vertical	lined screened
Angus Place	KV_MB10B	234859	6305069		66.600	61.9-64.9m	fractured rock	AQ5		observation		>50mm	vertical	lined screened
Angus Place	AP10PRB	235076	6304525	16.8	40.000		fractured rock	AQ6	5.36	observation	5.55	>50mm	vertical	Lined unscreened
Angus Place	KV_MB4D	235709	6304459		30.710	27.7-30.7m	fractured rock	AQ6		observation		>50mm	vertical	lined screened
Angus Place	KV_MB5D	235719	6304396		12.200	9.2-12.2	fractured rock	AQ6		observation		>50mm	vertical	lined screened
Angus Place	KV_MB6S	235992	6305049		18.510	15.5-18.5m	fractured rock	AQ6		observation		>50mm	vertical	lined screened
Angus Place	KV_MB6D	236122	6304315		27.500	24.5-27.5m	fractured rock	AQ6		observation		>50mm	vertical	lined screened
Angus Place	KV_MB7A	236272	6305490		15.800	12.8-15.8m	fractured rock	AQ6		observation		>50mm	vertical	lined screened
Angus Place	KV_MB9A	236375	6304064		21.000	19-21m	fractured rock	AQ6		observation		>50mm	vertical	lined screened
Angus Place	KV_MB9B	236409	6304181		33.000	24.1-27.1m	fractured rock	AQ6		observation		>50mm	vertical	lined screened
Angus Place	WE2	236438	6308766		1.300		Swamp		5.03	observation	6.24	>50mm	vertical	lined screened
Angus Place	XS01	236509	6309362	33.3	1.550		Swamp		5.34	observation	3.92	>50mm	vertical	lined screened
Angus Place	TS03	236530	6308525	56.3	1.650		Swamp		6.00	observation	4.175	>50mm	vertical	lined screened
Angus Place	WW1	236897	6307159		2.000		Swamp		5.03	observation	6.24	>50mm	vertical	lined screened
Angus Place	TS02	237071	6310956	55.3	2.080		Swamp		6.41	observation	4.35	>50mm	vertical	lined screened
Angus Place	KCK01	237106	6311453		2.200		Swamp		5.03	observation	6.24	>50mm	vertical	lined screened
Angus Place	WW4	237157	6308659		2.200		Swamp		5.03	observation	6.24	>50mm	vertical	lined screened
Angus Place	WW2	237248	6306777		2.500		Swamp		5.03	observation	6.24	>50mm	vertical	lined screened
Angus Place	WW3	237340	6307549		2.530		Swamp		5.03	observation	6.24	>50mm	vertical	lined screened
Angus Place	NS1	237443	6306772		2.700		Swamp		5.03	observation	6.24	>50mm	vertical	lined screened
Angus Place	NS2	237559	6307289		2.700		Swamp		5.03	observation	6.24	>50mm	vertical	lined screened
Angus Place	WE1	237732	6306580		2.800		Swamp		5.03	observation	6.24	>50mm	vertical	lined screened

Site ID	Bore ID	X Coordinate	Y Coordinate	Mean EC (uS/cm)	Bore Depth (m)	Monitored depth (m)	Lithology	Centennial Aquifer Reference	pH	Bore usage	DO (mg/L)	Bore Diameter (mm)	Alignment	Lining
Angus Place	TS01	238597	6307107	29.8	3.950		Swamp		5.60	observation	4.55	>50mm	vertical	lined screened
Angus Place	TG1	238869	6305665	51.5	1.100		Swamp		5.71	observation	4.01	>50mm	vertical	lined screened
Angus Place	KCK02	239159	6307947		5.000		Swamp		5.03	observation	6.24	>50mm	vertical	lined screened
Angus Place	NS3	239429	6306147		2.700		Swamp		5.03	observation	6.24	>50mm	vertical	lined screened
Angus Place	NS4	239856	6308995		2.700		Swamp		5.03	observation	6.24	>50mm	vertical	lined screened

Table B3 Springvale bore characteristics

Site ID	Bore ID	X Coordinate	Y Coordinate	Mean EC (uS/cm)	Bore Depth (m)	Monitored depth (m)	Lithology	Centennial Aquifer Reference	pH	Bore usage	DO (mg/L)	Bore Diameter (mm)	Alignment	Lining
Springvale	SPR1111SP	240404	6303962		60.00	45-60m	fractured rock	AQ4		observation		>50mm	vertical	lined screened
Springvale	SPR1210SP	239696	6300054		130.00	115-130m	fractured rock	AQ4		observation		>50mm	vertical	lined screened
Springvale	SPR1211SP	240239	6298938		130.00	115-130m	fractured rock	AQ4		observation		>50mm	vertical	lined screened
Springvale	SPR1101SP	238484	6303627		84.55	69.5-84.5m	fractured rock	AQ5		observation		>50mm	vertical	lined screened
Springvale	SPR1104SP	239746	6303184		50.60	35-50m	fractured rock	AQ5		observation		>50mm	vertical	lined screened
Springvale	SPR1106SP	239980	6304227		85.00		fractured rock	AQ5		observation		>50mm	vertical	Lined unscreened
Springvale	SPR1107SP	239739	6302330		55.00	40-55m	fractured rock	AQ5		observation		>50mm	vertical	lined screened
Springvale	SPR1108SP	239840	6301075		75.00	60-75m	fractured rock	AQ5		observation		>50mm	vertical	lined screened
Springvale	SPR1109SP	239187	6303321		60.00	45-60m	fractured rock	AQ5		observation		>50mm	vertical	lined screened
Springvale	SPR1110SP	238699	6302635		65.00	50-65m	fractured rock	AQ5		observation		>50mm	vertical	lined screened
Springvale	SPR1112SP	240852	6302995		50.10	35-50m	fractured rock	AQ5		observation		>50mm	vertical	lined screened
Springvale	SPR1301SP	239275	6299271		129.76	76.2-86.2m	fractured rock	AQ5		observation		>50mm	vertical	lined screened
Springvale	SPR1402AQ	238163	6303489		90.58		fractured rock	AQ5		observation		>50mm	vertical	Lined unscreened
Springvale	SPR1403SP	239133	6303287		50.60	31.6-50.6m	fractured rock	AQ5		observation		>50mm	vertical	lined screened
Springvale	RSS	238072	6303500		45.00	34.21m	fractured rock	AQ6		observation		>50mm	vertical	lined screened
Springvale	SPR1113SP	240625	6302160		60.00		fractured rock	AQ6		observation		>50mm	vertical	Lined unscreened
Springvale	SPR1401SP	238453	6303547		45.00		fractured rock	AQ6		observation		>50mm	vertical	Lined unscreened

Site ID	Bore ID	X Coordinate	Y Coordinate	Mean EC (uS/cm)	Bore Depth (m)	Monitored depth (m)	Lithology	Centennial Aquifer Reference	pH	Bore usage	DO (mg/L)	Bore Diameter (mm)	Alignment	Lining
Springvale	OS01	238139	6304226		467.080		fractured rock	NA		observation		>50mm	vertical	Lined unscreened
Springvale	RSE	236843	6304186		47.000		fractured rock	NA		observation		>50mm	vertical	Lined unscreened
Springvale	JS01	235779	6302692		9.400	9.3m	Swamp			observation		>50mm	vertical	lined screened
Springvale	JS02	235784	6302749		8.800	8.2m	Swamp			observation		>50mm	vertical	lined screened
Springvale	JS03	235857	6302731		6.700	6.6m	Swamp			observation		>50mm	vertical	lined screened
Springvale	GW2	240263	6303097	50.3	0.600		Swamp		6.02	observation	4.7	>50mm	vertical	lined screened
Springvale	GW1	239814	6302877	88.5	0.710		Swamp		6.38	observation	4.75	>50mm	vertical	lined screened
Springvale	BS3	242008	6301246	58.0	0.800		Swamp		5.30	observation	3.565	>50mm	vertical	lined screened
Springvale	GG1	240285	6302294	51.3	0.900		Swamp		5.66	observation	3.94	>50mm	vertical	lined screened
Springvale	CC1	241193	6302693	116.0	0.950		Swamp		6.53	observation	3.96	>50mm	vertical	lined screened
Springvale	SSE2	238831	6303352	146.0	1.000		Swamp		6.40	observation	3.8	>50mm	vertical	lined screened
Springvale	BS1	241045	6301305	47.0	1.100		Swamp		5.72	observation	4.24	>50mm	vertical	lined screened
Springvale	CW3	238977	6302179		1.100		Swamp		5.03	observation	6.24	>50mm	vertical	lined screened
Springvale	BS2	240809	6300174	36.0	1.150		Swamp		5.86	observation	4.075	>50mm	vertical	lined screened
Springvale	SS04	237791	6304398	59.0	1.150		Swamp		5.86	observation	5.63	>50mm	vertical	lined screened
Springvale	CW1	239352	6303196	38.0	1.200		Swamp		5.22	observation	7.29	>50mm	vertical	lined screened
Springvale	SS03	237485	6303838	69.5	1.250		Swamp		6.37	observation	6.49	>50mm	vertical	lined screened
Springvale	SS05	237782	6304627	62.8	1.270		Swamp		5.69	observation	5.57	>50mm	vertical	lined screened
Springvale	CW2	239382	6303247	27.3	1.350		Swamp		5.32	observation	7.5	>50mm	vertical	lined screened
Springvale	CW4	239070	6302377	45.0	1.400		Swamp		6.28	observation	5.9	>50mm	vertical	lined screened
Springvale	MS1	238860	6299169	68.5	1.450		Swamp		6.03	observation	4.465	>50mm	vertical	lined screened
Springvale	SS02	237783	6303571	112.3	1.600		Swamp		6.61	observation	4.13	>50mm	vertical	lined screened
Springvale	SSE3	239064	6303558	98.0	1.800		Swamp		5.88	observation	6.25	>50mm	vertical	lined screened
Springvale	SS01	237766	6303509	74.8	1.900		Swamp		5.83	observation	7.5	>50mm	vertical	lined screened
Springvale	SSE1	238668	6303143		2.300		Swamp		5.03	observation	6.24	>50mm	vertical	lined screened

Site ID	Bore ID	X Coordinate	Y Coordinate	Mean EC (uS/cm)	Bore Depth (m)	Monitored depth (m)	Lithology	Centennial Aquifer Reference	pH	Bore usage	DO (mg/L)	Bore Diameter (mm)	Alignment	Lining
Springvale	CWP	239814	6303801		5.000		SWAMP		5.03	observation	6.24	>50mm	vertical	lined screened
Springvale	SSB	237844	6303844		5.000		SWAMP		5.03	observation	6.24	>50mm	vertical	lined screened
Springvale	SSP	237647	6304963		5.000		SWAMP		5.03	observation	6.24	>50mm	vertical	lined screened
Springvale	SSW1	237230	6302421		5.000		SWAMP		5.03	observation	6.24	>50mm	vertical	lined screened

Table B4 Clarence bore characteristics

Site ID	Bore ID	X Coordinate	Y Coordinate	Mean EC (uS/cm)	Bore Depth (m)	Monitored depth (m)	Lithology	Centennial Aquifer Reference	pH	Bore usage	DO (mg/L)	Bore Diameter (mm)	Alignment	Lining
Clarence	CLRP04A	243240	6293153		182.500	180	fractured rock	AQ3		observation		>50mm	vertical	lined screened
Clarence	CLRP04B	243204	6293153		182.250	175, 181	fractured rock	AQ3		observation		>50mm	vertical	lined screened
Clarence	CLRP15	240912	6294870	62.9	116.000	116	fractured rock	AQ3	6.11	observation		>50mm	vertical	lined screened
Clarence	CC113	241692	6293105		226.000	30	fractured rock	AQ4		observation		>50mm	vertical	lined screened
Clarence	CLRP04C	243213	6293119	178.4	71.300	71	fractured rock	AQ4	6.82	observation		>50mm	vertical	lined screened
Clarence	CLRP05	242518	6297687	28.5	272.000	51	fractured rock	AQ4	5.04	observation		>50mm	vertical	lined screened
Clarence	CLRP07	242181	6293863	56.5	238.000	41	fractured rock	AQ4	5.83	observation		>50mm	vertical	lined screened
Clarence	CLRP08	242351	6291961	28.6	28.000	28	fractured rock	AQ4	4.78	observation		>50mm	vertical	lined screened
Clarence	CLRP10	242356	6295607		278.140	60	fractured rock	AQ4		observation		>50mm	vertical	lined screened

Table B5 Western Coal Services bore characteristics

Site ID	Bore ID	X Coordinate	Y Coordinate	Mean EC (uS/cm)	Bore Depth (m)	Monitored depth (m)	Lithology	Centennial Aquifer Reference	pH	Bore usage	DO (mg/L)	Bore Diameter (mm)	Alignment	Lining
Western Coal Services	BH01	225978	6305018	3245.0	18.3		fractured rock	AQ1	6.01	observation		>50mm	vertical	lined unscreened
Western Coal Services	BH02	225948	6303880	984.5	30		fractured rock	AQ1	7.22	observation		>50mm	vertical	lined unscreened
Western Coal Services	BH04	225611	6304579	4460.0	27.51		Lithgow Seam workings (void)	AQ1		observation		>50mm	vertical	lined unscreened
Western Coal Services	BH05	225757	6304656	4460.0	30.19		Lithgow Seam workings (void)	AQ1		observation		>50mm	vertical	lined unscreened
Western Coal Services	BH06	226183	6304758	2320.0	9.3		fractured rock	AQ1	6.45	observation		>50mm	vertical	lined unscreened
Western Coal Services	BH08	225979	6304608	4460.0	24.4	21.4–24.4	Lithgow Seam workings (void)	AQ1	6.46	observation		>50mm	vertical	lined unscreened

Site ID	Bore ID	X Coordinate	Y Coordinate	Mean EC (uS/cm)	Bore Depth (m)	Monitored depth (m)	Lithology	Centennial Aquifer Reference	pH	Bore usage	DO (mg/L)	Bore Diameter (mm)	Alignment	Lining
Western Coal Services	BH09	225876	6304526	4460.0	25.5	22.5–25.0	Lithgow Seam workings (void)	AQ1		observation		>50mm	vertical	lined unscreened
Western Coal Services	BH10	225653	6304342	4460.0	25.2	22.0–25.0	Lithgow Seam workings (void)	AQ1		observation		>50mm	vertical	lined unscreened
Western Coal Services	BH11	225088	6304251	4460.0	34.19		fractured rock	AQ1		observation		>50mm	vertical	lined unscreened
Western Coal Services	BH12	225667	6304819	4460.0	18.68		fractured rock	AQ1		observation		>50mm	vertical	lined unscreened

Table B6 Neubeck bore characteristics

Site ID	Bore ID	X Coordinate	Y Coordinate	Mean EC (µS/cm)	Bore Depth (m)	Monitored depth (m)	Lithology	Centennial Aquifer Reference	pH	Bore usage	DO (mg/L)	Bore Diameter (mm)	Alignment	Lining
Neubeck	EPPGW02	227160	6303755		23.500	20.5-23.5m	fractured rock	AQ1		observation		>50mm	vertical	lined screened
Neubeck	EPPGW03	227176	6303772		24.000	20.75-23.75m	fractured rock	AQ1		observation		>50mm	vertical	lined screened
Neubeck	EPPGW04	227097	6303780		24.000	20.6-23.6m	fractured rock	AQ1		observation		>50mm	vertical	lined screened
Neubeck	EPPGW05	227094	6303738		24.000	21-24m	fractured rock	AQ1		observation		>50mm	vertical	lined screened
Neubeck	EPPGW06	227053	6303740		24.000	21-24m	fractured rock	AQ1		observation		>50mm	vertical	lined screened
Neubeck	NB2R	226104	6306776	318.0	60.600	27-30m	fractured rock	AQ1	8.31	observation	4.218	>50mm	vertical	lined screened
Neubeck	NB3R	226140	6306068	594.0	57.500	55.5-57.5m	fractured rock	AQ1	6.93	observation	4.324	>50mm	vertical	lined screened
Neubeck	NB4R	225985	6305823	562.0	30.000	27-30m	fractured rock	AQ1	7.39	observation	4.876	>50mm	vertical	lined screened
Neubeck	NBDW2R	226239	6306390	718.3	57.500	50-53m	fractured rock	AQ1	7.01	observation	4.65	>50mm	vertical	lined screened
Neubeck	NBDW1	225757	6307121	437.8	47.400	Open to workings	fractured rock	AQ1	6.59	observation	3.318	>50mm	vertical	Lined unscreened
Neubeck	NBDW1-2	225774	6307113	435.0	53.800	Open to workings	fractured rock	AQ1	6.63	observation	3.98	>50mm	vertical	Lined unscreened
Neubeck	NBDB3-1	225460	6306112	499.4	30	Open to workings	fractured rock	AQ1	6.58	observation	3.7	>50mm	vertical	Lined unscreened
Neubeck	NBDB3-2	225461	6306092	515.3	29	Open to workings	fractured rock	AQ1	6.97	observation	4.08	>50mm	vertical	Lined unscreened
Neubeck	NBDB3-3	225465	6306121	496.0	28	Open to workings	fractured rock	AQ1	7.00	observation	4.99	>50mm	vertical	Lined unscreened
Neubeck	EPPD06	228991	6308263		105.000	105	fractured rock	AQ2		observation		>50mm	vertical	lined screened
Neubeck	NEU01	225389	6305910	391.8	2.200		alluvium		6.66	observation	4.536	>50mm	vertical	lined screened
Neubeck	NEU03	225374	6305785	721.4	2.900		alluvium		6.20	observation	4.198	>50mm	vertical	lined screened
Neubeck	NEU02	225313	6305866	655.6	4.500		alluvium		6.31	observation	3.384	>50mm	vertical	lined screened

Table B7 Inglenook bore characteristics

Site ID	Bore ID	X Coordinate	Y Coordinate	Mean EC (µS/cm)	Bore Depth (m)	Monitored depth (m)	Lithology	Centennial Aquifer Reference	pH	Bore usage	DO (mg/L)	Bore diameter (mm)	Alignment	Lining
Inglenook	CNG005	207960	6345167	537.5	36.200	22-25	Fractured rock	AQ1	6.38	Observation	2.28	>50 mm	Vertical	Lined screened
Inglenook	CNG008SP	210180	6340708	3195.0	94.500	91.5-94.5	Fractured rock	AQ2	10.57	Observation	2.71	>50 mm	Vertical	Lined screened
Inglenook	CNG010SP	209105	6345860		23.500	21.4-23.4	Fractured rock	NA		Observation		>50 mm	Vertical	Lined screened
Inglenook	CNG011SP	209880	6345308		116.500		Fractured rock	NA		Observation		>50 mm	Vertical	Lined screened
Inglenook	CNG014SP	208967	6348123		48.000	41.5-47.5	Fractured rock	NA		Observation		>50 mm	Vertical	Lined screened
Inglenook	CNG002	210869	6345680	572.0	16.210	7.2-10.2	Alluvium (clay)		6.60	Observation	4	>50 mm	Vertical	Lined screened

Appendix C – Bore prioritisation outcomes

Table C1 Results of Bore Prioritisation from Multi-Criteria Analysis Protocol

Centennial site	Bore ID	Easting	Northing	Bore use	Lithology	Bore depth (m)	pH	Mean EC (µS/cm)	Lining	Priority
Airly Mine	ARP05	224069.4	6333272	Observation	Alluvium	15	5.9	138	Lined screened	4.905
Airly Mine	ARP09	225330.1	6332730	Observation	Alluvium	6.2	5.57	117.4	Lined screened	4.905
Airly Mine	ARP08	224967	6333826	Observation	Fractured rock	4.2			Lined screened	3.905
Airly Mine	ARP07	224692	6332554	Observation	Fractured rock	120			Lined screened	3.333
Airly Mine	Production Bore	220485	6332879	Production bore	Fractured rock	84	6.5	5,000	Lined unscreened	1.190
Angus Place Colliery	TS03	236897	6307159	Observation	Swamp	1.65	6	56.25	Lined screened	4.714
Angus Place Colliery	TS02	237443	6306772	Observation	Swamp	2.08	6.41	55.33	Lined screened	4.714
Angus Place Colliery	TS01	237559	6307289	Observation	Swamp	3.95	5.6	29.8	Lined screened	4.714
Angus Place Colliery	TG1	236438	6308766	Observation	Swamp	1.1	5.705	51.5	Lined screened	4.714
Angus Place Colliery	XS01	237106	6311453	Observation	Swamp	1.55	5.34	33.25	Lined screened	4.667
Angus Place Colliery	WE2	236409	6304181	Observation	Swamp	1.3	5.03		Lined screened	4.190
Angus Place Colliery	WW1	234527	6304641	Observation	Swamp	2	5.03		Lined screened	4.190
Angus Place Colliery	KCK01	233152	6304633	Observation	Swamp	2.2	5.03		Lined screened	4.190
Angus Place Colliery	WW4	234859	6305069	Observation	Swamp	2.2	5.03		Lined screened	4.190
Angus Place Colliery	WW2	234566	6304686	Observation	Swamp	2.5	5.03		Lined screened	4.190
Angus Place Colliery	WW3	234591	6304901	Observation	Swamp	2.53	5.03		Lined screened	4.190
Angus Place Colliery	NS1	235719	6304396	Observation	Swamp	2.7	5.03		Lined screened	4.190
Angus Place Colliery	NS2	235709	6304459	Observation	Swamp	2.7	5.03		Lined screened	4.190
Angus Place Colliery	WE1	236375	6304064	Observation	Swamp	2.8	5.03		Lined screened	4.190
Angus Place Colliery	KCK02	233235	6304338	Observation	Swamp	5	5.03		Lined screened	4.190
Angus Place	NS3	235992	6305049	Observation	Swamp	2.7	5.03		Lined screened	4.190

Centennial site	Bore ID	Easting	Northing	Bore use	Lithology	Bore depth (m)	pH	Mean EC (µS/cm)	Lining	Priority
Colliery										
Angus Place Colliery	NS4	236272	6305490	Observation	Swamp	2.7	5.03		Lined screened	4.190
Angus Place Colliery	KV_MB2D	229718.6	6301383	Observation	Fractured rock	18.99			Lined screened	3.905
Angus Place Colliery	KV_MB8A	229166.4	6301607	Observation	Fractured rock	13			Lined screened	3.905
Angus Place Colliery	KV_MB5D	229632.1	6302212	Observation	Fractured rock	12.2			Lined screened	3.905
Angus Place Colliery	KV_MB6S	229986.9	6301785	Observation	Fractured rock	18.51			Lined screened	3.905
Angus Place Colliery	KV_MB7A	229530.8	6301971	Observation	Fractured rock	15.8			Lined screened	3.905
Angus Place Colliery	KV_MB1S	230600	6301290	Observation	Fractured rock	29.5			Lined screened	3.619
Angus Place Colliery	KV_MB3S	230277	6301743	Observation	Fractured rock	33.25			Lined screened	3.619
Angus Place Colliery	KV_MB3D	230277	6301743	Observation	Fractured rock	41.04			Lined screened	3.619
Angus Place Colliery	KV_MB4D	230237.9	6302344	Observation	Fractured rock	30.71			Lined screened	3.619
Angus Place Colliery	KV_MB6D	229982.9	6301783	Observation	Fractured rock	27.5			Lined screened	3.619
Angus Place Colliery	KV_MB9A	229149.6	6303042	Observation	Fractured rock	21			Lined screened	3.619
Angus Place Colliery	KV_MB9B	229151.2	6303047	Observation	Fractured rock	33			Lined screened	3.619
Angus Place Colliery	KV_MB1D	230600	6301290	Observation	Fractured rock	73			Lined screened	3.476
Angus Place Colliery	AP1105SP	238869.4	6305665	Observation	Fractured rock	75			Lined screened	3.476
Angus Place Colliery	KV_MB10A	229723.9	6302889	Observation	Fractured rock	59			Lined screened	3.476
Angus Place Colliery	KV_MB10B	229729.6	6302889	Observation	Fractured rock	66.6			Lined screened	3.476
Angus Place Colliery	AP10PRB	237247.6	6306777	Observation	Fractured rock	40	5.36	16.83333	Lined unscreened	2.762
Angus Place Colliery	AP4PRB	237157.2	6308659	Observation	Fractured rock	51	5.27	23.08333	Lined unscreened	2.619
Angus Place Colliery	AP5PR	236529.8	6308525	Observation	Fractured rock	333.34	5.92	18.66667	Lined unscreened	2.381

Centennial site	Bore ID	Easting	Northing	Bore use	Lithology	Bore depth (m)	pH	Mean EC (µS/cm)	Lining	Priority
Angus Place Colliery	AP1107SP	237071.2	6310956	Observation	Fractured rock	50			Lined unscreened	2.190
Angus Place Colliery	RNW	235076	6304525	Observation	Fractured rock	50.46			Lined unscreened	2.190
Angus Place Colliery	AP1104SP	239428.7	6306147	Observation	Fractured rock	80			Lined unscreened	2.048
Angus Place Colliery	AP1PRC	238597	6307107	Observation	Fractured rock	54			Lined unscreened	2.048
Angus Place Colliery	REN	236122	6304315	Observation	Fractured rock	55.08			Lined unscreened	2.048
Angus Place Colliery	AP1102SP	239856	6308995	Observation	Fractured rock	110			Lined unscreened	1.905
Angus Place Colliery	AP1110SP	239159.4	6307947	Observation	Fractured rock	110			Lined unscreened	1.905
Angus Place Colliery	AP1204SP	236509	6309362	Observation	Fractured rock	100			Lined unscreened	1.905
Angus Place Colliery	AP8PR	237340.1	6307549	Observation	Fractured rock	405.26			Lined unscreened	1.762
Angus Place Colliery	AP9PR	237732	6306580	Observation	Fractured rock	399.52			Lined unscreened	1.762
Clarence Colliery	CLRP08	242351.3	6291961	Observation	Fractured rock	28	4.78	28.6	Lined screened	4.190
Clarence Colliery	CLRP04C	243212.5	6293119	Observation	Fractured rock	71.3	6.82	178.4	Lined screened	4.190
Clarence Colliery	CLRP15	240912	6294870	Observation	Fractured rock	116	6.11	62.9	Lined screened	3.952
Clarence Colliery	CLRP07	242180.9	6293863	Observation	Fractured rock	238	5.83	56.5	Lined screened	3.810
Clarence Colliery	CLRP05	242517.9	6297687	Observation	Fractured rock	272	5.04	28.5	Lined screened	3.762
Clarence Colliery	CLRP04A	243240.1	6293153	Observation	Fractured rock	182.5			Lined screened	3.333
Clarence Colliery	CLRP04B	243204.5	6293153	Observation	Fractured rock	182.25			Lined screened	3.333
Clarence Colliery	CC113	241691.7	6293105	Observation	Fractured rock	226			Lined screened	3.190
Clarence Colliery	CLRP10	242355.9	6295607	Observation	Fractured rock	278.14			Lined screened	3.190
Inglenook	CNG005	207960.5	6345167	Observation	Fractured rock	36.2	6.38	537.5	Lined screened	4.238
Inglenook	CNG002	210869.1	6345680	Observation	Alluvium (Clay)	16.21	6.6	572	Lined screened	4.048

Centennial site	Bore ID	Easting	Northing	Bore use	Lithology	Bore depth (m)	pH	Mean EC (µS/cm)	Lining	Priority
Inglenook	CNG008SP	210180	6340708	Observation	Fractured rock	94.5	10.57	3,195	Lined screened	3.714
Inglenook	CNG010SP	209104.5	6345860	Observation	Fractured rock	23.5			Lined screened	3.619
Inglenook	CNG014SP	208967.2	6348123	Observation	Fractured rock	48			Lined screened	3.619
Inglenook	CNG011SP	209879.8	6345308	Observation	Fractured rock	116.5			Lined screened	3.333
Lidsdale Siding	MW1	228141	6300631	Observation	Alluvium	4.7	6.71	516.57	Lined screened	5.000
Lidsdale Siding	MW5	227780	6300647	Observation	Alluvium	3.5	5.96	143.8	Lined screened	4.905
Lidsdale Siding	MW6	227575	6300440	Observation	Alluvium	3.6	6.36	399	Lined screened	4.905
Lidsdale Siding	MW3	228150	6300502	Observation	Alluvium	3.7	5.33	340	Lined screened	4.857
Lidsdale Siding	MW2	228020	6300613	Observation	Alluvium	4.7	6.12	1,253	Lined screened	4.810
Lidsdale Siding	MW4	228007	6300853	Observation	Alluvium	2.9	4.4	501.78	Lined screened	4.762
Neubeck	NEU01	225388.7	6305910	Observation	Alluvium	2.2	6.66	391.8	Lined screened	5.000
Neubeck	NEU03	225373.5	6305785	Observation	Alluvium	2.9	6.20	721.4	Lined screened	4.905
Neubeck	NEU02	225312.7	6305866	Observation	Alluvium	4.5	6.31	655.6	Lined screened	4.905
Neubeck	NB4R	225985.1	6305823	Observation	Fractured rock	30	7.39	562	Lined screened	4.333
Neubeck	NB3R	226139.8	6306068	Observation	Fractured rock	57.5	6.93	594	Lined screened	4.190
Neubeck	NBDW2R	226239.5	6306390	Observation	Fractured rock	57.5	7.01	718.25	Lined screened	4.190
Neubeck	NB2R	226103.9	6306776	Observation	Fractured rock	60.6	8.30	318	Lined screened	4.095
Neubeck	EPPGW02	227160	6303755	Observation	Fractured rock	23.5			Lined screened	3.619
Neubeck	EPPGW03	227176	6303772	Observation	Fractured rock	24			Lined screened	3.619
Neubeck	EPPGW04	227097	6303780	Observation	Fractured rock	24			Lined screened	3.619
Neubeck	EPPGW05	227094	6303738	Observation	Fractured rock	24			Lined screened	3.619
Neubeck	EPPGW06	227053	6303740	Observation	Fractured rock	24			Lined screened	3.619
Neubeck	EPPD06	228991	6308263	Observation	Fractured rock	105			Lined screened	3.333
Neubeck	NBDW1	225757	6307121	Observation	Fractured	47.4	6.59	437.75	Lined unscreened	2.905

Centennial site	Bore ID	Easting	Northing	Bore use	Lithology	Bore depth (m)	pH	Mean EC (µS/cm)	Lining	Priority
					rock					
Neubeck	NBDB3-1	225460	6306112	Observation	Fractured rock	30	6.58	499.4	Lined unscreened	2.905
Neubeck	NBDB3-2	225461	6306092	Observation	Fractured rock	29	6.97	515.25	Lined unscreened	2.905
Neubeck	NBDB3-3	225465	6306121	Observation	Fractured rock	28	7	496	Lined unscreened	2.905
Neubeck	NBDW1-2	225774	6307113	Observation	Fractured rock	53.8	6.63	435	Lined unscreened	2.762
Springvale Mine	CC1	241193	6302693	Observation	Swamp	0.95	6.53	116	Lined screened	4.810
Springvale Mine	SS02	237783	6303571	Observation	Swamp	1.6	6.61	112.3	Lined screened	4.810
Springvale Mine	GW2	240263	6303097	Observation	Swamp	0.6	6.02	50.33	Lined screened	4.714
Springvale Mine	GW1	239814	6302877	Observation	Swamp	0.71	6.38	88.5	Lined screened	4.714
Springvale Mine	GG1	240285	6302294	Observation	Swamp	0.9	5.66	51.3	Lined screened	4.714
Springvale Mine	SSE2	238831	6303352	Observation	Swamp	1	6.4	146	Lined screened	4.714
Springvale Mine	BS1	241045	6301305	Observation	Swamp	1.1	5.72	47	Lined screened	4.714
Springvale Mine	BS2	240809	6300174	Observation	Swamp	1.15	5.86	36	Lined screened	4.714
Springvale Mine	SS04	237791	6304398	Observation	Swamp	1.15	5.86	59	Lined screened	4.714
Springvale Mine	SS03	237485	6303838	Observation	Swamp	1.25	6.37	69.5	Lined screened	4.714
Springvale Mine	SS05	237782	6304627	Observation	Swamp	1.27	5.69	62.8	Lined screened	4.714
Springvale Mine	CW4	239070	6302377	Observation	Swamp	1.4	6.28	45	Lined screened	4.714
Springvale Mine	MS1	238860	6299169	Observation	Swamp	1.45	6.03	68.5	Lined screened	4.714
Springvale Mine	SSE3	239064	6303558	Observation	Swamp	1.8	5.88	98	Lined screened	4.714
Springvale Mine	SS01	237766	6303509	Observation	Swamp	1.9	5.83	74.8	Lined screened	4.714
Springvale Mine	BS3	242008	6301246	Observation	Swamp	0.8	5.29	58	Lined screened	4.667
Springvale Mine	CW1	239352	6303196	Observation	Swamp	1.2	5.22	38	Lined screened	4.667
Springvale Mine	CW2	239382	6303247	Observation	Swamp	1.35	5.32	27.25	Lined screened	4.667
Springvale Mine	CW3	238977	6302179	Observation	Swamp	1.1	5.03		Lined screened	4.190
Springvale Mine	SSE1	238668	6303143	Observation	Swamp	2.3	5.03		Lined screened	4.190
Springvale Mine	CWP	239814	6303801	Observation	Swamp	5	5.03		Lined screened	4.190
Springvale Mine	SSB	237844	6303844	Observation	Swamp	5	5.03		Lined screened	4.190

Centennial site	Bore ID	Easting	Northing	Bore use	Lithology	Bore depth (m)	pH	Mean EC (µS/cm)	Lining	Priority
Springvale Mine	SSP	237647	6304963	Observation	Swamp	5	5.03		Lined screened	4.190
Springvale Mine	SSW1	237230	6302421	Observation	Swamp	5	5.03		Lined screened	4.190
Springvale Mine	JS01	235779	6302692	Observation	Swamp	9.4			Lined screened	4.095
Springvale Mine	JS02	235784	6302749	Observation	Swamp	8.8			Lined screened	4.095
Springvale Mine	JS03	235857	6302731	Observation	Swamp	6.7			Lined screened	4.095
Springvale Mine	RSS	238072	6303500	Observation	Fractured rock	45			Lined screened	3.619
Springvale Mine	SPR1104SP	239746	6303184	Observation	Fractured rock	50.6			Lined screened	3.619
Springvale Mine	SPR1112SP	240852	6302995	Observation	Fractured rock	50.1			Lined screened	3.619
Springvale Mine	SPR1403SP	239133	6303287	Observation	Fractured rock	50.6			Lined screened	3.619
Springvale Mine	SPR1101SP	238484	6303627	Observation	Fractured rock	84.55			Lined screened	3.476
Springvale Mine	SPR1107SP	239739	6302330	Observation	Fractured rock	55			Lined screened	3.476
Springvale Mine	SPR1108SP	239840	6301075	Observation	Fractured rock	75			Lined screened	3.476
Springvale Mine	SPR1109SP	239187.9	6303322	Observation	Fractured rock	60			Lined screened	3.476
Springvale Mine	SPR1110SP	238699	6302635	Observation	Fractured rock	65			Lined screened	3.476
Springvale Mine	SPR1111SP	240404	6303962	Observation	Fractured rock	60			Lined screened	3.476
Springvale Mine	SPR1210SP	239696	6300054	Observation	Fractured rock	130			Lined screened	3.333
Springvale Mine	SPR1211SP	240239	6298938	Observation	Fractured rock	130			Lined screened	3.333
Springvale Mine	SPR1301SP	239275	6299271	Observation	Fractured rock	129.76			Lined screened	3.333
Springvale Mine	RSE	236843	6304186	Observation	Fractured rock	47			Lined unscreened	2.190
Springvale Mine	SPR1401SP	238453	6303547	Observation	Fractured rock	45			Lined unscreened	2.190
Springvale Mine	SPR1106SP	239980	6304227	Observation	Fractured rock	85			Lined unscreened	2.048
Springvale Mine	SPR1113SP	240625	6302160	Observation	Fractured rock	60			Lined unscreened	2.048

Centennial site	Bore ID	Easting	Northing	Bore use	Lithology	Bore depth (m)	pH	Mean EC (µS/cm)	Lining	Priority
Springvale Mine	SPR1402AQ	238163	6303489	Observation	Fractured rock	90.58			Lined unscreened	2.048
Springvale Mine	OS01	238139.1	6304226	Observation	Fractured rock	467.08			Lined unscreened	1.762
Western Coal Services	BH07	225486	6303099	Observation	Fractured rock	33	7.02	1,092	Lined screened	4.238
Western Coal Services	BH15	225042	6304667	Observation	Fractured rock	25.5		4,460	Lined screened	3.714
Western Coal Services	BH02	225948	6303880	Observation	Fractured rock	30	7.21	984.5	Lined unscreened	2.905
Western Coal Services	BH06	226183	6304758	Observation	Fractured rock	9.3	6.45	2,320	Lined unscreened	2.905
Western Coal Services	BH03	226175	6304416	Observation	Fractured rock	18.57	4.49	1,006	Lined unscreened	2.857
Western Coal Services	BH01	225978	6305018	Observation	Fractured rock	18.3	6.01	3,245	Lined unscreened	2.810
Western Coal Services	BH12	225667	6304819	Observation	Fractured rock	18.68		4,460	Lined unscreened	2.571
Western Coal Services	BH13	225667	6304819	Observation	Disturbed sediment	12.37		4,460	Lined unscreened	2.381
Western Coal Services	BH11	225088	6304251	Observation	Fractured rock	34.19		4,460	Lined unscreened	2.286
Western Coal Services	BH14	224866	6304259	Observation	Fractured rock	33.2		4,460	Lined unscreened	2.286
Western Coal Services	BH08	225979	6304608	Observation	Disturbed sediment	24.4	6.46	4,460	Lined unscreened	2.238
Western Coal Services	BH04	225611	6304579	Observation	Disturbed sediment	27.51		4,460	Lined unscreened	2.095
Western Coal Services	BH05	225757	6304656	Observation	Disturbed sediment	30.19		4,460	Lined unscreened	2.095
Western Coal Services	BH09	225876	6304526	Observation	Disturbed sediment	25.5		4,460	Lined unscreened	2.095
Western Coal Services	BH10	225653	6304342	Observation	Disturbed sediment	25.2		4,460	Lined unscreened	2.095

Table C2 Bore Prioritisation Updated Based on Findings of Historic Stygofauna Surveys

Centennial site	Bore ID	Easting	Northing	Bore use	Lithology	Bore depth (m)	pH	Mean EC (µS/cm)	Lining	Priority
Airly Mine	ARP09	225330.1	6332729.6	Observation	Alluvium	6.2	5.57	117.4	Lined screened	4.905
Airly Mine	ARP05	224069.35	6333272.37	Observation	Alluvium	15	5.90	138	Lined screened	4.000

Centennial site	Bore ID	Easting	Northing	Bore use	Lithology	Bore depth (m)	pH	Mean EC (µS/cm)	Lining	Priority
Airly Mine	ARP08	224967	6333826	Observation	Fractured rock	4.2			Lined screened	3.905
Airly Mine	ARP07	224692	6332554	Observation	Fractured rock	120			Lined screened	3.333
Airly Mine	Production Bore	220485	6332879	Production bore	Fractured rock	84	6.50	5,000	Lined unscreened	1.190
Angus Place Colliery	TS03	236897	6307159	Observation	Swamp	1.65	6.00	56.25	Lined screened	5.714
Angus Place Colliery	TS02	237443	6306772	Observation	Swamp	2.08	6.41	55.33	Lined screened	5.714
Angus Place Colliery	TS01	237559	6307289	Observation	Swamp	3.95	5.60	29.8	Lined screened	5.714
Angus Place Colliery	TG1	236438	6308766	Observation	Swamp	1.1	5.71	51.5	Lined screened	4.714
Angus Place Colliery	XS01	237106	6311453	Observation	Swamp	1.55	5.34	33.25	Lined screened	4.667
Angus Place Colliery	WE2	236409	6304181	Observation	Swamp	1.3	5.03		Lined screened	4.190
Angus Place Colliery	KCK01	233152	6304633	Observation	Swamp	2.2	5.03		Lined screened	4.190
Angus Place Colliery	NS1	235719	6304396	Observation	Swamp	2.7	5.03		Lined screened	4.190
Angus Place Colliery	NS2	235709	6304459	Observation	Swamp	2.7	5.03		Lined screened	4.190
Angus Place Colliery	WE1	236375	6304064	Observation	Swamp	2.8	5.03		Lined screened	4.190
Angus Place Colliery	KCK02	233235	6304338	Observation	Swamp	5	5.03		Lined screened	4.190
Angus Place Colliery	NS3	235992	6305049	Observation	Swamp	2.7	5.03		Lined screened	4.190
Angus Place Colliery	NS4	236272	6305490	Observation	Swamp	2.7	5.03		Lined screened	4.190
Angus Place Colliery	WW1	234527	6304641	Observation	Swamp	2	5.03		Lined screened	4.190
Angus Place Colliery	WW4	234859	6305069	Observation	Swamp	2.2	5.03		Lined screened	4.190
Angus Place Colliery	WW2	234566	6304686	Observation	Swamp	2.5	5.03		Lined screened	4.190
Angus Place Colliery	WW3	234591	6304901	Observation	Swamp	2.53	5.03		Lined screened	4.190
Angus Place Colliery	KV_MB2D	229718.584	6301382.999	Observation	Fractured rock	18.99			Lined screened	3.905

Centennial site	Bore ID	Easting	Northing	Bore use	Lithology	Bore depth (m)	pH	Mean EC (µS/cm)	Lining	Priority
Angus Place Colliery	KV_MB8A	229166.35	6301607.4	Observation	Fractured rock	13			Lined screened	3.905
Angus Place Colliery	KV_MB5D	229632.107	6302212.473	Observation	Fractured rock	12.2			Lined screened	3.905
Angus Place Colliery	KV_MB6S	229986.853	6301784.546	Observation	Fractured rock	18.51			Lined screened	3.905
Angus Place Colliery	KV_MB7A	229530.77	6301970.73	Observation	Fractured rock	15.8			Lined screened	3.905
Angus Place Colliery	AP10PRB	237247.63	6306777.27	Observation	Fractured rock	40	5.36	16.83333	Lined unscreened	3.762
Angus Place Colliery	KV_MB1S	230599.984	6301290.026	Observation	Fractured rock	29.5			Lined screened	3.619
Angus Place Colliery	KV_MB3S	230276.955	6301743.088	Observation	Fractured rock	33.25			Lined screened	3.619
Angus Place Colliery	KV_MB3D	230276.955	6301743.088	Observation	Fractured rock	41.04			Lined screened	3.619
Angus Place Colliery	KV_MB4D	230237.899	6302344.472	Observation	Fractured rock	30.71			Lined screened	3.619
Angus Place Colliery	KV_MB6D	229982.873	6301782.596	Observation	Fractured rock	27.5			Lined screened	3.619
Angus Place Colliery	KV_MB9A	229149.56	6303042	Observation	Fractured rock	21			Lined screened	3.619
Angus Place Colliery	KV_MB9B	229151.22	6303046.53	Observation	Fractured rock	33			Lined screened	3.619
Angus Place Colliery	KV_MB1D	230599.984	6301290.026	Observation	Fractured rock	73			Lined screened	3.476
Angus Place Colliery	KV_MB10A	229723.92	6302889.14	Observation	Fractured rock	59			Lined screened	3.476
Angus Place Colliery	KV_MB10B	229729.62	6302888.59	Observation	Fractured rock	66.6			Lined screened	3.476
Angus Place Colliery	AP1105SP	238869.4	6305665	Observation	Fractured rock	75			Lined screened	3.476
Angus Place Colliery	AP5PR	236529.76	6308525.36	Observation	Fractured rock	333.34	5.92	18.66667	Lined unscreened	3.381
Angus Place	AP4PRB	237157.21	6308658.53	Observation	Fractured rock	51	5.27	23.08333	Lined unscreened	2.619
Angus Place Colliery	RNW	235076	6304525	Observation	Fractured rock	50.46			Lined unscreened	2.190
Angus Place Colliery	AP1107SP	237071.2	6310955.7	Observation	Fractured rock	50			Lined unscreened	2.190
Angus Place Colliery	REN	236122	6304315	Observation	Fractured rock	55.08			Lined unscreened	2.048

Centennial site	Bore ID	Easting	Northing	Bore use	Lithology	Bore depth (m)	pH	Mean EC (µS/cm)	Lining	Priority
Angus Place Colliery	AP1104SP	239428.7	6306147.1	Observation	Fractured rock	80			Lined unscreened	2.048
Angus Place Colliery	AP1PRC	238596.95	6307107.14	Observation	Fractured rock	54			Lined unscreened	2.048
Angus Place Colliery	AP1102SP	239856	6308995	Observation	Fractured rock	110			Lined unscreened	1.905
Angus Place Colliery	AP1110SP	239159.4	6307946.6	Observation	Fractured rock	110			Lined unscreened	1.905
Angus Place Colliery	AP1204SP	236509	6309362.3	Observation	Fractured rock	100			Lined unscreened	1.905
Angus Place Colliery	AP8PR	237340.11	6307548.69	Observation	Fractured rock	405.26			Lined unscreened	1.762
Angus Place Colliery	AP9PR	237731.97	6306579.65	Observation	Fractured rock	399.52			Lined unscreened	1.762
Clarence Colliery	CLRP08	242351.3	6291961	Observation	Fractured rock	28	4.78	28.6	Lined screened	4.190
Clarence Colliery	CLRP04C	243212.51	6293119.36	Observation	Fractured rock	71.3	6.82	178.4	Lined screened	4.190
Clarence Colliery	CLRP15	240912	6294870	Observation	Fractured rock	116	6.11	62.9	Lined screened	3.952
Clarence Colliery	CLRP07	242180.91	6293863.06	Observation	Fractured rock	238	5.83	56.5	Lined screened	3.810
Clarence Colliery	CLRP05	242517.86	6297686.96	Observation	Fractured rock	272	5.04	28.5	Lined screened	3.762
Clarence Colliery	CLRP04A	243240.13	6293153.4	Observation	Fractured rock	182.5			Lined screened	3.333
Clarence Colliery	CLRP04B	243204.472	6293153.485	Observation	Fractured rock	182.25			Lined screened	3.333
Clarence Colliery	CC113	241691.65	6293105.44	Observation	Fractured rock	226			Lined screened	3.190
Clarence Colliery	CLRP10	242355.92	6295607.15	Observation	Fractured rock	278.14			Lined screened	3.190
Inglenook	CNG005	207960.46	6345166.97	Observation	Fractured rock	36.2	6.38	537.5	Lined screened	4.238
Inglenook	CNG002	210869.07	6345679.78	Observation	Alluvium (clay)	16.21	6.60	572	Lined screened	4.048
Inglenook	CNG008SP	210180	6340707.9	Observation	Fractured rock	94.5	10.57	3,195	Lined screened	3.714
Inglenook	CNG010SP	209104.5	6345859.8	Observation	Fractured rock	23.5			Lined screened	3.619
Inglenook	CNG014SP	208967.24	6348123.12	Observation	Fractured rock	48			Lined screened	3.619

Centennial site	Bore ID	Easting	Northing	Bore use	Lithology	Bore depth (m)	pH	Mean EC (µS/cm)	Lining	Priority
Inglenook	CNG011SP	209879.8	6345308.3	Observation	Fractured rock	116.5			Lined screened	3.333
Lidsdale Siding	MW1	228141	6300631	Observation	Alluvium	4.7	6.71	516.57	Lined screened	5.000
Lidsdale Siding	MW5	227780	6300647	Observation	Alluvium	3.5	5.96	143.8	Lined screened	4.905
Lidsdale Siding	MW6	227575	6300440	Observation	Alluvium	3.6	6.36	399	Lined screened	4.905
Lidsdale Siding	MW3	228150	6300502	Observation	Alluvium	3.7	5.33	340	Lined screened	4.857
Lidsdale Siding	MW2	228020	6300613	Observation	Alluvium	4.7	6.12	1253	Lined screened	4.810
Lidsdale Siding	MW4	228007	6300853	Observation	Alluvium	2.9	4.40	501.78	Lined screened	4.762
Neubeck	NEU01	225388.7	6305910.25	Observation	Alluvium	2.2	6.66	391.8	Lined screened	6.000
Neubeck	NEU03	225373.5	6305784.7	Observation	Alluvium	2.9	6.20	721.4	Lined screened	5.905
Neubeck	NB4R	225985.05	6305823.42	Observation	Fractured rock	30	7.39	562	Lined screened	5.333
Neubeck	NEU02	225312.7	6305866.35	Observation	Alluvium	4.5	6.31	655.6	Lined screened	4.905
Neubeck	NB3R	226139.78	6306067.78	Observation	Fractured rock	57.5	6.93	594	Lined screened	4.190
Neubeck	NBDW2R	226239.46	6306389.57	Observation	Fractured rock	57.5	7.01	718.25	Lined screened	4.190
Neubeck	NB2R	226103.86	6306775.68	Observation	Fractured rock	60.6	8.31	318	Lined screened	4.095
Neubeck	NBDW1	225757	6307121	Observation	Fractured rock	47.4	6.59	437.75	Lined unscreened	3.905
Neubeck	EPPGW02	227160	6303755	Observation	Fractured rock	23.5			Lined screened	3.619
Neubeck	EPPGW03	227176	6303772	Observation	Fractured rock	24			Lined screened	3.619
Neubeck	EPPGW04	227097	6303780	Observation	Fractured rock	24			Lined screened	3.619
Neubeck	EPPGW05	227094	6303738	Observation	Fractured rock	24			Lined screened	3.619
Neubeck	EPPGW06	227053	6303740	Observation	Fractured rock	24			Lined screened	3.619
Neubeck	EPPD06	228991	6308263	Observation	Fractured rock	105			Lined screened	3.333
Neubeck	NBDB3-1	225460	6306112	Observation	Fractured rock	30	6.58	499.4	Lined unscreened	2.905
Neubeck	NBDB3-2	225461	6306092	Observation	Fractured rock	29	6.97	515.25	Lined unscreened	2.905
Neubeck	NBDB3-3	225465	6306121	Observation	Fractured	28	7.00	496	Lined unscreened	2.905

Centennial site	Bore ID	Easting	Northing	Bore use	Lithology	Bore depth (m)	pH	Mean EC (µS/cm)	Lining	Priority
					rock					
Neubeck	NBDW1-2	225774	6307113	Observation	Fractured rock	53.8	6.63	435	Lined unscreened	2.762
Springvale Mine	CC1	241193	6302693	Observation	Swamp	0.95	6.53	116	Lined screened	5.810
Springvale Mine	GW1	239814	6302877	Observation	Swamp	0.71	6.38	88.5	Lined screened	5.714
Springvale Mine	GG1	240285	6302294	Observation	Swamp	0.9	5.66	51.3	Lined screened	5.714
Springvale Mine	SSE2	238831	6303352	Observation	Swamp	1	6.40	146	Lined screened	5.714
Springvale Mine	SSE3	239064	6303558	Observation	Swamp	1.8	5.88	98	Lined screened	5.714
Springvale Mine	CW4	239070	6302377	Observation	Swamp	1.4	6.28	45	Lined screened	5.714
Springvale Mine	CW2	239382	6303247	Observation	Swamp	1.35	5.32	27.25	Lined screened	5.667
Springvale Mine	SSE1	238668	6303143	Observation	Swamp	2.3	5.03		Lined screened	5.190
Springvale Mine	CW3	238977	6302179	Observation	Swamp	1.1	5.03		Lined screened	5.190
Springvale Mine	SS02	237783	6303571	Observation	Swamp	1.6	6.61	112.3	Lined screened	4.810
Springvale Mine	GW2	240263	6303097	Observation	Swamp	0.6	6.02	50.33	Lined screened	4.714
Springvale Mine	BS1	241045	6301305	Observation	Swamp	1.1	5.72	47	Lined screened	4.714
Springvale Mine	BS2	240809	6300174	Observation	Swamp	1.15	5.86	36	Lined screened	4.714
Springvale Mine	SS04	237791	6304398	Observation	Swamp	1.15	5.86	59	Lined screened	4.714
Springvale Mine	SS03	237485	6303838	Observation	Swamp	1.25	6.37	69.5	Lined screened	4.714
Springvale Mine	SS05	237782	6304627	Observation	Swamp	1.27	5.69	62.8	Lined screened	4.714
Springvale Mine	MS1	238860	6299169	Observation	Swamp	1.45	6.03	68.5	Lined screened	4.714
Springvale Mine	SS01	237766	6303509	Observation	Swamp	1.9	5.83	74.8	Lined screened	4.714
Springvale Mine	BS3	242008	6301246	Observation	Swamp	0.8	5.30	58	Lined screened	4.667
Springvale Mine	CW1	239352	6303196	Observation	Swamp	1.2	5.22	38	Lined screened	4.667
Springvale Mine	SPR1104SP	239746	6303184	Observation	Fractured rock	50.6			Lined screened	4.619
Springvale Mine	SPR1107SP	239739	6302330	Observation	Fractured rock	55			Lined screened	4.476
Springvale Mine	SPR1109SP	239187.9	6303321.9	Observation	Fractured rock	60			Lined screened	4.476
Springvale Mine	SSB	237844	6303844	Observation	Swamp	5	5.03		Lined screened	4.190
Springvale Mine	SSP	237647	6304963	Observation	Swamp	5	5.03		Lined screened	4.190

Centennial site	Bore ID	Easting	Northing	Bore use	Lithology	Bore depth (m)	pH	Mean EC (µS/cm)	Lining	Priority
Springvale Mine	SSW1	237230	6302421	Observation	Swamp	5	5.03		Lined screened	4.190
Springvale Mine	CWP	239814	6303801	Observation	Swamp	5	5.03		Lined screened	4.190
Springvale Mine	JS01	235779	6302692	Observation	Swamp	9.4			Lined screened	4.095
Springvale Mine	JS02	235784	6302749	Observation	Swamp	8.8			Lined screened	4.095
Springvale Mine	JS03	235857	6302731	Observation	Swamp	6.7			Lined screened	4.095
Springvale Mine	RSS	238072	6303500	Observation	Fractured rock	45			Lined screened	3.619
Springvale Mine	SPR1112SP	240852	6302995	Observation	Fractured rock	50.1			Lined screened	3.619
Springvale Mine	SPR1403SP	239133	6303287	Observation	Fractured rock	50.6			Lined screened	3.619
Springvale Mine	SPR1101SP	238484	6303627	Observation	Fractured rock	84.55			Lined screened	3.476
Springvale Mine	SPR1108SP	239840	6301075	Observation	Fractured rock	75			Lined screened	3.476
Springvale Mine	SPR1110SP	238699	6302635	Observation	Fractured rock	65			Lined screened	3.476
Springvale Mine	SPR1111SP	240404	6303962	Observation	Fractured rock	60			Lined screened	3.476
Springvale Mine	SPR1210SP	239696	6300054	Observation	Fractured rock	130			Lined screened	3.333
Springvale Mine	SPR1211SP	240239	6298938	Observation	Fractured rock	130			Lined screened	3.333
Springvale Mine	SPR1301SP	239275	6299271	Observation	Fractured rock	129.76			Lined screened	3.333
Springvale Mine	SPR1113SP	240625	6302160	Observation	Fractured rock	60			Lined unscreened	3.048
Springvale Mine	RSE	236843	6304186	Observation	Fractured rock	47			Lined unscreened	2.190
Springvale Mine	SPR1401SP	238453	6303547	Observation	Fractured rock	45			Lined unscreened	2.190
Springvale Mine	SPR1106SP	239980	6304227	Observation	Fractured rock	85			Lined unscreened	2.048
Springvale Mine	SPR1402AQ	238163	6303489	Observation	Fractured rock	90.58			Lined unscreened	2.048
Springvale Mine	OS01	238139.056	6304226.003	Observation	Fractured rock	467.08			Lined unscreened	1.762
Western Coal Services	BH07	225486	6303099	Observation	Fractured rock	33	7.02	1,092	Lined screened	4.238

Centennial site	Bore ID	Easting	Northing	Bore use	Lithology	Bore depth (m)	pH	Mean EC (µS/cm)	Lining	Priority
Western Coal Services	BH15	225042	6304667	Observation	Fractured rock	25.5		4,460	Lined screened	3.714
Western Coal Services	BH02	225948	6303880	Observation	Fractured rock	30	7.22	984.5	Lined unscreened	2.905
Western Coal Services	BH06	226183	6304758	Observation	Fractured rock	9.3	6.45	2,320	Lined unscreened	2.905
Western Coal Services	BH03	226175	6304416	Observation	Fractured rock	18.57	4.50	1,006	Lined unscreened	2.857
Western Coal Services	BH01	225978	6305018	Observation	Fractured rock	18.3	6.01	3,245	Lined unscreened	2.810
Western Coal Services	BH12	225667	6304819	Observation	Fractured rock	18.68		4,460	Lined unscreened	2.571
Western Coal Services	BH13	225667	6304819	Observation	Disturbed sediment	12.37		4,460	Lined unscreened	2.381
Western Coal Services	BH11	225088	6304251	Observation	Fractured rock	34.19		4,460	Lined unscreened	2.286
Western Coal Services	BH14	224866	6304259	Observation	Fractured rock	33.2		4,460	Lined unscreened	2.286
Western Coal Services	BH08	225979	6304608	Observation	Disturbed sediment	24.4	6.46	4,460	Lined unscreened	2.238
Western Coal Services	BH04	225611	6304579	Observation	Disturbed sediment	27.51		4,460	Lined unscreened	2.095
Western Coal Services	BH05	225757	6304656	Observation	Disturbed sediment	30.19		4,460	Lined unscreened	2.095
Western Coal Services	BH09	225876	6304526	Observation	Disturbed sediment	25.5		4,460	Lined unscreened	2.095
Western Coal Services	BH10	225653	6304342	Observation	Disturbed sediment	25.2		4,460	Lined unscreened	2.095

This report: has been prepared by GHD for Centennial Coal and may only be used and relied on by Centennial Coal for the purpose agreed between GHD and the Centennial Coal as set out in Section 1 of this report.

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The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report.

The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

The opinions, conclusions and any recommendations in this report are based on assumptions made by GHD described in this report (refer Section 1 of this report). GHD disclaims liability arising from any of the assumptions being incorrect.

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The opinions, conclusions and any recommendations in this report are based on information obtained from, and testing undertaken at or in connection with, specific sample points. Site conditions at other parts of the site may be different from the site conditions found at the specific sample points.

Investigations undertaken in respect of this report are constrained by the particular site conditions, such as the location of buildings, services and vegetation. As a result, not all relevant site features and conditions may have been identified in this report.

Site conditions (including the presence of hazardous substances and/or site contamination) may change after the date of this Report. GHD does not accept responsibility arising from, or in connection with, any change to the site conditions. GHD is also not responsible for updating this report if the site conditions change.

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