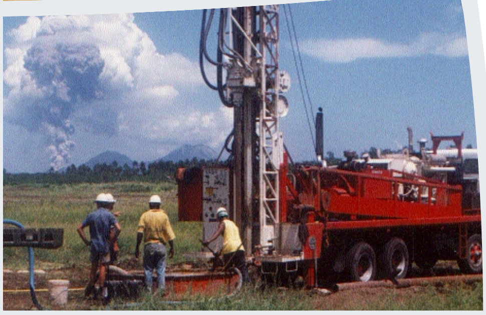
Appendix F
Groundwater Impact Assessment






Australasian
Groundwater & Environmental
Consultants Pty Ltd

REPORT on

MUSWELLBROOK COAL MINE DEVELOPMENT CONSENT MODIFICATION

GROUNDWATER IMPACT ASSESSMENT

prepared for
HANSEN BAILEY PTY LTD

Project No. G1504
June 2010

ABN:64 080 238 642

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EXECUTIVE SUMMARY

Muswellbrook Coal Company Limited (MCC) a wholly owned subsidiary of Idemitsu Kosan Co. Ltd Group operates the Muswellbrook Coal Mine (Muswellbrook Coal) in the Upper Hunter Valley of New South Wales.

This assessment forms part of a Statement of Environment Effects (SEE) being prepared by Hansen Bailey to support an application for a modification to Development Consent DA 205/2002 under Section 96(2) of the *Environmental Planning and Assessment Act 1979* (EP&A Act). The modification proposes to extend mining operations to within a 28.4ha area of which 8.2ha falls outside of the No. 1 Open Cut Extension Area (the Modification Area). A resource of 5.2 million tonnes (Mt) of coal has been identified in this area. No changes to the approved mining method, production rate, mine life or its coal transport arrangements are proposed.

The prime aquifers in the vicinity of the Modification Area that are likely to be impacted by the Modification are the Permian Greta Coal Measures.

A detailed groundwater impact assessment was undertaken by HLA Envirosciences in 2002 in support of an application for approval of the No. 1 Open Cut Extension. The study included a review of previous groundwater studies and development of a numerical groundwater flow model using MODFLOW. The study concluded that the proposed No. 1 Open Cut Extension will have negligible impact on water levels and aquifers except to lower the water level to the base of the Loder Seam, a drop in elevation of about 10m. It was stated that no mitigation measures are required for effects on groundwater from the No. 1 Open Cut Extension.

Monitoring of groundwater levels and groundwater quality is undertaken by MCC and the data indicates that groundwater levels in the St Heliers and Loder Seams fluctuate between about RL142m and RL158m and has not changed since 2002, prior to commencement of mining of the No. 1 Open Cut Extension. The groundwater from the coal seams is of poor quality with an Electrical Conductivity in the range 4500 - 6000µS/cm, and as such is only suitable for stock watering when there is no other water.

The No. 1 Open Cut Extension has been mined to a depth of RL138.5m and is currently at RL144m, and the No. 2 Open Cut is at a depth of RL43.4m. Groundwater levels in the coal measures (RL142 - 158m), however are maintained by the flooded underground workings with water being pumped into and out of the workings depending on mine requirements. The impact of mining the Modification Area, which will extend to a maximum depth of RL77m will be to lower the water level in the underground workings to this level. As such the radius of influence of the mine on the potentiometric surface will increase. A spreadsheet model based on classical groundwater flow equations indicate that the radius of influence will be about 1,050m from the mine, and as such will not extend beneath or impact the alluvial aquifers associated with the Hunter River, Sandy and Muscle Creeks.

The spreadsheet model also indicates steady state groundwater inflow to the Modification Area pit of 24ML/ year; however the water stored in the flooded underground workings will also have to be progressively lowered, that is the workings dewatered, as the Modification Area deepens.

It is assessed that as only the coal seam aquifer will be impacted, groundwater quality will not be adversely affected and there will be no impact on groundwater dependent ecosystems. There is only one registered bore within the radius of influence of the mine and it is located close to the No. 2 Open Cut.

The approved groundwater monitoring program is considered adequate; however monitoring bore RDH 615 which is within the footprint of the Modification Area will have to be relocated in the future.

In summary, it is concluded that the impact of mining within the Modification Area will be to lower groundwater levels in the flooded underground workings to about RL77m with the radius of influence on the potentiometric surface of the coal seam aquifers being approximately 1km around Muswellbrook Coal. The alluvial aquifers, groundwater quality and other groundwater users will not be impacted by the proposed Modification of the No. 1 Open Cut Extension Development Consent.

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Attachments:

Drawing No. 1 – Mine Layout
Drawing No. 2 – Mine Layout and Underground Workings

REPORT ON

MUSWELLBROOK COAL MINE DEVELOPMENT CONSENT MODIFICATION

GROUNDWATER IMPACT ASSESSMENT

1.0 INTRODUCTION

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This assessment forms part of a Statement of Environment Effects (SEE) being prepared by Hansen Bailey to support an application for a modification to Development Consent DA 205/2002 under Section 96(2) of the *Environmental Planning and Assessment Act 1979* (EP&A Act). The modification proposes to extend mining operations to within a 28.4ha area (known as Area C) of which 8.2ha falls outside of the No. 1 Open Cut Extension Area (the Modification Area). A resource of 5.2 million tonnes (Mt) of coal has been identified in this area. No changes to the approved mining method, production rate, mine life or its coal transport arrangements are proposed.

This report describes the groundwater regime of the Modification Area, existing Muswellbrook Coal operations and surrounding area and the potential impact of mining on this regime. The report has been prepared by Australasian Groundwater and Environmental Consultants Pty Ltd (AGE) at the request of Hansen Bailey Pty Ltd on behalf of MCC.

2.0 SCOPE OF WORK

The scope of work for the groundwater impact assessment is as outlined by Hansen Bailey, viz:

- *Desktop review of previous groundwater impact assessment reports, historical mining operations and groundwater monitoring data to ascertain an understanding of the existing groundwater environment;*
- *Identification of groundwater resources (including the location of all privately owned groundwater bores) in the vicinity of the site which could be impacted by the Modification;*
- *Assessment of the potential for any groundwater impacts resulting from the Modification. It is expected that no detailed groundwater modelling will be required given the extensive nature of open cut and underground mining in the vicinity of the operation.*
- *Relevant level of assessment of post-mine groundwater impacts including comment on post-mine void levels;*

- *The development of groundwater management strategies;*
- *Identification of any groundwater impact mitigation measures necessary for the Modification;*
- *A recommended post approval groundwater management program;*
- *Any other groundwater issues you consider relevant for this Modification (subject to prior approval by Hansen Bailey), and*
- *Provision of a detailed technical report.*

3.0 REGIONAL SETTING

3.1 Location

Muswellbrook Coal is located approximately 2.5km north-east of the township of Muswellbrook in the Upper Hunter Valley region of NSW, as shown on Drawing No. 1. The edge of the Hunter River floodplain is located approximately 2.8km to the west of the mine.

Surrounding open cut mining operations include Bengalla Mine (located approximately 10km to the west on the northern side of the Hunter River floodplain) and Mt Arthur Coal (located approximately 12km to the south-west on the southern side of the floodplain). Both these open cut mines extract coal from the Whittingham Coal Measures. The Drayton open cut mine, located approximately 13km to the south-south-west of Muswellbrook Coal is the only mine in the area which mines the Greta Coal Measures - that is, the same coal measures that are mined at Muswellbrook Coal.

3.2 Climate

The climate of the region is typical of temperate areas and is characterised by hot summers dominated by thunderstorms and mild dry winters.

Climate data collected by the Bureau of Meteorology (BoM)[1] is available for Jerrys Plains (Station No. 061086) located about 28km to the south-south-west of the Modification Area, and Scone (Station No. 061089) which is approximately 22km north of the Modification Area. Statistical data of mean monthly temperatures and rainfall are available from the Jerrys Plains Station for the period 1907 to 2009. However, the closest weather station to the mine to record evaporation is located at the township of Scone.

Jerrys Plains has a temperate climate with mean maximum temperatures ranging from 31.7°C in January to 17.4°C in July. Mean minimum temperatures range from 17.1°C in January to 3.8°C in July. Heat wave conditions can be expected between October and March and frosts between May and August.

The average annual rainfall at Jerrys Plains is 641.8 millimetres (mm), of which the majority falls in the warmer months of the year (November to February), with January being the wettest month (76.9mm).

Mean daily pan evaporation in the summer season reaches 7.1mm in December and 1.6mm in June. Average daily evaporation of 4.4mm/day (1606mm/year) exceeds mean rainfall throughout the year, the highest moisture deficit occurring during summer.

[1] http://www.bom.gov.au/climate/data/weather-data.shtml

In order to place recent rainfall years into an historical context, the Cumulative Rainfall Departure (CRD) shown on Figure 1, which is a summation of the monthly departures of rainfall from the long-term average monthly rainfall was calculated as follows:

$$CRD_n = CRD_{n-1} + (R_n - R_{av})$$

Where:

	CRD_n	=	CRD for a given month
	CRD_{n-1}	=	CRD for a preceding month
	R_{av}	=	long-term average rainfall for a given month
	R_n	=	actual rainfall for given month

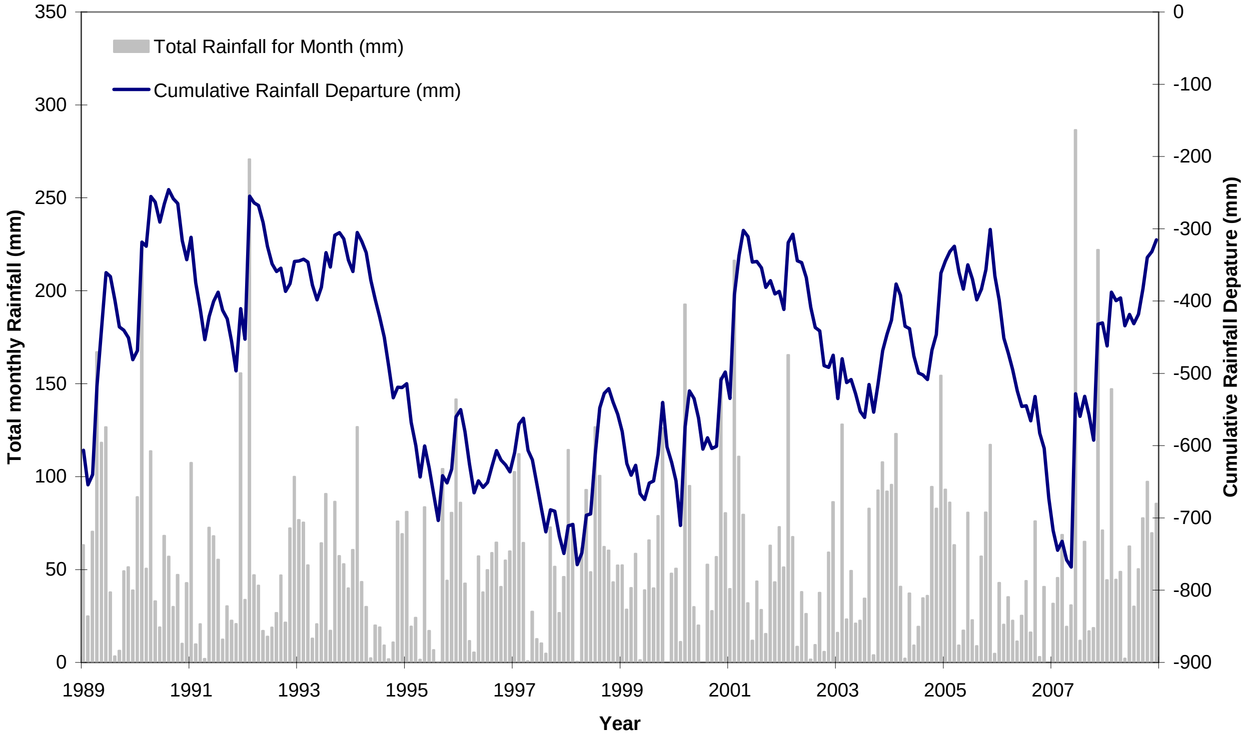


Figure 1: Cumulative Rainfall Departure Graph – Jerrys Plains (Station No. 061086)

The average monthly rainfall used to produce the CRD graph was obtained from the BoM Jerrys Plains Station (Station No. 061086), which has a continuous record for the period 1884-2009. A positive slope in the CRD plot indicates periods of above average rainfall, whilst a negative slope indicates periods when rainfall is below average. The CRD from 1994-2009 shown on Figure 1 indicates that the area experienced a period of generally below average rainfall from March 2001 until December 2003, and again between January 2006 and May 2007, but has experienced above average rainfall from then until the present.

3.3 Land Uses

The land in the vicinity of the Muswellbrook Coal and immediate surrounds has been selectively cleared for agricultural use, the predominant use being relatively low intensity cattle grazing. The rich alluvial plain of the Hunter River floodplain, approximately 2.8km to the west of the mine, however, supports a variety of intensive agricultural land uses including dairy and beef cattle grazing on improved pastures, fodder cropping, horse breeding and training.

3.4 Topography and Drainage

The topography in the vicinity of the Modification Area ranges in elevation from RL150m AHD (Australian Height Datum) on the alluvial floodplain of the Hunter River to around RL250m near the Muswellbrook Coal No. 2 Open Cut.

There are two main catchments in the vicinity of the Modification Area associated with Muscle and Sandy Creeks, both of which discharge into the Hunter River. Drainage from the Modification Area is to the north to Sandy Creek and west to the Hunter River.

The existing mining operations and Modification Area are well beyond the boundary of the alluvial floodplain and the 100-year flood limit of the Hunter River.

4.0 HISTORICAL, CURRENT AND PROPOSED MINING

Coal seams of the Greta Coal Measures are mined at Muswellbrook Coal. Underground mining commenced in 1908 and finished in 1997 with the closure of the No. 2 Underground Mine. Open cut mining commenced in 1944 in the No. 1 Open Cut and in 1972 in the No. 2 Open Cut, and continues to the present. The current and historical underground workings are shown on Drawing Nos. 1 and 2 respectively.

Current mining activities are focused on the No. 1 Open Cut Extension which was granted approval in September 2003 and began operations in March 2005. The No. 1 Open Cut Extension involves mining eastwards between the existing No. 1 Open Cut void and the previous western mining limits of the No. 2 Open Cut. The No. 1 Open Cut Extension mines through old underground workings created by the No. 2 Underground and the St. Heliers Colliery. The current depth of the No. 1 Open Cut Extension is at RL144m, although it has been mined to a depth of RL134.8m in the north-west area which has now been backfilled and rehabilitated.

The No. 2 Open Cut is also currently being mined and the base of the pit is at RL43.4m.

The Modification Area, the subject of the application for modification to the current Development Consent, is located to the immediate north and down dip of the current extent of the No. 1 Open Cut Extension void, as shown on Drawing No. 1. The Modification will continue to expose underground workings of the No. 2 Underground and St Heliers Colliery, extracting coal to the base of the Loder Seam. Mining in the Modification Area will be to a depth of about RL77m.

Mining will continue to be undertaken at a combined production rate of 2 Million tonnes per annum (Mtpa) product coal using the truck and shovel/excavator mining method.

5.0 LEGISLATION, POLICY AND GUIDELINES

The following section outlines New South Wales State Government legislation, policy and guidelines with respect to groundwater that must be addressed in assessing a mining proposal.

5.1 Water Management Act 2000

The objective of the *Water Management Act 2000* (WM Act) is the sustainable and integrated management of the State's water for the benefit of both present and future generations. The WM Act provides clear arrangements for controlling land based activities that affect the quality and quantity of the State's water resources. It provides for four types of approval:

- water use approval – which authorise the use of water at a specified location for a particular purpose, for up to 10 years;
- water management work approval;
- controlled activity approval; and
- aquifer interference activity approval – which authorises the holder to conduct activities that affect an aquifer, such as approval for activities that intersect groundwater, other than water supply bores, and may be issued for up to 10 years.

For controlled activities and aquifer interference activities, the WM Act requires that the activities avoid or minimize their impact on the water resource and land degradation, and where possible the land must be rehabilitated.

5.2 Water Sharing Plans

5.2.1 Hunter Regulated River Water Sharing Plan

The Hunter Regulated River Water Sharing Plan (HRRWSP) commenced on 1st July 2004 and applies for a period of 10 years to 30 June 2014. It is a legal document made under the WM Act and contains rules for how water is shared between the environment and water users and different categories of licences.

The HRRWSP applies to the river and tributary creeks (and associated alluvial sediments) regulated by Glenbawn and Glennies Creek Dams. The water source is divided into three management zones. These are:

1. the Hunter River from Glenbawn Dam to its junction with Glennies Creek;
2. the Hunter River downstream of its junction with Glennies Creek; and
3. Glennies Creek downstream of Glennies Creek Dam.

Muswellbrook Coal is located proximal to the first Hunter River management zone.

The vision for the HRRWSP is to achieve a healthy diverse and productive water source and sustainable management for the community, environment, towns, agriculture and industry. The HRRWSP also recognises the significance of water to the Aboriginal community.

The WM Act requires that the sharing of water must protect the water source and its dependent ecosystems and that water sharing plans establish specific environmental water rules. The environmental water rules are designed to:

- reserve all water volume above a specified limit for the environment;
- ensure that flows in the river do not drop below a prescribed minimum flow rate;

- provide water in Glenbawn and Glennies Creek Dams that can be used for water quality and other environmental management purposes; and
- preserve a portion of natural flows during periods when supplementary water access licences are permitted to extract water.

The HRRWSP provides for domestic and stock rights and native title rights – both forms of basic landholder rights which allow some extraction of water from the river without an access licence. All water extraction, other than basic landholder rights extractions, must be authorised by an access licence.

5.2.2 Water Sharing Plan for the Hunter Unregulated and Alluvial Water Sources

The Hunter Unregulated and Alluvial Water Sources Water Sharing Plan (HURAWSP) commenced on 1st August 2009 and applies for a period of 10 years to 31 July 2019. It is a legal document made under the WM Act. Water Sharing Plans for unregulated rivers and groundwater systems (such as the HURAWSP) have been completed using a “macro” or broader scale river catchment or aquifer system approach. Unregulated rivers are those which rely only on natural flow and are not regulated by releases from upstream dams.

The HURAWSP includes the Hunter unregulated river and creeks, the highly connected alluvial groundwater above the tidal limit, and tidal pool areas. A licence holder’s access to water is managed in the water sharing plan through the long-term average annual extraction limit which sets the total annual extraction rate through daily access rules.

The long term limit is a management tool against which total extraction will be monitored and managed over the 10-year life of the plan. The rules in the HURAWSP that determine when licence holders can and cannot pump on a daily basis are more specific. Basic landholder rights do not require a water access licence, however, water access licences are required for mining activities where these activities intercept an unregulated river or connected aquifer water.

With respect to groundwater, the HURAWSP includes rules that recognise that some alluvial aquifers are highly connected to their parent streams and in these circumstances, the goal of water sharing rules is to manage the surface water and highly connected groundwater as one resource.

The HURAWSP includes “cease to pump” rules that specify minimum water levels in surface water bodies and aquifers below which no extraction can be undertaken. For the groundwater users in highly connected systems the “cease to pump” rule will apply the same as for the river pumpers. For the groundwater pumpers in less connected systems, within 40 metres of the river, the cease to pump rules will apply from year six (1 August 2014) of the Water Sharing Plan and will be the same as for the river pumpers.

5.2.3 Outcomes of Water Sharing Plans for Mining Operations

Based on other recent mine developments based within the Hunter Valley area, the NSW Office of Water (NOW) is likely to require MCC to demonstrate that the Modification will achieve the following:

- no hydraulic connection between the mining operation and surface or alluvial groundwater sources governed under either the HRRWSP or the HURAWSP;

- no impacts on minimum base flows in rivers within the depressurisation cone of the mining footprint; and
- no impact of saturated thickness of alluvial groundwater sources or groundwater flow to groundwater dependent ecosystems.

5.3 State Groundwater Policy

The NSW State Government Groundwater Policy Framework Document (1997) was adopted in 1997 and aims to manage the State's groundwater resources to sustain their environmental, social and economic uses. The policy has three parts, namely the:

- NSW Government (1998a) Groundwater Quality Protection Policy, adopted in December 1998;
- NSW Government (2002) State Groundwater Dependent Ecosystems Policy adopted in 2002; and
- NSW Government (undated) Groundwater Quantity Management Policy advice.

5.3.1 Groundwater Quality Protection

The NSW Groundwater Quality Protection Policy (1998), states that the objectives of the policy will be achieved by applying the management principals listed below:

1. *"All groundwater systems should be managed such that their most sensitive identified beneficial use (or environmental value) is maintained.*
2. *Town water supplies should be afforded special protection against contamination.*
3. *Groundwater pollution should be prevented so that future remediation is not required.*
4. *For new developments, the scale and scope of work required to demonstrate adequate groundwater protection shall be commensurate with the risk the development poses to a groundwater system and the value of the groundwater resource.*
5. *A groundwater pumper shall bear the responsibility for environmental damage or degradation caused by using groundwaters that are incompatible with soil, vegetation and receiving waters.*
6. *Groundwater dependent ecosystems will be afforded protection.*
7. *Groundwater quality protection should be integrated with the management of groundwater quality.*
8. *The cumulative impacts of developments on groundwater quality should be recognised by all those who manage, use, or impact on the resource.*
9. *Where possible and practical, environmentally degraded areas should be rehabilitated and their ecosystem support functions restored."*

5.3.2 Groundwater Dependent Ecosystems

The NSW Groundwater Dependent Ecosystems Policy is specifically designed to protect valuable 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. The policy defines Groundwater Dependent Ecosystems as *"communities of plants, animals and other organisms whose extent and life processes are dependent on groundwater".*

Five management principles establish a framework by which groundwater is managed in ways that ensure, whenever possible, that ecological processes in dependent ecosystems are maintained or restored. A summary of the principles is as follows:

- groundwater dependent ecosystems (GDEs) can have important values. Threats should be identified and action taken to protect them;
- groundwater extractions should be managed within the sustainable yield of aquifers;
- priority should be given to GDEs, such that sufficient groundwater is available at all times to meet their needs;
- where scientific knowledge is lacking, the precautionary principle should be applied to protect GDEs; and
- planning, approval and management of developments should aim to minimise adverse affects on groundwater by maintaining natural patterns, not polluting or causing changes to groundwater quality and rehabilitating degraded groundwater ecosystems where necessary.

5.3.3 Groundwater Quantity Protection

The objectives of managing groundwater quantity in New South Wales are:

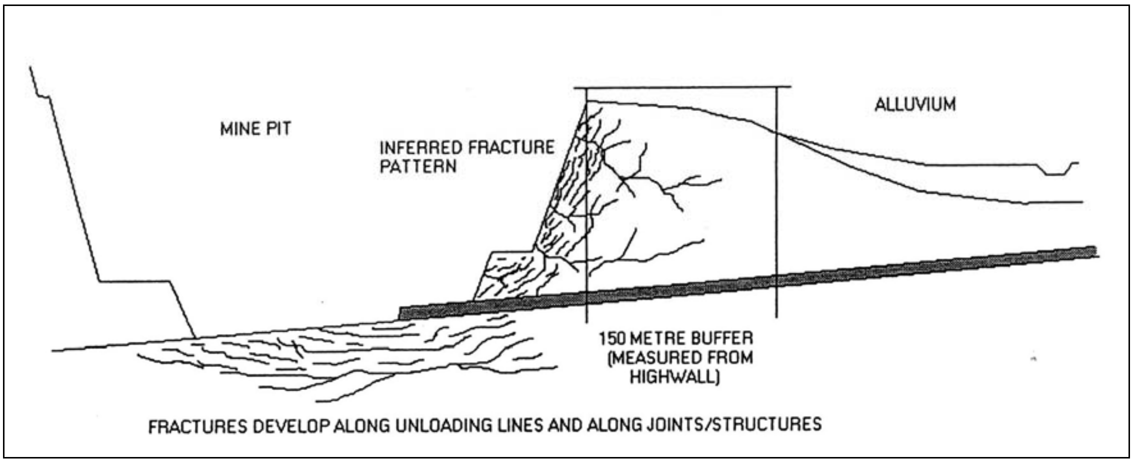
- *"to achieve the efficient, equitable and sustainable use of the State's groundwater;*
- *to prevent, halt and reverse degradation of the State's groundwater and their (sic) dependent ecosystems;*
- *to provide opportunities for development which generate the most cultural, social and economic benefits to the community, region, state and nation, within the context of environmental sustainability; and*
- *to involve the community in the management of groundwater resources."*

5.4 Aquifer Risk

The NSW Government (1998b) "Aquifer Risk Assessment Report" used a number of criteria to classify risks to various significant groundwater resources across the State. It classified the regulated reaches of the Hunter Valley Alluvium as a "high risk aquifer" and the Hunter Miscellaneous Tributaries Alluvium as "medium risk aquifers".

5.5 Buffer Zone Guidelines

Guidelines were prepared for the Hunter Region in April 2005, by the Department of Infrastructure, Planning and Natural Resources (DIPNR 2005), now the Department of Environment, Climate Change and Water to assist the coal mining industry in managing risks when mining close to streams using either longwall or open cut mining methods. The guidelines relate to the classification of a stream that may be impacted by mining and indicates that NOW will adopt a precautionary approach to mining in the vicinity of Schedule 3 streams, such as the Hunter River, and associated alluvial aquifers. With respect to open cut mining next to a Schedule 3 stream, the guideline requires a buffer of 150m between the mining area and the stream and its related alluvium as shown on Figure 2. The guideline states that *"the buffer provides a front line protection for surface and groundwater quality and managing connectivity"*.



Source: DIPNR Hunter Region (April 2005)

Figure 2: Buffer zone requirement for open cut mining operation next to river / alluvium

6.0 PREVIOUS INVESTIGATION

A detailed hydrogeological investigation of Muswellbrook Coal and an assessment of the impact of mining on the hydrogeological regime was undertaken by HLA Envirosciences (HLA) in 2002[2], as supporting documentation for approval for the No. 1 Open Cut Extension. The study also relied on groundwater investigations undertaken by Australian Groundwater Consultants (AGC) in 1984[3] and Douglas Partners Pty Ltd (DP) in 1997[4].

The study described the groundwater regime of the area around the mine, assessed the volume of water stored in the flooded underground workings and developed 3D numerical groundwater flow model using the MODFLOW software to predicted groundwater inflow to the proposed open cut extension.

Annual Environmental Management Reports (AEMR) have also been prepared by MCC describing the groundwater monitoring results and the impact of mining on the groundwater regime.

[2] HLA-Envirosciences Pty Ltd, (June 2002), *"Muswellbrook Coal Company Limited No. 1 Open Cut Extension, Water Management Study".*

[3] Australian Groundwater Consultants Pty Ltd, (June 1984), *"Effects of Mining on Groundwater Resources in the upper Hunter Valley"* NSW Coal Association

[4] Douglas Partners Pty Ltd, (December 1997), *" Preliminary Report on Hydrogeological Assessment, Proposed Landfill, Muswellbrook"*

7.0 SITE GEOLOGY

7.1 Stratigraphy

The geology of the area is based on the Hunter Coalfield Regional Geology 1:100,000 scale map, (NSW, Department of Mineral Resources, 2nd Ed. 1993).

The stratigraphic sequence across Muswellbrook Coal comprises a Permian coal seam sequence with an overburden and interburden consisting of lithic sandstone, interbedded with siltstone, tuffaceous claystone and mudstone. The Permian rocks from a regular layered sedimentary sequence consisting of two main units:

- the Maitland Group which includes the Branxton Formation that consists mostly of siltstone and sandstone; and
- the Greta Coal Measures that contain economic coal seams in the Rowan Formation.

The Greta Coal Measures which outcrop are of early to middle Permian age and are about 110m thick.

The major coal seams that are mined at Muswellbrook Coal are the Fleming, Hallett, Muswellbrook, St Heliers, Upper and Lower Lewis Seams and the Loder Seam which occur over a stratigraphic interval of about 60m, as shown on Figure 3. The seams range from 1m to 9.5m in thickness. The coal seams within the Modification Area may be affected by igneous intrusions, including doleritic dykes and sills.

Alluvial deposits which occur along Muscle and Sandy Creeks coalesce with the extensive alluvial floodplain of the Hunter River. The alluvial deposits of the Hunter River are a minimum 2.8km from the Modification Area, and of Sandy and Muscle Creeks, 2km and 2.5km respectively.

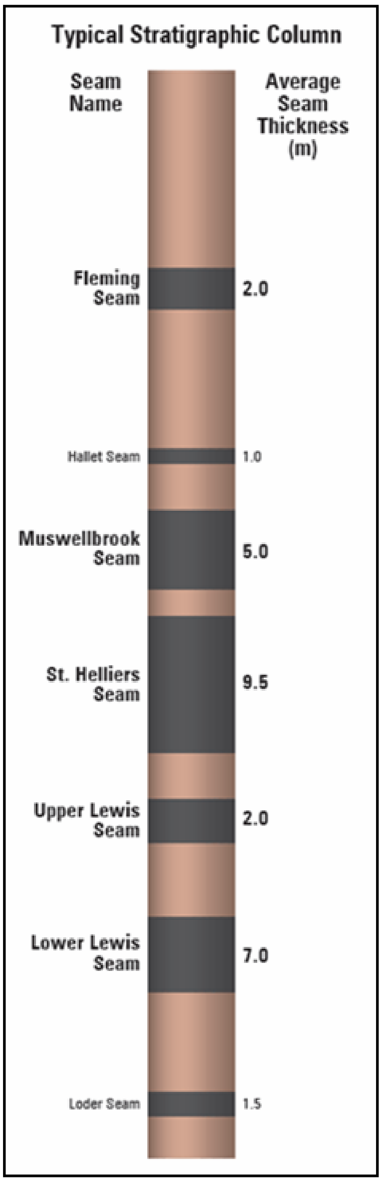


Figure 3: Stratigraphic Column

7.2 Structure

The coal measures within the region form part of the Muswellbrook Anticline, which trends north-south and is truncated to the east by the Aberdeen Thrust Fault. The Modification Area is located at the crest of the Muswellbrook Anticline where the Greta Coal Measures sub crop and dip to the north-west at about 7º.

The Aberdeen Thrust Fault dips to the east and trends approximately north-south. It has a displacement of approximately 400m vertical and 30km horizontal and intersects the No. 2 Open Cut. As a consequence of the faulting the younger Whittingham Coal Measures are exposed to the east of the fault.

HLA (2002)[2] report that there area seven laterally extensive, normal, north-east/south-west trending faults located to the east of the No. 1 Open Cut, that displace the seams by between 2m to 20m. The fault with a 20m displacement has been observed in the eastern highwall of the No. 1

Open Cut and HLA (2002)[2] note that similar faults observed elsewhere in the Hunter Valley act as barriers to groundwater flow.

8.0 GROUNDWATER REGIME – EXISTING ENVIRONMENT

Given that the HLA (2002)[2] study was extensive and that the Modification Area, subject of the application for modification to the Development Consent, is quite small (28.4ha) and is a continuation to the north of the current No. 1 Open Cut Extension, a detailed on-site investigation was not undertaken. Instead this report relies heavily on the work undertaken by HLA (2002)[2] and the earlier studies by DP (1997)[4] and AGC (1984)[3], supplemented by monitoring and data contained in the AEMR of June 2009[5].

In summary the following description of the groundwater regime is based on the site geology, the Muswellbrook Coal 2009 AEMR and past groundwater investigations undertaken at the site.

8.1 Groundwater Occurrence

Based on the geology and site location, it is assessed that there are two aquifer systems, viz:

- weathered bedrock (regolith); and
- the Permian coal measures

As discussed, the Modification Area is elevated and the nearest alluvial aquifers are associated with the Hunter River and Sandy and Muscle Creeks, well beyond the lease boundaries and influence of the Modification. Alluvial aquifers are therefore not discussed further in this report.

Apart from the aquifer systems, groundwater is also stored in the old, flooded, underground, bord and pillar workings of the No. 2 Underground and St Heliers Colliery.

There is also large area where recent and old spoil has been emplaced which HLA (2002)[2] state was laid in north-south strips in the No. 1 Open Cut and east-west strips in the No. 2 Open Cut. Infiltration of rainfall on the spoil and groundwater inflow from the side walls will over time develop of “spoil aquifer” that will discharge water from the low-wall to current pit workings or the final void.

8.2 Shallow Bedrock (Regolith) Aquifer

The regolith or shallow bedrock aquifer comprises surficial soils and weathered bedrock. The depth of the aquifer is variable and depends on such factors as:

- depth of weathering; and
- extent and frequency of fracturing.

Based on studies undertaken at other mine sites in the Upper Hunter region, the coal measures tend to weather to a relatively thin regolith (5m to 10m thick) comprising mixed sandy, silty-clayey sediments. Perched aquifers may occur at the interface between soils and bedrock in zones of locally increased permeability caused by weathering of the bedrock. Rainfall recharge to the shallow groundwater systems associated with the regolith is often variable, as silty-clayey zones have poor

[5] Muswellbrook Coal Company Limited, *“Annual Environmental Management Report (AEMR), 1 July 2008 and 30 June 2009”.*

transmission characteristics whereas sandy areas offer increased potential for groundwater recharge.

The regolith acts as a temporary water store during sustained wet periods and provides a source of recharge to the underlying coal measures. However, recharge to the underlying coal measures is inferred to be limited given the very low hydraulic conductivities of deeper strata and observed minimal change in water levels in deep monitoring bores throughout the region. This differentiation in properties between the regolith and underlying coal measures can sometimes result in the presence of shallow springs although none are noted within the Modification Area.

8.3 Permian Aquifers

The Permian strata may be categorised into the following hydrogeological units:

- hydrogeologically “tight” and hence very low yielding to essentially dry sandstone and lesser siltstone and mudstone that comprise the majority of the Permian interburden / overburden; and
- low to moderately permeable coal seams which are the prime water bearing strata within the Permian sequence.

8.3.1 Distribution

As discussed the Permian deposits occur across the whole of the Modification Area as a regular layered sedimentary sequence.

8.3.2 Hydraulic Parameters

The permeability of the coal seams is associated with cleats and closely spaced jointing with no preferred orientation. There is little or no primary porosity in the interburden and overburden, the permeability being associated with joint and fractures where they occur. As discussed the interburden is hydrogeologically “tight” and based on studies undertaken by AGC (1984)[3] and DP (1997)[4] is on average two orders of magnitude lower than the coal seams.

HLA (2002)[2] report a database of 14 packer test measurements of specific horizons at Muswellbrook Coal, as shown on Table 1 below. Overall the coal seams exhibit a permeability range from about 0.25m/day near the surface, to about 0.001m/day at a depth of 130m, whereas overburden and interburden permeabilities range from about 0.01m/day at surface, to about 0.0001m/day at a depth of 100m. The coal seam permeability data indicates a good relationship between depth of cover and horizontal permeability.

Table 1: MUSWELLBROOK COAL - PACKER TEST DATA								
Test or Bore	Test Interval (mbGL) (from)	(to)	Tested Coal Seam	Hydraulic Conductivity (m/day)	Average Test Depth (mbGL)	Reference	Comments
315	36.9	46.0	Overburden	2.20×10^{-3}	41.4	AGC 1984	
315	55.5	66.9	Overburden	7.20×10^{-4}	61.2	AGC 1984	
315	66.9	77.0	Coal	5.80×10^{-2}	71.9	AGC 1984	
315	74.9	84.0	Coal	2.90×10^{-3}	79.4	AGC 1984	
315	96.2	106.0	Flemming	3.40×10^{-2}	101.1	AGC 1984	
315	105.1	115.0	Hallet	3.00×10^{-3}	110.1	AGC 1984	
315	112.3	122.0	Muswellbrook	2.20×10^{-3}	117.2	AGC 1984	
315	124.9	134.0	St. Heliers	1.80×10^{-3}	129.5	AGC 1984	
315	131.6	142.0	Upper Lewis	1.60×10^{-3}	136.8	AGC 1984	
101	13.5	20.25	Overburden	6.90×10^{-3}	16.9	DP1997	
101	19.3	29.5	Overburden	1.70×10^{-3}	24.4	DP1997	
102	7	15	Loder Seam	2.5×10^{-1}	11.0	DP1997	
103	45	51	Muswellbrook	8.60×10^{-4}	48.0	DP1997	Sintered coal (diorite IB)
103	75	83.8	Upper Lewis	1.70×10^{-3}	79.4	DP 1997	Sintered coal (diorite IB)

A reduction in the hydraulic conductivity of the coal seam aquifers with depth is observed in many coal mines. AGC (1984)[6] developed an equation based on the interpretation of depth-dependent hydraulic conductivities of 17 seams in the Upper Hunter Valley as shown below:

$$k = k_o * e^{(-cz)}$$

with

k	=	hydraulic conductivity [m/day]
k_o	=	reference hydraulic conductivity = 5 [m/day]
c	=	slope of trendline (0.046 for Hunter Valley coal seams)
z	=	depth [m]
e	=	base of the natural logarithm (approximately 2.71828182846)

Applying the above equation allows prediction of the value of hydraulic conductivity of the interburden for different depths.

Permeability tests on two of the igneous (diorite) sills by AGC (1984)[3] indicate a slightly higher permeability than the coal seams of 1.5m/day for a sill at 80m depth and 1.4m/day for a sill at 50m depth.

[6] Australian Groundwater Consultants Pty Ltd, (June 1984), *"Effects of Coal Mining on Groundwater Resources in the Upper Hunter Valley",* Volume 1.

HLA (2002)[2] also report a reasonable estimate of the horizontal permeability of the open cut mine spoil at Muswellbrook Coal is 1m/day based on the water table level in the spoil and direction of flow. They also state that a reasonable estimate of storativity for mine spoil is 15%.

8.4 Recharge and Groundwater Flow

Groundwater recharge is by rainfall infiltration in the seam sub crop areas and via the regolith. Prior to mining at Muswellbrook Coal, the water table / piezometric surface of the coal measures aquifer system most likely formed a subdued reflection of the topography, with a groundwater mound beneath the topographically elevated areas along the crest of the Muswellbrook Anticline, and with groundwater flow to the creeks and Hunter River, similar to surface water flow. The maximum pre-mining groundwater level reported by HLA (2002)[2] was about RL230m to the immediate east of the No. 2 Open Cut, and RL210m in the Modification Area.

Underground and open cut mining at Muswellbrook Coal has extensively modified the water table / piezometric surface with a cone of depression around the existing pits. This has modified groundwater flow, with flow within the cone of depression being towards the pits where it is captured by strategically located sumps and used for dust suppression and in the Coal Preparation Plant, or is pumped back into the underground workings.

9.0 MONITORING OF IMPACT OF CURRENT MINING OPERATIONS

9.1 Mine Dewatering and Groundwater Levels

As stated previously the No.1 Open Cut Extension and the No. 2 Open Cut are currently being mined at Muswellbrook Coal.

MCC holds five licences under Part 5 of the *Water Act 1912*. Table 2 provides a summary of the licences and the volumes of groundwater that were extracted during the 2008-09 reporting period.

Table 2: SUMMARY OF GROUNDWATER EXTRACTED 2008-09

Bore/Location	License No.	Extraction Volume (ML)	Extraction Entitlement (ML)	Comment
	20BL168008	0	NIL	
RDH 529 (borehole pump #1)	20BL169014	88	1,000 ML pa	No. 2 Underground (St Heliers Seam)
No.1 O/C void	20BL169037	0	2,000 ML pa	Pit Floor RL 144.0m
No.2 O/C void	20BL169038	914	2,000 ML pa	Pit Floor RL13.4m
	20BL168337	0	4,000 ML pa	
RDH 607 (borehole pump #2)	20BL170473	396	3,000 ML pa	No. 2 Underground (St Heliers Seam)

During 2008-09, MCC pumped 914ML from the No. 2 Open Cut, which is at a depth of RL43.4m, to keep the pit dewatered. Some of this water was used in the Coal Preparation Plant and some was pumped to the No. 2 Underground workings. MCC also periodically pump the brackish to saline water in the flooded underground mine workings by two separate borehole pumps for use in dust suppression, the Coal Preparation Plant or for direct spontaneous combustion quenching and dust suppression at the No. 1 Open Cut. A total of 484ML was pumped from the St Heliers Seam of the flooded No. 2 Underground workings in 2008-09. The location of bores RDH 529 and RDH 607 from which groundwater from the underground workings is pumped is shown on Drawing No. 1.

The groundwater level in the area of the No.2 Open Cut is monitored in bore RDH 522 which intersects the flooded St Heliers Seam in the No.2 Underground workings. The monitoring data shows that the water level in the flooded workings varies between about RL148m and RL158m as shown on Figure 4, probably reflecting pumping into or out of the workings. In contrast the pit floor is at RL43.4m, that is, a difference in elevation of up to 115m between the pit floor and the flooded workings. MCC maintain a 40m barrier between the flooded underground and the pit. It is considered that much of the 914ML of water pumped from the pit during 2008-09 to keep it dewatered was likely seepage from the flooded underground via the barrier. The high head difference and relatively narrow barrier confirms the low permeability of the coal seams and interburden, and supports the HLA (2002)[2] statement that *changes in groundwater levels in the coal measures are largely dictated by the water storage strategy for the No. 2 Underground*.

The monitoring data indicates that groundwater levels have remained relatively constant in the flooded No. 2 Underground with a level of RL154.7m being recorded in January 2002 prior to commencement of the No. 1 Open Cut Extension.

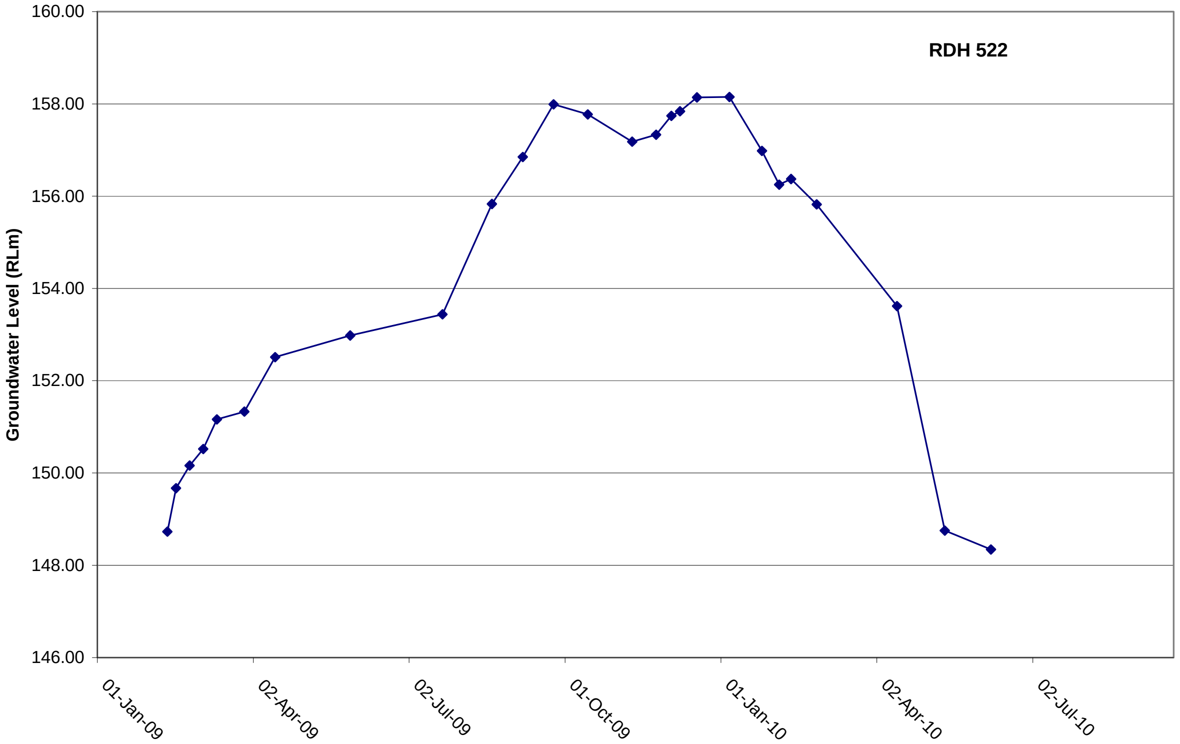


Figure 4: Water Level Monitoring Data from No. 2 Underground – St Heliers Seam

Monitoring in the area of the No. 1 Open Cut Extension indicates that groundwater levels have fluctuated between about RL142-150m in the flooded No. 2 Underground workings (St Heliers Seam) to between RL146-159m in the Loder Seam, as shown on Figure 5. This compares to a pit floor level varying from RL134.8m to RL144m at the present.

With respect to Figure 5, it should be noted that bore RDH 472 which was connected to the St Heliers Colliery workings (St Heliers Seam), was closed and decommissioned and replaced by RDH 615.

The groundwater level in RDH 615 which is set in the deeper Loder Seam indicates a higher level than in the flooded workings and this may be because the Loder Seam has not been depressurized to the extent of the St Heliers Seam, or because there is a groundwater gradient to the dewatered workings. MCC also advise that the water level in the flooded workings may now be higher than recorded in January 2007 due to the 2007 floods which recharged the workings and also because MCC has pumped water into the workings from pit dewatering and for spontaneous combustion control.

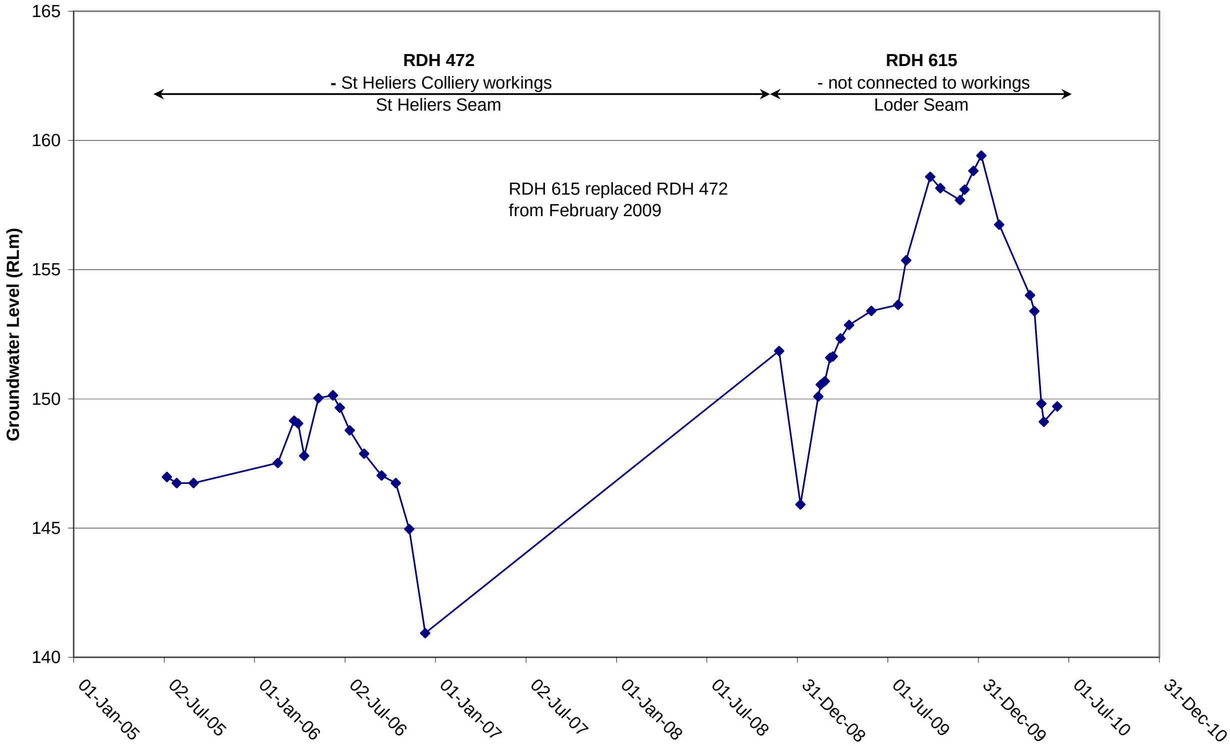


Figure 5: Water Level Monitoring Data from St Heliers Colliery

9.2 Groundwater Quality

Groundwater quality monitoring in the area of the No. 1 Open Cut Extension and the Modification Area was undertaken in bore RDH 472 from January 2006, and in RDH 615 which replaced RDH 472, since February 2009. Bore RDH 529 has been used for water quality monitoring in the area of No. 2 Open Cut. Bores RDH 472 and RDH 529 monitor the St Heliers Seam and RDH 615 the Loder Seam. The data indicates a poor quality, brackish to saline water with an Electrical Conductivity (EC) in the range 4500 - 6000µS/cm. The pH of the coal seam groundwater fluctuates between slightly acid to slightly alkaline, pH6.5 – 8.0.

Graphs of the EC and pH are shown on Figure 6 and Figure 7.

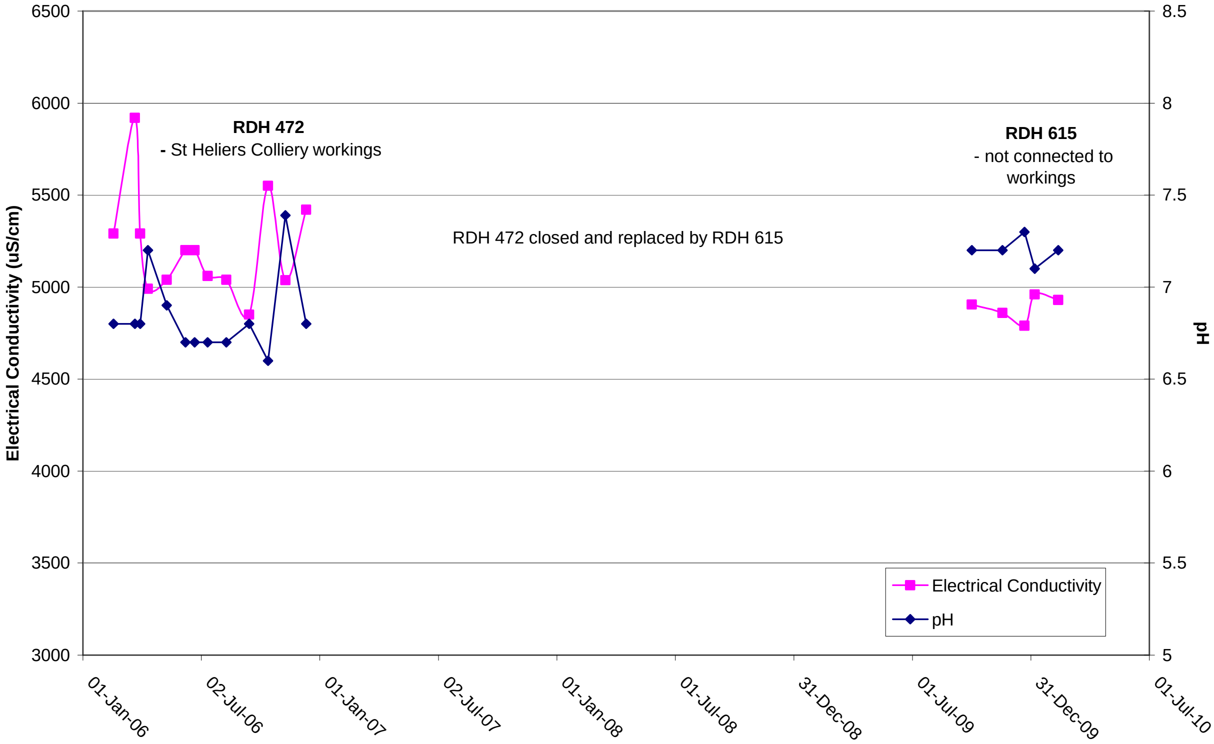


Figure 6: Groundwater Quality St Heliers Seam – No. 1 Open Cut Extension

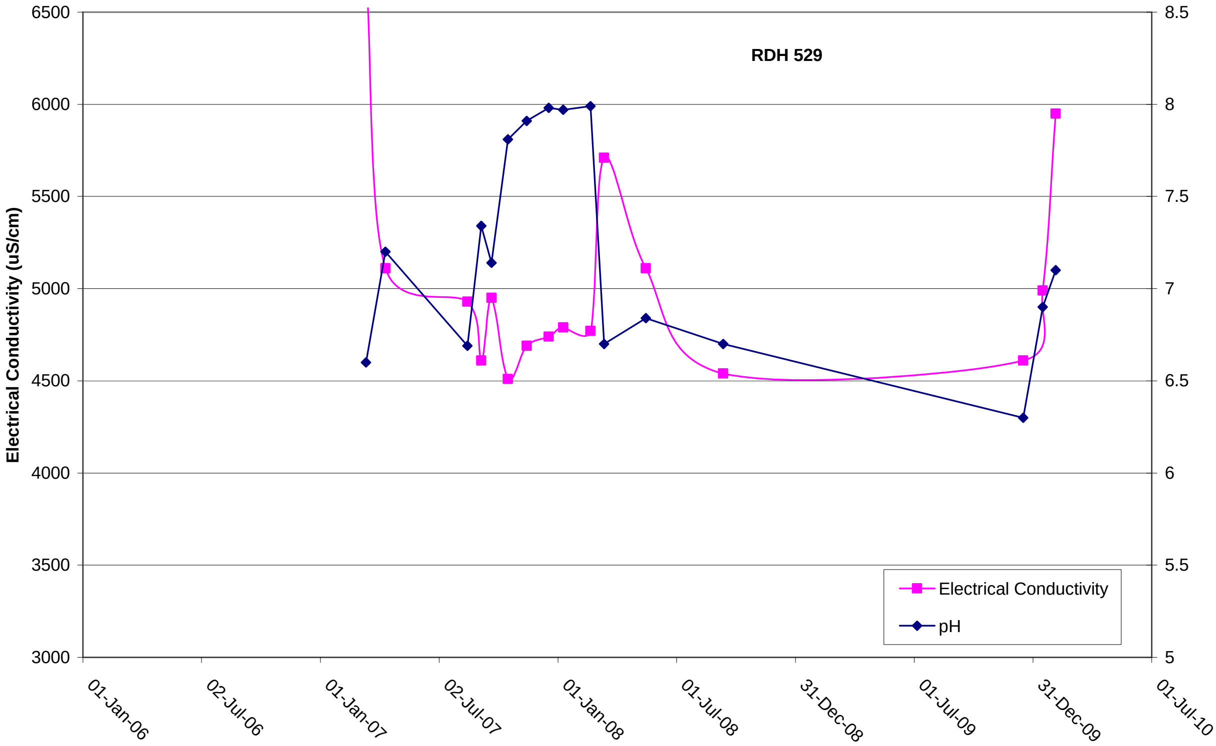
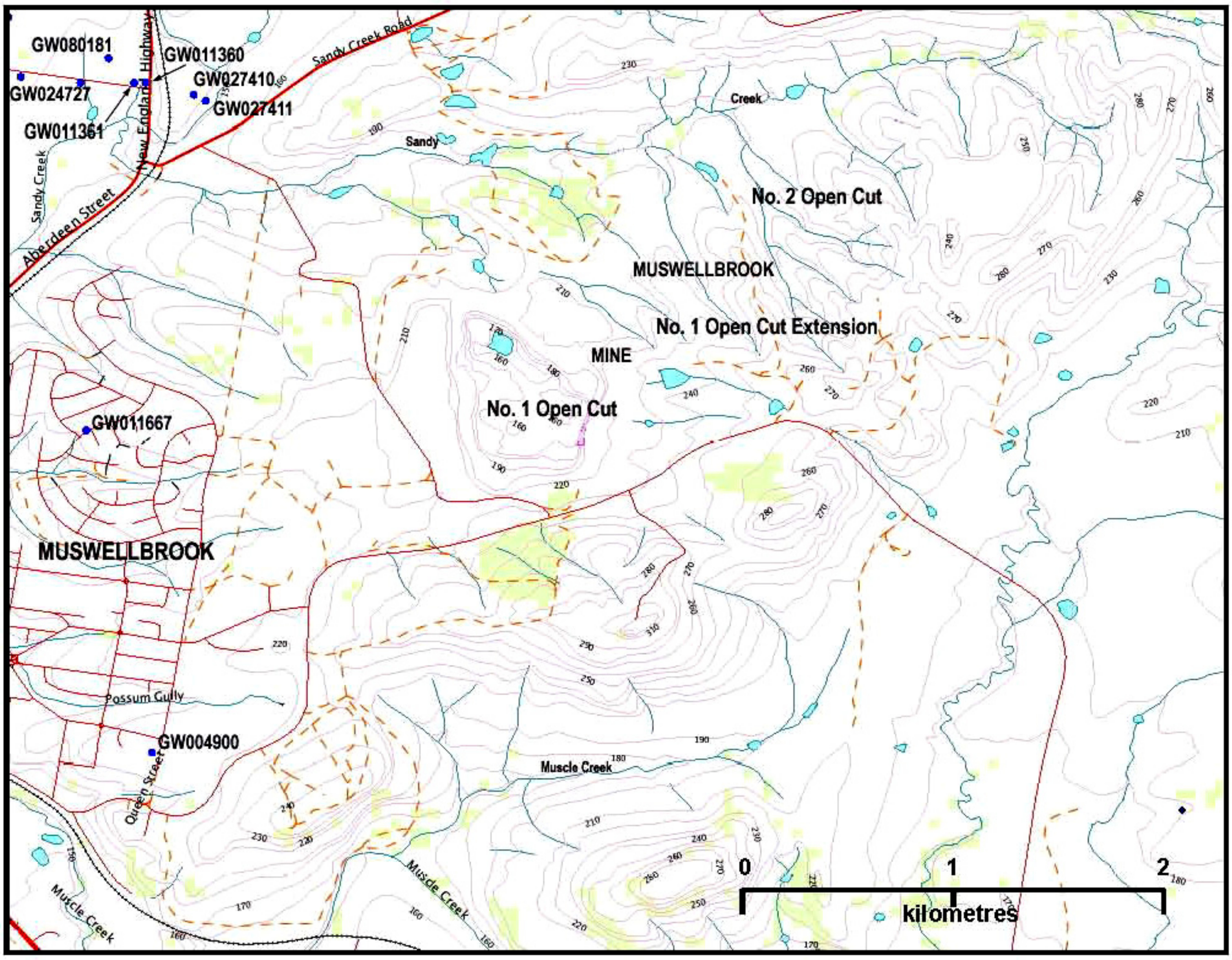


Figure 7: Groundwater Quality No. 2 Open Cut / Underground – St Heliers Seam

10.0 GROUNDWATER USE, QUALITY AND ENVIRONMENTAL VALUE

10.1 Groundwater Use – NOW Database

A search of the NSW Office of Water (NOW) database of registered bores and wells within a 2.5km radius of the Modification Area indicates that there are eight registered bores within this radius, as shown on Figure 8 and summarized in **Table 3**. Figure 8 indicates that most of the registered bores are concentrated in the alluvial area at the confluence of Sandy Creek and the Hunter River alluvial plain. The majority of the registered bores are at least 2km from the mine. The registered bores are primarily licensed for irrigation or industrial use with one or two for stock or domestic use.



Map created with NSW Groundwater Works – http://nratlas.nsw.gov.au

Figure 8: Plan showing NOW Registered Bores

Table 3: REGISTERED BORES WITHIN 2.5KM RADIUS OF MODIFICATION									
Registered No.	Licence No	Location (mE)	(mN)	Depth	Yield (L/s)	Salinity	Aquifer	Purpose
GW004900		6427819	302497	57.90	nr	nr	conglomerate	
GW027411	20BL019528	6431181	302667	nr	nr	nr	nr	Irrigation
GW027410	20BL145581	6431211	302614	12.20	Nr	good	nr	Irrigation
GW011360	20BL004515	6431268	302403	7.90	10.10	good	gravel	Industrial
GW011361	20BL004516	6431267	302351	7.90	10.10	good	gravel	Industrial
GW011667	20BL005300	6429477	302176	8.50	Nr	nr	gravel	Domestic
GW080181	20BL150465	6431392	302236	nr	Nr	nr	nr	Irrigation
GW024727		6431263	302115	nr	Nr	nr	nr	Stock

Note: nr = not recorded

10.2 Groundwater Quality and Environmental Value

10.2.1 Terminology

An assessment was made of the groundwater quality in terms of Australia New Zealand Environment Conservation Council (ANZECC) criteria and environmental value. The ANZECC (2000)[7] guideline refers to "environmental value" rather than "beneficial use" which is often used, and state that the term beneficial use has lost favour because of its exploitative connotations. For this reason the term "environmental value" has been adopted by the National Water Quality Management Strategy (NWQMS). The following environmental values are recognised in the NWQMS Guidelines:

- aquatic ecosystems;
- primary industries (irrigation and general water uses, stock drinking water, aquaculture and human consumption of aquatic foods);
- recreation and aesthetics;
- drinking water;
- industrial water; and
- cultural and spiritual values.

The guidelines state that *"where two or more agreed environmental values are defined for a water body, the more conservative of the associated guidelines should prevail and become the water quality objective".* The assessment of "environmental value" given in this report is based on this guideline.

10.2.2 Groundwater Quality

HLA (2002)[2] state that water quality analysis for 12 wells intersecting un-worked Greta Coal Measures indicate a mean EC of 5535 µS/cm and a mean pH of 7.6. Groundwater in the Greta Coal Measures in the Modification Area is dominated by sulfate and chloride. Monitoring undertaken by MCC since 2006 confirms an EC range of 4500-6000µS/cm and pH range of 6.5-8.0 for the St Heliers Seam, as discussed in Section 9.2. As such the water is not suitable for

[7] Australian and New Zealand Environment and Conservation Council, (2000), *"Australia and New Zealand Guidelines for Fresh and Marine Water Quality".* National Water Quality Management Strategy, Chapt. 3 Aquatic Ecosystems.

potable uses or for irrigation and is generally only useful for stock consumption during dry periods when better quality water is not available.

10.2.3 Environmental Value

The data shows that groundwater in the Permian strata is of poor quality and is typical of coal seam water quality. The general low yield and poor quality of the groundwater in the coal seams indicates that the environmental value can be classified as “primary industry” with the main potential use being for stock watering.

The alluvium is outside of the area of influence of Muswellbrook Coal and in particular the area of impact of the Modification Area and therefore has not been discussed or given an environmental value.

11.0 IMPACT OF OPEN CUT MINING THE MODIFICATION AREA

11.1 Numerical Modelling of Open Cut No. 1 Extension

HLA (2002)[2] developed a sophisticated 3D, numerical, groundwater flow model using the MODFLOW software to assess the impact of the then proposed No. 1 Open Cut Extension. The model consisted of 10 layers with layers 4 to 8 consisting of the coal seams to be mined and the interburden to the next mined seam.

The model domain covered an 8km x 8km area with Sandy Creek, Muscle Creek and the Hunter River forming the northern, southern and western boundaries respectively and the groundwater divide beneath Bell Mountain, the eastern boundary. The model was calibrated to steady state conditions of the measured groundwater level in six open resource holes. Calibrated recharge was 3.1% of the mean annual rainfall at Muswellbrook High School.

Predictive modelling consisted of transient simulation of the No. 1 Open Cut Extension mining activities from 2003 to 2011. The simulation indicated that inflow to the proposed No. 1 Open Cut extension increased from about 0.056ML/day (20.5ML/year) in 2003, to a maximum of around 0.22ML/day (80.3ML/year) in 2009-10. In addition the predictive simulations indicated a relatively stable inflow to the combined No. 2 Open Cut and No. 2 Underground Mines of 0.1ML/day (36.5ML/year) and about 0.14ML/day (51.0ML/year) to the No. 1 Open Cut Mine.

HLA (2002)[2] did not report the predicted radius of influence of mine dewatering on the potentiometric surface. They stated that changes in groundwater levels in the coal measures are largely dictated by the water storage strategy for the No. 2 Underground and that the proposed extension itself will have negligible impact on water levels and aquifers, except to lower the water levels to the base of the Loder Seam instead of the Lewis Seam (a drop in elevation of around 10m).

HLA (2002)[2] concluded that *“the proposed extension mines through strata and groundwater regimes already disturbed by mining. Mining will lower the water levels in the Greta Coal Measures to the base of the Loder Seam over a small area. In the wider area, water levels will fall to the Lewis Seam when the Sandy Creek underground mine commences. The Loder Seam contains brackish water and is not considered a groundwater resource”.*

The report reasoned that *"the proposed mining should improve the groundwater regime in the area because a large portion of mined workings will have been removed and replaced with spoil, creating a better environment for groundwater recovery and improved groundwater quality".*

HLA also concluded that *"the proposed extension itself will have negligible impact on water levels and aquifers, except to lower the water levels to the base of the Loder Seam instead of the Lewis Seam (a drop in elevation of around 10m)".* They state that *"no mitigation measures are required for effects on groundwater from the proposed extension".*

11.2 Spreadsheet Model

An additional 3D numerical model has not been developed for the current impact assessment of the Modification Area as:

- the detailed predictive model developed by HLA (2002) to assess the impact of the No. 1 Open Cut Extension encompasses the extent of the Modification Area;
- monitoring has shown that the model predictions are reasonably accurate; and
- The Modification Area is quite small and adjoins the No. 1 Open Cut Extension.

However a spreadsheet model was developed in order to provide a broad assessment of the radius of influence of mining the Modification Area on the piezometric surface of the coal measures aquifer system, and inflow to the Modification Area pit from the coal measures.

The equation developed by Marinelli and Niccoli (2002)[8] for inflow to a mine pit was used for the assessment. The analytical model presented by Marinelli and Niccoli is shown Figure 9.

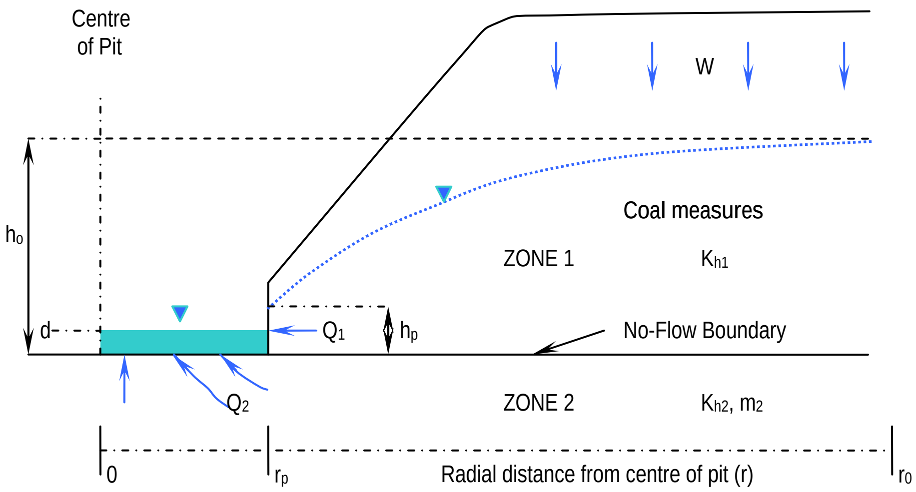


Figure 9: Pit Inflow Analytical Model (after Marinelli and Niccoli [2000])

There is no inflow to the mine void from Zone 2 of the model shown on Figure 9, because the floor below the Loder Seam is assumed to consist of essentially impermeable Permian sandstone, mudstone and siltstone. For Zone 1 the analytical solution considers steady-state, unconfined, horizontal, radial flow, with uniformly disturbed recharge at the water table. Although this is not

[8] Marinelli F and Niccoli W.L., (2000), *"Simple Analytical Equations for Estimating Groundwater Inflow to a Mine Pit",* Groundwater Vol. 38 No. 2, pp311-314.

strictly correct for the coal measures it is considered acceptable as the purpose of this calculation is to provide indicative estimates of the radius of influence and inflow only.

Additional assumptions for this solution are as follows:

- the pit walls are approximated as a right circular cylinder;
- groundwater flow is horizontal. The Dupuit-Forchheimer approximation (McWhorter and Sunada 1977) is used to account for changes in saturated thickness due to depression of the water table;
- the static groundwater level in the Loder Seam, the deepest seam to be mined, is approximately horizontal;
- uniform distributed recharge to the coal seam sub crop as a result of surface infiltration of rainfall; and
- groundwater flow toward the pit is axially symmetric.

In arriving at the radius of influence and the inflow rate, it was further assumed that:

- the hydraulic conductivity (k_{hi}) of the coal measure is 10^{-3}m/day as obtained from Table 1. Note that this will result in a conservative overestimate as the interburden is essentially impermeable;
- the pre-mining water table (potentiometric level) of the Loder Seam is at RL 210m, as used by HLA (2002) for their calibrated numerical model;
- the maximum depth of the pit is RL77m and hence the saturated thickness (h_o), of the coal measures is 133m. Note that this will also result in a conservative overestimate as the interburden is essentially dry;
- there is minimal rainfall recharge (W) to the coal measures. A value of 6.5mm/year, 1.0% of the annual average rainfall has been adopted;
- the height of the seepage face in the pit wall (h_p) is 1m; and
- the radius (r_p) of the Modification Area mine pit is 300m.

The radius of influence 'r_o', that is the maximum extent of drawdown in the piezometric surface of Muswellbrook Coal (including the Modification) is obtained by iteration and was assessed to be 1,050m.

The rate of inflow to the Modification Area was determined from the equation.

$$Q_1 \quad = \quad W\,\pi\,(r_o^2 - r_p^2) \qquad m^3/day$$

The equation indicates that the long term additional steady-state inflow to the Modification Area from the alluvium at the northern end of the proposed mine is 64m^3/day (24ML/year).

11.3 Impact on Groundwater Levels

The groundwater level (potentiometric surface), of the coal seam aquifers is currently governed by the water level in the flooded underground workings which as stated, monitoring indicates fluctuates between about RL146 – 160m. In comparison the pit floor of the No. 2 Open Cut is

RL43.4m. Mining of the Modification Area will however require a lowering of the water level in the underground workings to at least RL77m, the maximum depth to which the Modification Area will be mined, and this will have the impact of further lowering the groundwater level (potentiometric surface), around the mine. The spreadsheet model has indicated that the maximum radius of influence of dewatering the flooded workings to RL77m, based on a pre-mining coal seam water level of RL210m, is 1,050m. As such the cone of depression does not extend under the alluvial aquifers of the Hunter River, Sandy Creek and Muscle Creek, and will not impact alluvial groundwater which is governed by the Hunter River Regulated and Unregulated Water Sharing Plans.

11.4 Groundwater Inflow to Mine

The HLA (2002)[2], 3D numerical model indicated a maximum groundwater inflow to the No. 1 Open Cut Extension of 80ML/year and 36.5ML/year to the combined No. 2 Open Cut and No. 2 Underground mines. Extraction from the borehole pumps and the dewatering volume pumped from the No. 2 Open Cut is much higher than this prediction, as shown on Table 2, but as stated MCC pump water into the underground workings from the pits as well as out of the workings and there would also be considerable recycling of water via seepage through the 40m barrier separating the No. 2 Underground and No. 2 Open Cut. Therefore it is difficult to assess the actual volume of groundwater make (inflow) under current conditions.

The spreadsheet model indicates that steady state groundwater inflow to the Modification Area when it reaches maximum depth of RL77m, will be abut 24ML/year, which is a similar order of magnitude to that obtained by HLA (2002)[2] from the predictive modelling.

A large volume of stored water will also have to be pumped from the flooded underground workings as the Modification Area pit progresses to its maximum depth of RL77m.

11.5 Impact on Other Users

The NOW database of registered bores indicates, there are no registered bores within the assessed 1,050m radius of impact of the mine (see Figure 8).

As mine dewatering impacts the potentiometric surface of the coal measures and as it has been assessed that the alluvial aquifers will not be impacted, it is also concluded that groundwater dependent ecosystems will not be impacted by the Modification.

11.6 Impact on Groundwater Quality

The groundwater quality of the coal seam aquifers is poor; brackish to saline. As it is assessed that only the coal seam and not the alluvial aquifers will be impacted by mining, groundwater quality should not be adversely impacted.

12.0 GROUNDWATER MONITORING PROGRAM

The AEMR 2009 states that the groundwater monitoring program is based on two bores, viz:

- Bore DDH 529 which intersects the No. 2 Underground workings and monitors groundwater levels in the Lewis Seam; and
- Bore RDH 472 which intersects the St. Heliers Colliery workings and monitors groundwater levels in the St Heliers Seam and which has now been replaced by bore RDH 615.

Monitoring commenced in January 2002 at the start of the No.1 Open Cut Extension operation and is undertaken on a monthly basis, recording the following parameters:

- depth to standing water level;
- pH and electrical conductivity (EC).

A comprehensive water quality analysis is undertaken annually.

Given that the Modification Area overlies much of the old St Heliers Colliery workings, lies between No. 1 and No. 2 Open Cuts and is adjacent to the approved No. 1 Open Cut Extension, it is considered that the current approved monitoring program is adequate and that additional monitoring bores are not required.

It should however be noted that bore RDH 615 is within the footprint of the Modification Area and will therefore be removed by mining. A replacement bore will have to be constructed in the future and it is recommended that this be placed inside the Development Application boundary to the north-west of the Modification Area.

AUSTRALASIAN GROUNDWATER AND ENVIRONMENTAL CONSULTANTS PTY LTD

ERROL H. BRIESE
Principal Hydrogeologist / Managing Director

LIMITATIONS OF REPORT

Australasian Groundwater and Environmental Consultants Pty Ltd (AGE) has prepared this report for the use of Hansen Bailey Pty Ltd in accordance with the usual care and thoroughness of the consulting profession. It is based on generally accepted practices and standards at the time it was prepared. No other warranty, expressed or implied, is made as to the professional advice included in this report. It is prepared in accordance with the scope of work and for the purpose outlined in the Proposal emailed on the 28 January 2010.

The methodology adopted and sources of information used by AGE are outlined in this report. AGE has made no independent verification of this information beyond the agreed scope of works and AGE assumes no responsibility for any inaccuracies or omissions. No indications were found during our investigations that information contained in this report as provided to AGE was false.

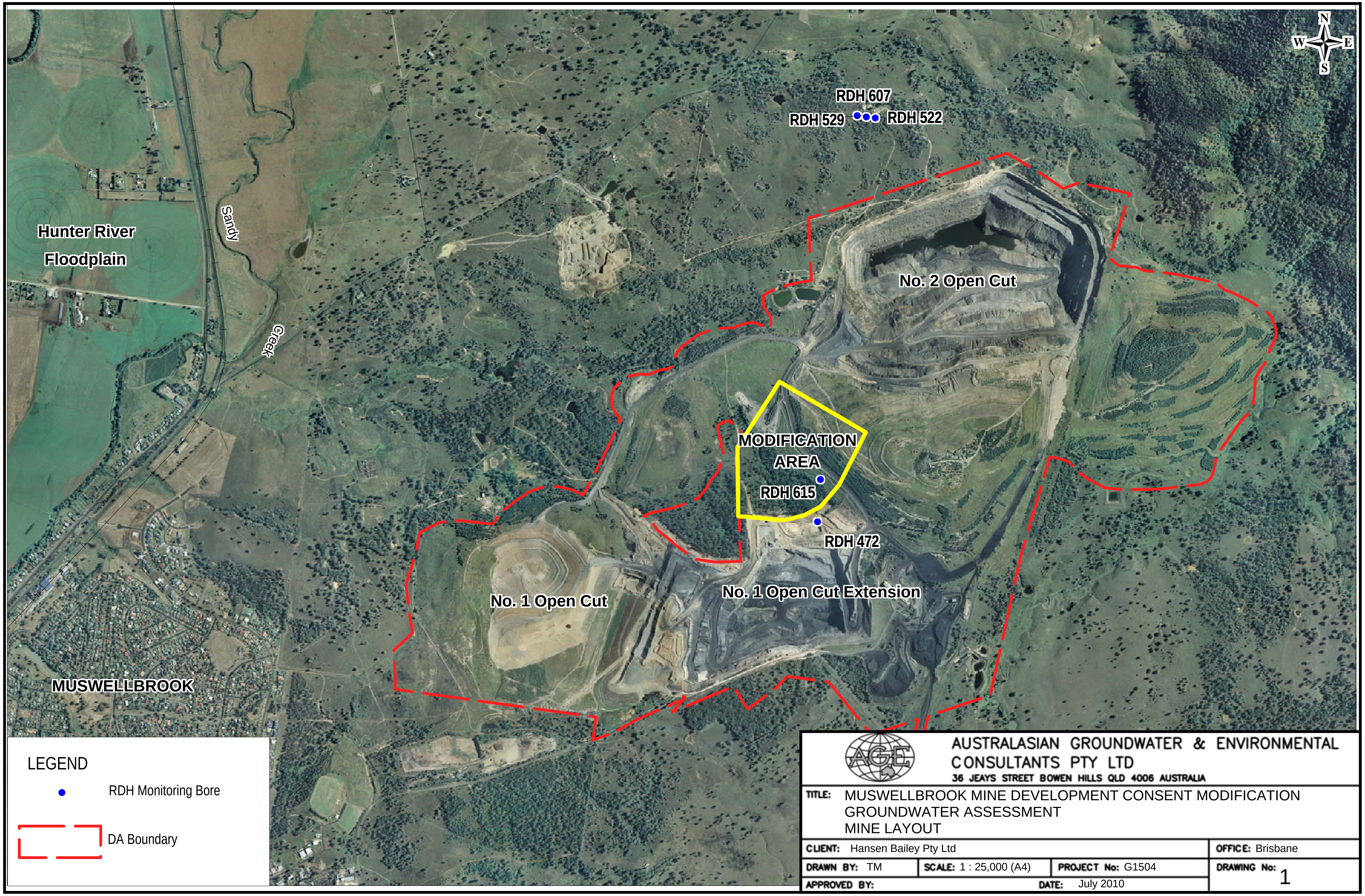
This study was undertaken between 3 June 2010 and 4 August 2010 and is based on the conditions encountered and the information available at the time of preparation of the report. AGE disclaims responsibility for any changes that may occurred after this time.

This report should be read in full. No responsibility is accepted for use of any part of this report in any other context or for any other purpose or by third parties. It may not contain sufficient information for the purposes of other parties or other users. This report does not purport to give legal advice. Legal advice can only be given by qualified legal practitioners.

This report contains information obtained by inspection, sampling, testing and other means of investigation. This information is directly relevant only to the points in the ground where they were obtained at the time of the assessment. Where borehole logs are provided they indicate the inferred ground conditions only at the specific locations tested. The precision with which conditions are indicated depends largely on the frequency and method of sampling, and the uniformity of the site, as constrained by the project budget limitations. The behaviour of groundwater is complex. Our conclusions are based upon the analytical data presented in this report and our experience.

Where conditions encountered at the site are subsequently found to differ significantly from those anticipated in this report, AGE must be notified of any such findings and be provided with an opportunity to review the recommendations of this report.

Whilst to the best of our knowledge, information contained in this report is accurate at the date of issue, subsurface conditions, including groundwater levels can change in a limited time. Therefore this document and the information contained herein should only be regarded as valid at the time of the investigation unless otherwise explicitly stated in this report.



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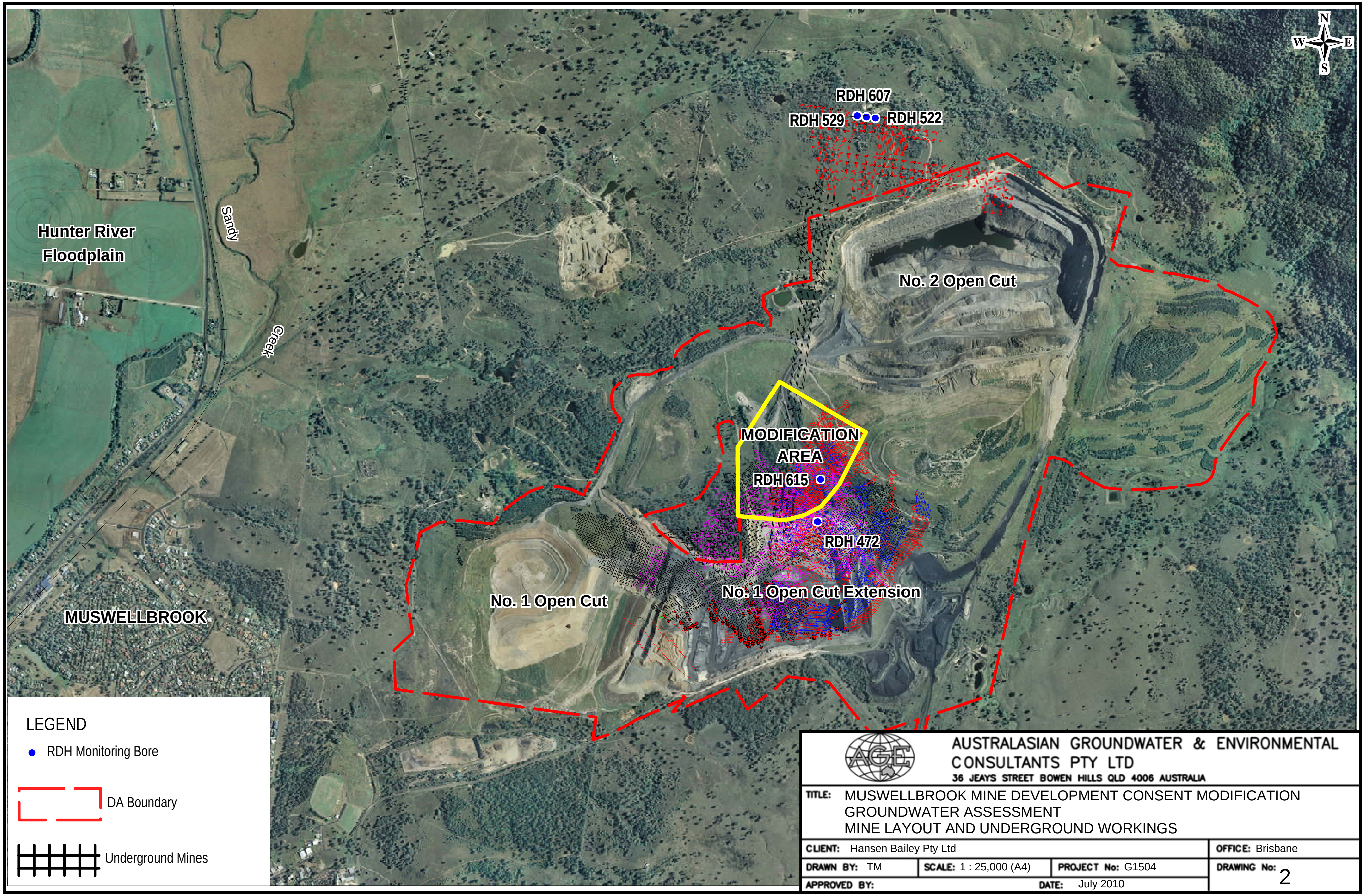
36 JEAYS STREET BOWEN HILLS QLD 4006 AUSTRALIA

TITLE: MUSWELLBROOK MINE DEVELOPMENT CONSENT MODIFICATION GROUNDWATER ASSESSMENT MINE LAYOUT			
CLIENT: Hansen Bailey Pty Ltd			OFFICE: Brisbane
DRAWN BY: TM	SCALE: 1 : 25,000 (A4)	PROJECT No: G1504	DRAWING No: 1
APPROVED BY:	DATE: July 2010		



AUSTRALASIAN GROUNDWATER & ENVIRONMENTAL CONSULTANTS PTY LTD
36 JEAYS STREET BOWEN HILLS QLD 4006 AUSTRALIA

TITLE:	MUSWELLBROOK MINE DEVELOPMENT CONSENT MODIFICATION GROUNDWATER ASSESSMENT MINE LAYOUT AND UNDERGROUND WORKINGS
CLIENT: Hansen Bailey Pty Ltd	OFFICE: Brisbane
DRAWN BY: TM	SCALE: 1 : 25,000 (A4)
PROJECT No: G1504	DRAWING No: 2
APPROVED BY:	DATE: July 2010