APPENDIX A

Air Quality and Greenhouse Gas Impact Assessment

4 March 2013

Chelsea Kavanagh
Hansen Bailey
PO Box 473
Singleton NSW 2330

Dear Chelsea,

Re: Narama West Modification – Air Quality and Greenhouse Gas Impact Assessment

Pacific Environment has been engaged by Hansen Bailey Environmental Consultants (Hansen Bailey) on behalf of Xstrata Coal Pty Limited (Xstrata Coal) to complete an air quality and greenhouse gas impact assessment for the Narama West Modification (the Modification). The purpose of the assessment is to form part of an Environmental Assessment (EA) being prepared by Hansen Bailey to support a modification to Project Approval (PA) 09_0176 under section 75W, Part 3A of the *Environmental Planning and Assessment Act 1979* (EP&A Act). The full air quality and greenhouse gas impact assessment is contained within Appendix 1, while a summary of findings is provided below.

The Modification

Ravensworth Operations Pty Ltd (Ravensworth Operations) is a wholly owned subsidiary of Xstrata Coal and comprises of the approved and active Ravensworth North and Narama mining areas and the former Cumnock, Ravensworth West and Ravensworth South mining areas. Ravensworth Operations is situated within the Singleton Local Government Area and located approximately 15 kilometres (km) north-west of Singleton and 17 km south-east of Muswellbrook in the Upper Hunter Valley of New South Wales.

Ravensworth Operations currently conducts open cut mining activities under PA 09_0176, which was approved 11 February 2011, to provide high quality thermal and semi-soft coking coal to export and domestic markets at a maximum of 16 Million tonnes per annum (Mtpa) of Run of Mine (ROM) coal.

Xstrata Coal is seeking a modification to PA 09_0176 under section 75W, Part 3A of the EP&A Act.

Pacific Environment Limited
Suite 1, Level 1, 146 Arthur Street, North Sydney, NSW 2060
(ASX: PEH) ABN: 43 692 285 758
www.pacific-environment.com
Ph: +61 2 9870 0900

The Modification involves:

- Recovery of approximately 2.7 Million tonnes of ROM coal by open cut mining methods over a period of two years in an approved overburden emplacement area within the Narama mining area (referred to as the Narama West Project),
- Production within the approved maximum limit of 16 Mtpa of ROM coal,
- Operations being undertaken via either truck and shovel or dragline mining techniques,
- Utilisation of the existing equipment fleet,
- Tailings and rejects emplacement as per approved existing operations,
- Utilisation of existing infrastructure, including the Coal Handling and Preparation Plant, coal terminal, rail loop, workshops and offices,
- Transportation of domestic coal to neighbouring power stations via the existing conveyor system,
- Transportation of product coal to the Port of Newcastle for export via the Main Northern Railway, and
- Retention of the approved final landform with overburden used to progressively backfill the final void.

Air Quality and Greenhouse Gas Impact Assessment

Given the relatively small scale and nature of the Modification to the approved Ravensworth Operations and the short time frame over which the Modification will occur (less than two years), a semi-quantitative air quality and greenhouse gas impact assessment has been completed.

Mining operations are likely to commence in 2013 and continue through to 2014, however, may occur later pending approval of the Modification, scheduling of operations and availability of equipment. For the purpose of this assessment, 2013 is the maximum year in terms of quantities of material disturbed by both proposed mining methods and would therefore yield the maximum emissions.

Emission estimates were calculated for 2013 under the two scenarios (truck and shovel and dragline). The estimated total suspended particulate emissions as a result of the Modification are approximately 1,368 tonnes per annum (tpa) for the truck and shovel scenario or 1,113 tpa for the dragline scenario.

Emissions generated by the Modification have been compared to those previously calculated in 2013 or Year 3 of the Air Quality Impact Assessment (AQIA) for the Ravensworth Operations Project EA (**PAEHolmes 2010**). This year of the AQIA is most relevant to the Modification as proposed.

During the period that the Narama West mining area is operational, mining intensity in the currently approved Narama mining area will be proportionally reduced with operations being spread further to the west and away from sensitive receivers. Any emissions from the Narama West mining area would therefore be off-set by reductions in emissions from the currently approved Narama mining area. It is therefore unlikely that the Modification will result in increases in ground level concentrations that would lead to exceedances of the annual PM_{10} criteria (Ravensworth Operations alone and cumulatively) at private receivers.

Five residences, which remain privately owned, were predicted to be affected (above 24-hour PM_{10} criterion) during Year 3 in the AQIA (**PAEHolmes 2010**). With consideration of the Modification and the proportional reduction in the emissions from the Narama mining area, the 24-hour average PM_{10} concentrations at private receivers are likely to remain similar to those modelled in Year 3 of the AQIA.

In order to keep emissions and concentrations to a minimum, meteorological forecasting and real-time continuous dust monitoring will be utilised to indicate when dust levels are approaching relevant criteria. This will allow for mining operations to be reviewed during periods of unfavourable meteorological conditions, such as high winds, and emissions to be managed at the source to mitigate potential exceedance of short-term criteria.

Ravensworth Operations implement a number of other procedures into the mine design to control dust emissions. These control procedures will continue to be implemented for the Modification, where applicable, and managed in accordance with the approved Air Quality and Greenhouse Gas Management Plan.

Greenhouse gas emissions from the Modification are estimated to generate a small increase to the overall GHG emissions from Ravensworth Operations. A number of reasonable and feasible measures are implemented at Ravensworth Operations to minimise GHG emissions. The effectiveness of these measures to reduce GHG emissions (and energy consumption) will continue to be monitored with consideration of the Modification, in accordance with National Greenhouse and Energy Reporting and Energy Efficiency Opportunity requirements and the approved Air Quality and Greenhouse Gas Management Plan.

Appendix 1: Narama West Modification – Air Quality and Greenhouse Gas Impact Assessment

1 INTRODUCTION

Pacific Environment has been engaged by Hansen Bailey Environmental Consultants (Hansen Bailey) on behalf of Xstrata Coal Pty Limited (Xstrata Coal) to complete an Air Quality and Greenhouse Gas Impact Assessment for the Narama West Modification (the Modification). The purpose of the assessment is to form part of an Environmental Assessment (EA) being prepared by Hansen Bailey to support the modification to Project Approval (PA) 09_0176 under section 75W, Part 3A of the *Environmental Planning and Assessment Act 1979* (EP&A Act).

Given the relatively small scale and nature of the Modification to the approved Ravensworth Operations and the short time frame over which the Modification will occur (less than two years), a semi-quantitative air quality and greenhouse gas impact assessment was deemed sufficient.

1.1 Background

Ravensworth Operations Pty Limited (Ravensworth Operations) is a wholly owned subsidiary of Xstrata Coal and comprises the active Ravensworth North and Narama mining areas and the former Cumnock, Ravensworth West and Ravensworth South mining areas. Ravensworth Operations is situated within the Singleton Local Government Area (LGA) and located approximately 15 kilometres (km) north-west of Singleton and 17 km south-east of Muswellbrook in the Upper Hunter Valley of New South Wales (NSW). **Figure 1** illustrates the location of Ravensworth Operations and its approved operations boundary.

The approved Ravensworth Operations currently carries out open cut mining activities under PA 09_0176, approved 11 February 2011, to provide high quality thermal and semi-soft coking coal to export and domestic markets at a maximum of 16 Million tonnes per annum (Mtpa) of Run of Mine (ROM) coal.

Figure 1: Regional Locality Plan

1.2 Modification Description

Xstrata Coal is seeking a modification to PA09_0176 under section 75W, Part 3A of the EP&A Act.

The Modification involves:

- recovery of an additional 2.7 Million tonnes (Mt) of ROM coal by open cut mining methods over a period of two years in an approved Overburden Emplacement Area (OEA) within the Narama mining area (referred to as the Narama West mining area),
- production within the approved maximum limit of 16 Mtpa of ROM coal,
- operations being undertaken via truck and shovel or dragline mining techniques,
- utilisation of the existing workforce and equipment fleet,
- tailings and rejects emplacement as per approved existing operations,
- utilisation of existing infrastructure, including the Coal Handling Preparation Plant (CHPP), coal terminal, rail loop, workshops and offices,
- transportation of domestic coal to neighbouring power stations via the existing conveyor system,
- transportation of product coal to the Port of Newcastle for export via the Main Northern Railway, and
- retention of the approved final landform with overburden used to progressively backfill the final void.

The conceptual layout of the Modification is illustrated in **Figure 2**.

Mining operations are likely to commence in 2013 and continue through to 2014, however, may occur later pending approval of the Modification, scheduling of operations and availability of equipment.

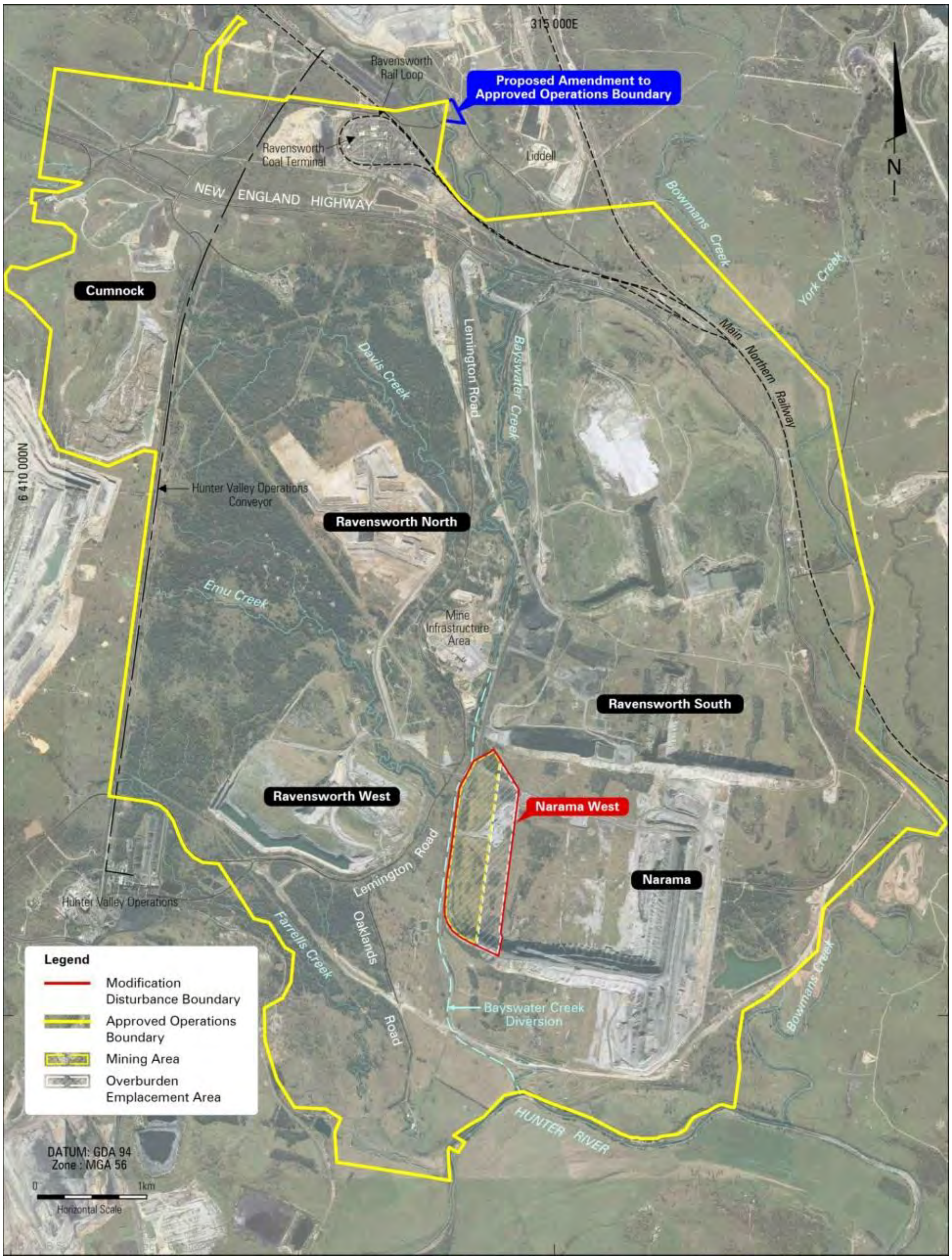


Figure 2: Conceptual Modification Layout

The proposed quantities of material to be mined from the Narama West mining area are shown in **Table** 1. In either case, 2013 is the maximum year in terms of quantities of material moved and would hence be the maximum year in terms of dust emissions.

The equipment required for the Narama West mining area will be sourced from the Narama mining area. In this regard, the equipment within the Narama West and Narama mining areas, when both operations are occurring concurrently, will remain consistent with that modelled for the Narama mining area alone in Year 3 of the air quality impact assessment (**PAEHolmes, 2010**) for the Ravensworth Operations Project EA. This will result in the intensity of operations (in terms of overburden removed and coal produced) in the Narama mining area (as modelled in Year 3) to be proportionally spread between the Narama and Narama West mining areas.

Table 1: Proposed Mining Material Quantities (Narama West)

Year	Overburden (million bcm)	ROM Coal (million tonnes)
Truck and Shovel		
2013	10.6	2.3
2014	1.8	0.4
Truck and Shovel Total	**12.4**	**2.7**
Dragline		
2013	8.0	0.95
2014	4.4	1.7
Dragline Total	**12.4**	**2.7**

1.3 Previous Studies

In 2010, PAEHolmes (now Pacific Environment Limited) prepared an Air Quality Impact Assessment (AQIA) for the Ravensworth Operations Project EA. The AQIA included an assessment of potential impacts from Ravensworth Operations, including open cut mining within existing mining leases held by Xstrata Coal and its subsidiaries in isolation and cumulatively with other surrounding mining and non-mining operations.

Dispersion modelling was used to predict offsite dust concentrations and deposition levels from mining activities associated with the Ravensworth Operations Project. Modelling took account of local meteorology and terrain and used dust emission estimates to predict ground level concentrations (glcs) for six conceptual mining scenarios (Year 3, 5, 10, 15, 20 and 25). Year 3 in the AQIA estimated dust emissions and resulting glcs from Ravensworth Operations for the year 2013. This year of the AQIA is most relevant to the Modification as proposed.

Model predictions at privately-owned residential residences were compared with air quality criteria established by the NSW Environment Protection Authority (EPA) and NSW DP&I. These criteria related to 24-hour and annual average PM_{10} (particulate matter less than 10 microns), annual average TSP (total suspended particulates) and annual average dust deposition.

The dispersion modelling indicated that for Year 3 or 2013, the Ravensworth Operations Project was likely to result in:

- exceedances of the 24-hour average PM_{10} criterion at six private residences, one of which has since been acquired by Xstrata Coal. These residences are shown in **Figure 3** and the predicted numbers of exceedances are shown in **Table 2** (**PAEHolmes 2010**).
- no exceedance of the annual average PM_{10} criterion at private residences.
- no exceedance of the annual average TSP criterion at private residences.
- no exceedance of the annual average dust deposition criterion at private residences.

Table 2: Predicted Air Quality Exceedances (AQIA) – Year 3

Residence ID	AQIA predicted no. of days exceeding the 24-hour average PM_{10} criteria of 50 µg/m^3
3	5
6A	6
6B	7
6C	5
13	1
34*	35

Source: PAEHolmes 2010
* Residence acquired by Xstrata Coal

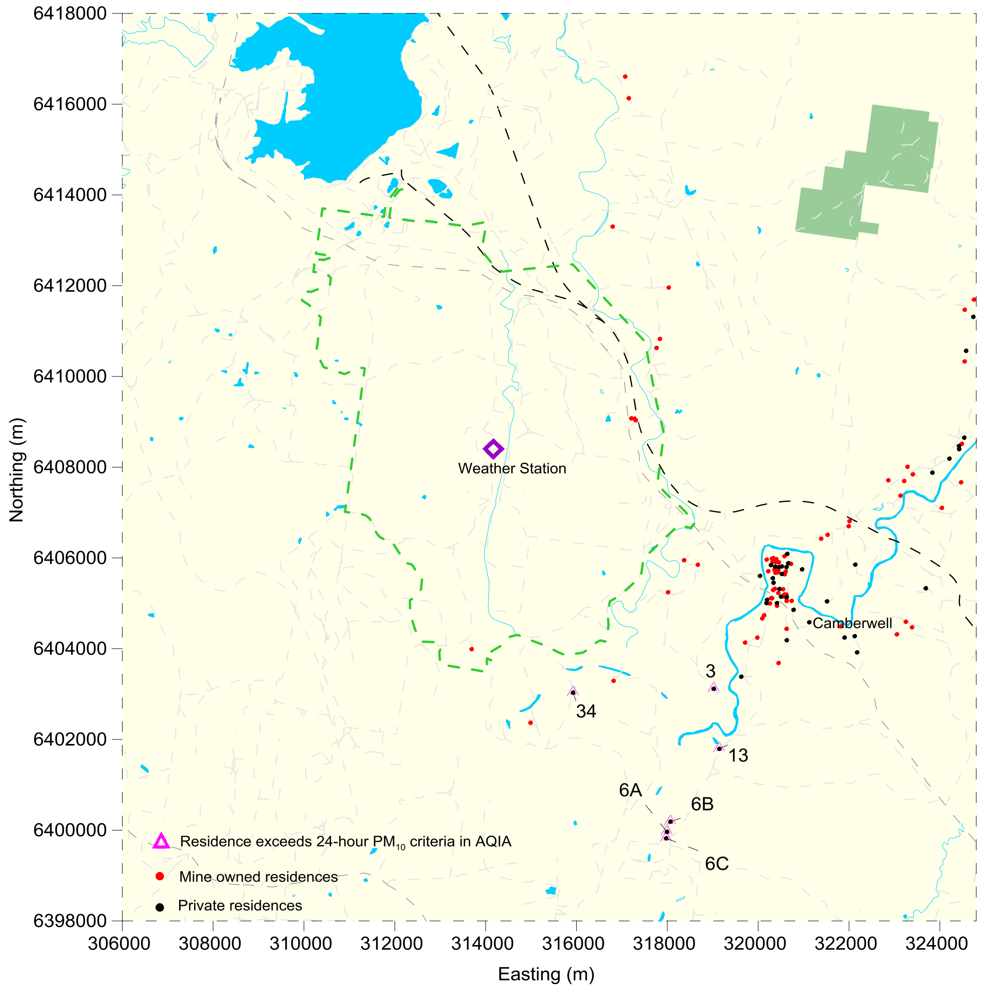


Figure 3: Residences Predicted to Experience Exceedances of the 24-hour Average PM_{10} Criteria (AQIA, PAEHolmes 2010)

The assessment of cumulative impacts (**PAEHolmes, 2010**) indicated that dust emissions from the Ravensworth Operations Project and other sources are unlikely to significantly contribute to the existing dust levels at Camberwell Village, located approximately 3 km to the east-southeast.

All measures to ensure compliance with the relevant criteria and minimise impacts at those residences identified in **Table 2** are managed in accordance with the approved Air Quality and Greenhouse Gas Management Plan as required by PA 09_0176.

2 ASSESSMENT CRITERIA

The air quality impact assessment criteria adopted for the current assessment are consistent with the AQIA for the Ravensworth Operations Project EA (**PAEHolmes 2010**) and include:

- 50 µg/m³ for 24-hour average PM_{10} for Ravensworth Operations and other sources
- 30 µg/m³ for annual average PM_{10} for Ravensworth Operations and other sources
- 90 µg/m³ for annual TSP concentrations for Ravensworth Operations and other sources
- 2 g/m²/month for annual average deposition (insoluble solids) for Ravensworth Operations considered alone
- 4 g/m²/month for annual predicted cumulative deposition (insoluble solids) for Ravensworth Operations and other sources

DP&I also include an acquisition criterion for Ravensworth Operations considered alone of 50 µg/m³ for 24-hour average PM_{10}.

3 EXISTING ENVIRONMENT

3.1 Dispersion Meteorology

Meteorological data are collected at the Ravensworth/Narama meteorological station operated by Ravensworth Operations (shown in **Figure 1**). The AQIA for the Ravensworth Operations Project EA (**PAEHolmes 2010**) used meteorological data from this station for the period April 2008 to March 2009. Windroses for this period are presented in **Figure 4**.

On an annual basis, the most common winds are from the north-west and the south-east. Very few winds originate from the north-east and south-western quadrants. Spring and autumn winds include both north-westerlies and south-easterlies. During summer, winds are predominantly from the south-east whilst during winter, winds are predominantly from the north-west. These prevailing winds are typical of seasonal patterns experienced in the central regions of the Hunter Valley. The wind conditions recorded at this meteorological station in more recent years have shown the same general characteristics in terms of wind direction. The 2008/2009 data have been used in this assessment to allow direct comparison with the previous AQIA for the Ravensworth Operations Project EA (**PAEHolmes 2010**).

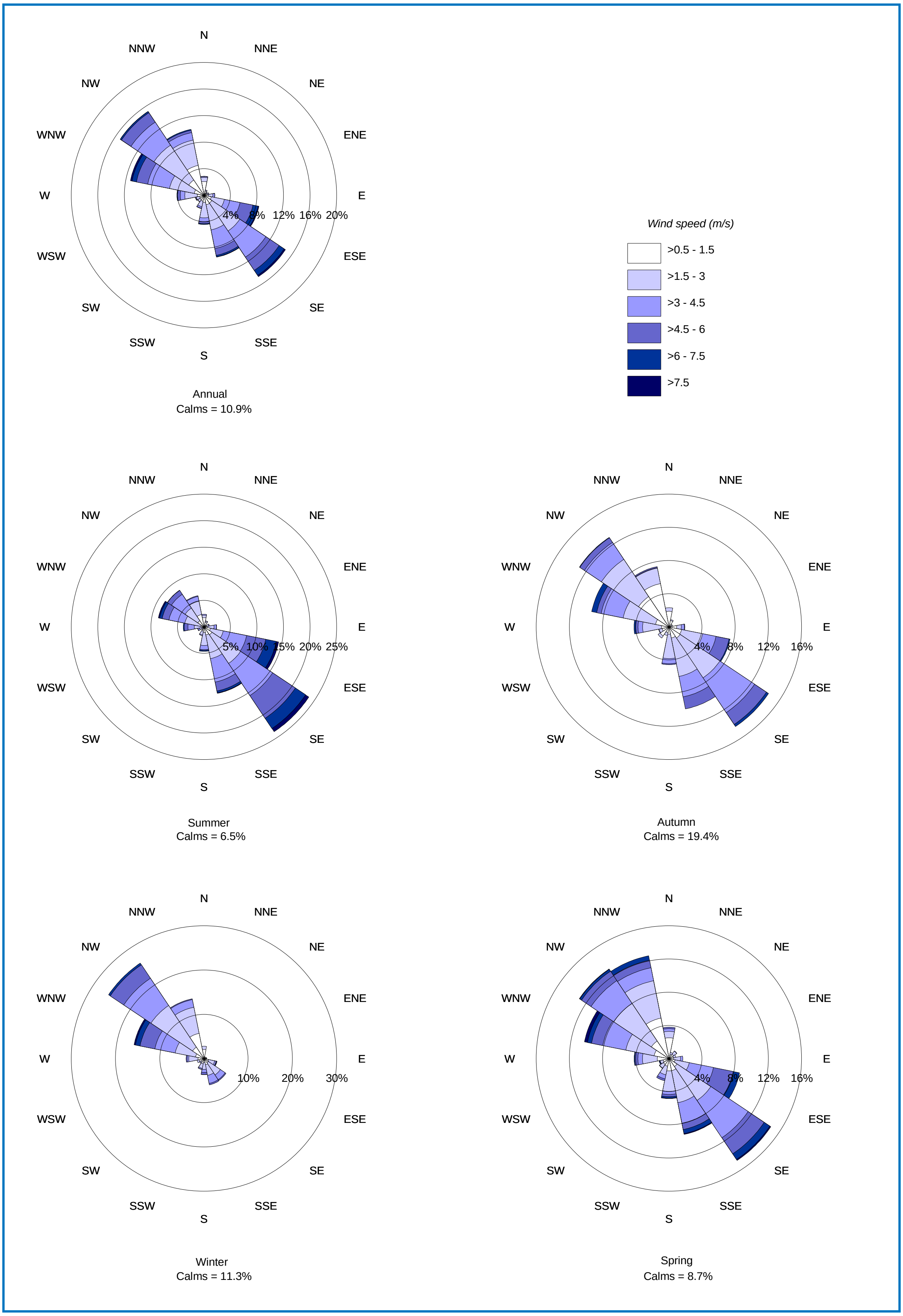


Figure 4: Windroses for Ravensworth/Narama 2008-2009

3.2 Existing Air Quality Network

Air quality monitoring data collected since 2004, in the area within and surrounding Ravensworth Operations, has been reviewed for the current assessment. Insoluble solids deposition levels are monitored monthly at 18 different locations and concentrations of TSP are monitored at seven locations, every sixth day. PM_{10} concentrations are also monitored at two of these locations (HV2 and HV6). The locations of the deposition and HVAS monitoring sites are shown in **Figure 5**.

The monitors measure the existing dust deposition and particulate concentrations due to emissions from all sources that contribute to dust in the air. These sources include emissions from Ravensworth Operations, emissions from neighbouring mining operations and other anthropogenic source as well as natural emission sources in the area. The data show that ground level concentrations are generally below their respective air quality criteria, with only three exceedances of the annual TSP criterion across all monitors since 2004. No exceedances of the annual PM_{10} criterion have been measured since monitoring began in 2007.

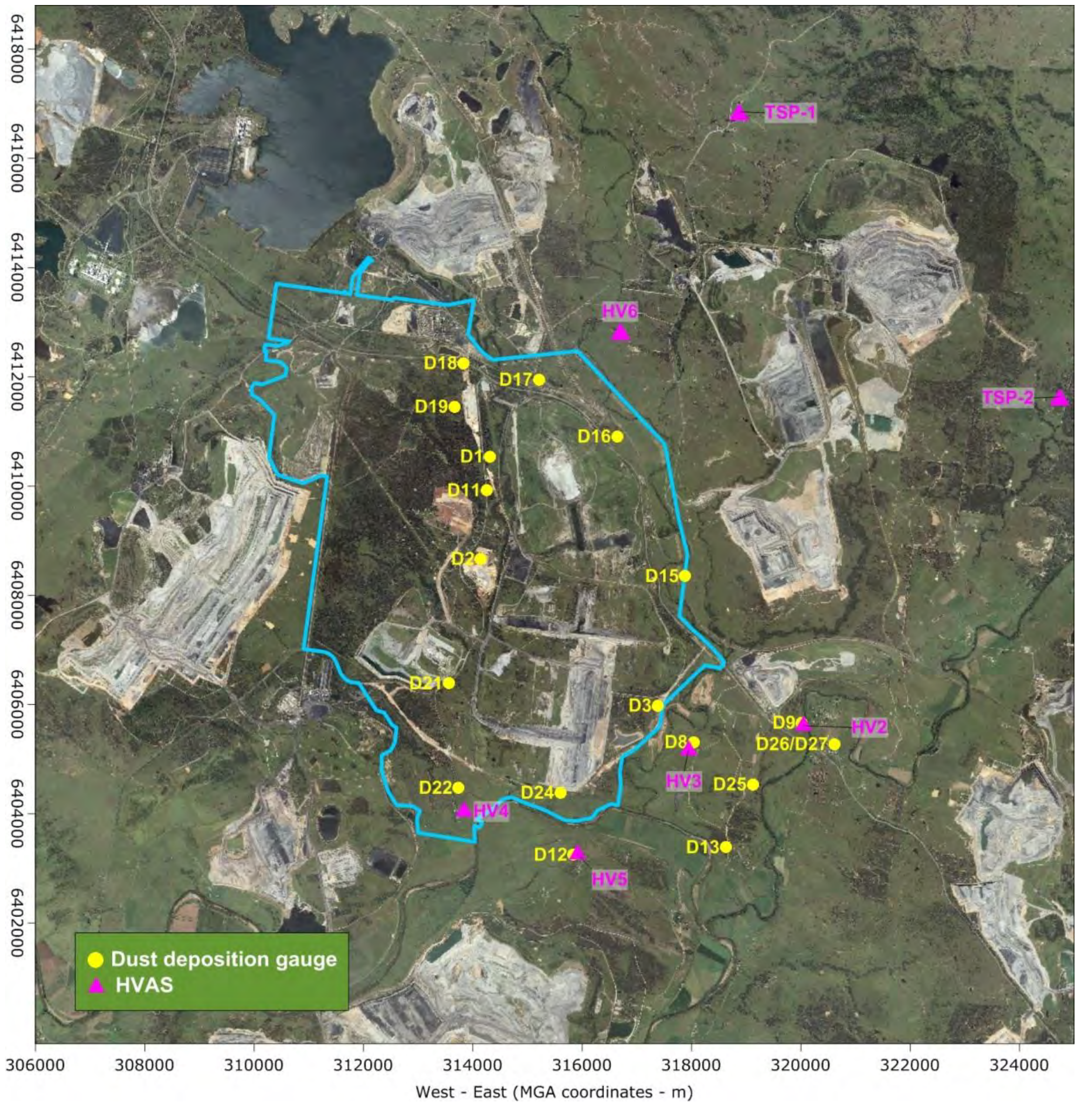


Figure 5: Air Quality Monitoring Network

4 DUST EMISSIONS

4.1 Estimated Emissions for the Modification

Dust emissions arise from various activities at open-cut coal mines. Dust emissions due to the Modification have been estimated by analysing the proposed activities taking place during a selected representative year of operation. The proposed quantities of material to be mined from the Narama West mining area were shown in **Table 3**. For the purpose of this assessment, 2013 is the maximum year in terms of quantities of material disturbed by both proposed mining methods and would therefore yield the maximum emissions.

In general, emission factors and emission calculations in the current assessment follow the same procedure as in the AQIA for the Ravensworth Operations Project EA (**PAEHolmes 2010**) to allow a direct comparison of the data. An exception has been made in calculating the wheel generated dust emissions from haul roads for the Modification. In the AQIA for the Ravensworth Operations Project, an emission factor of 1 kg TSP per vehicle kilometre travelled was used. In this current assessment, the US EPA emission factor (AP-42 13.2.2) was used, taking into account vehicle mass and silt content of haul roads. A 75 percent control for Level 2 watering (>2 L/m^2/hr) of haul roads was also applied for the Modification, which is supported by **Buonicore and Davis (1992)**, who state that a level of control of 90 percent is expected to be achieved by increasing the application rate of water and/or through the use of dust suppressants. It should also be noted that the NSW EPA are currently issuing draft Pollution Reduction Programs (PRPs) to Environmental Protection Licences (EPLs) for open cut mines which require an emission control of 80 percent on unsealed haul roads to be demonstrated and maintained. A control estimate of 75 percent is therefore conservative for this assessment.

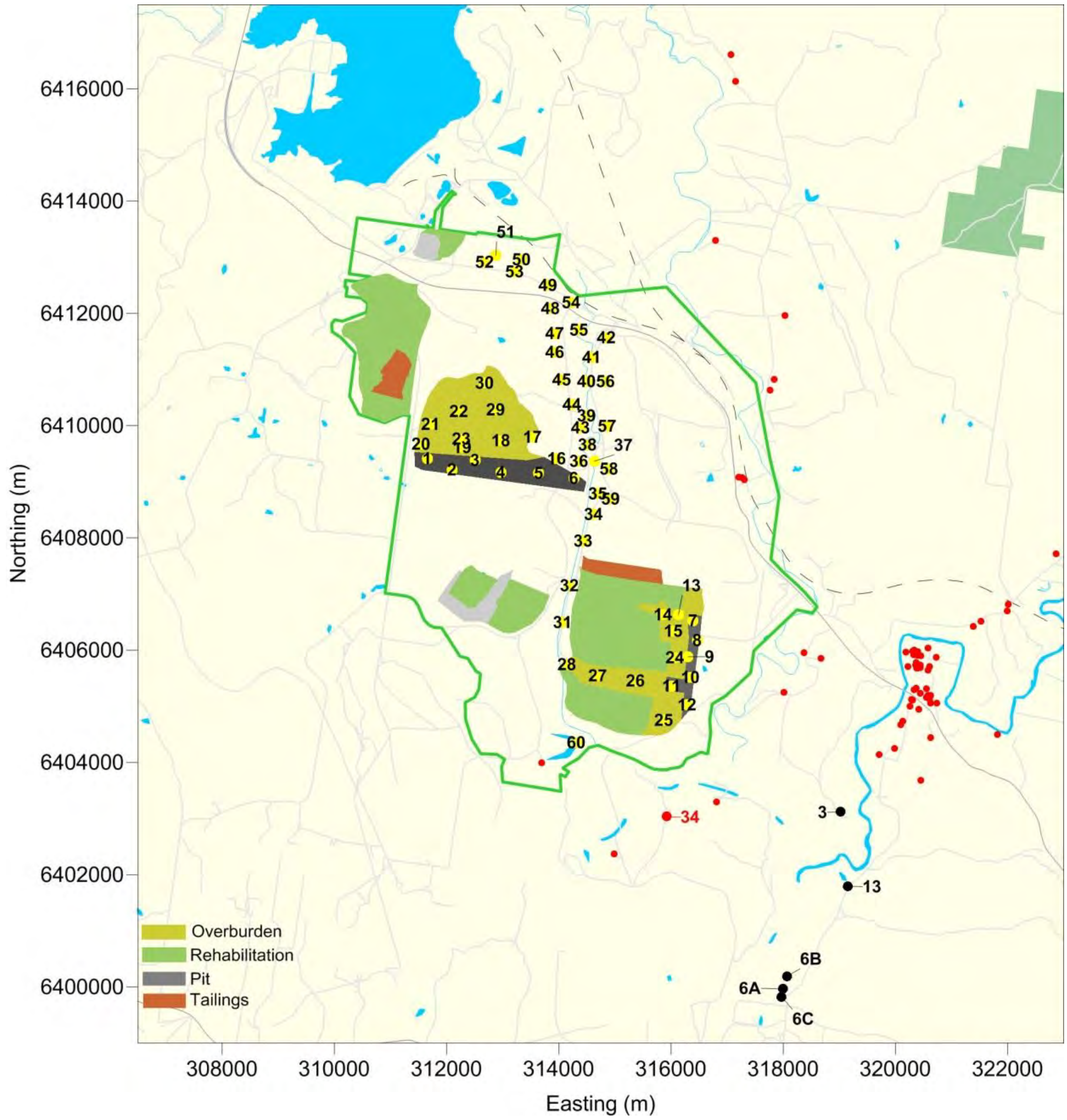
Emission estimates have been calculated for 2013 under the two scenarios (truck and shovel and dragline). The estimated TSP emissions as a result of the Modification for 2013 are approximately 1,368 tonnes per annum (tpa) for the truck and shovel scenario or 1,113 tpa for the dragline scenario, as shown in **Table 3**. The dragline scenario would therefore result in 19 percent lower dust emissions as compared with the truck and shovel scenario for Narama West mining area during 2013.

Table 3: TSP Emissions from Modification Activities for 2013

Activity	Truck and Shovel (kg per annum)	Dragline (kg per annum)
Overburden – Drilling	4,523	1,492
Overburden – Blasting	10,410	2,357
Overburden – Dragline	-	253,487
Overburden – Loading trucks	36,356	-
Overburden - Hauling to emplacement	354,734	111,523
Overburden - Emplacing at overburden emplacement area	36,356	11,430
Overburden -Rehandle (based on 10% Dragline rehandle)	-	25,349
Overburden - Dozers on overburden and rehabilitation	192,819	116,964
Coal – Drilling	1,020	994
Coal – Blasting	543	850
Coal - Dozers ripping	112,074	160,226
Coal - Loading ROM to trucks	154,129	63,843
Coal - Hauling to Crusher	54,469	32,720
Coal - Unloading ROM coal at crusher	702	291
Coal – Rehandle	70	29
Coal - Crushing ROM	6,160	2,552
Coal - Loading coal to conveyor/loading reject	702	291
Coal - Conveying to Coal Bin	1,437	1,437
Coal - Unloading coal at Coal Bin	400	166
Coal - Hauling rejects to emplacement	10,451	4,329
Wind erosion - Overburden emplacement area	119,136	119,136
Wind erosion - Mining area	191,669	191,669
Wind erosion - ROM stockpiles	11,914	11,914
Grading roads	68,746	-
Total	**1,368,820**	**1,113,049**

4.2 Emission Comparison Assessment

The AQIA for the Ravensworth Operations Project estimated dust emissions and glcs from the Ravensworth Operations in Year 3, the year most relevant to the Modification as proposed. **Figure 6** shows the location of dust generating sources for the approved operations, including the Narama mining area, in Year 3. As discussed previously, there were six impacted residences identified, one of which has since been acquired by Xstrata Coal.



Adapted from PAEHolmes (2010)

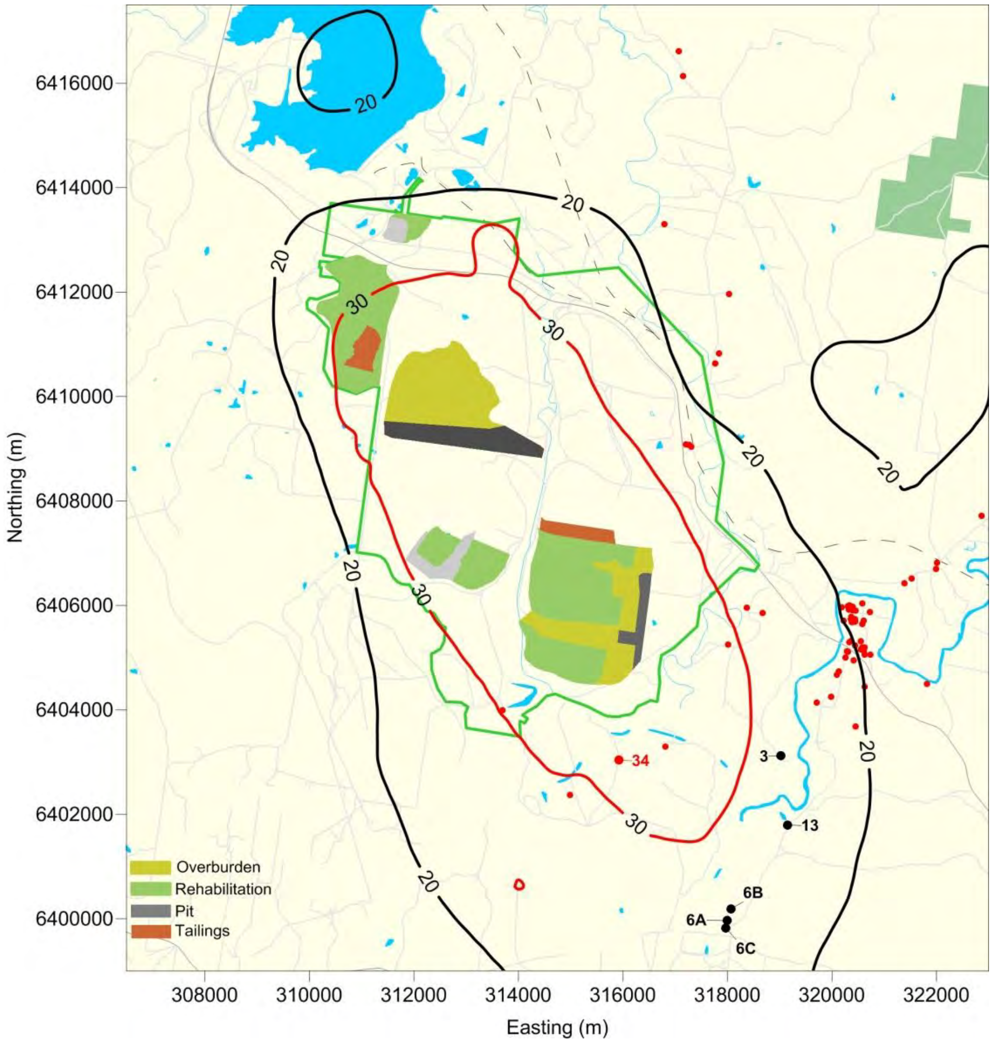
Figure 6: Modelled Source Locations for AQIA – Year 3

Under the Modification, a significant proportion of dust generating activities will be re-located approximately 2 km to the west of the currently approved Narama mining area operations (see **Figure 2**). Other activities such as hauling north to the CHPP, as well as activities at the CHPP itself, will occur in the same locations as those currently approved.

The equipment required for the Narama West mining area will largely be sourced from the Narama mining area. In this regard, activities occurring concurrently within the Narama West and Narama mining areas will remain similar to those modelled for the Narama mining area alone in Year 3 of the AQIA (**PAEHolmes, 2010**) for the Ravensworth Operations Project EA.

During the period that the Narama West mining area is operational, mining intensity in the currently approved Narama mining area will be proportionally reduced with operations being spread further to the west and away from sensitive receivers. The sources will be further from previously identified impacted receivers, although they will still lie in the prevailing wind direction from these sources. As there will be a reduction in the emissions from the currently approved Narama mining area (compared to what was modelled in Year 3 of the AQIA) to accommodate operations in the Narama West mining area, it is considered unlikely that the Modification will result in increases to ground level concentrations that would lead to exceedances of the annual PM_{10} criteria (Ravensworth Operations alone) at private receivers.

Dust emissions were also estimated from other nearby mines in the AQIA for Year 3. **Figure 7** shows the cumulative annual average PM_{10} concentrations predicted in the AQIA for Year 3. The five privately owned residences to the south-east were shown to remain within the NSW EPA annual average PM_{10} criterion of 30 µg/m^3. Considering that there will be a reduction in the emissions from the currently approved Narama mining area to accommodate operations for the Modification, the cumulative annual average PM_{10} concentrations at private receivers are likely to remain similar to those modelled in Year 3 of the AQIA (**PAEHolmes, 2010**).



Adapted from PAEHolmes (2010)

Figure 7: Predicted Annual Average PM_{10} Concentrations due to Emissions from Ravensworth Operations – Year 3 (Cumulative)

As discussed in **Section 1.3**, the AQIA predicted glcs for Year 3 (due to Ravensworth Operations) exceeding the NSW EPA 24-hour PM_{10} criterion of 50 µg/m^3 at six private residences. Residence 34 has since been acquired by Xstrata Coal. Given mining intensity in the Narama mining area will be proportionally reduced with operations being spread 2 km further to the west under the proposed Modification, the 24-hour average PM_{10} concentrations at private receivers are likely to remain similar to those modelled in Year 3 of the AQIA (**PAEHolmes, 2010**).

Meteorological forecasting and real-time continuous dust monitoring will be utilised to indicate when dust levels are approaching relevant criteria. This will allow for mining operations to be reviewed during periods of unfavourable meteorological conditions and emissions to be managed at the source to mitigate potential exceedance of short-term criteria.

5 GREENHOUSE GAS EMISSIONS

5.1 Background

Greenhouse gas (GHG) emissions for Ravensworth Operations were presented in the *Scope 1, 2 and 3 Energy & Greenhouse Assessment* (SSE Sustainability Consulting, 2009). The GHG emissions for the Modification have been determined according to the methodology in this document and are compared to the estimated GHG emissions for Ravensworth Operations.

The GHG Protocol establishes an international standard for accounting and reporting of GHG emissions. The GHG Protocol has been adopted by the International Standard Organisation, endorsed by GHG initiatives (such as the Carbon Disclosure Project) and is compatible with existing GHG trading schemes.

Three 'scopes' of emissions (scope 1, scope 2 and scope 3) are defined for GHG accounting and reporting purposes, as described below. This terminology has been adopted in Australian GHG reporting and measurement methods and has been employed in this assessment. The 'scope' of an emission is relative to the reporting entity. Indirect scope 2 and scope 3 emissions will be reportable as direct scope 1 emissions from another facility.

5.1.1 Scope 1: Direct Greenhouse Gas Emissions

Direct GHG emissions are defined as those emissions that occur from sources that are owned or controlled by the reporting entity. Direct GHG emissions that occur as a result of the Modification are:

- Transportation of materials, products, waste and employees. These emissions result from the combustion of fuels in entity owned/controlled mobile combustion sources (e.g. trucks, trains, ships and cars).
- Fugitive emissions. These emissions result from intentional or unintentional releases (e.g. methane emissions from coal mines).

5.1.2 Scope 2: Energy Product Use Indirect Greenhouse Gas Emissions

Scope 2 emissions are a category of indirect emissions that account for GHG emissions from the generation of purchased energy products (principally electricity).

5.1.3 Scope 3: Other Indirect Greenhouse Gas Emissions

Scope 3 emissions are defined as those emissions that are a consequence of the activities of an entity, but which arise from sources not owned or controlled by that entity. These include emissions associated with the extraction, processing and transport of diesel as well as production of electricity. The GHG Protocol provides that reporting scope 3 emissions is optional. If an organisation believes that scope 3 emissions are a significant component of the total emissions inventory, these can be reported along with scope 1 and scope 2. However, the GHG Protocol notes that reporting scope 3 emissions can result in double counting of emissions and can also make comparisons between organisations and/or products difficult because reporting is voluntary. Double counting needs to be avoided when compiling national (country) inventories under the Kyoto Protocol. The GHG Protocol also recognises that compliance regimes are more likely to focus on the 'point of release' of emissions (i.e. direct emissions) and/or indirect emissions from the purchase of electricity.

5.2 Greenhouse Gas Emission Estimates

Emissions of carbon dioxide (CO_2) would be the most significant GHG for the Modification. CO_2 is formed and released during the combustion of fuels used onsite.

Inventories of GHG emissions can be calculated using published emission factors. Different gases have different greenhouse warming effects (referred to as global warming potentials) and emission factors take into account the global warming potentials of the gases created during combustion. The estimated emissions are referred to in terms of carbon dioxide equivalent or CO_2-equivalent (CO_2-e) emissions by applying the relevant global warming potential. This greenhouse gas impact assessment has been conducted using the NGA Factors, published by the DCCEE (2012).

GHG sources related to the Modification that have been considered in the assessment include:

1. Fuel consumption (diesel) during mining operations – scope 1.
2. Release of fugitive methane (CH_4) during mining operations – scope 1.
3. Indirect emissions associated with onsite electricity use – scope 2.
4. Indirect emissions associated with the production of transport fuels – scope 3.
5. Indirect emissions associated with the production of electricity – scope 3.

Summaries of the annual GHG emissions are provided in the sub-sections below. For more detail on the calculation of these GHG emissions, refer to the assessment undertaken by SSE Sustainability Consulting (2009).

5.2.1 Scope 1 and 2 Emissions

The Scope 1 and 2 emissions reported for Ravensworth Operations (SSE Sustainability Consulting, 2009) and the Modification are listed in **Table 4**.

This current assessment assumes no electricity usage for truck and shovel operations (which depend instead on diesel usage). Dragline operations would use approximately 11.05 kWh of electricity per tonne of ROM coal. The emission factor used for CH_4 emission was 0.045 $TC0_2$-e (tonne carbon dioxide equivalent) per tonne ROM, which is the emission factor for NSW open-cut coal mines (SSE Sustainability Consulting, 2009).

The Modification (2013 to 2014) is estimated to generate an increase of less than 1 percent to the total Scope 1 and 2 GHG emissions for the whole (29 years) of Ravensworth Operations.

Table 4: Scope 1 and 2 Emissions

	Scope 1 usage	Scope 2 usage	Total Scope 1 & 2 usage	Units	Emission factor for Scope 1	Scope 1 Emissions (TC02-e)	Emission factor for Scope 2	Scope 2 Emissions (TC02-e)	Total Scope 1 + Scope 2 (TC02-e)	% of total	TC02-e / T ROM	TC02-e / T product
Ravensworth Operations - total for 29 years												
Onsite diesel	2,275,832	-	2,275,832	kL	2.7	6,140,512	-	0	6,140,512	24%	0.018	0.028
Methane (released)	711,836	-	711,836	tonnes	21	14,948,552	-	0	14,948,552	59%	0.045	0.067
Electricity	-	4,642,351	4,642,351	MWh		0	0.89	4,131,692	4,131,692	16%	0.012	0.019
Total	2,987,668	4,642,351				21,089,064		4,131,692	25,220,756	100%	0.076	0.113
Ravensworth Operations - Average per Year (Over 29 years)												
Onsite diesel	78,477	-	78,477	kL	2.7	211,742	-	0	211,742	24%	0.018	0.028
Methane (released)	24,546	-	24,546	tonnes	21	515,467	-	0	515,467	59%	0.045	0.067
Electricity	-	160,081	160,081	MWh		0	0.89	142,472	142,472	16%	0.012	0.019
Total	103,023	160,081				727,209		142,472	869,681	100%	0.076	0.113
Ravensworth Operations - Maximum Year (Year 15)												
Onsite diesel	81,903	-	81,903	kL	2.7	220,985	-	0	220,985	20%	0.014	0.021
Methane (released)	34,286	-	34,286	tonnes	21	720,000	-	0	720,000	64%	0.045	0.067
Electricity	-	207,160	207,160	MWh		0	0.89	184,372	184,372	16%	0.012	0.017
Total	116,189	207,160				940,985		184,372	1,125,357	100%	0.070	0.105
Modification Truck and Shovel Operations (2013 to 2014)												
Onsite diesel	10,545	-	10,545	kL	2.7	28,470	-	0	28,470	19%	0.011	0.019
Methane (released)	5,747	-	5,747	tonnes	21	120,696	-	0	120,696	81%	0.045	0.079
Electricity	-	-	-	MWh		-	0.89	-	0	0%	0.000	0.000
Total	16,292	207,160				149,167		0	149,167	100%	0.056	0.098
Modification Dragline Operations (2013 to 2014)												
Onsite diesel	5,149	-	5,149	kL	2.7	13,904	-	0	13,904	9%	0.005	0.009
Methane (released)	5,747	-	5,747	tonnes	21	120,696	-	0	120,696	75%	0.045	0.079
Electricity	-	29,638	29,638	MWh		-	0.89	26,378	26,378	16%	0.010	0.017
Total	10,896	29,638				134,601		26,378	160,978	100%	0.060	0.105
Comparison of the Modification to Ravensworth Operations												
Modification Truck and Shovel Operations % of Total	0.55%	0%	-		-	0.71%		0%	0.59%	-	-	-
Modification Dragline Operations % of Total	0.36%	0.64%	-		-	0.64%		0.64%	0.64%	-	-	-

5.2.2 Scope 3 Emissions

The Scope 3 emissions reported for Ravensworth Operations (SSE Sustainability Consulting 2009) and the Modification are listed in:

- **Table 5** Scope 3 emissions from diesel and electricity,
- **Table 6** Scope 3 emissions from transport, and
- **Table 7** Scope 3 emissions from end use of product coal.

The following assumptions were made in calculating Scope 3 emissions (SSE Sustainability Consulting 2009):

- 55 percent of product coal is consumed as thermal coal in overseas power stations. This thermal coal has an energy content of 27.0 GJ/T.
- 45 percent of product coal is consumed as coking coal in overseas steelmaking operations.

For Scope 3 emissions, the Modification is estimated to generate an increase of approximately 0.17 percent (truck and shovel operations) to 0.49 percent (dragline) to the total for Ravensworth Operations in terms of diesel and electricity usage (**Table 5**), 0.69 percent for transport (**Table 6**) and 0.5 percent for end usage of product (**Table 7**).

Table 5: Scope 3 Emissions from Diesel and Electricity

	Total Scope 1 & Scope 2 usage	Units	Emission factor for Scope 3	Scope 1 Emissions (TC0₂-e)
Ravensworth Operations (Over 29 years)				
On-site diesel	2,275,832	kL	0.20458	465,590
Electricity	4,642,351	MWh	0.18	835,623
Total				**1,301,213**
Ravensworth Operations - Average per Year (Over 29 years)				
On-site diesel	78,477	kL	0.20458	16,055
Electricity	160,081	MWh	0.18	28,815
Total				**44,869**
Modification Truck and Shovel Operations (2013 to 2014)				
On-site diesel	10,545	kL	0.20458	2,157
Electricity	0	MWh	0.18	0
Total				**2,157**
Modification Dragline Operations (2013 to 2014)				
On-site diesel	5,150	kL	0.20458	1,054
Electricity	29,638	MWh	0.18	5,335
Total				**6,388**

Table 6: Scope 3 Emissions from Transport

	Distance (km)	Total Product transported (tonne)	Emission factor (kg CO_2-e /tonne)	Scope 3 Emissions (TCO_2-e)
Ravensworth Operations (Over 29 years)				
Rail	103	222,567,336	0.0054	123,792
Ship	8,308	222,567,336	0.0126	23,298,527
Total				**23,422,319**
Ravensworth Operations - Average per Year (Over 29 years)				
Rail	103	7,674,736	0.0054	4,269
Ship	8,308	7,674,736	0.0126	803,397
Total				**807,666**
Modification Truck and Shovel or Dragline (2013 to 2014)				
Rail	103	1,528,821	0.0054	850
Ship	8,308	1,528,821	0.0126	160,038
Total				**160,889**

Table 7: Scope 3 Emissions from End Use of Product Coal

	Total Product	Emission factor (T CO_2-e /tonne)	Scope 3 Emissions (TCO_2-e)
Ravensworth Operations (Over 29 years)			
Thermal Coal	165,158,035	2.9106	480,708,977
Coking Coal	135,129,301	2.7096	366,146,354
Total	**300,287,336**		**846,855,331**
Ravensworth Operations - Average per Year (Over 29 years)			
Thermal Coal	5,695,105	2.9106	16,576,173
Coking Coal	4,659,631	2.7096	12,625,736
Total	**10,354,736**		**29,201,909**
Modification Truck and Shovel or Dragline (2013 to 2014)			
Thermal Coal	840,852	2.9106	2,447,383
Coking Coal	687,970	2.7096	1,864,122
Total	**1,528,821**		**4,311,505**

6 MITIGATION AND MANAGEMENT MEASURES

6.1 Dust

Several residences to the south-east of the Narama West mining area are in a prevailing downwind direction. It is therefore appropriate to ensure that dust emissions are kept to the minimum practicable level and within relevant criteria, where a management agreement or acquisition requirement is not already enforced.

Ravensworth Operations implement a number of procedures into the mine design to control dust emissions, which may be generated from trafficable areas, coal preparation and handling, dragline operations, prestrip operations, blasting, drilling and stemming. Control procedures used at Ravensworth Operations include:

- Watering of active mining areas, active spoil emplacement areas and haul roads that are subject to frequent vehicle movements.
- All drill rigs are equipped with dust control systems and are regularly maintained for effective use. These systems include dust curtains.
- Automatic sprays fitted to the dump hopper and crushing plant to minimise dust from coal processing activities.
- Minimising the area of disturbance by restricting vegetation clearing ahead of mining operations and rehabilitating mine spoil dumps as soon as practicable after mining.
- Undertaking temporary rehabilitation using pasture species on spoil dumps and voids to minimise dust emissions.
- Topsoil stripping is undertaken when there is sufficient moisture content in the soil.
- Restricting or ceasing dust-generating activities on extremely windy or dry days.
- Restricting blasting activities to periods of acceptable wind speed and direction.
- Utilising meteorological forecasting and real-time continuous dust monitoring to indicate when dust levels are approaching relevant criteria. This allows for mining operations to be reviewed during periods of elevated dust concentrations.

These control procedures will continue to be implemented for the Modification, where applicable, and managed in accordance with the approved Air Quality and Greenhouse Gas Management Plan.

The current and approved air quality monitoring network (see **Figure 5**) is sufficient to facilitate an adequate monitoring program necessary to verify compliance.

6.2 Greenhouse Gas

Ravensworth Operations implement a number of reasonable and feasible measures to minimise GHG emissions, including:

- Maximising energy efficiency as a key consideration in the development of the mine plan. For example, significant savings of GHG emissions (through increased energy efficiency) are achieved by mine planning decisions, which minimise haul distances for ROM coal and waste rock transport, and therefore fuel use.
- Identifying cost-effective energy saving opportunities.
- Regular maintenance of plant and equipment to minimise fuel consumption.

- Consideration of energy efficiency in the plant and equipment selection phase.

The effectiveness of these measures to reduce GHG emissions (and energy consumption) will continue to be monitored with consideration of the Modification, in accordance with National Greenhouse and Energy Reporting and Energy Efficiency Opportunity requirements and the approved Air Quality and Greenhouse Gas Management Plan.

7 CONCLUSION

Emissions generated by the Modification have been compared to those previously calculated in 2013 or Year 3 of the AQIA for the Ravensworth Operations Project EA (**PAEHolmes 2010**). During the period that the Narama West mining area is operational, mining intensity in the Narama mining area will be proportionally reduced with operations being spread further to the west and away from sensitive receivers. As there will be a reduction in the emissions from the Narama mining area (compared to what was modelled in Year 3) to accommodate operations in the Narama West mining area, it is considered unlikely that the Modification will result in significant increases to annual PM_{10} concentrations at private receivers.

Five residences, which remain privately owned, were predicted to be affected (above 24-hour PM_{10} criterion) during Year 3 in the AQIA (**PAEHolmes 2010**). Given mining intensity in the Narama mining area will be proportionally reduced with operations being spread 2km further to the west under the proposed Modification, the 24-hour average PM_{10} concentrations at private receivers are likely to remain similar to those modelled in Year 3 of the AQIA.

Meteorological forecasting and real-time continuous dust monitoring will be utilised to indicate when dust levels are approaching relevant criteria. This will allow for mining operations to be reviewed during periods of elevated dust concentrations and emissions to be managed at the source to mitigate potential exceedance of short-term criteria.

Ravensworth Operations implement a number of other procedures into the mine design to control dust emissions. These control procedures will continue to be implemented for the Modification, where applicable, and managed in accordance with the approved Air Quality and Greenhouse Gas Management Plan.

Greenhouse gas emissions from the Modification are estimated to generate a small increase to the overall GHG emissions from Ravensworth Operations. A number of reasonable and feasible measures are implemented at Ravensworth Operations to minimise GHG emissions. The effectiveness of these measures to reduce GHG emissions (and energy consumption) will continue to be monitored with consideration of the Modification, in accordance with National Greenhouse and Energy Reporting and Energy Efficiency Opportunity requirements and the approved Air Quality and Greenhouse Gas Management Plan.

8 REFERENCES

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APPENDIX B

Noise and Blasting Impact Assessment

SLR

global environmental solutions

Narama West Modification

Noise and Blasting Impact Assessment

Report Number 630.10467R1

27 February 2013

Ravensworth Operations Pty Ltd
PO Box 294
Muswellbrook NSw 2333

Version: Revision 0

Narama West Modification

Noise and Blasting Impact Assessment

PREPARED BY:

SLR Consulting Australia Pty Ltd
ABN 29 001 584 612
Level 1, 14 Watt Street Newcastle NSW 2300 Australia

(PO Box 1768 Newcastle NSW 2300 Australia)
T: 61 2 4908 4500 F: 61 2 4908 4501
E: newcastleau@slrconsulting.com www.slrconsulting.com

DOCUMENT CONTROL

Reference	**Status**	**Date**	**Prepared**	**Checked**	**Authorised**
630.10467R1	Revision 0	26 February 2013	Martin Davenport	John Cotterill	John Cotteill

Executive Summary

SLR Consulting Australia Pty Ltd has been engaged by Hansen Bailey Environmental Consultants (Hansen Bailey) on behalf of Xstrata Coal Pty Limited (Xstrata Coal) to complete a noise and blasting impact assessment for the Narama West Modification (the Modification). The purpose of the assessment is to form part of an Environmental Assessment being prepared by Hansen Bailey to support a modification to Project Approval (PA) 09_0176 under section 75W, Part 3A of the *Environmental Planning and Assessment Act 1979* (EP&A Act).

The Modification

Ravensworth Operations Pty Ltd (Ravensworth Operations) is a wholly owned subsidiary of Xstrata Coal and comprises of the active Ravensworth North and Narama mining areas and the former Cumnock, Ravensworth West and Ravensworth South mining areas. Ravensworth Operations is situated within the Singleton Local Government Area and located approximately 15 kilometres (km) north-west of Singleton and 17 km south-east of Muswellbrook in the Upper Hunter Valley of New South Wales.

Ravensworth Operations currently conducts open cut mining activities under PA 09_0176, which was approved 11 February 2011, to provide high quality thermal and semi-soft coking coal to export and domestic markets at a maximum of 16 Million tonnes per annum (Mtpa) of Run of Mine (ROM) coal.

Xstrata Coal is seeking a modification to PA 09_0176 under section 75W, Part 3A of the EP&A Act.

The Modification involves:

- Recovery of approximately 2.7 Million tonnes (Mt) of ROM coal by open cut mining methods over a period of two years in an approved overburden emplacement area (OEA) within the Narama mining area (referred to as the Narama West mining area).
- Production within the approved maximum limit of 16 Mtpa of ROM coal.
- Operations being undertaken via truck and shovel or dragline mining techniques.
- Utilisation of the existing equipment fleet.
- Tailings and rejects emplacement as per approved existing operations.
- Utilisation of existing infrastructure, including the coal handling and preparation plant (CHPP), coal terminal, rail loop, workshops and offices.
- Transportation of domestic coal to neighbouring power stations via the existing conveyor system.
- Transportation of product coal to the Port of Newcastle for export via the Main Northern Railway.
- Retention of the approved final landform with overburden used to progressively backfill the final void.

Mining operations are likely to commence in 2013 and continue through to 2014, however, may occur later pending approval of the Modification, scheduling of operations and availability of equipment.

Noise and Blasting Impact Assessment

Given the nature and scale of the Modification, a semi-quantitative noise impact assessment has been completed. The noise generated by the Modification has been predicted based on a review of previous detailed modelling results conducted for Ravensworth Operations.

Executive Summary

Umwelt Pty Ltd undertook a Noise Impact Assessment for the Ravensworth Operations Project EA (Umwelt, 2010). This assessment used the Environmental Noise Model (ENM) software to predict noise emissions from Ravensworth Operations. Year 3 (equivalent to 2013) was identified as the worst case mining scenario in the Noise Impact Assessment for Ravensworth Operations.

Operational noise levels in Year 3 of the Noise Impact Assessment (Umwelt, 2010) were predicted to meet the relevant intrusive and sleep disturbance criteria at all private receivers under various meteorological scenarios and when utilising the total approved equipment fleet. With consideration of the Modification, a portion of the equipment fleet as modelled in the Year 3 case will be redistributed from the Narama mining area to the Narama West mining area (which is located 2km further away from sensitive receivers). The intensity of noise generated from the Narama West and Narama mining area, when both operations are occurring concurrently, will not exceed that modelled in Year 3 for the Narama mining area alone. As such, the operational noise levels generated by existing operations with consideration of the Modification are comparable to that currently approved with no exceedance of the intrusive or sleep disturbance criteria predicted at any private receiver.

No additional traffic movements are proposed as part of the Modification and as such there will be no additional noise impacts from increased road traffic on the New England Highway, Lemington Road or Singleton LGA.

No additional rail movements or increase in production is proposed as part of the Modification and as such there will be no additional impacts from rail noise on the Main Northern Railway line.

No additional noise mitigation measures are required for the Modification beyond those conditions specified in PA 09_0176. Ravensworth Operations implement a number of controls in the mine design to minimise noise. These controls will continue to be implemented for the Modification and managed in accordance with the approved Noise Management Plan.

As part of the blasting impact assessment, calculations were conducted in order to estimate the allowable Maximum Instantaneous Charge for compliance with the relevant vibration and airblast criteria at the nearest sensitive receivers and infrastructure assets. As the Modification area is located further from closest receivers, vibration and airblast levels from blasts within the Modification disturbance boundary would be similar to those from adjacent approved mining areas.

Blast events within the Modification disturbance boundary will be monitored and managed in accordance with the existing Blast Management Plan to ensure compliance with applicable criteria.

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FIGURES

1 INTRODUCTION

SLR Consulting Australia Pty Ltd (SLR Consulting) has been engaged by Hansen Bailey Environmental Consultants (Hansen Bailey) on behalf of Xstrata Coal Pty Limited (Xstrata Coal) to complete a Noise and Blasting Impact Assessment for the Narama West Modification (the Modification). The purpose of the assessment is to form part of an Environmental Assessment (EA) being prepared by Hansen Bailey to support the Modification to Project Approval (PA 09_0176) under section 75W, Part 3A of the Environmental Planning and Assessment Act 1979 (EP&A Act).

The Noise Impact Assessment has been prepared with reference to Australian Standards (AS) 1055:1997 *Description and Measurement of Environmental Noise* Parts 1, 2 and 3 and in accordance with the New South Wales (NSW) Environment Protection Authority (EPA) *NSW Industrial Noise Policy* (INP), *Environmental Noise Control Manual* (ENCM), *NSW Interim Construction Noise Guideline* (ICNG) and *NSW Road Noise Policy* (RNP).

2 MODIFICATION OVERVIEW

2.1 Background

Ravensworth Operations Pty Limited (Ravensworth Operations) is a wholly owned subsidiary of Xstrata Coal and comprises of the active Ravensworth North and Narama mining areas and the former Cumnock, Ravensworth West and Ravensworth South mining areas. Ravensworth Operations is situated within the Singleton Local Government Area (LGA) and located approximately 15 kilometres (km) north-west of Singleton and 17 km south-east of Muswellbrook in the Upper Hunter Valley of NSW. **Figure 1** illustrates the location of Ravensworth Operations and its approved operations boundary.

Ravensworth Operations currently carries out open cut mining activities under PA 09_0176, approved 11 February 2011, to provide high quality thermal and semi-soft coking coal to export and domestic markets at a maximum of 16 Million tonnes per annum (Mtpa) of Run of Mine (ROM) coal.

2.2 Modification Description

Xstrata Coal is seeking a modification to PA 09_0176 under section 75W, Part 3A of the EP&A Act.

The Modification involves:

- Recovery of approximately 2.7 million tonnes (Mt) of ROM coal by open cut mining methods over a period of two years in an approved overburden emplacement area (OEA) within the Narama mining area (referred to as the Narama West mining area):
- Production within the approved maximum limit of 16 Mtpa of ROM coal.
- Operations being undertaken via truck and shovel or dragline mining techniques.
- Utilisation of the existing equipment fleet.
- Tailings and rejects emplacement as per approved existing operations.
- Utilisation of existing infrastructure including the coal handling and preparation plant (CHPP), coal terminal, rail loop, workshops and offices.
- Transportation of domestic coal to neighbouring power stations via the existing conveyor system.
- Transportation of product coal to the Port of Newcastle for export via the Main Northern Railway.
- Retention of the approved final landform with overburden used to progressively backfill the final void.

The conceptual layout of the Modification is illustrated in **Figure 2**.

Mining operations are likely to commence in 2013 and continue through to 2014, however, may occur later pending approval of the Modification, scheduling of operations and availability of equipment.

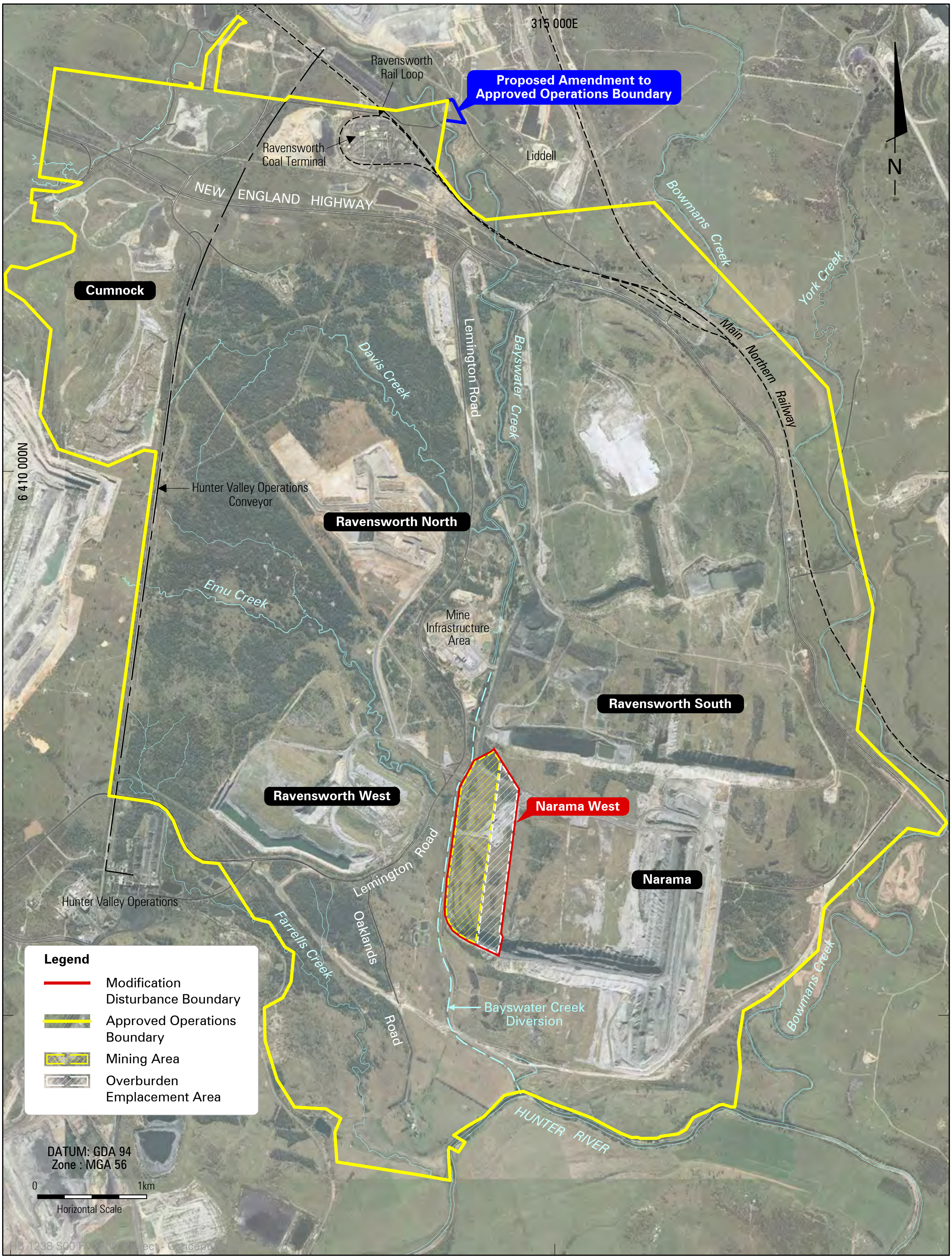
xstrata coal ravensworth open cut

Hansen Bailey ENVIRONMENTAL CONSULTANTS

NARAMA WEST MODIFICATION

Regional Locality Plan

FIGURE 1



NARAMA WEST MODIFICATION

Conceptual Modification Layout

xstrata coal ravensworth open cut

Hansen Bailey ENVIRONMENTAL CONSULTANTS

FIGURE 2

3 NOISE IMPACT ASSESSMENT

3.1 Land Ownership and Receivers

A number of private rural land holdings and residences are located to the east and south-east of Ravensworth Operations with the majority centralised at Camberwell Village, which is approximately 1.7 km from the approved operations boundary and 5.9 km from the Modification disturbance boundary.

3.2 Previous Noise Impact Assessment – Ravensworth Operations Project EA

3.2.1 Noise Modelling Methodology

Umwelt Pty Ltd undertook a Noise Impact Assessment for the Ravensworth Operations Project EA (Umwelt, 2010). This assessment used the Environmental Noise Model (ENM) software to predict noise emissions from Ravensworth Operations at the nearest receivers for six conceptual stages of mine development (Years 3, 5, 10, 15, 20 and 25).

A three-dimensional digital terrain map giving all relevant topographic information was used in the modelling process. The model used this map, together with noise source data, ground cover, shielding by barriers and/or adjacent buildings and atmospheric information to predict noise levels at the nearest potentially affected receivers.

The metrological conditions considered in the noise model to predict noise levels from Ravensworth Operations are provided in **Table 1**.

Table 1 Meteorological Scenarios for Operational Noise Modelling

Scenario	Temperature	Relative Humidity	Wind Speed (m/s)	Wind Direction, ° from North	Temperature Gradient, °C/100 m
1. Calm	20	65	-	-	-
2. Winter Evening, Night (NW Wind)	10	90	3	315	-
3. Winter Night (Inversion and gradient wind)	10	90	0.6	270	3
4. Winter Night (Inversion and drainage flow)	10	90	2	315	3
5. Summer Night (SSE Wind)	10	65	3	135	-

Year 3 (equivalent to 2013) was identified as the worst case mining scenario (Umwelt, 2010). Operational noise sources under this scenario include fixed equipment such as conveyors systems, rail loop, CHPP and coal terminal, and mobile equipment working in and around the CHPP and the Narama mining area.

3.2.2 Operational Noise Levels – Ravensworth Operations – Year 3

The operational noise levels from Ravensworth Operations for the identified worst case mining scenario (Year 3) for each of the meteorological scenarios outlined in **Table 1** are predicted to meet the relevant criteria at all assessed residential receiver locations (Umwelt, 2010).

Sleep disturbance noise levels for Ravensworth Operations worst case mining scenario (Year 3) are predicted to meet the relevant sleep disturbance criteria at all assessed residential receiver locations (Umwelt, 2010).

3.3 The Modification

3.3.1 Operational Noise

Given the nature and scale of the Modification, noise predictions presented in this assessment are 'semi-quantitative' and have been predicted based on a review of previous detailed modelling results conducted for Ravensworth Operations.

The assumptions used in the analysis were as follows:

- Equipment used simultaneously in the Modification area and Narama mining area would not exceed those modelled in the Year 3 scenario for the Ravensworth Operations Project EA (Umwelt, 2010) for the Narama mining area alone.
- All acoustically significant mining plant and equipment was situated in worst case locations (eastern boundary) inside the mining area or on the OEA within the Modification disturbance boundary.
- All acoustically significant plant and equipment operates simultaneously and in accordance with the extraction and operational schedules approved for Ravensworth Operation (Umwelt, 2010).
- Approved rail loading and rail movements were considered on the Ravensworth rail loop.

Operational noise levels in Year 3 of the noise impact assessment (Umwelt, 2010) were predicted to meet the relevant intrusive and sleep disturbance criteria at all private receivers under various meteorological scenarios and when utilising the total approved equipment fleet. With consideration of the Modification, a portion of the equipment fleet as modelled in the Year 3 case will be redistributed from the Narama mining area to the Narama West mining area (which is located 2km further away from sensitive receivers). The intensity of noise generated from the Narama West and Narama mining area, when both operations are occurring concurrently, will not exceed that modelled in Year 3 for the Narama mining area alone. As such, the operational noise levels generated by existing operations with consideration of the Modification are comparable to that currently approved with no exceedance of the intrusive or sleep disturbance criteria predicted at any private receiver.

Ravensworth Operations implement a number of controls in the mine design to minimise noise. These controls will continue to be implemented for the Modification and managed in accordance with the approved Noise Management Plan.

3.3.2 Road Traffic Noise

No additional road traffic movements are proposed as part of the Modification and as such there will be no additional noise impacts from increased road traffic on the New England Highway, Lemington Road or the Singleton LGA.

3.3.3 Rail Noise

No additional rail movements or increase in production is proposed as part of the Modification and as such there will be no additional impacts from rail noise on the Main Northern Railway line.

4 BLASTING IMPACT ASSESSMENT

The approach of this assessment was to determine the limiting factors to the blast design for the Modification with the aim of achieving the relevant criteria at all locations. Calculations were conducted using the respective site law equations in order to determine the allowable Maximum Instantaneous Charge (MIC).

Table 2 contains the results of allowable MIC calculations based on the site laws developed for ground vibration and airblast. The distances presented in **Table 2** are the potential nearest distance that blasting could occur to the identified nearest receiver or infrastructure asset. Actual vibration and airblast levels for any given blast will depend upon the blast location within the active mining area in relation to the nearest noise/vibration-sensitive receivers.

Table 2 Allowable MIC and Blast Emissions Predictions

Receiver/Infrastructure Asset	Approximate Distance to Nearest Receiver/Infrastructure Asset (m)	Allowable MIC Based on Ground Vibration or Airblast (kg)	Blast Emission Prediction Based on Allowable MIC	
			Predicted PVS Ground Vibration (mm/s)	Predicted Airblast Level (dB Linear)
Closest Resident	3162	1,800	5.0	114.7
Camberwell Church	5510	5,480	5.0	112.8
Ravensworth Public School	5540	6930	<10.0	<133.0
Chain of Ponds Hotel	5820	7640	<10.0	<133.0
Ravensworth Homestead	3180	2280	10.0	118.0
Aboriginal axe grinding groove site (REA86)*	2115	4960	<30.0	-
1,000ML dam wall and proposed dam wall	2425	5010	<25.0	-
Conveyors, including the Hunter Valley Operations conveyor	2735	>10,000	<100.0	-
Main Northern Railway culverts and bridges	3320	9390	<100.0	-
Ashton underground mine	3335	1190	6.0	115.4

* Xstrata Coal is currently seeking to increase the vibration criteria for REA86. Allowable MIC calculations for this location are based on the approved criteria as outlined in PA 09_0176. Refer to the main volume of the EA for further details.

Ravensworth Operations currently has a network of blast monitors within the surrounding residential areas which are used to provide feedback on ground vibration and airblast levels for each blast. Data collected from the monitors is correlated with blast parameters such as charge weight and location and used to ensure future blasts are adequately designed to avoid exceedances of appropriate noise and vibration criteria. This feedback and design process will continue to be appropriate for future blasts within the Modification disturbance boundary and will be managed in accordance with the existing Blast Management Plan.

As the Modification area is located further from closest receivers, vibration and airblast levels from blasts within the Modification disturbance boundary would be similar to those from adjacent approved mining areas.

Residents in the area surrounding the Modification will be exposed to blast emissions from a number of mines in the area. The impacts from blasting are very short in duration (several seconds only), however, Ravensworth Operations will continue to coordinate blasting times with other mines in order to avoid concurrent blasting events.

5 CONCLUSION

SLR Consulting has conducted a Noise and Blasting Impact Assessment for the Modification.

Given the redistribution of equipment, the intensity of noise generated from the Narama West and Narama mining area, when both operations are occurring concurrently, will not exceed that modelled in Year 3 for the Narama mining area alone as presented in the noise impact assessment (Umwelt, 2010) for the Ravensworth Operations Project EA. As such, the operational noise levels generated by existing operations with consideration of the Modification are comparable to that currently approved with no exceedance of the intrusive or sleep disturbance criteria predicted at any private receiver.

No additional traffic movements are proposed as part of the Modification and as such there will be no additional noise impacts from increased road traffic on the New England Highway, Lemington Road or Singleton LGA.

No additional rail movements or increase in production is proposed as part of the Modification and as such there will be no additional impacts from rail noise on the Main Northern Railway line.

No additional noise mitigation measures are required for the Modification beyond those conditions specified in PA 09_0176. Ravensworth Operations implement a number of controls in the mine design to minimise noise. These controls will continue to be implemented for the Modification and managed in accordance with the approved Noise Management Plan.

Calculations were conducted in order to estimate the allowable MICs for compliance with the relevant vibration and airblast criteria at the nearest sensitive receivers and infrastructure assets. As the Modification area is located further from closest receivers, vibration and airblast levels from blasts within the Modification disturbance boundary would be similar to those from adjacent approved mining areas.

Blast events within the Modification disturbance boundary will be monitored and managed in accordance with the existing Blast Management Plan to ensure compliance with applicable criteria.

6 REFERENCES

SLR Consulting (2009)

Heggies report 30-2246-R1R1 Blast Emissions Impact Assessment Narama Extended Project dated 25 June 2009

Umwelt Pty Ltd (2010)

Umwelt report 2383/R12/Final Ravensworth Operations Project Noise Impact Assessment dated January 2010

APPENDIX C

Surface Water Impact Assessment

Gilbert & Associates Pty Ltd

4th March, 2013

Chelsea Kavanagh
Environmental Scientist
Hansen Bailey Environmental Consultants
via Email

RE: Letter Report – Narama West Modification Surface Water Impact Assessment and Flood Assessment

Chelsea,

Further to our proposal dated 22/11/2012, the following letter report has been prepared to detail findings of a water balance impact assessment and flood assessment for the proposed Narama West Modification (the Modification).

1.0 Introduction

Gilbert & Associates Pty Ltd (G&A) has been engaged by Hansen Bailey Environmental Consultants (Hansen Bailey) on behalf of Xstrata Coal Pty Limited (Xstrata Coal) to complete a water balance impact assessment and flood assessment for the Modification. The purpose of the assessment is to form part of an Environment Assessment (EA) being prepared by Hansen Bailey to support the Modification to Project Approval (PA) 09_0176 under section 75W, Part 3A of the *Environmental Planning and Assessment Act 1979* (EP&A Act).

1.1 Background

Ravensworth Operations Pty Limited (Ravensworth Operations) is a wholly owned subsidiary of Xstrata Coal and comprises of the active Ravensworth North and Narama mining areas and the former Cumnock, Ravensworth West and Ravensworth South mining areas. Ravensworth Operations is situated within the Singleton Local Government Area and located approximately 15 kilometres (km) north-west of Singleton and 17 km south-east of Muswellbrook in the Upper Hunter Valley of New South Wales (NSW). Figure 1 illustrates the location of Ravensworth Operations.

Ravensworth Operations currently carries out open cut mining activities under PA 09_0176, approved 11 February 2011, to provide high quality thermal and semi-soft coking coal to export and domestic markets at a maximum of 16 Million tonnes per annum (Mtpa) of Run of Mine (ROM) coal.

PO Box 2143, Toowong, QLD 4066
Ph: 07 3367 2388 Fax: 3367 2833
E-mail: gaconslt@bigpond.net.au
ABN: 62 085 419 852

(Hansen Bailey, 2013)

Figure 1 Site Locality Plan

1.2 Modification Description

Xstrata Coal is seeking a modification to PA 09_0176 under section 75W, Part 3A of the EP&A Act. The Modification involves:

- Recovery of approximately 2.7 Million tonnes (Mt) of ROM coal by open cut mining methods over a period of two years in an approved overburden emplacement area (OEA) within the Narama mining area (referred to as the Narama West mining area);
- Production within the approved maximum limit of 16 Mtpa of ROM coal;
- Operations being undertaken via truck and shovel or dragline mining techniques;
- Utilisation of the existing equipment fleet;
- Tailings and rejects emplacement as per approved existing operations;
- Utilisation of existing infrastructure, including the Coal Handling and Preparation Plant (CHPP), coal terminal, rail loop, workshops and offices;
- Transportation of domestic coal to neighbouring power generators via the existing conveyor system;
- Transportation of product coal to the Port of Newcastle for export via the Main Northern Railway; and
- Retention of the approved final landform with overburden used to progressively backfill the final void.

The conceptual layout of the Modification is illustrated in Figure 2.

PO Box 2143, Toowong, QLD 4066
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E-mail: gaconslt@bigpond.net.au
ABN: 62 085 419 852

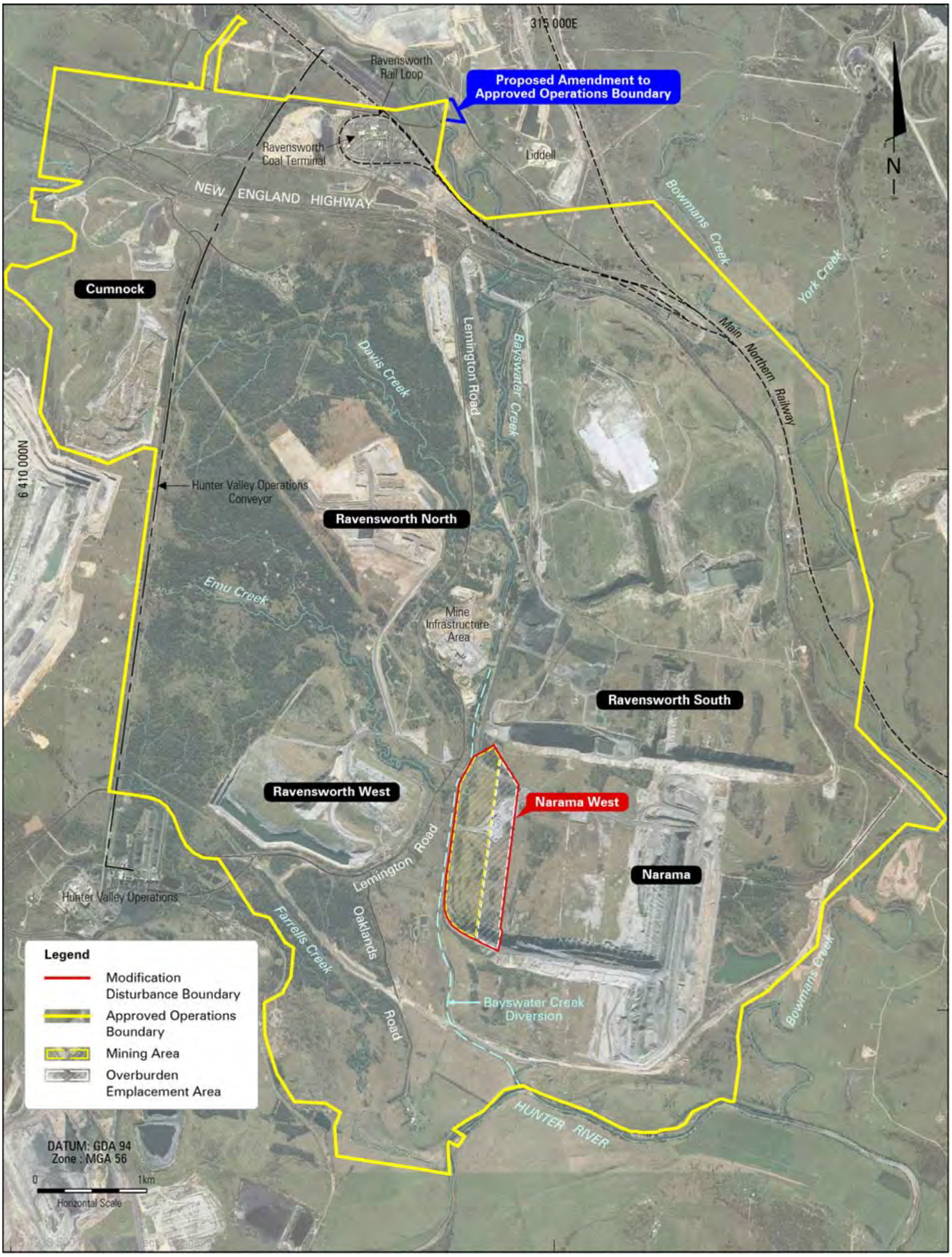

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Figure 2 Conceptual Layout of Modification

2.0 Water Balance Impact Assessment

The aim of the water balance impact assessment is to compare the predicted future water balance without the Modification (i.e. the existing approved operation) to that with the Modification (proposed). The locations of the storages included in the water balance model are shown in Figure 3 while a schematic representation of the water management system is shown in Figure 4. The Modification water balance differs from the existing water balance with the inclusion of the Narama West mining area and the associated surface drainage effects (i.e. catchment changes to the Narama mining area, Haul Road Dam, EEA3 and EEA4 – refer Figure 3).

The Modification water balance includes two possible mining techniques: (i) Truck and Shovel and (ii) Dragline. The two different techniques result in differences in disturbed catchment area and coal washing rates with time (refer Section 2.2) and hence the water balance for both techniques has been simulated.

2.1 Model Description

The model uses the GoldSim® package to simulate the water (mass) balance of all existing and proposed storages on a sub-daily time interval. Historical climate data (DataDrill[1], Jeffrey et. al. 2001) is used for prediction of catchment rainfall runoff and evaporation. The model simulates 119, 22¼-year "realizations", derived using the climatic record from 1892 to 2010[2]. The first realization uses climatic data from 1892-1915, the second 1893-1916, the third 1894-1917, and so on. The results from all realizations were used to generate water storage volume estimates and other relevant water balance statistics. This method effectively includes all recorded historical climatic events in the water balance model, including high, low and median rainfall periods. Results can be extracted for any water balance component for any time period in the simulation and statistical analyses undertaken.

The model includes simulation of flows in the Hunter River in order to model available opportunities for water release (in parallel with climatic variations) in accordance with the Hunter River Salinity Trading Scheme (HRSTS). The model also uses output from the Hunter River Integrated Quantity Quality Model in order to simulate variations in available licensed extraction from the Hunter River (in parallel with climatic variations).

[1] The Data Drill is a system which provides synthetic data sets for a specified point in Australia by interpolation between surrounding point records held by the Bureau of Meteorology (BoM).

[2] Additional climate data after 2010 was generated by "wrapping" data from the beginning of the climate record to after 2010. In this way, the drought period of 2005-06 could be simulated as occurring at varying time through the mine life.

PO Box 2143, Toowong, QLD 4066
Ph: 07 3367 2388 Fax: 3367 2833
E-mail: gaconslt@bigpond.net.au
ABN: 62 085 419 852

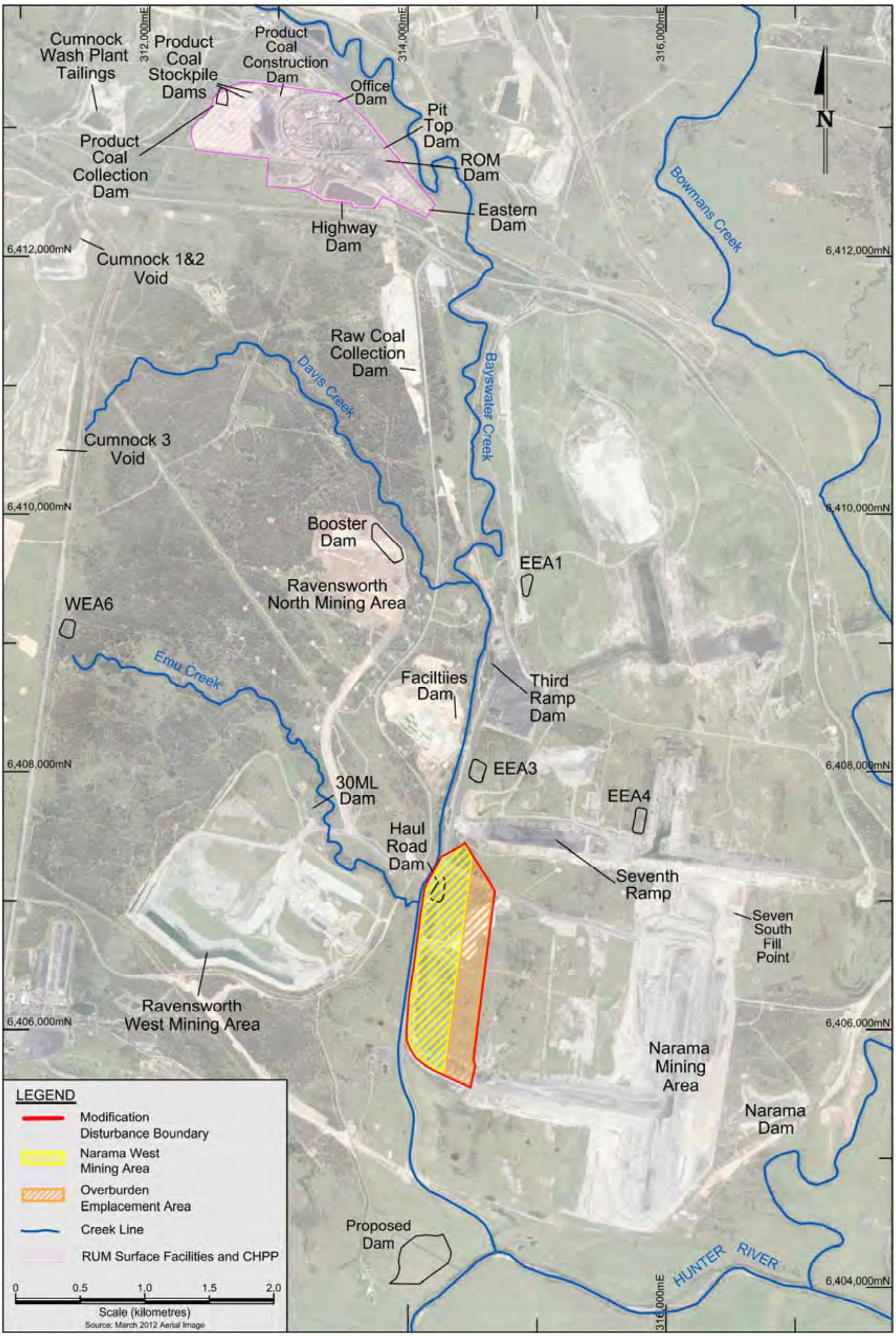

Figure 3 Locations of Modelled Storages

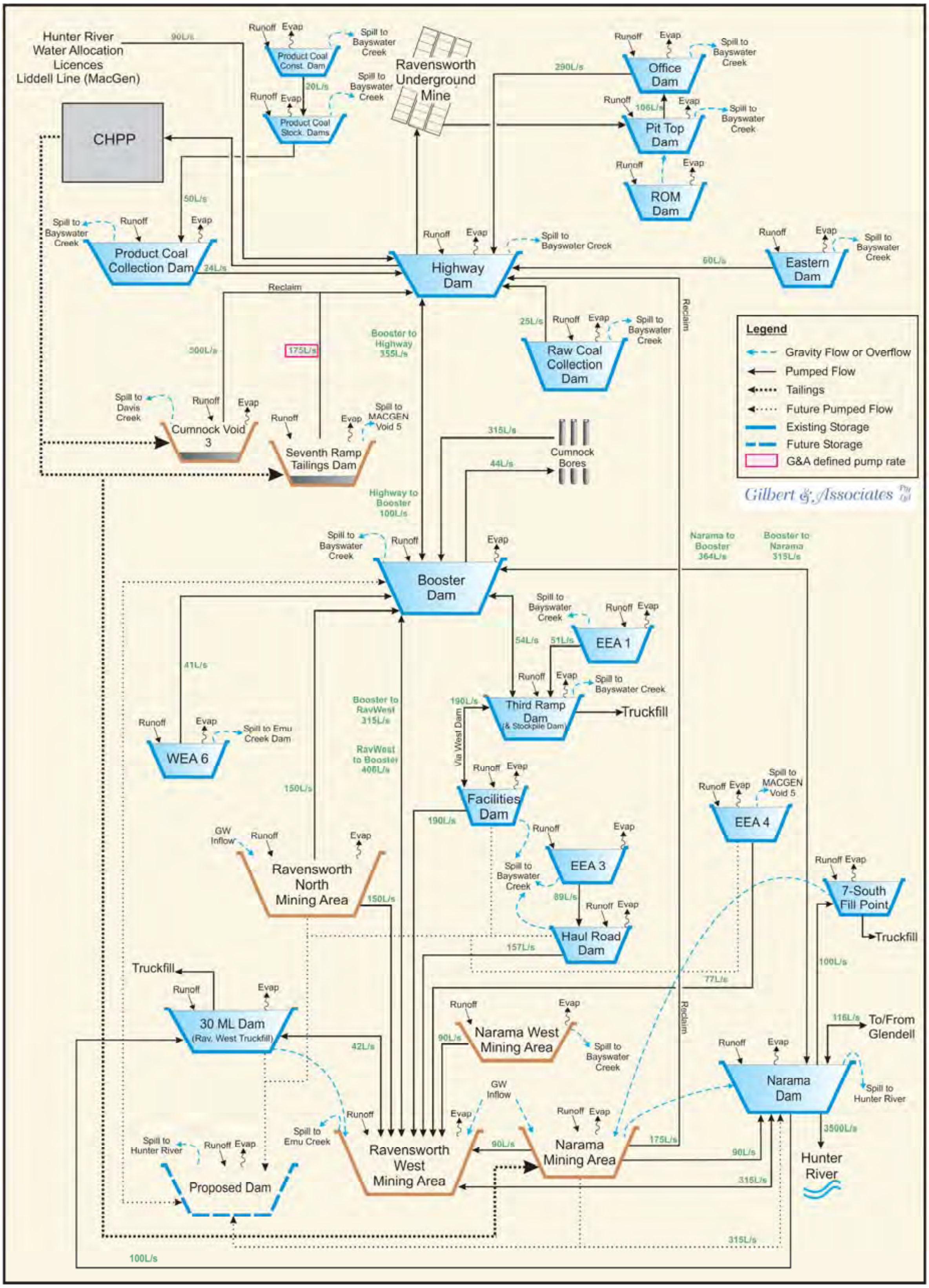

Figure 4 Water Management System Schematic

PO Box 2143, Toowong, QLD 4066
Ph: 07 3367 2388 Fax: 3367 2833
E-mail: gaconslt@bigpond.net.au
ABN: 62 085 419 852

2.2 Key Model Assumptions

A number of key assumptions have been made in the model as follows:

- The model simulation reported herein commences on 1/10/2012 and finishes on 31/12/2034. While the Modification period is two years, the model has been run for the entire mine life to include any follow-on effects.

- The water balance model includes a simulation of daily rainfall-runoff from rainfall data. For dam storage surface areas (i.e. water), rainfall was assumed to add directly to storage volume with no losses. For other sub-catchments, rainfall runoff was simulated using the Australian Water Balance Model – Boughton (2004).

- Storage volumes calculated by the model are used to calculate storage surface area (i.e. water area) based on storage volume-area-level relationships for each water storage either provided by Ravensworth Operations or estimated from supplied plans. Evaporation from storages is calculated in the model by multiplying storage surface area by daily pan evaporation rate. A pan factor of 0.9 was used in the model for all storages (except the tailings storages and pits), to allow for the typically lower evaporation from open water bodies compared to evaporation pans[3]. A pan factor of one is considered appropriate for the tailings storages because the tailings are dark with low reflectance, which would likely increase the effective evaporation rate.

- Mining operations for the Modification are likely to commence in 2013 and continue through to 2014, however, may occur later pending approval of the Modification, scheduling of operations and availability of equipment. The below assumptions for the Truck and Shovel and Dragline scenarios have been developed for modelling purposes only and have been confirmed by Xstrata Coal personnel.

  For the Truck and Shovel mining technique, catchment areas were determined based on a date allocation to each 'stage' of mining (refer Figure 5):

  - Start excavation = 1/7/2013
  - Stage 1 excavation, overburden to OEA = 1/10/2013
  - Stage 2 excavation, overburden to backfill Stage 1 void = 1/1/2014
  - Stage 3 excavation, overburden to backfill Stage 2 void = 1/4/2014
  - Stage 4 excavation, overburden to backfill Stage 3 void = 1/7/2014
  - Narama West mining area (i.e. Stage 4) completely backfilled = 1/10/2014[4]

  For the Dragline mining technique, catchment areas were determined based on the following key dates of surface disturbance (refer Figure 5):

  - Start excavation = 1/7/2013
  - Stage 1 (northern half) excavated while Stage 1 (southern half) undisturbed, overburden to OEA = 1/10/2013

[3] This is a widely accepted value in hydrological practice

[4] This model run assumes backfilling would be complete 3 months after cessation of mining in the Narama West mining area.

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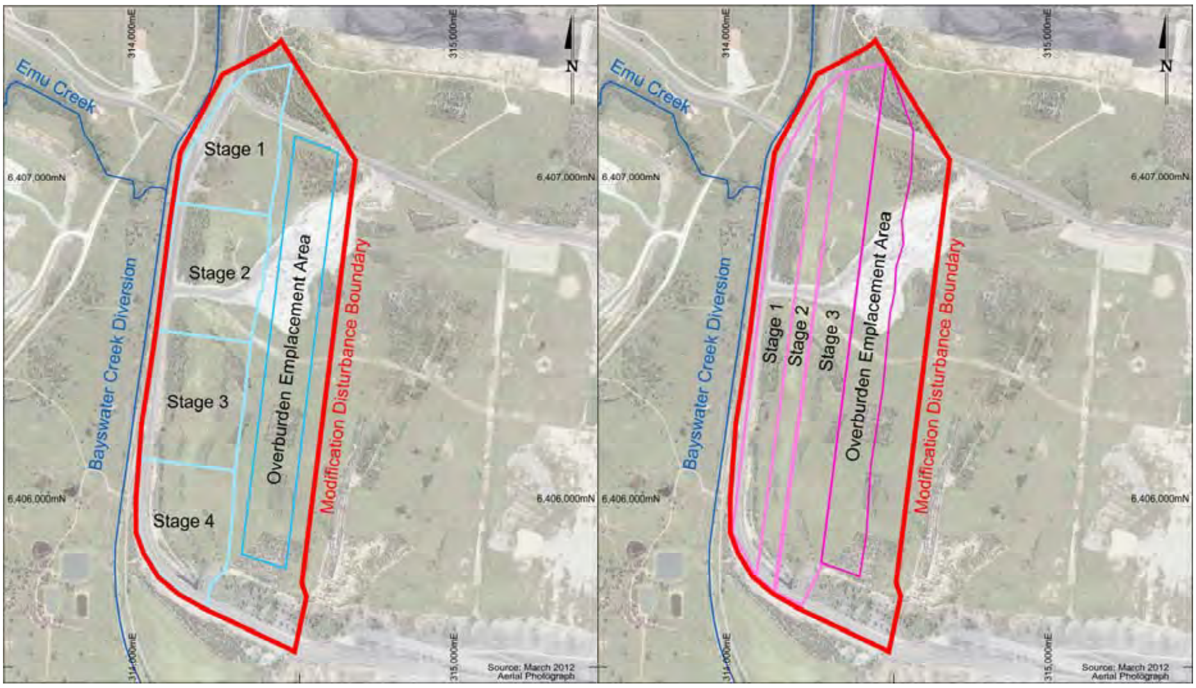
Ph: 07 3367 2388 Fax: 3367 2833
E-mail: gaconslt@bigpond.net.au
ABN: 62 085 419 852

- Stage 1 excavated, overburden to OEA = 1/1/2014
- Stage 2 (northern half) excavated while Stage 2 (southern half) disturbed, overburden to backfill Stage 1 void (northern half) = 1/4/2014
- Stage 2 excavated while Stage 3 (northern half) disturbed, overburden to backfill Stage 1 void = 15/5/2014
- Stage 3 (northern half) excavated while Stage 3 (southern half) disturbed, overburden to backfill Stage 2 void (northern half) and OEA = 1/8/2014
- Stage 3 excavated, overburden to backfill Stage 2 void (southern half) and OEA = 1/10/2014
- Narama West mining area (i.e. Stage 2 and Stage 3) completely backfilled = 1/01/2015[5].



Truck and Shovel *Dragline*

Figure 5 Mining Technique Layout Comparison

- Future ROM coal washing (CHPP feed) rates are summarised in Figure 6 and vary for each mining technique. Note that the coal washing rate attributable to the underground operations remains constant for each technique.
- CHPP demand is calculated based on the ROM coal washing rate, product and reject yield percentages, and a moisture balance using moisture (water) contents for ROM coal, product coal, coarse rejects and tailings provided by Ravensworth Operations (moisture contents differ for underground and open cut coal). Calculated CHPP

[5] This model run assumes backfilling would be complete 3 months after cessation of mining in the Narama West mining area.

demand peaks at 10.8 ML/d and follows a similar trend to the total plots shown in Figure 6.

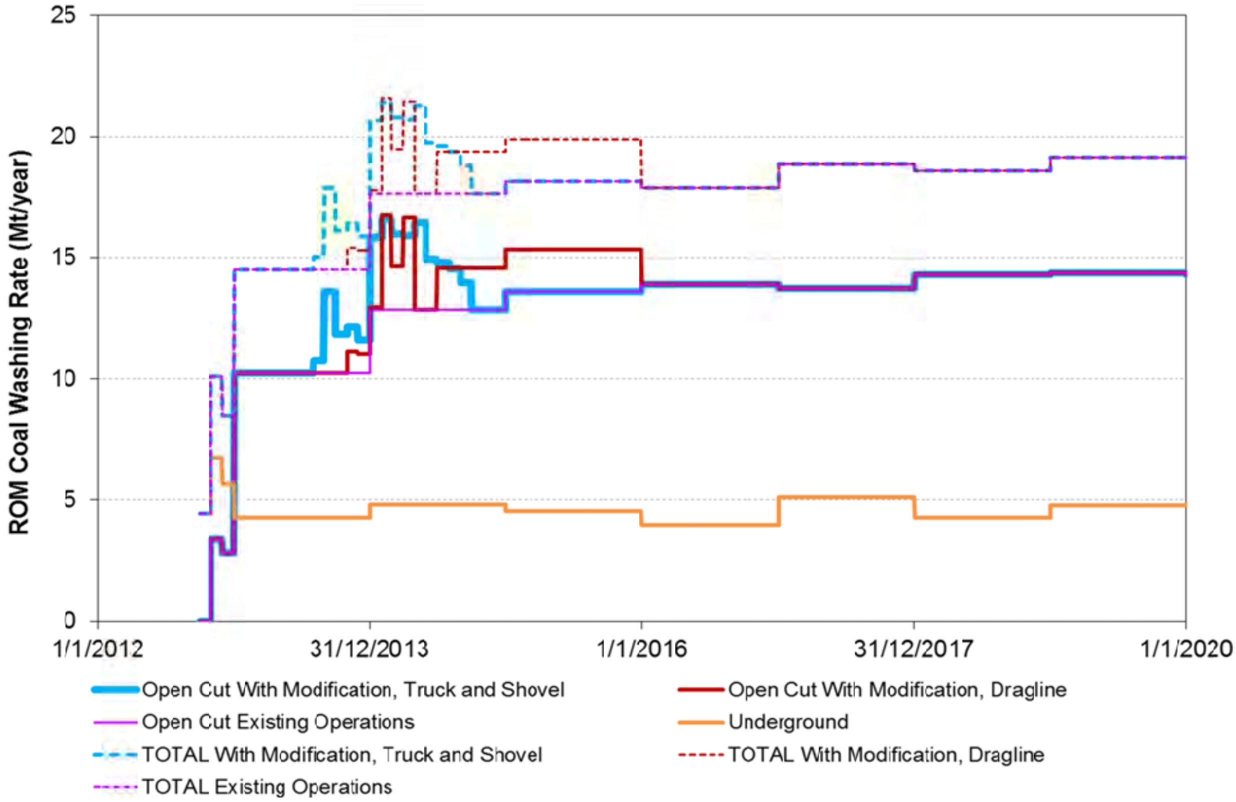


Figure 6 Future ROM Coal Washing Rates

In consultation with Xstrata Coal, the following assumptions within the water balance are confirmed to be consistent with the currently approved operations:

- Storage surface sub-catchment areas were measured from mining stage plans at different future points in time. The catchment areas were split into different sub-catchment types (defined on the basis of vegetation coverage and surface type with the aid of an aerial photograph) and include: hardstand, natural surface, open cut, tailings, OEA and completed rehabilitation. The model assumes linear interpolation of sub-catchment areas between all stage plans.
- Underground and open cut groundwater inflow rates as predicted by Mackie Environmental Research (2011, 2009). Zero effective groundwater inflow has been assumed to the Narama West mining area based on information from Australasian Groundwater and Environmental Consultants (AGE, 2013). A water balance model run has also been included whereby groundwater inflow to the Narama West mining area was set to 0.5 ML/d to test the sensitivity of model results to this input parameter.
- CHPP tailings are currently discharged to the Seventh Ramp and assumed in the future to be discharged to Cumnock 1 and 2, Cumnock Wash Plant, Cumnock 3 and

Narama voids in turn. Direct surface reclaim of tailings water will not be possible from both Cumnock 1 and 2 and the Cumnock Wash Plant voids (ATC Williams, 2012), with tailings water and rainfall runoff infiltrating through the floor of these voids and into the Cumnock Underground. Water will be pumped out of the Cumnock Underground via a bore or bores and into the Booster Dam. Tailings disposal to Cumnock 3 void is planned to occur in parallel with Coal & Allied's Hunter Valley Operations. No agreement is currently in place regarding recovery of water from this storage. The model assumes that from 1/1/2014, tailings water (based on water liberated from Ravensworth Operations tailings deposition only) and void catchment rainfall runoff will be reclaimed from Cumnock 3 at a maximum rate of 500 L/s.

- Future haul road water demand was calculated from measured snapshot plan haul road lengths, multiplied by a width of 35 m, the daily pan evaporation rate (less rainfall) and by a factor of 1.3 (to allow for higher evaporation off the dark, highly trafficked haul roads). No haul road use was assumed on days in which rainfall exceeded evaporation. Haul road demand was assumed distributed evenly between the three truckfill points: Seven South Fill Point, 30ML Dam and Third Ramp Dam. If either of the first two did not have enough water to supply their truckfill demands on a given day, the residual demand was attempted to be sourced from the Third Ramp Dam.
- Underground demand (for use in longwall mining – cooling and underground dust suppression) rates are expected to increase by 25 % compared to the current operation up to 0.71 ML/d (as per information provided by Ravensworth Underground Mine [RUM] personnel). All of this water is assumed lost to ROM coal or ventilation losses (zero recovery).
- Modelled default pumped transfer rates from storages are shown in Figure 4.
- Initial storage values were mostly based on values reported by RUM and Ravensworth Operations personnel as at early October 2012 with the main storage values as follows: Cumnock Underground 6600 ML, Highway Dam 200 ML, Narama Dam 276 ML, Ravensworth West Mining Area 1469 ML.
- A number of storages are not yet commissioned hence a date was assumed when these storages are to be included in the water balance model. Similarly, a number of storages are decommissioned during the mine life. A summary of modelled storage start and end dates are given in Table 1.
- Bores into the Cumnock Underground are currently decommissioned however will need to be recommissioned due to the Cumnock Underground receiving inflow in the form of tailings bleed and rainfall runoff from Cumnock 1 and 2 and Cumnock Wash Plant voids. The model assumes these bores will be recommissioned on 1/10/2013[6] and pump to the Booster Dam at a rate of 315 L/s, which is equivalent to the advised pump rate from the Booster Dam to Narama Dam.

[6] Capital expenditure allowance in 2013 for Cumnock borefield power and pumps – later in 2013 as advised by Ravensworth Operations personnel.

PO Box 2143, Toowong, QLD 4066
Ph: 07 3367 2388 Fax: 3367 2833
E-mail: gaconslt@bigpond.net.au
ABN: 62 085 419 852

Table 1 Modelled Storage Start and End Dates

Storage	Start Date	End Date
Cumnock Void 3	1/10/2013	31/8/2019
EEA1	1/7/2015	-
EEA4	15/2/2013	-
Proposed Dam	1/7/2025	-
Haul Road Dam	1/4/2014	-
Narama West Mining Area	1/7/2013***	1/10/2014* 1/1/2015**
Ravensworth West Mining Area	Existing	1/1/2027
Seventh Ramp Tailings Storage	Existing	15/11/2013
Thirty ML Dam	Existing	30/06/2024
WEA6	15/1/2019	-

* Truck and Shovel mining technique
** Dragline mining technique
*** Dependent on actual approval date

- The Ravensworth West mining area acts as the main water storage on site but is required to be dewatered down to the volumes shown in Figure 7 over time to reduce the level of saturation in dragline overburden to the north which could otherwise impact the Ravensworth North mining area operation[7].

  Therefore is it assumed that when the required maximum storage volume of Ravensworth West Mining Area drops to 800 ML (on approximately 7/8/2019 assuming linear interpolation between points in Figure 7), the Proposed Dam will be commissioned as a replacement water storage. The Proposed Dam[8] is conceptually to be located approximately 2 km south of the Modification disturbance boundary to the north of the Hunter River (refer Figure 3).

- Currently the pipeline linking Ravensworth Operations with the nearby Glendell Mine (and Mt Owen operations) is decommissioned. For modelling purposes only, this pipeline would be recommissioned by 1/3/2013 with transfer of water in either direction only limited by pumping rate (set to 10 ML/d) and not limited by the availability of water from Glendell or storage capacity at Mt Owen. The actual date of recommissioning may occur later.

7 As advised by Ravensworth Operations personnel.
8 Previously referred to as the "Proposed Main Storage Dam" in the 2010 Environment Assessment (Umwelt, 2010).

PO Box 2143, Toowong, QLD 4066
Ph: 07 3367 2388 Fax: 3367 2833
E-mail: gaconslt@bigpond.net.au
ABN: 62 085 419 852

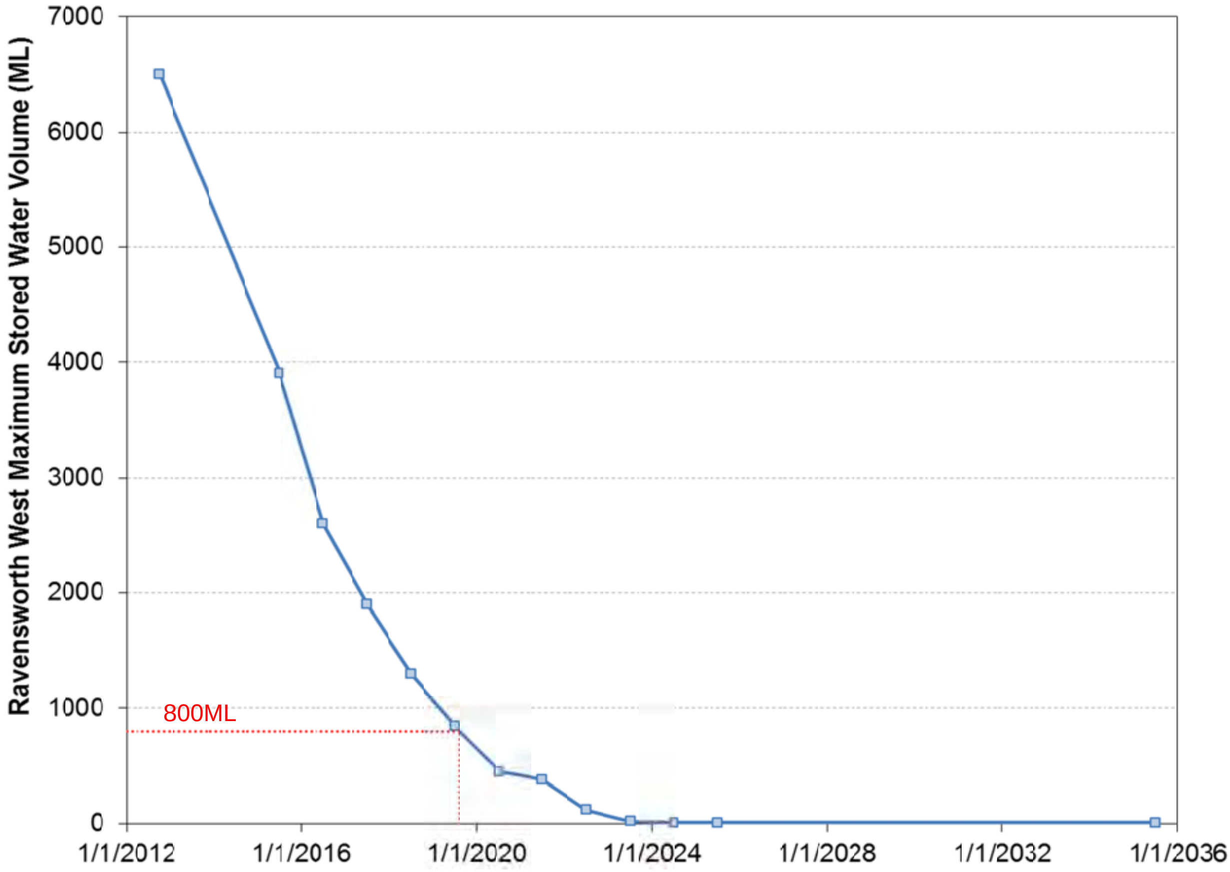


Figure 7 Ravensworth West Mining Area Dewatering Requirements

2.2 Model Results

Model results are described below by comparing the water balance simulation of the existing operation with the Modification (for both Truck and Shovel and Dragline mining techniques).

2.2.1 Overall Water Balance

Table 2 below summarises the water balance for the median 22¼ year rainfall simulated (median over all realizations). Note that the difference between total inflows and outflows in Table 2 represents a predicted change in the volume of water stored.

PO Box 2143, Toowong, QLD 4066
Ph: 07 3367 2388 Fax: 3367 2833
E-mail: gaconslt@bigpond.net.au
ABN: 62 085 419 852

Table 2 Comparison of Median Rainfall Water Balance

	Existing Operation	*With Modification*	
		Truck and Shovel	*Dragline*
	INFLOWS (ML/year)		
Rainfall Runoff	2,416	2,416	2,416
Tailings Bleed[9]	2,459	2,498	2,514
General Security Entitlement	1,018	1,020	1,021
High Security Entitlement	2	2	2
Underground Groundwater Inflow	313	313	313
Open Cut Pit Groundwater Inflow	353	353	353
From Glendell Mine	0	0	0
TOTAL	6,561	6,602	6,618
	OUTFLOWS (ML/year)		
Evaporation	870	871	870
CHPP Supply	2,850	2,874	2,882
Haul Road Supply	540	540	540
Underground Supply	119	119	119
External Spill	111	111	112
HRSTS Release	253	262	284
To Glendell Mine	1,983	1,992	1,978
TOTAL	6,726	6,769	6,785

It may be seen from Table 2 that tailings water and rainfall runoff contribute the majority of the inflows to the mine. Approximately 42% of modelled system outflow is accounted for in CHPP make-up.

2.2.2 Supply Reliability

No shortfalls were simulated for supply to the CHPP, the underground and haul road dust suppression in any simulated 22¼ year realization

2.2.3 Risk of Mining Disruption

The potential risk of disruption to mining has been assessed by tracking the number of days in each realization where there was more than 200 ML stored in each active mining area (an arbitrary volume chosen to represent conditions which could lead to mining disruption).

[9] Tailings bleed is water that is liberated from tailings as it settles.

PO Box 2143, Toowong, QLD 4066
Ph: 07 3367 2388 Fax: 3367 2833
E-mail: gaconslt@bigpond.net.au
ABN: 62 085 419 852

Over all modelled climatic realizations, the Narama West mining area does not contain greater than 200 ML of water on any given day. In order to assess the sensitivity of this model result, groundwater inflow to the Narama West mining area was increased to 0.5 ML/d. This resulted in the Narama West mining area storing greater than 200 ML of water for an average of one day per year (averaged over all climatic realizations and years of active mining).

Results indicate that, for the existing operation, the Ravensworth North mining area would contain more than 200 ML of water for an average (over all climatic realizations and years of active mining) of 77 days per year. This number increases to an average of 78 days per year (over all climatic realizations and years of active mining) for both mining techniques of the Modification.

3.0 Surface Water Impact Assessment

It is understood that there will be minimal changes to the final landform resulting from the Modification (see Section 1.2). There is also little difference in total catchment area captured by site storages for the Modification compared with that captured by the approved existing operation. Therefore final landform drainage or catchment excision (downstream flow) impacts on the receiving environment compared with the approved existing operation would be insignificant.

4.0 Flood Assessment

The Modification disturbance boundary (see Figure 2) is adjacent to the Bayswater Creek diversion. The following sub-sections detail a flood assessment which has been carried out to assess the risk of potential flood inflows from the Bayswater Creek diversion to the proposed Narama West mining area.

4.1 Outline of Modelling

A rainfall-routing model for Bayswater Creek was set up using RORB modelling software (Laurenson and Mein, 1997) in order to generate estimates of peak flow rates[10] for a 100 year average recurrence interval (ARI) event and a 250 year ARI event. These event ARIs were chosen as being representative of rare to extreme flood events that would have a reasonably low risk of occurring or being exceeded during the period of mining within the Narama West mining area.

The Bayswater Creek catchment is highly modified both by the presence of Lake Liddell (11.5 km upstream of the Modification disturbance boundary) and a number of open cut mining operations in the area. The hydrologic model incorporates these modified catchment characteristics.

Predicted peak flow rates for the above ARIs were then input to HEC-RAS (USACE, 2010), a 1-dimensional hydraulic model, used to estimate the resulting peak water levels and

[10] RORB generates estimated streamflow hydrographs resulting from corresponding event-based rainfall patterns. Different rainfall event durations were simulated to derive the peak flow rate for each event.

associated flow conditions over the 3.2 km length of Bayswater Creek shown in Figure 8. HEC-RAS is a standard and commonly used model for predicting water surface profiles for steady, gradually varied flow in natural or constructed channel systems. HEC-RAS uses as input:

- channel or natural creek cross-sectional geometry to a sufficient degree of accuracy that frictional losses caused by bed shear and form losses caused by flow expansions and contractions are accurately modelled;
- estimates of channel or natural creek roughness/friction factors;
- flow rates (in this case 100 year and 250 year ARI peak flow rates); and
- starting (boundary) conditions at either end of the channel or stream reach being modelled (usually an estimated depth at both ends).

Note that HEC-RAS is a 1-dimensional flow model which predicts flow depth and velocity assuming uniform flow conditions within each given cross-section. Any two or three dimensional flow effects are not simulated. However, given the fairly uniform nature of the constructed Bayswater Creek diversion in the vicinity of the proposed Narama West mining area, such effects are likely to be small and should not affect model predicted water levels.

4.2 Hydrologic Modelling

The total catchment area of Bayswater Creek to the end of the modelled reach was approximately 95.6 km^2. This included approximately 63.9 km^2 for the catchment area of Lake Liddell and 31.7 km^2 downstream of the Lake Liddell spillway to downstream of the Modification disturbance boundary.

A rainfall intensity-frequency-duration relationship was developed for Bayswater Creek for both a 100 year ARI event and a 250 year ARI event using methods outlined in Australian Rainfall and Runoff (I. E. Aust, 1998).

A conservative assumption was made that the lake was full at the time of the rainfall event with outflow from the lake determined by flow over the spillway. Predicted peak flow rates at the upstream end of the hydraulic model (3200 m chainage in Figure 8), downstream of the confluence with Emu Creek (2400 m chainage in Figure 8) and the end of the hydraulic model (0 m chainage in Figure 8) are summarised in Table 3 below.

PO Box 2143, Toowong, QLD 4066
Ph: 07 3367 2388 Fax: 3367 2833
E-mail: gaconslt@bigpond.net.au
ABN: 62 085 419 852

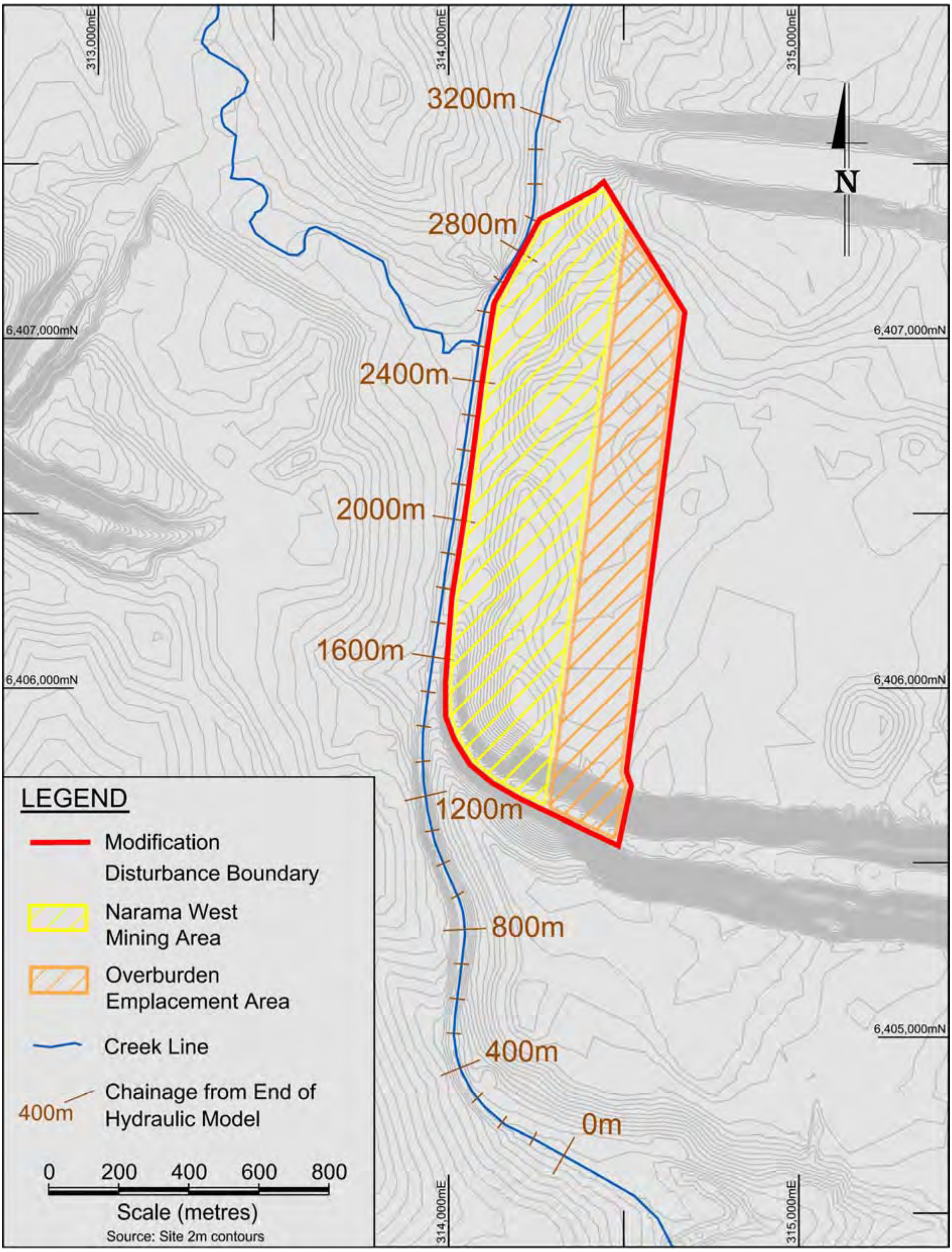


Figure 8 Hydraulic Model Extents

Table 3 Peak Flow Rate Estimates

Chainage from end of hydraulic model (m)	Peak Flow Rate Estimate (m^3/s)	
	100 year ARI	250 year ARI
3200	106.6	135.9
2400	123.8	157.8
0	125.5	160.0

4.3 Hydraulic Modelling

The hydraulic conditions which are predicted to occur in the Bayswater Creek diversion during both a 1 in 100 year ARI flood event and a 1 in 250 year ARI flood event were estimated using the HEC-RAS model. Manning's n[11] values were estimated using supplied photographs along the length of the Bayswater Creek diversion and literature based guidelines (Chow, 1959).

Bayswater Creek cross-sectional geometries were supplied by Ravensworth Operations at regular 200 m intervals along Bayswater Creek. A number of additional cross-sections at key locations were manually generated using supplied 2 m topographic contours, notably near/at contractions and expansions in the channel geometry, near the culvert and concentrated around what was assessed to be the lowest point on the left bank[12]. Given the 200 m interval between the supplied cross-sections, there is a degree of uncertainty regarding the derived top level of the left bank. Notwithstanding, the results presented below should be regarded as providing a reasonable indication of peak flood levels during the modelled flood events.

The Narama West mining area is located to the east of the Bayswater Creek diversion on the left or east bank. In order to gain a preliminary understanding of whether flow in the diversion would impact on the mining area, the top of bank reduced level (RL) along the length of the left bank was found from supplied cross-sections and compared against predicted flood levels.

Bounding water levels at each end of the modelled reach were set to 'normal' or uniform channel depth, which were determined for the given channel cross-sections and assuming Manning's n values at those locations.

Figure 9 shows a longitudinal plot of modelled water levels for both the 100 year ARI flow event (Q100) and the 250 year ARI flow event (Q250). Figure 9 also shows the level of the channel base and the left bank.

[11] Manning's n is the friction factor used to simulate the effects of channel roughness on flow water levels and velocities in the model.
[12] Left bank is on the left side when looking downstream.

PO Box 2143, Toowong, QLD 4066
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E-mail: gaconslt@bigpond.net.au
ABN: 62 085 419 852

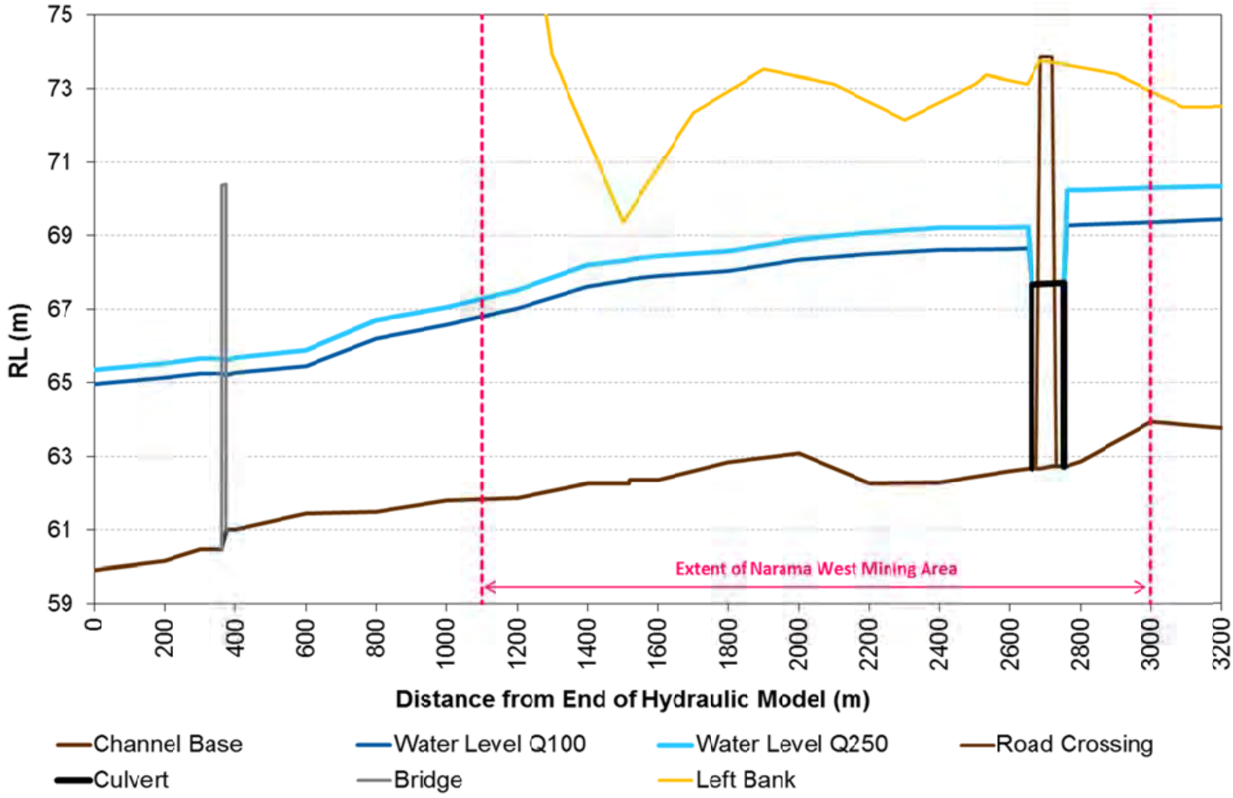

Figure 9 Hydraulic Model Flood Level Results

Figure 9 illustrates that for both the Q100 and Q250 peak flow rates, predicted peak water levels were below the top level of the left bank and hence overtopping of Bayswater Creek flood waters into the Narama West mining area would not occur for both of these events. The apparent drop in water level at the culvert and road crossing is due to water ponding against the embankment and then flowing through the culvert.

The modelling also predicts that, at both peak flow rates, high velocities (i.e. greater than 2 m/s) would occur between chainages 1500 m and 600 m (refer Figure 10). As a requirement of PA 09_0176, the Bayswater Creek diversion will be remediated to provide a hydraulically and geomorphically stable stream. Such activities are scheduled to occur following completion of the Narama West mining area

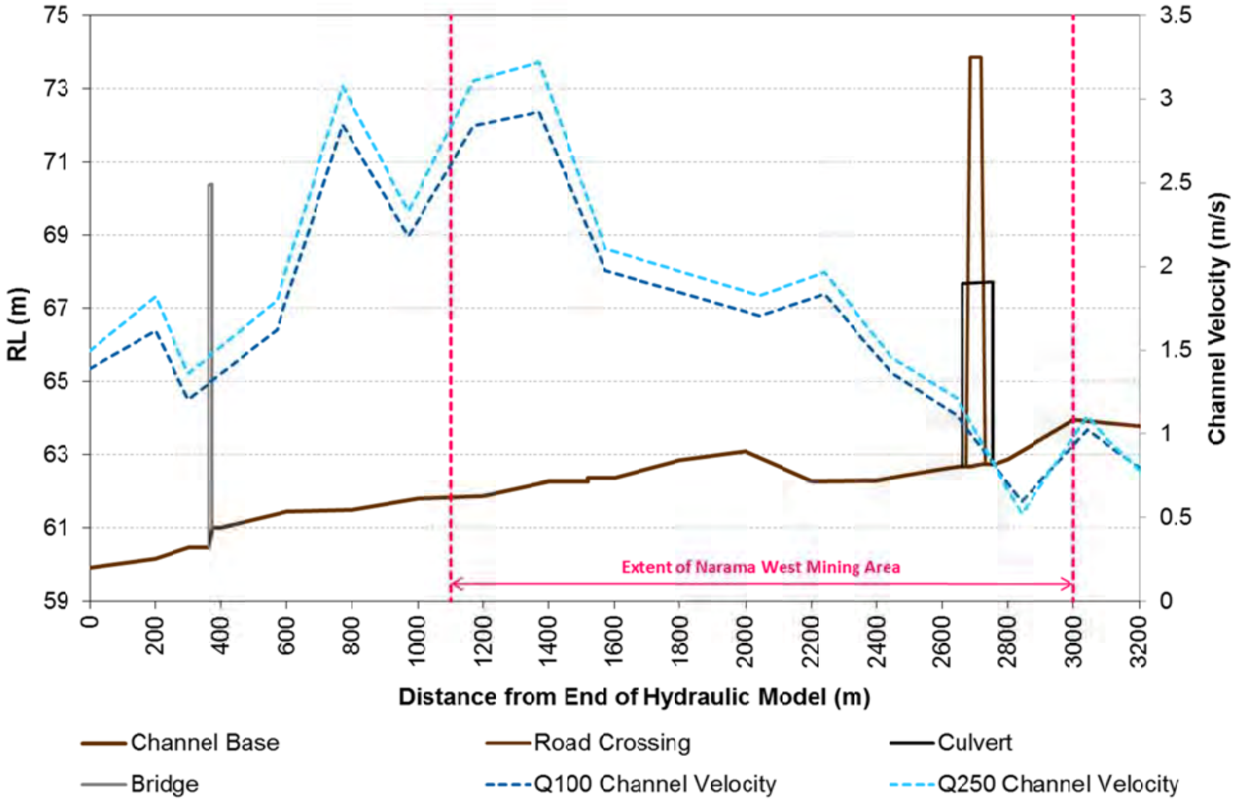

Figure 10 Hydraulic Model Channel Velocity Results

Further testing indicates that the predicted water levels in the vicinity of the Narama West mining area are relatively sensitive to changes in Manning's n. Figure 11 shows a longitudinal plot of modelled water levels with Manning's n values decreased by 20% (i.e. 80% of original estimates) and increased by 20% (i.e. 120% of original estimates). For the latter case, predicted peak flow water levels along the Bayswater Creek diversion increased by approximately 0.5 m over the length of the proposed extent of the Narama West mining area for the Q250 flow event. However, this water level was still below the assessed top level of the left bank.

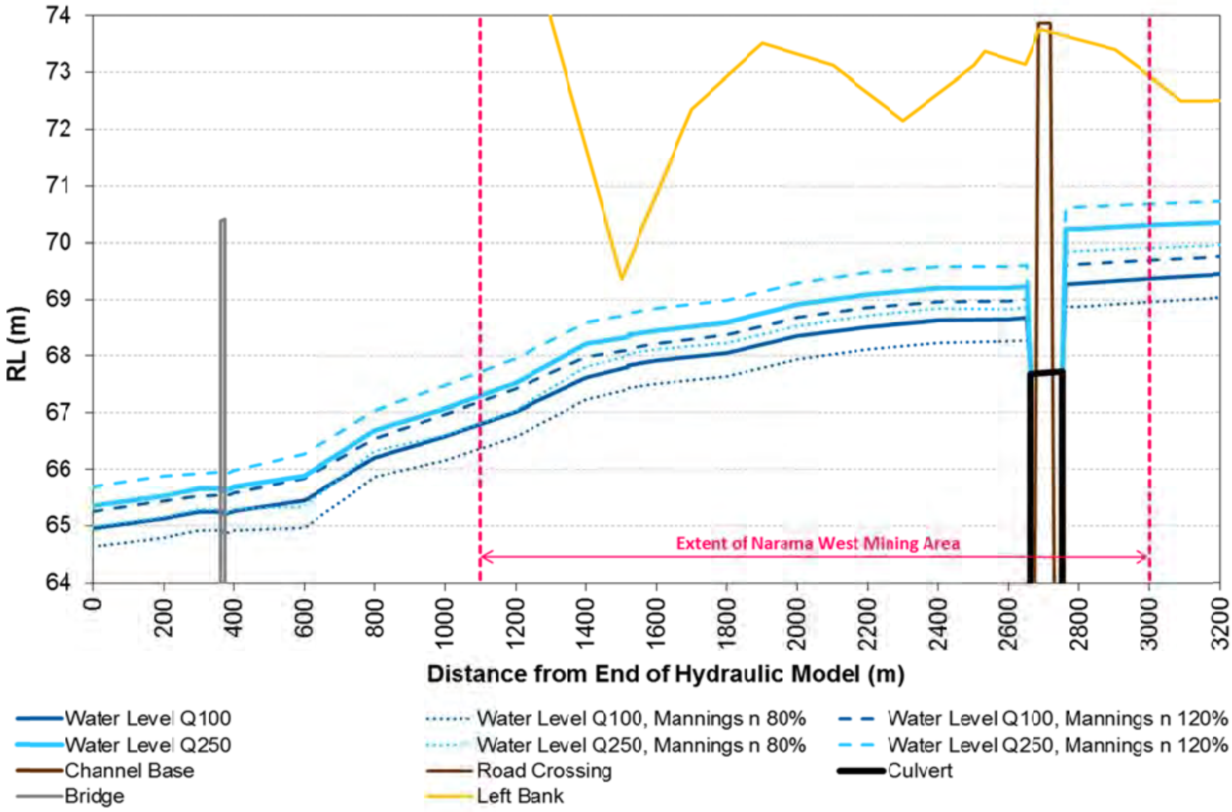

Figure 11 Hydraulic Model Manning's n Sensitivity Results

Ravensworth Operations has indicated that, prior to operations commencing, the longitudinal profile along the top of the left bank of Bayswater Creek between the diversion and the edge of the Narama West mining will be surveyed so that overflow levels can be more reliably determined. Additional cross-sections will also be surveyed at key locations in the diversion so that the hydraulic modelling can be validated prior to mining to improve confidence in predicted flood levels. Should the surveyed levels of the lowest point on the left bank be below predicted flood levels at any point, then the level would be built up to above the predicted flood level prior to commencement of mining.

5.0 Conclusions

The results of the water balance modelling reported herein indicate that site water supply reliability remains high for all demands on the water management system and that there would be little change in system inflows and outflows for the Modification. Modelling also indicates that the Narama West mining area would be managed such that, on any given day, no more than 200 ML would be stored. A sensitivity analysis shows that for an increased groundwater inflow rate, on average, there would be one day per year where more than 200 ML is stored.

Given the minimal changes to final landform drainage and catchment area reporting to site storages, impacts on the receiving environment compared with the approved existing operation would be insignificant.

Results of hydrologic and hydraulic modelling indicate that for 1 in 100-year and 1 in 250-year ARI flow events, the predicted peak water level in the Bayswater Creek diversion would not overtop to the Narama West mining area. The modelling also predicts high velocities, at both peak flow rates, within the Bayswater Creek diversion adjacent to the Narama West mining area. As a requirement of PA 09_0176, the Bayswater Creek diversion will be remediated to provide a hydraulically and geomorphically stable stream. Such activities are scheduled to occur following completion of the Narama West mining area. Ravensworth Operations has indicated that a follow-up survey of the diversion will be undertaken to confirm the geometry used in the hydraulic modelling prior to mining.

Please do not hesitate to call if you have any queries.

Regards

Dayjil Fincham
Water Resources Engineer

Tony Marszalek
Principal Water Resources Engineer

PO Box 2143, Toowong, QLD 4066
Ph: 07 3367 2388 Fax: 3367 2833
E-mail: gaconslt@bigpond.net.au
ABN: 62 085 419 852

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APPENDIX D

Groundwater Impact Assessment

Australasian Groundwater & Environmental Consultants Pty Ltd

REPORT on

NARAMA WEST MODIFICATION

GROUNDWATER IMPACT ASSESSMENT

prepared for
HANSEN BAILEY ENVIRONMENTAL CONSULTANTS

Project No. G1623
February 2013

ABN:64 080 238 642

Australasian
Groundwater & Environmental
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REPORT on

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GROUNDWATER IMPACT ASSESSMENT

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HANSEN BAILEY ENVIRONMENTAL CONSULTANTS

Project No. G1623
February 2013

Level 2 / 15 Mallon Street
Bowen Hills Qld 4006
Ph (+617) 3257 2055
Fax (+617) 3257 2088
Email: brisbane@ageconsultants.com.au
Web: www.ageconsultants.com.au

A.B.N 64 080 238 642

EXECUTIVE SUMMARY

Australasian Groundwater and Environmental Consultants Pty Ltd (AGE) has been engaged by Hansen Bailey Environmental Consultants (Hansen Bailey) on behalf of Xstrata Coal Pty Limited (Xstrata Coal) to complete an groundwater impact assessment for the Narama West Modification (the Modification). The purpose of the assessment is to form part of an Environmental Assessment being prepared by Hansen Bailey to support a modification to Project Approval (PA) 09_0176 under section 75W, Part 3A of the *Environmental Planning and Assessment Act 1979*.

The Modification

Ravensworth Operations Pty Ltd (Ravensworth Operations) is a wholly owned subsidiary of Xstrata Coal and comprises of the active Ravensworth North and Narama mining areas and the former Cumnock, Ravensworth West and Ravensworth South mining areas. Ravensworth Operations is situated within the Singleton Local Government Area and located approximately 15 kilometres (km) north-west of Singleton and 17 km south-east of Muswellbrook in the Upper Hunter Valley of New South Wales (NSW).

Ravensworth Operations currently conducts open cut mining activities under PA 09_0176, which was approved 11 February 2011, to provide high quality thermal and semi-soft coking coal to export and domestic markets at a maximum of 16 Million tonnes per annum (Mtpa) of Run of Mine (ROM) coal.

Xstrata Coal is seeking a modification to PA 09_0176 under section 75W, Part 3A of the EP&A Act.

The Modification involves:

- Recovery of approximately 2.7 Million tonnes of ROM coal by open cut mining methods over a period of two years in an approved overburden emplacement area within the Narama mining area (referred to as the Narama West mining area);
- Production within the approved maximum limit of 16 Mtpa of ROM coal;
- Operations being undertaken via truck and shovel or dragline mining techniques;
- Utilisation of the existing equipment fleet;
- Tailings and rejects emplacement as per approved existing operations;
- Utilisation of existing infrastructure, including the Coal Handling and Preparation Plant, coal terminal, rail loop, workshops and offices;
- Transportation of domestic coal to neighbouring power stations via the existing conveyor system;
- Transportation of product coal to the Port of Newcastle for export via the Main Northern Railway; and
- Retention of the approved final landform with overburden used to progressively backfill the final void.

Groundwater Impact Assessment

The Narama mining area has advanced towards the east mining down-dip to the floor of the Bayswater Seam. The historic Narama void has since been backfilled with overburden. This has left a relatively small remnant strip of coal between the Bayswater Creek diversion to the west and the edge of the Narama mining area to the east. The Modification will seek to recover this coal by means of open cut mining methods within the Narama mining area (referred to as the Narama West mining area).

The geology within the Narama West mining area consists of a regular layered south-easterly dipping sedimentary sequence, which can be categorised into the following hydrogeological units:

- hydrogeologically "tight" and hence very low yielding to essentially dry sandstone, siltstone and conglomerate 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.

There is no alluvium within the immediate vicinity of the Narama West mining area. Previous mining activities within the Narama mining area removed the southern portion of the alluvium associated the original alignment of Bayswater Creek.

There are no monitoring bores within the Narama West mining area; however, groundwater levels have been inferred from water level measurements in surrounding bores, from the structure of the coal seams and from the mining history. Groundwater levels in the Bayswater Seam range from approximately RL 40 m on the western margin of the Narama West mining area, to RL 20 m to the south-east. Based upon the Bayswater Seam floor structure contours, it is assessed that the coal seam is unsaturated over the eastern and southern part of the Narama West mining area and potentially partially saturated to the north and west.

A 2D cross sectional model was constructed to simulate groundwater levels in the Narama West mining area. The model indicated that the existing Narama mining area is likely to have largely drained the coal seams in the area of the proposed Narama West mining area and confirmed the conclusion that the area is only partially saturated or unsaturated.

The groundwater seepage rate to the proposed Narama West mining area was estimated to be very low at less than 20 m^3/day. This relatively low volume is considered unlikely to be evident during mining and will be removed by evaporation and as bound moisture in the coal and overburden. Any groundwater seepage collected in the Narama West mining area can be absorbed under the existing water licence. No additional licensing for groundwater interception under the *Water Act 1912* is required.

As the Narama West mining area contains a limited volume of groundwater, there will be negligible impact of the alluvial water sources in the area. Any losses from the alluvium will be consistent with those predicted for existing approved operations. As such, no additional licensing for groundwater interception under the *Water Management Act 2000* and relevant water sharing plan is required.

No identified private boreholes are located within or near the Narama West mining area. In this regard, the Modification will not impact existing groundwater users.

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NARAMA WEST MODIFICATION

GROUNDWATER IMPACT ASSESSMENT

1.0 INTRODUCTION

Australasian Groundwater and Environmental Consultants Pty Ltd (AGE) has been engaged by Hansen Bailey Environmental Consultants (Hansen Bailey) on behalf of Xstrata Coal Pty Limited (Xstrata Coal) to complete a groundwater impact assessment for the Narama West Modification (the Modification). The purpose of the assessment is to form part of an Environmental Assessment (EA) being prepared by Hansen Bailey to support a modification to Project Approval (PA) 09_0176 under section 75W, Part 3A of the Environmental Planning and Assessment Act 1979 (EP&A Act).

2.0 MODIFICATION OVERVIEW

Ravensworth Operations Pty Limited (Ravensworth Operations) is a wholly owned subsidiary of Xstrata Coal and comprises the active Ravensworth North and Narama mining areas and the former Cumnock, Ravensworth West and Ravensworth South mining areas. Ravensworth Operations is situated within the Singleton Local Government Area (LGA) and located approximately 15 kilometres (km) north-west of Singleton and 17 km south-east of Muswellbrook in the Upper Hunter Valley of New South Wales (NSW). Figure 1 illustrates the location of Ravensworth Operations and its approved operations boundary.

Ravensworth Operations currently carries out open cut mining activities under PA 09_0176, approved 11 February 2011, to provide high quality thermal and semi-soft coking coal to export and domestic markets at a maximum of 16 Million tonnes per annum (Mtpa) of Run-of-Mine (ROM) coal.

2.1 Modification Description

Xstrata Coal is seeking a modification to PA 09_0176 under section 75W, Part 3A of the EP&A Act. The Modification involves:

- Recovery of approximately 2.7 Million tonnes (Mt) of ROM coal by open cut mining methods over a period of two years in an approved overburden emplacement area (OEA) within the Narama mining area (referred to as the Narama West mining area);
- Production within the approved maximum limit of 16 Mtpa of ROM coal;
- Operations being undertaken via truck and shovel or dragline mining techniques;

- Utilisation of the existing equipment fleet;
- Tailings and rejects emplacement as per approved existing operations;
- Utilisation of existing infrastructure, including the coal handling production plant (CHPP), coal terminal, rail loop, workshops and offices;
- Transportation of domestic coal to neighbouring power stations via the existing conveyor system;
- Transportation of product coal to the Port of Newcastle for export via the Main Northern Railway; and
- Retention of the approved final landform with overburden used to progressively backfill the final void.

The conceptual layout of the Modification is illustrated in Figure 2.

Mining operations are likely to commence in 2013 and continue through to 2014; however, may occur later pending approval of the Modification, scheduling of operations and availability of equipment.

2.2 Methodology

The methodology adopted to determine the impacts of the Modification comprised of:

- meeting with NSW Office of Water (NOW) to discuss an appropriate approach to the assessment;
- reviewing:
  - baseline water level and quality monitoring data;
  - previous groundwater studies; and
  - current water licenses held by Ravensworth Operations.
- quantifying the potential groundwater impacts associated with the Narama West mining area on surface water flows (Hunter River and Bayswater Creek diversion), other groundwater users, private bores and groundwater dependent ecosystems;
- outlining mitigation measures if necessary;
- identify any requirements for water licensing; and
- comparing the impacts with the requirements of the *Aquifer Interference Policy* (AI Policy) (NOW, 2012).

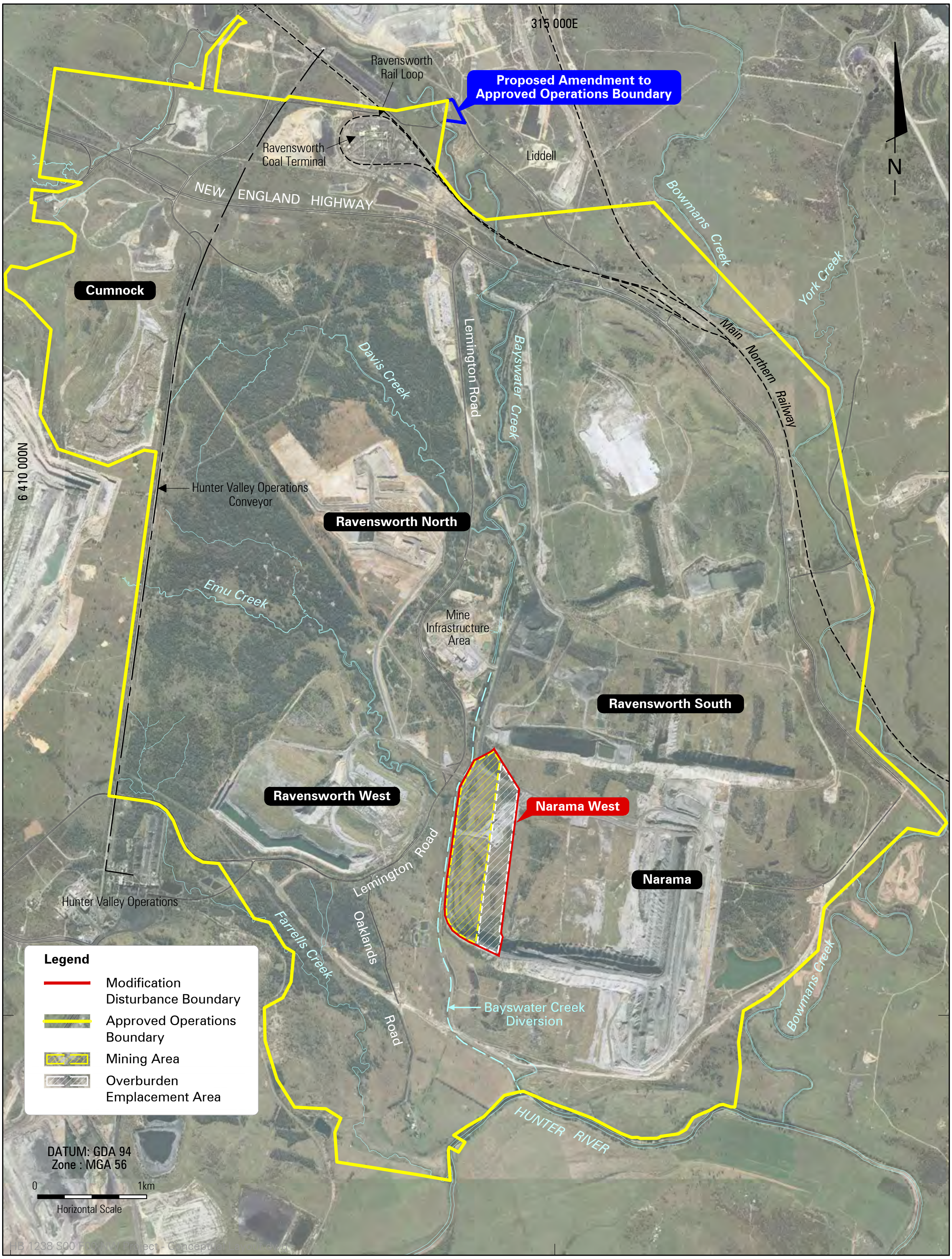
xstrata coal ravensworth open cut

Hansen Bailey ENVIRONMENTAL CONSULTANTS

NARAMA WEST MODIFICATION

Regional Locality Plan

FIGURE 1



NARAMA WEST MODIFICATION

Conceptual Modification Layout

FIGURE 2

3.0 LEGISLATION, POLICY AND GUIDELINES

The following sections outline NSW State Government legislation, policy and guidelines for groundwater that must be addressed for mining proposals.

3.1 Water Act 1912

The *Water Act 1912* manages water sources, including rivers, lakes and groundwater aquifers in NSW, and provides water licencing procedures. The *Water Act 1912* is progressively being replaced by the *Water Management Act 2000* (WM Act) but some provisions of the *Water Act 1912* are still in force where water sharing plans are not in place. This is the case for the area within the Modification disturbance boundary where water sharing plans are enforced for the Hunter River and associated alluvial flood plain but the adjoining Permian bedrock area remains regulated under the *Water Act 1912*.

Table 1 summarises the approvals Ravensworth Operations currently hold under the *Water Act 1912* for interception of groundwater during mining.

Table 1: SUMMARY OF WATER LICENSES – WATER ACT 1912

Approval Number	Holder	Review Date	Extraction Limit	Purpose
20BL170749	Ravensworth Operations Pty Limited	2016	150 ML	Narama mining area groundwater
20BL170462	Ravensworth Operations Pty Limited	2016	100 ML	Ravensworth West mining area groundwater
20BL168240	Cumnock	2013	2520 ML	Cumnock underground groundwater
20BL170776	Cumnock	2016	50 ML	South open cut void groundwater
20BL173096	Xstrata Cumnock Management	2017	576 ML	Ravensworth North groundwater extraction

GSS Environmental (2011)

Umwelt (2011) report that during 2011, the Ravensworth Operations water balance indicated:

- The Ravensworth West mining area had a total inflow of 240 megalitres (ML) primarily due to rainfall runoff with no measureable groundwater inflow; and
- The Narama mining area had a total inflow of 1,240 ML due to rainfall runoff of approximately 1.8 ML/day, seepage from the tailings emplacement areas to the north of the mining area estimated at 1.3 ML/day, and groundwater inflow of less than 0.5 ML/day.

3.2 Water Management Act 2000

The objective of the 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 the following four types of approval:

- water use approval – which authorises 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 minimise their impact on the water resource and land degradation, and where possible the land must be rehabilitated. There are two water sharing plans that are valid for the proposed Narama West mining area being:

- *Water Sharing Plan for the Hunter Regulated River Water Source 2003,* and
- *Water Sharing Plan for the Hunter Unregulated and Alluvial Water Sources 2009.*

3.2.1 Water Sharing Plan for the Hunter Regulated River Water Source 2003

The *Water Sharing Plan for the Hunter Regulated River Water Source* commenced in July 2004 and applies until June 2014. It sets out rules for protecting the environment, extractions, managing licence holders' water accounts and water trading. According to the NSW Office of Water (NOW) the Hunter Regulated River Water Source lies within the Hunter Water Management Area and comprises the following:

- the bed and banks of all rivers, from the upstream limit of Glenbawn Dam water storage downstream to the estuary of the Hunter River, and from the upstream limit of Glennies Creek Dam water storage downstream to the junction with the Hunter River; and
- the unconsolidated alluvial sediments underlying the waterfront of all rivers which have been declared by the Minister to be regulated rivers, except those unconsolidated alluvial sediments within one metre of works taking water pursuant to licences issued under Part V of the *Water Act 1912* or their equivalent aquifer access licences issued under the *Water Management Act 2000*.

Ravensworth Operations has available water access licence WAL10711 comprising 25 units (equivalent to a maximum of 25 ML/year) under the Hunter Regulated River Water Source (Zone 1B – Hunter River from Goulburn River junction to Glennies Creek junction).

3.2.2 Water Sharing Plan for the Hunter Unregulated and Alluvial Water Sources 2009

The *Water Sharing Plan for the Hunter Unregulated and Alluvial Water Sources* commenced in August 2009 and applies until 2019. The *Water Sharing Plan for the Hunter Unregulated Alluvial Water Sources* includes the Hunter unregulated rivers and creeks, and the highly connected alluvial groundwater. There are 39 water sources covered by the water sharing plan with nine of these further sub-divided into management zones. The proposed Narama West mining area is within the Jerrys Management Zone.

3.3 State Groundwater Policy

The NSW State Groundwater Policy (Framework Document) 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 components parts, namely:

- the NSW Groundwater Quality Protection Policy, adopted in December 1998;
- the NSW Groundwater Dependent Ecosystems Policy adopted in 2002; and
- the NSW Groundwater Quantity Management Policy (undated document).

3.3.1 Groundwater Quality Protection

The NSW Groundwater Quality Protection Policy (1998), states that the objectives of the policy will be achieved by applying the management principles 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."*

3.3.2 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 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.

3.3.3 Groundwater Quantity Protection

The objectives of managing groundwater quantity in NSW 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*."

3.3.4 NSW Aquifer Interference Policy

The AI Policy forms the basis for assessment of aquifer interference activities under the EP&A Act. It clarifies the need to hold water access licences or Water licences (as the case may be) under the WM Act and *Water Act 1912* and establishes consideration in assessing whether 'minimal impact' occurs.

The WM Act defines an aquifer interference activity as that which involves any of the following:

- *"penetration of an aquifer;*
- *interference with water in an aquifer;*
- *obstruction of the flow of water in an aquifer;*
- *taking of water from an aquifer in the course of carrying out mining or any other activity prescribed by the regulations; and*
- *disposal of water taken from an aquifer in the course of carrying out mining or any other activity prescribed by the regulations."*

Examples of aquifer interference activities (NOW 2012) include mining, coal seam gas extraction, injection of water, and commercial, industrial, agricultural and residential activities that intercept the water table or interfere with aquifers.

According to the WM Act, an aquifer is defined as a geological structure or formation, or an artificial landfill that is permeated with water or is capable of being permeated with water. This is at odds with the commonly used definition, which refers to an aquifer as a groundwater system that is sufficiently permeable to yield productive volumes of groundwater. The definition of aquifer provided by the WM Act is more consistent with the term groundwater system, which refers to any type of saturated geological formation that can yield low to high volumes of water.

The AI Policy states that "*all water taken by aquifer interference activities, regardless of quality, needs to be accounted for within the extraction limits defined by the water sharing plans. A water licence is required under the WM Act (unless an exemption applies or water is being taken under a basic landholder right) where any act by a person carrying out an aquifer interference activity causes:*

- *the removal of water from a water source; or*
- *the movement of water from one part of an aquifer to another part of an aquifer; or*
- *the movement of water from one water source to another water source, such as:*
    - *from an aquifer to an adjacent aquifer; or*
    - *from an aquifer to a river/lake; or*
    - *from a river/lake to an aquifer."*

The AI Policy requires assessment of the likely volume of water taken from a water source(s) as a result of an aquifer interference activity. The AI Policy states that a water licence is required for the aquifer interference activity regardless of whether water is taken directly for consumptive use or incidentally. Activities may induce flow from adjacent groundwater sources or connected surface water. Flows induced from other water sources also constitute take of water. In all cases, separate access licences are required to account for the take from all individual water sources.

In water sources where water sharing plans do not yet apply, an aquifer interference activity that takes groundwater is required to hold a water licence under the *Water Act 1912*. It is possible for the *Water Act 1912* to apply in a groundwater source and the WM Act to apply in a connected surface water source or vice versa. Where this occurs and the aquifer interference activity is taking water from both water sources, then licences will be required under each Act.

In addition to the volumetric water licensing considerations, the following information needs to be considered to enable assessment and approval of the activity:

- establishment of baseline groundwater conditions including groundwater depth, quality and flow based on sampling of all existing bores in the area;
- a strategy for complying with any water access rules applying to relevant categories of water access licences, as specified in relevant water sharing plans;
- details of potential water level, quality or pressure drawdown impacts on nearby water users who are exercising their right to take water under a basic landholder right;
- details of potential water level, quality or pressure drawdown impacts on nearby licensed water users in connected groundwater and surface water sources;
- details of potential water level, quality or pressure drawdown impacts on groundwater dependent ecosystems;

- details of potential for increased saline or contaminated water inflows to aquifers and highly connected river systems;
- details of the potential to cause or enhance hydraulic connection between aquifers; and
- details of the potential for river bank instability, or high wall instability or failure to occur.

In particular, the AI Policy describes minimal impact considerations for aquifer interference activities based upon whether the water source is "*highly productive*" or "*less productive*" and whether the water source is alluvial or porous / fractured rock in nature. In general the policy applies a predicted 2 m drawdown maximum limit at existing groundwater users.

The NOW's assessment of impacts and subsequent advice and proposed conditions of approval for a project is based on an "*account for, mitigate, avoid/ prevent, and remediate*" approach. NOW's methodology is based on "*a risk management approach to assessing the potential impacts of aquifer interference activities, where the level of detail required to be provided by the proponent is proportional to a combination of the likelihood of impacts occurring on water sources, users and dependent ecosystems and the potential consequences of these impacts*."

The AI Policy divides groundwater sources into *"highly productive"* and *"less productive"*. Highly productive groundwater is defined by the AI Policy as a groundwater source that is declared in the Regulations and will be based on the following criteria:

- has total dissolved solids of less than 1,500 mg/L; and
- contains water supply works that can yield water at a rate greater than 5 L/s. Highly productive groundwater sources are further grouped by geology into alluvial, coastal sands, porous rock, and fractured rock. "Less productive" groundwater includes aquifers that cannot be defined as "highly productive" according the yield and water quality criteria.

The Hunter River alluvium adjacent to the Modification has been assessed and determined to satisfy the "highly productive" criteria, while the Permian coal measures are "less productive" porous rock. The AI Policy defines Minimal Impact Considerations for "highly productive" and less productive groundwater (Table 2). If these considerations are not met, the Modification needs to demonstrate to the Minister's satisfaction that the impact will be sustainable, or that "*make good agreements*" are in place.

Table 2: SUMMARY MINIMAL IMPACT CONSIDERATIONS – AQUIFER INTERFERENCE POLICY

Category	Water Table	Water Pressure	Water Quality
Highly productive alluvium – Hunter River Alluvium	1. Less than or equal to a 10% cumulative variation in the water table, allowing for typical climatic “post-water sharing plan” variations, 40 m from any: (a) high priority groundwater dependent ecosystem; or (b) high priority culturally significant site; listed in the schedule of the relevant water sharing plan; or A maximum of a 2 m decline cumulatively at any water supply work.	1. 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.	1. (a) Any change in the groundwater quality should not lower the beneficial use category of the groundwater source beyond 40 m from the activity; and (b) No increase of more than 1% per activity in long-term average salinity in a highly connected surface water source at the nearest point to the activity. Redesign of a highly connected(3) surface water source that is defined as a “reliable water supply”(4) is not an appropriate mitigation measure to meet considerations 1.(a) and 1.(b) above. (c) No mining activity to be below the natural ground surface within 200 m laterally from the top of high bank or 100 m vertically beneath (or the three dimensional extent of the alluvial water source - whichever is the lesser distance) of a highly connected surface water source that is defined as a “reliable water supply”. (d) Not more than 10% cumulatively of the three dimensional extent of the alluvial material in this water source to be excavated by mining activities beyond 200 m laterally from the top of high bank and 100 m vertically beneath a highly connected surface water source that is defined as a “reliable water supply”.
Less productive porous rock – Permian Coal Measures		A cumulative pressure head decline of not more than a 2 m decline, at any water supply work.	Any change in the groundwater quality should not lower the beneficial use category of the groundwater source beyond 40 m from the activity.

4.0 PREVIOUS STUDIES

Mackie Environmental Research (MER) (2009) conducted a groundwater assessment for the Ravensworth Operations Project EA, which reviewed the impact of extending open cut mining (Ravenworth North mining area) within the existing mining leases held by Xstrata Coal and its subsidiaries. MER (2009) concluded that the Permian coal measures surrounding Ravensworth Operations had been significantly depressurised and dewatered from existing mining activities and that this would continue to occur with consideration of the Ravensworth North mining area.

MER (2012) also assessed the impact of realigning the panels for the Ravensworth Underground Mine. MER noted that historical mining of the Ravensworth No. 2, Ravensworth South and Narama mining areas had substantially depressurised and dewatered the coal measures down to the Bayswater Seam. Underground mining activities have also reduced pore pressures in the Pikes Gully Seam and the deeper Liddell Seam.

5.0 REGIONAL SETTING

5.1 Topography and Drainage

The topography of the area is influenced by the underlying geology, which is comprised of sedimentary coal measures overlain by alluvial sediments in low-lying flood plains. Topographic elevations range from Reduced Level (RL) 160 metres (m) within the north to RL 100 m within the south of the approved operations boundary (refer Figure 3).

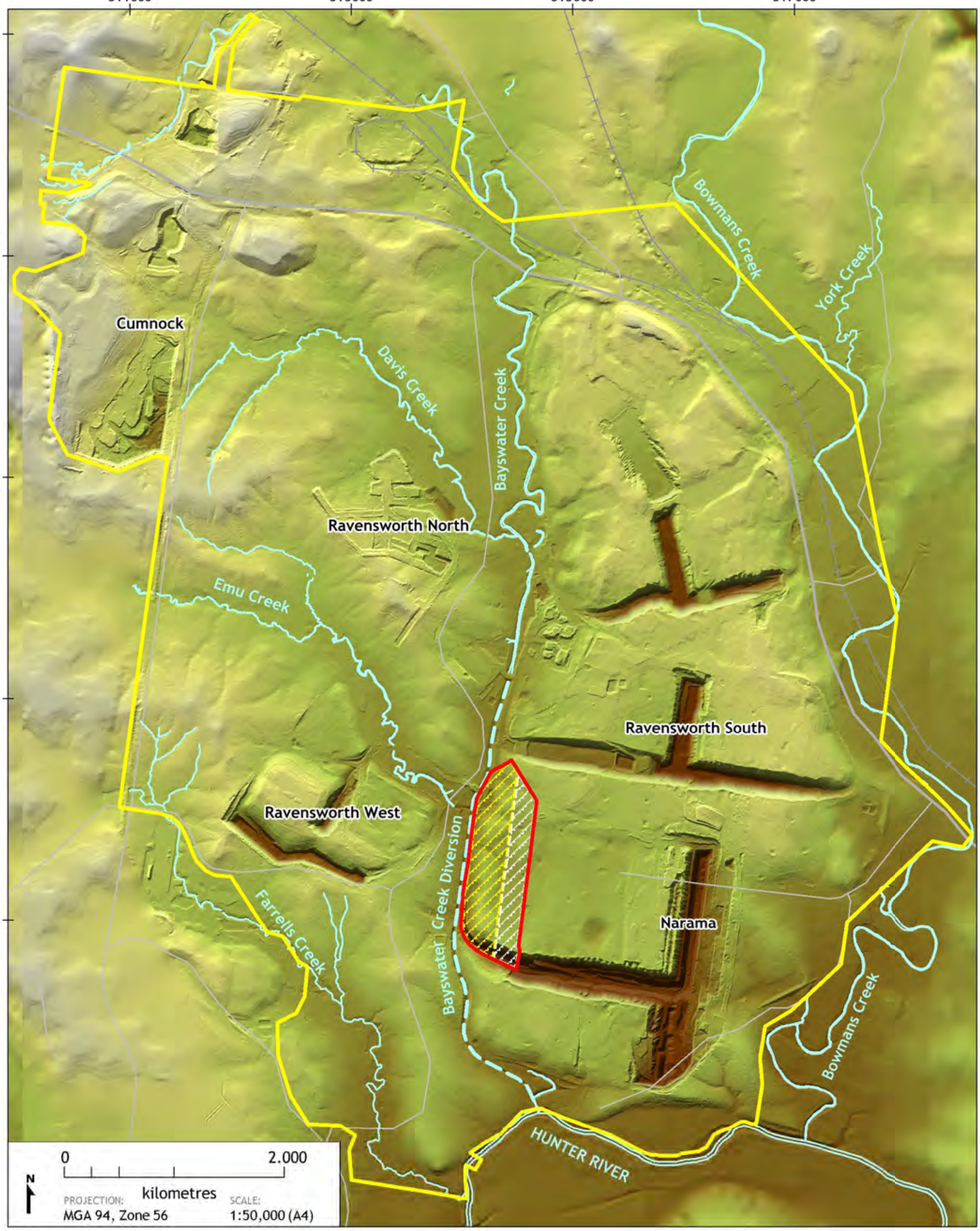
The Hunter River alluvium to the south of the existing Narama mining area is at RL 62 m and falls to approximately RL 60 m further to the east. Similarly the bed level of the Hunter River falls from RL 54 m to approximately RL 50 m.

Bayswater Creek is ephemeral and flows in a southerly direction through the approved operations boundary. Bayswater Creek was diverted around the Narama mining area in the 1990s. The diverted section of Bayswater Creek now runs in a north-south direction adjacent to the western boundary of the rehabilitated Narama overburden emplacement area.

5.2 Geology

Ravensworth Operations is within the Hunter Valley Coalfields which form part of the Sydney Basin. The Sydney Basin is approximately 350 km long and 100 km wide, and is comprised of Permian and Triassic sedimentary units that have undergone multiple phases of deformation and faulting. The geology of the region area is dominated by the Muswellbrook Anticline to the west, and the Bayswater Syncline to the east of Ravensworth Operations. Both fold structures trend in a north to north-west direction, with the Bayswater Syncline truncated by the Antienne Thrust Fault located north of Lake Liddell. Figure 4 shows the 1:100,000 scale regional geological map published by Department of Mineral Resources (Glen & Beckett, 1993). The Quaternary alluvium in Figure 4 has been digitised based on 1:25,000 Geology Maps of Singleton (McIlveen, 1984), Muswellbrook (Summerhayes, 1983), Jerrys Plains (Sniffin & Summerhayes, 1987) and Doyles Creek (Sniffin *et al*, 1988).

Bowmans Creek is mapped as having a veneer of Quaternary alluvium, which extends to the Hunter River (Figure 4). Bayswater Creek is also mapped as having a narrow alluvium along the creek alignment. However, the central portion of the alluvium has been removed by previous activities in the Narama mining area.



LEGEND:
- Modification Disturbance Boundary
- Approved Operations Boundary
- Watercourse
- Road
- Rail
- Mining Area
- Overburden Emplacement Area

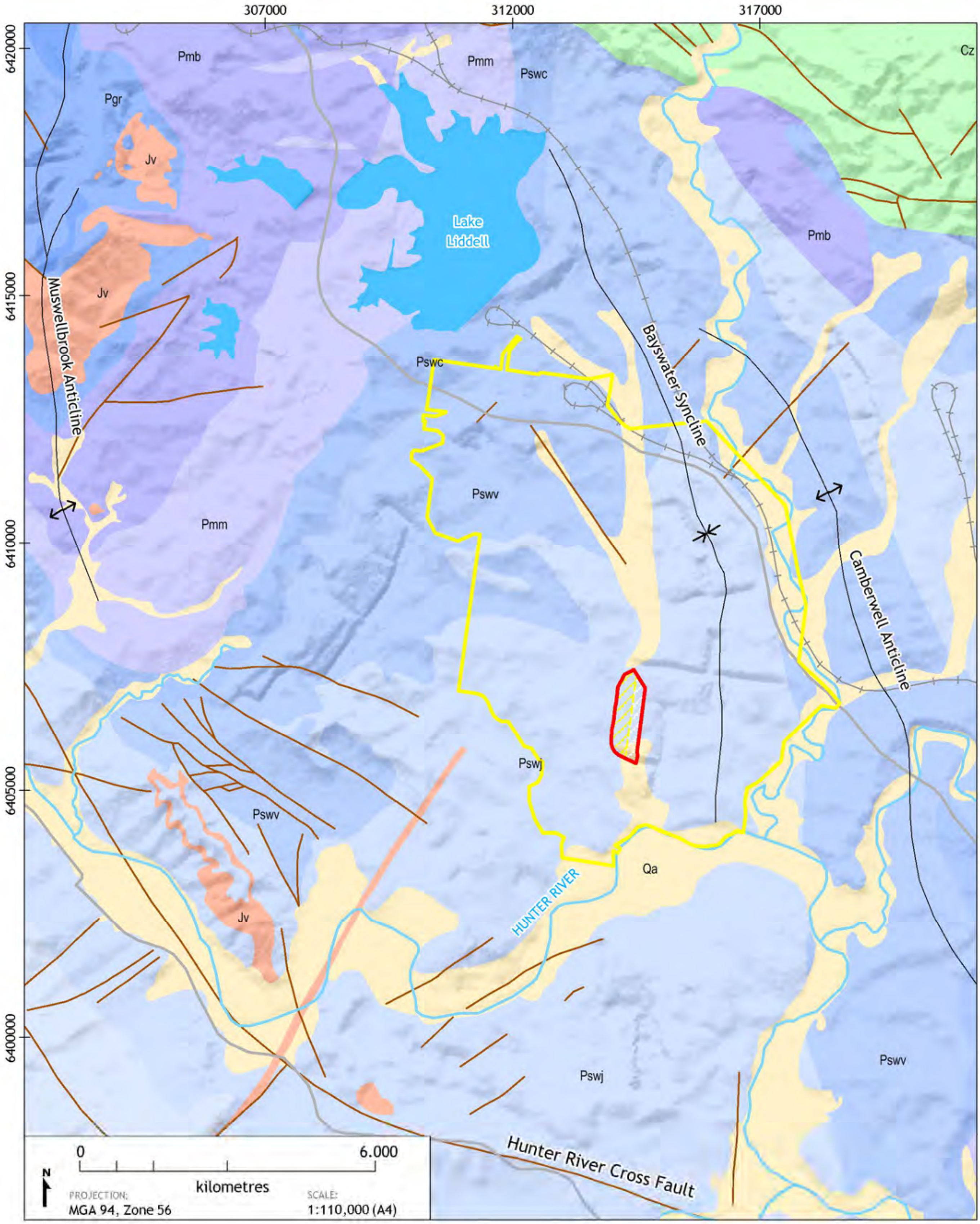
Elevation (mAHD)
180
120
60
-13

Narama Modification Groundwater Impact Assessment (G1623)

Topography and Drainage

DATE: 18/12/2012

FIGURE No: 3



LEGEND:

100K Geology based on 1:100,000 Hunter Coalfield Regional Geology

- Qa - Quaternary Alluvium
- TV - Tertiary Basalt
- Rn - Hawkesbury Sandstone, Narrabeen G.
- Jv - Jurassic Volcanics
- Psl - Wollombi Coal Measures
- Pswj - Denman F., Jerrys Plains Subgroup
- Pswv - Archerfield Ss., Vane Subgroup
- Pswc - Saltwater Creek Formation
- Pmm - Mulbring Siltstone
- Pmb - Branxton Formation
- Pgr - Greta Coal Measures
- Cz - Tuff and Ignimbrite
- Water
- Fault
- Road
- Rail
- Main Water-course
- Mining Area
- Overburden Emplacement Area
- Modification Disturbance Boundary
- Approved Operations Boundary

Narama Modification Groundwater Impact Assessment (G1623)

Surface Geology

DATE: 18/12/2012

FIGURE No: 4

5.2.1 Stratigraphy

The stratigraphic sequence within the Ravensworth Operations area comprises unconsolidated Quaternary alluvium and Permian bedrock sediments (Figure 5). The Quaternary alluvium overlies the Permian sediments and consists of clay, silt and sand. The Permian sediments comprise coal seams with interbedded sequences consisting of sandstone, siltstone, tuffaceous mudstone, and conglomerate.

The main economic sequence targeted by the Ravensworth Operations is the Permian Whittingham Coal Measures, which are divided into the Jerrys Plains Subgroup and the Vane Subgroup. The Jerrys Plains Subgroup (Burnamwood Formation) hosts the Vaux, Broonie and Bayswater Seams whilst the Vane Subgroup (Foybrook Formation) hosts the Lemington to Barrett Seams. Existing operations target coal resources from the Broonie, Bayswater, Lemington, Pikes Gully, Arties, Liddell and Barrett Seams.

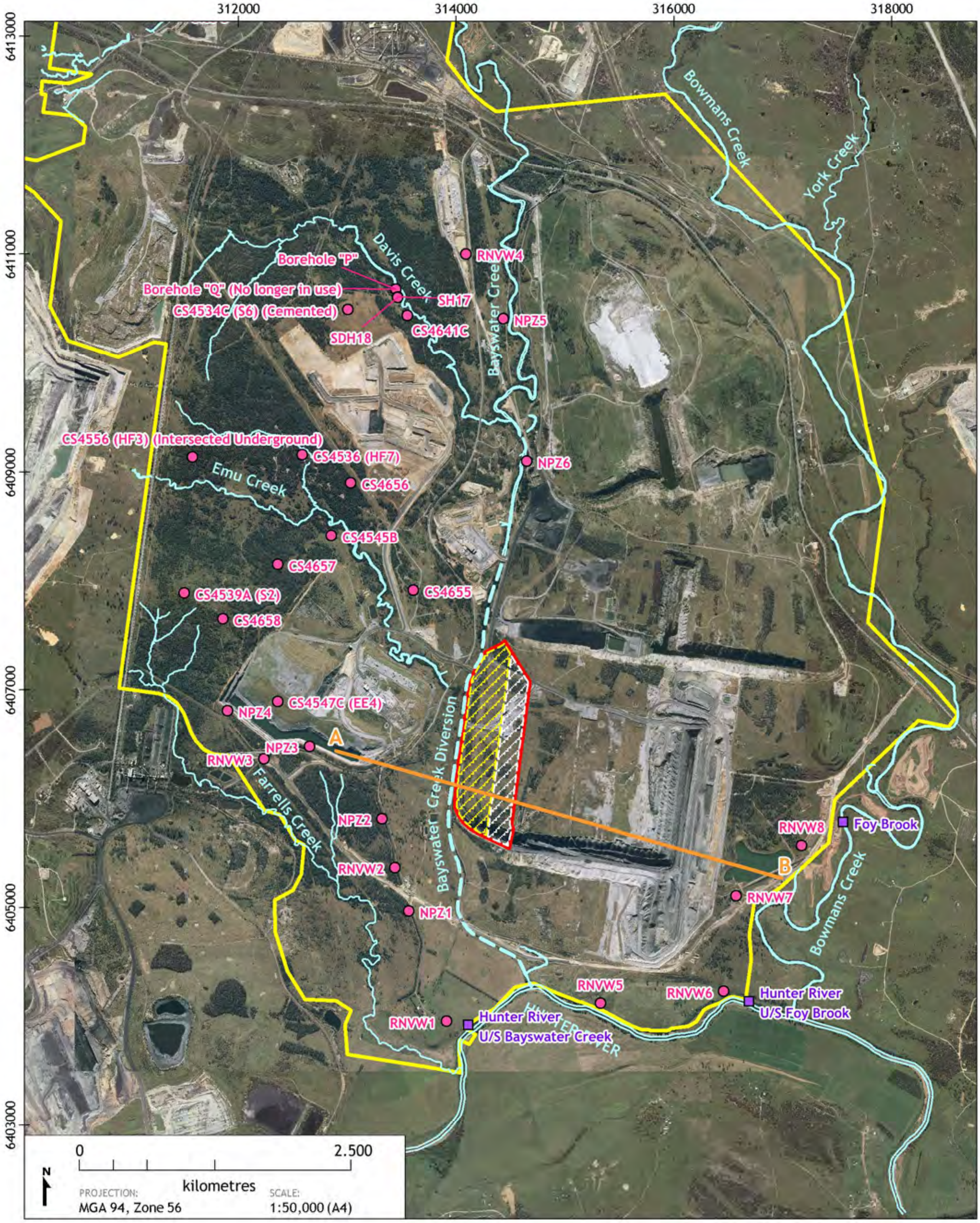
The Bayswater Seam is the primary target in the Narama West mining area.

SINGLETON SUPER GROUP	WITTINGHAM COAL MEASURES	DENMAN FORMATION		
		JERRYS PLAINS SUBGROUP	MOUNT LEONARD FORMATION	WHYBROW SEAM
			ALTHORP FORMATION	
			MALABAR FORMATION	REDBANK CREEK SEAM
				WAMBO SEAM
				WHYNOT SEAM
				BLAKEFIELD SEAM
			SAXONVALE MBR	
			MOUNT OGILVIE FORMATION	GLEN MUNRO SEAM
				WOODLANDS HILL SEAM
			MILBRODALE FORMATION	
			MOUNT THORLEY FORMATION	ARROWFIELD SEAM
				BOWFIELD SEAM
				WARKWORTH SEAM
			FAIRFORD FORMATION	
			BURNAMWOOD FORMATION	MOUNT ARTHUR SEAM
				PIERCEFIELD SEAM
				VAUX SEAM
				BROONIE SEAM
				BAYSWATER SEAM inc. RAVENSWORTH
		ARCHERFIELD SANDSTONE		
		VANE SUBGROUP	BULGA FORMATION	
			FOYBROOK FORMATION	LEMINGTON - WYNN SEAM
				PIKES GULLY - BENGALLA SEAM
				ARTIES - EDENGLASSIE SEAM
				LIDDELL – RAMROD COOK SEAM
				BARRET SEAM
				HEBDEN SEAM
		SALTWATER CREEK FORMATION		

Figure 5: Generalised Stratigraphic Profile

5.3 Existing Monitoring Network

Ravensworth Operations maintains an existing network of 26 standpipe piezometers and 12 vibrating wire piezometers (VWPs) (see Figure 6), which continuously monitors groundwater level and quality under existing mining activities.



LEGEND:

- Modification Disturbance Boundary
- Approved Operations Boundary
- Monitoring Bore
- Stream Gauging Stations
- Cross Section "A - B"
- Watercourse
- Mining Area
- Overburden Emplacement Area

Narama Modification Groundwater Impact Assessment (G1623)

Monitoring Bore Locations

DATE: 18/12/2012

FIGURE No: 6

Aerial Photo from June 2012; Wider Background from March 2012

The most relevant bores located around the Narama West mining area are situated along the Hunter River, Bowans Creek and Farrells Creek (Table 3). These bores are primarily multi sensor VWPs (RNVW series and CS4655). NPZ1 and NPZ2 are nested monitoring bores.

Table 3: MONITORING BORE CONSTRUCTION DETAILS

Bore ID	Type	Easting[1]	Northing[1]	Ground Level (m AHD[2])	VWP Sensor Depths (mbGL[3])
CS4655	VWP	313604	6407913	89.6	36.9, 78, 132.4, 150.1, 181.3, 203.8, 225.3, 250.7
NPZ1	3 x stand pipes	313562	6404972	91.4	34, 49.7, 130
NPZ2	3 x stand pipes	313315	6405816	100.9	26.6, 49.7, 120
RNVW1	VWP	313911	6403955	79.8*	48, 68, 109, 150, 190, 240, 270, 326
RNVW2	VWP	313433	6405371	101.5*	43, 85, 140, 180, 239, 258, 305
RNVW3	VWP	313433	6405371	89.9*	61, 103, 143, 180, 210, 254
RNVW4	VWP	314086	6411001	81.1*	101.5, 114, 163, 200.5, 225
RNVW5	VWP	315323	6404123	62.31	19, 50, 87, 139, 215, 279, 350
RNVW6	VWP	316453	6404231	60.12	19, 43, 66, 116, 195, 265, 330
RNVW7	VWP	316569	6405112	70	-
RNVW8	VWP	317171	6405576	63	-

1. coordinate projection - MGA94, Zone 56
2. mAHD – metres Australian Height Datum
3. mbGL – metres below ground level

6.0 HYDROGEOLOGICAL REGIME

The conceptual hydrogeology of the site is a summary of data presented in previous more detailed investigations (MER, 2009a; MER, 2012; Umwelt, 2011). Three main aquifer systems have been identified within the vicinity of the Narama West mining area, these are:

- Quaternary alluvium primarily associated with the Hunter River and major drainages;
- parts of the overlying weathered zone or regolith; and
- Permian coal seams.

6.1 Quaternary Alluvium

6.1.1 Distribution and Hydraulic Head

Regionally the Quaternary alluvium forms an aquifer where the porosity and hydraulic conductivity are high enough to support stock and domestic supplies to local landholders. The main distribution of the alluvial sediments is to the south of the Narama West mining area in association with the Hunter River. The extent of the Quaternary alluvium is shown in Figure 4.

The Hunter River alluvium is commonly in direct hydraulic connection with the Hunter River. Elsewhere in the approved operations boundary, the alluvial sediments are evident, including

Bowmans Creek, Bayswater Creek and Davis Creek. However, in the minor drainages, the alluvium is considered to be localised and has a lower storage capacity to retain groundwater.

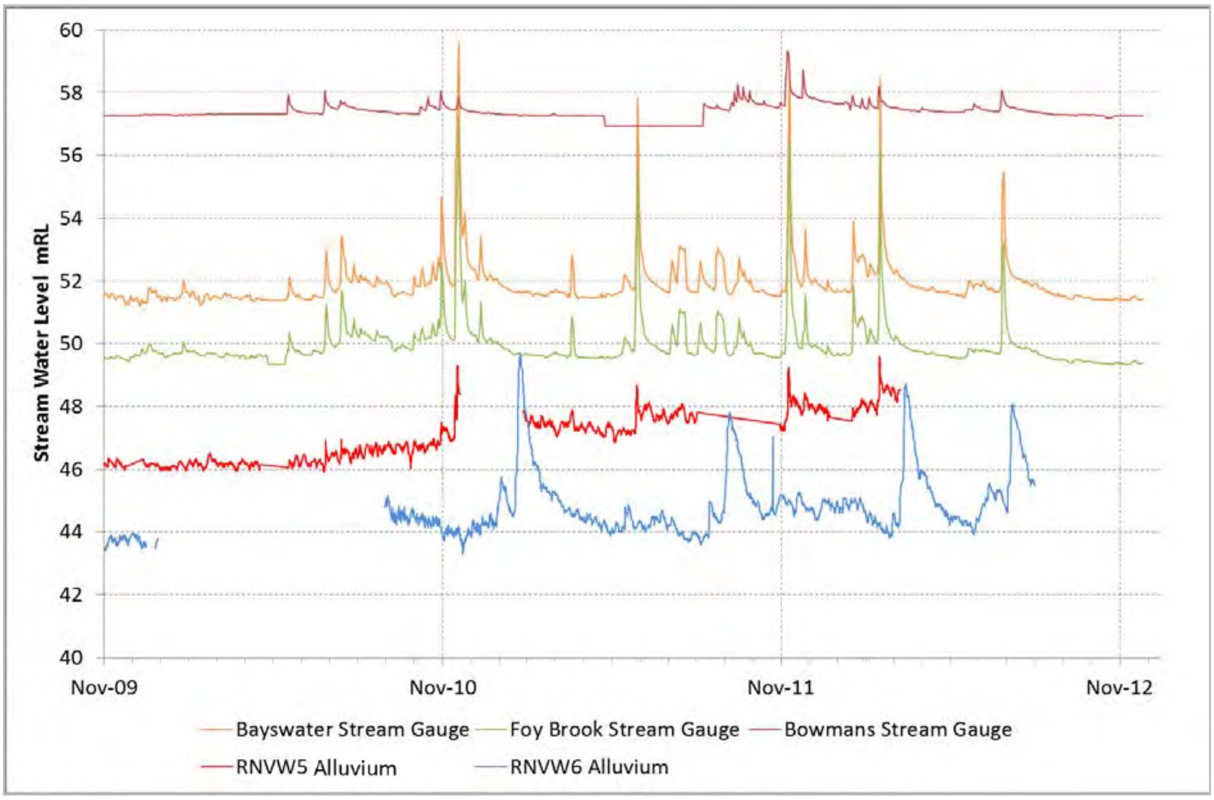
The main channel of the Hunter River is approximately 1.4 km to the south of the proposed Narama West mining area. The alluvium associated with the Hunter River is generally comprised of 10 m to 20 m of unconsolidated gravels, sands, silts and clays. The alluvium typically includes three main lithological units as follows (MER, 2009):

- a surface layer comprised of sands, gravels and minor clay;
- a middle layer of silty gravels and sands interbedded with silt and clay layers;
- a coarse cobble-gravel basal section.

The groundwater level in the Hunter River alluvium is approximately 45 m AHD to 50 m AHD flowing west to east and is of a similar level to that observed in the Hunter River.

Previous mining activities within the Narama mining area has removed the southern portion of the alluvium associated the original alignment of Bayswater Creek. There is no notable baseflow in Bayswater Creek due to the removal of the alluvium.

Bores RNVW5 and RNVW6 are the closest bores to the Narama West mining area and monitor the Hunter River alluvium. Both bores have vibrating wire pressure sensors grouted in the alluvium and in the underlying coal seams. Figure 7 shows the groundwater pressures measured at these sites in the alluvium and the stream flow gauging from the Hunter River.



Note: calibration data for the alluvial sensors in RNVW5 and RNVW6 has not been validated against water level measurements

Figure 7: Groundwater Levels – Stream Gauging and Alluvial Water Levels

The water levels recorded in RNVW5 correlate with the peak flows in the Hunter River and indicate that the river recharges the alluvial aquifer during high flow events. The groundwater level in RNVW6 appears to be correlated with flows in the Hunter River, but delayed by about 30 to 60 days, indicating the storm flows in the Hunter River flows take some time to infiltrate the alluvial aquifer in this location.

6.1.1 Hydraulic Parameters

MER (2012) describes the Hunter River alluvium typically being moderately to highly permeable with a hydraulic conductivity between 0.02 m/day to 50 m/day and an effective porosity between 1% and 25%.

6.1.2 Regional and Local Recharge, Discharge and Groundwater Flow

MER (2012) notes the water table surface at Ravensworth Operations has an irregular surface, which is strongly influenced by mining operations, including the Ravensworth No.2, Ravensworth South and Narama mining areas.

Figure 8 shows the water table surface simulated by MER (2012), which combined water levels measured in piezometers. The water table shows a hydraulic gradient from the Hunter River towards the Narama mining area and the Narama West mining area. Groundwater levels are inferred to be approximately 0 m AHD in the active Narama mining area, and between 20 m AHD and 40 m AHD in the area of the Narama West mining area, meaning this area is relatively dry. MER (2012) notes a remnant south-easterly and southward flow towards the Hunter River can still be inferred in some areas from the equipotentials.

The equipotentials indicate a gradient from the Hunter River towards the alluvial aquifer, which is also evident in monitoring bores RNVW5 and RNVW6.

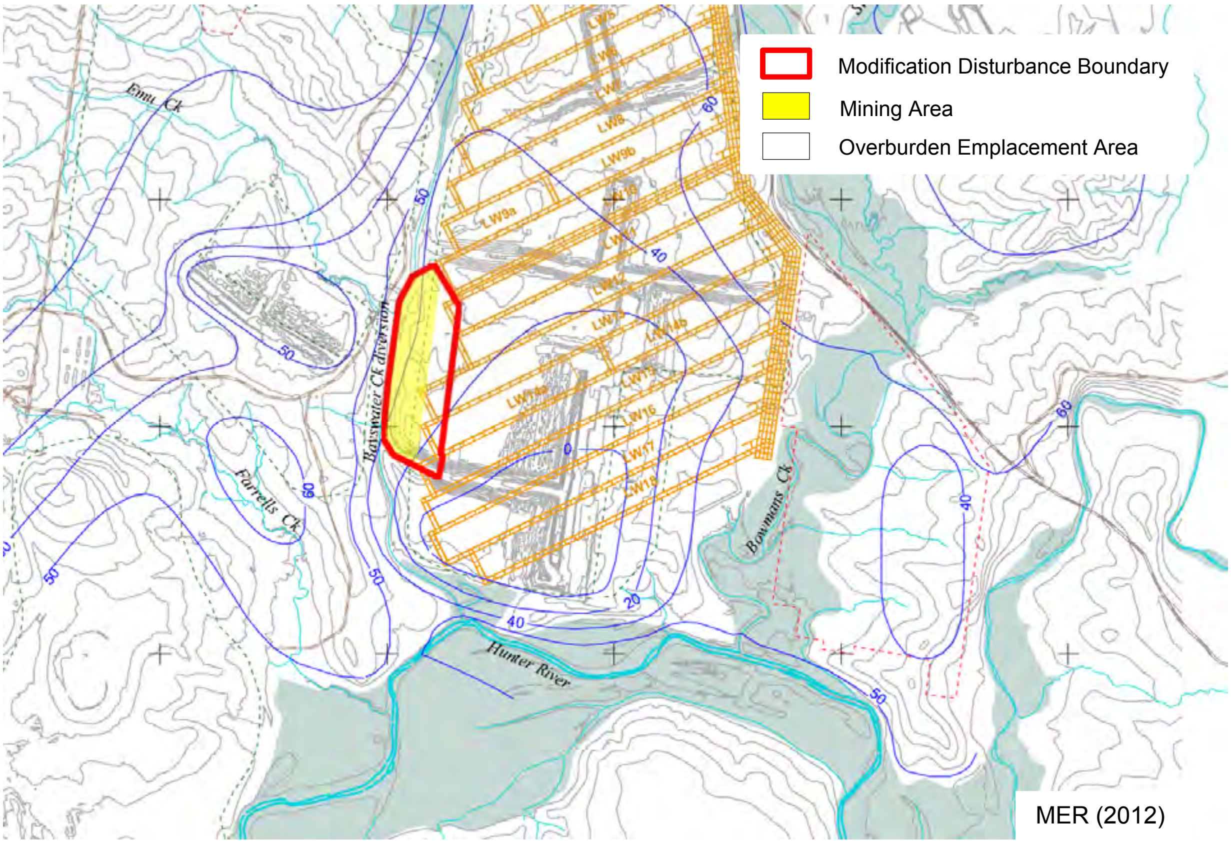


Figure 8: Groundwater Levels 2010-2011

6.2 Coal Seams

6.2.1 Distribution and Hydraulic Head

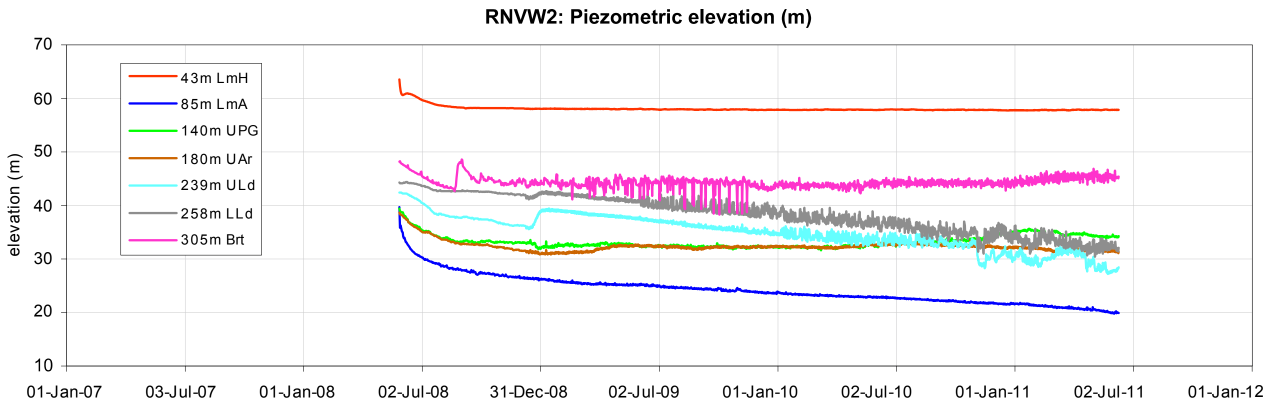
The Permian formations occur as a regular layered south-easterly dipping sedimentary sequence, which can be categorised into the following hydrogeological units:

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

The coal seam aquifers are typically confined above and below by Permian interburden or overburden. Groundwater within the coal seams is transmitted through the cleats of the coal. As the depth of the coal seam below ground level increases, so to do the confining pressure on the coal cleats. This increased depth of burial typically results in a decrease in the hydraulic conductivity of the coal seam.

There are a number of VWP arrays surrounding the approved operations boundary. These VWPs measure hydraulic heads within selected coal seams in the stratigraphic profile. The VWP data show that there are complex vertical gradients occurring to the south and to the west of the approved operations boundary. The vertical gradients within the Permian coal seam have been influenced by the historic and existing mining that has occurred in the region.

Figure 9 shows the piezometric levels measured by the pressure sensors installed in RNVW2 which is located approximately 1 km to the south-west of the Narama West mining area.



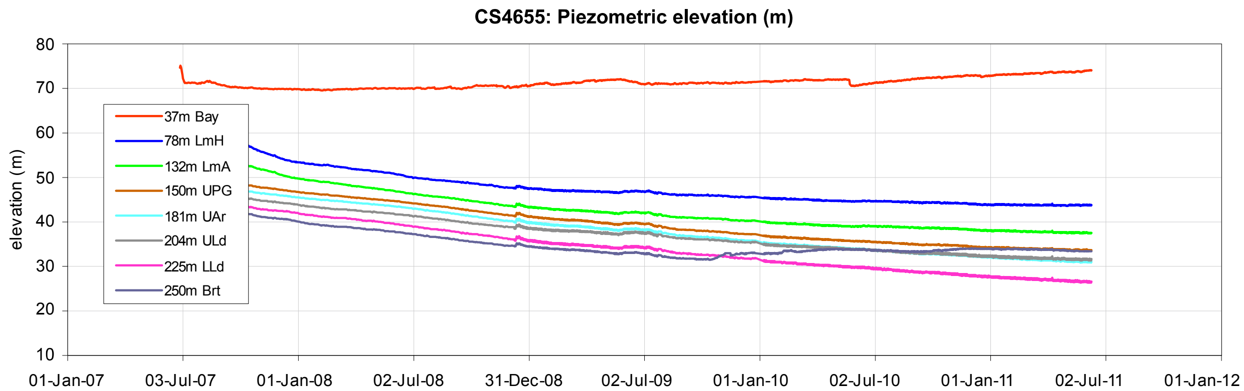
MER, 2012. Note: Potential error in the data for LmH

Figure 9: Piezometric Levels – RNVW2

RNVW2 shows that there is an upward hydraulic gradient from the deepest coal seam (Barrett Seam) to the shallowest seam (Lemington Seam) where hydraulic head is low.

VWP array CS4655 is located approximately 1 km to the north-west of the Narama West mining area.

Figure 10 shows piezometric levels for the CS4655 and indicates there is a downward hydraulic gradient from the shallowest seam (Bayswater Seam) to the deepest seam (Barrett Seam) where hydraulic head is low. The coal seams at CS4655 tend to have piezometric levels that are closer together within the range of RL 30 – 50 m.



MER, 2012

Figure 10: Piezometric Levels – CS4655

6.2.2 Hydraulic Parameters

MER (2009, 2012) documented significant hydraulic conductivity data derived from airlift testing, packer testing and core permeability testing. Table 4 summaries the range of hydraulic parameters for the Permian strata. Figure 11 shows the data graphically and highlights the significant difference in permeability between the interburden material and the coal seams.

Table 4: INDICATIVE RANGE OF PERMIAN HYDRAULIC PARAMETERS			
Lithology	**Kxy Range (m/day)**	**Bulk Porosity (%)**	**Effective Porosity (%)**
Permian sandstones	$5 \times 10^{-6} – 5 \times 10^{-4}$	1 – 18	0.01 – 5
Permian siltstones	$5 \times 10^{-7} – 1 \times 10^{-4}$	1 – 15	0.01 – 1
Permian claystones and shales	$5 \times 10^{-8} – 1.3 \times 10^{-6}$	1 – 15	0.01 – 0.1
Coal seams – dull	$1 \times 10^{-4} – 1 \times 10^{-1}$	0.1 – 2	0.1 – 2
Coal seams – dull and bright	$1 \times 10^{-3} – 1 \times 10^{-1}$	0.1 – 3	0.1 – 3

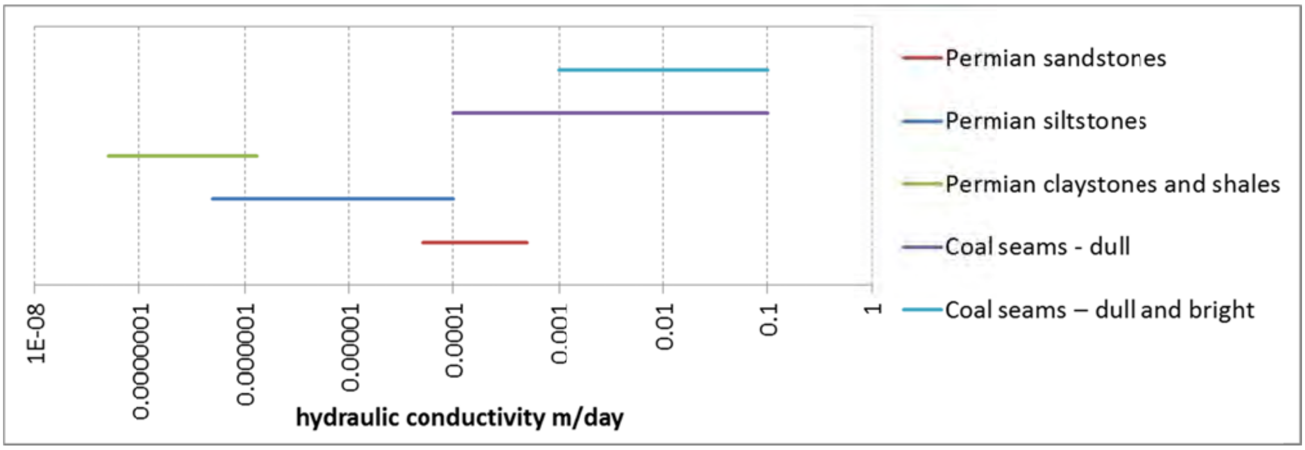


Figure 11: Range of Coal Measures Hydraulic Conductivity

6.2.3 Regional and Local Recharge, Discharge and Groundwater Flow

The coal seams are progressively confined below the Hunter River to the south of the approved operations boundary by the lower permeability Permian overburden. This confining overburden layer provides a measure of hydraulic isolation between the Permian coal seams and the Hunter River alluvium (MER, 2009).

Figure 12 presents the groundwater levels simulated by MER (2012) in the Bayswater Seam for a modification to the Ravensworth Underground Mine. The modelling indicates groundwater levels between RL 20 m and RL 40 m. MER (2012) notes that in the Narama mining area, the groundwater contours represent the geometry of the pit floor (with mining down to the floor of the Bayswater Seam). The model indicates that the Narama West mining area is relatively dry.

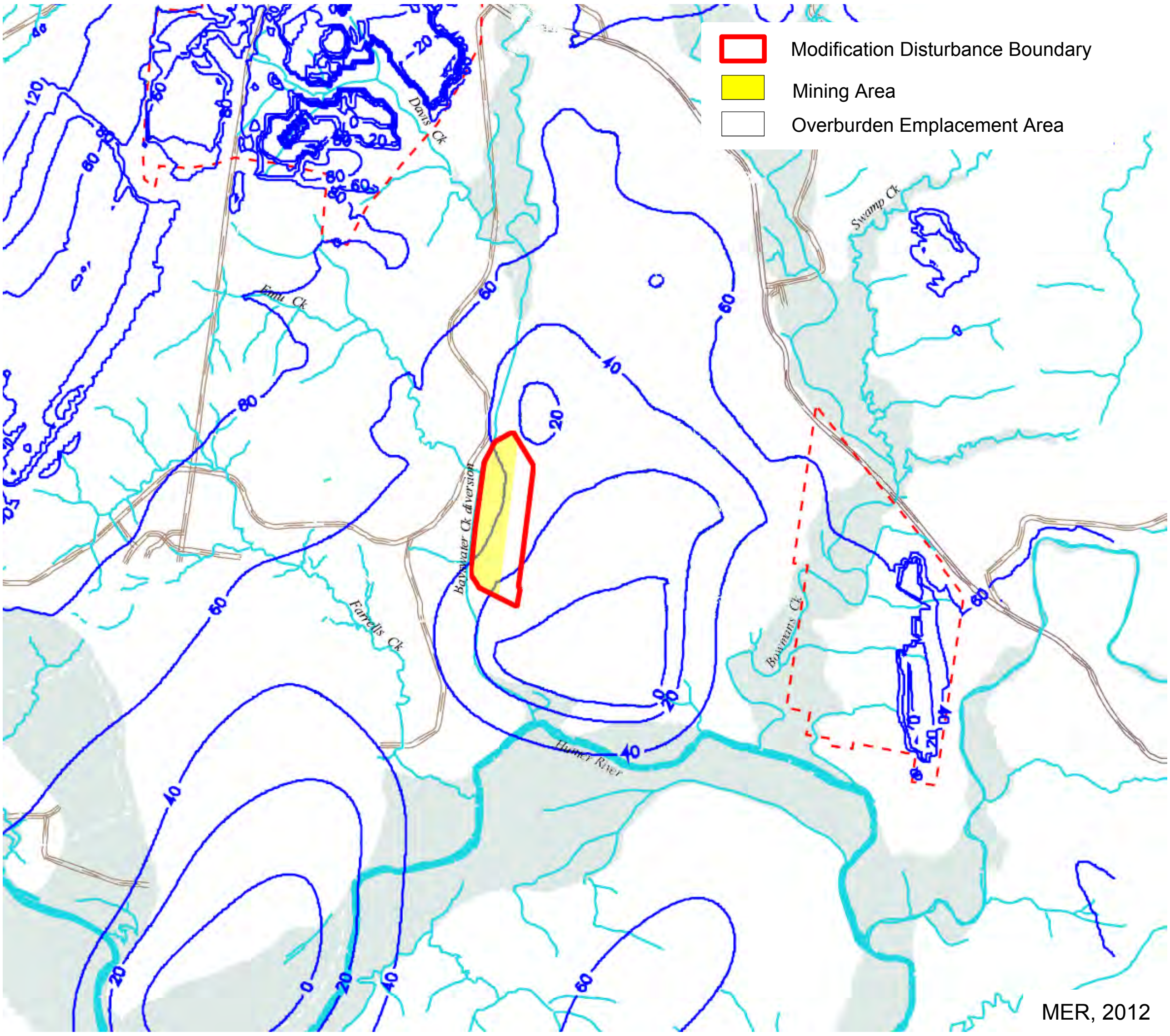
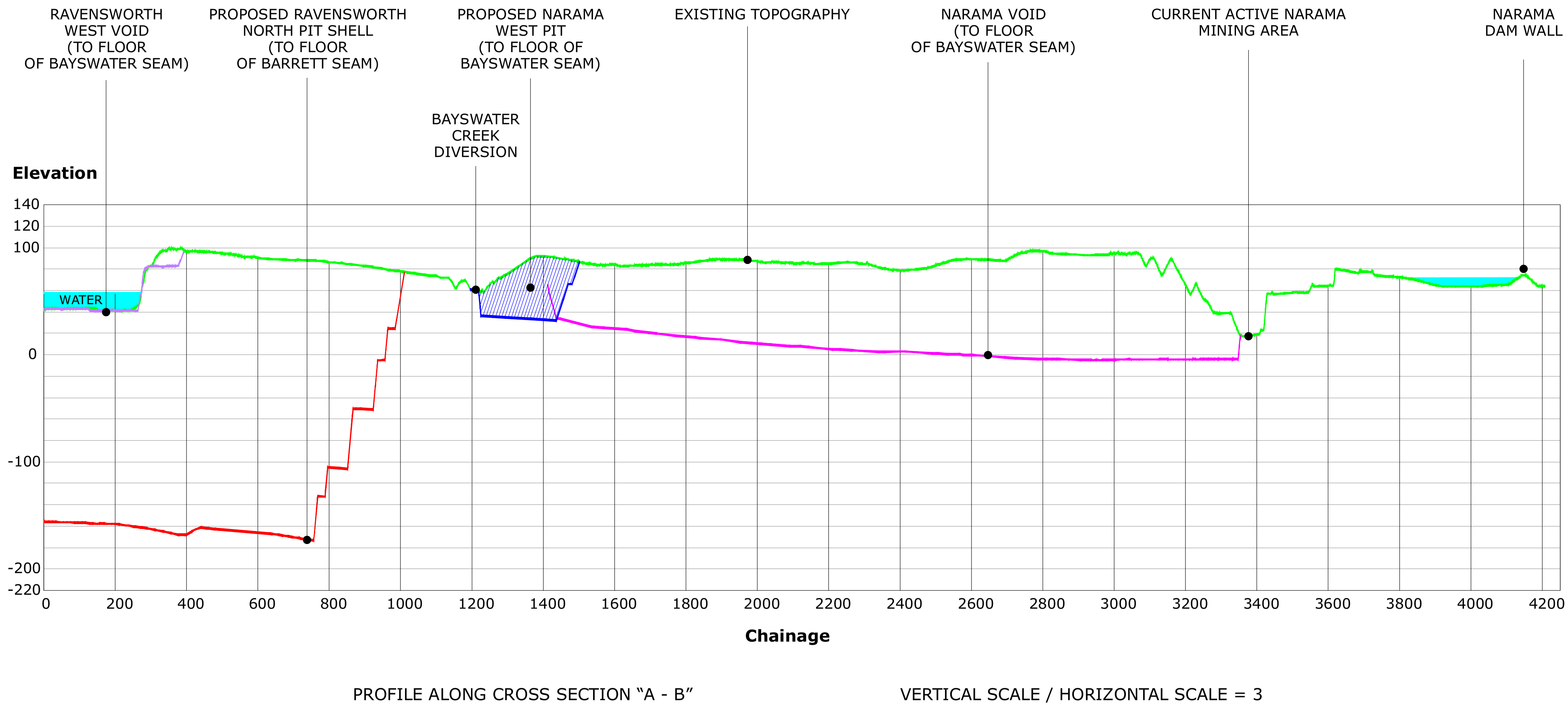


Figure 12: Groundwater Level Contours – Bayswater Seam

7.0 MINE PLAN

As outlined in Section 2.0, the Modification involves the recovery of approximately 2.7 Mt of ROM coal by open cut mining methods. This mining will occur over a two-year period within the Narama West mining area (see Figure 2). Coal production will remain within the approved maximum limit of 16 Mtpa of ROM coal with operations being undertaken via truck and shovel or dragline mining techniques.

The Narama West mining area is approximately 1.7 km x 0.3 km and occurs to the west of the existing Narama mining area and approximately 0.5 km to the east of the historical and rehabilitated Ravensworth West mining area. Figure 13 presents a cross section through the proposed Narama West mining area and shows the relationship with the adjacent mining areas.



Cross Section of the Narama West Mining Area

Figure 13

Narama Modification Groundwater Impact Assessment (G1623)

8.0 IMPACT ASSESSMENT

8.1 Local Hydrogeological Regime

There are no monitoring bores within the proposed Narama West mining area. However, the groundwater levels can be inferred from water level measurements in surrounding bores, from the structure of the coal seams, and from the mining history.

The Narama mining area has extracted coal down to the Bayswater Seam to the east and down-dip of the proposed Narama West mining area. This has left a small remnant strip of coal between the Bayswater Creek diversion to the west and the edge of the Narama mining area to the east. The historic Narama void (see Figure 13) has been backfilled with overburden, which is more permeable than the Bayswater Seam and the Permian overburden. The presence of this higher hydraulic conductivity material adjacent to the remnant Bayswater Seam within the Narama West mining area is expected to enhance seepage and drawdown in this coal seam.

The interpreted groundwater level contours for the Bayswater Seam show that on the western margin of the Narama West mining area, the groundwater levels are likely to be approximately RL 40 m. These levels reduce to the east and south following the dip of the Permian strata. At the south-eastern corner of the Narama West mining area, the groundwater levels are assessed to be RL 20 m. Based upon the Bayswater Seam floor structure contours, it is assessed that the coal seam is unsaturated over the eastern and southern part of the Narama West mining area and potentially partially saturated to the north and west.

8.2 2D Cross Sectional Model

A cross sectional model was constructed to test the above conclusion that the Bayswater seam is largely unsaturated within the proposed Narama West mining area. Figure 13 shows the 2D SEEP/W cross sectional model was developed.

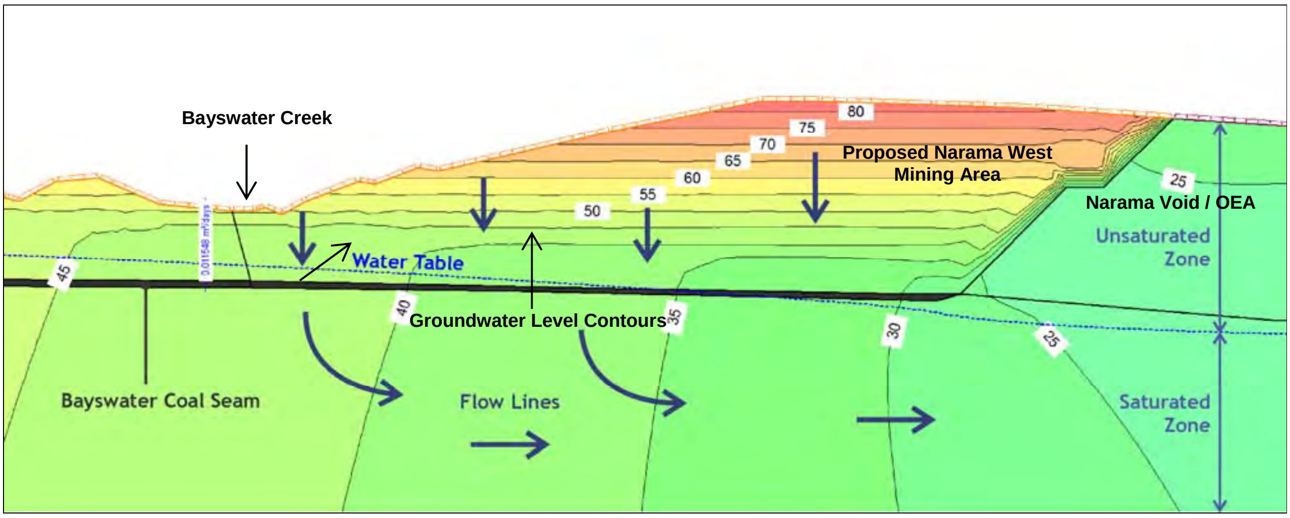


Figure 14: 2D SEEP/W Cross Section Model Predictions

The model assumed:

- steady state conditions;
- a RL 60 m constant head representing the current water level in the Ravensworth West final void;
- seepage from the active Narama mining area where the coal is currently exposed at approximately RL -4 m;
- recharge to the Permian ground surface at a rate of 36.5 mm/year and a rate of 182.5 mm/year to the overburden. These recharge rates are significantly higher than those expected in the region. For regional models in the Hunter Valley, AGE typically apply 0.1% of rainfall recharge to the Permian, and 5% of annual rainfall as recharge to spoil.

Figure 14 shows the simulated groundwater levels from the SEEP/W cross sectional model. Even with the application of conservative hydraulic parameters, the model shows that the Bayswater Seam within the Narama West mining area is only partially saturated. A water level of approximately RL 42 m is predicted to occur in the western portion of the Narama West mining area. To the east, the model predicts that the coal seam is unsaturated and is effectively dry. This agrees well with the water levels predicted by MER (2012) and the conceptual understanding of the site hydrogeology. The presence of the higher hydraulic conductivity spoil serves to drain the coal seam and spoil to the base of the active workings in the Narama mining area.

8.3 Seepage Rate to Mining Area

The cross sectional model predicts that under steady state conditions, there is approximately 0.0115 m^3/day per m of model section. If this cross sectional model is considered representative of the full 1,700 m length of mine area, this seepage is equivalent to a flux of 19.6 m^3/day through the Narama West mining area. This relatively low volume is considered unlikely to be evident during mining and will be removed by evaporation and as bound moisture in the coal and overburden. The mining method (truck and shovel or dragline) will not impact the groundwater seepage rate to the workings of the mining area.

8.4 Impact on Groundwater Levels

The numerical modelling undertaken by MER (2009) provided model predictions of groundwater impact for the Ravensworth Operations Project. Pre-mining groundwater levels in the project area were predicted to be approximately RL 55 m to RL 60 m. The model showed that within the proposed Narama West mining area, the 2009 piezometric level in the shallow Permian coal measures are between RL 0 m and RL 40 m; this is consistent with the groundwater level data. These predicted model elevations represent a drawdown of between 20 m to 60 m from pre-mining groundwater levels. The drawdown in 2040 is predicted to be 80 m to 170 m below pre-mining levels, consistent with piezometric elevations of RL -110 m and RL -25 m. Based upon this predicted drawdown, the Bayswater Seam within the proposed Narama West mining area will be fully dewatered and depressurised from the approved mining activities at Ravensworth Operations.

As a result of the predicted depressurisation from the existing approved mining activities, it is assessed that there will be no further impact to groundwater relating from the Modification.

8.5 Impact on Surface Water

MER (2009a) modelled the baseflow contributions to Bowmans Creek, Bayswater Creek and the Hunter River. The modelling showed that there is an existing loss in flow to Bowmans Creek and Bayswater Creek that is attributable to the historical mining operations of Ravensworth No. 2, Ravensworth South and Ravensworth Underground mining areas. However, the simulation of Ravensworth North mining area showed that the baseflow impacts to Bowmans Creek, Bayswater Creek and the Hunter River resulting from this development are negligible. Simulation of the Narama mining area also demonstrates that impacts to baseflow from these operations are predicted to be negligible.

8.6 Impact on Existing Users

MER (2009a) identified that there were no private boreholes within 3 km of the Ravensworth North mining area that would be measurably impacted from associated operations. Similarly there are no identified private boreholes within or near the Narama West mining area. In this regard, the Modification will not impact existing groundwater users.

8.7 Impact on Groundwater Dependent Ecosystems

There are no known Groundwater Dependant Ecosystems (GDEs) within Ravensworth Operations and therefore the Narama West mining area will not impact on GDEs.

8.8 Post Closure Final Void

MER (2009) concluded that at closure, a lake would likely form in the Ravensworth North mining area that would have an inward hydraulic gradient and act as a sink for the surrounding groundwater system. It was considered that depending on the final closure plan leaching of salts from the spoil piles and evaporative concentration of salts via evaporation would result in a void lake more saline than water in the surrounding coal seams. The proposed Narama West mining area will be backfilled with overburden as mining progresses and no open void will remain after mining. As there is no open void and the final landform will be similar to previously assessments, the conclusions of MER (2009) are considered to remain valid. The post mining landform at the Narama West mining area will not intercept groundwater and no post closure water licensing is required.

9.0 WATER LICENCING

9.1 Water Act 1912 - Permian Coal Measures

Groundwater seepage from the Permian strata requires licencing under the *Water Act 1912*. Ravensworth Operations currently has licence 20BL170749 to account for up to 150 ML/year of groundwater intercepted by the Narama West mining area.

Water pumped from the open cut mining areas is a combination of rainfall, seepage from spoil and groundwater from the coal seams. Ravensworth Operations use a model to determine the contribution of each source to the overall water balance. The groundwater seepage component contributing to the water balance is estimated to be less than 0.5 ML/day from the Narama West mining area. As discussed previously, the Narama West mining area is likely to contain only a very limited volume of groundwater that will be undetectable during mining due to evaporation and the moisture being bound to the coal and overburden.

Any groundwater seepage collected in the Narama West mining can be absorbed under the existing water licence. No additional licensing for groundwater interception under the *Water Act 1912* is required.

9.2 Water Management Act 2000 - Quaternary Alluvium and Hunter River

Groundwater loss or leakage from the alluvium is required to be accounted for under a water sharing plan. MER investigated the impacts of the Ravensworth North mining area (MER 2009) and modifications to the Cumnock Underground mining area (MER 2012). MER (2009) concluded the Ravensworth North mining area will result in some additional transfer of groundwater from the alluvium to underlying Permian strata, but that this would not impact on baseflow in the Hunter River alluvium. MER recommended installing VWP arrays RNVW5 and RNVW6 adjacent to the Hunter River to monitor water levels in the alluvium and Permian strata. Work undertaken by MER (2012) for the Cumnock Underground mining area again concluded that there would be no change to baseflow for the Hunter River and Bayswater Creek.

As the proposed Narama West mining area contains only a very limited volume of groundwater, it will have negligible impact of the alluvial water source in the area, and that any losses from the alluvium will be consistent with those predicted for the existing approved operations. No additional licensing for groundwater interception under the WM Act and relevant water sharing plan is required.

10.0 AQUIFER INTERFERENCE POLICY

The AI Policy (2012) has the following key requirements:

- a water licence is required for the aquifer interference activity regardless of whether water is taken directly for consumptive use or incidentally. Activities may induce flow from adjacent groundwater sources or connected surface water. Flows induced from other water sources also constitute take of water. In all cases, separate access licences are required to account for the take from all individual water sources.
- minimal impact considerations require:
  - the cumulative water table and pressure head decline no more than 2m at any water supply work;
  - any change in the groundwater quality should not lower the beneficial use category of the groundwater source beyond 40 m from the activity; and
  - no increase of more than 1% per activity in long-term average salinity in a highly connected surface water source at the nearest point to the activity.

Ravensworth Operations currently has water licenses in place under the *Water Act 1912* to account for all groundwater intercepted by mining. Any groundwater seepage collected in the Narama West mining area will be absorbed under the existing water licence and therefore no additional water licenses are required.

Previous investigations (MER, 2009; MER, 2012) have concluded that there would be no change to baseflow for the Hunter River and Bayswater creeks. As the proposed Narama West mining area contains only a very limited volume of groundwater, it will have negligible impact on the alluvial water source in the area, and any losses from the alluvium will be consistent with those predicted for the existing approved operations. No additional licensing for groundwater interception under the WM Act and relevant water sharing plan is required.

The Modification meets the minimal impact considerations as:

- there are no private water bores where the cumulative water table and pressure head decline is more than 2 m; and
- at post mining, the Narama West mining area will be fully backfilled. The void that will remain after cessation of the Ravensworth North mining area is expected to dominate the groundwater regime and be a sink for groundwater flow. In this regard, no impact on water quality in the alluvium or Hunter River is expected.

11.0 MONITORING AND MITIGATION MEASURES

Ravensworth Operations has a Water Management Plan that outlines groundwater monitoring requirements. As a component of this plan, Ravensworth Operations maintains a groundwater monitoring network comprising of monitoring bores and VWP arrays, which effectively surround the Narama West mining area. The existing monitoring network and program is considered adequate to monitor the impact of the Modification.

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AUSTRALASIAN GROUNDWATER AND ENVIRONMENTAL CONSULTANTS PTY LTD

Reviewed by:

DANIEL BARCLAY
Principal Hydrogeologist

JAMES TOMLIN
Principal Hydrogeologist

LIMITATIONS OF REPORT

Australasian Groundwater and Environmental Consultants Pty Ltd (AGE) has prepared this report for the use of Hansen Bailey Environmental Consultants 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 dated 24 October 2012.

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 19 November 2012 and 14 February 2013 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.