



Australian Government



BIOREGIONAL
ASSESSMENTS

PROVIDING SCIENTIFIC WATER RESOURCE
INFORMATION ASSOCIATED WITH COAL
SEAM GAS AND LARGE COAL MINES

Coal and coal seam gas resource assessment for the Hunter subregion

Product 1.2 for the Hunter subregion from the
Northern Sydney Basin Bioregional Assessment

3 November 2015



A scientific collaboration between the Department of the Environment,
Bureau of Meteorology, CSIRO and Geoscience Australia

The Bioregional Assessment Programme

The Bioregional Assessment Programme is a transparent and accessible programme of baseline assessments that increase the available science for decision making associated with coal seam gas and large coal mines. A bioregional assessment is a scientific analysis of the ecology, hydrology, geology and hydrogeology of a bioregion with explicit assessment of the potential direct, indirect and cumulative impacts of coal seam gas and large coal mining development on water resources. This Programme draws on the best available scientific information and knowledge from many sources, including government, industry and regional communities, to produce bioregional assessments that are independent, scientifically robust, and relevant and meaningful at a regional scale.

The Programme is funded by the Australian Government Department of the Environment. The Department of the Environment, Bureau of Meteorology, CSIRO and Geoscience Australia are collaborating to undertake bioregional assessments. For more information, visit <http://www.bioregionalassessments.gov.au>.

Department of the Environment

The Office of Water Science, within the Australian Government Department of the Environment, is strengthening the regulation of coal seam gas and large coal mining development by ensuring that future decisions are informed by substantially improved science and independent expert advice about the potential water related impacts of those developments. For more information, visit <http://www.environment.gov.au/coal-seam-gas-mining/>.

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Cover photograph

Oblique view west of Muswellbrook showing Bengalla coal storage (left foreground) with irrigated agriculture and riparian vegetation either side of the Hunter River and Mount Arthur coal mine in the distance (right background), NSW, 2014

© Google earth (2015), Sinclair Knight Merz Imagery date 16 December 2008. Position 32°17'58" S, 150°48'51" E, elevation 136 m, eye altitude 1.59 km



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Adam Ramage assisted with edits to Table 5.

Introduction

The Independent Expert Scientific Committee on Coal Seam Gas and Large Coal Mining Development (IESC) was established to provide advice to the federal Minister for the Environment on potential water-related impacts of coal seam gas (CSG) and large coal mining developments.

Bioregional assessments (BAs) are one of the key mechanisms to assist the IESC in developing this advice so that it is based on best available science and independent expert knowledge. Importantly, technical products from BAs are also expected to be made available to the public, providing the opportunity for all other interested parties, including government regulators, industry, community and the general public, to draw from a single set of accessible information. A BA is a scientific analysis, providing a baseline level of information on the ecology, hydrology, geology and hydrogeology of a bioregion with explicit assessment of the potential direct, indirect and cumulative impacts of CSG and coal mining development on water resources.

The IESC has been involved in the development of *Methodology for bioregional assessments of the impacts of coal seam gas and coal mining development on water resources* (the BA methodology; Barrett et al., 2013) and has endorsed it. The BA methodology specifies how BAs should be undertaken. Broadly, a BA comprises five components of activity, as illustrated in Figure 1. Each BA will be different, due in part to regional differences, but also in response to the availability of data, information and fit-for-purpose models. Where differences occur, these are recorded, judgments exercised on what can be achieved, and an explicit record is made of the confidence in the scientific advice produced from the BA.

The Bioregional Assessment Programme

The Bioregional Assessment Programme is a collaboration between the Department of the Environment, the Bureau of Meteorology, CSIRO and Geoscience Australia. Other technical expertise, such as from state governments or universities, is also drawn on as required. For example, natural resource management groups and catchment management authorities identify assets that the community values by providing the list of water-dependent assets, a key input.

The Technical Programme, part of the Bioregional Assessment Programme, will undertake BAs for the following bioregions and subregions:

- the Galilee, Cooper, Pedirka and Arckaringa subregions, within the Lake Eyre Basin bioregion
- the Maranoa-Balonne-Condamine, Gwydir, Namoi and Central West subregions, within the Northern Inland Catchments bioregion
- the Clarence-Moreton bioregion
- the Hunter and Gloucester subregions, within the Northern Sydney Basin bioregion
- the Sydney Basin bioregion
- the Gippsland Basin bioregion.

Technical products (described in a later section) will progressively be delivered throughout the Programme.

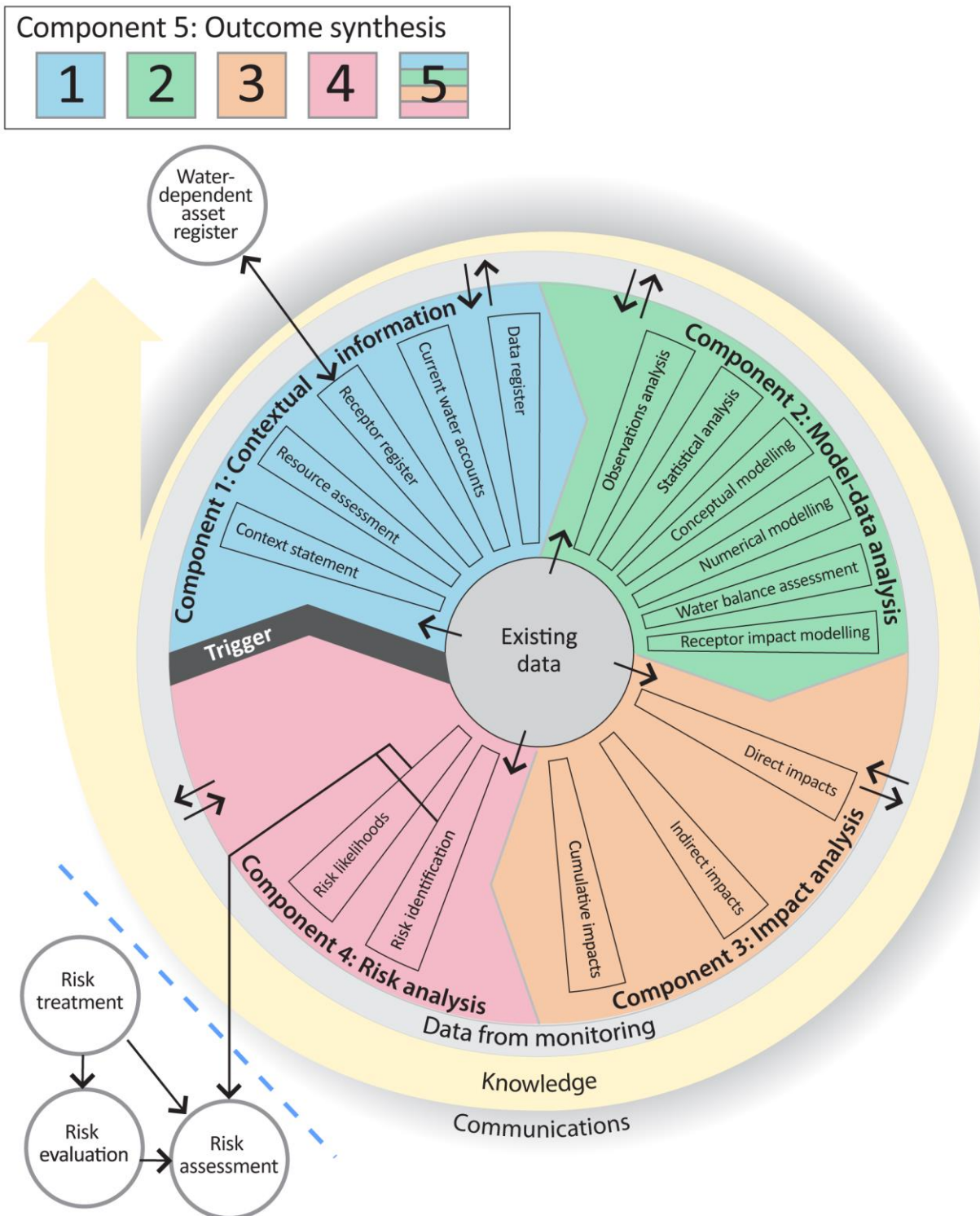


Figure 1 Schematic diagram of the bioregional assessment methodology

The methodology comprises five components, each delivering information into the bioregional assessment and building on prior components, thereby contributing to the accumulation of scientific knowledge. The small grey circles indicate activities external to the bioregional assessment. Risk identification and risk likelihoods are conducted within a bioregional assessment (as part of Component 4) and may contribute activities undertaken externally, such as risk evaluation, risk assessment and risk treatment. Source: Figure 1 in Barrett et al. (2013), © Commonwealth of Australia

Methodologies

For transparency and to ensure consistency across all BAs, submethodologies have been developed to supplement the key approaches outlined in the *Methodology for bioregional assessments of the impact of coal seam gas and coal mining development on water resources* (Barrett et al., 2013). This series of submethodologies aligns with technical products as presented in Table 1. The submethodologies are not intended to be ‘recipe books’ nor to provide step-by-step instructions; rather they provide an overview of the approach to be taken. In some instances, methods applied for a particular BA may need to differ from what is proposed in the submethodologies – in this case an explanation will be supplied. Overall, the submethodologies are intended to provide a rigorously defined foundation describing how BAs are undertaken.

Table 1 Methodologies and associated technical products listed in Table 2

Code	Proposed title	Summary of content	Associated technical product
M01	<i>Methodology for bioregional assessments of the impacts of coal seam gas and coal mining development on water resources</i>	A high-level description of the scientific and intellectual basis for a consistent approach to all bioregional assessments	All
M02	<i>Compiling water-dependent assets</i>	Describes the approach for determining water-dependent assets	1.3 Description of the water-dependent asset register
M03	<i>Assigning receptors and impact variables to water-dependent assets</i>	Describes the approach for determining receptors associated with water-dependent assets	1.4 Description of the receptor register
M04	<i>Developing a coal resource development pathway</i>	Specifies the information that needs to be collected and reported in product 1.2 (i.e. known coal and coal seam gas resources as well as current and potential resource developments). Describes the process for determining the coal resource development pathway (reported in product 2.3)	1.2 Coal and coal seam gas resource assessment 2.3 Conceptual modelling
M05	<i>Developing the conceptual model for causal pathways</i>	Describes the development of the conceptual model for causal pathways, which summarises how the ‘system’ operates and articulates the links between coal resource developments and impacts on receptors	2.3 Conceptual modelling
M06	<i>Surface water modelling</i>	Describes the approach taken for surface water modelling across all of the bioregions and subregions. It covers the model(s) used, as well as whether modelling will be quantitative or qualitative.	2.6.1 Surface water numerical modelling
M07	<i>Groundwater modelling</i>	Describes the approach taken for groundwater modelling across all of the bioregions and subregions. It covers the model(s) used, as well as whether modelling will be quantitative or qualitative. It also considers surface water – groundwater interactions, as well as how the groundwater modelling is constrained by geology.	2.6.2 Groundwater numerical modelling

Code	Proposed title	Summary of content	Associated technical product
M08	<i>Receptor impact modelling</i>	Describes how to develop the receptor impact models that are required to assess the potential impacts from coal seam gas and large coal mining on receptors. Conceptual, semi-quantitative and quantitative numerical models are described.	2.7 Receptor impact modelling
M09	<i>Propagating uncertainty through models</i>	Describes the approach to sensitivity analysis and quantifying uncertainty in the modelled hydrological response to coal and coal seam gas development	2.3 Conceptual modelling 2.6.1 Surface water numerical modelling 2.6.2 Groundwater numerical modelling 2.7 Receptor impact modelling
M10	<i>Risk and cumulative impacts on receptors</i>	Describes the process to identify and analyse risk	3 Impact analysis 4 Risk analysis
M11	<i>Hazard identification</i>	Describes the process to identify potential water-related hazards from coal and coal seam gas development	2 Model-data analysis 3 Impact analysis 4 Risk analysis
M12	<i>Fracture propagation and chemical concentrations</i>	Describes the likely extent of both vertical and horizontal fractures due to hydraulic stimulation and the likely concentration of chemicals after production of coal seam gas	2 Model-data analysis 3 Impact analysis 4 Risk analysis

Each submethodology is available online at <http://www.bioregionalassessments.gov.au>. Submethodologies might be added in the future.

Technical products

The outputs of the BAs include a suite of technical products variously presenting information about the ecology, hydrology, hydrogeology and geology of a bioregion and the potential direct, indirect and cumulative impacts of CSG and coal mining developments on water resources, both above and below ground. Importantly, these technical products are available to the public, providing the opportunity for all interested parties, including community, industry and government regulators, to draw from a single set of accessible information when considering CSG and large coal mining developments in a particular area.

The information included in the technical products is specified in the BA methodology. Figure 2 shows the information flow within a BA. Table 2 lists the content provided in the technical products, with cross-references to the part of the BA methodology that specifies it. The red rectangles in both Figure 2 and Table 2 indicate the information included in this technical product.

This technical product is delivered as a report (PDF). Additional material is also provided, as specified by the BA methodology:

- all unencumbered data syntheses and databases
- unencumbered tools, model code, procedures, routines and algorithms
- unencumbered forcing, boundary condition, parameter and initial condition datasets
- the workflow, comprising a record of all decision points along the pathway towards completion of the BA, gaps in data and modelling capability, and provenance of data.

The PDF of this technical product, and the additional material, are available online at <http://www.bioregionalassessments.gov.au>.

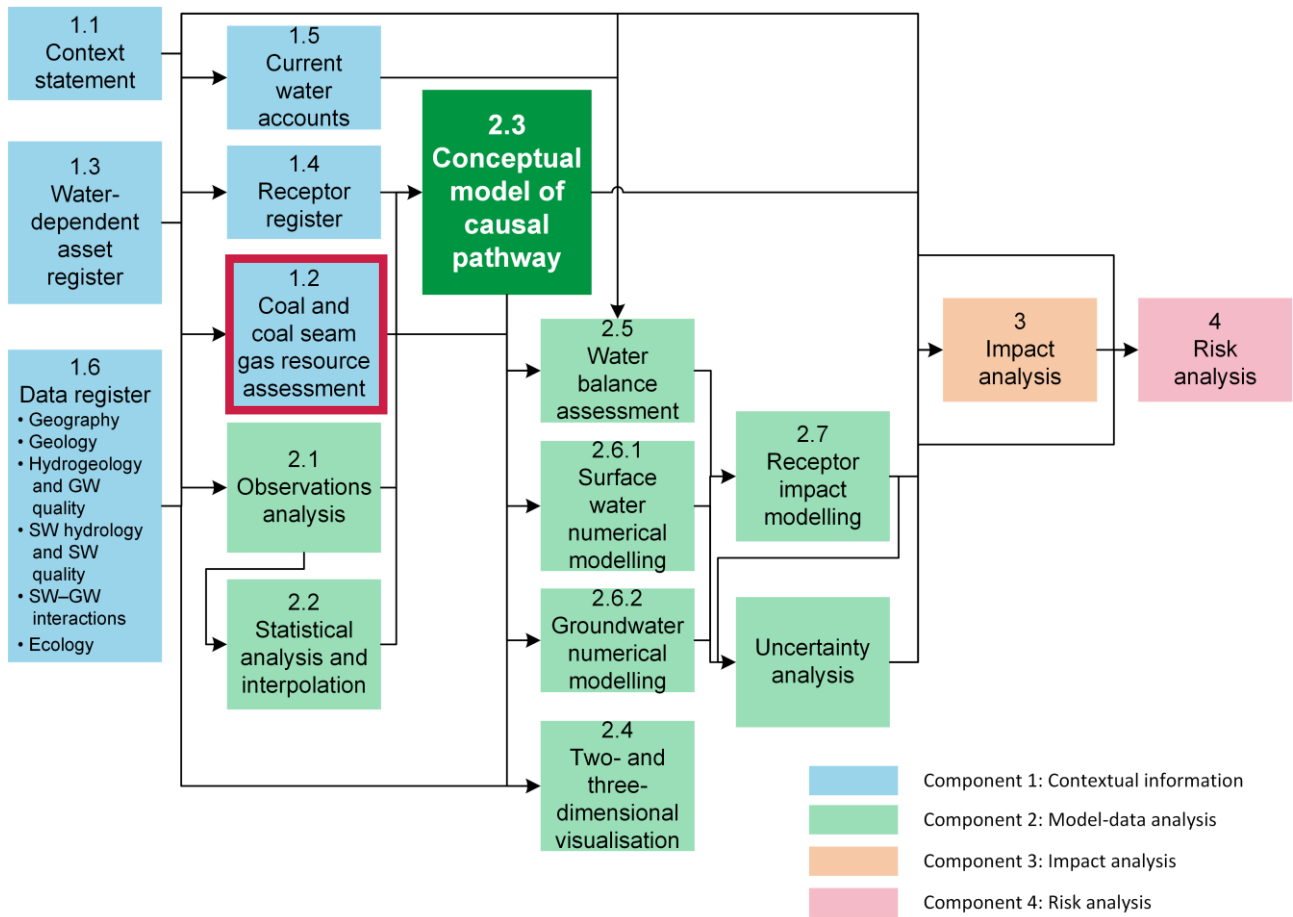


Figure 2 The simple decision tree indicates the flow of information through a bioregional assessment

The red rectangle indicates the information included in this technical product.

Table 2 Technical products delivered by the Northern Sydney Basin Bioregional Assessment

For each subregion in the Lake Eyre Basin Bioregional Assessment, technical products are delivered online at <http://www.bioregionalassessments.gov.au>, as indicated in the 'Type' column^a. Other products – such as datasets, metadata, data visualisation and factsheets – are provided online.

Component	Product code	Title	Section in the BA methodology ^b	Type ^a
Component 1: Contextual information for the Hunter subregion	1.1	Context statement	2.5.1.1, 3.2	PDF, HTML
	1.2	Coal and coal seam gas resource assessment	2.5.1.2, 3.3	PDF, HTML
	1.3	Description of the water-dependent asset register	2.5.1.3, 3.4	PDF, HTML, register
	1.4	Description of the receptor register	2.5.1.4, 3.5	PDF, HTML, register
	1.5	Current water accounts and water quality	2.5.1.5	PDF, HTML
	1.6	Data register	2.5.1.6	Register
Component 2: Model-data analysis for the Hunter subregion	2.1-2.2	Observations analysis, statistical analysis and interpolation	2.5.2.1, 2.5.2.2	PDF, HTML
	2.3	Conceptual modelling	2.5.2.3, 4.3	PDF, HTML
	2.5	Water balance assessment	2.5.2.4	PDF, HTML
	2.6.1	Surface water numerical modelling	4.4	PDF, HTML
	2.6.2	Groundwater numerical modelling	4.4	PDF, HTML
	2.7	Receptor impact modelling	2.5.2.6, 4.5	PDF, HTML
Component 3: Impact analysis for the Hunter subregion	3-4	Impact analysis	5.2.1	PDF, HTML
Component 4: Risk analysis for the Hunter subregion		Risk analysis	2.5.4, 5.3	
Component 5: Outcome synthesis for the Northern Sydney Basin bioregion	5	Outcome synthesis	2.5.5	PDF, HTML

^aThe types of products are as follows:

- 'PDF' indicates a PDF document that is developed by the Northern Sydney Basin Bioregional Assessment using the structure, standards, and look and feel specified by the programme.
- 'HTML' indicates the same content as in the PDF document, but delivered as webpages.
- 'Register' indicates controlled lists that are delivered using a variety of formats as appropriate.

^b*Methodology for bioregional assessments of the impacts of coal seam gas and coal mining development on water resources* (Barrett et al., 2013)

About this technical product

The following notes are relevant only for this technical product.

- All reasonable efforts were made to provide all material under a Creative Commons Attribution 3.0 Australia Licence.
- All maps created as part of this BA for inclusion in this product used the Albers equal area projection with a central meridian of 151.0° East for the Northern Sydney Basin bioregion and two standard parallels of -18.0° and -36.0°.
- Contact bioregionalassessments@bom.gov.au to access metadata (including copyright, attribution and licensing information) for all datasets cited or used to make figures in this product. At a later date, this information, as well as all unencumbered datasets, will be published online.
- The citation details of datasets are correct to the best of the knowledge of the Bioregional Assessment Programme at the publication date of this product. Readers should use the hyperlinks provided to access the most up-to-date information about these data; where there are discrepancies, the information provided online should be considered correct. The dates used to identify Bioregional Assessment Source Datasets are the dataset's published date. Where the published date is not available, the last updated date or created date is used. For Bioregional Assessment Derived Datasets, the created date is used.

References

Barrett DJ, Couch CA, Metcalfe DJ, Lytton L, Adhikary DP and Schmidt RK (2013) Methodology for bioregional assessments of the impacts of coal seam gas and coal mining development on water resources. A report prepared for the Independent Expert Scientific Committee on Coal Seam Gas and Large Coal Mining Development through the Department of the Environment, Department of the Environment, Australia. Viewed 5 February 2016, <http://www.iesc.environment.gov.au/publications/methodology-bioregional-assessments-impacts-coal-seam-gas-and-coal-mining-development-water>.



1.2 Coal and coal seam gas resource assessment for the Hunter subregion

The coal and coal seam gas resource assessment summarises the known coal and coal seam gas resources, and developments both now and potentially in the future. The following data and information are presented:

- the geology and spatial distribution of known coal resources
- the baseline of current coal and coal seam gas extraction
- exploration and mining tenements
- proposed future developments (both new developments and expansion or closure of existing developments), including details of location, timing, methods and extraction volumes as determined from proposed development plans.

This information will be used to develop the coal resource development pathway (as reported in product 2.3), which articulates the most likely combination of developments at a subregion or bioregion scale, including all individual coal and coal seam gas resource projects that are expected.



1.2.1 Available coal and coal seam gas resources

Summary

Coal and coal seam gas resources (CSG) in the Hunter subregion are contained within the Hunter, Newcastle and Western Coalfields of the geological Sydney Basin. The major economic coal seams mined in the Hunter Coalfield are part of the Greta and the Wittingham coal measures, and in the Newcastle Coalfield the Greta, Tomago and the Newcastle coal measures contain extensive resources. Most of the coal produced from the Western Coalfield is contained in three main economic units within the Illawarra Coal Measures: the Lithgow Coal, Ulan Coal, and the Katoomba Coal Members. The origin of most of the methane (CH₄) in the Sydney Basin can be attributed to the microbial reduction of primarily magmatic carbon dioxide (CO₂). Areas down-dip of the Hunter and Newcastle Coalfields, as well as in the extreme north of the Western Coalfield, have been identified as being prospective for CSG.

1.2.1.1 Coal

1.2.1.1.1 Hunter Coalfield

The major economic coal seams mined in the Hunter Coalfield of the geological Sydney Basin (Figure 3) are part of the Greta Coal Measures and the Wittingham Coal Measures. In some regions, such as around the Glencore Mangoola mine, coals from the Newcastle Coal Measures are also mined. The main stratigraphic units for the Hunter Coalfield are shown in Figure 4.

Greta Coal Measures

Coals of the Greta Coal Measures occur to depths greater than 600 m in the Hunter Coalfield. The sequence is about 200 m thick in the Muswellbrook area and 60 to 75 m thick in the Lochinvar area (Basden, 1969; p. 323). The coals characteristically have low ash and medium moisture contents. The Saint Heliers Coal Member dips slightly to the north and has a thickness of approximately 9.5 m at Muswellbrook No 2 Coal Mine, whereas the Loder Coal Member dips slightly to the north with a thickness of 1.5 m (Idemitsu Kosan, 2010). In the Muswellbrook area the seams associated with the Muswellbrook Anticline are thicker compared to those in the south near the Lochinvar Anticline (Figure 5). Six seams are identified in the Muswellbrook area, although these cannot be consistently correlated between the northern and southern parts of the anticline (Beckett, 1988).

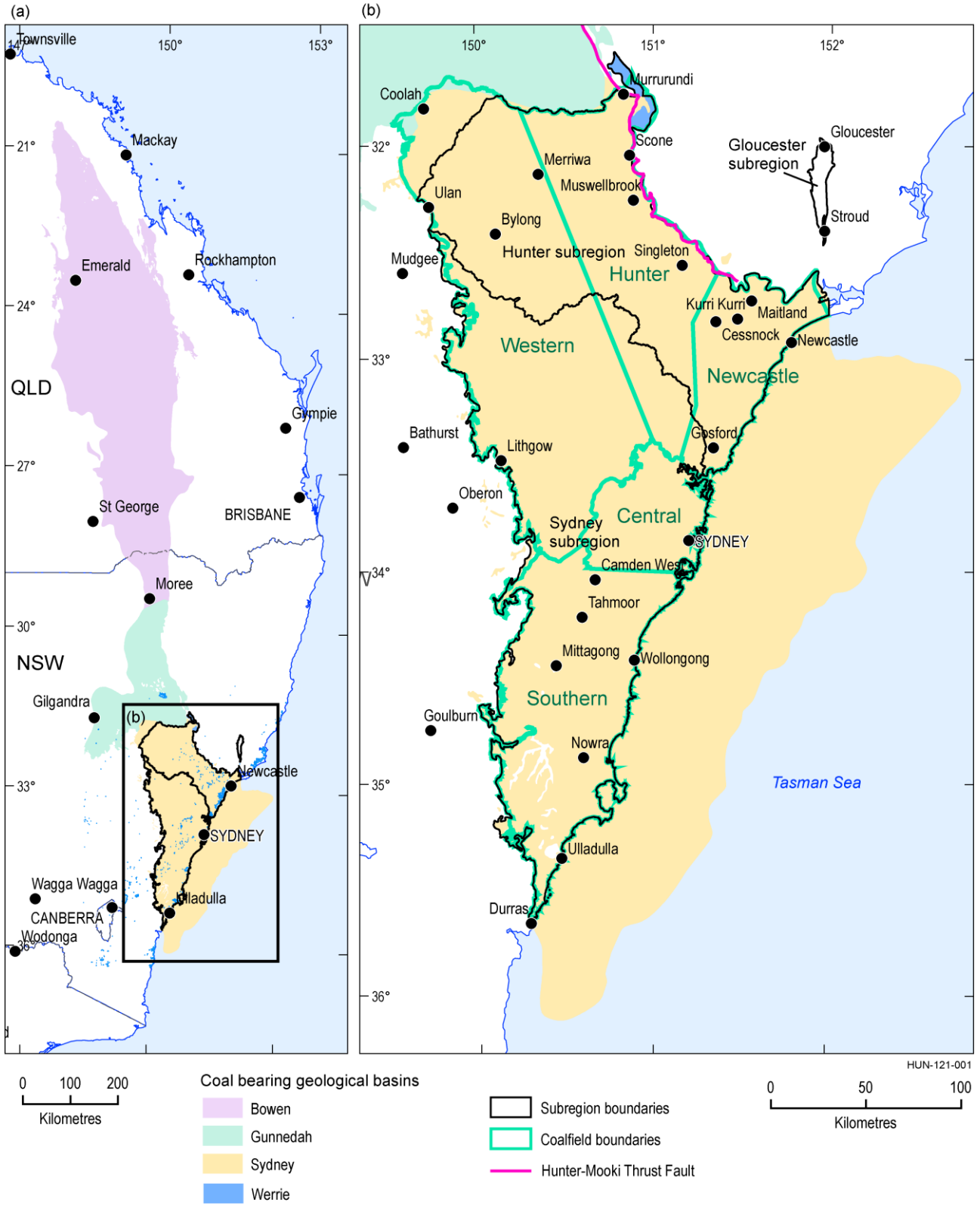


Figure 3 Location of the Sydney Basin showing the main coalfields of the basin

Data: Geoscience Australia (Dataset 1)

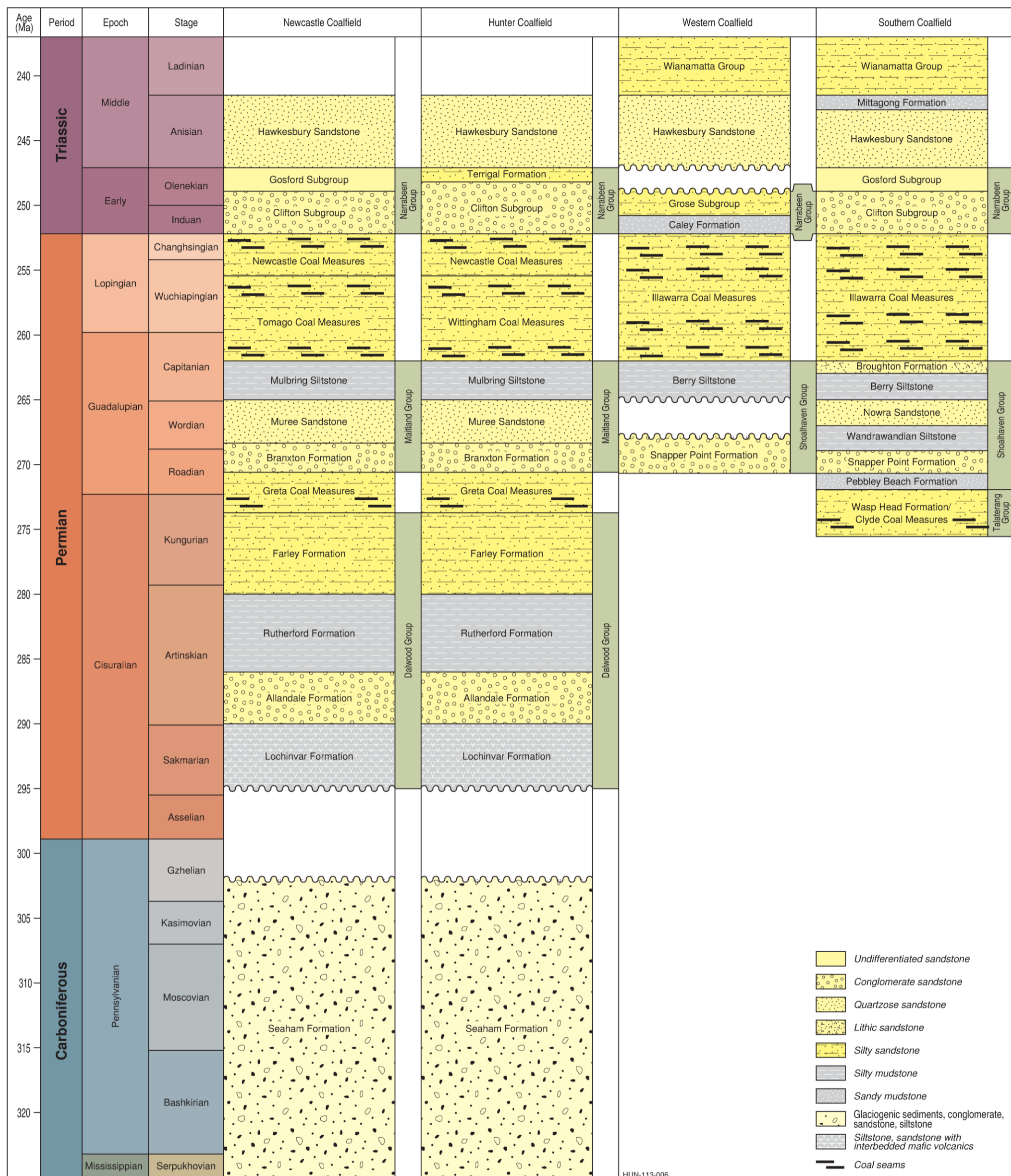


Figure 4 Generalised stratigraphic column of the Permian and Triassic units in the main coalfields of the Sydney Basin (Younger Jurassic and Cenozoic units that occur in the Hunter subregion are not shown here as they do not contain economic coal resources)

Source: Geoscience Australia (2014)

This figure has been optimised for printing on A3 paper (297 mm x 420 mm).

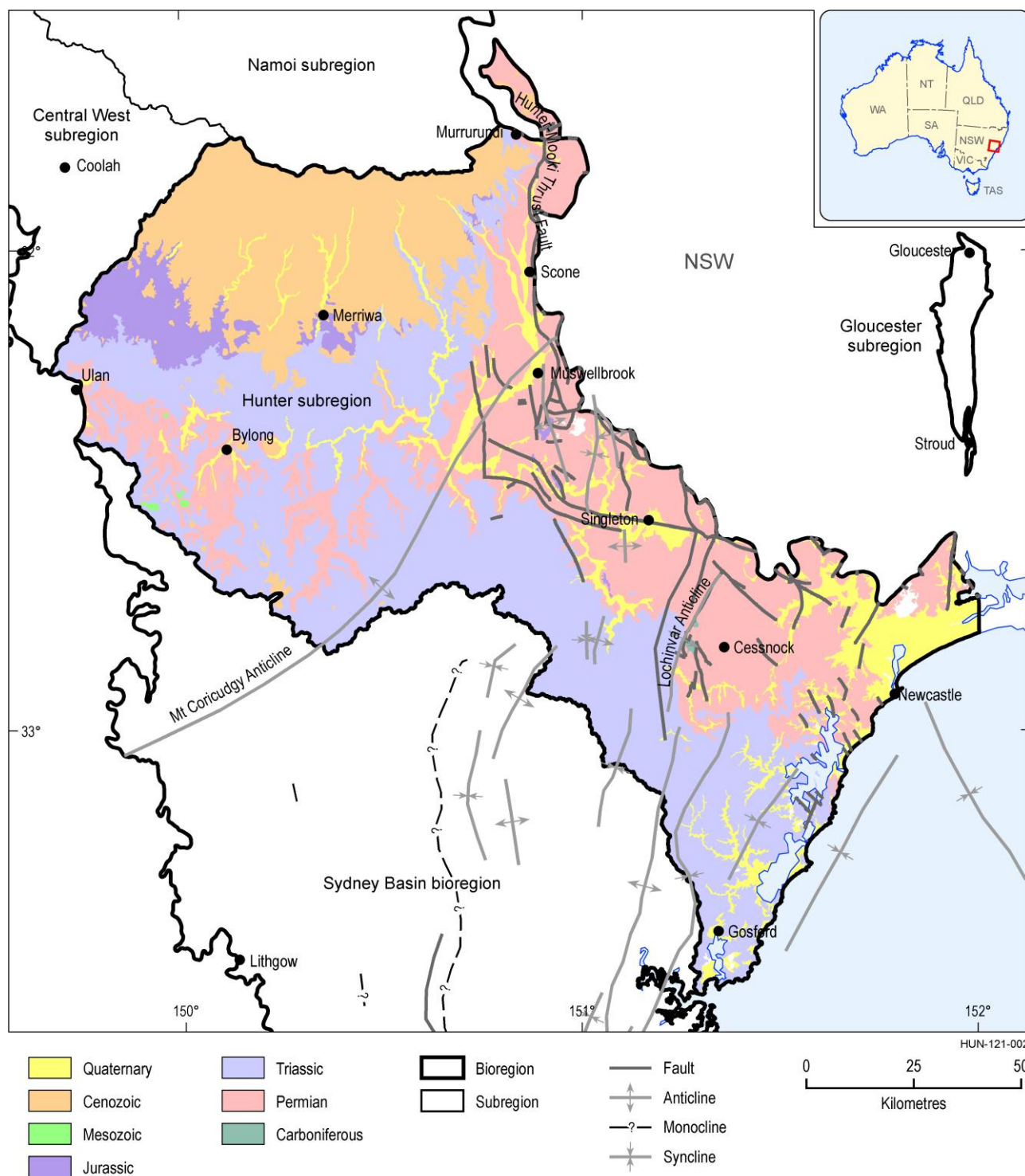


Figure 5 Surface geological map of the Hunter subregion

Data: Geoscience Australia (Dataset 2)

The Greta Coal Measures near the Lochinvar Anticline include the Lower and Upper Homeville coal members, which are low ash-yielding coals with high volatile matter. The informally named Greta Coal Seam is up to 11 m thick and split by the Kearsley Lens, with a maximum thickness of about 5 m. It consists mainly of hard, bituminous coal with very low ash and high volatile matter (Basden, 1969, p. 325). Seam continuity is commonly disrupted by faulting and some seams are thermally affected by igneous intrusions (Beckett, 1988). In the Singleton area the Greta Coal Measures are

generally high in inertinite and have an average mean maximum vitrinite reflectance ($R_{v,max}$) of 0.91%. Ward et al. (2007) attributed $R_{v,max}$ suppression in these marine-influenced coals to the preservation of aliphatic structures in vitrinite.

Wittingham Coal Measures

Vane Subgroup

The coal seams of the Foybrook Formation are well developed in the Muswellbrook area but are characterised by erratic splitting. The lower seams of the Vane Subgroup generally have similar thicknesses and are characteristic of the facies change from lower to upper delta plain deposits (Sniffin and Beckett, 1995, p. 192). The Liddell Coal Member is the thickest coal-bearing unit, up to 14 m in the Foybrook area. Most of the seams are characterised by multiple splitting, thus, individual coal seams tend to be thin and of inferior quality (Sniffin and Beckett, 1995, p. 185). Where the Wittingham Coal Measures crop out around the Lochinvar Anticline they are about 60 to 75 m thick.

The coal seams at the Mount Owen Mining Complex are situated between two regional thrust faults, the Hunter Thrust and Hebden Thrust, each limiting the lateral extent of coal (Glencore, 2014a). The uppermost seam of this subgroup, the Lemington Coal Member, is particularly prone to splitting, having a maximum net coal thickness of 16.1 m and a maximum total seam thickness of 107.8 m. In the central regions of the coalfield the seam names of the Vane Subgroup differ. Here, the counterpart of the Lemington Coal Member, the Wynn Coal Member, is not as variable in thickness (Pinetown, 2012, p. 112). The coals of the Hunter Coalfield are generally high in vitrinite, followed by inertinite and then liptinite with variable proportions of mineral matter. However, seams of the Vane Subgroup contain less inertinite compared to the seams of the Jerrys Plains Subgroup (Pinetown, 2012, p. 118).

Jerrys Plains Subgroup

Coal distribution in the Jerrys Plains Subgroup of the Wittingham Coal Measures is more variable compared to that of the Vane Subgroup. Although most of the upper delta plain seams are laterally extensive (Sniffin and Beckett, 1995, p. 192), some of the largest variations occur in the Blakefield, Mount Arthur and Piercefield coal members (Pinetown, 2012, p. 112). In the east of the coalfield the Jerrys Plains Subgroup is primarily absent as a result of extensive uplift and subsequent erosion. In the central part of the coalfield, seam thickness in the Jerrys Plains Subgroup is less variable than in the south. Seams of the Jerrys Plains Subgroup in the north of the coalfield generally have similar splitting behaviour and distribution patterns to those in the central and southern regions. The lowest seam, the Bayswater Coal Member seam, varies in thickness from about 1 to 14 m, and has a dull character with high inertinite content. The brighter coals such as the Broonie through to the Warkworth coal members are subject to extensive splitting. The stratigraphic section from the Bayswater Coal Member to the Warkworth Coal Member varies from about 100 to 300 m thick.

Coal seams in the middle of the Jerrys Plains Subgroup are subject to splitting, and the thickness of individual seams varies between about 0.3 and 4 m within a section from 70 to 200 m thick. The upper seams, occurring within a section ranging from 70 to 200 m, are also usually split and

associated with several tuffaceous claystone marker beds (Sniffin and Beckett, 1995, p. 193). In the Warkworth-Broke area the Whybrow Coal Member, which is the uppermost unit in the subgroup, varies in thickness from about 2 to 5 m. General characteristics of coals in the Hunter Coalfield are provided in Table 3.

Table 3 General coal characteristics across the Hunter Coalfield

Coalfield region	Moisture content	Ash yield	Volatile matter
South	Between about 1 and 4%, decreasing steadily with increasing depth	Between 12 and 38%, with high (>50%) ash yields for thinner seams at the top of the subgroup	
East	Between 1 and 4%	Between 6 and 30%	Between 21 and 37% for the lower seams of the Jerrys Plains Subgroup
Central	Between 2 and 4%	Between 9 and 21%	Between 10 and 36%
West	Between 3 and 8%	Between 6 and 36%	Between 19 and 37%
North	Between 2 and ~8%	High ash yields >50%	Between 22 and 36%

Data: Pinetown (2012)

Vitrinite is the dominant maceral group in coals of the Jerrys Plains Subgroup (generally greater than 50%). Inertinite is most abundant in seams from the Bowfield Coal Member to the Bayswater Coal Member, which could indicate greater extent of oxidation during deposition of coals in the Jerrys Plains Subgroup (Pinetown, 2012, p. 118). Coals in the south of the Hunter Coalfield are generally of higher rank in comparison to those in the north for the same depth, all generally increasing linearly with increasing depth. $R_{v,max}$ for coals in the south of the coalfield varies within a broad range between 0.56 and 1.15%, although most are greater than 0.75%. In the central regions, $R_{v,max}$ is about 0.72 to 1.00%, whereas in the west $R_{v,max}$ is between 0.65 and 0.95% (Pinetown, 2012, p. 120).

Newcastle Coal Measures

South of the Hunter River Cross Fault the upper coal seams of the Newcastle Coal Measures are generally thin, indicating fluvial conditions with rapid channel migration, seam splitting and erosion towards the end of coal measure deposition (Sniffin and Beckett, 1995, p. 192). Seams of the Abbey Green Coal (historically part of the Wollombi Coal Measures) are split, varying between 0.8 and 97.4 m thick (Pinetown, 2012, p. 111). Elsewhere in the coalfield the coal seams of the Newcastle Coal Measures are only present towards the west, and show distribution patterns that indicate fluvial depositional conditions with rapid channel migration depositing thinner coal seams. The coal sequence at the Mangoola Coal Mine typically shows a massive conglomerate/sandstone overburden between 15 and 90 m thick. This includes the Awaba Tuff, about 9 to 10 m thick at the site, which separates the Great Northern and Fassifern coal members (Umwelt (Australia) Pty Limited, 2013). An $R_{v,max}$ of 0.56% for the Fassifern Coal Member of the Newcastle Coal Measures in the south of the coalfield, occurring about 90 m below surface was recorded by Pinetown (2012, p. 118).

1.2.1.1.2 Newcastle Coalfield

Greta Coal Measures

The Homeville Coal Member of the Greta Coal Measures is up to 6 m thick and generally thicker east of Cessnock. The overlying Greta seam (informal unit) is up to 11 m thick in the vicinity of Cessnock but thins over a relatively short distance towards the south. The upper portion of the seam is of lower quality and is high in sulfur (Agnew et al., 1995, p. 209). At the Austar Coal Mine the Greta seam is described as a 7 m thick, semi-hard coking coal and thermal coal (Yancoal, 2015a), with low ash and medium moisture contents (Idemitsu Kosan, 2010, p. 2). Agnew et al. (1995, p. 209) recorded moisture contents of 1.7 and 2.1%, ash yields of 5.9 and 6.3%, and volatile matter contents of 42.6 and 42% for the Homeville Coal Member and the Greta seam, respectively. These coals are generally vitrinite-rich, with mean vitrinite content about 67% for the two main seams (Agnew et al., 1995, p. 210).

Tomago Coal Measures

Coal seams of the Tomago Coal Measures are generally split and vary in lateral extent, mainly due to their depositional environments. The coals are generally vitrinite-rich, with contents greater than 72% (Agnew et al., 1995, p. 210). Of the main coal units in the sequence the Rathluba Formation varies between 1.5 and 3 m in thickness, the Big Ben Coal Member is 1.5 to 4.5 m thick, and the (informally named) Donaldson seam between 1 and 3 m thick. The Rathluba Formation contains a number of stone bands and coal quality is variable. The Big Ben Coal Member contains mudstone interbeds and thickens towards the west of the coalfield, and the Donaldson seam commonly has a number of splits enclosed within a 30 m thick section (Agnew et al., 1995, p. 209). Agnew et al. (1995, p. 210) recorded moisture contents between 2.1 and 2.5%, ash yields between 10.6 and 12.8%, and volatile matter contents between 34.9 and 37% for these seams. Compared to the coals of the Newcastle Coal Measures the Tomago Coal Measures have relatively high sulfur contents.

Newcastle Coal Measures

The lowest seam in the Newcastle Coal Measures, the informally named Borehole coal seam, occurs throughout the coalfield. In the east it varies between 1.5 and 2.5 m thick, and thickens to 2.5 m towards the north-west of the coalfield. The coals immediately overlying the Borehole coal seam (the Yard, Dudley and Nobbys coal seams) are relatively thin and have limited resources (Agnew et al., 1995, p. 209). The Victoria Tunnel coal seam is best developed along the coast, east of Lake Macquarie. The next seam of economic interest, the Australian seam (an informally named, local seam), is generally 2.5 m in its basal section, but can be as thick as 16 m in places.

Of the upper seams of the Newcastle Coal Measures, the Fassifern, Great Northern and Wallarah coal seams are the most notable, with thicknesses varying between 2.5 and 3 m although some seams such as the Fassifern seam are up to 8 m and the Great Northern seam up to 7 m (Agnew et al., 1995, p. 209). At the Tasman Coal Mine, for example, semi-soft coking and thermal coal is produced from the Fassifern coal seam where it is reported to be 2.2 to 2.5 m thick (Tyler and Sutherland, 2011). The Great Northern seam is approximately 120 m deep and the Wallarah seam

about 80 m below surface at Myuna Colliery (AECOM, 2011, p. 37). The uppermost seam of the sequence, the Vales Point coal seam, consists of up to three splits (Agnew et al., 1995, p. 209).

1.2.1.1.3 Western Coalfield

Illawarra Coal Measures

Western Coalfield coals are mainly bituminous thermal coals with medium to high ash and low sulfur. Most of the coal is produced from three main economic units within the Illawarra Coal Measures: the Lithgow Coal, Ulan Coal, and the Katoomba Coal Member (Yoo et al., 2001, p. 87).

The Lithgow Coal contains economic resources between Lithgow and Rylstone and in the Bylong area. In the Lithgow area it ranges from 1.5 to 4.6 m in thickness, has an ash yield of between 14 and 35%, and is medium to high volatile coal which is low in sulfur (Yoo et al., 2001, p. 87). The Lidsdale Coal has a thickness of up to 2 m, with a raw ash yield of about 30% (Yoo et al., 2001, p. 88). The Ulan Coal is a 14 m thick coal-bearing unit best developed in the Ulan and Wilpinjong area. It is divided into upper and lower sections by a 0.3 m thick tuffaceous claystone. In the Ulan area, the lower section (known as the D working section, or DWS) ply is approximately 3 m thick and has an average raw ash yield of 11 to 13% (air dried). In comparison, the upper section is about 7 m thick and has an ash yield of up to 45%. In the Wilpinjong area, the upper section of the Ulan Coal ranges in thickness from 1.4 to 3.5 m, with an ash yield range of 14.5 to 30.7% (Yoo et al., 2001, p. 89). At Moolarben Coal Mine, the Ulan seam has a mean thickness of approximately 12 m throughout the deposit (Yancoal, 2015b). Only the lowest 3 m of the Ulan Coal is mined at the Ulan Mine. Due to the coal's particularly high quality only about 30% of the coal requires washing (Ulan Coal, 2015). The coal is of high quality with low sulfur, nitrogen and phosphorous, providing good handling and combustion properties (Ulan Coal, 2015).

The Irondale Coal has some economic potential at Running Stream, and north of the Wilpinjong and Moolarben area, where it is up to 2 m thick with an ash yield of 10.6% (Yoo et al., 2001, p. 90). In the area north of Ulan, the Moolarben Coal Member ranges in thickness from 1.76 to 2.72 m with an ash yield for selected sections of 27 to 34%. The seam is potentially mineable in the Cockabutta Creek area and the area around Moolarben (Yoo et al., 2001, p. 90). In the northern part of the Western Coalfield the Turill Coal Member is 3.5 to 4 m thick at 210 to 600 m depth, consisting mainly of dull coal with common bright layers. The ash yield of the seam ranges from 23 to 45% (Yoo et al., 2001, p. 91). The Middle River Coal Member is a 12 to 20 m thick interbedded unit with a high proportion of tuff, claystone, carbonaceous claystone and coal. Ash yields of selected sections are, on average, around 26% (Yoo et al., 2001, p. 91).

The Katoomba Coal Member has been mined to produce coal for thermal use and is a medium-volatile, low-sulfur steaming coal, mostly 1.5 to 3.0 m thick, with an ash yield between 11 and 23%. It occurs east of Rylstone but its economic distribution has been affected by erosion prior to deposition of sandstone and conglomerate units of Narrabeen Group. It contains a high proportion of claystone layers and has poor beneficiation characteristics (Yoo et al., 2001, p. 91).

According to Hutton (2009, p. 43) there is little possibility of economic seams in the Yarrunga Coal Measures and the Clyde Coal Measures of the Shoalhaven Group, since the seams are

discontinuous and thin. Furthermore, there is little information available on the character and distribution of these coal measure sequences in the Hunter subregion.

1.2.1.2 Coal seam gas

1.2.1.2.1 Hunter Coalfield

Numerous researchers have investigated the origin and composition of coal seam gas (CSG) in eastern Australian basins. According to Smith et al. (1992, p. 63), Smith (1999) and Ahmed and Smith (2001, p. 814), wet thermogenic gases, which initially charged the Sydney Basin were lost due to uplift and erosion, and were almost completely replaced by very dry biogenic methane (CH₄) and magmatic carbon dioxide (CO₂). The origin of most of the methane in the Sydney Basin can be attributed to the microbial reduction of primarily magmatic carbon dioxide. Evidence for large scale igneous injections of carbon dioxide into coal measure sequences of the Sydney Basin has been provided by Baker et al. (1995), and further supported by Golab et al. (2006, p. 296) in a study on dawsonite formation in coals of the Hunter Coalfield.

Burra et al. (2014, p. 448) provided an alternative Sydney Basin gas model based on research into groundwater chemistry and the behaviour of dissolved gases such as carbon dioxide. According to their observations the central and eastern parts of the basin do not host spatially extensive carbon dioxide gas accumulations whereas northern, western and southern parts of the basin commonly contain CO₂-rich gases at depth. These researchers suggested that this was derived from local- to continental-scale magmatic intrusions and is a product of carbonate dissolution or acetate fermentation.

Craig (2005) investigated CSG distribution in the Hunter Coalfield using gas data from six boreholes drilled between 1991 and 2004. Three of the boreholes were drilled west of the Mount Ogilvie Fault, one to the east of the Bayswater Syncline, and two in the south-west of the coalfield. It was reported that elevated gas contents of around 24.6 m³/t are present in the south, where gas contents vary from about 1.0 m³/t in the upper seams of the Jerrys Plains Subgroup to greater than 24.0 m³/t in the Vane Subgroup (Craig, 2005). Gas contents in the Jerrys Plains Subgroup and upper seams of the Vane Subgroup are noticeably lower in the north than in the south of the coalfield, ranging from approximately 8.0 m³/t at 200 m depth, to a maximum of 14.8 m³/t at about 300 m depth. Coals in the Muswellbrook region show even lower gas contents (Craig, 2005). The study reported that carbon dioxide content increases with depth in the south of the coalfield from 11% at 350 m depth to 84% at 700 m depth. Similarly in the north, carbon dioxide increases with increasing depth, although not consistently for the entire area. Other trends in gas distribution reported by Craig (2005) include observations that no significant relationship could be established between maceral composition and gas content, and that no strong correlations could be made between volatile matter, yield and coal rank or gas content. Since the boreholes were distal to the prominent geological structures in the coalfield Craig (2005) concluded that there are no structural controls on gas distribution, but that the depth of the coal seams appeared to have the greatest influence on gas contents.

Thomson et al. (2008, p. 7) proposed four distinct zones of gas layering in the lower part of the Hunter Coalfield. The layering with respect to gas composition was attributed to tectonic history and was regarded as being independent of coal seam depth. The distinct zones include Zone 1

which is the area near the surface characterised by high carbon dioxide concentrations originating from the oxidation of coal, with hardly any methane present. Zone 2 extends from below Zone 1 to about 400 m, where CSG consists mainly of biogenic methane. Zone 3 is a mixed gas zone with significant concentrations of both magmatic carbon dioxide and thermogenic methane, whereas gas in the deeper seams of Zone 4 contains mainly thermogenic methane and very little carbon dioxide (Thomson et al., 2008, p. 7). According to Thomson et al. (2008, p. 8–9), thermogenic methane was generated during the burial of coal seams in the Triassic and Jurassic, after which significant volumes of magmatic carbon dioxide were first introduced by igneous activity during the Jurassic and Cretaceous. Some of the trapped methane and carbon dioxide escaped as a result of basin uplift during the Late Cretaceous to Early Cenozoic, with uplift assisting the formation of biogenic methane through the reduction of magmatic carbon dioxide. Cenozoic volcanism then injected even more carbon dioxide into the basin, which was followed by continued generation of biogenic methane (Zone 2) and the oxidation of coal (Zone 1) to the present (Thomson et al., 2008, p. 8–9). This model was further developed by Thomson et al. (2014) who provided a rationale for the origin and timing of emplacement of the various coal seam gases in the western and eastern parts of the Sydney Basin.

In an investigation on the origin, distribution and controls on CSG in the Hunter Coalfield, Pinetown (2012, 2013) suggested that five CSG ‘compartments’ were present that have different gas attributes, structural features and local geology; one of which is located in the south, three in the central region, and one in the northern part of the coalfield. Within these compartments similar patterns exist for gas content and composition, coal petrology, and other reservoir characteristics, with boundaries defined by structures in some cases. In other cases compartment boundaries extend across structural boundaries. The compartments identified include the area south of the Hunter River Cross Fault, which is characterised on average by the highest gas contents ($\sim 9 \text{ m}^3/\text{t}$), adsorption capacities ($\sim 23 \text{ m}^3/\text{t}$), permeabilities (between about 100.0 and 1.0 mD) and vitrinite reflectances (0.56 to 1.15%) in the coalfield (Pinetown, 2012, p. 293). Of the three compartments located in the central region of the coalfield, with the Hunter-Mooki Thrust Fault and Muswellbrook Anticlines in the east, and the Mount Ogilvie Fault in the west forming the main boundaries, the eastern-most compartment contains predominantly methane, the central compartment is characterised by low gas contents, and the compartment west of the Mount Ogilvie Fault is considered to have intermediate gas contents (Pinetown, 2013, p. 145). In the north the compartment located to the west of the Aberdeen Thrust Fault is characterised by in situ gas contents of up to approximately $14 \text{ m}^3/\text{t}$, and carbon dioxide as the dominant gas component (between $\sim 60\%$ and $\sim 90\%$) from the surface to about 500 m depth (Pinetown, 2013, p. 148).

Following on from this, Pinetown (2014) used basin modelling to improve understandings of the origin and temporal evolution of CSG in the Hunter Coalfield. Burial history models show that coals in the south of the coalfield appear to have the greatest potential for thermogenic gas generation, and that those areas with low gas contents and decreased permeability have been uplifted more, and buried less, compared with areas that have high gas contents. According to Pinetown (2014, p. 422) it appears that present-day gas contents may partially reflect coal ranks and adsorption capacities, with late-stage biogenic gas generation replenishing methane volumes that were lost following uplift during the Late Cretaceous. Patterns of gas distribution in the Hunter Coalfield are

controlled by a variety of factors, including the geological setting and burial history, which control migration of groundwater and therefore biogenic gas production (Pinetown, 2013, p. 147–150). Pinetown (2014, p. 423) suggests that the Hunter Coalfield is a compartmentalised CSG reservoir and that delineating compartments within the coalfield provides improved understanding of the CSG distribution, through which the implications for CSG exploration, coal mine safety and fugitive emissions from open-cut coal mines can be assessed.

Pinetown (2013) also studied gas distribution in the Hunter Coalfield as a natural analogue to assess the potential of carbon dioxide storage in coal. Using a simplistic approach a theoretical total storage capacity of about 9512 Mt of carbon dioxide is estimated for coals between 300 and 800 m depth, with an average coal permeability of 1.5 mD between these depths. According to Pinetown (2013, p. 155) the southern region of the coalfield shows the greatest potential for carbon dioxide storage given its high permeability, proximity to potential carbon dioxide sources, and thick sequence of coal seams, including deeper seams as possible storage targets. The actual available storage capacity, however, could be considerably less owing to factors such as high existing carbon dioxide concentrations in some areas, low permeability in many areas, the presence of national parks, and existing and proposed coal mines.

1.2.1.2.2 Newcastle Coalfield

In comparison with the Hunter Coalfield, information on the Newcastle Coalfield is relatively sparse as the CSG resources of the Newcastle Coalfield have not been widely investigated. According to Creech (1992), regional gas distribution in the Newcastle Coalfield appears to be a relict feature of gas migration during coalification, and in-seam tuff layers, faulting and igneous dykes impede the migration process. Creech (1994) showed that it is highly likely that gas distribution in the coalfield is controlled by the Macquarie Syncline, and that there is no overall increase in the gas content with increasing depth. Burra et al. (2014, p. 448) stated that gas in the eastern part of the basin, such as areas of the Newcastle Coalfield, is generally dominated by biogenic and thermogenic hydrocarbons with elevated wet gas contents at depth.

Areas down-dip of the (Hunter and) Newcastle Coalfield (and in the extreme north of the Western Coalfield) have been identified as being prospective for CSG by Ward and Kelly (2013). Vitrinite reflectance increases to over 1% at depths of around 70 m indicating thermogenic gas generation from the deeper parts of the basin may be possible (Ward and Kelly, 2013, p. 40).

1.2.1.2.3 Western Coalfield

Geological conditions of the western margins of the Sydney Basin are generally not favourable for coal seam gas development as the coals are relatively immature compared to those in other coalfields, and the structural setting and shallow depth of the coals along the western margins has most likely resulted in gas escape. To date, limited studies have been conducted and reported on investigating the western margins of the Sydney Basin. Recent observations by Thomson et al. (2014, p. 401) showed that gas contents down to a depth of about 60 m are generally low as most results show gas contents of less than 0.7 m³/t with gas composition being dominated by carbon dioxide. These observations are supported by the work of Odins and Bocking (1994) who suggested that gas contents can be very low in the western regions of the basin to depths of up to 200 m.

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1.2.1 Available coal and coal seam gas resources

1.2.2 Current activity and tenements

Summary

As at May 2015, there were 25 operating mines and complexes in the Hunter subregion. Of these there are seven complexes: Bulga, Donaldson, Hunter Valley Operations, Mount Arthur, Mount Owen, Ravensworth and Ulan. Six mines are currently either in care and maintenance or recently closed. Of these, one mine, Newstan Colliery is proposing two new projects: the Newstan Extension Project and the Northern Coal Logistics Project that will extract coal for a period of 21 years. No coal seam gas is currently produced in the Hunter subregion.

1.2.2.1 Coal

This section provides information about all coal mines currently operating in the Hunter subregion. The amount and type of information that is provided here is a function of availability, typically depending on the stages of mining that have been reported on and the age of mining, complying with requirements to publish information. Typically, however, the same information has been made available where possible for each mine as a basis for reporting, based on a template used for each mine. Water licensing information has been included where available and mine water management can be found in Product 2.1. The interested reader is referred to these reports for further information. The mines described in Section 1.2.2.1.1 to Section 1.2.2.1.6 are under care and maintenance or recently closed and the mines described from Section 1.2.2.1.7 onwards are 'current'. For a development to be considered current, commercial development for that particular mine needs to have been commenced prior to December 2012.



Figure 6 Mines and infrastructure in the Hunter subregion, as at May 2015

Data: Bioregional Assessment Programme (Dataset 1), Bioregional Assessment Programme (Dataset 2)

1.2.2.1.1 Awaba Colliery

Awaba Colliery is in the Newcastle Coalfields approximately 1 km from Awaba township and 5 km south-west of Toronto (Figure). It covers 2519 ha and is bordered to the north by Newstan Colliery, to the south-east by Myuna Colliery and to the west and south-west by Mandalong Mine,

all of which are owned by Centennial Coal (Centennial Coal, 2012a, p. 7). Awaba Colliery is covered by Consolidated Coal Lease (CCL) 746 which provided the right for mining at Awaba Colliery (Centennial Coal, 2014a, p. 7), reported as being current by NSW Trade and Investment (Resources and Energy) as at November 2014 (at which time, the most recent update available was dated 1 April 2014) (NSW Trade and Investment, 2014, p. 7). No other information regarding the status of this lease is currently available (November 2014).

Mining has taken place at Awaba Colliery continuously since 1947. The mine was originally state-owned, and in 2002 was purchased by Centennial Coal Company Ltd (Centennial Coal; owned by Banpu Public Company Ltd) from the NSW Government. Although Centennial Coal's operations were approved until 31 December 2015, coal resources were exhausted earlier than expected and mining ceased in March 2012 (Centennial Coal, 2012a, p. 5). Subsequently, all mine access points were decommissioned (Centennial Coal, 2012a, p. 6).

Historically, the underground mining operations at Awaba produced over 35 Mt of coal through the combination of bord-and-pillar and continuous miner techniques (Centennial Coal, 2012a, p. 5). Coal was mined from the informally named Great Northern and Fassifern coal seams (Centennial Coal, 2012a, p. 7). During its last full year of operations (2011) the mine extracted 0.9 Mt of coal (Centennial Coal, 2012a). The mine produced thermal coal, which was originally used entirely by the nearby Wangi Wangi Power Station for state-wide electricity generation. However, following its sale to Centennial Coal, some thermal coal was also exported for sale (Centennial Coal, 2012a).

Awaba Colliery operated under NSW Environmental Protection Licence 443 (Centennial Coal, 2014a, p. 9). Following its closure, Centennial Coal continues to undertake annual environmental reporting that focuses on various measures such as rehabilitation, monitoring, complaints, data trends, non-compliance and discrepancies between predicted and actual impacts of the project (Centennial Coal, 2014a, p. 8).

1.2.2.1.2 Cumnock Mine

Cumnock No.1 Colliery Pty Ltd (Cumnock Mine, part of the Ravensworth Complex), formerly known as the Liddell State Coal Mine, has been under care and maintenance since 2011. Cumnock Mine is part of Ravensworth Surface Operations (Xstrata Coal, 2012). This mine operated from the early 1950s and was purchased by Xstrata Coal Pty Limited (now Glencore plc) via its subsidiary Helios Australia Pty Ltd from Cumnock Coal in 2007, who in turn purchased the mine from the NSW Electricity Commission in 1991 (Glencore, 2014a).

The Cumnock Mine is located between Muswellbrook and Singleton in the Upper Hunter Valley. Mining was initially underground using longwall methods. However, from 1993 to 1994, and 2002 to 2003, coal was also extracted using open-cut methods (Glencore, 2014a), producing thermal coal. All coal mining activities ceased at Cumnock in 2011 and current and planned activities are limited to pumping of wet tailings from the Ravensworth Coal Handling and Processing Plant to voids and pits approved for tailings emplacement and ongoing, progressive and extensive rehabilitation works (Xstrata 2012a, p. 4, p. 12).

1.2.2.1.3 Mannering Colliery

Mannering Colliery is an underground coal mine south of Lake Macquarie, approximately 3 km south of Mannering Park and 60 km south of Newcastle (Figure) (EMGA Mitchell McLennan 2014a, p. 16; EMGA Mitchell McLennan, 2014b, p. E.1, p. 3). The Mannering Colliery pit top is approximately 1.1 km south of Chain Valley Colliery's pit top, within Consolidated Coal Lease (CCL) 721 and CCL 719 (EMGA Mitchell McLennan, 2014b, p. E.4). Mannering Colliery, formerly known as Wye State Mine since it first operated in 1960 (EMGA Mitchell McLennan Pty Ltd, 2014b, p. 2), is now owned by Centennial Mannering Pty Ltd, a wholly owned subsidiary of Centennial Coal (EMGA Mitchell McLennan, 2014a, p. E.4, p. 16). Approved operations involved extraction of up to 1.1 Mt/year of run-of-mine (ROM) coal from the Fassifern and Great Northern coal seams until March 2018 (EMGA Mitchell McLennan, 2014b, p. E.5).

Mannering Colliery was placed on care and maintenance in November 2012. In late 2013, Mannering Colliery (MC) and Chain Valley Colliery (CVC) entered into an agreement enabling LakeCoal Pty Ltd (LakeCoal), owners of Chain Valley, to operate Mannering until 2022 (effective 17 October 2013) (EMGA Mitchell McLennan, 2014a, p. 4; EMGA Mitchell McLennan, 2014b, p. 1). As part of this agreement, LakeCoal accepted responsibility for environmental management at Mannering Colliery (EMGA Mitchell McLennan, 2014a, p. 16). LakeCoal is wholly owned by LDO Coal Pty Ltd (LakeCoal Mannering Colliery, n.d.). Mining commenced at Mannering Colliery as a bord-and-pillar, although this was later replaced by longwall mining. Operations focused on the Great Northern coal seam (of the Moon Island Beach Formation) and the Fassifern coal seam (of the Boolaroo Formation) of the Permian Newcastle Coal Measures (EMGA Mitchell McLennan, 2014a, p. E.4-5, p. 16; EMGA Mitchell McLennan, 2014b, p. E.1, p. E.4, p. 27).

Since 2008 Mannering Colliery has had approval to produce up to 1.1 Mt/year of ROM coal until March 2018 (EMGA Mitchell McLennan Pty Ltd, 2014a, p. E.4-5, p. 16). An extension project has been proposed to join the Mannering and Chain Valley collieries. Details of this planned development are outlined in Section 1.2.3.

1.2.2.1.4 Newstan

Currently under care and maintenance, the Newstan underground coal mine is owned by Centennial Coal (100%). The site was originally state-owned and mined for over 125 years before being sold to Centennial Coal in 2002 as part of the Powercoal acquisition (Centennial Coal, 2012b) at which time Centennial Coal was the buyer of the entire package of NSW Government's Powercoal coal mines (SMH, 2002). The mine is in the Newcastle Coalfields, near the town of Toronto. Full production capacity was 4.0 Mt/year, and the mine produced both thermal and semi-soft coking coal, mainly from the Great Northern coal seam (Centennial Coal, 2012b). Operations were performed underground using longwall and continuous miner processes. On-site facilities include a coal handling and preparation plant (CHPP), reject-emplacement infrastructure, dedicated haul roads and a rail facility to the Vales Point Power Station (Figure) and the ports of Newcastle and Kembla.

Coal produced was originally transported to the local Wangi Wangi Power Station for state-wide electricity generation. From 2002, coal was also exported. Difficult geological conditions at the

mine led to Newstan being placed on care and maintenance in 2008. Thereafter, an extensive exploration drilling programme was undertaken over several years (Centennial Coal, 2012b).

Due to prevailing economic conditions affecting the coal industry in general, and with the aim of reducing costs across the Centennial Group, Newstan was again placed on care and maintenance in August 2014, with operations currently under review (Centennial Coal, 2014b). However, in anticipation of improved market conditions in the future, and as the mine is close to local power stations and the Port of Newcastle, approval application for an extension project will continue to be progressed (Centennial Coal, 2014b). There are estimated remaining coal reserves at the site of 68.3 Mt, equivalent to 20.2 years of further operations at proposed production rates. Water management improvements have been developed including the Southern Reject Emplacement Area, Clean Water Diversion Drain and the Final Pollution Control Dam expansion (Centennial Coal, 2012b).

Although currently under care and maintenance, Newstan is proposing two projects: the Newstan Extension Project and the Northern Coal Logistics Project (Centennial Coal, 2012b). The Newstan Extension Project seeks to extend underground operations to extract up to 4.5 Mt/year ROM coal (currently authorised for up to 4.0 Mt/year) for a period of 21 years (DGR, 2012). At the time of writing (May 2015) the status is that the Director General's Requirements for the environmental assessment were issued in March 2012 (DGR, 2012). The environmental impact statement (EIS) for the Northern Coal Logistics Project was submitted in 2014 (NSW Department of Planning and Environment, 2014a) and a response to submissions was published on 4 February 2015 (Centennial Coal, 2015).

1.2.2.1.5 Ravensworth Underground Mine

Ravensworth Underground Mine, formerly Newpac Colliery (Glencore, 2014b, p. 11), is part of the Ravensworth Mining Complex. The mine has been managed by Xstrata Coal NSW (now Glencore plc) since February 2008 and is a joint venture operation between Resource Pacific Pty Ltd (owned by Glencore and Marubeni) and POSCO (Glencore, 2014b, p. 3). Ravensworth Underground Mine currently has approval until 2023 (Glencore, 2014b, p. 33). Coal resources as at December 2013 were reported to be 320 Mt (measured), 220 Mt (indicated) and 250 Mt (inferred) (GlencoreXstrata, 2014, p. 49). Glencore announced in mid-2014 that Ravensworth Underground Mine operations would be suspended in late 2014, due to increasingly difficult economic conditions. Despite a temporary reprieve towards the end of 2014, the underground operation was placed into care and maintenance due to economic constraints in October 2014 (Xstrata Coal, 2015). Environmental management and rehabilitation will be performed while the established Ravensworth Complex Environment Management System will continue to be implemented (Glencore, 2014c, p. 2).

1.2.2.1.6 Westside Coal Mine

The Westside Coal Mine is approximately 20 km south-west of Newcastle. Westside Coal Mine is owned by Glencore plc (Glencore) and was managed by Oceanic Coal Australia Limited (OCAL) on behalf of the Macquarie Coal Joint Venture (MCJV). Mining operations were undertaken by Thiess Australian Mining. The mine began operations in 1992 (GHD, 2010, p. 1), and mining ceased in February 2012 (Glencore, 2013a). OCAL was granted development consent in 2003 by the NSW

Minister for Planning to construct the Westside Mine Southern Extension, a 21 year development allowing open-cut operations to continue for a further 7 to 12 years (GHD, 2010, p. 1). Less than 1 Mt/year of ROM thermal coal was produced at the mine (Glencore, 2013a) where the open-cut operation was run using truck and shovel with dozer push processes (Glencore, 2013a). Final void filling was undertaken progressively, and rehabilitation works were completed by April 2012 (Glencore, 2013a).

Rehabilitation methods included developing the bulk landscape shape, spreading topsoil, contouring drains, adding gypsum, and preparing and fertilising vegetation. The haul road width was reduced to minimise dirty storm water runoff, bunds were removed and drains were constructed and revegetated with couch grass (Glencore, 2013a). Activities including ongoing land and water management, and flora, fauna and soil surveys are used to monitor rehabilitation efforts and are reported monthly by Glencore (Glencore, 2014d; and for example Xstrata Coal, 2014).

1.2.2.1.7 Ashton Coal Mine

Ashton Coal Mine is owned and operated by Yancoal Australia Ltd (Ashton Coal, 2015a). Open-cut operations started in 2004, and underground extraction using longwall operations commenced in 2006 (Ashton Coal, 2015b). The mine is approximately 14 km north-west of Singleton in the Upper Hunter Valley, and is adjacent to several other open-cut mines: Glendell (Glencore), Integra (Vale Australia), Lemington (part of Hunter Valley Operations, Rio Tinto Coal Australia), Ravensworth (Glencore), and Narama (Glencore) (Ashton Coal, 2015a).

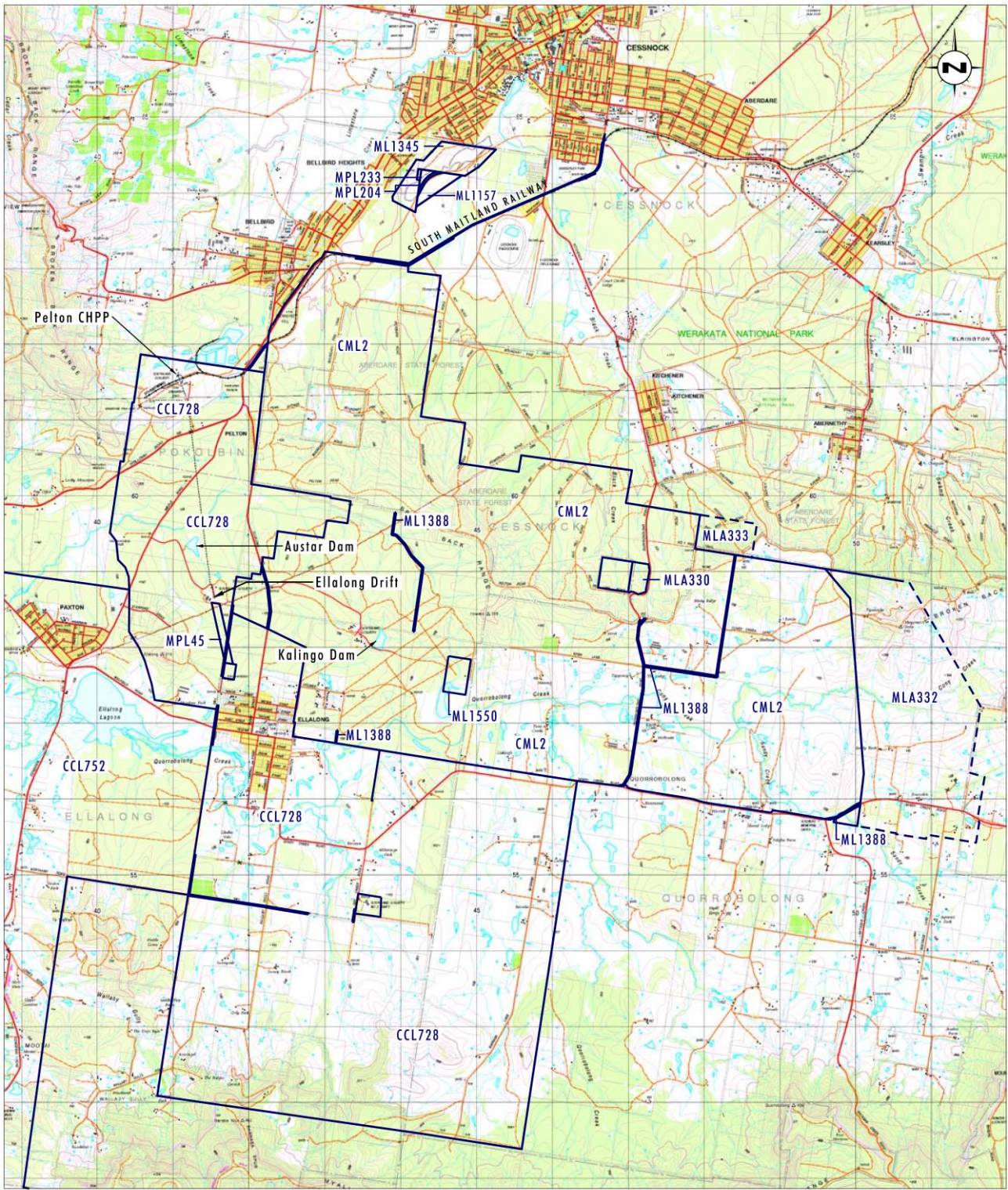
At present, the Barrett pit and the Arties pit are mined at Ashton (Ashton Coal, 2015c). Extraction from the North East Open Cut ceased in 2010. Yancoal applied to move open-cut operations to the South East Open Cut site and the Ashton Mine South East Open Cut Project was approved in October 2012 (NSW Department of Planning and Environment, 2015a). The project operations in the South East Open Cut are planned to continue until 2017 (Ashton Coal, 2015c), while underground mining is planned to continue until 2023 (Ashton Coal, 2015c). From the open-cut operations coal is produced from the Pikes Gully, Arties, Liddell and Barrett coal measures (Ashton Coal, 2015c), whereas underground operations target the Pikes Gully, Upper Liddell, Upper Lower Liddell and the Lower Barrett coal seams (Ashton Coal, 2015c).

The current open-cut and underground production capacity is approximately 3.9 Mt/year (Ashton Coal, 2015a) and approximately 3.2 Mt/year of ROM coal is extracted through underground operations (Ashton Coal, 2015d). Current resources and reserves for Ashton of 437 Mt and 60.8 Mt, respectively, are reported in the OZMIN database (Geoscience Australia, 2015). Open-cut mining takes place using backhoe-style excavators and earthmoving trucks (Ashton Coal, 2015c) and multi-seam extraction underground uses longwall mining (Ashton Coal, 2015d). The on-site coal handling and preparation plant (CHPP) (Ashton Coal, 2015e) produces semi-soft coking coal and some thermal coal products (Ashton Coal, 2015a), mainly for the Asian steel-making industry.

Ashton Coal Mine has a nil discharge environment protection licence and as a result there are no site discharges of contaminated or saline water. All such water is captured using the site water management system and is used for dust suppression and coal processing (Ashton Coal, 2015f).

1.2.2.1.8 Austar Coal Mine

Austar Coal Mine is an amalgamation of several older mines (Bellbird, Pelton-Ellalong, Southland) and operates within a number of mining leases (as shown in Figure 7) under 12 separate development consents issued by Cessnock City Council between 1974 and 2002 (Austar, 2015a, p. 1). Austar recommenced underground mining in the former Bellbird South Colliery in 2005 (Austar, 2015a, Table 2.1). Austar Coal Mine is now owned by Yancoal Australia Ltd who purchased the mine in December 2004 (Austar, 2015b), although the mine operated for over 100 years as the Pelton Colliery (Austar, 2015a; Yancoal, 2015a). Operations under Yancoal commenced in April 2005 (Austar Coal, 2015c), with a planned life of mine of 21 years (Umwelt, 2008). The mine is located 8 km south-west of Cessnock (Figure) in the Newcastle Coalfields (Yancoal, 2015b), and current operations involve deep underground longwall mining (Yancoal, 2015b).



Source: Topo Maps: LPI NSW, Mine Leases: Austar Coal Mine

Legend
 [Solid Line] Mining Leases
 [Dashed Line] Pending Mining Lease Application Areas

Figure 7 Existing Austar Mining Leases for the Hunter subregion

Source: Figure 2.2 from Umwelt (2011a), © Yancoal Australia

The mine has approved production of 3.6 Mt/year of ROM coal (Austar, 2015a), with total reserves of 50.9 Mt (Yancoal, 2015a) and total resources of 167 Mt (OZMIN database, 2015) (50.2 Mt of ROM coal (Umwelt, 2008)). Coal is extracted from the 7 m thick Greta Coal Measures

(Umwelt, 2008) using modern longwall mining methods (Austar, 2015a). Coal from Austar Coal Mine is brought to the surface at the Ellalong Drift and Pit Top via an underground conveyor through the Ellalong East and South Headings. Coal is then conveyed to the Pelton CHPP via an overland conveyor system, where it is then processed and handled. Semi-hard coking coal and thermal coal products for international markets (Yancoal, 2015a) are then railed to the Port of Newcastle via the Austar Rail Line, the South Maitland Railway and the Main Northern Rail Line (Austar, 2015a, p. 6). Water management systems as part of the mining operation include drains, diversion banks, sedimentation, treatment and clean water dams, a lime treatment plant and a water treatment plant (Austar, 2015a).

1.2.2.1.9 Bengalla Coal Mine

Bengalla Coal Mine is owned by Coal and Allied Industries Ltd (Coal and Allied), in turn 80% owned by the Rio Tinto Group (Rio Tinto, 2015a). Bengalla is 4 km south-west of Muswellbrook in the Upper Hunter Valley, and supplies international markets with approximately 7 Mt/year of thermal coal. Development consent was granted by NSW Government for Bengalla in 1996 and the site commenced production in 1999, initially for up to 21 years. On 3 March 2015, consent was granted for the Bengalla Continuation Project, allowing up to 15 Mt/year ROM coal to be extracted at the site until 28 February 2039 (NSW Department of Planning and Environment, 2015b, p. 5).

Bengalla is an open-cut mine, using dragline, truck and shovel methods for extracting coal from around 270 m depth (Hansen Bailey, 2013, p. 68). On-site infrastructure includes a CHPP and associated facilities, administration and bathhouse, rail loop and loading facilities (Hansen Bailey, 2013, p. 1). In November 2010, Coal and Allied, in consultation with their joint venture partners, reached agreement on a A\$141 million expansion of Bengalla. Under the development consent of the Bengalla Continuation Project a new ROM hopper and associated product coal stockpile will be built, and modifications will be made to the CHPP to facilitate two-stage washing (NSW Department of Planning and Environment, 2015b). The addition of two permanent tailings drying areas and a laydown area with associated facilities, along with the purchase of additional mining equipment, was also included in the upgrade. Current resources and reserves for Bengalla of 417 Mt and 171 Mt, respectively, are reported in the OZMIN database.

Licences related to Bengalla operations include (Hansen Bailey, 2013, p. 25):

- Mining Lease (ML) 1397 (27 June 1996 to 27 June 2017)
- ML 1450 (from 11 June 1999 to 11 June 2020)
- ML 1469 (from 5 June 2000 to 5 June 2021)
- ML 1592 (from 19 April 2007 to 19 April 2028)
- Groundwater extraction license 20 BL169798 (Expiry date: 31 October 2015)
- Hunter River Water Access license 1,449 High Security units and an additional 4,562 units of General Security units
- Environmental Protection Licence EPL 6538.

Excess water accumulated on site is discharged into the Hunter River in accordance with the Hunter River Salinity Trading Scheme. Under pre-mining conditions groundwater flowed from the

Permian rock units to the overlying alluvium. The extension of Bengalla's operations is estimated to result in a maximum flow reduction to the alluvium of approximately 0.63 ML/day at the beginning of the extension operations. Groundwater modelling shows that as mining moves away from the alluvium, the reduction in flow decreases to approximately 0.25 ML/day in later years (Hansen Bailey, 2013, p. 182).

The aim of Bengalla's rehabilitation plan is to re-establish agricultural land with at least 10% open woodland corridors across all disturbed areas, with the exception of the eastern face of the overburden emplacement area. The eastern face of the overburden emplacement area will be rehabilitated to contain a higher density woodland community to assist with further mitigating adverse visual impacts (Hansen Bailey, 2013, p. XV).

An ecological impact assessment was undertaken by Cumberland Ecology to determine the impacts of Bengalla's extension on biodiversity values, including threatened species, populations and ecological communities. The mine disturbance area is projected to affect approximately 881 ha of native vegetation, including forest and woodland communities. An additional 69 ha of non-native vegetation will be removed, including tree and shrub plantations. The project will remove approximately 554 ha of threatened ecological communities including 535 ha of critically endangered Box Gum Woodland. This area to be impacted represents 9% of the species community in the Hunter Valley, and 0.2% of this community in NSW (Hansen Bailey, 2013, p. XIV–XV).

1.2.2.1.10 Bloomfield Coal Mine

Bloomfield Coal Mine is owned by Bloomfield Collieries Pty Ltd, part of The Bloomfield Group. Coal has been mined at this location for over 100 years and the current open-cut operations are approved until 31 December 2021 (Bloomfield Group, 2013, p. 5). The mine is at Buttai, 4 km south-west of Cessnock, and approximately 20 km north-west of Newcastle (Bloomfield Group, 2008, p. E.1). Current operations are approved to mine 0.88 Mt/year ROM coal, with future stages (stage 2, year 1–5, stage 3, years 5–7 and stage 4, years 7–10) proposing to gradually increase production to a maximum of 1.3 Mt/year ROM coal. The project is currently at Stage 2. The final project stage (stage 5) will involve site rehabilitation (approximately years 10 to 12 of the project) (Bloomfield Group, 2008, p. E.2; NSW Government, 2009, p. 19).

Coal is extracted at Bloomfield from the Tomago Coal Measures (NSW Department of Planning, 2013, p. 4). Open-cut mining first occurred in 1964, and underground mining also occurred until 1992 (Bloomfield Group, 2013, p. 5). Multi-seam truck and excavator or face shovel operations are undertaken in sequential mining blocks (Bloomfield Group, 2008, p. E.2).

Current assessments of economically recoverable reserves indicate approximately 14 Mt ROM coal remaining in the project area (Bloomfield Group, 2008, p. E.2). Coal is processed at the on-site CHPP. Product coal is mainly of thermal quality although some semi-soft coking coal is also produced and mostly exported to Asian markets (Bloomfield Group, 2013, p. 5).

Bloomfield Mine site facilities are shared by Bloomfield Mine and Yancoal's nearby Donaldson Mine and Abel Mine (Yancoal, 2013). The project area covers approximately 317 ha of which 299 ha are presently disturbed by mining-related activities (Bloomfield Group, 2008, p. E.1). Pit

water inflow and runoff is transferred to Lake Kennerson for use at the CHPP (NSW Department of Planning, 2013, p. 4). Progressive rehabilitation is undertaken at open-cut pits, with the aim to rehabilitate the site in accordance with pre-mining land capability to support future industrial land use (if required). Final rehabilitation is expected to take two years (NSW Department of Planning, 2013, p. 4).

1.2.2.1.11 Bulga Coal Complex

The Bulga Coal Complex (Bulga Coal), approximately 12 km south-west of Singleton in the Hunter Valley, is owned by Bulga Coal Management Pty Ltd, a subsidiary of Glencore (SLR Consulting Australia, 2014, p. 1). Bulga Coal consists of two coal mining operations: Bulga Open Cut and Bulga Underground. The mining activities and associated operations, which were first approved in 2001, occur on various mining leases (ML), coal leases (CL), exploration licences (EL) and mining authorities (AUTH) (Table 4).

Table 4 Mining leases at Bulga Coal Complex for the Hunter subregion

Lease type ^a	Number
ML	1494
ML	1547
ML	1674
MLA	467
CL	219
CL	224
EL	5277
EL	5461
AUTH	447
AUTH	450

Data: SLR Consulting Australia Pty Ltd (2014)

^aTypes: ML = Mining Lease; MLA = Mining Lease Application; CL = Coal Lease; EL = Exploration Licence; AUTH = Authorisation

Coal production at Bulga Coal (in total combination from open-cut ROM plus underground ROM) is approved for 20 Mt/year (NSW Department of Planning and Environment, 2014b, p. 7), although annual production rates are typically about 16 Mt (Bulga Coal, n.d.). A proposed expansion plan aims to access 205 Mt of coal from the complex (NSW Department of Planning and Environment, 2014b, p. 2). Coal resources of the Bulga Coal Complex were reported in 2013 as 1150 Mt (measured), 610 Mt (indicated) and 800 Mt (inferred) (GlencoreXstrata, 2013, p. 49). The Bulga Open Cut Mine area includes the CHPP for Bulga Coal. The Bulga Underground Operations area incorporates the Blakefield South Mine and the approved (though yet to commence) Blakefield North Underground Mine. The CHPP and rail loading facility are in the north-east of the Bulga Coal Complex and service both open-cut and underground operations (SLR Consulting Australia, 2014, p. 1). Coal produced at the complex is semi-soft coking coal and thermal coal, which is railed to the Port of Newcastle for export to China and Japan, predominantly for steel making and energy generation (Bulga Coal, n.d.).

Bulga Coal operates under a single, annually renewed Environmental Protection Licence (EPL) 563, which specifies requirements for local air quality, blasting and surface water monitoring. The EPL enables water discharge off site in accordance with Hunter River Salinity Trading Scheme. The Bulga Coal Complex currently has 13 groundwater licences (including seven monitoring bores, five dewatering mining licences and one mining, underground workings) and nine surface water licences totalling up to 1323 ML (SLR Consulting Australia, 2014, p. 3).

Bulga Open Cut Mine

Bulga Open Cut Mine operates a dragline, truck and shovel operation, using excavators and front-end loaders to target the Redbank Creek, Blakefield, Glen Munro and Woodlands Hill coal members of the Wittingham Coal Measures (Bulga Coal, n.d.). It is approved to operate until 2025, extracting up to 12.2 Mt/year of ROM coal (NSW Department of Planning and Environment, 2014a, p. 1) within the 20 Mt/year ROM allowed across the complex (NSW Department of Planning and Environment, 2014b, p. 7). Coal reserves have been reported as 190 Mt (proved) and 17 Mt (probable) (GlencoreXstrata, 2013, p. 50). The Bulga Optimisation Project received NSW PAC development consent on 1 December 2014 to produce 12.2 Mt/yr ROM coal until 31 December 2035 (NSW Department of Planning and Environment, 2014d). An extensive water management and water re-use system is in place at Bulga Open Cut. The 2014 approval includes an additional environmental dam and new discharge point in addition to an extensive range of biodiversity offsets (NSW Department of Planning and Environment, 2015e, p.14).

Bulga Underground Mine

Bulga Underground Mine is a longwall mining operation that targets the Whybrow, Blakefield, Glen Munro and Woodlands Hill coal members (Bulga Coal, n.d.). Individual seams are 4.5 to 8 m thick within the Blakefield South Mine; extraction thickness ranges from approximately 1.2 to 3.7 m. Longwall panels are up to 3.5 km long and 400 m wide (Bulga Coal, n.d.). Coal reserves have been reported as 130 Mt (proved) and 28 Mt (probable) (GlencoreXstrata, 2013, p. 50). Bulga Underground Operations began longwall mining in 2010 at Blakefield South Mine, which is currently mining in longwall panel 5 and where extraction of longwall panel 7 is scheduled to commence in November 2015 (Glencore, 2015b, page 3). Preparation is underway to mine the Blakefield Coal Member to the north of current operations (known as the Blakefield North Longwall Modification, under Bulga Coal Continued Underground Operations consent). Development at Blakefield North is scheduled to commence in 2016, with mining to start in 2018 (Bulga Coal, n.d.).

Bulga Underground Mine is approved to operate until 2031 and can extract up to 14 Mt/year of ROM coal (NSW Department of Planning and Environment, 2014b, p. 7) although extraction of coal across the whole complex must not exceed 20 Mt/year (NSW Department of Planning and Environment, 2014b, p. 7). An application to modify Bulga Underground (DA 376-8-2003) was submitted in 2012 (SLR Consulting Australia, 2014, p. 1–2), the Blakefield North Longwall Modification, and was subsequently approved by the NSW Department of Planning and Infrastructure in October 2013 (SLR Consulting Australia, 2014, p. 1). The modified plans include realignment of the previous longwall layout, increase of gas drainage infrastructure, relocation of mine ventilation fans and addition of a small-scale power plant (up to 32 MW) (SLR Consulting Australia, 2014, p. 1–2).

1.2.2.1.12 Chain Valley Colliery

Chain Valley Colliery (CVC), which commenced mining in 1962 (LakeCoal Chain Valley Colliery, n.d.), is operated by LakeCoal, which is wholly owned by LDO Coal Pty Ltd on behalf of the Wallarah Coal Joint Venture (EMGA Mitchell McLennan, 2014b, p. E.4). CVC is approximately 60 km south of Newcastle, and is adjacent to the Vales Point Power Station at the southern end of Lake Macquarie (EMGA Mitchell McLennan, 2014a, p. E.1). The CVC mining tenements cover approximately 2200 ha (EMGA Mitchell McLennan Pty Ltd, 2014a, p. E.3). Current operations are approved until 31 December 2027 and include extraction of up to 1.5 Mt/year ROM coal from the Fassifern coal seam (EMGA Mitchell McLennan, 2014a, p. 13). Estimated reserves at CVC are approximately 19.5 Mt of ROM coal (EMGA Mitchell McLennan, 2014a, p. 13).

CVC has one underground mine with two current workings at ML 1052. These use continuous miner and mini-wall extraction methods, which is similar to longwall mining but with a narrower face-width (EMGA Mitchell McLennan, 2014a, p. E.1, p. E.3).

CVC produces thermal coal, with up to 660,000 tonnes per year delivered by public road to Port Waratah Coal Services for export. The remainder is sold domestically, with the main customer Delta Electricity Vales Point Power Station (VPPS). Coal is transported by private roads to the VPPS (EMGA Mitchell McLennan, 2014a, p. E.5, p. 3, p. 4, p. 5), and on public roads to the other domestic customers (EMGA Mitchell McLennan, 2014a, p. E.3). Onsite, the colliery hosts a coal preparation plant for sizing and crushing (EMGA Mitchell McLennan, 2014a, p. E.3).

CVC is licensed under NSW's *Water Act 1912* for extraction of 4,443 ML/year for mine dewatering and on-site industrial use (EMGA Mitchell McLennan, 2014a, p. E.7). Mine water inflows are currently pumped to the CVC pit top area and then onto a licensed discharge point on Swindles Creek (a tributary of Lake Macquarie) (EMGA Mitchell McLennan, 2014a, p. E.8). Water demand is 120 ML/year and is supplied from Wyong Shire Council's potable water mains (EMGA Mitchell McLennan Pty Ltd, 2014a, p. 13). Median annual groundwater inflow to the Fassifern underground operation at CVC is currently 2773 ML (EMGA Mitchell McLennan, 2014a, p. 30).

No coal rejects are generated at CVC (EMGA Mitchell McLennan, 2014a, p. 13). Mining parameters have been designed to protect Lake Macquarie foreshore and local seagrass communities, consistent with the mining lease conditions and the existing subsidence management plan (EMGA Mitchell McLennan Pty Ltd, 2014a, p. 15).

Decommissioning of surface facilities and final rehabilitation plans following mine closure are detailed by EMGA Mitchell McLennan (2014a, p. 13). Rehabilitation will be carried out progressively (EMGA Mitchell McLennan, 2014a, p. 15). The plans include restoration of ecosystem function including maintenance of self-sustaining ecosystems comprising native plant species and landforms consistent with the surrounding environment (EMGA Mitchell McLennan, 2014a, p. 14).

Additional to the approved operations at CVC, existing plans to link the CVC with the neighbouring underground mine at the Mannering Colliery are outlined below.

Manning Colliery Modification 2

Manning Colliery Modification 2 was approved on 27 November 2014, to construct an underground linkage between the Chain Valley Colliery and the Manning Colliery, targeting the Fassifern coal seam (NSW Department of Planning and Environment, 2014a, 2014b). The project plans to install and use an underground conveyor belt system and ancillary services, enabling ROM coal to be transferred on conveyors between Chain Valley and Manning. The existing Manning Colliery infrastructure would be used to transport coal from the Chain Valley underground workings at a rate of not greater than 1.1 Mt/year. All coal will be sold domestically to Vales Point Power Station (EMGA, 2014b, p. E.4–E.5). Approval was granted with conditions specifically regarding landscape and rehabilitation and the mining closure plan (NSW Department of Planning and Environment, 2014e, 2014f).

The total resource at Manning Colliery is estimated at approximately 14.8 Mt of ROM coal (EMGA Mitchell McLennan, 2014b, p. 13). Existing facilities include coal crushing facility, overland conveyor between the Manning Colliery's pit top area and the Vales Point Power Station, worker's amenities, workshops, offices, carparks, ventilation fans (EMGA Mitchell McLennan Pty Ltd, 2014b, p. 13).

Daily water discharge at Manning Colliery is licensed up to 4 ML. Potable water for use in surface facilities and underground operations may be supplied under licence by Wyong Shire Council via a direct, metered pipeline (EMGA Mitchell McLennan Pty Ltd, 2014b, p. 13). Extraction of groundwater from mine workings will be undertaken in accordance with Bore Licence 20BL172016 issued under NSW's *Water Act 1912* (EMGA Mitchell McLennan Pty Ltd, 2014b, p. 8).

1.2.2.1.13 Donaldson Coal Complex

The Donaldson Coal Complex consists of three mines – one open-cut mine (Donaldson) and two underground mines (Abel and Tasman). In 2013, the mines transitioned to lower production volumes. In April 2013, Donaldson Open Cut ceased after exhaustion of reserves and in July 2013, Tasman underground also finished mining. At the time of writing (May 2015), only Abel underground is in production. The mining complex is about 20 km west of Newcastle. The complex is owned by the Yancoal Australia Group, which was formed following the merger of Gloucester Coal and Yancoal in mid-2012 (Yancoal, 2015a, p. 1). There are four mining leases for the three mine areas: ML 1461 (Donaldson Open Cut), ML 1555 (Tasman underground), ML 1618 (Abel underground) and ML 1653 (Abel underground) (Yancoal, 2015a, p. 1). In addition, there are four exploration licences (EL) held by Donaldson Coal in the area, namely EL 5337, EL 5497, EL 5498 and EL 6954.

Abel Coal Mine

Abel Coal Mine is owned by Donaldson Coal Ltd (Donaldson Coal) which is a part of the Yancoal Australia Group. The mine project was approved in 2007 and the mine started operations in 2008 (Abel, 2011), with a planned mine life of 20 years (Abel, 2007, p. 5). The Abel Coal Mine is approximately 25 km from the Port of Newcastle, with the access portal coming off the high wall of the Donaldson Open Cut Mine. In 2007 the mine had a proposed production up to 4.5 Mt/year of ROM coal (Abel, 2007, p. 3) which is produced via underground extraction using bord-and-pillar

mining methods with continuous miners (Donaldson Coal, 2015a). Coal is extracted from the Upper Donaldson and Lower Donaldson coal seams (Abel, 2007, p. 5).

The mine uses existing surface infrastructure and the Bloomfield CHPP, rail loader and rail loop for coal processing and loading (Donaldson Coal, 2015a). Coal is transported via conveyor through the high wall to the surface infrastructure area of the Donaldson Open Cut Mine, then onto the Bloomfield CHPP, where it is processed and loaded for transport by rail to the Port of Newcastle (Donaldson Coal, 2015a). Current resources and reserves for Abel of 630 Mt and 115 Mt, respectively, are reported in the OZMIN database.

Donaldson Open Cut Mine

The Donaldson Open Cut Mine, near Beresfield in the Lower Hunter Valley, is approximately 25 km from the Port of Newcastle. It occurs on Mining Lease (ML) 1461 within the Maitland and Cessnock Councils (Donaldson Coal, 2015b). Donaldson Coal was granted project approval for the Donaldson Open Cut Mine under Section 75J of NSW's *Environmental Planning and Assessment Act 1979* on 25 January 2001 (Donaldson Coal, 2012, p. 1). Open-cut operations commenced in 2001 (Yancoal, 2015c, p. 1) and ceased in 2013 (Yancoal, 2015c; Yancoal, 2014, p. 5). Donaldson Coal proposed the development of the Abel underground mine south from the high wall of Donaldson Open Cut Coal Mine in 2005 (Abel, 2005, p. 2).

Coal was extracted by conventional truck and shovel haul back methods in the former open-cut operation (Donaldson Coal, 2015b), producing 2.5 Mt/year of ROM coal (Abel, 2005, p. 18). Coal produced from the Donaldson Mine was trucked to the Bloomfield CHPP, blended and washed to produce coking and thermal coal products, and then transported by rail to the Newcastle Coal Infrastructure Group (NCIG) port facility in Newcastle for the export market.

At the Donaldson complex, soil, other overburden and coal are removed, and the mine area is progressively backfilled and rehabilitated (Donaldson Coal, 2015b). Rehabilitation at the complex commenced in 2003 (Yancoal, 2014, p. 5).

Tasman Coal Mine

Tasman Coal Mine is an underground mine owned by Donaldson Coal (Tyler and Sutherland, 2011). The mine is located south of Maitland, approximately 20 km from the Port of Newcastle (Donaldson Coal, 2015c).

Mining at Tasman Coal Mine started in late 2006 (Tyler and Sutherland, 2011). The mine had consent to operate until 2025 (Abel, 2007, p. 7) under ML 1555 (Kuskie, 2008, p. 2), with a production limit of 0.975 Mt/year of ROM coal. Operations targeted the Fassifern coal seam, which has a thickness of 2.2 to 2.5 m in the mine area (Tyler and Sutherland, 2011). Extraction occurred via bord-and-pillar mining methods using continuous miners for first workings and secondary extraction using breaker line supports (Donaldson Coal, 2015; Tyler and Sutherland, 2011).

Coal from Tasman Coal Mine was washed at Bloomfield's CHPP under a commercial arrangement between Donaldson and Bloomfield Collieries (Abel, 2007, p. 7), to produce semi-soft coking and thermal coal for the export market (Yancoal, 2015c). The Tasman Mine ceased production in July

2013. Current resources and reserves for Tasman of 254.7 Mt and 34.6 Mt, respectively, are reported in the OZMIN database (as of December 2012).

1.2.2.1.14 Drayton Mine

Drayton Mine is an open-cut operation which is 88% owned by Anglo American Metallurgical Coal Pty Ltd (AAMC) as a joint venture with partners NCE Anglo American, Mitsui Coal Anglo American, Deasung Anglo American and Hyundai Anglo American. The mine is operated and managed by Anglo American (AAMC, n.d.). The mining operation started in 1983 (AAMC, n.d.), with coal reserves expected to be depleted by 2015 (AAMC, n.d.).

Drayton Mine is between the towns of Muswellbrook (13 km to the north) and Singleton (34 km to the south) in the Upper Hunter Valley. Drayton is 100 km from the major port city of Newcastle and 200 km from Sydney. The mine produces more than 5 Mt/year ROM coal (AAMC, 2013.). As at December 2012, ROM reserve of 12 Mt were estimated within the current mine layout (AAMC, 2013). Open-cut operations involve a dragline and excavators, and there is a significant fleet of trucks and approximately 500 employees (AAMC, n.d.). The mine has produced more than 5 Mt/year of thermal coal following the upgrade of its Coal Treatment Unit (CTU) in 2011. Drayton is now able to cater for an export market which includes Japanese power generators (AAMC, 2013, p. 1) but also provides coal for the domestic thermal market.

In 2013, AAMC sought approval for the Drayton South Coal Project to extend the life of the Drayton Mine. On 17 October 2014, the NSW Planning Assessment Commission (PAC) passed determination of the proposal, refusing the project for several reasons including that the project was not in the public interest and that the economic benefits of the project did not outweigh the potential impacts on the local equine, viticulture and tourism industries (NSW PAC, 2014a, p. 2). AAMC are, however, continuing to seek approval for a new extension to the Drayton Mine, (Drayton Mine Extension) (Hansen Bailey, 2014) (Section 1.2.3). On 23 January 2015, a Gateway Application for the Drayton South Coal Project was submitted to the Mining and Petroleum Gateway Panel who are currently assessing the application (NSW Mining and Petroleum Gateway Panel, 2015).

1.2.2.1.15 Hunter Valley Operations

Hunter Valley Operations (HVO), 24 km north-west of Singleton, is a multi-pit open-cut mining complex which uses dragline truck and shovel methods to extract thermal and semi-soft coking coal for sale to international markets (Rio Tinto, 2015b). The different pits and parts of the mine include (Coal and Allied, 2014a, p. 15; Rio Tinto, 2014a, p. 3; Rio Tinto, 2013):

- West Pit (previously Howick Pit)
- North Pit (previously Hunter Valley Number 1)
- Carrington
- South Pit (previously Lemington Pit and South Pit or Hunter Valley Number 2) incorporating Cheshunt and the former Lemington South Pit and the Riverview Pit
- Mitchell (inactive)
- Lemington South Pit (inactive)

- Auckland (prospect)
- Southern (prospect).

The mine area trends 20 km north-west to south-east and is 10 km wide, extending to a depth of 515 m below the topographic surface.

Coal production at HVO commenced in 1968 at the current West Pit, which was then part of Howick Coal Mine. The Hunter Valley No. 1 Mine began production in 1979. In 2000 Coal and Allied merged the Howick and Hunter Valley mines to create Hunter Valley Operations. The Lemington Mine, which began production in 1971, was acquired and merged into HVO in 2001. In March 2009 Coal and Allied received approval from the NSW Government to replace the multiple approvals under which HVO South operated with a single Project Approval valid for 21 years. The approval included extraction of a further 84 Mt of coal and upgrades to a range of infrastructure at the mine. In 2013 HVO produced more than 11 Mt of thermal coal and 2.6 Mt of semi-soft coking coal. HVO had marketable reserves of 277 Mt as of 31 December 2013.

The on-site facilities at HVO include an oil-water separator plant and drainage to the dirt water dam, three CHPPs with different storage facilities for processed (saleable) and unprocessed (ROM) coal, water storage and tailings facilities, sewage treatment and disposal facilities, a fuel storage system, and conveyor system (Coal and Allied, 2014a, p. 38, p. 96, p. 104).

HVO manages water according to three main objectives: fresh water usage is minimised, impacts on the environment and HVO neighbours are minimised, and interference to mining production is minimised. This is achieved by minimising freshwater use from the Hunter River, preferentially using mine water for coal preparation and dust suppression by (Rio Tinto, 2014b, p. 17):

- an emphasis on control of water quality and quantity at the source
- segregating waters of different quality where practical
- recycling on-site water
- ongoing maintenance and review of the system
- disposing of water to the environment in accordance with statutes and regulations.

Coal and Allied operates a ground disturbance permit process, which is activated prior to any vegetation removal, topsoil stripping or clearing on the mine site. The ground disturbance permit (GDP) follows a systematic process, which ensures that a range of environmental conditions and licences are checked for the specific area to be cleared, and for the identification of any potential environmental issues such as drainage issues, threatened species, and the identification of any seed or timber resources that may be salvaged (Coal and Allied, 2014a, p. 166). A total of 199.5 ha of mined land was rehabilitated in 2013. Rehabilitation quality improvements were achieved through the use of mixed waste compost to improve soil fertility, direct drilling of seed, and setting up seed harvesting areas to facilitate use of locally sourced seed (Coal and Allied, 2014, p. 4).

Howick/West Pit

In 2000 the Howick Coal Mine became part of Rio Tinto's Hunter Valley Operations as a result of the merger with Hunter Valley Mines. The Howick Coal Mine is 24 km north-west of Singleton in

the Upper Hunter Valley. It is owned by Coal and Allied, a fully owned subsidiary of Rio Tinto Coal Australia. Coal production began at HVO in 1968 at the West Pit which, at the time, was part of the Howick Coal Mine (Rio Tinto, 2015b).

In 2003 an EIS was prepared to allow for the expansion of the HVO West Pit to the east of the then current mine operation, and the consolidation of 18 development consents for HVO North (West Pit Extension and Minor Modification Environmental Impact Statement, 2003). Development Consent (DA-450-10-2003) was granted by the NSW Department of Infrastructure, Planning and Natural Resources (DIPNR) on 12 June 2004. The consent has twice been modified (AECOM, 2011a, p. 9): on 16 August 2005 to enable minor changes to the Hunter Valley Load Point, and on 25 June 2006 to allow for the extension of the Carrington Pit, which is supported by the Carrington Pit Extended Statement of Environmental Effects (SEE) (ERM, 2005). Licences related to Howick Coal Mine are Environmental Protection License (EPL) 640 and Mining Lease (ML) 1560 (AECOM, 2011a, p. 13).

1.2.2.1.16 Integra

Integra Coal Operations Pty Ltd is responsible for the operation of the Integra Coal Project (Integra) in the Hunter Coalfields, 10 km north-west of Singleton. The project was formed in 2006 through integration of the Glennies Creek and the Camberwell joint ventures (Corkery, 2007, p. A–6). Integra is owned by Vale Australia and operates both underground and open-cut coal mining operations (Integra, 2013, p. 16). The mine produces three types of coal: semi-soft coking coal (43%), thermal coal (6.9%) and semi-hard coking coal (50.1%) (Integra, 2013, p. 43–44). The operations have been active since 1991 and include:

- Integra North Open Cut Coal Mine (North Open Cut), which was formerly known as the Glennies Creek Open Cut Mine
- Integra Underground Coal Mine (Integra Underground), which was formerly known as the Glennies Creek Underground Coal Mine
- Integra Open Cut (formerly referred to as the Camberwell Coal Mine) which comprises the North Pit which ceased mining in 1999 and has been backfilled, and the South Pit.

Of these, mining is currently taking place in the Integra Underground, the South Pit and the North Open Cut (Vale, 2012, p. 11).

Integra Coal has approval to dispatch up to 7.3 Mt of product coal from the site each calendar year (Integra, 2013, p. 20). This coal is sold to both export (28%) and local markets (72%). Mining at Glennies Creek Colliery commenced in 1996 (Corkery, 2007, p. A–11). The underground mine is a modern, longwall operation (Integra, 2013, p. 14). The operations at the original Camberwell Coal Mine commenced open-cut mining in 1991 and are now approved (Integra Open Cut) until 31 December 2035 (Project Approval PA_08_0101).

The facilities onsite include a CHPP, rail loading facilities, workshops, administration buildings, coal stockpiles, mobile plant and equipment. There are six piezometers installed to monitor groundwater in the region of the dam wall (Integra, 2013, p. 15, p. 21, p. 42).

The mine does not hold a water discharge license and separates clean, sediment-laden mine water to minimise adverse environmental impacts. Water management infrastructure includes dams, pipelines and associated drainage structures which allow for catchment of water from undisturbed areas to be diverted, where possible, away from disturbed and sediment-laden mine water (Integra, 2013, p. 38). Major rehabilitation objectives are to (Integra, 2013, p. 93):

- return the site to a suitable land capability class
- reshape all slopes to gradients which provide long-term stability
- locate dams on natural and reformed watercourses and gullies to provide short-term retention and sedimentation control during mining and rehabilitation, and long-term stock watering
- prevent contaminants from leaving the site
- revegetate lands disturbed by mining activities
- minimise dust generation during the rehabilitation process.

1.2.2.1.17 Liddell

Liddell Coal Operations (Liddell) is an open-cut mine operated and managed by Liddell Coal Operations Pty Limited, a wholly owned subsidiary of Glencore Coal Pty Ltd, on behalf of a joint venture between Glencore (67.5%) and Mitsui Matsushima Australia (32.5%) (Glencore, 2014e). Liddell Colliery has had continued mining, either open-cut or underground, since the 1950s (Liddell Coal, 2002).

Liddell Coal is located at Hebden, 25 km north-west of Singleton in the Upper Hunter Valley (Liddell Coal, 2014). Pits currently mined are South Pit and Entrance/Barrier Pit (Xstrata Coal, 2013, p. 12). The mine operates a truck and excavator, and dragline and highwall operation (Glencore, 2014e). Mining is expected to continue until approximately 2023. Coal resources as at December 2013 were reported to be 100 Mt (measured), 210 Mt (indicated) and 350 Mt (inferred) (GlencoreXstrata, 2014, p. 49). Potential economic extraction at Liddell Coal is from the Lemington, Pikes Gully, Arties, Liddell and Barrett seams (Glencore, 2014f). Proved marketable reserves as at end of 2013 were 20 Mt and total marketable reserves were 36 Mt (GlencoreXstrata, 2014, p. 49).

Both semi-soft coking coal and thermal coal are mined at the Liddell Colliery (Glencore, 2014e). The coal seams targeted by the current and planned mining operations range from 0.7 to 9.5 m in thickness and include the Lemington, Pikes Gully, Arties, Liddell and Barrett coal members (Glencore, 2014e) in addition to the Hebden Gully Coal Member (Glencore, 2014e).

The water management system at Liddell Colliery manages surface water runoff to existing pits and operational areas, groundwater seepage in open-cut and old underground workings, mine operation water for the CHPP, dust suppression, and off-site discharges and water sharing arrangements (Xstrata Coal, 2013, p. 5). Liddell Colliery consumes approximately 4.9 ML/day of water in the CHPP (at a rate of 7 Mt/year ROM production) (Xstrata Coal, 2013c, p. 5). The main water storage onsite is the raw water transfer void with a capacity of approximately 500 ML which receives water from both open-cut pits (South Pit and Entrance/Barrier Pit) and other dams, as well as the Liddell underground mine (Xstrata Coal, 2013c, p. 12). Surface water storage totals

2473 ML and underground water storage in old workings totals 7160 ML (Xstrata Coal, 2013, p. 5, p. 14). Water is stored in underground workings because a barrier to groundwater flow exists between the Hazeldene and old Liddell workings. This allows water levels in the Hazeldene underground workings to be maintained as groundwater levels are reduced in the Liddell underground mine (Xstrata Coal, 2013c, p. 7).

1.2.2.1.18 Mandalong Mine

Mandalong Mine is owned by Centennial Coal and operated by Centennial Mandalong Pty Ltd, which is a wholly owned subsidiary of Centennial Coal Company NSW (Centennial Coal, 2012e, 2012f). Mandalong Mine was purchased in 2002 (as part of the Powercoal acquisition) and operations started in 2005 (Centennial Coal, 2012e). The planned life of mine is approximately until 2033 (Centennial Coal, 2012f, p. 2). Coal mined is for the domestic and export thermal coal markets.

Mandalong Mine is about 25 km south-west of Newcastle near Morisset (Centennial Coal, 2012f, p. 1). It is an underground longwall coal mining operation that comprises the Mandalong Mine underground working and surface infrastructure near Morisset, the Cooranbong Colliery underground workings and surface infrastructure near Dora Creek (Mandalong Mine – Cooranbong Entry Site) and the Delta Entry Site, which encompasses an entry and coal delivery system near Wyee at the Vales Point Rail Unloader Facility (Centennial Coal, 2012f, p. 1). Mandalong Mine operates within ML 1443 and ML 1543 (Centennial Coal, 2012g, p. 1). The mine has approval to extract up to 6 Mt/year (Centennial Coal, 2014c). Facilities at the site include overland conveyors, private haul roads to Newstan where coal is loaded for rail transport to the Port of Newcastle or on to dedicated conveyors for delivery to domestic power customers (Centennial Coal, 2012e), Eraring Power Station and Vales Point Power Station.

As at 2012, the site was reported to have an estimated remaining reserve of 88 Mt (Centennial Coal, 2012e). Coal is extracted from the West Wallarah coal seam (informal name) (Centennial Coal, 2014c, p. 1). Mandalong Mine is connected to both town water and sewerage. Potable water for underground use is supplied by the Hunter Water Corporation via pipeline to Cooranbong. The total potable water used in 2014 was 415.8 ML compared with 337 ML in 2012 (Centennial Coal, 2014c, p. 62). Potable water is primarily used for longwall continuous miners and conveyors for coolant and dust suppression (Centennial Coal, 2014c, p. 62). Managing runoff from rainfall events is the only surface water management required at Mandalong. Clean water is diverted around the western area of the site. A dam has been constructed to capture the water. Clean runoff from other parts of the site has been diverted around the eastern perimeter. All other water that is considered 'dirty' is directed to sediment control systems and is then used for irrigation of surrounding grassed areas as required. Oil-water separators are used to remove hydrocarbons from potentially contaminated runoff (Centennial Coal, 2014c, p. 62). An extensive groundwater monitoring network has been established to meet groundwater management requirements (Centennial Coal, 2014c, p. 65).

1.2.2.1.19 Mangoola Coal Mine

Mangoola Coal Mine (formerly known as the Anvil Hill Mine) was acquired by Xstrata Mangoola Pty Ltd (now Glencore) from Centennial Hunter Pty Ltd in 2007 after Project Approval PA06_0014

was granted (Umwelt, 2013b, p. 1; Glencore, 2014g). The mining lease was granted on 20 November 2008 (NSW Department of Primary Industries, 2008) and mining is expected to continue until approximately 2026 (Umwelt, 2013e, p. 1).

Mangoola Coal Mine is located near Wybong, 20 km west of Muswellbrook and approximately 10 km north of Denman (Umwelt, 2013b, p. 1; Glencore, 2014g). There are three open-cut pits at Mangoola Coal Mine: the Northern Pit, the Main Pit and the Southern Pit (NSW Office of Water, 2008, p. 2). The Mangoola Coal Exploration Program was undertaken (by Mangoola Coal, Glencore) during 2014 to better understand coal resource potential within the Authorisation Lease (AL) 9 and Exploration Licence (EL) 5552 within which is situated ML 1626 and Mangoola Coal Mine (Glencore, 2014h). Currently the mine is approved to produce 13.5 Mt/year (Project Approval 06_2014, approved 28 April 2014) (NSW Department of Planning and Infrastructure, 2014) which was increased from the previously approved limit of 10.5 Mt/year (Glencore, 2014g). Mining is performed using truck and excavator operations (Umwelt, 2013b, p. 1). Coal resources as at December 2013 were reported to be 180 Mt (measured), 70 Mt (indicated) and 1100 Mt (inferred) (GlencoreXstrata, 2014, p. 49). The coal sequence at Mangoola typically shows a massive conglomerate/sandstone overburden 15 to 90 m thick. This includes the Awaba Tuff, typically 9 to 10 m thick at the site, lying between the Great Northern and Fassifern coal seams. The Awaba Tuff is covered by overburden with a depth of around 10 m and is found between the deeper Fassifern and Great Northern seams.

Most of Mangoola Coal Mine lies within the Wybong Creek catchment and is managed under the Wybong Creek Water Sharing Plan 2003 (Umwelt, 2013c, p. 9). Licensable water from the Wybong Creek Water Source will not be used for mining purposes, in accordance with the project approval (Umwelt, 2013c, p. 9, p. 19). The main sources of water for the Mangoola Coal Mine are direct rainfall into the catchment, dirty and clean/raw water catchments and groundwater inflow to open-cut pits (Umwelt 2013c, p. 19, p. 28). Water can be extracted under license from the Hunter River to meet the deficit in the site's water balance (Umwelt, 2013c, p. 28). Dirty water is generally runoff from disturbed areas; when water has been in contact with coal and has the potential to be saline. Clean water is pumped from the Hunter River into the raw water dam (Umwelt, 2013c, p. 28), which has a storage capacity of 2567 ML (Umwelt 2013c, p. 24). Major (greater than 10 ML capacity) on-site water storages amount to approximately 7200 ML (Umwelt, 2013c, p. 24).

Glencore currently holds licences under NSW's *Water Act 1992* for Mangoola Coal Mine including extraction bores, test bores and monitoring bores (Umwelt, 2013d, p. 6). The volume of groundwater extracted from works authorised by bore licences shall not exceed 700 ML in any 12 month period (NSW Office of Water, 2012, p. 3). Most creek lines support vegetation that prefers moist or waterlogged soil and there are some semi-permanent ponds along the three major creeks supporting a variety of native vegetation, in addition to 20 dams in the area of various depths and sizes (Umwelt, 2011b, p. 2.4–2.6). Rehabilitation of the overburden emplacement areas and backfilled pits will be conducted progressively over the life of the mine as soon as practicable after mining disturbance. Rehabilitation of infrastructure areas will occur as soon as practicable following decommissioning of infrastructure (Umwelt, 2011b, p. 4.1).

Detailed planning for mine closure is scheduled to commence once the remaining life of mine becomes less than five years. Consultation will occur with the local community, relevant

government authorities and in accordance with the Mangoola Coal Sustainable Development Management System (Umwelt, 2013e, p. 2). The Rehabilitation and Offset Management Plan (ROMP) describes short- and long-term management of ecological values of the project area (Umwelt (Australia) Pty Limited, 2011b, p. 1.1–1.2).

1.2.2.1.20 Moolarben

Moolarben Coal is mostly owned by Yancoal Australia (80%). The remaining 20% is owned by Sojitz Moolarben Resources Pty Ltd (10%) and the combined total 10% owned by a group of seven South Korean power companies (Moolarben, 2013a). The open-cut mine is in the Western Coalfield of the Sydney Basin, approximately 45 km north-east of Mudgee and 25 km east of Gulgong (Yancoal, 2015d, 2015e). Approval to operate was received in accordance with the Stage 1 Project Approval (05_0117) granted by the Minister for Planning on 6 September 2007 (Moolarben, 2015). Operations at the mine commenced in May 2010 (Moolarben, 2015). The Stage 1 Project Approval allowed for three open-cut mines (OC1, OC2 and OC3), one underground mine (UG4), a CHPP, raw and product coal stockpiles, a rail loop and rail loader, and office and workshop support facilities (Moolarben, 2015). Application for Stage 2 of the Moolarben Coal Project was lodged with the NSW Minister for Planning on 1 May 2008 and was approved subject to conditions on 30 January 2015 (NSW Department of Planning and Environment, 2015c). The Stage 2 Project Application comprises one open-cut (OC4), two underground coal mines (UG1 and UG2), and some additional infrastructure which would be operated in conjunction with the approved Stage 1 infrastructure (Moolarben, 2015). At full production, including open-cut and underground operations from Stage 1 and Stage 2, the Moolarben Coal Complex will have the capacity to produce 17 Mt/year of ROM coal (Moolarben, 2015). Open-cut operations use truck and shovel methods (Moolarben, 2013b, p. 12) and underground coal extraction occurs via longwall (Moolarben, 2013b, p. 3). The projected life of mine for Stage 2 is 24 years (Moolarben, 2013b, p. 39). Coal is produced from the Ulan Coal unit, which has a mean thickness of approximately 12 m throughout the deposit (Yancoal, 2015e). At December 2013 the mine had recoverable reserves totalling 313 Mt. The mine produces thermal coal products for overseas markets (Yancoal, 2015e).

1.2.2.1.21 Mount Arthur Coal Mine Complex

Mount Arthur Coal Mine is an open-cut coal mine first owned by Coal Operations Australia Ltd, and then by Hunter Valley Energy Coal Pty Ltd (HVEC), both wholly owned subsidiaries of BHP Billiton. The mine is 8 km south of Muswellbrook in the Upper Hunter Valley. It consists of two areas: the northern open-cut (formerly known as Mount Arthur North) and the southern open-cut (including Bayswater No. 2, Bayswater No. 3, and the South Pit extension).

BHP Billiton was granted the Mount Arthur North Coal Exploration lease in July 1998 and received development consent and a mining lease in 2001 (BHP Billiton, 2001) and mining commenced in 2002. In 2007, the South Pit Extension project was approved. Mount Arthur North was then extended 2.4 km further to the south and the previously approved extraction rate of 15 Mt/year was increased by 3 Mt/year (NSW Department of Planning, 2007, p. ii).

Underground operations were authorised in 2008 for the Mount Arthur Underground Project for a mining rate of up to 8 Mt/year. The project comprises longwall mining operations from five coal seams with transport of ROM coal by conveyor, but no underground mining is currently taking

place (BHP Billiton, 2013, p. 2-1). In 2010, the NSW Government approved a mining rate for the Mount Arthur complex of 36 Mt/year of ROM coal with a maximum of 32 Mt/year from open-cut mining. In 2013, HVEC proposed to extend the duration of the mining operations to 2026 (instead of 2022). This was approved by the NSW Government Planning Assessment Commission in 2014 (NSW Planning Assessment Commission, 2014b, p. 2).

Mount Arthur North is comprised of several sub-pits, namely Macleans Hills, Windmill, Calooland and Roxburgh. Coal is currently extracted from 15 different seams at Mount Arthur North (BHP Billiton, 2013, p. 2-1). Multi-bench multi-strip shovels and excavators are used for mining operations, 24 hours a day, 7 days a week. Coal is transported onsite by a fleet of trucks to the CHPP in the eastern part of the mine complex. The CHPP is approved to process 36 Mt/year of ROM coal. It is connected by conveyors to the loading facilities that consist of a ROM pad area with two ROM coal hoppers for stockpiling (BHP Billiton, 2013, p. 2-1).

Product coal for the domestic market is transported by conveyors to Bayswater Power Station owned by Macquarie Generation. Coal for the export market is loaded onto trains at the rail loading facility and then transported to the Port of Newcastle via the Antiene Rail Spur and the Main Northern Railway line. The approved capacity of rail haulage is 27 Mt/year (BHP Billiton, 2013, p. 2-3).

About 30% of ROM coal processed becomes reject coal. Of the reject coal 19% is coarse and stored in overburden emplacements or stockpiling or other infrastructures. The remainder is the fine rejects or tailings stored in the tailings emplacement area, which has a maximum height of 280 m (BHP Billiton, 2013, p. 2-3).

Water is managed onsite according to their Site Water Management Plan approved in 2012 by the NSW Department of Planning and Infrastructure. A network of on-site mine water storages and sediment storages provide water supply for non-potable use, mainly for the CHPP. The Bayswater Main Dam is the most important storage supply for the CHPP plant. The total capacity of the on-site storages is 13.5 ML. They are filled with groundwater seepage and runoff from the industrial area, workshops and administration area, and all the areas disturbed by mining (BHP Billiton, 2012, p. 5-6).

The Mount Arthur Coal Mine Complex also uses water pumped from the Hunter River and treated effluent from the facilities operated by Muswellbrook local council. Water in the mine storage sites is re-used onsite. Excess water is transferred from the Bayswater Main Dam to the environmental dam, then directed to the Hunter River under the Hunter River Salinity Trading Scheme (BHP Billiton, 2012, p. 5-6). SubZero Group Ltd signed a contract with HVEC to decommission the Bayswater Main Dam and upgrade the water system network. Operations for this upgrade began in April 2013 (SubZero Group Ltd, 2013). As part of the development of Mount Arthur North, the channel of Whites Creek has been diverted to avoid the infrastructure (BHP Billiton, 2013, p. 2-3).

Bayswater No. 3

Bayswater No. 3 is part of the Mount Arthur Coal Mine, an open-cut coal mine 8 km south of Muswellbrook. The mine is currently owned by Hunter Valley Energy Coal Pty Ltd (HVEC), a

subsidiary of BHP Billiton. The Mount Arthur Coal Mine Complex includes Bayswater No. 2 (completed extraction), Bayswater No. 3, Mount Arthur North, and the South Pit extension of Mount Arthur North. Open-cut mining commenced in 1966 at Bayswater No. 2 and ceased in 1998 after the construction of the Mount Arthur North Mine. Approval was granted for Bayswater No. 3 development in 1994 (WSP Global Inc, 2013, p. 1). In 2007, an extraction rate of up to 3.8 Mt/year for Bayswater No. 3 was approved by the NSW Government (NSW Department of Planning, 2007, p. 8). Other information regarding the further development of mining operations, equipment, processing and transportation of coal, and water management are detailed in Section 1.2.2.2.17.

1.2.2.1.22 Mount Owen Complex

The Mount Owen Complex has operated for over 20 years. It is situated approximately 20 km north-west of Singleton, 24 km south-east of Muswellbrook and to the north of Camberwell village. The Mount Owen Complex consists of three open-cut operations: Mount Owen (known as North Pit), Ravensworth East (where the pits are known as West and Bayswater North pits) and Glendell (Barrett Pit) (Glencore, 2014i). Mining leases and titles include CL 358, 383 and 382, CCL 715, Miscellaneous Purposes Licence (MPL) 3.43, ML 1410, ML 1476, ML 1415, ML 1355, ML 1419, ML 1453, ML 1561, ML 1608, ML 1629 and ML 1475. The current mine operating plans for Mount Owen and Ravensworth East Mines are approved to December 2015 (Glencore, 2013b, p. 3), whereas Glendell Mine is approved to December 2024 (NSW Department of Planning, 2008, p. 4). The complex is currently approved to produce 18.5 Mt/year ROM coal from the three mines combined. The mining operations are managed by Mount Owen Pty Ltd, owned by Glencore Coal Australia Pty Limited (Glencore Coal) and operated by Thiess Pty Ltd.

The Mount Owen Complex shares facilities between Glendell, Mt Owen and Ravensworth East. There is a CHPP that has the ability to process 15 Mt/year ROM coal (up to 15 Mt/year from Mount Owen and up to 5 Mt/year jointly from Ravensworth East and Glendell pits in a combination that totals 15 Mt/year) (Glencore, 2013b). Both thermal and semi-soft coking coal are produced at Mount Owen and sold to export markets. Measured resources at the Mount Owen Complex are 300 Mt, indicated resources are 148 Mt and inferred resources are 181 Mt (2013 estimates, Glencore Xstrata, 2014, p. 50).

The Mount Owen Complex is situated between two regional thrust faults (Hunter Thrust and Hebden Thrust), each limiting the lateral extent of the coal seams. The seam dips vary and can be up to 45 degrees in areas around the Hebden and Hunter thrusts where the thrusts may offset seams by up to 40 m. Twenty-two mineable coal intervals within 11 coal seams have been identified at the mine and these range from 0.2 to 10 m in thickness, within a total 350 m interval. Within this zone coal seams comprise a total thickness of approximately 55 m. Potential economic extraction at Mount Owen is from the Lemington, Pikes Gully, Arties, Upper Liddell, Middle Liddell, Barrett, Upper Hebden and Lower Hebden coal seams. Mining at the Mount Owen Complex targets the Wittingham Coal Measures with the North Pit located between the Hunter and Hebden thrusts (Glencore, 2013b, p. 21).

The Mount Owen Complex water management system captures water from approximately 781 ha including the open-cut pits, overburden dumps, Ravensworth East tailings pits and surface infrastructure facilities. Mount Owen Complex manages water onsite and can transfer water to or from Glencore's Liddell and Ravensworth mines (Glencore, 2014j, p4). Runoff from disturbed

areas is transferred to Environmental Control Dam 2 (ECD2), which is used for dust suppression. Potable water is pumped from Glennies Creek and treated prior to use, with additional water to meet site demands imported from Ravensworth East, Liddell Borehole or Glennies Creek. The Liddell Coal Borehole provides water sourced from inundated underground workings at Liddell Mine. Mount Owen also holds an extraction licence for up to 1000 ML/year from Glennies Creek. Surplus water can be discharged to Swamp Creek at a maximum rate of 66 ML/day (Umwelt, 2003, p. 8.4). Rehabilitation is undertaken progressively as mining is completed. All areas disturbed within the Ravensworth State Forest boundary will be rehabilitated to similar woodland community (Umwelt, 2003, p. 2.5). Under S 96 (2) of NSW's *Environmental Planning and Assessment Act 1979*, the mine was granted permission to discharge mine water to the Hunter River in accordance with the Hunter River Salinity Trading Scheme (Umwelt, 2003, p. 1.3).

Mount Owen Mine

Mount Owen open-cut mine is owned by Glencore Coal Australia Pty Limited (Glencore Coal) and is operated by Thiess Pty Ltd (Thiess) (Glencore, 2013b, p. 1, p. 13). The Mount Owen Mine commenced open-cut operations in 1993 (Umwelt, 2003, p. 1.1; Glencore, 2013, p. 1). In 2004, development consent was granted to Mount Owen to increase both the mining area and the production rate (to 10 Mt/year ROM coal). Additionally, this approval allowed for a new satellite pit (the Eastern Rail Pit) and increased processing capacity.

Mount Owen Mine is about 25 km north-west of Singleton, 26 km south-east of Muswellbrook and 10 km north of Camberwell (Umwelt, 2003, p. 1.1). Mount Owen Continued Operations Project is proposed to extend the life of the Mount Owen Mine until 2030 (providing an additional 92 Mt coal) although total annual ROM production is not planned to change (Glencore, 2014k). See also Section 1.2.3, Mount Owen Continued Operations Project. The mine currently produces 8 Mt/year ROM coal for supply to export markets (Umwelt, 2003, p. 1.1). The mine is operated by means of large excavators and haul trucks supported by ancillary equipment including water carts, dozers, graders, fuel and service carts, loaders and drills. The coal that is uncovered is hauled to the CHPP for processing. Clean coal is conveyed to the product stockpile before being transported by rail for approximately 120 km to the Port of Newcastle for export.

Water is used at Mount Owen Mine for coal washing, dust suppression and amenities. The major water use is coal washing, which accounts for approximately 18.6 ML/day, of which 16 ML is recycled water. Average daily water usage for dust suppression is 1.14 ML, with the remainder used for amenities (Umwelt, 2003, p. 8.5).

Ravensworth East Mine

Ravensworth East Mine, formally known as Swamp Creek Mine (previously mined by Hebden Mining Company) operates under the management of Glendell (Glencore, 2014| Ravensworth East page). The Ravensworth East Open Cut Mine was acquired in June 1997 by Peabody Resources Limited (Peabody) after a period of care and maintenance under the previous owner, Electricity Commission of NSW (Xstrata Coal, 2007, p. 8). Approval under a new Mining Lease (ML 1415) was granted in 2000 for production of up to 4 Mt/year ROM coal (Glencore, 2013a, p. 2). Ravensworth East Mine is owned by Glencore Coal Australia Pty Limited (Glencore) (since 2002), and operates

under the management of Glendell Tenements Pty Ltd. Mining activities are conducted by Glencore (Glencore, 2013b, p. 13).

Mining operations recommenced in August 2000, and mining is expected to continue for up to 21 years under the current operation schedule (Glencore, 2013b, p. 2). In 2004, Ravensworth East was integrated into the Mount Owen Complex (Glencore, 2014l, Ravensworth East page). The Ravensworth East Mine is about 26 km north-west of Singleton within ML 1415 and ML 1453, and consists of the West Pit, Stage 2, and the Ravensworth West pit (Glencore, 2013b, p. 22) (Glencore, 2013a, p. 2). An application to modify the Ravensworth East Mine development area has been lodged with NSW Department of Planning and Industry (Ravensworth East Resource Recovery Project discussed under Mount Owen Continuation Project, see Section 1.2.3) and a decision is currently pending (Glencore, 2013b, p. 3). Ravensworth East is currently approved to produce 4 Mt/year of ROM coal (Glencore, 2014m, p. 2). The mine produces thermal coal that is sold to both the domestic and export markets (Glencore, 2013b, p. 21). As at 31 December 2013, measured resources at Ravensworth East were 6.1 Mt, indicated resources were 4 Mt and inferred resources were 5 Mt (GlencoreXstrata, 2014, p. 50). The mining targets are the Ravensworth coal seam to the underlying Bayswater Coal Member, dipping south-east at 15 degrees (Glencore, 2013b, p. 22). The West Pit is constrained to the east by the previously mined tailings pits and the Mount Owen rail loop, and to the south and north by the lease boundary (Glencore, 2013b, p. 22).

Glendell Coal Mine

The Glendell Coal Mine is an approved open-cut coal mine adjoining the Ravensworth East and Mount Owen Mines at Mount Owen Complex (Glencore 2015a). Glendell Coal Mine was initially approved in 1983 whilst under the joint venture ownership of Renison Goldfields and Dalgety Australia Ltd for 30 years extraction up to 2013. The mine was later fully acquired by Renison Goldfields Consolidated Ltd in 1989, and in 1992 was sold to a consortium of Savage Resources (56.5%), Marion Coal Pty Ltd (16%) and Mitsui Matsushima (27.5%). In 1994 a new joint venture between Savage Resources (37.5%) and Mitsui Matsushima (32.5%) was formed and in 1999 Savage Resources sold its share to Pasmaenco who, in turn, sold it that year to Glencore Coal Australia Pty Ltd (Glencore Coal). Glencore's stake was later sold to Xstrata Coal Pty Limited (Xstrata) in 2003. In 2003, Xstrata acquired the mine in its entirety and was integrated with the adjoining Mount Owen and Ravensworth East mines (NSW Department of Planning, 2008, p. 1). Glendell Coal Mine is owned by Glencore Coal, and operates under management of Glendell Tenements Pty Ltd (Glencore, 2013b, p. 13).

Due to various factors, mining operations were delayed (NSW Department of Planning, 2008, p. 1) and first extraction took place in 2008. Modification plans extended the time allowing extraction for 16 years to 2024 (NSW Department of Planning, 2008, p. 4). Extraction takes place via truck and excavator (NSW Department of Planning, 2008, p. 4). The mine was initially authorised to extract up to 3.6 Mt/year, but in 2008 a modification was made allowing extraction of up to 4.5 Mt/year ROM coal (Glencore, 2013b, p. 2).

Construction commenced in April 2008 and the first coal was extracted at Glendell Coal Mine in June 2008 (Glencore, 2015a). Glendell is a multi-seam coal deposit consisting of a number of coal seams of the Foybrook Formation, the lowermost coal-bearing unit of the Wittingham Coal Measures. Mineable coal seams include Pikes Gully, Arties, Upper Liddell, Middle Liddell, Lower

Liddell and Barrett that range in thickness from 0.3 to 3.5 m and coal is mined using open-cut methods (Glencore, 2013b, p. 21). The approved mining area is approximately 685 ha and 200 m deep (Glencore, 2013b, p. 21).

Thermal coal is produced at the mine for both the overseas and domestic markets (NSW Department of Planning, 2008, p. 4). Coal is processed at the Mount Owen CHPP, whilst water is managed as part of the Mount Owen water management system (Glencore, 2015b) The mine's final void is expected to be 65 million m³ and will be progressively rehabilitated (NSW Department of Planning, 2008, Appendix A).

1.2.2.1.23 Mount Thorley–Warkworth

Mount Thorley–Warkworth (MTW) is an integrated operation of two adjacent open-cut mines, Mouth Thorley and Warkworth, 15 km south-west of Singleton in the Upper Hunter Valley (Rio Tinto, 2015c). Coal and Allied manages MTW on behalf of the joint venture partners Coal and Allied Industries Ltd (80%) and POSCO Australia Pty Ltd (20%).

MTW uses dragline truck and shovel methods. Nine hundred and twenty-seven employees (as at 31 December 2013) work in shifts to keep the mine operational 24 hours a day, 7 days a week. The facilities onsite include two CHPP (one for each mine), four tailings dams (two for each mine), administration buildings, stand pipe piezometers, and three tailing emplacements: Abbey Green South, Centre Ramp Tailings Storage Facility, and Tailings Dam 2 (Coal and Allied, 2014b, p. 17, p. 19, p. 86, p. 87). In January 2010 Coal and Allied proposed an extension of the approved Abbey Green North Pit by approximately 75 ha to the west. This extension enabled the extraction of approximately 5 Mt of additional ROM coal from the Mount Arthur, Warkworth and Bowfield coal members, which are already approved for extraction (EMGA, 2010, p. 5). Mount Thorley operates two pits, namely the Loders Pit and the Abbey Green South Pit, and Warkworth operates the North Pit, South Pit, Abbey Green North Pit and West Pit (EMGA, 2010, p. 21; Coal and Allied, 2014b, p. 36). Mount Thorley has been in operation since 1981, and after a business restructuring of the former owner, mining company R.W. Miller, Coal and Allied became managers of the mine in 1989. Coal and Allied manages Warkworth on behalf of the joint venture partners: CNA Warkworth Australasia Pty Ltd (26.82%), CNA Resources Ltd (28.75%), Mitsubishi Development Pty Ltd (28.9%), Nippon Steel Australia Pty Ltd (9.53%) and Mitsubishi Materials (Australia) Pty Ltd (6%). In 2013 Mount Thorley produced more than 2.3 Mt of thermal coal and 1.8 Mt of semi-soft coking coal and reported marketable reserves of 21 Mt as at 31 December 2013 (Rio Tinto, 2015c), with 150.3 Mt of total resources reported in the OZMIN database.

In 2013, Warkworth produced approximately 6.9 Mt of thermal coal and more than 1.2 Mt of semi-soft coking coal and had marketable reserves of 233 Mt as at 31 December 2013 (Rio Tinto, 2015d). Current resources and reserves for Warkworth of 846.2 Mt and 372 Mt, respectively, are reported in the OZMIN database.

In 2009 a preliminary environmental assessment was presented and later approved, which extends the current mine life (2021) to 2031. The proposal also includes: transferral and disposal of overburden from Warkworth to the Loders Pit at Mount Thorley following completion of coal extraction at Loders Pit; replacement of an ageing equipment fleet to allow for improved mining efficiencies, and the upgrading of some support infrastructure (Mitchell McLennan, 2009, p. 11). In

2012, the Warkworth Extension Project was approved. In April 2013 the Land and Environment Court (LEC) upheld an appeal to the planning approval for the Warkworth Extension Project.

An adaptive water management approach is implemented at MTW to: preferentially re-use poor quality mine water over clean water; minimise the use of fresh water; and protect clean water systems. This is achieved by (Coal and Allied, 2014b, p. 101):

- using mine water for coal preparation and dust suppression
- an emphasis on control of water quality and quantity at the source
- segregating waters of different quality where practical; recycling on-site water
- ongoing maintenance and review of the water management system
- disposing of water to the environment in accordance with statutory requirements.

The primary post-mining rehabilitation objectives include (Coal and Allied, 2014b, p. 131):

- recreating approximately 2114 ha of Endangered Ecological Community (EEC) woodland to a standard comparable to similar reference EEC communities
- establishing approximately 305 ha of trees over grassland areas
- recreating 928 ha grassland communities with a native component on the residual disturbed mining areas
- establishing a network of tree corridors to ensure connectivity of woodland community areas
- providing additional habitats for threatened species
- creating an additional north/south wildlife corridor providing connectivity to other habitats.

Application for the Warkworth Continuation Project, which enables mining beyond 2017, was submitted in 2014 and is currently being assessed (NSW Department of Planning and Environment, 2014g, p. E.1–E.2).

1.2.2.1.24 Muswellbrook No. 2 Coal Mine

Muswellbrook No. 2 Coal Mine is 3 km north-east of Muswellbrook in the Upper Hunter Valley. The mine is owned by Muswellbrook Coal Company Limited (MCC), a wholly owned subsidiary of the Japanese company Idemitsu Kosan Ltd. Underground operations began in 1907 and continued until 1997. Open-cut extraction was undertaken at the No. 1 coal mine from 1944 to 1970, and briefly recommenced from 2000 to 2002. The NSW Government granted development consent for the No. 1 Open-Cut Extension in 2003 (DA 205/2002) (AECOM, 2009, p. 5). Operations commenced at No. 1 Open Cut Extension in 2005 and are approved until 2018 (MCC, 2014, p. 1).

Operations began at the No. 2 Open-cut in 1965 and remain ongoing. The licenses held for this complex are CCL 713, AUTH 176, ML 1304 (until 2024), ML 1513 (until 2013) and ML 1562 (until 2026) (NSW Trade and Investment, 2014, p. 4, p. 6, p. 13, p. 16, p. 17). MCC is currently investigating the possibility of also developing two other areas within the mining lease in addition to the West Muswellbrook Project, which alone could produce over 7 Mt/year (Idemitsu Kosan, 2010). In December 2014, a Gateway Application for the West Muswellbrook Project was

submitted to the NSW Mining and Petroleum Panel by whom it is currently being assessed (NSW Mining and Petroleum Gateway Panel, 2015).

Operations are undertaken with shovels and excavators to remove overburden, and with a fleet of trucks to transport coal to the on-site CHPP. The approved mining rate is 2 Mt/year, but current operations are producing below the maximum approved limit (MCC, 2014, p. 13). Following processing, the coal is either sent to the Port of Newcastle for export or used for the domestic market in nearby power plants (Idemitsu Kosan, 2010, p. 1). The seams targeted by open-cut operations include the Fleming, Hallett, Muswellbrook, Saint Helliers, Lewis and Loder coal seams, part of the Permian Greta Coal Measures. The seams dip slightly to the north and their thickness varies from 1.5 (Loder coal seam) to 9.5 m (Saint Helliers coal seam). The extracted coal has low ash and medium moisture contents (Idemitsu Kosan, 2010, p. 2). Rehabilitation is ongoing at Muswellbrook, and includes replacing soil and re-vegetating (Idemitsu Kosan, 2010, p. 1).

1.2.2.1.25 Myuna Colliery

Myuna Colliery began mining at the site in 1982 (Centennial Coal, 2012c, 2012d). Myuna Colliery has been owned and operated by Centennial Coal since 2002 when it was acquired from Powercoal (Centennial Coal, 2012c, 2012d). An application was submitted in 2010 to continue mining by extending the consent within the lease area. The application was approved in 2012 to continue for a further 21 years to 31 December 2032 (Centennial Coal, 2011, p. 1; Centennial Coal 2012c).

Myuna is located in Wangi Wangi, Lake Macquarie, in the Newcastle Coalfields, near Toronto and 25 km south-west of Newcastle, NSW (Centennial Coal, 2011, p. 1; Centennial Coal, 2012c). Mining Lease (ML) 1370 provides the rights to mine coal resources at the site and covers approximately 653 ha; CCL 762 (title for coal mining purposes) covers approximately 10,820 ha (Centennial Coal, 2012d, p. 2-3). An increase of ROM coal extraction from 2 to 3 Mt/year was agreed on 27 February 2015 (NSW Department of Planning and Infrastructure, 2015a, 2015b). At this mine, thermal coal is extracted and is used in the domestic market (Centennial Coal, 2012c). The mine is an underground operation using bord-and-pillar methods (Centennial Coal, 2011, p. 1; Centennial Coal, 2012c). Remaining coal reserves in 2012 were reported as 17.2 Mt (Centennial Coal, 2012c), with 338.2 Mt of total resources reported in the OZMIN database.

The site has a dedicated overland coal conveyor to Eraring Power Station and on-site coal crushing plant (Centennial Coal, 2012). The main targets for extraction are the Wallarah, Great Northern and Fassifern coal seams (Centennial Coal, 2011, p. 1; Centennial Coal, 2012c). The Fassifern seam is approximately 140 m below surface; the Great Northern Seam is approximately 120 m deep and the Wallarah coal seam is about 80 m deep (AECOM, 2011b, p. 37, see Figure 6.1 for stratigraphy). Annual average total potable water demand (2005 to 2010) is 118 ML/year (GHD, 2013, p. 21). Clean and dirty surface water is separated onsite through a series of diversions away from clean and dirty catchments. Water underground is diverted into other underground areas where it is allowed to settle and then siphoned to surface storage for further settling before discharging (AECOM, 2011b, p. 29, p. 30). Water is supplied from the Hunter Water Corporation Potable Supply for the bathhouse, administration and supply store. Discharge from buildings is by sewerage pump to the Hunter Water Corporation Trade Waste system. Water used in the wash-down bay is sent to the oil and water separator and trade waste system (GHD, 2013, p. 22). Water

from the Hunter Water Potable Supply is also used in the CHPP and outflows to Mine Water Settling Pond 2 (GHD, 2013, p. 23). A full description of the water management process and water balance is given in GHD (2013).

Rehabilitation of surface facilities will occur within five years of completion of mining (Centennial Coal, 2011, p. 1). At the time of developing their responses to EIS submissions (Centennial Coal, 2011, p. 19), Centennial Coal stated that as there was no Lake Macquarie Strategic Land Use Strategy available, it was not possible to determine an appropriate post-mining land use plan (Centennial Coal, 2011, p. 19).

1.2.2.1.26 Ravensworth Complex

The Ravensworth Complex is approximately mid-way between Muswellbrook and Singleton in the Hunter Coalfield. It comprises the Ravensworth Surface Operations (Narama and Ravensworth North open-cut mines), Ravensworth Coal Handling and Preparation Plant (RCHPP) and Ravensworth Underground Mine (Glencore, 2014b, p. 1; Glencore, 2014n). The former Ravensworth South and Ravensworth No. 2 open-cut mines operated from the early 1970s and ceased in 1987 at the completion of a coal supply contract to domestic power generators (Glencore, 2014b). Up to the end of 2013, 3382 ha had been rehabilitated across the Ravensworth Complex (Glencore, 2014b, Appendix B). In December 2014, Ravensworth Operations Project – Modification 2 (Changes to Final Landform) was approved, which defined rehabilitation objectives that must minimise visual impacts of the development, be consistent with natural terrain and incorporate micro-relief and be free-draining. The plan defines that the final void will be designed as a long-term groundwater sink, with the size, depth and catchment to be minimised (NSW Department of Planning and Environment, 2014h, 2014i, p. 18).

Ravensworth Surface Operations

Ravensworth Surface Operations (also known as Ravensworth Operations or Ravensworth Open Cut) is owned and operated by Ravensworth Operations Pty Ltd, and managed by Glencore (Glencore, 2014b, p. 2). Ravensworth Surface Operations includes two active open-cut mining areas, Narama Mine and Ravensworth North Mine, in addition to the Cumnock Mine, which has been under care and maintenance since 2011 (see Section 1.2.2.1.2) (Xstrata, 2012). Ravensworth West Mine, also at the site, commenced production in April 2006, but ceased mining in 2011. Project approval for the life of mine has been granted for the operations to continue for up to 29 years (completion date of 31 December 2039) (Glencore, 2014b, p. 2).

Ravensworth Surface Operations is licensed to produce up to 16 Mt/year ROM thermal coal, which is sold to both the domestic (Bayswater and Liddell power plants) and export markets (Glencore, 2014b, 2014m). Measured resources at the Ravensworth Surface Operations are 446 Mt, indicated resources are 220 Mt and inferred resources are 150 Mt (estimated December 2013, Glencore Xstrata, 2014, p. 50).

Coal is mined via truck and shovel methods and is hauled to the ROM coal pad and transferred further via internal coal haul roads. The coal is crushed by rotary sizers then transported by conveyor belt to Bayswater and Liddell power stations. If required, coal is washed at the on-site CHPP.

Narama Mine

Narama Mine commenced operations in 1993 (Glencore, 2014n). Narama is a strip mine that uses dragline and truck and loader methods to remove overburden and coal, with mined coal trucked to the crushing plant. Coal is then moved by conveyor to the Bayswater and Liddell power plants. The mine targets the Foybrook and Burnamwood formations, specifically the Broonie, Bayswater, Lemington, Pikes Gulley, Arties, Liddell, Barrett, and Hebden Gully coal members. Coal resources as at December 2013 were reported to be 26 Mt (measured) (GlencoreXstrata, 2014, p. 49).

Ravensworth North Mine

Ravensworth North Mine commenced operations in April 2012. It is a multi-seam, open-cut mine, west of Bayswater Creek, which includes the existing Ravensworth West Open Cut Mine. It is adjacent to the former Cumnock Underground Mine workings. Ravensworth North Mine is excavated using truck and shovel methods. Coal is processed at the Ravensworth CHPP and processed for both domestic and export markets (Glencore, 2014b, p. 31). The Ravensworth North Mine has a proposed life of 29 years (Glencore, 2014b). The majority of future mining at the greater Ravensworth Mining Complex is expected to occur at the Ravensworth North Mine (Glencore, 2014b, p. 33). Coal resources as at December 2013 were reported to be 420 Mt (measured), 220 Mt (indicated) and 150 Mt (inferred) (GlencoreXstrata, 2014, p. 49).

During year 5 (2016) of mining activity at Ravensworth North Mine, the entire catchment of Emu Creek within the site boundary will be mined, requiring careful management of Emu Creek (Glencore, 2014b, p. 57). At Ravensworth North Mine coal is extracted from nine seam groups within the Foybrook Formation and the Burnamwood Formation. Specifically, coal is extracted from the Broonies, Bayswater, Upper- and Lower Lemington, Pikes Gulley, Arties, Liddell, and Barrett coal seams (Glencore, 2014b). The deepest target seam is the Barrett Seam, which is approximately 160 m below surface in the north-west and 260 m deep in the south-east of the mine (Glencore, 2014b, p. 32).

Ravensworth Underground Mine

Ravensworth Underground Mine, is part of the Ravensworth Mining Complex and was placed into care and maintenance in October 2014. See Section 1.2.2.1.5.

1.2.2.1.27 Rix's Creek Mine

Rix's Creek Mine is owned by Bloomfield Collieries Pty Ltd (AECOM, 2013, p. 1). The mine has operated at its current site since 1990, although previous coal mining activity has occurred in the area since the late 1800s at the nearby New Park Colliery (AECOM, 2013, p. i). Mining is expected to continue until 2016 under current approvals (AECOM, 2013, p. i; The Bloomfield Group, 2012, p. 5), although the Rix's Creek Continuation of Mining Project (The Bloomfield Group, 2014a) seeks to extend operations for a further 21 years.

Rix's Creek Mine is approximately 5 km north-west of Singleton. Mining takes place at Mining Lease (ML) 1432 in two open-cuts, the North Pit 1 and the West Pit 3 (The Bloomfield Group, 2012, p. 5) using a multi-seam bench system, simultaneously mining up to nine seams (The Bloomfield Group, 2014b). Coal is transported on site by trucks to the rail loader then railed to Port Waratah

Coal Services (The Bloomfield Group, 2014b). The mine produces from 1.5 to 2.8 Mt/year ROM coal (The Bloomfield Group, 2014; AECOM, 2013) of both thermal and semi-soft coking quality. Coal from Rix's Creek is sold to domestic and overseas customers (The Bloomfield Group, 2014b). A CHPP is onsite (The Bloomfield Group, 2014b).

The coal mined at Rix's Creek is extracted from the Wittingham Coal Measures (part of the Singleton Supergroup), including the Barrett coal seam, Liddell coal seam, Arties coal seam and Pikes Gully coal seam (The Bloomfield Group, 2014b). The Rix's Creek plan for eventual decommissioning and rehabilitation has been developed to return land to stable, sustainable post-mining uses, by dividing the site into like units ('domains') that will allow focus on the treatment of like areas (the Bloomfield Group 2012, p. 3).

1.2.2.1.28 Ulan

Ulan Coal Mines Limited

Ulan Coal Mines Limited (UCML) is a joint venture between Xstrata Coal Pty Ltd (90%) and Mitsubishi Development (10%) (Umwelt, 2011c). Xstrata Coal is wholly owned by Glencore. Xstrata Coal NSW (XCN) maintains management responsibility for UCML. UCML operates the Ulan Mine Complex, in the Western Coalfields of NSW, approximately 38 km north-north-east of Mudgee (Figure) and 19 km north-east of Gulgong (Xstrata Coal, 2012b, p. 9). Mining in the Ulan area has taken place since the 1920s (Xstrata Coal, 2012b, p. 10) when Ulan No. 1 Colliery supplied coal to local markets for a short period and then from 1942 to 1950, supplying coal to a power station north of Ulan Village and to other local markets (Ulan Coal, 2015). The power station closed in 1969. Ulan No. 2 continued to supply coal from the underground mine to local markets and additional coal was extracted from an open-cut mine established in the 1980s. Ulan No. 3 commenced in 1986 both as underground and open pit mining (Ulan Coal, 2015).

The current lease areas are approximately 4 to 5 km north of Ulan Village although the mine's colliery holding boundary is approximately 1.5 km north of the village. Ulan Mine Complex covers approximately 17,959 ha and is at the headwaters of the Talbragar and Goulburn river catchments (Umwelt, 2011c, p. 1; Ulan Coal, 2015). The NSW Department of Planning provided project approval (08_0184) in 2010 for coal production of up to 20 Mt/year over the next 21 years (Ulan Coal, 2015, Overview of operations). Production across the various pits at the Ulan Mine Complex equated to 7 Mt ROM coal (equating to 5.9 Mt of product coal) in 2012, 7.26 Mt ROM (6.24 Mt product coal) in 2013 and a projected 10.8 Mt ROM (10.6 Mt product coal) in 2014 (Glencore, 2014o, p. 24). The majority of coal from the Ulan Mine Complex is sold to the thermal export market and some higher-ash content coal is sold to the domestic market for power generation (Umwelt, 2011c, p. 2.1).

UCML currently hold 13 mining and exploration leases for the Ulan Mine Complex situated partially within the Central West subregion (Umwelt, 2011, p. 4.1); four of the leases cover existing activity. Ulan Mine Complex has two approved underground mining operations (Ulan No. 3, currently in operation, and Ulan West, which commenced production of longwall coal in May 2014) and an open-cut operation (Umwelt, 2011, p. 2.1). The Ulan Mine Complex is at the western limit of the Sydney Basin and the southern end of the Gunnedah Basin. At the complex, ten coal seams occur within the Permian Illawarra Coal Measures, eight above the Ulan coal seam

and one below. The seams range in thickness from 0.4 to 10 m, with Ulan coal seam being the thickest (Umwelt, 2011c, p. 1.4). Apart from the Ulan Seam, all seams within the mining leases are considered to be uneconomic at present due to their high ash content (Xstrata, 2012b, p. 23). Only the lowest 3 m of the Ulan coal seam are mined due to particularly high quality and as a result, only approximately 30% of the coal requires washing (Ulan Coal, 2015). The water balance for the Ulan Mine Complex for 2012 reported that intercepted water sources including rainfall on dams and ponds was 384 ML and runoff from catchments was 1615 ML, although detail per mine/pit was not available (Xstrata Coal, 2013a). As at 31 December 2013 resources of thermal coal reported at the Ulan site were 310 Mt measured, 410 Mt indicated and 700 Mt inferred (GlencoreXstrata, 2014, p. 49).

Part of Ulan No. 3 mine site is situated in the Central West subregion of the Northern Inland Catchments bioregion, including the currently mined area. However, for the purpose of this bioregional assessment product, all of the Ulan Mining Complex is discussed, even though the subregion boundary of Central West and Hunter intersects the mine complex.

Ulan No. 3 underground mine

Mining at Ulan No. 3 is performed through longwall mining methods using continuous miners and shuttle car operation (Ulan Coal, 2015). Coal is moved by conveyor to the surface where the higher-ash coal is moved by truck and conveyor to the wash plant. Coal that does not require washing is crushed and prepared for transport off site (Ulan Coal, 2015). When coal is ready for transport it is loaded at a dedicated loading facility for rail to both domestic markets and for export via the Port of Newcastle (Umwelt, 2011c, p. 2.1). The complex currently operates 24 hours a day, 7 days a week (Umwelt, 2011c, p. 2.1), with on-site facilities including mine ventilation and power supply infrastructure, fuel storage and workshops, administration buildings, tailings emplacement areas, overland and underground conveyors, stockpiles, processing and sizing stations, mine access, service boreholes, water management infrastructure, communications infrastructure, access roads and monitoring equipment (Umwelt, 2011c, p. 2.1–2.2).

Coal is of high quality with low sulfur, nitrogen and phosphorous providing good handling and combustion properties (Ulan Coal, 2015). Most coal is sold as thermal coal in the export market but some higher-ash content coal is supplied to the domestic market for power generation (Umwelt, 2011c, p. 1.6).

North 1 underground mine

The North 1 underground mine was identified in Ulan Coal Mines Continued Operations Project as a separate underground operation with longwall panels in an area that had not been previously mined, adjacent to (on the western edge of) an area that was mined in the early 1990s (Umwelt, 2011c, p. 3.1). Since that time, this is considered to be part of the Ulan No. 3 underground mine area, and not a separate entity (B Anderson (Glencore), 2014, pers. comm.).

Ulan Open Cut operation

In December 2010, open-cut mining recommenced at the Ulan Mine Complex across 239 ha adjoining the previous open-cut mining area approved for highwall mining (Umwelt, 2013, p. 2.2). Access to the Ulan Open Cut extension is via an existing road off Ulan Road approximately 1 km

north of the Cope Road junction (NSW Department of Planning, 2010, p. 9). Coal from the open-cut area is hauled by truck from the pit to a crushing facility onsite and then moved by conveyor to the CHPP (Ulan Coal, 2012, p. 57) before stockpiling and transporting off site. Coal rejects are stockpiled onsite and used for backfilling (Ulan Coal, 2012, p. 59). Approximately 158 ha of vegetation may be disturbed during construction and mining of the Ulan Open Cut extension (Ulan Coal, 2012, p. 34). Topsoil will be used for other areas undergoing rehabilitation or will be stockpiled for future rehabilitation. Minimal soil handling will be performed to reduce soil structure degradation (Ulan Coal, 2015). Overburden is blasted to fracture and aid its removal by dragline or excavator and truck to expose the Ulan Seam (Ulan Coal, 2015). The coal is crushed and then transported by overland conveyor, stockpiled and then further transported by conveyor to the CHPP, which has been upgraded to allow 20 Mt/year of coal to be processed (NSW Department of Planning, 2010, p. 9). Coal is stockpiled before being transported by rail to the Port of Newcastle or to domestic customers as required (Ulan Coal, 2015).

Ulan West underground mine

Ulan West underground longwall mine commenced production in May 2014 at longwall 1 (LW1). On 28 May 2015, mining commenced at longwall 2 (LW2) (B Anderson (Glencore), 2015, pers. comm.) and is anticipated to continue for approximately 12 months (Xstrata Coal, 2013b, p. 8). About 126 Mt of coal from the Ulan Seam is expected to be mined at Ulan West over 21 years, at depths of 80 to 225 m below surface (NSW Department of Planning, 2010, p. 9). Ulan West underground mine surface water management infrastructure includes water treatment facilities and piped services. Storage for potable water, mine wastewater, processing and fire water supply and other storage such as air, nitrogen and diesel have been developed along with a rail refuelling facility (Umwelt, 2011c, p. 2.3; Ulan Coal, 2015).

1.2.2.1.29 Wambo Mine Complex

The Wambo Mine Complex is near Warkworth village, 15 km west of Singleton in the Upper Hunter Valley. The mine is operated by Wambo Coal Pty Ltd, which was 75% acquired by Peabody Energy Australia Ltd in 2006. Development consent for open-cut and underground mining operations was granted in 1969 by the Patrick Plains Shire Council (Peabody, 2013).

In the existing open-cut, mining began in 1993 and targeted the Wambo, Whynot and Redbank Creek coal members in the 'lease swap' area. These seams actually belong to the historical United Collieries' mining lease. In 2010, equipment was extracted from the United Collieries underground mine, the necessary sections were sealed and the operation entered a period of Suspension of Operations (Glencore, 2015c). In exchange, Wambo Coal Mine allowed United Collieries to exploit the underground reserves in this area. Operations stopped and restarted in 2001 to mine the Whybrow coal seam in the Bates North Pit. In 2002 the Wambo, Whynot, Redbank Creek and Whybrow coal members were mined in the Ridge, Hunter and Homestead pits (Wambo Coal, 2014a, p. 16). The current Mining Operations Plan, which is valid from 2010 to 2016, allows the continuation of mining in Bates, Bates South and Homestead Pits, as well as the development of Montrose East and West Pits (Wambo Coal, 2010, p. 1).

Homestead underground mine was operated from 1979 and closed in 1999 when the last longwall (Longwall 9) was completed. Current underground operations began in 2007 in North Wambo

Underground Mine (Wambo Coal, 2011, p. 6–7). In 2013 approval was granted for extraction in Longwall 7 and Longwall 8. A proposal was submitted for Longwall 9 and Longwall 10 in North Wambo underground in December 2012 (Wambo Coal, 2014a, p. 16) and approved in 2013 (NSW Planning Assessment Commission, 2013, p. 1). A development of additional longwall panels (the proposed Longwall 10A) in the Wambo coal seam contiguous with the existing North Wambo Underground Mine was submitted in October 2014 (Wambo Coal, 2014b) and approved in April 2015 (NSW Department of Planning and Environment, 2015e, p. 43).

The existing leases and titles for Wambo Coal are CL 365, CL 374, CL 397, CCL 743, ML 1402, ML 1572, ML 1594, AUTH 444 and EL 1711. The current operations are under NSW development consent DA-305-7-2003 granted in 2004. The approved mining rate is up to 14.7 Mt/year for both underground and open-cut mining. In 2013 the Wambo Mine Complex produced 9.6 Mt of ROM coal, with 4.1 Mt from open-cut operations and 5.5 Mt from underground operations. Following processing at the CHPP, it was then transformed into 6.2 Mt of saleable coal (Wambo Coal, 2014a, p. 1, p. 18, p. 19).

Coal is mined with open-cut mining methods using shovels and excavators. It is transported to the on-site CHPP with haul trucks via the internal haul roads. The coal is then stockpiled or stored in the 400 tonne bin before being loaded by front-end loader for processing in the ROM crusher (Wambo Coal, 2014a, p. 16). Thermal coal is loaded at the rail loading facility to be transported to the Port of Newcastle. It is shipped by Port Waratah Coal Services and Newcastle Group Infrastructure facilities to the Asian market, mainly Japan, South Korea and China (Peabody, 2013).

Rehabilitation is currently taking place at the Wambo Mine Complex under the Rehabilitation Management Plan and the Mining Operation Plan for the open-cut mine (2010 to 2016) and the underground mine (2013 to 2015). Land is reshaped and biosolids used as topsoil.

1.2.2.1.30 West Wallsend Colliery

West Wallsend Colliery is situated south of Killingworth near Lake Macquarie in the Newcastle Coalfield, (Glencore, 2014o) and includes leases CCL 718, CCL 725 and ML 1451 (Glencore, 2014o). West Wallsend Colliery is operated by Oceanic Coal Australia Limited (OCAL) on behalf of Macquarie Coal Joint Venture (MCJV). OCAL is the majority shareholder in MCJV with 70% ownership, with co-owners being Marubeni Coal Pty Ltd, OCAL Macquarie Pty Ltd and JFE Mineral (Australia) Pty Ltd (which also owns OCAL Macquarie Pty Ltd and is wholly owned by Glencore plc, previously Xstrata Coal (Australia) Pty Ltd) (Glencore, 2014o, 2014n). The current mining area includes the previously described Lachlan and Wakefield project areas (Glencore, 2014p). West Wallsend Colliery commenced in 1969, with Coal and Allied Industries Ltd developing a bord-and-pillar operation to extract the Borehole and Young Wallsend coal seams. In 1989, a longwall unit was installed to extract the Borehole coal seam and new longwall mining equipment was installed in 1997 to operate in a thicker seam section.

Majority ownership of West Wallsend has changed several times since establishment, although it has been owned by Xstrata since 2002 who were taken over by Glencore plc in 2013 (Glencore, 2014q). The current project life has been approved to 2027 (15 years from Project Approval sign off in 2012) under the continued operations plan (Department of Planning and Infrastructure, 2012, p. 26). The underground mining project may produce up to 5.5 Mt/year of ROM coal

(Department of Planning and Infrastructure, 2012, p. 3, p. 26) using longwall mining methods (Glencore, 2014q, 2014o, p. 4).

Coal is transferred into a Bradford Breaker (which removes impurities from the raw coal), conveyed to a 200 tonne load-out bin and loaded into haul trucks, then transported to the Macquarie Coal Preparation Plant (MCP) for processing. From there it is conveyed to a product stockpile and then to a rail load-out facility (Glencore, 2014q). Coal is screened and separated according to size and washed. Estimated measured coal resources as at 31 December 2013 were 65 Mt, and indicated coal resources were 25 Mt (no inferred coal resources stated) (GlencoreXstrata, 2014, p. 50).

Most product coal is transported to the Port of Newcastle for export, with the remainder being sold to the domestic market for coking. The mine supplies both thermal and semi-soft coking coal products, principally to Asian utilities and steel mills. A minor amount of coal is transported to the Eraring Power Station via internal haul road when required (Glencore, 2014q). West Wallsend Colliery currently mines coal from West Borehole coal seam (Glencore, 2014p, p. 1) although the Nobbys, Dudley and Yard coal seams (informal names) have been previously extracted. The thickness of the West Borehole coal seam varies from 3 to 6.5 m at the mine site. The roof of the West Borehole coal seam is predominantly the Nobbys Tuff claystone (Glencore, 2014q). The near-surface geology within the lease area comprises Permian sedimentary rock units (Newcastle Coal Measures). The structure and disposition of these strata is strongly influenced by the Macquarie Syncline, which trends north-north-west, bisecting the West Wallsend Colliery lease to the east of the underground mine. In this area the strata dip to the east at an angle of about 2 to 4 degrees (Glencore, 2014p, p. 1).

The mine plan aims to progressively rehabilitate disturbed areas to the same or better level of biodiversity, species abundance and landscape quality that was present prior to mining (Glencore, 2014q). Predicted land surface subsidence above underground workings is 0.34 to 2.52 m (Glencore, n.d.).

1.2.2.1.31 Wilpinjong Coal Mine

Wilpinjong Coal Mine is 40 km north-east of Mudgee in the Western Coalfield. It was bought by Wilpinjong Coal Pty Ltd in 2006, a wholly owned subsidiary of Peabody Energy Australia. The NSW Minister of Planning granted Project Approval 05-0021 under NSW's *Environmental and Assessment Act, 1979* in February 2006. Open-cut mining began in September 2006. Mining is currently undertaken by Wilpinjong Coal Pty Ltd under Mining Lease (ML) 1573 (Peabody Energy, 2014a, p. 1). Operations are planned to continue until 2027 (Peabody Energy, 2014a, p. 2).

The Project Approval for Wilpinjong has undergone six modifications to date. These have included increasing the ROM mining rate from 13 Mt/year to 15 Mt/year in 2010 (MOD3), and then to 16 Mt/year in 2014 (MOD6). Peabody Energy submitted the sixth modification to the Project Approval in 2014 to increase the mining surface area to 800 ha, comprising a 500 ha extension to the existing pit and a new 300 ha pit. The modification also sought approval for a 16 Mt/year mining rate of ROM coal, a 13 Mt/year production rate of thermal coal and the extension of mine life from 21 to 28 years. However, only the increase in the ROM coal mining rate was approved in the 2014 to 2019 Mining Operations Plan (MOP) (Peabody Energy, 2014b, p. 1). The mining

operations are undertaken over 1990 ha (including infrastructure) within six open-cut pits using strip mining configuration. Overburden is blasted and pushed to the previous void strip using bulk push dozers. It is then loaded in trucks using hydraulic excavators (Peabody Energy, 2014a, p. 24). The approved rate of waste rock production was increased from 28 million bank cubic metres (Mbcm) to 33.3 Mbcm in February 2014 (MOD5), then up to 34.1 Mbcm in December 2014 (MOD6) (Peabody Energy, 2014a, p. 10). Coal and interburden is sometimes blasted depending on its thickness and hardness, and is then pushed by dozers to the previous strip or hauled in the strip using haul trucks.

Coal is transported by the fleet of trucks on the internal haul roads to the ROM pad. Coal is loaded in the ROM hopper, although some is stored in the stockpile and later dumped in the ROM hopper (Peabody Energy, 2014a, p. 24). Coal is washed in the CHPP with a feed rate of approximately 8.5 Mt/year. The CHPP plant can process 6 Mt/year of saleable thermal coal. With the addition of the 6.5 Mt/year of bypass coal, the approved production rate of saleable coal is up to 12.5 Mt/year since MOD4 approval in 2012. The approved quantity of coal rejects (coarse rejects and tailings) is up to 2.5 Mt/year (Peabody Energy, 2011, p. 5). The coarse rejects are transported with the mining fleet and stored in the waste overburden dumps, while the tailings are transported via pipeline to the open-cut voids (Peabody Energy, 2014a, p. 24).

Coal is loaded at the train loading facility that operates at a rate of 4000 tonnes per hour, then railed east of the mine for the domestic product market or to the Port of Newcastle via the Gulgong–Sandy Hollow Railway. A reverse osmosis plant was installed in 2012 to treat mine water before it is discharged into Wilpinjong Creek (Peabody Energy, 2014a, p. 10). Rehabilitation is ongoing since 2008 in the mine waste rock emplacements and the tailings storage facilities, mainly involving revegetation of disturbed areas. From 2008 to 2013 about 180 ha of land was rehabilitated (Peabody Energy, 2014a, p. 105).

1.2.2.2 Coal seam gas

Santos and Dart Energy drilled seven CSG wells on PEL 456 with promising CSG potential in the thickest net coal pay in the north Sydney Basin (NSW Trade and Investment, 2013). Dart Energy completed four well-drilling programs with encouraging results in the Nelson Bay area and a pilot program was to be proposed to assess the CSG potential of the area (NSW Trade and Investment, 2013). However, Dart Energy has recently plugged a test drill site at Fullerton Cove and sold PEL 458 to another CSG firm, AJ Lucas. There are currently no coal seam gas operations in the Hunter subregion. Figure 8 shows current coal seam gas (CSG) tenements (as at 19 March 2015), which are owned by AGL Energy Limited (AGL), Santos Ltd (Santos) and Dart Energy Limited (Dart Energy).

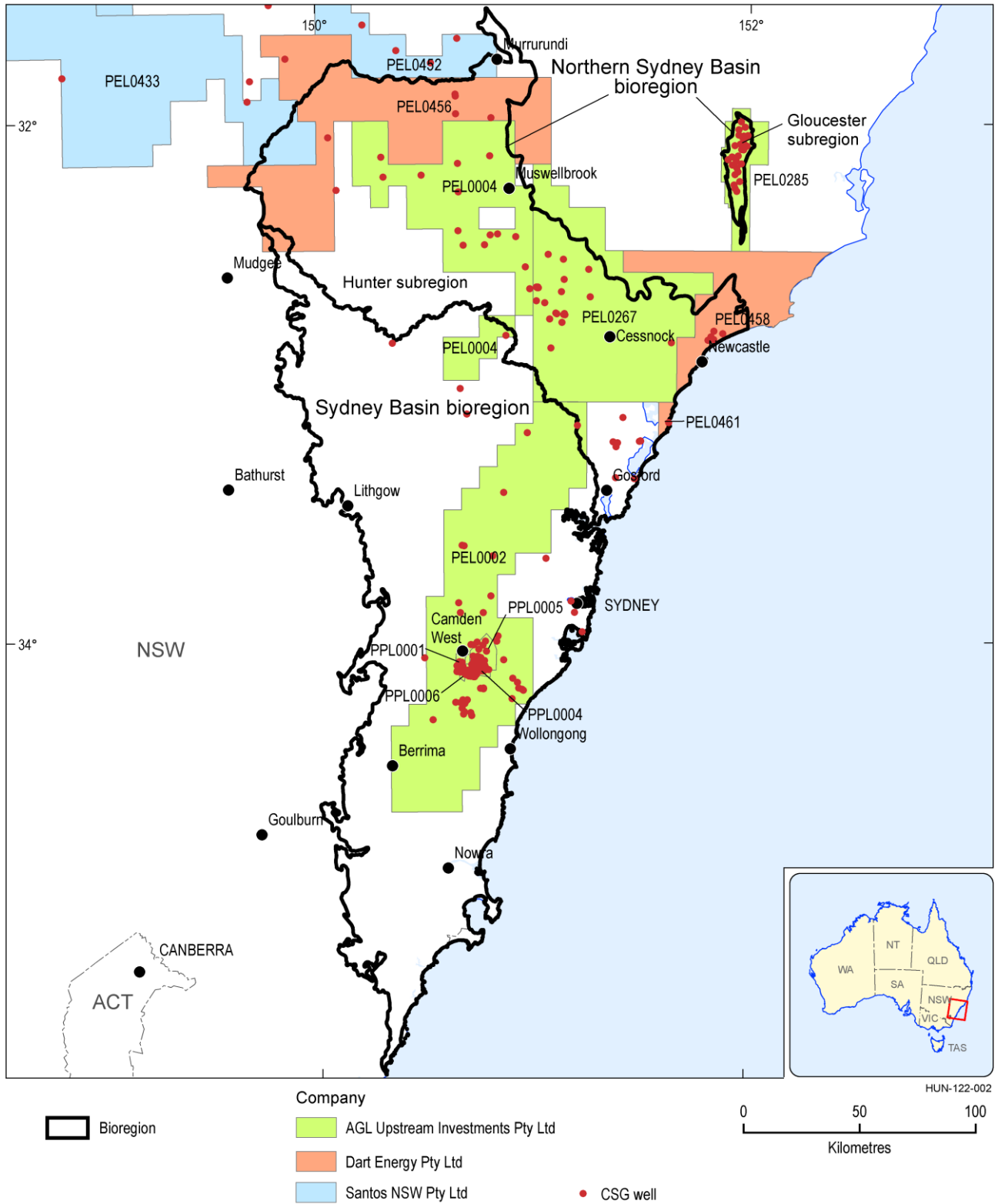


Figure 8 Map showing coal seam gas (CSG) tenements (as at May 2015), which are owned by AGL Energy Limited, Santos Ltd and Dart Energy Limited

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1.2.3 Proposals and exploration

Summary

This section summarises coal resource development exploration proposals that were known to be in train as at May 2015. New coal projects or extensions associated with existing operating mines and complexes in the Hunter subregion include Bulga, Chain Valley, Drayton South, Drayton, Mandalong, Mangoola, Mannering and Mount Owen. Other activities reported in this section include new coal mine projects such as the Bylong and Ferndale and exploration of deposits such as the Mitchell's Flat and Monash coal deposits. Locations of these proposed mines and projects are shown in Figure 9. Coal seam gas (CSG) activities in the Hunter subregion have generally been limited to a few exploration studies in the Hunter and Newcastle coalfields, including exploration by AGL Energy Limited (AGL) in an area to the south of Singleton; exploration by Santos Ltd (Santos) and Dart Energy Limited (Dart Energy) in the area between Murrurundi and Gulgong; and exploration by Dart Energy around Nelson Bay and Fullerton Cove. No information about future plans for these CSG projects was available at the time of writing.

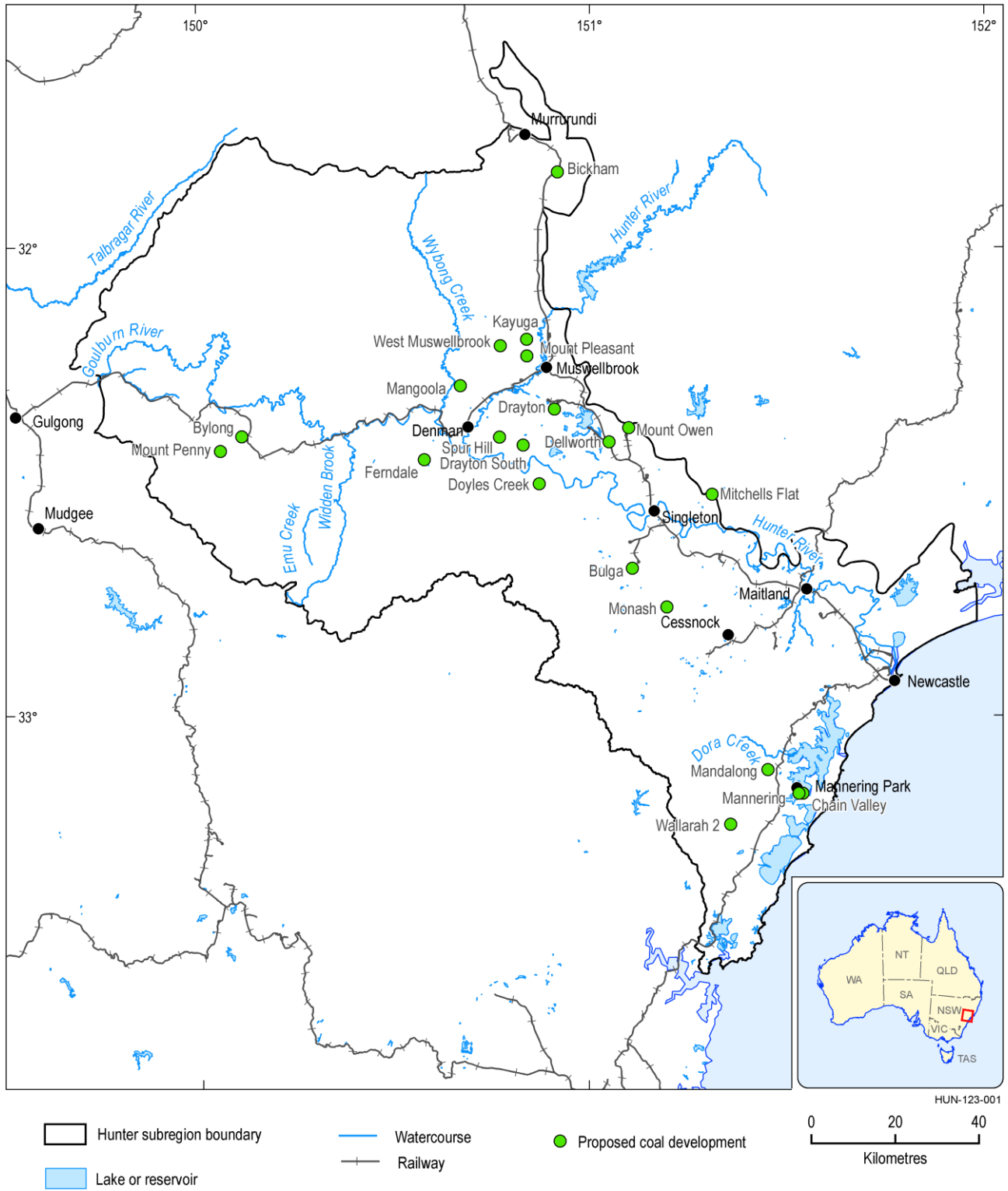


Figure 9 Coal resource development proposals in the Hunter subregion, as at May 2015

Data: Bioregional Assessment Programme (Dataset 1)

1.2.3.1 Coal

1.2.3.1.1 Bickham Coal Project

The Bickham Coal Project is owned by Bickham Coal Company Pty Ltd (Bickham Coal Company) and consists of Exploration Licence (EL) 5888 and EL 5306 approximately 12 km south-east of Murrurundi and 25 km north of Scone, in the northern part of the Hunter subregion (Bickham Coal Company Pty Ltd, 2013). The area of the exploration licences covers 1154 ha on which there are 127 boreholes including water bores, cored bores and some geophysically logged holes (Bickham Coal Company Pty Ltd, 2013a). Thermal coal resources of 36.3 Mt (Ewers et al, 2002) were been identified at the Bickham Coal Project and further exploration has identified a potential underground resource of an additional 210 Mt of coal.

Initially both open-cut and underground mining had been proposed at Bickham. In 2009 the Bickham Coal Project Water Resource Assessment and Draft Water Management Plan was presented to the New South Wales Department of Planning (Bickham Coal Company Pty Ltd, 2009). After an independent review of the proposal by the Planning Assessment Commission (PAC), in May 2010, the NSW PAC announced that the Bickham open-cut coal mine would not proceed (Bickham Coal Company Pty Ltd, 2010; NSW Government, 2010). The reason for this was risk of water contamination and drainage, and the incompatibility of land use, threatening the viability of the region's internationally renowned thoroughbred breeding industry (Bickham Coal Company Pty Ltd, 2010). A ground and surface water impact assessment has been performed and proposed measures to minimise risk of impacts have been identified (Bickham Coal Company Pty Ltd, 2009, p. A-11). In 2004, Bickham Coal Company announced that preliminary work had started on the commencement of an environmental impact statement (EIS) (Bickham Coal Company Pty Ltd, 2004) although to date no EIS has been submitted.

1.2.3.1.2 Bulga Coal Optimisation Project and Blakefield North Underground Mine

Bulga Coal Management Pty Ltd has consent for the Bulga Coal Optimisation Project (BOP). The EIS was submitted in 2013 and in January 2014 the NSW Minister for Planning and Infrastructure requested that the NSW Planning Assessment Commission review the project and conduct a public hearing (SLR Consulting Australia Pty Ltd, 2014, p. 2–3). The NSW Planning Assessment Commission public hearing regarding the project was held on 25 June 2014 and development consent for the BOP was given on 1 December 2014 (NSW Department of Planning and Environment, 2015a).

The BOP expands and continues the Bulga open-cut mining operations to access 205 Mt of coal from seams within and beneath the existing open-cut mine until 2035 (increasing current approved operations by an additional 11 years) (NSW Department of Planning and Environment, 2014a, p. i). Continuing operations to the previously approved 12.2 Mt/year will extract coal from three contiguous pits (Main Pit, South Pit and East Pit) and proposes one smaller pit (Bayswater Pit). The proposal includes two new out-of-pit overburden emplacements, realignment of infrastructure currently within the proposed footprint, continued use of the coal handling and preparation plant (CHPP) and the Saxonvale Rail Loop to transport coal via rail to Newcastle Port. There will be progressive rehabilitation of over 2500 ha of native woodland species and a biodiversity offset strategy incorporating 1500 ha of existing native woodland to compensate for

611 ha that will be cleared as a result of the project (NSW Department of Planning and Environment, 2014a, p. i–ii, p. 1, p. 5).

Infrastructure will include the construction of a new 3000 ML water storage dam (Northern Dam), sewage treatment plant, upgrades to the existing CHPP and new conveyors (NSW Department of Planning and Environment, 2014a, p. 8). The optimisation project requires up to approximately 6900 ML of water per year that will be supplied by captured rainfall, groundwater inflows and licensed extraction from the Hunter River. The existing water management system will be augmented by the construction of a new 300 ML water dam (Northern Dam). Total operating life will be 21 years (NSW Department of Planning and Environment, 2014a, p. 6).

1.2.3.1.3 Bylong Coal Project

The Bylong Coal Project is in the Upper Bylong Valley, approximately 95 km from Mudgee and 220 km from the Port of Newcastle (KEPCO, 2014; Cockatoo Coal Limited, 2013a). Korea Electric Power Corporation Bylong Australia Pty Ltd (KEPCO) appointed WorleyParsons to manage the project. KEPCO are holders of Authorisation 287 (granted in 1982) and Authorisation 342 (granted in 1984) over an area of approximately 10,300 ha (KEPCO, 2011; KEPCO, 2015). KEPCO purchased the Bylong Coal Project from Anglo American plc in 2010 (Cockatoo Coal Limited, 2013a). In January 2014, a Gateway assessment application was submitted for review by the independent panel to assess the potential impact on the environment and to provide recommendations that will be considered when the project submits its EIS to the New South Wales Government (NSW Government). The Gateway certificate was granted on 16 April 2014.

Exploration to date has defined a mineable, economic coal resource of approximately 121 Mt within the authorisation area (KEPCO, 2014). The project is expected to produce up to 6 Mt/year of run-of-mine (ROM) coal that will be processed in the onsite CHPP providing an output of approximately 4 to 5 Mt/year of product coal (KEPCO, 2014). The plan is to mine underground in addition to two open-cut areas, extracting thermal coal for the export and domestic market, with construction proposed to start around 2016 (Cockatoo Coal Limited, 2013a). The open-cut mine life is planned for approximately 8 years with progressive rehabilitation occurring, and the longwall underground mine is planned to operate for 22 years, starting around project year 7 (KEPCO, 2014). KEPCO announced an EIS and a development application for submission to the NSW Department of Planning and Infrastructure (now NSW Department of Planning and Environment) (Cockatoo Coal Limited, 2013b, p. 1) were being prepared in June 2014. NSW Department of Planning and Environment confirmed to KEPCO that an EIS needs to be lodged by 23 June 2016 or they must consult further with the Department (NSW Department of Planning and Environment, 2014b). No further announcements have been made regarding the EIS as at 20 May 2015.

1.2.3.1.4 Chain Valley Modification 1

The Chain Valley Modification 1 Project proposes to construct an underground link between the current Chain Valley Colliery (CVC) and Mannering Colliery (MC) within the Fassifern coal seam (EMGA Mitchell McLennan Pty Ltd, 2014a, p. E.1). The MC is owned by Centennial Mannering Pty Ltd, a wholly owned subsidiary of Centennial Coal Company Ltd (EMGA Mitchell McLennan Pty Ltd, 2014a, p. E.4; EMGA Mitchell McLennan Pty Ltd, 2014b, p. E.1). Mining commenced at the MC in

1960 using bord-and-pillar and longwall mining of the Great Northern and Fassifern coal seams. Since 2008, the MC has been approved to produce up to 1.1 Mt/year of ROM coal until March 2018 (EMGA Mitchell McLennan Pty Ltd, 2014a, p. E.4–E.5).

Mining operations were halted at the MC in November 2012 and it was placed on care and maintenance. However, in late 2013 the owners of CVC (LakeCoal Pty Ltd (LakeCoal)) and MC entered into an agreement enabling LakeCoal to operate the MC until 2022 (effective 17 October 2013) (EMGA Mitchell McLennan Pty Ltd, 2014a, p. 4). Work as part of the CVC modification project will include the installation and use of an underground conveyor belt system and ancillary services, enabling ROM coal to be transferred on conveyors between the CVC and MC. MC infrastructure will transport coal from CVC underground workings to the Vales Point Power Station at a rate of no more than 1.1 Mt/year (EMGA Mitchell McLennan Pty Ltd, 2014a, p. E.5).

Groundwater modelling of CVC's approved operations predicts that median annual groundwater inflow to the Fassifern workings will increase to 3832 ML (from the current 2773 ML) once miniwall mining in Area 1 approaches its fullest lateral extent (EMGA Mitchell McLennan Pty Ltd, 2014a, p. E.7, p. 30). CVC's licence under NSW's *Water Act 1912* allows for extraction of 4443 ML/year for the purposes of mine dewatering and industrial use (EMGA Mitchell McLennan Pty Ltd, 2014a, p. E.7). The current approval for the CVC (SSD-5465) was granted by the NSW Minister for Planning and Infrastructure on 23 December 2013, which allows for continued mining within the Fassifern coal seam and incorporates the operations approved under MP10_0161, as modified (EMGA Mitchell McLennan Pty Ltd, 2014a, p. 7). Proposed modification does not cause changes to surface infrastructure or approved areas of surface disturbance, and mine rehabilitation plans are therefore not impacted (EMGA Mitchell McLennan Pty Ltd, 2014a, p. 36). The CVC currently operates under development consent SSG-5465, which was granted on 23 December 2013 by the NSW Minister for Planning and Infrastructure (EMGA Mitchell McLennan Pty Ltd, 2014a, p. E.1).

1.2.3.1.5 Dellworth Project

The Dellworth Project, owned by NuCoal Resources Ltd is anticipated to have more than 10 years mine life (NuCoal Resources Ltd, 2012). The site (under EL 6594, valid until July 2015) is approximately 20 km north of Singleton (NuCoal Resources Ltd, 2012) and 4 km north-north-west of Ravensworth. In June 2014, NuCoal Resources Ltd reported that although thermal coal resources have been identified at Dellworth for the domestic market, the resources at its other nearby project (Savoy Hill) are more marketable and lower cost than at Dellworth, so the company is concentrating on Savoy Hill for the time being (NuCoal Resources Ltd, 2012; NuCoal Resources Ltd, 2014a, p. 2). Further independent geological assessments are being undertaken to determine the viability of pursuing an assessment lease for the Dellworth tenement area (NuCoal Resources Ltd, 2014b, p. 1). Target seams at the Dellworth Project are the Bayswater Coal Member at the base of the Burnamwood Formation of the Wittingham Coal Measures (NuCoal Resources Ltd, 2012). A preliminary concept study by Palaris provided a draft mining plan for the prospective areas over a 10-year anticipated mine life producing 500 kt/year to 1 Mt/year of coal for domestic consumers (NuCoal Resources Ltd, 2012, p. 1). As at 6 January 2015, no EIS has been submitted.

1.2.3.1.6 Doyles Creek

The Doyles Creek Project is located in the Hunter Valley about 20 km north-north-west of Singleton and has been cancelled. According to the OZMIN database (Geoscience Australia, 2015), resource tonnage of 173.7 Mt of thermal coal has been reported. In 2009, NuCoal Resources Ltd acquired all of the issued capital of Doyles Creek Mining Pty Ltd along with the relevant exploration licence (EL 7270). In December 2013, the Independent Commission Against Corruption (ICAC) recommended that EL 7270 be expunged or cancelled as the granting of EL 7270 was linked to suspicions of corruption (ICAC, 2013, p.6). In January 2014, the NSW Government acted on this recommendation and cancelled EL 7270 (NuCoal Resources Ltd, 2015). The company is assessing remaining assets held in the Doyles Creek area (NuCoal Resources Ltd, 2014b), although the future of the prospect is currently unclear.

1.2.3.1.7 Drayton South Coal Project

Anglo American Metallurgical Coal Pty Ltd (AAMC) and its joint venture partners sought approval for the Drayton South Coal Project to extend the life of the Drayton Mine, located 13 km south of Muswellbrook, which is due to run out of reserves in 2015 (Anglo American, 2015). The planned project was to develop a new open-cut and highwall mining operation to extract up to 7 Mt/year of ROM coal for a further 27 years (NSW Planning Assessment Commission, 2013). The NSW Planning and Assessment Commission (PAC) rejected the plan on 21 October 2014. The project did not: (i) provide a sufficient buffer to protect Coolmore and Darley from the impacts of mining as recommended in the PAC Review Report and the Gateway Panel Report, (ii) demonstrate it will not adversely impact on equine health and (iii) act in the public interest (NSW Planning Assessment Commission, 2014, p. 2). On 23 January 2015, a Gateway Application for the Drayton South Coal Project was submitted to the NSW Mining and Petroleum Gateway Panel who issued the Gateway Certificate on 2 April 2015 (NSW Mining and Petroleum Gateway Panel, 2015).

1.2.3.1.8 Drayton Mine Extension Project

The Drayton Mine Extension Project plans to extend the life of Drayton Mine by a further 15 years. Based on current operations, mining is expected to finish at Drayton in 2015. The extension project aims to access 75 Mt of thermal coal for export, maintaining an average extraction rate of 6 Mt/year ROM coal (with maximum rate of 7 Mt/year) using excavator and dragline (Hansen Bailey, 2014, p. 1). The project plans to use existing assets and infrastructure at Drayton Mine, and will progressively rehabilitate mine areas as resources are exhausted.

The proponent claims that the Drayton Mine Extension Project addresses NSW Government concerns that previously led to refusal of the Drayton South Project, and that the project includes provision of a sufficient buffer zone to nearby horse studs, to protect equine health in neighbouring areas. The project applicant is AAMC, the current managers of the existing operations, and is the controlling partner of the Drayton Joint Venture and the Drayton South Venture along with Mitsui Coal Development (Australia) Pty Ltd, Mitsui Mining Australia Pty Ltd, Hyundai Australia Pty Ltd and Daesung Australia Ltd (Hansen Bailey, 2014, p. 6). On 19 December 2014, the NSW Director General's requirements for the environmental assessment were issued, providing specific instructions on issues that must be addressed in the EIS including, for example, air quality impacts, likely impacts on local horse studs, noise, land and water (NSW Department of

Planning and Environment, 2014c, p. 2–3). No new changes have been identified as at 25 March 2015.

1.2.3.1.9 Ferndale Project

Loyal Coal Pty Ltd and Yarrowa Coal Pty Ltd (each 100% owned subsidiaries of Coalworks Limited (Coalworks)) originally co-owned (50%) the Ferndale Project with joint venture partner Boardwalk Ferndale Pty Ltd. In 2014, Whitehaven Coal Limited (Whitehaven Coal) acquired Boardwalk Ferndale Pty Ltd. On 17 February 2012, Coalworks announced an inferred resource in EL 7430 of 743 Mt of bituminous coal (Coalworks Limited, 2012, p. 1). Of this, 443 Mt has been identified within the Newcastle Coal Measures at depths amenable to open-cut mining to a maximum depth of 250 m below surface (Whitehaven Coal Limited, 2014, p. 4; Coalworks Limited, 2012, p. 1). A further 300 Mt of coal is inferred within the deeper Wittingham Coal Measures with underground mining potential (Coalworks Limited, 2012, p. 1) to a maximum depth of 500 m (Whitehaven Coal Limited, 2014, p. 4). The project will target thermal coal from the open-cut mine and semi-soft coking coal from the underground operation.

EL 7430 expired on 17 December 2014 (Whitehaven Coal Limited, 2014) and the status of its renewal, the EIS and therefore the continuation of this project is unclear (7 January, 2015).

1.2.3.1.10 Kayuga Project

The Kayuga project is located 250 km north-west of Sydney in the Upper Hunter Valley, about 10 km north-west of Muswellbrook. It is owned by Anglo Coal (Dartbrook Management) Pty Ltd. The Kayuga project is part of the Dartbrook Mine, which has been offered for sale in 2015 (Anglo American, 2014). The Kayuga project applied for mining leases over two portions of land and both applications received objections in the NSW Court of Appeal (2000). Kayuga Coal Pty Ltd disputed the objections but it was found the land contains 'improvements', such as fences, or characteristic features of the agricultural land. In 2000, Kayuga Coal Pty Ltd proved that the characteristic features could not be included in the 'improvements' specified in S62(1) of the NSW *Mining Act 1992* but they could not prove that the fences were not included in these 'improvements' (New South Wales Court of Appeal, 2000). The size of the Kayuga coal resource is not evident and has not been reported in the OZMIN database.

1.2.3.1.11 Mandalong Southern Extension

Mandalong is an underground longwall coal mine, operated by Centennial Mandalong Pty Ltd (GSS Environmental, 2013, p. i). The company has sought approval for the Mandalong Southern Extension Project to extend its existing underground mining operations into the Southern Extension Area and utilise existing and proposed new surface infrastructure within EL 6317. The project seeks to extract up to 6 Mt/year of ROM coal from the West Wallarah and Wallarah-Great Northern coal seams, extending the life of mine. Although consent has not been finalised, the draft consent document states that mining operations may continue until the end of 2040 (NSW Department of Planning and Environment, 2015, p. 5). An EIS has been submitted and the project is under review (GSS Environmental, 2013, p. iii). The EIS reported that groundwater inflows into the underground workings are predicted to increase from 3 ML/day (in 2018) to 5.9 ML/day (in 2035 to 2036) (GSS Environmental, 2013, p. iv). The EIS also indicated no significant adverse

impacts on existing catchment boundaries and watercourse alignments. A draft development consent was prepared in January 2015, which is currently under review by the NSW PAC, as at 26 March 2015 (NSW Planning Assessment Commission, 2015).

1.2.3.1.12 Mangoola Coal Exploration Program

The Mangoola Coal Exploration Program was undertaken during 2014 to better understand coal resource potential within the Authorisation Lease (AL) 9 and EL 5552 areas (Glencore, 2014a). The mine is currently approved to produce 13.5 Mt/year (Project Approval 06_2014, approved 28 April 2014) (NSW Department of Planning and Infrastructure, 2014a). Further details or results of the program have not yet been released (as at 7 January 2015).

1.2.3.1.13 Mannering Colliery Modification 2

Mannering Colliery is currently under care and maintenance (see also Section 1.2.2 and also Section 1.2.3.1.4). Mannering Colliery Modification 2 was approved on 27 November 2014. The modification will include construction of an underground linkage between the CVC and the MC within the Fassifern coal seam workings (NSW Department of Planning and Environment, 2014 d). Approval was given with conditions specifically regarding landscape and rehabilitation and the mining closure plan (NSW Department of Planning and Environment, 2014 d). Further details of the current operation have been provided in Section 1.2.2.

1.2.3.1.14 Mitchells Flat Project

The Mitchells Flat deposit contains mainly Wittingham Coal Measures and is located 12 km east of Singleton. The deposit is owned by Glencore plc. The project was approved as an underground coal mine in 1991 and received a mining lease in 1993. It also has shallower coal resources that are potentially amenable to open-cut development. The inferred and indicated coal resources at Mitchells Flat are estimated to be 160 and 112 Mt, respectively, and total resources stated in the OZMIN database are 520 Mt. These resources can produce steaming coal and soft coking coal (Glencore, 2015).

1.2.3.1.15 Monash Deposit

The Monash Deposit is 95 km north-west of Newcastle (Gloucester Coal, 2011, p. 11). It is wholly owned by Yancoal Australia Ltd (Yancoal), which has been granted two exploration licenses: EL 6123 and EL 7579 (Gloucester Coal, 2011, p. 20). According to the OZMIN database the total resources for Monash are estimated to be 577 Mt. Two types of coal can be produced from this deposit: metallurgical and thermal coal (Yancoal, 2014, p. 26). The life of a mine at this deposit is estimated to be more than 20 years with a ROM potential of up to 9 Mt/year (Gloucester Coal, 2011, p. 20).

1.2.3.1.16 Mount Owen Continued Operations Project

Mount Owen Continued Operations Project proposes to extend the life of the existing Mount Owen Complex (see Section 1.2.2) (Glencore, 2013, p. 3; Glencore, 2014b, p. 1). It will further develop the northern part of the previously disturbed Ravensworth East Mine, referred to as the Bayswater North Pit (BNP), in addition to changes to the current North Pit (Glencore, 2014b, p. 1). The project EIS was submitted in January 2015 (Umwelt (Australia) Pty Limited, 2015).

The project seeks to:

- extract approximately 74 Mt of ROM coal from the North Pit Continuation through open-cut methods, extending mining until approximately 2030
- maintain the current approved Ravensworth East extraction rate of 4 Mt/year
- extract approximately 12 Mt/year of ROM coal from the BNP followed by extraction of 6 Mt of ROM coal from the Ravensworth East Resource Recovery Project (RERR) mining area (Umwelt (Australia) Pty Limited, 2015, p. 2).

Infrastructure approval is also sought including upgrades and improvements to the existing CHPP and stockpile facilities (Umwelt (Australia) Pty Limited, 2015, p. 3). The EIS public exhibition period ended on 6 March 2015 and public submissions are currently being reviewed by Glencore (NSW Department of Planning and Environment, 2015b).

1.2.3.1.17 Mount Penny Deposit

Mount Penny is a thermal coal deposit located 60 km north-east of Mudgee on EL 7406. It is owned by Cascade Coal Pty Ltd (Cascade Coal) and includes 95.3 Mt of measured resource and 22.3 Mt of indicated resource (Mt Penny Coal Pty Ltd, 2011, p. 4). The initial development plan for Mount Penny involved a new open-cut mine, producing 5 Mt/year of ROM coal over at least 21 years (Mt Penny Coal Pty Ltd, 2011, p. 8, p. 19). Cascade Coal intended to use the produced thermal coal for export and domestic markets. Production was to have been supported by facilities such as a bi-directional rail loop, administration and storage complex, workshop, and CHPP (Mt Penny Coal Pty Ltd, 2011, p. 8).

The exploration licences originally held by Cascade Coal were cancelled by the NSW Government in 2013 following adverse findings by the ICAC (NSW Parliament, 2014). The future of the Mount Penny Deposit is currently uncertain.

1.2.3.1.18 Mount Pleasant Mine Project

Mount Pleasant has been owned by Coal and Allied Industries Limited (Coal and Allied) since 1992. Exploration, mining studies and an EIS were completed in 1997, and development consent was originally granted in 1999. Production was initially estimated at up to 10.5 Mt/year of ROM thermal coal for international markets. The deposit has proved and probable reserves of 394 Mt of thermal coal, and over 1 Bt of identified resources (Rio Tinto, 2015). The mine project is 4 km from Muswellbrook and has four proposed pits: the North Pit, the South Pit, the Piercefield Pit and the Warkworth South Pit. The deposit trends 5 km north to south and is 6 km wide. It extends to a depth of approximately 220 m below the topographic surface (Rio Tinto, 2015). Modification 1 to the project (Mt Pleasant Coal Mine – Modification 1) was approved in September 2011 including updates to the EIS, which provided consent for mining operations to be carried on until December 2020 (NSW Department of Planning and Environment, 2015c). As at May 2015, no mining has commenced at Mt Pleasant Coal Mine, and it continues to be the subject of ongoing development studies.

The proposed Mount Pleasant Mine is an open-cut mining operation using a truck and shovel method. Around 350 employees would work in shifts to keep the mine operational 24/7 (Rio Tinto,

2015). Mining infrastructure would be constructed in the south-west corner of the project area, including a CHPP and associated coal stockpiles, an industrial area with workshops, administration and employee facilities, and a rail loading facility including a rail loop extending from the Muswellbrook–Ulan Rail line. Coarse rejects from the CHPP would be hauled by truck to the overburden emplacements. Fine rejects would be directed to a fines reject emplacement facility on the western side of the project area. Water requirements for the mine would be met through mine pit inflows, harvesting of catchment runoff and make-up water from the Hunter River. Water would primarily be used in the CHPP for dust suppression and ancillary uses such as vehicle wash-down. Water storages would be designed and sized appropriately to capture the estimated volumes of water through harvesting of catchment runoff and estimated make-up requirements. The release of water from these storages would accord with the Hunter River Salinity Trading Scheme and other regulatory requirements (Coal and Allied Operations Pty Ltd, 2011, p. 65).

The possible threatened fauna are considered to have limited impacts from activities that occur in the project area (Coal and Allied Operations Pty Ltd, 2011, p. 128). The duration and timing of impacts in the project area will occur based on the following development sequence: vegetation clearing and topsoil removal, overburden removal, coal extraction, placement of overburden in the previously mined area, final landform shaping, and replacement of topsoil and revegetation. When mining is completed the removal of vegetation for pit development will stop (Coal and Allied Operations Pty Ltd, 2011, p. 154). The mine will be rehabilitated to its final landform with reshaping and rehabilitation lagging by three years. The final mining area will be contoured and shaped. Parts of the final shape will be steep slopes and water-filled voids which will not support similar vegetation to the rest of the mine, resulting in an overall reduction in revegetated area (Coal and Allied Operations Pty Ltd, 2011, p. 125).

1.2.3.1.19 Spur Hill Project

The Spur Hill Project is wholly owned by Malabar Coal Ltd (Malabar Coal). Located in the Upper Hunter Valley, it is 3 km east of Denman and 15 km south-west of Muswellbrook (Malabar Coal, 2015). The exploration activities and environmental studies began in January 2012. On 10 December 2013, Malabar Coal received approval to undertake the Spur Hill Coal Exploration Drilling Program. During environmental studies it has been shown that changes to agricultural productivity will not be significant over the long term (Spur Hill, 2013a, p. 25) and that activities will not affect the environment or threatened species, populations or ecological communities (Spur Hill, 2013b, ES-2).

The proposed underground mine is expected to produce coking coal using the longwall mining method (Spur Hill, 2015). The production will be approximately 154 Mt of ROM coal over the life of mine, which represents up to 8 Mt/year ROM coal (mine life up to 25 years, including construction, development and operation). A total resource of 625.9 Mt is reported (Spur Hill, 2015). Facilities such as a CHPP, rail spur and loop are proposed for handling, processing and transporting coal. The project will develop a water management system comprising water storages, sumps, pumps, pipelines, sediment control, mine dewatering and sewage treatment facilities (Spur Hill, 2013a, p. 9). The rehabilitation of disturbed areas will be progressive during the mine life and the rehabilitation of mine-related infrastructure areas will occur at the end of the

project (Spur Hill, 2013a, p. 9). As at 25 March 2015, only Director General's Requirements were issued but no EIS has been submitted for Spur Hill.

1.2.3.1.20 Wallarah 2

Walarah 2 is a proposed underground mine 100 km north of Sydney on the Central Coast (NSW Government, 2011, p. 3). The mine is owned by Wyong Coal Pty Ltd. Expected production may be up to 5 Mt/year of coal over 28 years, using longwall mining methods (Earth Systems, 2013, p. 11, p. 20). Coal is proposed to be exported from Newcastle (NSW Government, 2011, p. 3). The depth of the mine is likely to range from 345 to 690 m below ground level (NSW Department of Planning and Infrastructure, 2014a, p. 20).

Onsite facilities include staff amenities, ventilation systems and service boreholes, water bores and surface water management infrastructure, bulk storage facilities and a rail provisioning facility (NSW Government, 2011, p. 9). Exploration drilling commenced in June 1996 and was completed in 2002 with a total of 352 boreholes, followed by five larger diameter boreholes that were drilled to assist with coal characterisation (NSW Government, 2011, p. 7; Hansen Bailey, 2013, p. 12).

The project was refused in 2011 by the Minister for Planning because of uncertainty about the subsidence predictions, inadequate studies of the potential surface water quality impacts, uncertainty about ecological impacts and uncertainty around the heritage impacts. The project was resubmitted in 2013 (Earth Systems, 2013, p. 32). PAC reviewed the project in 2014 and although a number of conditions related to water-related impacts were suggested (PAC, 2014, p. iii), as at mid-2015, the Department has not finalised its Final Assessment Report. The project has encountered legal difficulties as the project does not have legal consent of the owner of some of the land for its development application to be determined (Colin Phillips, NSW Department of Planning and Environment, pers. comm.).

1.2.3.1.21 West Muswellbrook Project

As part of the Muswellbrook No.2 Coal Mine, a gateway application has been made for the West Muswellbrook Project. The gateway application seeks assessment for a Gateway Certificate that will confirm their proposal meets the required criteria to proceed with a development application. At the time of writing, a determination has not been made by the Gateway Panel and thus no development application has been made (NSW Government Mining and Petroleum Gateway Panel, 2015).

1.2.3.2 Coal seam gas

CSG activities in the Hunter subregion have generally been limited to a few exploration studies in the Hunter and Newcastle coalfields. According to Ward and Kelly (2013, p. 41) the main CSG exploration in the Hunter Coalfield was the AGL Hunter Gas Project focused on an area to the south of Singleton. AGL announced an initial reserve estimates of 142 PJ 2P (proved plus probable) and 271 PJ 3P (proved plus probable plus possible) in October 2010 (Ward and Kelly, 2013, p. 41). However, in 2013, AGL revised their Hunter reserves to 0 due to the effects of the NSW Government's Strategic Regional Land Use Policy (AGL, 2013, p.2). Santos and Dart Energy also explored for CSG resources in the area between Murrurundi and Gulgong, drilling seven CSG wells on PEL 456 with promising CSG potential in the thickest net coal pay in the north Sydney Basin

(NSW Trade and Investment, 2013). In the Nelson Bay area, Dart Energy completed four well-drilling programs that showed encouraging results. Consequently, a pilot program was to be proposed to assess the CSG potential of the area (NSW Trade and Investment, 2013). Dart Energy was also exploring for CSG in the Tomago Coal Measures of the Fullerton Cove area on PEL 458, in the northern part of the Newcastle Coalfield (Ward and Kelly, 2013, p. 41) but recently finished plugging a test drill site at Fullerton Cove and sold PEL 458 to another CSG firm, AJ Lucas.

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1.2.4 Catalogue of potential resource developments

Summary

This section summarises all of the proposals for coal resource development in the Hunter subregion post-December 2012 identified in the mine activity summaries in Section 1.2.2 and Section 1.2.3.

In all 42 post-December 2012 proposals are identified, including 27 proposals to extend existing operations and 15 proposals to initiate new mines. This list will be used as the basis for defining the additional coal resource developments (ACRD) to be modelled in the coal resource development pathway (CRDP) (see product 2.3).

No known coal seam gas (CSG) developments are currently proposed for this subregion.

In this section, information provided in Section 1.2.2 and Section 1.2.3 of this report is used to compile a list of coal mines in the Hunter subregion which have post-December 2012 expansion or new development plans. Table 5 lists 42 proposals, including 27 coal mines with expansion plans and 15 potential new mines. The locations of these coal developments are shown in Figure 10, noting that where a mine has two proposals it is represented by a single point on the map.

The Notes field includes information, obtained from mine environmental impact statements, NSW Government websites and company reports, on whether advice from the Independent Expert Scientific Committee on Coal Seam Gas and Large Coal Mining Development (IESC) has been sought. As at March 2015, some proposals were pre-EIS or awaiting EIS approval, some were approved but not yet commenced and some had commenced.

A map showing lease areas for CSG exploration held by three companies in the Sydney and Gloucester Basin areas is included at the end of Section 1.2.2. These companies are AGL Upstream Investments Pty Limited (AGL Upstream Investments), Dart Energy Limited (Dart Energy), and Santos Ltd. As at March 2015, no there were no coal seam gas proposals in the Hunter subregion.

Table 5 Potential post-December 2012 coal resource developments in the Hunter subregion, as at 10 March 2015.

Mine name	Complex name	Owner	Longitude	Latitude	Status of EIS ^a	Notes
Ashton		Yancoal Australia Ltd	151.07°	-32.47°	EIS for modification 5 – SE open cut submitted November 2009	Recommendation made to NSW Planning Assessment Commission August 2011. Maximum permitted production rate of 2.25 million tonnes per annum (Mt/y) (Wells Environmental Services, 2012, p. 4, Table 1)
Ashton ^b		Yancoal Australia Ltd	151.07°	-32.47°	EIS approved	Ashton purchased December 2009. Maximum permitted production rate of 3.2 Mt/y (Wells Environmental Services, 2012, p. 4, Table 1)
Austar ^b		Yancoal Australia Ltd	151.31°	-32.87°	EIS approved	Known as Southland Coal Mine from December 2004, previously known as Pelton Colliery and existed for about 100 years. Maximum permitted production rate of 3.6 Mt/y (Umwelt Australia Pty Ltd, 2011, p. 4, Table 1)
Bengalla		Wesfarmers Limited	150.85°	-32.27°	EIS approved	Extension approved March 2015. IESC advice 24 May 2013. Maximum permitted production rate of 15 Mt/y (Hansen Bailey, 2014b, p. 3, Table 1)
Bickham ^b		Bickham Coal	150.918°	-31.844°	Pre-EIS	Proposed new mine.
Bloomfield		Bloomfield Group	151.58°	-32.79°	EIS approved	Modification 3 approved February 2013. Maximum permitted production rate of 1.3 Mt/y (Bloomfield Group, 2012)
Bulga	Bulga Coal Complex	Bulga Coal Management Pty Ltd (Glencore)	151.11°	-32.69°	EIS approved	IESC advice 10 February 2014. Maximum permitted production rate of 12.2 Mt/y from the open cut operations but not exceeding 20 Mt/y for open cut and underground operations combined (Umwelt Australia Pty Ltd, 2013, p. 12, Table 2.1)
Bylong ^c		KEPCO Bylong/Cockatoo	151.11°	-32.407°	EIS by June 2016	Two open-cut mines. IESC advice 4 March 2014. Open cut and underground operations have a combined maximum permitted production rate of 6 Mt/y (Hansen Bailey, 2014a, p. 4).
Bylong ^{b, c}		KEPCO Bylong/Cockatoo	151.11°	-32.407°	EIS by June 2016	Open cut and underground operations have a combined maximum permitted production rate of 6 Mt/y (Hansen Bailey, 2014a, p. 4).
Chain Valley ^b		LakeCoal Pty Ltd	151.55°	-33.17°	EIS approved	Link to Mannering Mine. Maximum permitted production rate increased from 1.2 Mt/y to 1.5 Mt/y in 2013 (EMGA Mitchell McLennan, 2012, p. E.1)
Dellworth ^{b, c}		NuCoal Resources Ltd	151.05°	-32.42°	Pre-EIS	Savoy Hill more likely to proceed than Dellworth
Doyles Creek ^c		NuCoal Resources Ltd	150.871°	-32.51°	Pre-EIS	Exploration licence EL 7270 cancelled by NSW Government 31 Jan 2014
Drayton		Anglo American	150.91°	-32.35°	EIS in preparation	Mine extension. Director General Requirements issued December 2014. Maximum permitted production rate of 8 Mt/y (Hansen Bailey, 2011, p. 1)
Drayton South			150.83°	-32.427°		IESC advice 23 February 2015. Maximum permitted production rate of 6.4 Mt/y (Hansen Bailey, 2015, p. 1)
Ferndale ^{b, c}		Whitehaven Coal Limited	150.577°	-32.469°	Pre-EIS	Proposed new mine.
Kayuga ^c		Anglo American	150.839°	-32.201°	Pre-EIS	Proposed new mine.
Liddell	Mount Owen Complex	Glencore/Mitsui	151°	-32.395°	EIS approved	Modification 5 was approved March 2015. IESC advice 10 April 2014. Maximum permitted production rate of 8 Mt/y (SLR, 2013a, p. ii)
Mandalong southern extension ^{b, c}		Centennial Coal Company Ltd	151.46°	-33.12°	EIS submitted	Purchased in 2002. Maximum permitted production rate of 6 Mt/y (GSS Environmental, 2013, p. 67)
Mangoola		Glencore	150.67°	-32.3°	EIS approved	Formally known as Anvil Hill Mine. Maximum permitted production rate of 13.5 Mt/y (EMGA Mitchell McLennan, 2013, p. 23)
Mannering ^b		Centennial Coal Company Ltd	151.54°	-33.17°	EIS approved	Link to Chain Valley only. Maximum permitted production rate of 1.1 Mt/y (EMGA Mitchell McLennan, 2014a, p. E.1)
Mitchells Flat ^{b, c}		Glencore	151.314°	-32.532°	EIS approved	Glencore advises in concept phase as at March 2015
Monash		Yancoal	151.199°	-32.773°	Pre-EIS	Proposed new mine.
Moolarben		Yancoal Australia Ltd	149.78°	-32.29°	EIS submitted	IESC advice 1 February 2013. Maximum permitted production rate of 9 Mt/y from Stage 1 and 12 Mt/y from Stage 2 of open cut operations but not exceeding 13 Mt/y for open cut and underground operations combined (Moolarben Coal, 2015, p. 2, Table 1)

Mine name	Complex name	Owner	Longitude	Latitude	Status of EIS ^a	Notes
Moolarben ^b		Yancoal Australia Ltd	149.78°	-32.29°	EIS approved	Maximum permitted production rate of 4 Mt/y from the underground operations but not exceeding 13 Mt/y for open cut and underground operations combined (Moolarben Coal, 2015, p.2, Table 1)
Mount Arthur	Mount Arthur Coal Mine	BHP Billiton	150.87°	-32.34°	EIS approved	Modification 1 – extension of mining approved September 2014. Maximum permitted production rate of 32 Mt/y (BHP Billiton, n.d., p. 3)
Mount Owen	Mount Owen Complex	Glencore	151.1°	-32.39°	EIS submitted	Maximum permitted production rate of 18.5 Mt/y (Umwelt Australia Pty Ltd, 2015, p. 1)
Mount Penny ^c		Cascade Coal	150.055°	-32.438°	Pre-EIS	Exploration licence EL7406 cancelled by NSW Government 31 Jan 2014. IESC advice submitted Dec 2012.
Mount Pleasant ^c		Rio Tinto	150.84°	-32.237°	EIS approved	Modification 1 approved September 2011. IESC advice 24 February 2012. Maximum permitted production rate of 10.5 Mt/y (EMGA Mitchell McLennan Pty Ltd, 2010, p. 1)
Mount Thorley-Warkworth		Mount Thorley-Warkworth	151.09°	-32.641°		IESC advice 29 June 2012. Maximum permitted production rate of 10 Mt/y (EMGA Mitchell McLennan, 2014b)
Muswellbrook No 2	Muswellbrook Coal Mine	Idemitsu Kosan Ltd	150.941°	-32.248°		Maximum permitted production rate of 2 Mt/y (Muswellbrook Coal Company Limited, 2014, p. 1)
Muswellbrook West ^c	Muswellbrook Coal Mine	Idemitsu Kosan Ltd	150.772°	-32.215°		Referred to IESC 2015
Myuna ^b		Centennial Coal Company Ltd	151.57°	-33.06°	EIS approved	Maximum permitted production rate increased from 2 Mt/y to 3 Mt/y in 2014 (Centennial Coal, 2014, p.26, Table 4)
News tan		Centennial Coal Company Ltd	151.577°	-32.976°	Pre-EIS	Two new proposals, but as at April 2015 in care and maintenance. Maximum permitted production rate of 4 Mt/y (SLR, 2013b, p. 20)
Ravensworth East ^b	Ravensworth Complex (Underground)	Resource Pacific Pty Limited (owned by Glencore and Marubeni) and Posco	151.04°	-32.44°	EIS approved	Modification 9 – changes to longwall layout approved June 2013. No additional mining. Maximum permitted production rate of 7 Mt/y (GSS Environmental, 2012, p.12)
Rix's Creek		Bloomfield Group	151.13°	-32.58°	EIS in preparation	Maximum permitted production rate of 2.5 Mt/y (AECOM Australia Pty Ltd, 2013, p. 1)
Savoy Hill ^c		NuCoal Resources Ltd	150.9°	-32.4°		Exploration phase
Spur Hill ^{b, c}		Malabar Coal Ltd	150.77°	-32.41°	EIS submitted	Pending approval. IESC advice 10 February 2014. Maximum permitted production rate of 8 Mt/y (Spur Hill Underground Coking Coal, 2014, p. 3)
Ulan ^b		Glencore	149.75°	-32.215°	EIS approved	Production began in May 2014. from Ulan West underground longwall mine.
Wallarah 2 ^{b, c}		Wyang Coal Pty Ltd	151.388°	-33.235°	EIS submitted	Pending approval. IESC advice 24 May 2013. Maximum permitted production rate of 5.0 Mt/y (Hansen Bailey, 2013, p. 4)
Wambo		Wambo Coal Company Ltd	151°	-32.58°	EIS in preparation	Maximum permitted production rate of 8 Mt/y from the open cut operations but not exceeding 14.7 Mt/y for open cut and underground operations combined (Peabody Energy, 2014, p.4, Table 1)
Wambo ^b		Wambo Coal Company Ltd	151°	-32.58°	EIS in preparation	Maximum permitted production rate of 7.5 Mt/y from the underground operations but not exceeding 14.7 Mt/y for open cut and underground operations combined (Peabody Energy, 2014, p.4, Table 1)
Wilpinjong		Wilpinjong Coal Pty Ltd	149.89°	-32.33°	EIS in preparation	Maximum permitted production rate of 16 Mt/y (Peabody Energy, n.d., p. 9, Table 1)

^aThe status of the project within an environmental impact statement (EIS): pre-EIS, EIS in preparation, EIS submitted, EIS closed, supplementary EIS and EIS approved

^bUnderground mine

^cNew mine

IESC = Independent Expert Scientific Committee on Coal Seam Gas and Large Coal Mining Development

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Figure 10 Map showing locations of coal mines with expansion plans and potential new mines in the Hunter subregion for post December 2012

Data: Bioregional Assessment Programme (Dataset 1)

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1.2.4 Catalogue of potential resource developments

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