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 Clarence-Moreton bioregion

Product 1.2 from the Clarence-Moreton Bioregional Assessment

21 January 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/>.

Bureau of Meteorology

The Bureau of Meteorology is Australia's national weather, climate and water agency. Under the *Water Act 2007*, the Bureau is responsible for compiling and disseminating Australia's water information. The Bureau is committed to increasing access to water information to support informed decision making about the management of water resources. For more information, visit <http://www.bom.gov.au/water/>.

CSIRO

Australia is founding its future on science and innovation. Its national science agency, CSIRO, is a powerhouse of ideas, technologies and skills for building prosperity, growth, health and sustainability. It serves governments, industries, business and communities across the nation. For more information, visit <http://www.csiro.au>.

Geoscience Australia

Geoscience Australia is Australia's national geoscience agency and exists to apply geoscience to Australia's most important challenges. Geoscience Australia provides geoscientific advice and information to the Australian Government to support current priorities. These include contributing to responsible resource development; cleaner and low emission energy technologies; community safety; and improving marine planning and protection. The outcome of Geoscience Australia's work is an enhanced potential for the Australian community to obtain economic, social and environmental benefits through the application of first class research and information. For more information, visit <http://www.ga.gov.au>.

ISBN-PDF 978-0-642-70654-6

Citation

Raiber M, Rassam D and Hartcher MG (2015) Coal and coal seam gas resource assessment for the Clarence-Moreton bioregion. Product 1.2 from the Clarence-Moreton Bioregional Assessment. Department of the Environment, Bureau of Meteorology, CSIRO and Geoscience Australia, Australia.

Authorship is listed in relative order of contribution.

Copyright

© Commonwealth of Australia 2015
With the exception of the Commonwealth Coat of Arms and where otherwise noted, all material in this publication is provided under a Creative Commons Attribution 3.0 Australia Licence <http://www.creativecommons.org/licenses/by/3.0/au/deed.en>.

Disclaimer

The information contained in this report is based on the best available information at the time of publication. The reader is advised that such information may be incomplete or unable to be used in any specific situation. Therefore decisions should not be made based solely on this information or without seeking prior expert professional, scientific and technical advice.
The Bioregional Assessment Programme is committed to providing web accessible content wherever possible. If you are having difficulties with accessing this document please contact <bioregionalassessments@bom.gov.au>.

Cover photograph

Rainforest waterfall in Border Ranges National Park, NSW, 2008

Credit: Liese Coulter, CSIRO

Australian Government
Department of the Environment
Bureau of Meteorology
Geoscience Australia

CSIRO

Contents

Figures

Tables

Contributors to the Technical Programme

The following individuals have contributed to the Technical Programme, the part of the Bioregional Assessment Programme that undertakes bioregional assessments. Leaders are underlined.

Assistant Secretary	Department of the Environment: Gayle Milnes
Programme Director	Department of the Environment: Anthony Swirepik
Technical Programme Director	Bureau of Meteorology: Bronwyn Ray
Projects Director	CSIRO: David Post
Principal Science Advisor	Department of the Environment: Peter Baker
Science Directors	CSIRO: Brent Henderson Geoscience Australia: Trevor Dhu
Integration Lead	Bureau of Meteorology: Richard Mount
Programme management	Bureau of Meteorology: Graham Hawke, Louise Minty CSIRO: Paul Hardisty, Warwick McDonald Geoscience Australia: Stuart Minchin
Project Leaders	CSIRO: Alexander Herr, Tim McVicar, David Rassam Geoscience Australia: Hashim Carey, Kriton Glenn
Assets and receptors	Bureau of Meteorology: <u>Richard Mount, Eliane Prideaux</u> Department of the Environment: Rachael Carter, Larry Guo, Glenn Johnstone, Brad Moore, Jin Wang Geoscience Australia: Joe Bell
Bioregional Assessment Information Platform	Bureau of Meteorology: <u>Brian Cannell,</u> Trevor Christie-Taylor, Jason Guo, Joseph Zhao CSIRO: <u>Peter Fitch</u> Department of the Environment: Geraldine Cusack Geoscience Australia: <u>Neal Evans</u>
Communications	Bureau of Meteorology: Mel Martin CSIRO: Chris Gerbing Department of the Environment: Sophie Alexander, Milica Milanja, Kirsty Rolls Geoscience Australia: David Beard, Chris Thompson

Coordination	Bureau of Meteorology: Julie Burke, Sarah van Rooyen CSIRO: Ruth Palmer Department of the Environment: James Hill, Sunita Johar, Craig Watson Geoscience Australia: Tenai Luttrell
Ecology	CSIRO: Tanya Doody, Brendan Ebner, Kate Holland, Craig MacFarlane, Tracey May, Patrick Mitchell, Justine Murray, Anthony O'Grady, Chris Pavey, Jodie Pritchard, Nat Raisbeck-Brown, Ashley Sparrow, Georg Wiehl
Geology	CSIRO: Deepak Adhikary, Luke Connell, Emanuelle Frery, Jane Hodgkinson, James Kear, Manoj Khanal, Zhejun Pan, Kaydy Pinetown, Matthias Raiber, Hayley Rohead-O'Brien, Regina Sander, Peter Schaubs, Garth Warren, Paul Wilkes, Andrew Wilkins, Yanhua Zhang Geoscience Australia: Tim Evans, Steven Lewis, John Magee, Martin Smith
Geography	Bureau of Meteorology: Natasha Herron
Geographic information systems	CSIRO: Caroline Bruce, Jody Bruce, Malcolm Hodgen, Steve Marvanek, Arthur Read Geoscience Australia: Gerard Stewart, Kirsten Walker
Groundwater modelling	CSIRO: Olga Barron, Russell Crosbie, Tao Cui, Warrick Dawes, Lei Gao, Sreekanth Janardhanan, Luk Peeters, Praveen Kumar Rachakonda, Wolfgang Schmid, Saeed Torkzaban, Chris Turnadge, Binzhong Zhou Geoscience Australia: Wenping Jiang
Hydrogeology	CSIRO: Konrad Miotlinski Geoscience Australia: Rebecca Cassel, Jim Kellett, Sarah Marshall, Rebecca Norman, Jessica Northey, Tim Ransley, Martin Smith, Baskaran Sundaram, KokPiang Tan, Luke Wallace, Gabrielle Yates
Information management	Bureau of Meteorology: Belinda Allison, Jill McNamara, Brendan Moran, Suzanne Slegers CSIRO: Nick Car, Phil Davies, Andrew Freebairn, Mick Hartcher, Geoff Hodgson, Brad Lane, Ben Leighton, Trevor Pickett, Ramneek Singh, Matt Stenson Geoscience Australia: Luke Caruana, Penny Kilgour, Matti Peljo
Products	CSIRO: Maryam Ahmad, Daniel Aramini, Heinz Buettikofer, Simon Gallant, Karin Hosking, Frances Marston, Linda Merrin, Becky Schmidt, Sally Tetreault-Campbell, Catherine Ticehurst Geoscience Australia: Veronika Galinec, Daniel McIlroy,
Risk and uncertainty	CSIRO: Simon Barry, Jeffery Dambacher, Jess Ford, Keith Hayes, Geoff Hosack, Yang Liu, Warren Jin, Dan Pagendam, Carmel Pollino
Surface water hydrology	CSIRO: Santosh Aryal, Mat Gilfedder, Fazlul Karim, Lingtao Li, Dave McJannet, Jorge Luis Peña Arancibia, Xiaogang Shi, Tom Van Niel, Neil Viney, Bill Wang, Ang Yang, Yongqiang Zhang

Acknowledgements

This technical product was reviewed by several groups:

- Discipline Leaders: Steven Lewis (geology)
- Senior Science Leaders: David Post (Projects Director), Trevor Dhu (Science Director, Geoscience Australia), Brent Henderson (Science Director, CSIRO) , Becky Schmidt (Products Manager, CSIRO)
- Technical Assurance Reference Group: Chaired by Peter Baker (Principal Science Advisor, Department of the Environment), this group comprises officials from the NSW, Queensland, South Australian and Victorian governments.
- Additional reviewers: These companies provided feedback on the accuracy of our descriptions of their operations: Metgasco Limited, ERM Gas, Arrow Energy, New Hope Group, Dart Energy.

Valuable comments were also provided by Peter Stanmore (SRK Consulting).

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.

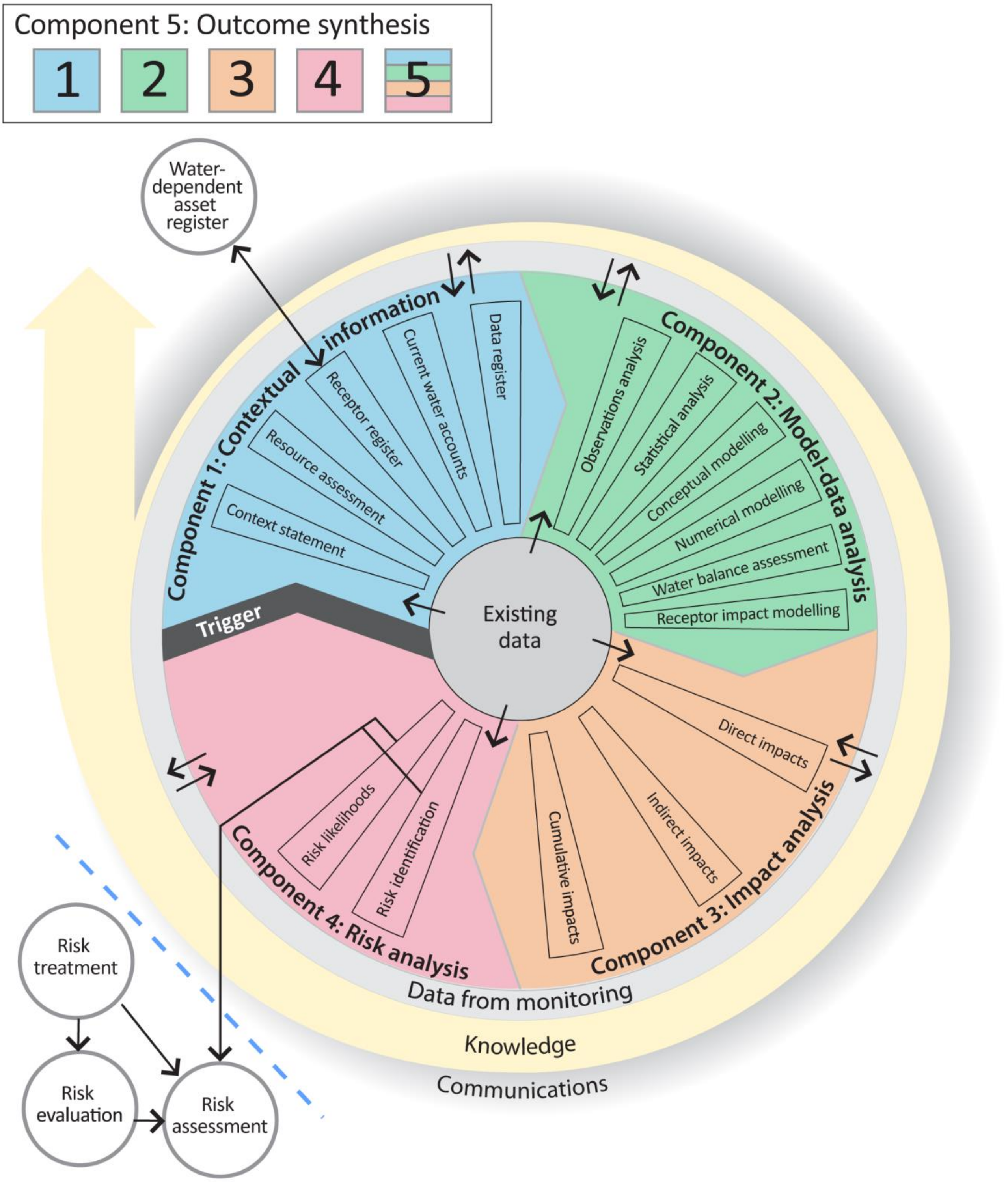


Figure 1 Schematic diagram of the bioregional assessment methodology

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	*Methodology for bioregional assessments of the impacts of coal seam gas and coal mining development on water resources*	A high-level description of the scientific and intellectual basis for a consistent approach to all bioregional assessments	All
M02	*Compiling water-dependent assets*	Describes the approach for determining water-dependent assets	1.3 Description of the water-dependent asset register
M03	*Assigning receptors and impact variables to water-dependent assets*	Describes the approach for determining receptors associated with water-dependent assets	1.4 Description of the receptor register
M04	*Developing a coal resource development pathway*	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	*Developing the conceptual model for causal pathways*	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	*Surface water modelling*	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	*Groundwater modelling*	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	*Receptor impact modelling*	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	*Propagating uncertainty through models*	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	*Risk and cumulative impacts on receptors*	Describes the process to identify and analyse risk	3 Impact analysis 4 Risk analysis
M11	*Hazard identification*	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	*Fracture propagation and chemical concentrations*	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>.

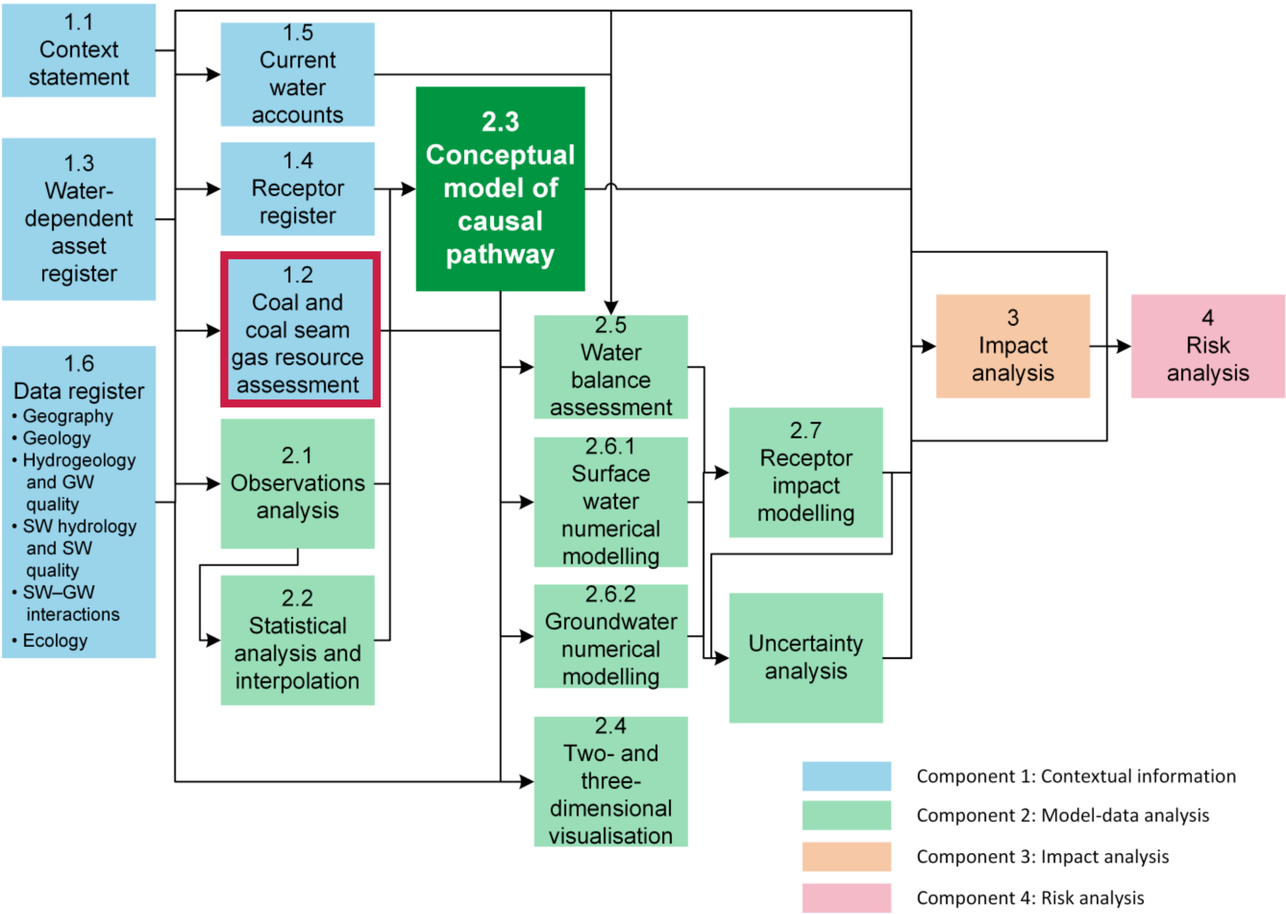


Figure 2 The simple decision tree indicates the flow of information through a bioregional assessment

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

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 150° East for the Clarence-Moreton bioregion and two standard parallels of –18.0° and –36.0°.

Table 2 Technical products being delivered as part of the Clarence-Moreton Bioregional Assessment

For each subregion in the Clarence-Moreton Bioregional Assessment, technical products will be delivered as data, summaries and reports (PDFs) as indicated by ■ in the last column of Table 2. The red rectangle indicates the information covered in this technical product. A suite of other technical and communication products – such as maps, registers and factsheets – will also be developed through the bioregional assessments.

Component	Product code	Information	Section in the BA methodology[a]	Report
Component 1: Contextual information for the Clarence-Moreton bioregion	1.1	Context statement	2.5.1.1, 3.2	■
	1.2	Coal and coal seam gas resource assessment	2.5.1.2, 3.3	■
	1.3	Description of the water-dependent asset register	2.5.1.3, 3.4	■
	1.4	Description of the receptor register	2.5.1.4, 3.5	■
	1.5	Current water accounts and water quality	2.5.1.5	■
	1.6	Data register	2.5.1.6	
Component 2: Model-data analysis for the Clarence-Moreton bioregion	2.1-2.2	Observations analysis, statistical analysis and interpolation	2.5.2.1, 2.5.2.2	■
	2.3	Conceptual modelling	2.5.2.3, 4.3	■
	2.4	Two- and three-dimensional representations	4.2	[b]
	2.5	Water balance assessment	2.5.2.4	■
	2.6.1	Surface water numerical modelling	4.4	■
	2.6.2	Groundwater numerical modelling	4.4	■
	2.7	Receptor impact modelling	2.5.2.6, 4.5	■
Component 3: Impact analysis for the Clarence-Moreton bioregion	3	Impact analysis	5.2.1	■
Component 4: Risk analysis for the Clarence-Moreton bioregion	4	Risk analysis	2.5.4, 5.3	■
Component 5: Outcome synthesis for the Clarence-Moreton	5	Outcome synthesis	2.5.5	■

[a]Barrett et al. (2013)
[b]The two- and three-dimensional representations will be delivered in products such as 2.3, 2.6.1 and 2.6.2.

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 18 April 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 Clarence-Moreton bioregion

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

The geological Clarence-Moreton Basin contains substantial coal, coal seam gas (CSG) and conventional gas resources. Within the Clarence-Moreton bioregion, black coal was first discovered in 1824 in the Ipswich Coal Measures and in 1864 in the Walloon Coal Measures. Coal is also present in other formations, but economic coal deposits are located mainly within the Walloon Coal Measures, the Ipswich Coal Measures and the Nymboida Coal Measures.

The cumulative thickness of coal seams varies considerably throughout the Clarence-Moreton bioregion, ranging from approximately 1 m near the basin margins to about 120 m in the Casino Trough, a major depositional centre within the Clarence-Moreton bioregion in NSW where the Walloon Coal Measures are thickest (up to approximately 700 m). The coal rank of the Walloon Coal Measures ranges from high-volatile bituminous to low-volatile bituminous and sub-bituminous, and the coal has been described as slightly higher in rank than the coals in the linked geological Surat Basin.

Both conventional and unconventional gas resources occur in the Clarence-Moreton bioregion. Methane adsorption tests of coal samples from the Clarence-Moreton bioregion in NSW demonstrated that the coals are fully saturated or close to full saturation. This is attributed to the low permeability of the coal seams, the interbedded nature of the coal seams, and to the presence of a regional top seal (the Maclean Sandstone). Numerous igneous intrusions have penetrated the coal seams in the Clarence-Moreton bioregion, and these heating events may have affected the maturity of coal seams and gas generation at the regional scale.

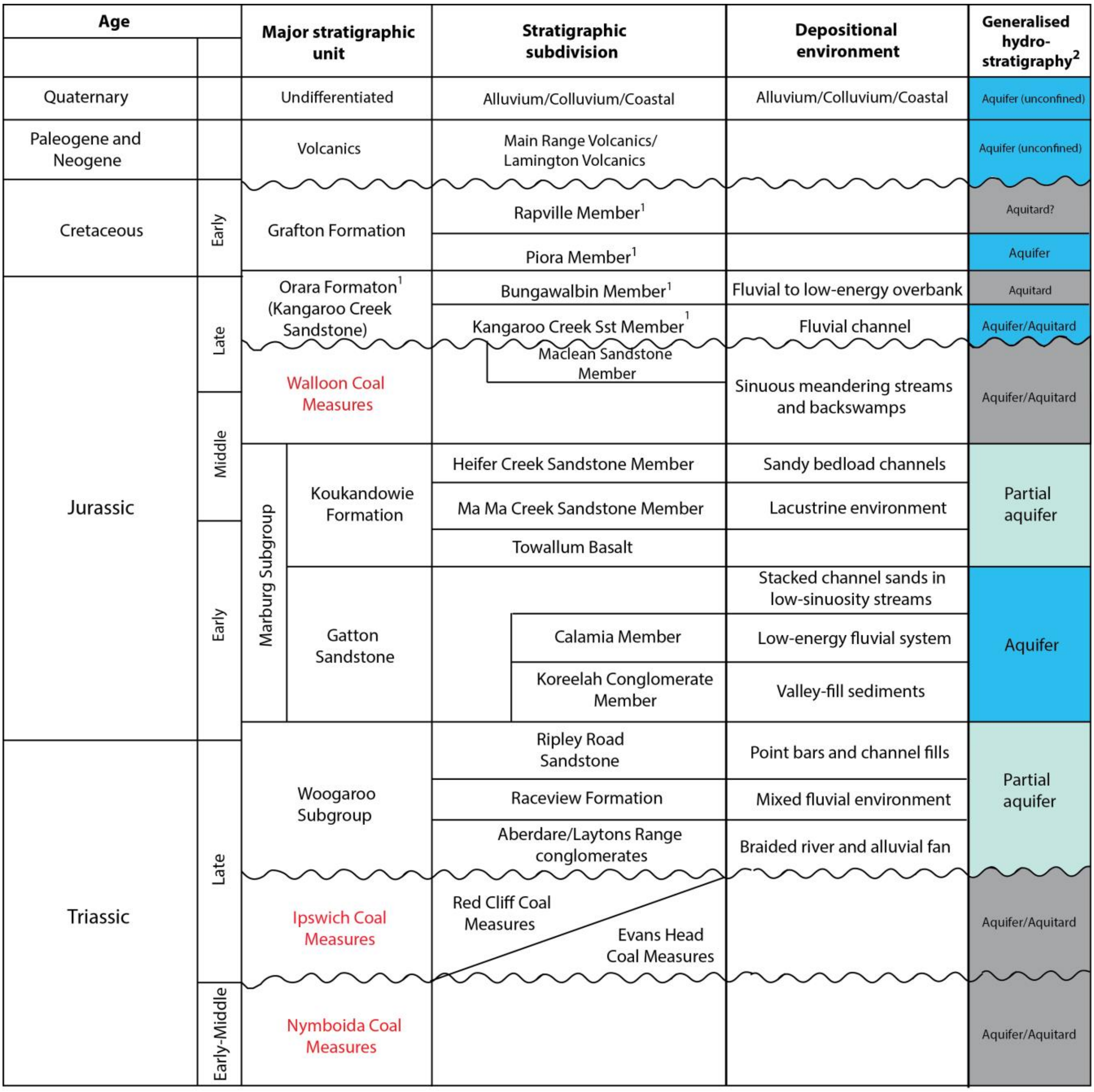
Gas isotope analyses indicate that the gas contained within the coal seams is thermogenic, in contrast to gas in the adjacent Surat Basin where gas is primarily of biogenic origin.

1.2.1.1 Coal

A detailed overview on the characteristics of the stratigraphic units (Figure 3) and the geological framework of the Clarence-Moreton bioregion is given in product 1.1 of the Clarence-Moreton Bioregional Assessment (Rassam et al., 2014).

Goscombe and Coxhead (1995) provided an overview of the geology of the Clarence-Moreton Basin, including information about the coal resources, their quality and utilisation potential for coals from various deposits in the Walloon Coal Measures and equivalents in other basins. The Australian Energy Resource Assessment (Geoscience Australia and BREE, 2014) estimated that there are 2177 Mt of Economically Demonstrated Resources (EDR) of thermal black coal and 15 Mt of Subeconomic Demonstrated Resources (SDR) of thermal coal in the Clarence-Moreton Basin (EDR, 2014).

The primary coal exploration targets within the Clarence-Moreton bioregion are the Jurassic Walloon Coal Measures, the Late Triassic Ipswich Coal Measures in south-east Queensland, and the Triassic Nymboida, Red Cliff and Evans Head coal measures in NSW. In addition, coal is also contained within the Koukandowie Formation, the Gatton Sandstone and the Raceview Formation (a member of the Woogaroo Subgroup). However, the coal within these units has not been mined economically in the past (Ingram and Robinson, 1996).



[1]proposed stratigraphic revision by Doig and Stanmore (2012)

[2]the generalised hydrostratigraphy is modified from Radke and O'Brien (2012)

Figure 3 Stratigraphic column for the Clarence-Moreton Basin (modified from Rassam et al., 2014)

Source data: Wells and O'Brien (1994) and Doig and Stanmore (2012)
Major coal-bearing stratigraphic units are highlighted in red

Reviews of coal geology and coal resources in the Clarence-Moreton Basin in Queensland were published by the Department of Minerals and Energy (Cameron, 1970; Matheson, 1993). These summaries provide historical information on early developments, suggesting that coal in the Rosewood–Walloon Coalfield was first detected in 1864 to 1865 at Walloon and Rosewood west of Ipswich, whereas coal from the Ipswich Coal Measures was first discovered in 1824.

At present, one coal mine operates within the Clarence-Moreton bioregion (Jeebropilly Mine in south-east Queensland; Figure 4). Another mine, New Oakleigh Mine, ceased operations in January 2013. The coal of the Clarence-Moreton and Ipswich basins is used for domestic electricity generation and industrial use in Brisbane and for export (Geoscience Australia and BREE, 2014). Mining of the Nymboida Coal Measures has been restricted to small areas near Nymboida in the south-western part of the Clarence-Moreton Basin in NSW where the Nymboida Coal Measures outcrop (Ingram and Robinson, 1996). No economic coal mining has occurred from the Red Cliff and Evans Head coal measures (Wells, 1995).

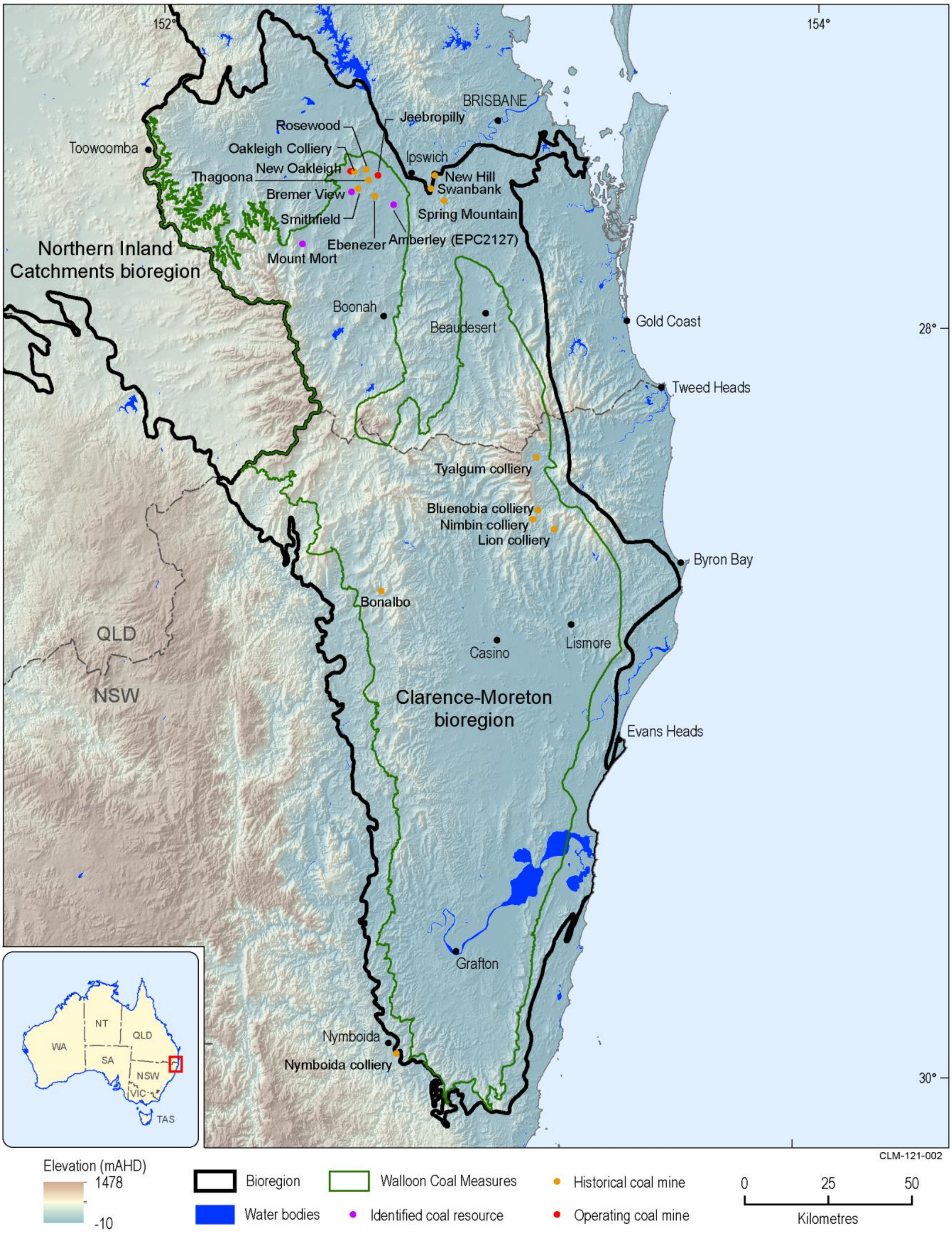


Figure 4 Identified coal resources and operating and historical coal mines in the Clarence-Moreton bioregion (additional historical coal mines in Queensland that are not included in the OZMIN database are described in Cameron, 1970)

The New Oakleigh Mine was closed in 2013
EPC = exploration permit for coal
Locations of historical coal mines in NSW are based on Henley et al. (2001) and Brown et al. (2007)

1.2.1.1.1 Walloon Coal Measures

The Walloon Coal Measures are composed of coal, shale, sandstone, siltstone and mudstone (e.g. Rassam et al., 2014). Coals in the Walloon Coal Measures are high-volatile bituminous to low-volatile bituminous and sub-bituminous (Matheson, 1993; Ingram and Robinson, 1996; Doig and Stanmore, 2012), based on the American Society for Testing and Materials (ASTM) classification scheme (Appendix A). The coal of the Walloon Coal Measures in the Clarence-Moreton Basin has been described as slightly higher in rank than the Walloon Coal Measures coals in the linked Surat Basin (Matheson, 1993). Kerogen types in the Walloon Coal Measures range from Type I to Type III (O'Brien et al., 1994), but most are Types II and III (O'Brien et al., 1994; Ingram and Robinson, 1996). The maceral composition of the coal is dominated by vitrinite, whereas the disseminated organic material is composed of vitrinite and to a lesser degree liptinite and inertinite (Ingram and Robinson, 1996). Ingram and Robinson (1996) suggested that the volatile content of the coal may be as high as 54% with a mean hydrogen content of about 6 to 7%. Doig and Stanmore (2012) explained that the rank of the coal varies with depth of burial, location and proximity to igneous intrusions. The coal of the Walloon Coal Measures is classified as thermal black coal (OZMIN database, Geoscience Australia, 2012). The unit is generally thinner near the basin margins, and ranges between 400 and 700 m in the central Laidley and Logan sub-basins (Figure 5). The discrepancy between the Walloon Coal Measures thickness suggested by the isopach (thickness) contours (Figure 5) based on Ingram and Robinson (1996) and the thickness recorded at exploration wells north of Casino is due to data that have become available from more recent exploration drilling. An updated isopach map of the Walloon Coal Measures based on all available well log and seismic data will be presented in companion product 2.3 for the Clarence-Moreton bioregion. The coal seams are not as well developed in the southern part of the Clarence-Moreton bioregion in NSW, as suggested by the decrease of the thickness of coal within the Walloon Coal Measures south of the Casino and Lismore troughs (Doig and Stanmore, 2012). Recent well completion reports indicate that there is, for example, a net coal thickness of 19.1 m within the Walloon Coal Measures at the Peacock 1 CSG exploration well (Gordon, 2010), 49 m in the Walloon Coal Measures in Corella E9 CSG well (Johnson et al., 2008a) and 55 m within the Walloon Coal Measures sequence at the Corella E10 CSG well (Johnson et al., 2008b), whereas a cumulative thickness of 120.1 m of coal has been recorded at the Kingfisher-1 petroleum exploration well (Burgess, 2010). This shows that only a comparatively small part of the Walloon Coal Measures consists of coal, and the majority is composed of interburden.

The coal within the Walloon Coal Measures occurs within multiple seams. In the Corella E9 CSG exploration well, for example, nine different seams have been identified within the Walloon Coal Measures sequence (Johnson et al., 2008a). The Richmond Seam (one of the youngest and thickest seams in the Walloon Coal Measures) is very extensive and can be correlated over tens of kilometres based on its distinct signal that can be identified in geophysical logs (Doig and Stanmore, 2012). Arrow Energy Pty Ltd has differentiated coal seams encountered in CSG exploration wells in the Clarence-Moreton bioregion into an 'Upper Coal Zone' and a 'Lower Coal Zone' (e.g. Nightingale, 2010), each of which can consist of several coal seams of variable thickness. It is currently unknown whether the coal seams of the Walloon Coal Measures in the Clarence-Moreton bioregion in NSW and Queensland can be correlated with the coal seams in the western part of the Clarence-Moreton Basin (part of the Northern Inland Catchments bioregion) and the Surat Basin. However, Doig and Stanmore (2012) suggested that the high inertinite content of the Richmond Seam in the Casino area (17%) and in the upper Juandah Coal Measures, a major sequence of coal seams in the western part of the Clarence-Moreton Basin and in the Surat Basin (10%), may indicate that these seams are time equivalents.

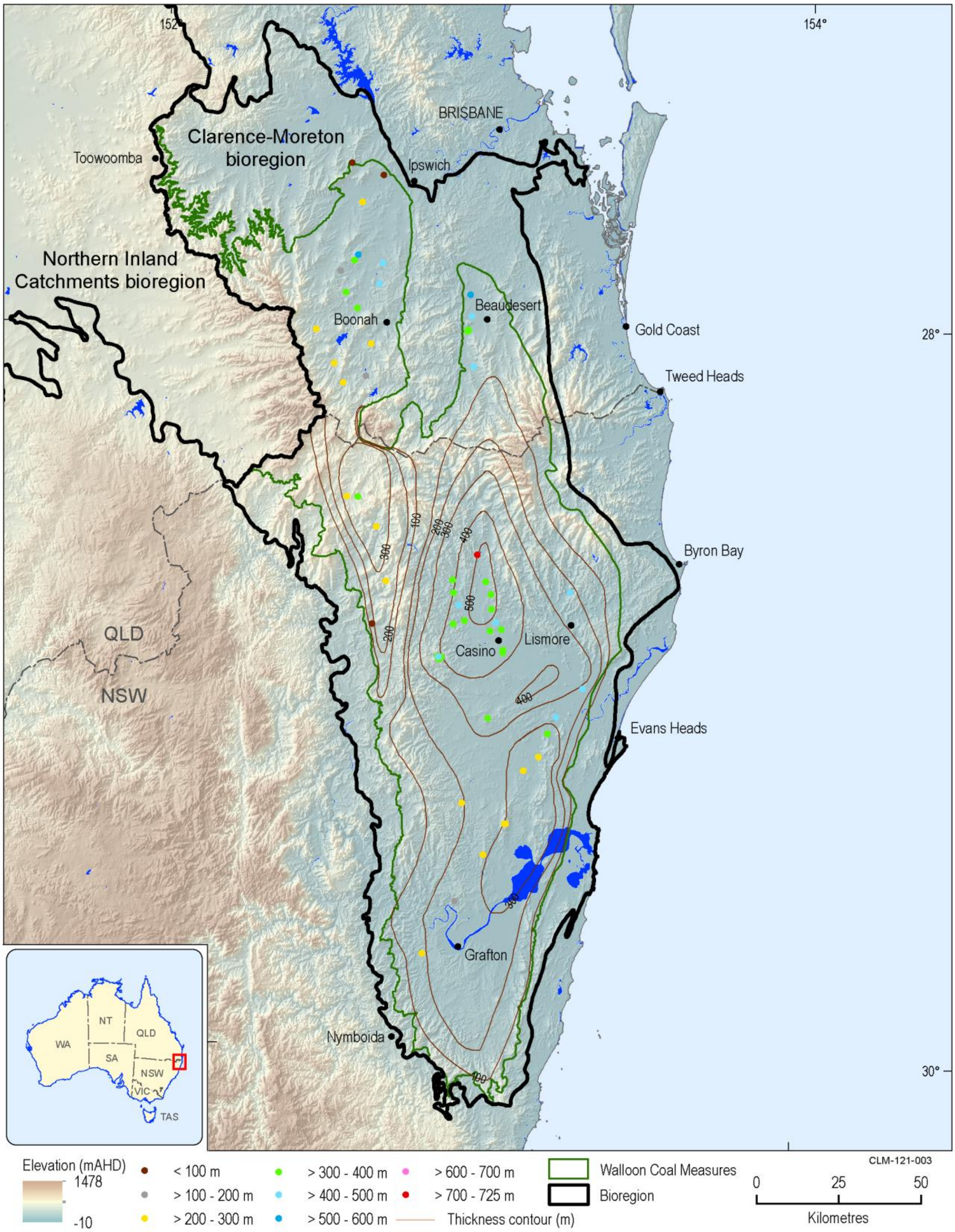


Figure 5 Isopach (thickness) map of Walloon Coal Measures (Ingram and Robinson, 1996) and comparison with thickness of Walloon Coal Measures recorded at coal seam gas, coal exploration, petroleum exploration and stratigraphic wells in the Clarence-Moreton bioregion

Source data: isopach contours modified from Ingram and Robinson (1996); the thickness of the Walloon Coal Measures is only shown for wells where the full sequence of the Walloon Coal Measures (i.e. where the formation underneath the Walloon Coal Measures (Koukandowie Formation)) has been intersected. Coal seam gas, petroleum and coal exploration well locations and Walloon Coal Measures thickness data are sourced from (i) NSW Digital Imaging Geological Systems (NSW Trade & Investment, 2014a), © NSW Trade & Investment; (ii) Queensland Digital Exploration Reports (State of Queensland, 2014), © The State of Queensland 2014. Stratigraphic well data are based on Wells and O’Brien, 1994.

1.2.1.1.2 Ipswich, Red Cliff and Evans Head coal measures

The Ipswich, Red Cliff and Evans Head coal measures are time equivalents (Figure 3) and are therefore discussed together in this section.

The Late Triassic Ipswich Coal Measures outcrop along the eastern part of the Ipswich Basin south of Ipswich (Figure 4). The unit is absent west of the West Ipswich Fault, and is covered by the sedimentary sequences of the Walloon Coal Measures and the Bundamba Group throughout the remainder of the Laidley sub-basin in Queensland (Korsch et al., 1989; Chern, 2004). In NSW, well completion reports and seismic data (e.g. Ingram and Robinson, 1996) demonstrate that the Ipswich Coal Measures (and time equivalents) and the Nymboida Coal Measures are covered by at least 1500 m to 2000 m of younger Clarence-Moreton Basin sequences in the central part of the basin (Figure 6). A combined thickness of the Ipswich (and equivalents) and Nymboida Coal Measures in the Clarence-Moreton Basin in NSW of approximately 1600 m to 2000 m has been suggested by Hartogen Energy Ltd (1983) and Ingram and Robinson (1996).

Chern (2004) suggested that the Ipswich Coal Measures locally contain thick thermal coal with a moderate to high ash content, but that their lateral extent is discontinuous. The black coal of the Ipswich Coal Measures is classified as high-volatile bituminous (Staines et al., 1995). Smyth (1994) reported that the Ipswich Coal Measures are vitrinite-rich (36 to 86%) and contain minor liptinite, whereas the dispersed organic matter (DOM) has a volumetric liptinite content of up to 50%. The coal from the Ipswich Coal Measures has a high ash content, but is low in sulfur and chlorine (Staines et al., 1995).

More than 20 coal seams of the Ipswich Coal Measures have been mined in the past (Staines et al., 1995) at mines near Ipswich (e.g. Spring Hill, Swanbank and New Hill; Figure 4).

Coal seams of the Late Triassic Evans Head Coal Measures are contained within sequences of sandstone, carbonaceous shale and conglomerate. The Evans Head Coal Measures outcrop at isolated locations at the eastern basin margin. They have a total thickness of approximately 600 m, but the coal seams are generally thin, ranging between 0.3 and 1.5 m (Wells, 1995; Stewart and Alder, 1995).

The Red Cliff Coal Measures have a total thickness of approximately 600 m, and consist of shale, sandstone, breccia and coal (Wells, 1995). They outcrop only in isolated areas at the south-eastern basin margins.

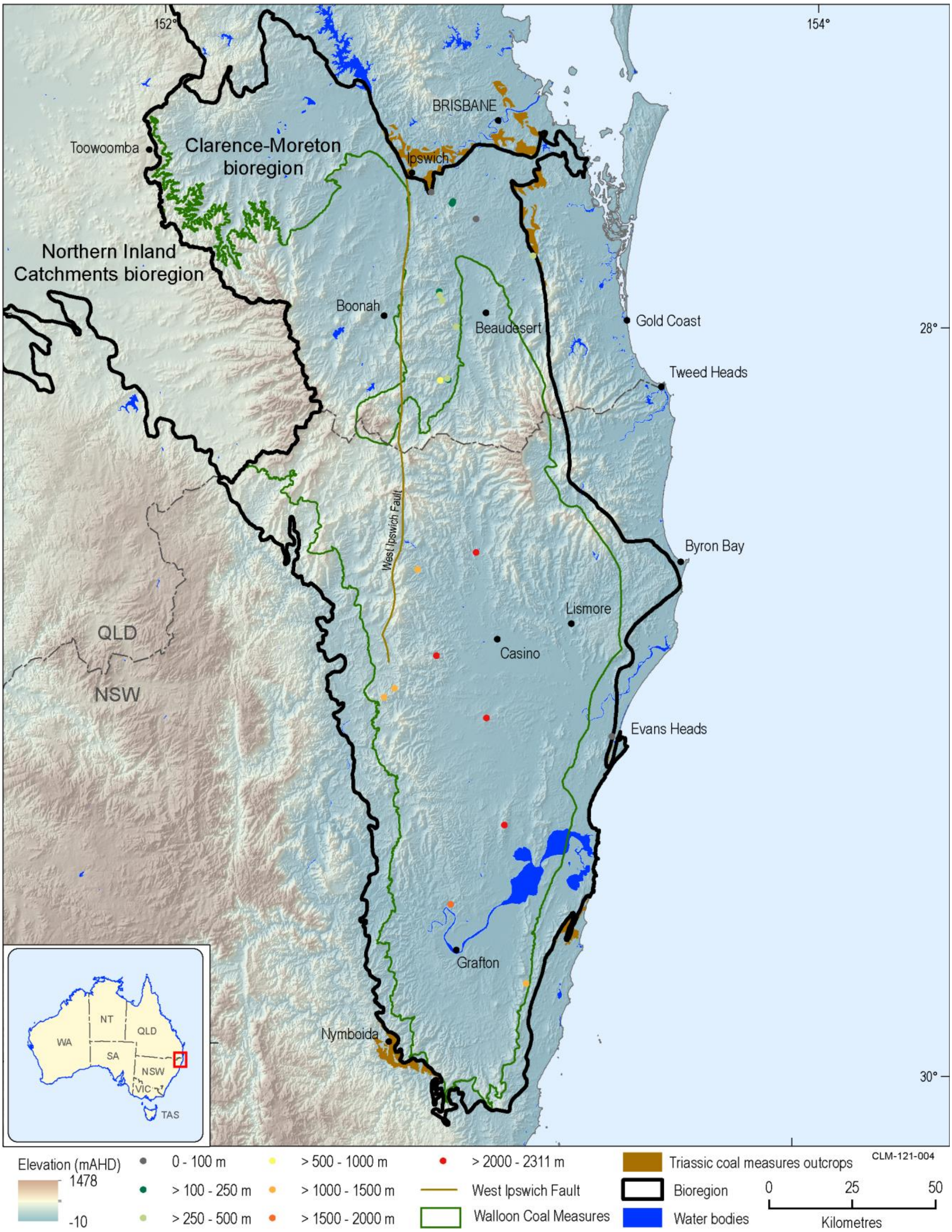


Figure 6 Depth to the top of the Ipswich Coal Measures (and equivalents) intersected at exploration and stratigraphic wells in the Clarence-Moreton bioregion. The Ipswich Coal Measures are absent west of the West Ipswich Fault. The extent of the Walloon Coal Measures is shown for comparison

Source data: coal seam gas and petroleum exploration well locations and depth to Ipswich Coal Measures are sourced from (i) NSW Digital Imaging Geological Systems (NSW Trade & Investment, 2014a), © NSW Trade & Investment; (ii) Queensland Digital Exploration Reports (State of Queensland, 2014), © The State of Queensland 2014. Stratigraphic well data are based on Wells and O'Brien, 1994.

1.2.1.1.3 Nymboida Coal Measures

The Early to Middle Triassic Nymboida Coal Measures outcrop over an area of approximately 90 km^2 at the south-western margin of the Clarence-Moreton Basin in NSW (Stewart and Alder, 1995). Throughout the remainder of the Clarence-Moreton Basin in NSW, these Late Triassic coal measures underlie the Ipswich Coal Measures or the Bundamba Group where the Ipswich Coal Measures are absent, possibly occurring as restricted sediment packages within paleovalleys as suggested by seismic interpretations (Willis, 1994). Seismic data also suggest that the overall thickness of the Nymboida Coal Measures increases away from the basin margins and may exceed 1000 m in the central basin (Hartogen, 1983). Coal seams of the Nymboida Coal Measures are relatively thin (up to 2 m including non-coal bands; Wells, 1995) and discontinuous. The only seam of the Nymboida Coal Measures which was mined until 1979 at the Nymboida Colliery (Figure 4) is the Farquhars Creek Seam. The coal of the Nymboida Coal Measures is relatively high ash, medium volatile and bituminous coal with an exceptionally high calorific value (Stewart and Alder, 1995). An exploration programme by Waratah Coal Pty Ltd tested the resource potential of the Farquhars Creek Seam for underground mining of coking coal (Marketwire, 2007). Other seams within the Nymboida Coal Measures are lenticular, containing coal that approaches semi-anthracite in rank (Stewart and Alder, 1995).

Among the Nymboida, Red Cliff and Evans Head coal measures, the Nymboida Coal Measures are the only proven economic coal resources (Wells, 1995).

1.2.1.2 Coal seam gas

Within the Clarence-Moreton bioregion, there are both conventional gas and unconventional gas (CSG) resources (e.g. Martin and Saxeby, 1982; Ingram and Robinson, 1996; Doig and Stanmore, 2012). However, potential impacts of conventional gas development are not considered by the Clarence-Moreton Bioregional Assessment, and this product therefore focuses on unconventional (CSG) resources.

The Clarence-Moreton Basin has been described as under-explored for hydrocarbons (Ingram and Robinson, 1996; Doig and Stanmore, 2012). Nevertheless, hydrocarbon shows in the Clarence-Moreton Basin date back to 1902, when flows of methane were reported from the Grafton-1 well in NSW. Since then, numerous oil and gas shows have been reported in the Clarence-Moreton Basin.

In some wells, for example Shannon-1 in the Casino Trough, strong gas shows have been reported from the Walloon Coal Measures suggesting that there is potential for gas and possibly also for oil and wet gas. However, Ingram and Robinson (1996) noted that the high vitrinite levels of the Walloon Coal Measures indicate that the overall potential for oil generation may not be very good. Total organic carbon ranges from less than 1% to more than 20% for the older Ipswich and Nymboida coal measures. Vitrinite reflectance from 0.95% to approximately 4% suggests a high level of maturity, which is likely to promote methane rather than wet gases.

The primary target for CSG exploration in the Clarence-Moreton bioregion is the Walloon Coal Measures. In addition, ten exploration wells have targeted the Ipswich Coal Measures near the basin margins in Queensland (Figure 5). While there has been exploration for conventional gas and oil from the older coal measures in the Clarence-Moreton Basin in the past, no CSG exploration programme has to date targeted the Nymboida, Red Cliff or Evans Head coal measures and the exploration of the CSG potential of the Ipswich Coal Measures has targeted areas where they occur at shallow depths near the basin margins (Figure 4). This focus on the Walloon Coal Measures as the primary exploration target is for example related to the more continuous nature and greater thickness of the Walloon Coal Measures compared to the Triassic coal measures. In addition, the substantial depth at which these older coal measures occur throughout much of the Clarence-Moreton Basin (Figure 6) suggest that that there is no potential for coal seam gas extraction from these older coal measures.

Recent evaluation by the Australian Energy Market Operator (2013) estimated total CSG reserves and resources as at 31 December 2012 of 16,808 PJ in the Clarence-Moreton Basin, of which 445 PJ are 2P (proved and probable). However, this estimate includes the western part of the Clarence-Moreton Basin (part of the Northern Inland Catchments bioregion). Metgasco Limited reported CSG reserves and resources within the petroleum exploration licence PEL 13 and PEL 16 in NSW of 4768.7 PJ, of which 338 PJ are considered to be 2P (Metgasco, 2013). In 2012, Red Sky Energy Limited reported certified 2P resources of 17 PJ based on a two core hole programme. The Australian Energy Resource Assessment (Geoscience Australia and BREE, 2014) estimated that there are 100 PJ of total demonstrated conventional gas and 428 PJ of proved and probable CSG resources in the Clarence-Moreton Basin.

Methane adsorption tests of coal samples from the Clarence-Moreton bioregion in NSW demonstrated that the coals are fully saturated or close to full saturation (MHA, 2009, as cited in Doig and Stanmore, 2012), which indicates that there was no loss of gas from the coals (Doig and Stanmore, 2012). This was attributed to the low permeability and interbedded nature of the coals. In addition, they suggested that where the feldspathic Maclean Sandstone overlies the coal seams of the Walloon Coal Measures and where this sandstone is not compromised by faulting, it may act as a top seal which prevents the escape of gas and has an important role in CSG accumulation. The ‘fair to good’ seal potential (Stewart and Alder, 1995) of the Maclean Sandstone is attributed to the tight character of this sand- and siltstone and the clay content in the matrix, which reduces the permeability.

Exploration drilling by Arrow Energy has shown a very wide range of gas saturation levels within the coal seams of the Ipswich Coal Measures (from about 5.8 to 75%), but most intersected seams are undersaturated and only three seams had saturation levels greater than 50% (Oberhardt and Pinder, 2005).

The Clarence-Moreton Basin formed over basement rocks that are intensively intruded by granite (Sommacal et al., 2008). Cenozoic intrusive and extrusive activity has been widespread throughout the Clarence-Moreton bioregion. The granitic rocks may have potential as a geothermal energy source, and may also have influenced the maturity of overlying coal measures. In addition, the Cenozoic igneous activity could have been important locally for generating hydrocarbons, although it is possible that this magmatic activity may have been a general heating event in the Clarence-Moreton Basin, which could have affected hydrocarbon generation on a regional scale (Martin and Saxby, 1982; Ingram and Robinson, 1996; Doig and Stanmore, 2012). A similar potentially beneficial influence of igneous intrusions on CSG potential has also been discussed for the Gunnedah Basin, part of the bioregional assessment for the Namoi subregion (e.g. Gurba and Weber, 2001; Northey et al., 2014).

Isotope data suggest that methane in coal seams in the adjacent Surat Basin is of biogenic origin (e.g. Papendick et al., 2011). In contrast, gas isotope analyses by Metgasco in its NSW tenements confirmed that the gas in the Walloon Coal Measures is of a thermogenic origin (Doig and Stanmore, 2012), and a thermogenic origin has also been reported for CSG in the Namoi subregion (Stewart and Alder, 1995). A gas isotope analysis by Arrow Energy (Pinder, 2007) collected from flowing gas at the surface at Kalbar-1 also suggested a thermogenic origin of the methane.

References

Australian Energy Market Operator (AEMO) (2011) Gas Statement of Opportunities for Eastern and South Eastern Australia. Council of Australian Governments (COAG), 274 pp.

Brown, RE, Cranfield, LC, Denaro, TJ, Burrows, PE, Henley, HF, Stroud, WJ, Brownlow, JW 2007 Warwick-Tweed Heads 1:250 000 Metallogenic Map SH/56 2-3 Provisional 1st ed. Geological Survey of New South Wales, Maitland and Geological Survey of Queensland, Brisbane.

Burgess LEL (2010) Kingfisher-E1 Geological Well Report. Westminster Geological Pty Ltd prepared for Metgasco Ltd, 213 pp.

Cameron, JB (1970) The Rosewood-Walloon Coalfield. GSQ Publication 344. Geological Survey of Queensland, Brisbane, 59 pp.

Chern PKZN (2004) Patterns of coal sedimentation in the Ipswich Basin Southeast Queensland. MSc thesis, Queensland University of Technology, School of Natural Resources.

Doig A and Stanmore P (2012) The Clarence-Moreton Basin in New South Wales; geology, stratigraphy and coal seam characteristics, Eastern Australasian Basins Symposium IV.

Geoscience Australia (2012) OZMIN Mineral Deposits Database, Canberra.

Geoscience Australia and BREE (2014) Australian Energy Resource Assessment. 2nd Ed. Geoscience Australia, Canberra.

Gordon J (2010) Well completion report Peacock-1, PEL 445, Clarence-Moreton Basin. Arrow Energy, 126 pp.

Goscombe PW and Coxhead BA (1995) Clarence-Moreton, Surat, Eromanga, Nambour, and Mulgildie Basins. In: Ward CR, Harrington HJ, Mallett CW and Beeston JW (eds) Geology of Australian Coal Basins. Geological Society of Australia Incorporated Coal Geology Group. Special Publication No. 1, 489–512.

Gurba LW and Weber CR (2001) Effects of igneous intrusions on coalbed methane potential, Gunnedah Basin, Australia. International Journal of Coal Geology 46, 113–131.

Hartogen Energy Ltd (1983) Richmond Range seismic survey, Clarence-Moreton Basin, 7 pp.

Henley HF, Brown RE, Brownlow JW, Barnes RG and Stroud WJ (2001) Grafton-Maclean 1:250 000 Metallogenic Map, 1st edition, Geological Survey of New South Wales, Sydney.

Ingram FT and Robinson VA (Facer RA (ed)) (1996) Petroleum prospectivity of the Clarence-Moreton Basin in New South Wales. New South Wales Department of Mineral Resources, Petroleum Bulletin 3.

Johnson D, Symington R, Willink L and Beatty B (2008a) Well Completion Report, Corella E09, Clarence-Moreton Basin, PEL 16. Metgasco, 43 pp.

Johnson D, Symington R, Willink L and Beatty B (2008b) Well Completion Report, Corella E10, Clarence-Moreton Basin, PEL 16, Stratheden JV. Metgasco, 50 pp.

Korsch RJ, O'Brien PE, Sexton MJ, Wake-Dyster KD and Wells AT (1989) Development of Mesozoic transtensional basins in easternmost Australia. Australian Journal of Earth Sciences 36, 13–28.

Marketwire (2007) Waratah Coal Inc. Confirms Hard Coking Coal at Nymboida Project. Viewed 25 August 2014, <http://www.marketwired.com/press-release/waratah-coal-inc-confirms-hard-coking-coal-at-nymboida-project-752862.htm>.

Martin, AR and Saxeby JD (1982) Geology, sources and hydrocarbon generation in the Clarence-Moreton Basin. APEA Journal, 22, 5–16.

Matheson SH (1993) Coal geology and resources of the Moreton Basin, Queensland. Queensland Minerals and Energy Review Series. Department of Minerals and Energy, Queensland.

Metgasco (2013) Annual report. Viewed 30 June 2014, <http://www.metgasco.com.au/sites/metgasco.com.au/files/2013%20Annual%20Report.pdf>.

MHA Petroleum Consultants (2009) Independent review for Stratheden Joint Venture; Final Report (unpublished).

NSW Trade & Investment (2014a) NSW Digital Imaging Geological Systems. Viewed 5 November 2014, <http://digsopen.minerals.nsw.gov.au/>.

Nightingale M (2010) A-P 644P, AEL Mount Lindsay 7, Well completion report. Arrow Energy, 88 pp.

Northey J, Pinetown K and Sander R (2014) Coal and coal seam gas resource assessment for the Namoi subregion. Product 1.2 for the Namoi subregion from the Northern Inland Catchments Bioregional Assessment. A report to the Australian Government from the Northern Inland Catchments Bioregional Assessment. Office of Water Science, Bureau of Meteorology, CSIRO and Geoscience Australia, Australia.

Oberhardt M and Pinder B (2005) Swanbank-1 Well completion report. Arrow Energy NL, 184 pp.

O'Brien PE, Powell TG and Wells AT (1994) Petroleum potential of the Clarence-Moreton Basin. In: Wells AT and O'Brien PE (compilers and editors) Geology and petroleum potential of the Clarence-Moreton Basin, New South Wales and Queensland. Australian Geological Survey Organisation, Bulletin 241, 277–290.

Papendick SL, Downs KR, Vo KD, Hamilton SK, Dawson GKW, Golding SD and Gilcrease PC (2011) Biogenic methane potential for Surat Basin, Queensland coal seams. International Journal of Coal Geology 88, 123–134.

Pinder B (2007) A-P 641P, Arm Kalbar 1, Well completion report. Arrow Energy, 33 pp.

Radke BM and O'Brien PE (2012) Chapter 4: Stratigraphy of the Great Artesian Basin. In: Ransley TR and Smerdon BD (eds) Hydrostratigraphy, hydrogeology and system conceptualisation of the Great Artesian Basin. A technical report to the Australian Government from the CSIRO Great Artesian Basin Water Resource Assessment. CSIRO Water for a Healthy Country Flagship, Australia.

Rassam D, Raiber M, McJannet D, Janardhanan S, Murray J, Gilfedder M, Cui T, Matveev V, Doody T, Hodgen M and Ahmad ME (2014) Context statement for the Clarence-Moreton bioregion. Product 1.1 from the Clarence-Moreton Bioregional Assessment. Department of the Environment, Bureau of Meteorology, CSIRO and Geoscience Australia, Australia.

Smyth M (1994) Organic petrology of sediments in the Clarence-Moreton Basin. In: Wells AT and O’Brien PE (compilers and editors) Geology and petroleum potential of the Clarence-Moreton Basin, New South Wales and Queensland. Australian Geological Survey Organisation, Bulletin 241, 230–236.

Sommacal S, Pryer L, Blevin J, Chapman J and Cathro D (2008) Clarence-Moreton SEEBASETM and GIS Project. Confidential report to NSW Department of Primary Industries by FrOG Tech Pty Ltd.

Staines HRE, Falkner AJ and Thornton MP (1995) Ipswich Coal Field. In: Ward CR, Harrington HJ, Mallett CW and Beeston JW (eds) Geology of Australian Coal Basins. Geological Society of Australia Incoporated Coal Geology Group. Special Publication No. 1.

State of Queensland (2014) Queensland Digital Exploration Reports. Viewed 5 November 2014, <http://www.dnrm.qld.gov.au/mapping-data/qdex-reports>.

Stewart JR and Alder JD (1995) New South Wales Petroleum Potential. New South Wales Department of Mineral Resources, Sydney.

Ward CR and Kelly FB (2013) Background paper on New South Wales geology: With a focus on basin containing coal seam gas resources, Technical report for Office of the NSW Chief Scientist and Engineer. University of New South Wales, Sydney. Viewed 10 September 2013, <http://www.chiefscientist.nsw.gov.au/__data/assets/pdf_file/0009/31788/NSW-Geology-Background-Paper_Ward-and-Kelly_UNSW.pdf>.

Wells AT (1995) Nymboida, Red Cliff and Evans Head Coal Measures, New South Wales. In: Ward CR, Harrington HJ, Mallett CW and Beeston JW (eds) Geology of Australian Coal Basins. Geological Society of Australia Incorporated Coal Geology Group. Special Publication No. 1.

Wells AT and O’Brien PD (compilers and editors) (1994) Geology and petroleum potential of the Clarence-Moreton Basin, New South Wales and Queensland. Australian Geological Survery Organisation, Bulletin 241. Australian Geological Survey Organisation, Canberra.

Willis IL (1994) Stratigraphic implications of regional reconnaissance observations in the southern Clarence-Moreton Basin, New South Wales. In: Wells AT and O'Brien PE (compilers and editors) Geology and petroleum potential of the Clarence-Moreton Basin, New South Wales and Queensland. Australian Geological Survey Organisation, Bulletin 241. Australian Geological Survey Organisation, Canberra, 48–71.

1.2.2 Current activity and tenements

Summary

As of November 2014, one operating coal mine occurs within the Clarence-Moreton bioregion. This coal mine, Jeebropilly Mine, is located west of Ipswich in south-east Queensland. Another coal mine, New Oakleigh Mine, ceased operations in January 2013 and is currently undergoing revegetation and rehabilitation.

As of November 2014, there is no coal seam gas (CSG) production for commercial purposes in the Clarence-Moreton bioregion. Some CSG production occurs for pilot testing and this information is discussed in Section 1.2.3.2.

1.2.2.1 Coal

Operating and historical coal mines in the Clarence-Moreton bioregion are shown on Figure 4. At present, only one mine, the Jeebropilly Mine near Amberley west of Ipswich in south-east Queensland (Figure 8), operates within the Clarence-Moreton bioregion. Jeebropilly Mine is an open-cut mine owned by New Hope Group, which has been operating since 1982. Operations temporarily ceased in 2007, but resumed in 2008.

There are multiple coal mines in the Clarence-Moreton bioregion which are now closed. These closed coal mines are clustered in different parts of the bioregion (Figure 4):

- Walloon-Rosewood Coalfield: open-cut mines in the Walloon-Rosewood Coalfield targeted the Walloon Coal Measures; this field includes recently closed coal mines such as the New Oakleigh Mine as well as Jeebropilly Mine. The Walloon-Rosewood Coalfield became a significant coal mining area supplementing production from the Ipswich Coalfield to supply the needs of south-east Queensland (Matheson, 1993).
- Ipswich Coalfield: includes historical open-cut and underground operations that mined the Ipswich Coal Measures (Figure 4). Until 1966, coal was exclusively mined from underground mines. Open-cut production started to exceed underground mining in 1985 (Staines et al., 1995).
- Nymboida Coalfield: About 927,000 tonnes of economic resources of coal have been recovered from the Nymboida Coal Measures in the south-western part of the Clarence-Moreton bioregion (Figure 4).
- The Walloon Coal Measures have been mined at Bonalbo, Ramornie, Nimbin and Tyalgum in NSW (Wells, 1995) (Figure 4). These mines have been small operations for local supply (e.g. Relph, 1958). For example, at the Lions Colliery at Nimbin, 11,115 t of coal were mined between 1942 and 1950, supplying coal to a local power station (Rayner, 1950).

Currently, no coal is produced from the Clarence-Moreton bioregion in NSW.

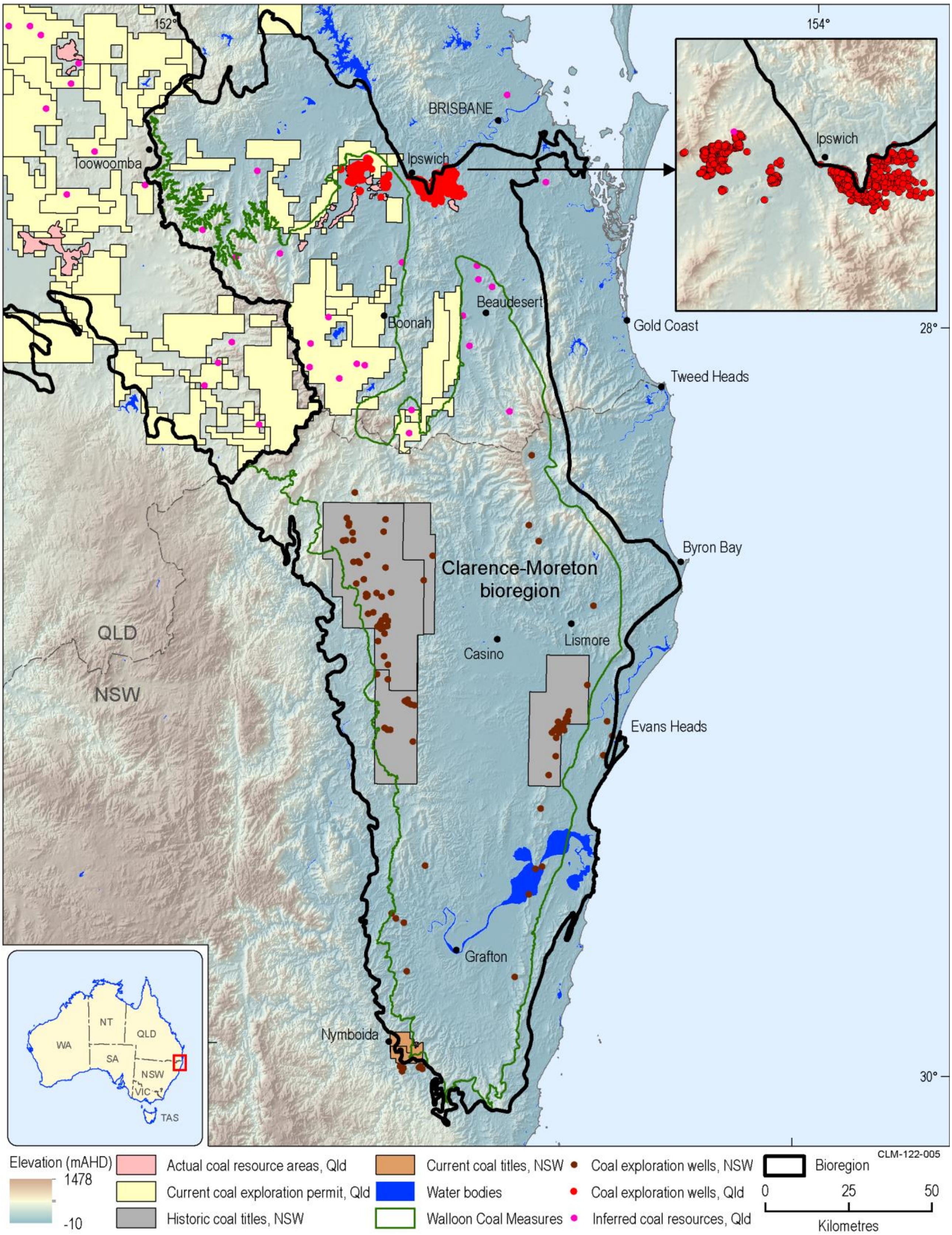


Figure 7 Coal exploration wells, inferred coal resources and historical and current coal exploration titles in Queensland and NSW in the Clarence-Moreton bioregion

1.2.2.1.1 Jeebropilly Mine

Jeebropilly Mine is currently the only operational coal mine within the Clarence-Moreton bioregion. It is west of Ipswich in south-east Queensland, and coal is mined from the Walloon Coal Measures coal seams in open-cut operations. The mine is owned by New Hope Group, and it temporarily ceased operations in February 2007 after 25 years of continuous operation. During that time, the coal-washing plant at Jeebropilly continued to process coal from the nearby New Oakleigh Mine. The mine was recommissioned in 2008 due to rising export prices for coal. Exploration activity at the Jeebropilly Mine has focused on defining the remaining coal resource within existing mining leases and expanding the geological database to include coal washability testing. According to current plans, production at the Jeebropilly Mine will continue until 2017, followed by rehabilitation and closure (Gomez Gane (New Hope Group), 2014, pers. comm.).

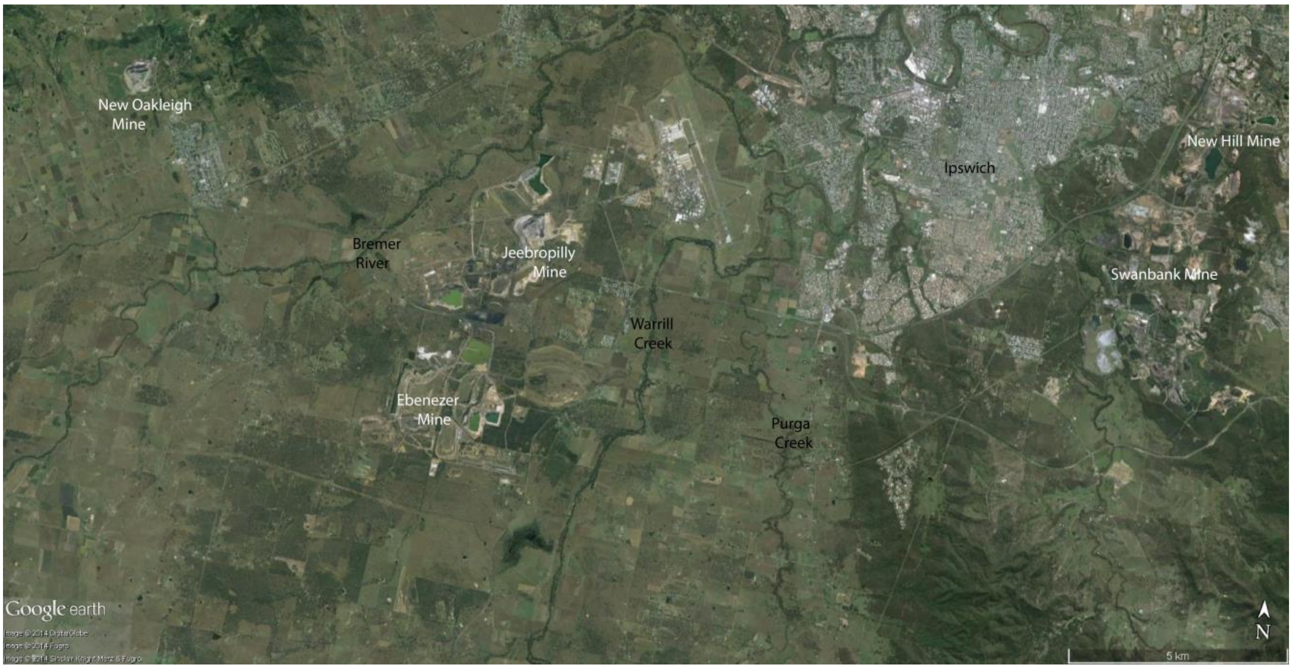


Figure 8 Active and historical coal mines in south-east Queensland in the Clarence-Moreton bioregion

Source: Google (2014). This figure is not covered by a Creative Commons Attribution licence. Map data © Google, SIO, NOAA, U.S. Navy, NGA, GEBCO, Landsat.

1.2.2.1.2 New Oakleigh Mine

Mining at the New Oakleigh Mine, west of Ipswich (Figure 8), dates back to the early 1900s, although large scale operations commenced in 1948. New Hope Group purchased New Oakleigh in 1999 and operated it until January 2013 (New Hope Group, 2014), when it was closed due to declining production rates (Mining Australia, 2013). Backfilling of the former mine pits commenced in August 2012. These will be contoured in preparation for revegetation and rehabilitation (New Hope Group, 2014).

1.2.2.2 Coal seam gas

There is currently no CSG production for commercial purposes in the Clarence-Moreton bioregion. Some CSG production occurs for pilot testing (discussed in Section 1.2.3.2).

The CSG and conventional gas exploration companies within the Clarence-Moreton bioregion are currently Metgasco Limited (in NSW), Arrow Energy Limited (in Queensland), ERM Power Limited (NSW), Dart Energy Limited (NSW), Red Sky Energy Limited (NSW) and Clarence Moreton Resources Pty Ltd (NSW).

The tenements of each CSG exploration company are shown in Table 3.

Table 3 CSG and conventional gas exploration companies and petroleum tenements in the Clarence-Moreton bioregion (locations of tenements are shown in Figure 10)

Company	State	Tenement
Arrow Energy Limited	Queensland	ATPs 641 and 644
Clarence Moreton Resources Pty Ltd	NSW	PELs 457, 478 and 479
Dart Energy Limited	NSW	PEL 445
ERM Power Limited (conventional gas exploration)	NSW	PELs 457, 478 and 479
Metgasco Limited	NSW	PELs 13, 16 and 426
Red Sky Energy Limited	NSW	PELA 135

ATP = authority to prospect; PEL = petroleum exploration licence; PELA = petroleum exploration licence application

References

Brown, RE, Cranfield, LC, Denaro, TJ, Burrows, PE, Henley, HF, Stroud, WJ, Brownlow, JW (2007) Warwick-Tweed Heads 1:250 000 Metallogenic Map SH/56 2-3 Provisional 1st ed. Geological Survey of New South Wales, Maitland and Geological Survey of Queensland, Brisbane.

Google (2014) Google earth version 7.1.2.2014. Google, California.

Henley HF, Brown RE, Brownlow JW, Barnes RG and Stroud WJ, 2001, Grafton-Maclean 1:250 000 Metallogenic Map, 1st edition, Geological Survey of New South Wales, Sydney.

Matheson SH (1993) Coal geology and resources of the Moreton Basin, Queensland. Queensland Minerals and Energy Review Series. Department of Minerals and Energy, Queensland.

Mining Australia (2013) New Hope to shut Oakleigh coal mine. Viewed 19 August 2014, <http://www.miningaustralia.com.au/news/new-hope-to-shut-oakleigh-coal-mine>.

New Hope Group (2014) Last coal leaves New Oakleigh Mine. Viewed 30 June 2014, <http://www.newhopegroup.com.au/news/2013/last-coal-leaves-new-oakleigh-mine>.

Relph RE (1958) Geology of the Nimbin area. Technical Report. Department of Mines NSW, Volume 3, p. 42–46.

Staines HRE, Falkner AJ and Thornton MP (1995) Ipswich Coal Field. In: Ward CR, Harrington HJ, Mallett CW and Beeston JW (eds) Geology of Australian Coal Basins. Geological Society of Australia Incorporated Coal Geology Group. Special Publication No. 1.

Wells AT (1995) Nymboida, Red Cliff and Evans Head Coal Measures, New South Wales. In: Ward CR, Harrington HJ, Mallett CW and Beeston JW (eds) Geology of Australian Coal Basins. Geological Society of Australia Incorporated Coal Geology Group. Special Publication No. 1.

1.2.3 Proposals and exploration

Summary

There are currently no proposals for the development of new coal mines within the Clarence-Moreton bioregion. However, large areas of the Clarence-Moreton bioregion in Queensland are covered by current coal exploration permits. At present, coal exploration occurs in the south-western Clarence-Moreton bioregion in NSW, where Waratah Coal Pty Ltd is exploring the economic potential of the Nymboida Coal Measures for coal mining, and west of Ipswich, where Cuesta Coal is exploring the coal resources of the Amberley Deposit.

Coal seam gas (CSG) and conventional gas exploration occur in different parts of the Clarence-Moreton bioregion in both Queensland and NSW. The major target of the CSG exploration is the Walloon Coal Measures, although exploration also tests the resource potential of the Ipswich Coal Measures. Recent CSG exploration campaigns have tested the economic potential of the Walloon Coal Measures throughout different parts of the Clarence-Moreton bioregion. The largest number of CSG exploration wells has been drilled in the Casino Trough. The thickest accumulation of Walloon Coal Measures (>700 m), thick coal seams and the high gas saturation of the coal seams suggest that conditions for CSG development are favourable in this depositional centre.

Within the Clarence-Moreton bioregion, the area near Casino currently appears to be the most likely for any CSG development to proceed.

1.2.3.1 Coal

There are no current proposals for development of new coal mines within the Clarence-Moreton bioregion. However, there was an attempt in 2013 by OGL Resources Limited to recommission the Ebenezer Mine (Figure 8) and purchase the Bremer View Coal Project (Mining Lease (ML) 4712). The Ebenezer Mine (ML 4712) operated from 1988 to 2003, producing more than 20 Mt of thermal coal (Miningoilgas, 2013). OGL planned to mine 13 Mt of coal over the next decade. However, in August 2013, OGL informed that an Asset Sale Agreement between OGL and Zedemar Holdings Pty Ltd for the acquisition of the Ebenezer Mine and Bremer View Coal Project has lapsed (ASX, 2013a).

Coal exploration wells, inferred coal resources and current coal exploration licences exist within the Clarence-Moreton bioregion in both Queensland and NSW (Figure 7). Most historical coal exploration drilling has focused on the Walloon Coal Measures at the basin margin (Figure 7). Active coal exploration currently occurs in the south-western part of the Clarence-Moreton bioregion, where Waratah Coal has recently drilled 15 exploration bores targeting the Nymboida Coal Measures within exploration licence (EL) 7186 and EL 6467. No resource estimates or additional information are publicly available from Waratah Coal. In Queensland, Cuesta Coal Limited has reported inferred thermal coal resources of greater than 50 Mt at the Amberley Deposit (Figure 5). These resources were identified within eight coal seams of the Walloon Coal Measures in Exploration Permit for Coal (EPC) 2127, following drilling of 14 open and three cored exploration wells (ASX, 2012).

1.2.3.2 Coal seam gas

There have been petroleum, conventional gas and unconventional gas exploration activities in different parts of the Clarence-Moreton bioregion, including drilling of 105 CSG exploration wells and 49 petroleum exploration wells to date (Figure 9).

In conventional gas reservoirs, gas flow occurs naturally without prior depressurisation of the coal seams. Potential impacts of development of conventional gas resources are therefore not considered within the bioregional assessment, and these resources and potential developments are not discussed in detail in this report.

Petroleum tenures in Queensland that cover areas of CSG exploration and production are called ‘authority to prospect’ (ATP) and petroleum leases (PL). The ATP grants the holder the right for petroleum exploration, whereas the PL gives its holder the right to explore for, test for, and produce petroleum (DNRM, 2014).

In NSW, exploration activities are governed by the NSW *Petroleum (Onshore) Act 1991*. There are three main types of permits (or titles) issued under the Act. These are: petroleum exploration licences (PEL), petroleum assessment leases (PAL) and petroleum production leases (PPL). A PPL allows commercial petroleum extraction or production.

Current petroleum exploration permits (Queensland), current petroleum titles (NSW) and petroleum title applications (NSW) are shown in Figure 10.

CSG exclusion zones were introduced by the NSW Government in October 2013 for existing residential zones in all local government areas of the state. In July 2014, further amendments were made. The exclusion zones ban new coal seam gas activity inside those zones, and also within a 2 km buffer around all residential zones (NSW Government, 2014) (Figure 11).

The Commonwealth’s *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) was amended in June 2013 to ‘provide that water resources are a matter of national environmental significance, in relation to coal seam gas and large coal mining development’. Following this amendment, an ‘action which involves a CSG development or a large coal mining development now requires approval from the Australian Government Environment Minister (the Minister) if the action has, will have, or is likely to have a significant impact on a water resource’ (Department of the Environment, 2013).

On the 13th of November 2014, the NSW government has released its new NSW Gas Plan (NSW Trade and Investment, 2014b).

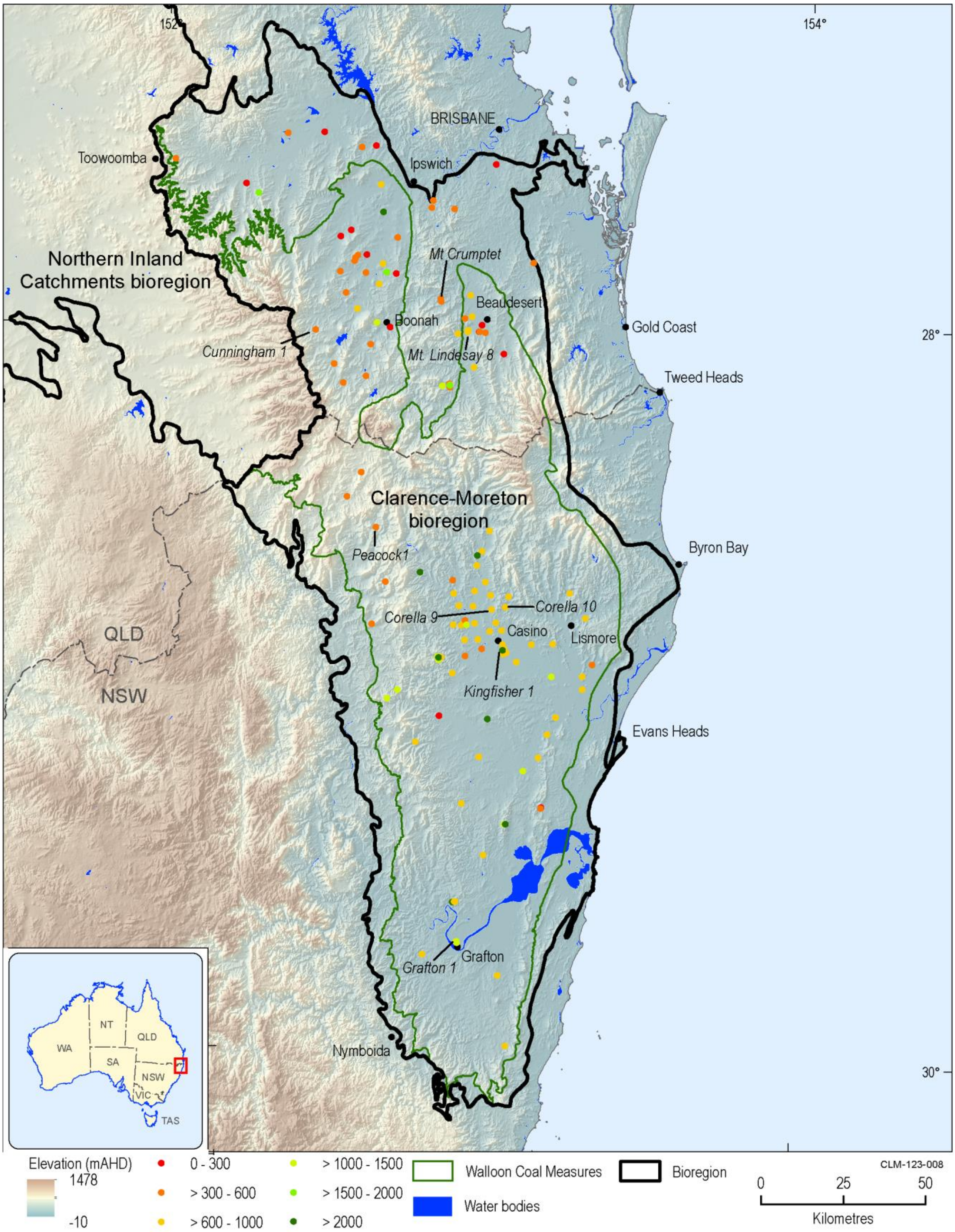


Figure 9 Spatial distribution and depth of coal seam gas and petroleum exploration wells in the Clarence-Moreton bioregion. Wells drilled outside the boundary of the Walloon Coal Measures target the older coal seams (i.e. Ipswich Coal Measures).

Source data: coal seam gas and petroleum exploration well location and depth of wells are sourced from (i) NSW Digital Imaging Geological Systems (NSW Trade & Investment, 2014a), © NSW Trade & Investment; (ii) Queensland Digital Exploration Reports (State of Queensland, 2014), © The State of Queensland 2014.

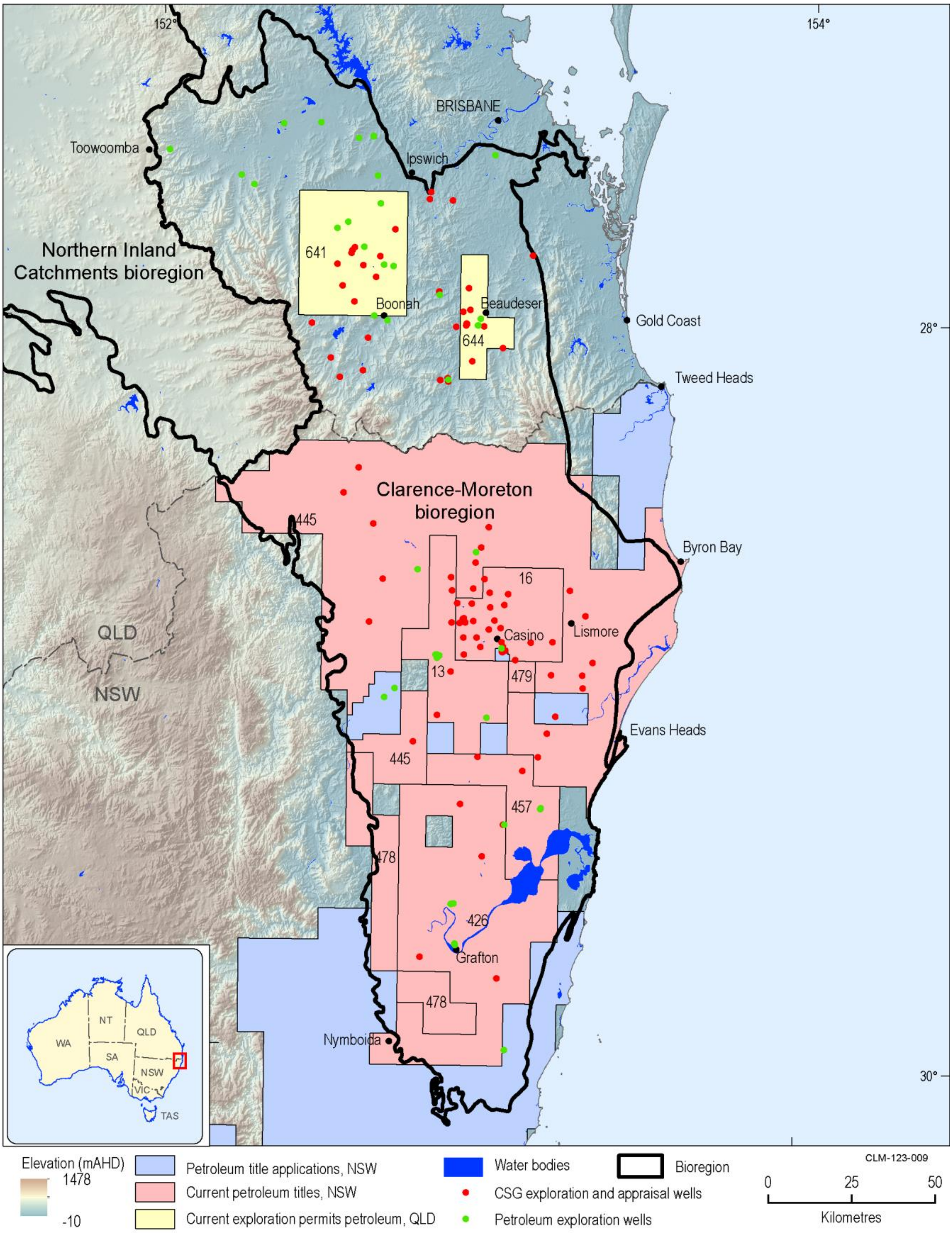


Figure 10 Current petroleum exploration permits (Queensland), current petroleum titles (NSW), petroleum title applications (NSW), existing CSG exploration and appraisal wells and petroleum exploration wells in the Clarence-Moreton bioregion

Source data: coal seam gas and petroleum exploration and appraisal well location and depth of wells are sourced from (i) NSW Digital Imaging Geological Systems (NSW Trade & Investment, 2014a), © NSW Trade & Investment; (ii) Queensland Digital Exploration Reports (State of Queensland, 2014), © The State of Queensland 2014.

1.2.3.2.1 Metgasco West Casino Project

Metgasco has drilled gas exploration wells to evaluate both conventional (not part of the bioregional assessment) and unconventional gas resources and to test different drilling techniques in the Walloon Coal Measures and other stratigraphic units in NSW in PEL 13, PEL 16 and PEL 426, covering an area of approximately 4550 km^2. In March 2013, Metgasco suspended its drilling exploration programme in the Clarence-Moreton Basin in response to the announcement of proposed new NSW government regulations (Metgasco, 2013). In 2014, Metgasco planned to recommence its exploration programme with the drilling of the conventional Rosella-1 well in PEL 16 to follow up the discovery of gas in deeper sands in the 2009 Kingfisher E01 exploration well.

While exploration has evaluated CSG potential throughout different parts of PEL 13, PEL 16 and PEL 426, most of Metgasco's exploration drilling has focused on the upper Richmond Seam in areas where the thickest accumulation of Walloon Coal Measures has been observed in the Casino Trough (Figure 5 and Figure 9) around Casino. The conditions there were considered favourable due to the gas content and high gas saturation of the coal seams. The Richmond Seam also has higher permeability than some of the deeper coals. The combination of permeability and fully saturated coals results in gas flow without significant early water production relative to other CSG operations. Extraction of CSG from the Walloon Coal Measures in the Casino Trough was initially expected from depths of approximately 500 to 700 m (Metgasco, 2007b). However exploration along the western side of the Casino Trough has since demonstrated high levels of gas saturation at depths as shallow as 250 m.

Initially, trial production wells were drilled vertically into the target coal seams in an area south of Casino. However, the low flow rates of these vertical wells and reservoir modelling suggested that horizontal drilling could potentially offer a better mechanism for increasing the gas production rates. Subsequently, Metgasco drilled two horizontal trial production wells (South Casino-9 and South Casino-10) in 2006 to test the commercial potential of the Walloon Coal Measures with horizontal drilling techniques. South Casino-9 was a horizontal well designed to increase the productive capacity of gas from the upper Richmond Seam of the Walloon Coal Measures drilled in an east to west direction to intersect the South Casino-5 vertical well, while South Casino-10 was drilled from north to south to intersect the South Casino-8 well (Johnson et al., 2009). These early tests proved largely unsuccessful, but further lateral drilling (e.g. pilot wells Corella P11, Corella P18 and Harrier P01) demonstrated that adequate gas rates could be sustained. In any future development drilling programme it is likely that the initial wells would be lateral wells targeting the Richmond Seam from multi-well drilling pads, to minimise the surface footprint, while later wells would be vertical, enabling development of the deeper coal seams (Peter Stanmore (Metgasco), 2014, pers. comm.).

In 2012, Metgasco commenced plans to apply for a petroleum assessment lease (PAL), which would have allowed the development of up to five wells, and for a larger petroleum production lease (PPL) north-west of Casino. However, the work on this 'West Casino Gas Project' is currently on hold (Metgasco, 2014b). If approved, production from the project area was to be used to provide gas to: 1) Richmond Dairies and other Casino businesses; 2) a compressed natural gas project, supplying gas to industries within a 100 km range of Casino; and 3) small scale power generation in Casino. Supplying gas for the proposed new power station ('Richmond Valley Power Station') would involve the drilling of approximately 20 horizontal wells in coal seams and the subsequent production of gas and water to the surface (Metgasco, 2006). This project has gained full development approval, but no development has occurred yet.

In addition to the Richmond Valley Power Station, Metgasco has also proposed construction of a pipeline from Casino to Ipswich, which would feed into the existing Roma – Brisbane pipeline in Queensland (Metgasco, 2007a). This pipeline, named Lions Way pipeline, would have a length of approximately 150 km with an intended capacity of 27 PJ per year (Geoscience Australia and BREE, 2012; Metgasco, 2014a). No environmental impact statement (EIS) has been submitted for this project yet.

The water management plan for Metgasco's 2012 to 2014 exploration programme (Metgasco, 2012) outlines, among other aspects, produced water volumes, water treatment and water monitoring (discussed in detail in later bioregional assessment products).

In September 2014, Metgasco has announced that its gas reserves and resources have been downgraded from those reported in 2013, with all reserves moved to the resource category (Metgasco, 2014c).

If CSG development proceeds, it will initially likely focus on specific areas west and north-west of Casino which have been identified as the most prospective exploration areas. However, it is currently difficult to predict the number of wells that will be drilled due to many factors related to, for example, regulations and contracted volumes.

1.2.3.2.2 Arrow Energy 'Boonah and Beaudesert' Project

Arrow Energy Pty Ltd currently holds exploration permits ATP 641 and ATP 644 in the Clarence-Moreton bioregion in south-east Queensland (Figure 10). Within these tenements, Arrow Energy has to date drilled 31 exploration wells, targeting both the Walloon Coal Measures and the Triassic Ipswich Coal Measures where they occur at shallow depths to evaluate regional geology, coal properties, gas content and permeability of the coal. In different intervals of the Ipswich Coal Measures of the Mount Crumpet-1 well, water flow rates ranging from 0 to 0.5 L/s were encountered (Oberhardt, 2009). Likewise, in flow tests evaluating the permeability of the Walloon Coal Measures, very low water flow rates were encountered for different intervals, for example ranging from 0.01 to 0.02 L/s in Cunningham-1 (Oberhardt, 2010).

In addition to the exploration wells, Arrow Energy has drilled three production trial wells (Mount Lindesay-7, Mount Lindesay-8 and Mount Lindesay-11) for extended production testing over a time period of up to 239 days. The initial 30 days production testing at depth interval 341.1 to 512.8 m at Mount Lindesay-8, for example, produced no gas while 69,840 L of water was produced. During the extended 239 days trial period, 72,000 m^3 of total gas and 552 m^3 L of water were produced (Oberhardt, 2011).

Groundwater management associated with the production trials has been outlined by an underground water impact report (Arrow Energy, 2012).

No resource estimates are available, and ATP 641 and ATP 644 will expire in March 2018 and October 2019 respectively. At this stage, there is currently no submission of an EIS for development of gas resources in these tenements. Arrow will continue to work in accordance with the terms of the ATPs and accompanying environmental authority requirements (Herbert (Arrow Energy), 2014, pers. comm.).

1.2.3.2.3 Clarence Moreton Resources/ERM Gas

Clarence Moreton Resources Pty Ltd. is the holder of PELs 457, 478 and 479. Freely flowing gas from sandstone reservoirs has been has been observed at some of the exploration wells in the Clarence-Moreton bioregion. This observation resulted in additional exploration efforts to further investigate these conventional gas resources that do not involve or require water extraction. Target intervals are the Kangaroo Creek Sandstone in PELs 457 & 479, and Triassic sandstone members in PEL 478, aiming to assess conventional gas potential of these units.

Initially, exploration was conducted under a farm-in-agreement with Red Sky Energy who completed two wells intersecting the Walloon Coal Measures. Subsequent to demonstrated conventional gas flow from a shallow sandstone reservoir in the Talma 1 well in PEL 457 above the Walloon Coal Measures, Red Sky's interests in PELs 457 and 479 were acquired by ERM Gas. ERM Gas has now assumed operatorship of the drilling programme of the Talma-2 conventional gas pilot well in this PEL on behalf of Clarence Moreton Resources. This pilot well has gained approval, and it is testing the conventional gas potential of the Kangaroo Creek Sandstone (conventional gas resources above the Walloon Coal Measures and separated from the Walloon Coal Measures by the Maclean Sandstone Member).

There are no current proposals for further exploration of CSG resources (Hodda (ERM Gas), 2014, pers. comm.).

1.2.3.2.4 Dart Energy

Dart Energy Limited holds PEL 445, which was previously held by Arrow Energy, within the northern part of the Clarence-Moreton bioregion in NSW. In April 2013, Dart Energy announced that its Australian assets in NSW will be placed under 'care and maintenance' with minimal activity for at least 12 months, awaiting 'regulatory clarity and certainty' (ASX, 2013b). In October 2014, Dart Energy was acquired by IGas Energy (ASX, 2014). In December 2014, PEL 445 was renewed for six years (NSW Trade and Investment, 2014c). The renewal is subject to new conditions, which allow Dart Energy to undertake 'low impact exploration activities including data review, mapping and technical evaluation'. Associated with the renewal, Dart Energy has also relinquished more than a quarter of PEL 445, in particular along the eastern part of the PEL title.

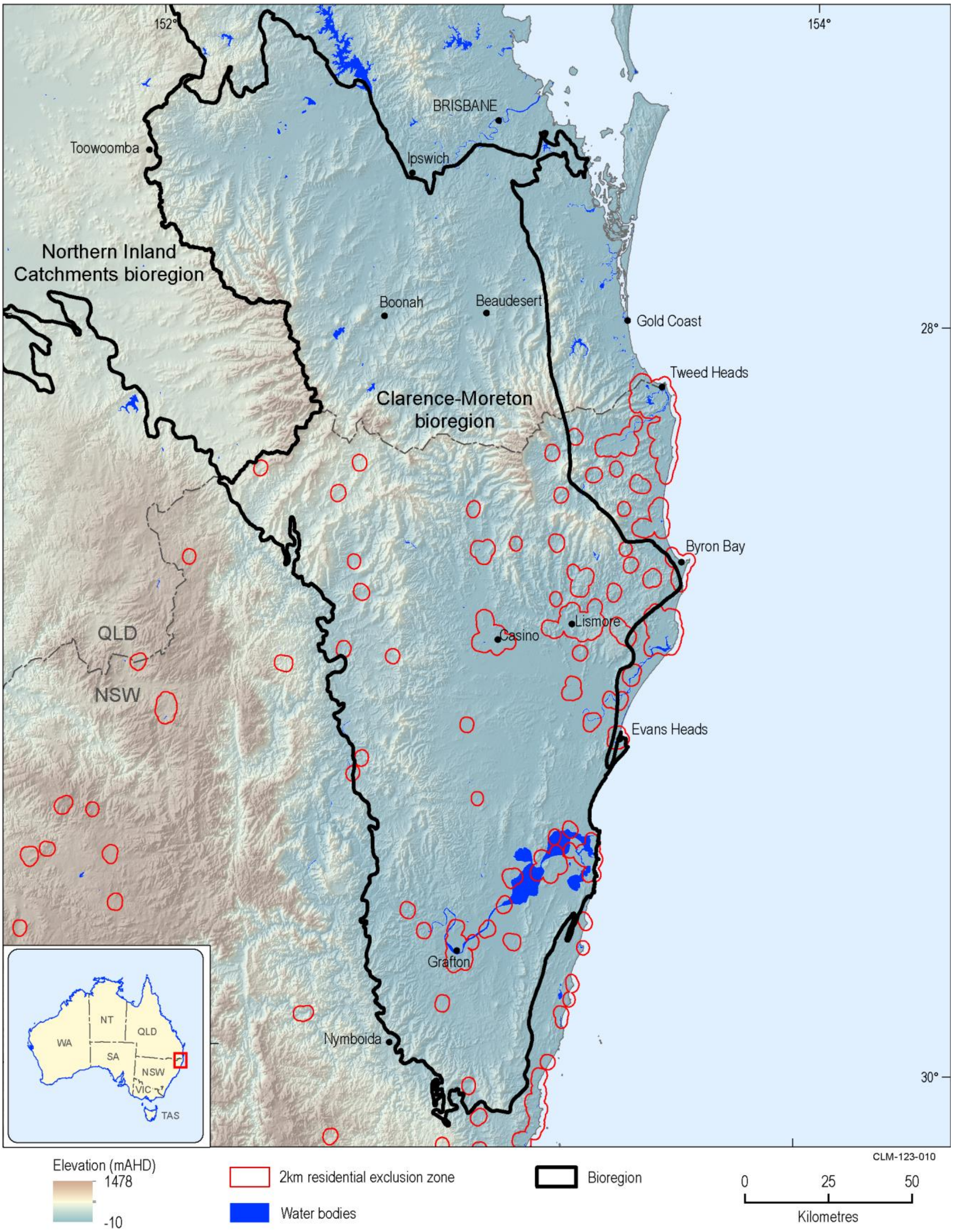


Figure 11 Residential coal seam gas exclusion zones (2 km) in the Clarence-Moreton bioregion in NSW (as of 26 August 2014)

References

Arrow Energy (2012) Underground Water Impact Report – For Authority to Prospect 644. Arrow Energy, 48 pp.

ASX (2012) Amberley Deposit Resource Upgrade. Viewed 19 August 2014, <http://www.resourcesrising.com.au/pdfs/cqc/01330931.pdf>.

ASX (2013a) OGL Resources Acquisition option lapse, 1 August 2013, 1 pp.

ASX (2013b) Dart Energy Limited – Strategic and Corporate Restructure, April 2013. 11 pp.

ASX (2014) Dart Energy Limited – Implementation of Scheme of Arrangement, 16th of October 2014, 1 pp.

Department of the Environment (2013) Significant Impact Guidelines 1.3, Commonwealth of Australia 2013: Coal seam gas and large coal mining developments – impacts on water resources. Viewed 17 October 2014, <http://www.environment.gov.au/resource/significant-impact-guidelines-13-coal-seam-gas-and-large-coal-mining-developments-impacts>.

DNRM (2014) Petroleum and gas tenure types and forms. Queensland Department of Natural Resources and Mines, Brisbane. Viewed 30 June 2014, <http://mines.industry.qld.gov.au/mining/petroleum-gas-tenures.htm>.

Geoscience Australia and BREE (2012) Australian gas resources assessment 2012, Canberra. Geoscience Australia, GeoCat # 74032.

Johnson D, Symington R, Willink L and Beatty B (2009) Well Completion Report, WCR, South Casino 9, PEL 16, Lismore Area, NSW. Metgasco, 11 pp.

Metgasco (2006) Casino Gas Project and Richmond Valley Power Station – Project Application for Major Project Status including: Application for Petroleum Production Lease and Application for Development Approval of Proposed Power Station. Metgasco, 18 pp.

Metgasco (2007a) Casino Ipswich Gas Pipeline – Project Description Report CIP-RP-G-02. Metgasco, 22 pp.

Metgasco (2007b) Casino gas project – hydrogeological assessment, M09388A01.500, Metgasco Ltd, North Sydney.

Metgasco (2012) Water Management Plan – 2012–2014 Exploration Phase. Metgasco, 149 pp.

Metgasco (2013) 2013 Annual report. 67 pp. Viewed 30 June 2014, <http://www.metgasco.com.au/asx-announcements/2013-annual-report>.

Metgasco (2014a) Lions Way Pipeline. Viewed 30 July 2014, <http://www.metgasco.com.au/information/lions-way-pipeline>.

Metgasco (2014a) Lions Way Pipeline. Viewed 30 July 2014, <http://www.metgasco.com.au/information/lions-way-pipeline>.

Metgasco (2014b) West Casino Gas Project. Viewed 30 July 2014, <http://www.metgasco.com.au/information/west-casino-gas-project>.

Metgasco (2014c) 2014 Annual report. 72 pp. Viewed 8 December 2014, <http://www.metgasco.com.au/sites/metgasco.com.au/files/2014_annual_report_0.pdf>.

Miningoilgas (2013) Ebenezer Company Profile. Viewed 19 August 2014, <http://www.miningoilgas.com.au/index.php/products/a-z?sobi2Task=sobi2Details&catid=12&sobi2Id=178>.

NSW Government (2013) Coal seam gas exclusion zones. Viewed 16 October 2014,

<http://www.planning.nsw.gov.au/coal-seam-gas-exclusion-zones>.

NSW Trade & Investment (2014a) NSW Digital Imaging Geological Systems. Viewed 5 November 2014, <http://digsopen.minerals.nsw.gov.au/>.

NSW Trade & Investment (2014b) NSW Gas Plan. Viewed 8 December 2014, <http://www.resourcesandenergy.nsw.gov.au/__data/assets/pdf_file/0005/534830/NSW-Gas-Plan.pdf>.

NSW Trade & Investment (2014c) New conditions for Dart Energy's PEL 445. Media release Resources and Energy 4th of December 2014. Viewed 8 December 2014, <http://www.resourcesandenergy.nsw.gov.au/__data/assets/pdf_file/0016/537010/New-conditions-for-Dart-Energys-PEL-445.pdf>.

Oberhardt N (2009) A-P 644P, ARM Mount Crumpet 1, Well completion report. Arrow Energy, 235 pp.

Oberhardt N (2010) A-P 791P, ARM Cunningham 1/1A, Well completion report. Arrow Energy, 120 pp.

Oberhardt M (2011) A-P 644P, AEL Mount Lindsay 8, Well production pilot 30 day testing and extended testing report to 28/10/10. Arrow Energy.

Rayner EO (1950) Coal in the Tyalgum Nimbin area JCB report No. 50/2. Coal exploration report, 18 pp.

State of Queensland (2014) Queensland Digital Exploration Reports. Viewed 5 November 2014, <http://www.dnrm.qld.gov.au/mapping-data/qdex-reports>.

1.2.4 Catalogue of potential resource developments

Summary

All developments within the Clarence-Moreton bioregion are currently at the pre-environmental impact statement (EIS) stage. However, subject to regulatory approval, the West Casino Gas Project may move towards an EIS within the time frames considered by the bioregional assessment.

All developments within the Clarence-Moreton bioregion are currently at the pre-environmental impact statement (EIS) stage. However, subject to regulatory approval, the West Casino Gas Project may be likely to move towards an EIS within the time frames considered by the bioregional assessment. In this section, we present the current coal exploration projects and potential coal seam gas resource developments.

Table 4 shows the current coal exploration projects within the Clarence-Moreton bioregion.

Table 5 lists potential coal seam gas resource developments. All of these are currently at the pre-EIS stage.

Table 4 Catalogue of potential coal resource developments for the Clarence-Moreton bioregion

Project name	Company	Longitude	Latitude	Record date[a]	Material[b]	Total coal resources[c] (Mt)	Status of EIS[d]
Amberley	Cuesta Coal Limited	152°	–27.7°	na	Thermal coal	54.7	Pre-EIS
Bremer View	OGL Resources Limited	152°	–27.7°	na	Thermal coal	276.9	Pre-EIS
Ebenezer	OGL Resources Limited	152°	–27.7°	na	Thermal Coal	31.3	Pre-EIS
Mount Mort	Unknown	152°	–27.8°	na	Thermal coal	20	Pre-EIS
Nymboida	Waratah Coal Pty Ltd	na	na	na	Coking coal	unknown	Pre-EIS

[a]The record date is the most recent date for updated coal resource numbers.
[b]Materials fall into one of the following four classes: thermal coal, coking coal, pulverised coal injection (PCI) and unspecified.
[c]This is based on Joint Ore Reserves Committee (JORC) codes of measured, indicated and inferred coal resources.
[d]The status of the project within an environmental impact statement (EIS): pre-EIS, EIS in preparation, EIS submitted, EIS closed, supplementary EIS and EIS approved.
na means 'data not available'

Table 5 Identified 2P gas resources and potential coal seam gas resource developments for the Clarence-Moreton bioregion

Project name	Company	Longitude	Latitude	Record date[a]	2P coal seam gas reserves[b] (PJ)	Status of EIS[c]	Notes
Boonah-Beaudesert	Arrow Energy Pty Ltd	na	na	na	na	No current EIS proposal	na
PEL 479	Clarence Moreton Resources	na	na	na	17	No current EIS proposal	ASX 2012
PEL 445	Dart Energy Limited	na	na	na	na	Pre-EIS	na
West Casino Gas Project	Metgasco Limited	na	na	na	338[d]	Pre-EIS, Pilot testing	Development is likely to proceed first in PEL 16 (Figure 8)

[a]The record date is the most recent date for updated coal seam gas resource numbers.
[b]The Petroleum Resource Management System of the Society of Petroleum Engineers (PRMS-SPE) code 2P refers to estimated quantities of proved reserves plus probable reserves.
[c]The status of the project within an environmental impact statement (EIS): pre-EIS, EIS in preparation, EIS submitted, EIS closed, supplementary EIS and EIS approved.
[d]In September 2014, Metgasco has announced that it has reclassified its gas reserves as resources (Metgasco, 2014c).
na means 'data not applicable'

References

ASX announcement (2012) Certified Reserves Red Sky Energy. Viewed on 1 September 2014, <http://redskyenergy.com.au/wp-content/uploads/2013/03/030212-Certified-Reserves-Update.pdf>.

CSIRO (2007) CSIRO PressurePlot™ software and PressureDB™ database. Viewed 1 August 2011, <http://www.csiro.au/products/pressureplot.html>.

CSIRO (2009) Water in the Gulf of Carpentaria Drainage Division. A report to the Australian Government from the CSIRO Northern Australia Sustainable Yields Project. CSIRO Water for a Healthy Country Flagship, Australia. Viewed 21 August 2012, <http://www.clw.csiro.au/publications/waterforahealthycountry/nasy/documents/GulfOfCarpentaria/NASY-Gulf-of-Carpentaria-Drainage-Division-Report.pdf>.

De Deckker P (1979) Ostracods from the mound springs area between Strangways and Curdimurka, South Australia. Transactions of the Royal Society of South Australia 103(6), 155–168.

Exon NF (1971) Roma, Queensland. Explanatory notes. 1:250,000 geological series – sheet SG55/12. Bureau of Mineral Resources, Geology and Geophysics, Canberra.

Healy RW (2010) Estimating groundwater recharge. Cambridge University Press, Cambridge.

Ivkovic KMJ (2006) Modelling groundwater-river interactions for assessing water allocation options. PhD Thesis, Australian National University. Viewed 24 August 2014, <https://digitalcollections.anu.edu.au/handle/1885/49342digitalcollections.anu.edu.au/handle/1885/49342>.

Love AJ, Rosseau-Gueutin P, Simmons C, Karlstrom K, Crossey L, Shand P and Priestley S (2010) Toward a new paradigm for the Great Artesian Basin; hydrologic mixing, partitioned sub-basins, and mantle influences on groundwater quality. Groundwater 2010, Proceedings of National Groundwater Conference. International Association of Hydrogeologists, Australia.

Love AJ, Wohling D, Fulton S, Rousseau-Gueutin P and De Ritter S (eds) (2012) Allocating water and maintaining springs in the Great Artesian Basin, Volume II: Groundwater recharge, hydrodynamics and hydrochemistry of the Western Great Artesian Basin. National Water Commission, Canberra.

Metgasco (2014c) 2014 Annual report. 72 pp. Viewed 8 December 2014, <http://www.metgasco.com.au/sites/metgasco.com.au/files/2014_annual_report_0.pdf>.

Quigley MC, Clark D and Sandiford M (2010) Tectonic geomorphology of Australia. In: Bishop P and Pillans B (eds) Australian landscapes. Geological Society, London, 243–265.

Silcock JL (2010) Experiencing waterholes in an arid environment, with particular reference to the Lake Eyre Basin, Australia: a review. Geographical Research. DOI: 10.1111/j.1745-5871.2010.00642.x.

Appendix A

The American Society for Testing and Materials (ASTM) classification scheme for coal rank, referred to in places throughout this report, is shown below.

Class	Group	Fixed Carbon Limits (Dry, Mineral-Matter-Free Basis) (%)		Volatile Matter Limits (Dry, Mineral-Matter-Free Basis) (%)		Calorific Value Limits (Moist [A], Mineral-Matter-Free Basis) (Mj/kg)		Agglomerating Character
		Equal or greater than	Less than	Greater than	Equal or less than	Equal or greater than	Less than	
Anthracite	Meta-anthracite	98			2			Nonagglomerating
	Anthracite	92	98	2	8			
	Semianthracite [B]	86	92	8	14			
Bituminous	Low volatile bituminous coal	78	86	14	22			Commonly agglomerating [D]
	Medium volatile bituminous coal	69	78	22	31			
	High volatile A bituminous coal		69	31		32.6 [C]		
	High volatile B bituminous coal					30.2 [C]	32.6	
	High volatile C bituminous coal					26.7	30.2	
						24.4	26.7	Agglomerating
Subbituminous	Subbituminous A coal					24.4	26.7	Nonagglomerating
	Subbituminous B coal					22.1	24.4	
	Subbituminous C coal					19.3	22.1	
Lignite	Lignite A					14.7	19.3	
	Lignite B						14.7	

GAL-120-019

A. Moist refers to coal containing its natural inherent moisture but not including visible water on the surface of the coal.

B. If agglomerating, classify in low volatile group of the bituminous class.

C. Coals having 69% or more fixed carbon on a dry, mineral-matter-free basis are classified according to fixed carbon, regardless of calorific value.

D. There may be nonagglomerating varieties in these groups of the bituminous class, with notable exceptions in the high volatile C bituminous group.

Figure 12 Classification of coal by rank. Coal maturity increases from lignite to anthracite

Source: modified after Wood et al. (1983)

Reference:

Wood GH, Kehn TM, Devereux Carter, M and Culbertson WC (1983) Coal resource classification system of the U.S. Geological Survey. Geological Survey Circular 891, United States Geological Survey, Denver. Viewed 4 August 2014, <http://www.pubs.usgs.gov/circ/c891/>.

www.bioregionalassessments.gov.au

Australian Government
Department of the Environment
Bureau of Meteorology
Geoscience Australia

CSIRO