SENATE REFERNCES COMMITTEE ON
RURAL AFFAIRS & TRANSPORT

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Inquiry into the management of the Murray Darling Basin
Impacts of mining Coal Seam Gas

CANBERRA, ACT – TUESDAY, 9 AUGUST 2011

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Opening address
Senate Committee Inquiry into the Murray Darling Basin
9 August, 2011
Canberra

Mr Chairman, Senators, thank you very much for the opportunity to appear at this hearing.

My name is James Baulderstone. I am responsible for Santos' Eastern Australian business.

I am joined by Mark Macfarlane, President of our GLNG joint venture in Queensland, and James Purtill, General Manager-Sustainability GLNG.

We have followed the work of the Committee with great interest. We have provided the Committee with a detailed submission on the key issues that have been under discussion.

Santos has over 50 years of experience in exploring, developing and operating some of Australia's most important oil and gas resources. We have lead CSG exploration and production for 20 years. We have worked with and alongside Australian agricultural producers safely and successfully… to our mutual benefit… throughout this time.

Like many witnesses to date, I too am from an agricultural background. I grew up and went to school in a small rural community in the Murray Mallee. My father is a third generation farmer.

My initial University education was an honours degree in environmental science specialising in sustainable agricultural development.

With this background, I have a personal interest in and commitment to ensuring that Santos treats the landholders with whom it works… as I would expect my father… to be treated.

Santos understands there is a social licence to operate that is based on open and honest communication with landowners, community groups and community leaders.

Santos is committed to setting the standards in this regard.

We support a strong regulatory framework for the industry. You have our commitment to continue to work constructively with Government and relevant community bodies in that regard.

Let me say from the outset that we hear, loud and clear, the concerns that have been expressed to you by various witnesses representing farming and rural communities.

However, in our view, not all evidence given has been well informed or accurate. There is understandable angst and fear being created and it is important that the facts are communicated and understood.

Mr Chairman, there has been much discussion in this committee's hearings about Australia's essential requirement for food security.

The need for lower carbon energy security is no less urgent or less critical.

These are not mutually exclusive. Australia must do both.

We believe that our submission and our evidence today will go some way to demonstrating four things:

1. That CSG developments can co-exist with agriculture and deliver tangible economic benefits for rural communities and the Australian economy;
2. That our processes, particularly in relation to water, gas extraction and environmental protection …are safe and sustainable;
3. That our dealings with landholders are fair, cooperative and open; and
4. That CSG can make a major, immediate contribution to reducing carbon emissions

We will confine our opening comments to the first three items.

Mark will first address economic benefits and our process safety. I will then conclude with landholder relations and land access.

[MARK]

Thank you Senators.

Our story in Queensland… especially in the Roma region… is a very positive one. We have been producing gas in that region since the 1960s. We are an integral part of the Roma and surrounding communities.

Since 1996, our exploration and development activities in the Roma region have increased to support the [$16 billion] GLNG project which involves the construction of a [420 km] pipeline from Roma to Gladstone and the construction of multibillion dollar plant and port infrastructure on Curtis Island in the Gladstone port.

This Queensland mega-project will generate substantial economic benefits to regional Queensland, the State and indeed for Australia. Over time, GLNG will deliver on average $9 billion in annual export income for Australia.

Santos and its joint venture partners will create around 5,000 construction jobs over the next four years and 1,000 permanent jobs. Australian suppliers for the project have already secured contracts worth around $2 billion.

Royalties that will accrue to the people of Queensland from the GLNG project are the equivalent of $500,000 per day over the life of the project.

The Commonwealth Government will collect an additional estimated $40 billion in income tax.

We are realising these economic benefits without compromising the strong and respectful partnership we have built with our landholders and the communities in which we are operating.

Neither are we compromising the regional environment.

It's particularly important to get CSG water use into perspective.

1. We take water from coal seams… not the surface aquifers that supply agriculture and towns.

2. Total water draw by CSG operations is expected to be a fraction of that consumed by agriculture and town usage
3. We have comprehensive water monitoring systems in place and will publish the data collected
4. There is also a very positive story of what we can do with treated CSG water to support landholders and the community.

The coal seams we target are hundreds of meters below the acquifers that farmers and other water users rely on. Coal seam gas is extracted from the coal seams at average depths of around 500 metres, down to around 1000 metres.

Water used by farmers comes from aquifers typically less than 100 metres below the ground…they are separated from coal seams by hundreds of metres of impervious rock.

Given the physical rock barrier… and the pressure difference between deep saline water bearing coal seams and surface aquifers… there can be no contamination of the surface aquifers.

In Queensland our modeling has been conducted and reviewed by independent experts for both state and federal governments. It has concluded that our CSG operations will have both minimal and manageable impacts on water resources.

Our submission addresses this point in more detail.

We have in place comprehensive water monitoring and management systems throughout our CSG areas. This ensures we know what is happening with water within the coal seams… and the aquifers. We would not operate where we see evidence of a direct connection between a well and an aquifer.

The final point on water Senators …is that our CSG operations in Queensland ultimately <u>produce…not reduce…</u> water for agriculture and town use.

CSG water is typically saline and is normally unusable for either agriculture or drinking water. We have worked with our landholders and the Roma community to ensure this water is put to beneficial use.

For example, we are treating our CSG water and using it to recharge the Roma town aquifer in a project with the CSIRO.

We are using treated CSG water to irrigate forage crops and millions of indigenous eucalypts.

In New South Wales…James' team is in the early stages of determining the best re-use options for the Gunnedah region. There is a real possibility that treated, reusable water can be used to re-pressurise aquifers that have been depleted over the years by agricultural, industrial and town use.

Based on an estimate of 80% re-use…which is similar to our Queensland operations, Santos' net water extraction is expected to be between only 0.7 and 1.4 gigalitres per year. Again by comparison total groundwater and surface water draw from the Namoi Catchment… for agriculture, other industries and town drinking water supply…. is currently around of 540 gigalitres per year.

[DRILLING SAFETY AND WELL INTEGRITY]

Senators, some of the other issues we've heard raised before the Committee include questions about the safety of our wells and infrastructure.

Our submission explains in detail how we ensure our operations are conducted safely and sustainably. I'd like to highlight a few points.

It is critical to our success that no connectivity between surface aquifers and coal seams is created by our drilling activities. Our process doesn't work if that happens.

Our wells are typically between 10cm and 30cm in diameter, are drilled and are fully lined with steel casing. This is cemented to the side of the hole, to isolate any aquifers that are intersected and to ensure well integrity.

- These precautions, optimise safety for people, the environment and equipment;

- They isolate drilling fluids and support pressure containment equipment;

- They are regularly monitored and pressure tested.

When we have finished with a well it is completely filled with concrete and sealed. There is no possibility of leakage in the future**.** This is a proven, time tested drilling process…subject to conservative, precautionary standards.

Finally, I would like to make some comments on the issue of fraccing.

Hydraulic fracturing or fraccing is a process where sand is injected under pressure to create small pathways the size of sand grains in the coal seam to allow the gas to flow more freely. This practice has been undertaken safely by the industry for decades.

The so called “fraccing fluid” contains, in addition to sand and water, a tiny proportion …around 1 per cent … of essentially gelling agents. This assists in carrying and dispersing the sand in the coal seam.

These additives are not special or specific to the oil and gas industry. They are used in many everyday products including - swimming pools, toothpaste, baked goods, ice cream, detergents and soap.

Let me assure the Committee that we are completely transparent about what chemicals we use. The list is contained in our submission and has been approved under our Commonwealth and State environment assessments.

Fraccing is only required in some parts of coal seams to make these wells more efficient. The key benefit of fraccing is that it means fewer wells are required on the surface. This minimises our footprint.

I’ll now hand back to James to conclude our statement.

JAMES

Thanks Mark.

Further to Mark's comments on fraccing, Santos supports the NSW Government's review of this practice. We are confident that our position will be endorsed once the scientific facts are objectively assessed.

We want to conclude our statement today with some brief comments on our relationship with landholders.

As I indicated earlier, there can be no question that there are instances where the actions of some in our industry have contributed to a deterioration in relations between the gas industry and primary producers.

Santos holds itself to a higher standard.

Our approach to compensation is explained in some detail in our submission including the rates we pay.

Broadly speaking, when we sit down to discuss a farm access agreement there are three elements on the table.

An initial payment to cover the first 12 months of operations… an ongoing annual payment …and in-kind compensation for costs such as road upgrades, fence restoration… or beneficial water use.

The compensation amount varies and depends on the level of activity we undertake on a property.

The impact is different on virtually every farm.

Those who host greater activity should receive greater compensation.

In the past …we have used a standard confidentiality requirement, and landowners have not raised issues directly with us about that.

However, in recognition of concerns expressed that this may compromise a landowner's ability to discuss issues with their neighbours….Santos will be changing its policy.

Going forward…confidentiality obligations will be waived at the request of the landholder.

We will continue to assess the form and nature of our compensation payments. We are happy to consider adjusting and adapting these arrangements in consultation with the landholders who choose to work with us.

The Committee may also be interested in how we locate infrastructure. We also plan locations of our infrastructure in consultation with landholders to minimise impact on their operations.

- Santos' well facilities are generally spaced around a kilometre apart. In some locations horizontal drilling allows for even lower frequency.

- Construction of pipelines and well facilities is generally a year or less. Any disruption caused during this period is part of the compensation calculation… which is made for each farmer.

- Santos pipelines are buried typically between .75 and 1.2 metres below the surface thereby not interfering with traditional agriculture.

- Once developed …the operating footprint of a producing well is only 25 metres by 25 metres. When the well is no longer productive… the site is completely rehabilitated in the manner which is outlined in our submission.

In conclusion, I hope we have been able to go some way to demonstrating to you that CSG can productively co-exist with agriculture… and other land users… for everyone's benefit.

We have highlighted that Santos operates safely and sustainably. CSG draws water from coal seams….not from aquifers used by farmers and other land users.

The water we do produce from the coal seams…equates to less than 1% of the water used in relevant catchment areas in NSW.

CSG water is generally non-potable or useable for agriculture without undergoing expensive treatment. Santos is committed to paying for such treatment so that we can add to ….not take away from… Australia's valuable water resources.

As a leader in the Australian gas industry Santos is committed to ensuring that we set and practice the highest standards in everything that we do.

We support a rigorous regulatory and compliance regime in which the entire community can have confidence. But that regime must recognise the significant benefits for regional communities and Australia that CSG will deliver…in productive co-existence with agriculture.

Thank you Senators.

We're now very happy to take any questions.

[ENDS]

SENATE REFERENCE COMMITTEE ON RURAL AFFAIRS AND TRANSPORT

MANAGEMENT OF THE MURRAY-DARLING BASIN SYSTEM

OPENING STATEMENT

CATHERINE TANNA
EXECUTIVE VICE PRESIDENT, BG GROUP AUSTRALIA
MANAGING DIRECTOR, QGC PTY LIMITED

9 AUGUST 2011

We thank the committee for the invitation to appear and we acknowledge the traditional custodians of the land on which we now meet.

I am Catherine Tanna, Executive Vice President of BG Group Australia and Managing Director of QGC Pty Limited, BG's wholly owned Australian subsidiary.

With me is Dr Jeff Jurinak, QGC's Vice President, Developments; Tony Nunan, General Manager, Land and Community Management; and Rob Millhouse, General Manager, Government Affairs.

We have a keen interest in the gas industry debate, welcome and encourage it, and trust forums such as this add much-needed fact, insight and understanding.

Today, we want to cover four key issues: the benefits of gas; water management; land access and community fabric.

Natural gas has been produced from coal seams in Queensland for the past 20 years.

Our company has been producing it for 12 years and we now supply about 20% of Queensland's gas demand.

Natural gas from coal supplies more than 80% of Queensland's total gas.

Our industry will have long-term benefits.

We are diversifying Queensland's economy.

The Queensland Curtis LNG Project which we are developing involves an investment of at least $15 billion during construction over the next three years.

We will create an average of 5000 jobs during construction and up to 1000 across Queensland during operations.

We will pay about $1 billion a year in taxes and royalties to the Commonwealth and Queensland Governments, with about three quarters of this going to the Commonwealth.

We will provide a $32 billion boost to the Queensland economy over the next 10 years.

Since the start of 2010 we have spent $2.3 billion – three-quarters of it in Australia and more than half – or $1.3 billion – in Queensland.

We already employ directly 3600 people, 95% of whom are Australian.

We have more than 550 contracts for services and equipment and more than 1500 businesses have registered an interest in being involved in our project.

Many are small family businesses that are growing and prospering – like Easternwell, the drilling business in Toowoomba which recently won an $80 million contract with QGC.

And Ostwald Brothers, the engineering and construction business in Dalby that has a $60 million contract with QGC.

Natural gas is the cleanest of fossil fuels and vital for transition to cleaner power generation.

It produces up to 70% less greenhouse gas emissions than coal when used to produce electricity.

It is ready now – reliably meeting power needs; not requiring taxpayer subsidy; not caught in the uncertainties of nuclear power.

This industry is good for Queensland and good for Australia.

It is also regulated.

Indeed, we would argue that it is the most heavily regulated industry of its type in the world.

Environmental assessment of the QCLNG Project was done under Australian and Queensland legislation.

The assessment took more than two years, involved more than 4000 meetings, briefings and presentations across interest groups, and resulted in a 12,000-page report.

The assessment was advertised widely across Australia for comment and resulted in about 40 submissions.

When approved, the Queensland and Australian Governments imposed more than 1500 conditions – 1200 from the state and 300 from the Commonwealth.

These conditions require us to obtain more than 900 permits and those 900 permits have a further 8000 conditions attached to them.

We invested more than $25 million in the environmental impact assessment.

Much has been said about water management and the impact we will have on the Great Artesian Basin.

In our view, the industry's potential negative impact on water resources is vastly over-stated.

Any suggestion that we will ruin aquifers ignores geology and commercial reality.

Let me explain.

The Great Artesian Basin is comprised of several separate aquifers, not one big homogenous underground lake as some would have us believe.

The basin has an estimated 65,000 million megalitres of water, equivalent to 130,000 Sydney Harbours.

The whole gas industry in the Surat Basin in Queensland will extract less than 0.004% of the total over the next 40 years.

We produce as little water as we can and we continuously look for ways to reduce water production because it is expensive to manage.

Much has been made of the apparent imbalance in water regulation between the gas industry and agriculture.

It is true that that we have a right to extract water in gas production.

But with that right comes an obligation to treat the water for beneficial use and to put it back into the water cycle.

We pay for and operate facilities to upgrade the water we produce, taking an otherwise relatively low-quality resource that might, at best, be used to water stock, and purifying it so it can be put to beneficial use on farms, with industry and as town supply.

Indeed, our company will invest more than $1 billion by 2014 on water treatment facilities, research, modelling, monitoring and management.

We have made no secret that we will have an impact on water resources.

Allow us to put that in context.

We extract water from the Walloon Coal Measures, a thick geological feature of solid rock which has thin coal seams embedded within it, most not more than 30cm thick and each a few hundred metres long and wide.

If it helps to picture this geology, imagine a currant cake where the currants are the coal seams and the cake is the solid rock.

We drill into these seams (or currants) and extract the water which reduces the hydrostatic pressure and allows the gas to flow.

Water produced from these coal seams is salty and, as mentioned, is, at best, good only for watering stock.

The rock that surrounds coal seams within the Walloons is so dense as to be virtually impermeable.

As a result, we do not expect to drain water from anything other than the Walloons coal seams which, in QGC's area, are hydraulically isolated from the major aquifers of agricultural interest above or below them.

If we find exceptions driven by local geology, we know we can isolate connection through the design of our wells.

On our tenements, we know of only about 35 bores that extract water from the Walloons.

Most of the other 400 registered farm bores on our project tenements tap shallower, freshwater aquifers.

Indeed, it is interesting to note that farmers who currently extract water from coal seams will eventually produce gas as they drain the seams into which their bores have been sunk.

That is why the Surat Basin has examples of water bores that now produce gas – it has nothing to do with our activity; it is simply a product of what happens when coal seams are drained of water, even if that occurs with a farm bore used to water stock.

That said, we acknowledge we will have to ‘make good’ any impact we have on farmers underground water supplies.

However, we believe that any QGC impact will be limited to existing Walloons water bores in QGC tenements.

Two particular water resources of concern to this committee are the Condamine Alluvium and the Murray-Darling Basin.

Our LNG project tenements cover about 4687 km2 of the Surat Basin and lie south-east from about Dalby to north-west of Wandoan in south-west Queensland.

The vast majority of our tenements are not in the most heavily irrigated agricultural land overlying the Condamine Alluvium east of Dalby.

Our environmental impact assessment did not identify any measurable impacts on Murray-Darling Basin water resources as a result of our gas development.

Geoscience Australia reported it highly unlikely that dewatering of the Walloon Coal Measures within our tenements would have any significant impact on the Condamine Alluvium.

And, a recent study by the University of Southern Queensland has shown that the gas industry will have little impact on the Great Artesian Basin or aquifers required for agriculture.

Notwithstanding, State and Commonwealth regulators have taken a precautionary approach to gas extraction from coal seams.

They have set trigger drawdown levels as early warning systems to any impact we may have.

With these triggers, we follow a precautionary principle so we can respond before any significant impact occurs.

Under our State and Commonwealth environmental conditions, we have produced a water management and monitoring plan that covers water extraction, hydraulic fracturing, make good, reporting and research.

This plan was submitted to the Australian and Queensland Governments for approval earlier this year and will be followed with a second-stage plan in early 2012.

As part of this plan, we are monitoring more than 1000 bores within our own and neighbouring tenements which will give an early indication of any impact.

This work is part of a $60 million monitoring program over the next three years which will establish the monitoring regime for the life of the project.

With the water we produce and treat, we have an agreement with SunWater, a State-owned corporation, to pipe the water to the Chinchilla Weir in the Condamine River for beneficial use in a scheme managed by SunWater.

This good quality water can allow shallow, stressed aquifers to be "rested" and can recharge the bed and banks of the Condamine River, providing a positive impact on the environment.

Where we have to 'make good', we will deepen existing bores, sink new ones, or provide alternative supplies.

Another issue of public concern is hydraulic fracturing.

This process that has been used around the world – including Queensland – for more than 50 years in more than a million wells, without any significant environmental or health impact.

It can increase well productivity by two or three times which can reduce the number of wells that need to be drilled.

More than 99% of fluid used in hydraulic fracturing is water and sand.

We also re-use water from well to well where possible.

Given we are tapping coal seams that are saturated with water, all of the fluid we pump in, and more, is returned to the surface within weeks of injection.

The trace amounts of chemicals that remain break down naturally or become so highly diluted as to be virtually immeasurable.

The gas industry in Queensland does not use chemicals that are known to cause cancer and we supported the Government ban on benzene, toluene, ethyl benzene and xylene, or BTEX.

Like farmers who use chemicals to grow food, the gas industry is very careful with the chemicals we use to produce our energy.

All of our chemicals are publicly disclosed and all chemicals used in hydraulic fracturing that have been imported to Australia have been registered under the National Industrial Chemicals Notification and Assessment Scheme.

They are assessed under the scheme if they are considered by authorities to have a significant health and environmental concern.

The fact that some have not been assessed suggests they are not of concern.

QGC is not aware of any deleterious effects anywhere from the use of chemicals it uses for hydraulic fracturing.

Many chemicals used in hydraulic fracturing are found in retail products, some even in the kitchen.

I will now make a few comments about land agreements and land access.

While much has been said about the basic architecture of resource ownership, a fundamental principle of Australia’s legal system is that the Crown owns mineral and petroleum resources.

Companies like ours are effectively invited to invest our money to extract the resource on behalf of the state – and we pay a royalty for the privilege.

This invitation comes with responsibilities and obligations.

We are obliged, before entering a property, to give notice of entry and to negotiate in good faith to agree compensation with the landholder.

We do not just “give notice”; we “ask for entry”.

We pay the legal fees that landholders incur in our negotiations – but they choose their lawyers.

We prefer voluntary agreements and now have more than 800 agreements following negotiations on land access with about 1000 landholders.

We negotiate the location of wells and infrastructure, taking into account the location of homes, cattle yards, community assets, roads, good quality agricultural land, farming practices, topography, geology, cultural heritage and environmental constraints to ensure the co-existence of agriculture and the gas industry.

We prefer to build our major infrastructure on land we own so we minimise impact on landholders.

Every piece of infrastructure in the gas fields is there with landholder permission.

We pay compensation to landholders based on the quality of the land, the use made of it and the impact of gas development.

We fund independent valuations for compensation agreements.

QGC has several landholders receiving compensation of between $75,000 and more than $200,000 a year, income streams which they would otherwise not receive were it not for the gas industry.

We note that some people have suggested that the gas companies insist on confidentiality around these compensation agreements.

In this regard, the committee might refer to the Queensland Petroleum and Gas Act and regulations which govern our activities.

This act and the regulations – not us – set the rules around confidentiality of information.

Senators, development of the gas industry will bring change.

During construction of our project over the next four years, we will have a visible impact and we are doing our best to manage that impact.

But we do not threaten agriculture or our host communities.

We know we can co-exist; we do co-exist; and we expect to co-exist for decades.

We have many examples of a constructive partnership with our host communities and our landholder neighbours.

Indeed, very few of our critics even have land affected by our operations.

We bring opportunity for landholders to diversify their income, an opportunity they otherwise would not get.

We support many small businesses in country towns that are thriving.

We also have a relationship with our wider host communities.

We have established Queensland's first comprehensive social impact management plan in which we are investing $150 million in community programs before we have earned our first cent of revenue.

The initiatives were developed over two years of consultation, assessment and dedicated studies.

Examples include:

- $6 million for a Sustainable Communities Fund for community organisations
- $3.5 million for Gladstone Hospital
- $1.2 million in rental assistance for apprentices
- $1 million for student driver safety training for students across 80 schools
- $800,000 for 23 community groups across the project
- $200,000 to help six local businesses improve business planning
- $58,000 for a women's health centre in Gladstone
- $40,000 for neighbourhood centres in the gas fields

In addition, the gas industry provides $10 million a year towards an emergency aero-medical service which is also available for community use.

The committee may be interested to know that the service's helicopter transferred a critically ill young stockman from Roma to Brisbane on the weekend.

In conclusion, we know we are bringing significant change to many communities.

We welcome balanced discussion about these changes and how we make them as positive as possible.

It is important that we encourage critical examination of the industry – indeed, we promote this.

But we think it reasonable to hold people to account for what they say, just as we are held to account.

We have to substantiate what we say and be accountable for it.

Everyone in this debate needs to do likewise.

Coal Seam Gas Factsheet #1

Introduction

Coal seam gas (CSG), also known as coal bed methane, is a form of natural gas, typically extracted from coal seams at depths of 300-1000 metres.

CSG is a mixture of a number of gases, but is mostly made up of methane (generally 95-97 per cent pure methane).

Underground, CSG is typically attached by adsorption to the coal matrix, and is held in the coal underground by the pressure of formation water in the coal cleats and fractures.

COAL SEAM GAS PRODUCTION IN AUSTRALIA

Australia has relatively large supplies of CSG resources, especially in Queensland and New South Wales (NSW).

CSG has been produced in Queensland from the Bowen Basin since 1997 and in the Surat Basin since 2005. Exploration is also occurring in other Queensland basins, northern NSW, and other parts of Australia where there are known coal deposits.

DIFFERENT FORMS OF GAS

Conventional and unconventional gas

Unconventional gas (including CSG, shale gas, and tight gas) and conventional gas differ in the geology of the reservoirs from which they are produced.

Conventional gas reservoirs largely consist of porous sandstone formations capped by impermeable rock, with the gas trapped by buoyancy. The gas can move to the surface through wells without the need to pump.

Unconventional gas is generally produced from complex geological systems that prevent or significantly limit the migration of gas and require innovative technological solutions for extraction.

CSG

CSG is entirely adsorbed into the coal matrix. Movement of CSG to the surface through wells normally requires extraction of formation water from the coal cleats and fractures. This reduces the pressure, allowing methane to be released from the coal matrix. Over time, water production decreases and gas production increases. CSG production normally requires a higher density of wells than conventional gas production, however CSG wells are typically shallower than conventional wells and cost much less to drill.

Shale gas

Shale gas is generally extracted from a clay-rich sedimentary rock which has naturally low permeability. The gas it contains is either adsorbed (i.e., closely to the surface matrix of the organic matter) or in a free state in the pores of the rock. *[Note: the US documentary 'Gasland' refers to coal and shale gas; there are important differences between the two in terms of the geological location and characteristics of the reservoirs they are found in and the processes employed to extract them].*

Tight gas

Tight gas is trapped in ultra-compact reservoirs characterised by very low porosity and permeability. The rock pores that contain the gas are minuscule, and the interconnections between them are so limited that the gas can only migrate through it with great difficulty.

Underground Coal Gasification

Gas from Underground Coal Gasification (UCG) can also be sometimes confused with CSG. UCG is the *in situ* conversion of coal into a combustible gas that can be used as a fuel or chemical feedstock.

USEFUL WEBLINKS

http://www.qwc.qld.gov.au/csg/about.html (Queensland Water Commission, CSG facts)

http://www.qwc.qld.gov.au/csg/pdf/csg-qwc-role.pdf (Queensland Water Commission's role in groundwater management)

http://www.cabinet.qld.gov.au/MMS/StatementDisplaySingle.aspx?id=72747 (media release on legislation passed by the Queensland Government to manage and protect Queensland's groundwater near CSG projects)

http://www.derm.qld.gov.au/environmental_management/coal-seam-gas/csg-water.html (Queensland Government policy for managing CSG water)

http://www.dme.qld.gov.au/mines/coal_seam_gas.cfm (Queensland Government Department of Employment, Economic Development and Innovation: Mines and Energy, CSG information)

http://www.dpi.nsw.gov.au/minerals/geological/overview/regional/sedimentary-basins/methanensw (NSW Government Primary Industries, CSG in NSW)

http://www.appea.com.au/industry/csg/introduction.html (Australian Petroleum Production and Exploration Association, CSG in Australia, with further links to fact sheets on CSG industry, CSG production, fraccing, groundwater and salt management, industry's economic benefit, CSG environmental performance and response to the US documentary 'Gasland')

http://www.environment.gov.au/epbc/notices/pubs/gladstone-ga-report.pdf (Summary of advice in relation to the potential impacts of CSG extraction in the Surat and Bowen Basins, Queensland. Report provided by Geoscience Australia and Dr MA Habermehl, for the Australian Government Department of Sustainability, Environment, Water, Population and Communities)

http://www.abare.gov.au/publications_html/energy/energy_10/ch_4.pdf (Joint Geoscience Australia and ABARE report on energy resources – Chapter 4 includes information on CSG)

http://www.frogtech.com.au/bowen-surat-basin-csg/ (FrOG Tech ('From Oil To Groundwater') is an Australian based natural resources consultancy; this website provides information on CSG in Bowen and Surat Basins)

http://www.frogtech.com.au/gloucester-basin-csg/ (FrOG Tech information on CSG in Gloucester Basin)

http://www.frogtech.com.au/clarence-morton-basin-csg/ (FrOG Tech information on the Clarence-Morton Basin)

http://topdocumentaryfilms.com/gasland/ (link to watch the 'Gasland' documentary online)

For further information:

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Please note: the information contained in this factsheet is presented as background material for the Senate Rural Affairs and Transport Committee's inquiry into coal seam gas mining in the Murray Darling Basin. This factsheet was compiled using publicly available information from various organisations, including state government departments and non-government organisations/companies.

Coal Seam Gas Factsheet #2

CSG Produced Water and Site Management

COAL SEAM GAS (CSG) EXTRACTION

Target coal seams for CSG production are generally 300-1000 metres below ground surface. Production normally requires the drilling of many wells at a more dense spacing than normally required for conventional gas production.

CSG is adsorbed into the coal matrix and is held in place by the pressure of formation water. To extract the gas, a well is drilled into the coal seam and formation water from the coal cleats and fractures is pumped and withdrawn. The removal of water in the coal seam reduces the pressure enabling the CSG to be released (desorbed) from the coal micropores and cleats, allowing the gas and 'produced water' to be carried to the surface.

In some cases (historically 5 to 30 per cent) the coal permeability is low and gas production is small (sub-economic). In these cases, to further assist the flow of gas through the coal to the producing well, the coal can be hydraulically fractured or ‘fracced’ (see Factsheet #3 for further information on fraccing).

CSG PRODUCED WATER

Produced water (also known as CSG water or wastewater) is the water that is pumped out of coal seams in order to release CSG. The gas comes up with the produced water. Over time, the volume of produced water normally declines and the volume of produced gas normally increases.

Once they reach the surface, the produced water and the methane (along with other gases) are separated. The methane is collected and passed to a central compressor station where it is added to a pipeline network for delivery to users.

How much water is produced from CSG production?

No two wells or coal seams behave identically and water production can vary from a few thousand to hundreds of thousands of litres a day, depending on the underground water pressures and geology.

Whether the process of water extraction poses a problem or not will depend on the interaction, if any, between CSG production and aquifer systems and on what is done with the produced water.

What is the water quality like?

The water that is produced from a coal seam has generally been underground for a long time with very little fresh water penetration. As a result, the water is often quite salty. CSG water contains mainly sodium chloride (varying from 200 to more than 10,000 milligrams per litre), sodium bicarbonate and traces of other compounds.

CSG WATER TREATMENT AND USES

Water quality is highly variable from site to site, but it is generally not fit for human consumption. Depending on its quality, produced water can be used directly, treated and then used, or directly reinjected.

What are the potential uses for CSG water?

CSG produced water has a number of uses, depending on its quality and quantity. However, generally, without treatment, the beneficial uses of CSG water are limited.

The potential uses for CSG water include:

- water as a supply for local farmers and communities
- irrigation of agricultural crops or plantation forestry
- dust suppression
- industrial purposes (e.g. drilling, coal washing for coal mining, cooling in power stations)
- discharge of interim or occasional surpluses of treated water into local river or weir/dam systems (if the water is treated and conditioned to equal standards for discharge into rivers, it can contribute favourably to environmental outcomes for river systems already exposed to heavy irrigation demand)
- reinjection into suitable underground aquifers or discharge as surface water.

How is coal seam gas water treated?

Treatment of CSG water depends on the quality and quantity of the produced water, the intended use of the water, and the prevailing environmental laws and regulations.

To treat the water to a standard suitable for town water supply or other purposes, such as farm irrigation, would require at least reverse osmosis (RO), or a similar technology to remove the dissolved salts and other chemical compounds. RO is a robust and well-proven technology that can filter out up to 95 per cent of the salts and organic compounds. Some operators have used RO to treat produced water, which is then used on plantations, in fish ponds and for other beneficial uses.

The treatment process results in a super saline brine or solid salt, depending on the process used, which can require further treatment or disposal. For instance, brine can be disposed of by injection into deep geological formations.

How is CSG water disposed of?

At present in Queensland most untreated CSG water is disposed of in evaporation ponds ranging from 1 to 100 hectares in area. Evaporation ponds, however, are to be discontinued as a primary means for the disposal of CSG water because of concerns over leakage of saline waters into soils, aquifers and rivers. Remediation of all ponds is anticipated to occur within three years.

Treated CSG water can also be reinjected into suitable underground aquifers, surface water systems or back into the subsurface, but impacts to those aquifers need to be considered.

MONITORING AND MANAGEMENT OF CSG SITES

Characterising CSG sites for production and for drilling wells is important in assessing the potential of CSG production. Technologies such as three-dimensional geophysical surveying techniques, mathematical based modelling and imaging of underground reservoirs can be used to observe subsurface aquifers and geological strata, determine how coal seams are connected to aquifers and assess the potential for groundwater contamination.

Groundwater modelling can assist in indicating the extent to which coal seams are connected to aquifers, and to predict whether drawing water from one can impact levels in the other. Seismic mapping technologies can be used to map fracture locations and channels for water movement underground.

Although absolute guarantees about potential impacts are not possible, existing knowledge from research on aquifers and groundwater models make it possible to estimate the level of risks of adverse impacts.

What monitoring and management procedures are used to assess the suitability of a site for CSG operations?

A number of detailed evaluation tests and analyses can be used to help determine the suitability of a site for drilling and extraction of CSG.

These analyses can include:

- geological site descriptions from well data – to characterise the rock layers associated with each coal seam well and their distribution, deposition and age;
- seismic surveys – to define the geological structure beneath the ground surface and identify faults or fractures that could potentially create leakage pathways that may also be associated with subsurface water movement;
- formation pressure measurements – to map the rate and direction of groundwater movement;
- hydrodynamic assessments – to determine the connectivity of aquifers in the subsurface;
- analysis of water quality samples – to measure barriers to flow between the deep and shallow groundwater zones or areas;
- analysis of groundwater samples – to determine the existing water quality levels at the site before CSG production, and to use as a baseline to monitor any changes during and after production.

Information gathered from all the analyses and geological characterisations can be used to build computer models of the site. These models can then be used to make predictions on the impact of CSG production.

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Coal Seam Gas Factsheet #3

Hydraulic Fracturing (Fraccing)

Hydraulic fracturing, or fraccing, is a method used by the oil and gas industry since the 1940s to increase the rate of oil and gas extraction and the total amount extracted from reservoirs. Fracturing has been used to enhance CSG production from coal seams since the 1970s in the United States (US) and since the mid 1990s in Australia. Increased CSG activity, mostly in Queensland and New South Wales, has caused a parallel increase in the use of hydraulic fracturing.

This factsheet contains information about the technology of the fraccing process. Although the technological aspects of fraccing are known, the impacts of fraccing are less well characterised.

Estimating the likely impacts of fraccing is complex, and depends on various factors such as the nature of land use in surrounding areas, geology, and hydrodynamics, which need to be considered on a regional and case by case basis (see Factsheet #5 for further information about estimating impacts of CSG production).

TECHNOLOGY OF THE FRACCING PROCESS

Why is fraccing necessary?

Without the recent and significant technological advancements made in horizontal drilling and fraccing, a portion of the natural gas found in coal seams would be uneconomic and unrecoverable. Fraccing is the most common method used to increase the production from a CSG well, but not all gas wells require fraccing. Generally only wells that intersect lower permeability coal seams require fraccing and these are usually deeper seams.

Where has fraccing been used in Australia?

Fraccing has been widely used in Australia. Fraccing for stimulation of petroleum wells, as distinct from CSG wells, has been used in most states in Australia with most of the activity in South Australia and Queensland.

How is fraccing carried out in CSG production?

The decision to frac a well is often made before drilling commences because the process requires additional considerations in well design and construction procedures.

Typically, a well is fully cased from top to bottom with steel casing. To gain access to the coal, the casing is perforated at specific intervals along the well, where the fracture treatment is to be carried out.

Fraccing involves injecting fluid made up of water, sand and a few additives under high pressure into the cased well. The pressure caused by the injection typically creates one fracture in the coal seam where the well is perforated that, for a large CSG treatment, might typically extend to a distance of 200 to 300 metres from the well. The fractures grow slowly. For example an average velocity may be less than 10 metres per minute initially and slowing to less than 1 metre per minute at the end of the treatment.

The last part of the fracture treatment involves adding a proppant (usually quartz sand) into the fluid, which acts to keep the fracture open after injection stops, and forms a conductive channel in the coal through which the water and gas can travel back to the well.

After the fracturing is complete, part of the fluid injected (which is made up of at least 96 per cent water) is brought back to the surface and treated before being used again or disposed of.

How deep is hydraulic fracturing performed?

Hydraulic fracturing takes place hundreds of metres below ground, generally deeper than local groundwater supplies. Targeted fraccing zones are typically located at around 300 to 1000 metres below the freshwater zones and are separated by low permeability shales and sandstones. The fracture treatments are designed to grow only in the zone of rock that contains coal seams because growth out of zone increases the cost and reduces the effectiveness of the treatment. Each site must be characterised by measuring rock properties and stress so that the potential for fracture growth can be assessed.

What does the fraccing fluid contain?

Water and sand make up more than 96 per cent of the fraccing fluid.

Other materials that make up the remainder of the fluid are added to make the mixture thicker and more viscous and then to break these fluids to a thin fluid at the end of the injection. Some commonly used chemical additives include:

- sodium hypochlorite (used in bleach and as a biocide in swimming pools)
- hydrochloric acid (a strong corrosive acid)
- surfactants (used in soaps)
- cellulose (the structural component of the primary cell wall of green plants)
- guar (used as a gelling agent, e.g. as a food additive to thicken some food products)
- acetic acid (the basis of vinegar)
- bactericides (to inhibit bacteria forming that may corrode the steel casing or plug the permeability in the fracture and coal seam).

Added chemicals make up about 1 per cent of the fraccing fluid.

The exact nature of the fraccing mixtures used by CSG companies may vary depending on the well and may be commercially confidential.

How much water is used during the fraccing process?

Generally between 100 and 10,000 cubic metres of water may be used to frac a well. A well may be fractured at different depths along the wellbore.

What happens to the frac fluid after it is pumped down the well?

Some of the frac fluid is flushed from the coal seam soon after fraccing operations are completed. These fluids are brought to the surface inside the steel casing. This fluid is then pumped to lined containment pits or tanks. Wherever possible, the fluid is recycled for further frac treatments or taken to an off-site location to be disposed of safely and appropriately with the produced water.

A portion of the fracturing fluid remains in the fracture and in the coal seam until the well is put on production. This frac fluid is then produced along with the seam water and handled and treated with the produced seam water.

What are the strategies undertaken to ensure that groundwater is not contaminated by fraccing activities?

Similar to CSG production wells, wells to be fractured are fully lined with steel casing, which are cemented in place to isolate and protect all aquifers overlying the target coal seam. Before fraccing is conducted, the integrity of the cement bond between the casing and rock needs to be confirmed and verified.

The risk of groundwater contamination is assessed by characterisation of the CSG site and monitoring and management procedures. Characterisation methods are used to assess the rock that separates the coal from any water bearing aquifers. These methods include geophysical logging of the rock penetrated by the well using special well logging tools, three-dimensional geophysical surveying techniques, mathematically based modelling and imaging of underground reservoirs to observe subsurface aquifers and geological strata. Stress and well testing are often carried out to measure stress and pore pressure in the rock strata.

Coal seams are typically comprised of softer lower stressed strata compared to the rock layers above and below the coal seam. This contrast in stiffness and stress, together with the precise positioning of fraccing perforations made in the CSG well casing, help keep the fracture confined to the coal seams being treated.

Monitoring methods also provide quality control on the fracture design and fracture growth, to ensure the fractures extend only in the target coal seam regions. The extent of fracturing can be measured at the time of fraccing through well logging and remote monitoring.

Models that predict fracture growth are used with the remote monitoring methods to assess potential risks of fracturing into zones above or below the coal seams. However, absolute guarantees about fracture growth are not possible because estimation of the growth is based on limited data reflecting the statistical variation of parameters in a sequence of rock layers.

If a hydraulic fracture grows into a groundwater aquifer, the extraction of gas and water from the CSG well means the flow of fluid will be from the aquifer towards the CSG well.

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Coal Seam Gas Factsheet #4

The Great Artesian Basin and Coal Seam Gas

The Great Artesian Basin (GAB) is Australia's largest groundwater basin and underlies more than 1.7 million square kilometres of eastern Australia (Figure 1). The GAB extends beneath parts of Queensland, New South Wales, South Australia and the Northern Territory and is one of the largest natural underground water reservoirs in the world. It comprises a sequence of aquifers within rocks ranging from 65 to 250 million years old, deposited in the Triassic, Jurassic and Cretaceous periods.

The primary target of coal seam gas (CSG) production is from coal seams contained within specific GAB rock layers laid down in the Jurassic period. These coal seams are referred to as the Walloon Coal Measures and are located in the Surat and Clarence Moreton Basins.

What is the relationship between the Murray-Darling and the key basins?

- The Murray-Darling Basin (MDB) is the catchment for the Murray and Darling rivers and tributaries (extent shown on Figure 1). The MDB is one of 12 major drainage divisions in Australia.
- The GAB is a groundwater basin delineated by the extent of Jurassic and Cretaceous beds that include the main confined aquifers.
- The GAB underlies a large portion of the MDB in northern NSW and southern Queensland and its extent is depicted in Figure 1.
- The GAB consists of a number of different geologic basins where sediments were deposited in the Triassic, Jurassic and Cretaceous periods. These depositional basins include the Surat Basin, Eromanga Basin, Carpentaria Basin and a portion of the Clarence Moreton Basin. The boundaries between these depositional basins are defined by geologic structures, such as ridges and major faults in the sub-surface.
- The GAB also overlies older geologic basins, such as the Bowen Basin. These basins are deeper than the GAB, and in the case of the Bowen Basin, have a boundary that extends beyond the boundary of the GAB. The Bowen Basin contains older, deeper coal seams and the Fairview and Scotia gas fields.

GROUNDWATER IN THE GAB

Groundwater resources in the GAB and Bowen Basin support an extensive pastoral industry, inland population centres, mining activities, and other extractive industries. There are many resources present in the basins – water, gas, oil and geothermal energy – and demand for these resources is increasing. From the perspective of the whole-GAB, water from rain and some rivers enters the groundwater along the elevated margins. From these areas of recharge, groundwater is driven by topographic gradient to lower-lying parts of the landscape where it can discharge back to the ground surface. From the perspective of the whole-GAB, groundwater discharge occurs through springs, artesian bores, extraction bores and very slowly by a diffuse seepage process across broad sections of arid land.

The mechanics of groundwater flow in the GAB, or hydrodynamics, is governed by the structure and nature of the sequence of aquifers. Across much of the GAB, the Jurassic and Cretaceous beds that form aquifers are confined by nearly impervious rock layers. These confining beds and relative elevation difference with the more elevated recharge areas results in the artesian groundwater pressure. A schematic slice representation of groundwater flow through the GAB is illustrated on Figure 2.

Within the Walloon Coal Measures CSG is trapped by groundwater pressure. CSG extraction occurs by drilling into the coal seam and lowering the groundwater pressure (see Factsheet #2 for further information).

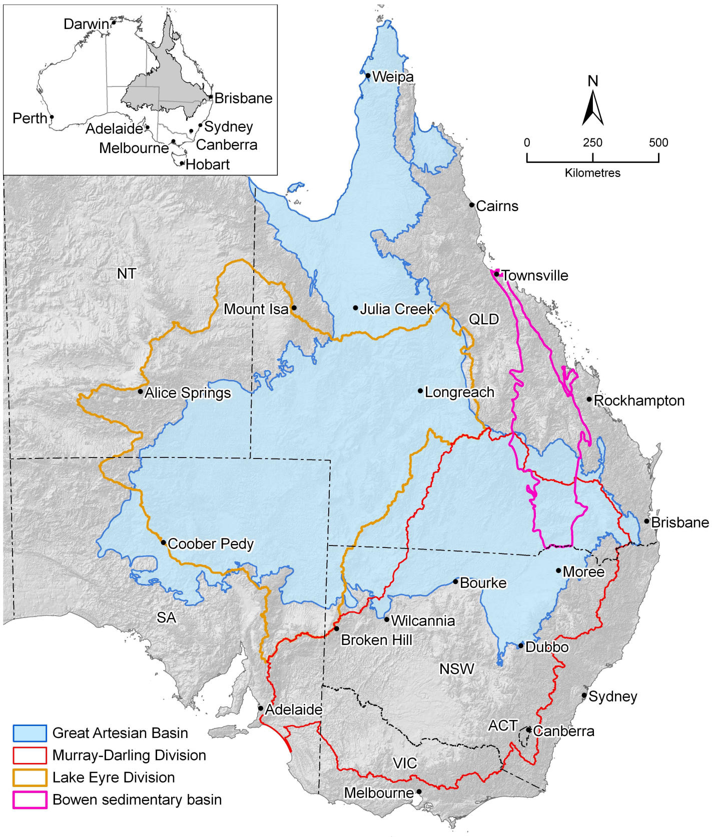

Figure 1. Geographic extent of the Great Artesian Basin and selected overlying surface water drainage divisions.

What is the connection between the MDB and GAB?

The MDB and GAB are related by the upward groundwater pressures exerted by the GAB in central and western NSW and Queensland, and leakage from rivers and alluvial sediments of the MDB to the GAB where Jurassic and Cretaceous beds are exposed along the western slopes of the Great Dividing Range. Areas where rivers are known to cross GAB aquifers include the Macquarie-Castlereagh region of NSW, Border Rivers region of NSW and Queensland, and the Condamine-Balonne region of Queensland.

The connection between MDB rivers and alluvial aquifers and the underlying GAB is complex and spatially variable. While some rivers are known to gain or lose water with GAB aquifers, in some locations this connection is restricted and leakage from rivers and alluvial aquifers is rejected and becomes river baseflow.

How is groundwater monitored?

Many of the GAB aquifers, particularly the Cadna-owie Formation – Hooray Sandstone aquifers, have been the subject of many investigations and groundwater flow is generally well understood. Yet, information on the layering of confining beds is sparse. The thickness and structure of confining beds will govern whether vertical flow from one aquifer to another is impeded.

As part of monitoring CSG sites the extent to which coal seams are connected to aquifers, and extent and thickness of confining layers, can be mapped. When combined with measurement of groundwater pressure, hydrodynamic assessment can be completed to map the rate and direction of groundwater movement and the connectivity of aquifers in the sub-surface.

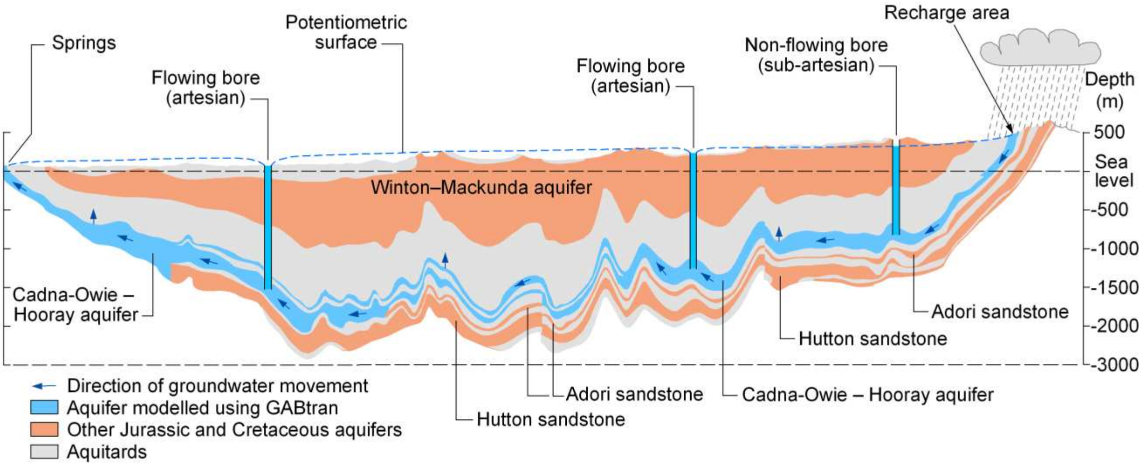

Figure 2. Schematic slice through the Great Artesian Basin illustrating predominant aquifers in the Jurassic and Cretaceous beds in blue, confining layers in grey, and other aquifers in red. The slice represents schematic layering from major spring zones in South Australia (left side of figure) to major recharge areas in Queensland (right side of figure).

THE GAB WATER RESOURCES ASSESSMENT

CSIRO and Geoscience Australia have initiated an integrated re-appraisal of the latest hydrogeology and hydrochemistry of the entire GAB to better understand how the whole groundwater system operates. This re-appraisal will build on the approach taken by CSIRO and partners in the Murray-Darling Basin, South-West Western Australia, Northern Australia, and Tasmania Sustainable Yields projects and is due to be completed by the end of 2012.

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Coal Seam Gas Factsheet #5

Challenges, benefits and risks of CSG production

To resolve the issues of water extraction and fraccing across several development proposals and thousands of wells, and to assess the potential cumulative impacts, requires a good characterisation of the basin geology and hydrodynamics.

There are a variety of methods employed to avoid or reduce the risks associated with coal seam gas (CSG) production and each of these is individually complex (see Factsheet #2 for detailed information on monitoring and management methods).

The levels of risk deemed to be appropriate are established by the relevant environmental authorities and based on the evaluation of risks and hazards. Applying comprehensive science can give insights into the risks associated with individual CSG operations.

Industry uses groundwater models to predict and minimise environmental impacts. However, the modelling of a regional groundwater system the size of the Surat, Bowen or even the Great Artesian Basin is a major challenge especially because of the scarcity of groundwater data in these sparsely populated regions.

The difficulty in the Great Artesian Basin is that groundwater flow velocities are slow, waters are old, and unforeseen consequences of extraction may take decades or centuries to work through the aquifers. Estimating the added impact of CSG production is further complicated by the fact that the region has had a significant history of groundwater extraction, for which the long term impacts have not been fully established.

The overriding issue is the uncertainty of the potential cumulative, regional impacts of multiple developments.

KEY ISSUES

Estimating social and environmental impacts associated with CSG production is complex because of dependencies on a number of factors including:

- the nature of land use in surrounding areas
- the amount, density, and location of surface infrastructure required
- geology
- hydrodynamics
- the type of CSG operations being conducted
- economics and logistics of producing and transporting the gas
- management and monitoring practices in place.

Generally each of these, as well as other factors, need to be considered on a regional and case by case basis when assessing the potential impacts of CSG production.

In many areas of Australia, there has been a substantial history of groundwater extraction, for example, for agricultural use. The long term impact of groundwater extraction remains uncertain, which adds to the complexities involved in estimating the likely impacts of CSG production.

ENVIRONMENTAL IMPACTS

The main environmental impacts associated with the production of CSG relate to the volume and quality of produced water, its treatment and the potential for groundwater contamination.

Water quantity

Generally large amounts of low quality water are produced from CSG operations, although the quantity of water withdrawal can vary during the extraction process from a few thousand to hundreds of thousands of litres a day.

The removal of large quantities of water may affect groundwater flow and may result in reduced groundwater levels in the surrounding aquifer systems. This could potentially impact on communities heavily reliant on bore water and potentially have a long term effect on regional subsidence and productivity of agricultural land.

Water quality and treatment

Water produced from CSG production differs in quality from site to site but is normally high in salt content. It can also contain other undesirable dissolved substances such as sodium bicarbonate and traces of other compounds. Depending on its quality, produced water can be used directly, reinjected into the subsurface, or treated and then used or directly reinjected.

Treatment of the produced water would allow for various surface uses or aquifer recharge, but this is expensive and energy intensive, which may increase the carbon penalty (and cost) of CSG extraction. Treating the water also produces a waste stream of super saline brine that needs to be disposed of or further treated to produce commercially usable salts.

Water use and disposal

The salty nature and commonly poor quality of CSG water could potentially be harmful for soil, groundwater and vegetation quality if it is inappropriately used or disposed of. High levels of salt can potentially affect drainage, damage soil structure and potentially increase susceptibility to erosion. Using saline water for irrigation may change soil structure or cause salt to accumulate in the soil.

Disposal into rivers may lead to increased river salinity or concentrations of metals in organisms. Continual discharge of treated water that is of high quality into rivers can also potentially cause clean water pollution, and may alter the natural concentrations of salts, ions and nutrients of river systems and potentially impact on the ecosystems they support.

Groundwater contamination

Poor management of CSG wells and fraccing operations or failure of CSG wells could result in interactions between the CSG-bearing subsurface layers and aquifer horizons. This may result in aquifer depression, effects on groundwater flow and fugitive gas migrating upwards.

Infrastructure footprint

Each CSG field may have about 20,000 wells to depths of up to 700 metres below the ground (in Queensland developments so far). These wells are often laid out on a grid within a few hundred metres of each other and are connected by a network of roads, pipelines and compressor stations.

Although the surface footprint of coal seam gas infrastructure is comparatively small compared to some industries such as mining, it can potentially compromise the scenic quality and economic viability of the landscape, and it may fragment habitat, displace local wildlife populations and may adversely impact threatened or endangered species in a region.

SOCIAL ISSUES

In Australia, a number of significant CSG fields underlie agricultural land. Social impacts flow from the access and use of competing natural resources and management practices, and the effects of potential environmental damage on the long term viability of agricultural productivity and an associated reduction in property values.

Although CSG projects inject funds into a region during their operation, many regional communities are concerned about long term economic viability after production ceases if the productivity of large areas of agricultural land is reduced or lost. Many of these issues are faced by other industries such as mining.

Other potential social impacts include:

- demographic change, immigration, change in labour markets, availability of services;
- reduction in property values due to visual impact of infrastructure;
- potential increase in traffic and noise pollution on affected properties and areas;
- change to rural amenity and community values;
- feelings of "intrusion" by others on farmers' land.

POTENTIAL BENEFITS OF CSG PRODUCTION

Natural gas extracted from coal seams offers a number of benefits over other forms of energy production, including:

- Natural gas is typically cleaner burning than coal and usually considered one of the cleanest of fossil fuels, burning much more efficiently than coal or oil and generating approximately 50 per cent less greenhouse emissions than conventional electricity generation. One petajoule (PJ) of gas is the equivalent heat energy content to about 43,000 tonnes of black coal or 29 million litres of petrol.
- Currently most of Australia's electricity is generated from coal fired power, which is one of the most intense greenhouse gas emitters for power generation. As Australia moves towards a lower carbon economy, natural gas presents an intermediate option for energy production between higher emission coal sources, and lower or zero emission renewable sources.
- Natural gas can be directly used for a broad range of heating uses and for powering fast-response, electricity-generating turbines.
- Australia has abundant resources of natural gas. Geoscience Australia estimates Queensland's coal seam gas resources at around 150 trillion cubic feet (157,500 PJ) – enough to power the whole of Queensland for more than 1000 years.
- Resources are often close to major markets for distribution.
- Gas is relatively easy to store and can be transported over long distances.
- Natural gas energy typically has reduced emissions of carbon dioxide, nitrogen oxides, sulfur dioxides and other harmful gases (particularly for the industrial and electric generation industries) compared to coal.
- Natural gas energy can cause less smog and acid rain compared to coal.
- Natural gas is a competitively priced fuel for electricity generation.
- CSG production leaves the coal resource intact for future extraction.

- Gas can be piped to a liquefied natural gas (LNG) plant where it can be processed into LNG for worldwide export to assist other countries switching from coal to gas fired power.
- CSG exports can potentially provide benefits to Australia in terms of revenue and jobs.

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Coal Seam Gas Factsheet #6

Hydrology of the Great Artesian Basin

CSIRO

GREAT ARTESIAN BASIN HYDROGEOLOGY

The Great Artesian Basin (GAB) is composed of a sequence of sediments that form aquifers and confining layers (aquitards). The thickness and lateral extent of sediments that have formed the aquifers and aquitards depend on conditions at the time of sediment deposition, which ranges from 65 to 250 million years ago, and all the geologic forces that have occurred since. By their very nature it is challenging to visualise the exact structure. Just as the study of geology attempts to unravel the history and understand the structure of geological rock systems from the deep subsurface to what is exposed at the surface, the study of hydrogeology focuses on movement of fluids through these complex geologic structures.

Groundwater pressure and movement

Groundwater in the GAB is mostly under artesian pressure, which is a result of confining layers preventing movement of groundwater up to ground surface. Considering the extent of artesian conditions across significant portions of the GAB, there must be extensive and relatively tight confining layers at a broad scale.

Extraction of groundwater from aquifers will lead to a change in pressure conditions around the location of extraction. For instance, widespread drilling of artesian bores in the late 1800s led to decline in the artesian pressure of some GAB aquifers. Because aquifers readily transmit groundwater horizontally along the depositional layering, the pressure change associated with extraction will propagate more easily through aquifers horizontally than vertically through aquitards.

When several layers of aquifers and aquitards are present, pressure changes caused by groundwater extraction will propagate at various rates in various directions, depending on the physical properties unique to each aquifer and aquitard layer. Groundwater movement through aquitards is very slow, and response to pumping in an overlying or underlying aquifer will be slower compared with that within the aquifer. Generally, this concept is referred to as a leaky aquifer response. Because the science of hydrogeology is based on finding water resources, from aquifers, the study of aquitards is less frequent.

Likewise, pressure conditions in aquitards are often not part of usual groundwater monitoring programs. Groundwater movement through aquitards is often visualised using computer models, by which the age of the water contained within the pores of the confining layers can be estimated. Relative to aquifers, changes in aquitards from pumping could take a very long time to detect.

IMPACT OF COAL SEAM GAS PRODUCTION ON GROUNDWATER

The extraction of coal seam gas (CSG) can potentially impact groundwater, depending on the location and method used for extraction. CSG is absorbed into the coal matrix and is held in place by the pressure of surrounding formation water. To extract the gas, a well is drilled into the coal seam and formation water from naturally occurring fractures (cleats) is pumped and withdrawn. The removal of water in the coal seam reduces the pressure enabling the CSG to be released (desorbed) from the coal micropores and cleats, allowing the gas and 'produced water' to be carried to the surface through the wellbore.

In some cases the coal permeability is low and gas production is small. To further assist the flow of gas through the coal to the producing well the coal can be hydraulically fractured or ‘fracced’. This process of ‘fraccing’ involves injecting fluid made up of water, sand and a few additives under high pressure into a steel cased well. To gain access to the coal, the steel casing is perforated at specific intervals along the well, where the fracture treatment is to be carried out. The pressure caused by the injection typically creates one fracture in the coal seam where the well is perforated that, for a large CSG treatment, might typically extend to a distance of 200 to 300 metres from the well. The fractures grow slowly. For example an average velocity is approximately 10 metres per minute initially and slowing to less than one metre/minute at the end of the treatment.

The last part of the fracture treatment involves adding a proppant, usually quartz sand, into the fluid. This acts to keep the fracture open after injection stops, and forms a conductive channel in the coal through which the water and gas can travel back to the well. After the fracturing is complete, part of the fluid injected (which is made up of more than 96 per cent water) is pumped back to the surface and treated before being used again or disposed of.

Movement of water and chemicals

Groundwater modelling is undertaken to predict the extent to which coal seams are connected to aquifers, and whether drawing water from one can impact levels in the other and over what timescale. Seismic mapping technologies are also used to map fracture locations and channels for water movement underground.

The movement of naturally occurring or introduced chemicals (such as those used for CSG extraction) in groundwater depends on the physical properties of the aquifer or aquitard and the properties of the chemical. Some chemicals dissolve very easily in water and move at nearly the same rate as groundwater. Other chemicals tend to attach to sediments or undergo degradation reactions and move much more slowly than the groundwater.

DEFINITIONS:

Groundwater: water that occurs within the zone of saturation beneath the Earth's surface. Geologic units can be defined based on their ability to store and transmit water.

Formation water: another term for groundwater that occurs within the pores of rock. Formation water might not have been the water present when the rock originally formed. In contrast, **connate water** is the water trapped in the pores of a rock during its formation, and may be called fossil water. Water from fluids introduced to a formation through drilling or other interference, such as mud, does not constitute formation water.

Aquifer: a permeable material that can transmit significant quantities of water to a well, spring, or surface water body. Generally, 'significant' is defined based on human need rather than on an absolute standard. Aquifers are often composed of unconsolidated sand and (or) gravel deposits, consolidated deposits that are permeable (e.g. sand stone, limestone), or consolidated formations that are generally less permeable (e.g. granitic and metamorphic rocks). An artesian aquifer has enough natural pressure to allow water in a well to rise to ground surface.

Aquitard: a saturated geologic unit that is less permeable than an aquifer and incapable of transmitting useful quantities of water.

For further information:

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Coal Seam Gas Factsheet #7

CSIRO and Gas Resource Management Research

Natural gas, such as coal seam gas (CSG), has the potential to be a transition fuel for electricity generation in a carbon constrained world. CSIRO's CSG research is focused on develop knowledge and technologies that have the potential to increase the benefits that Australia's natural gas resources can bring to our nation and the world. CSIRO is working to develop sound and proven technologies to produce CSG in a socially and environmentally responsible way and establish and inform safe operating and monitoring guidelines for CSG operations.

The work is being undertaken from the perspectives of managing CSG resources and understanding and managing the impacts of CSG production.

CSIRO's research aims to:

- gain greater understanding of our CSG resources and their production
- improve the management of CSG production and its impacts
- develop technologies to improve fracturing designs and the control of fracture placement and propagation
- develop optimal monitoring strategies to assess CSG reservoir performance and the longer term impacts of CSG production on other resources and the environment
- assist government regulators to effectively manage competing resources
- develop practices to assist land management and agricultural enterprises
- identify socio-economic opportunities and risks of CSG development
- develop strategies for mitigating CSG production impacts, including research targeted at the use of produced water.

Current CSIRO CSG resource management research activities include:

- integrated reservoir characterisation including understanding gas generation, adsorption and distribution and their relationships to coal properties
- microbial enhancement of gas production
- improving the understanding of CSG reservoir processes that affect gas migration and production such as coal permeability behaviour with respect to stress and gas content
- further development of the CSG reservoir simulator SIMEDWin.
- simulating coupled flow and geomechanical processes in coal seam reservoirs using the FLAMED model
- carbon dioxide storage in coal seams to enhance CSG recovery under support from the CO_2 Cooperative Research Centre and the Asia Pacific Partnership for Clean Development
- improvement of hydraulic fracture stimulation.

Some current CSIRO capabilities that can be applied to CSG resource management include:

- structural geology and fault seal analysis
- sedimentology
- coal geology and petrology
- organic geochemistry, including gas and isotope geochemistry
- petrophysics
- geophysics
- petroleum hydrogeology
- reservoir engineering and numerical modelling
- hydraulic fracturing
- tiltmeter monitoring of hydraulic fractures
- reservoir stimulation
- flow assurance
- gas processing
- chemical conversion of gas
- tracer analysis and sensors
- hydrates
- core flooding

GAS INDUSTRY SOCIAL AND ENVIRONMENTAL IMPACTS RESEARCH

CSIRO is a foundation partner of the Gas Industry Social and Environmental Research Alliance (GISERA), which was launched in July 2011. GISERA will research environmental, social and economic impacts and opportunities associated with the natural gas industry.

The Alliance will initially focus on the impacts of Queensland's coal seam gas to liquid natural gas (CSG-LNG) development across five main areas:

- surface and groundwater
- agricultural land management
- terrestrial biodiversity
- marine environment
- social and economic impacts and opportunities.

This suite of subject areas may change over time as knowledge is gained and further gaps and opportunities develop.

The capabilities being applied to this research include:

- hydrology
- agricultural systems
- plant and animal ecology
- marine ecology
- human geography
- social psychology
- economics.

Further information is available at www.gisera.org.au

For further information:

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phone 08 8303 8743, email glen.walker@csiro.au

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Coal Seam Gas Factsheet #8

The Great Artesian Basin: groundwater, geology and stratigraphy

The Great Artesian Basin (GAB) is Australia's largest groundwater basin and underlies more than 1.7 million square kilometres of eastern Australia (Figure 1). The GAB extends beneath parts of Queensland, New South Wales, South Australia and the Northern Territory and is one of the largest natural underground water reservoirs in the world.

Geology of the GAB

The GAB underlies a large portion of the Murray–Darling Basin in northern NSW and southern Queensland. It consists of a sequence of aquifers within rocks ranging from 65 to 250 million years old, deposited in the Triassic, Jurassic and Cretaceous periods. These depositional basins include the Surat Basin, Eromanga Basin, Carpentaria Basin and a portion of the Clarence Moreton Basin. The boundaries between these depositional basins are defined by geologic structures, such as ridges and major faults in the sub-surface.

The GAB also overlies older geologic basins, such as the Bowen Basin. These basins are deeper than the GAB, and in the case of the Bowen Basin, have a boundary that extends beyond the boundary of the GAB. The Bowen Basin contains older, deeper coal seams and the Fairview and Scotia gas fields.

Groundwater in the GAB

Groundwater resources in the GAB and Bowen Basin support an extensive pastoral industry, inland population centres, mining activities, and other extractive industries. There are many resources present in the basins, such as water, conventional oil and gas, unconventional gas and geothermal energy, and demand for these resources is increasing. From the perspective of the whole GAB, water from rain and some rivers enters the groundwater along the elevated margins. From these areas of recharge, groundwater is driven by topographic gradient to lower-lying parts of the landscape where it can discharge back to the ground surface. Groundwater discharge throughout the GAB occurs through springs, artesian bores, extraction bores and very slowly by a diffuse seepage process across broad sections of arid land.

The mechanics of groundwater flow in the GAB, or hydrodynamics, is governed by the structure and nature of the sequence of aquifers. Across much of the GAB, the Jurassic and Cretaceous beds that form aquifers are confined by nearly impervious rock layers. These confining beds and their relative elevation difference with the more elevated recharge areas results in the artesian groundwater pressure. A schematic slice representation of groundwater flow through the GAB is illustrated on Figure 2.

Since the 1880s, groundwater pressure has declined due largely to uncontrolled bores and open bore drains. Rehabilitating (capping) artesian bores and upgrading them with closed pipe systems was the focus of the GAB Sustainability Initiative (GABSI), which commenced in 1999.

COAL SEAM GAS IN THE GAB

The primary target of coal seam gas (CSG) production is coal seams contained within specific GAB rock layers laid down in the Jurassic period. These coal seams are referred to as the Walloon Coal Measures and are located in the Surat and Clarence Moreton Basins.

Impact of CSG on groundwater

Target coal seams for CSG production are generally 100–1500 metres below the ground surface. Production normally requires the drilling of many wells at a more dense spacing than normally required for conventional gas production.

CSG is absorbed into the coal matrix and is held in place by the pressure of surrounding formation water. To extract the gas, a well is drilled into the coal seam and formation water from the coal cleats and fractures is pumped and withdrawn. The removal of water in the coal seam reduces the pressure enabling the CSG to be released (desorbed) from the coal micropores and cleats, allowing the gas and 'produced water' to be carried to the surface up the production wellbore.

In some cases (historically 5 to 30 per cent) the coal permeability is low and gas production is small (sub-economic). To further assist the flow of gas through the coal to the producing well, the coal can be hydraulically fractured or 'fracced'.

To resolve the issues of water extraction and fraccing across several development proposals and thousands of wells requires a good characterisation of the basin geology and hydrodynamics. New well and seismic data adds information to update geological models and reduce the scientific uncertainty associated with these models. There are a variety of methods employed to avoid or reduce the risks associated with CSG production and each of these is individually complex.

The levels of risk deemed to be appropriate are established by the relevant environmental authorities. Applying comprehensive science can give insights into the risks associated with individual CSG operations and develop methods to manage the known risks.

The overriding issue is the uncertainty of the potential cumulative, regional impacts of multiple developments. The main environmental impacts associated with the production of CSG relate to the volume and quality of produced water, treatment of produced water, and the risks associated with potential groundwater contamination and the uncertain extent of fugitive methane emissions.

For further information:

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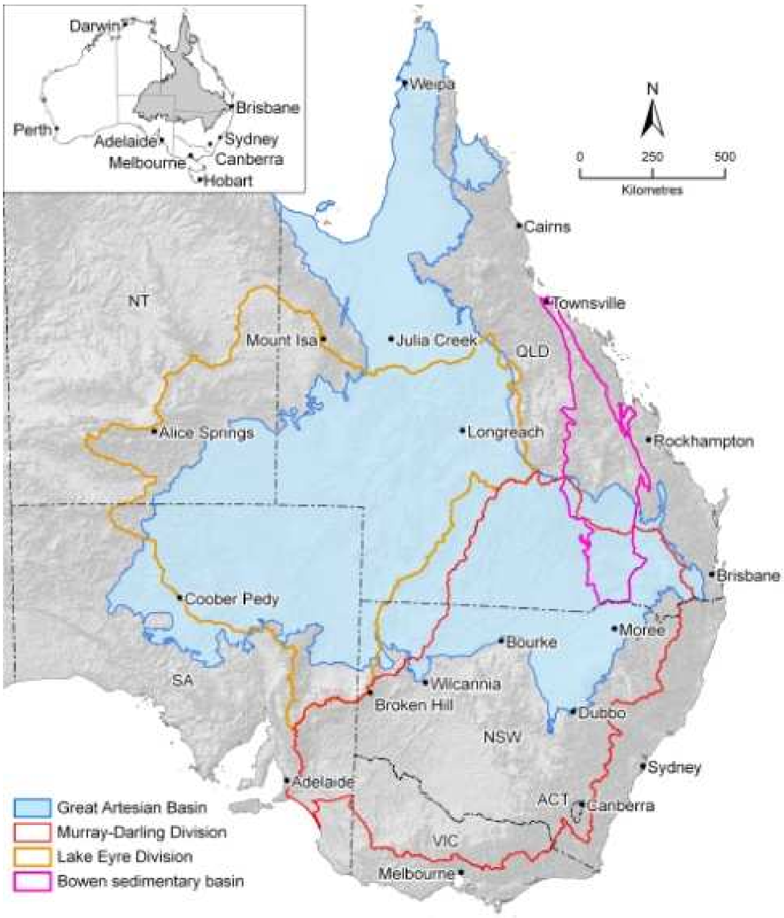

Figure 1. Geographic extent of the Great Artesian Basin and selected overlying surface water drainage divisions.

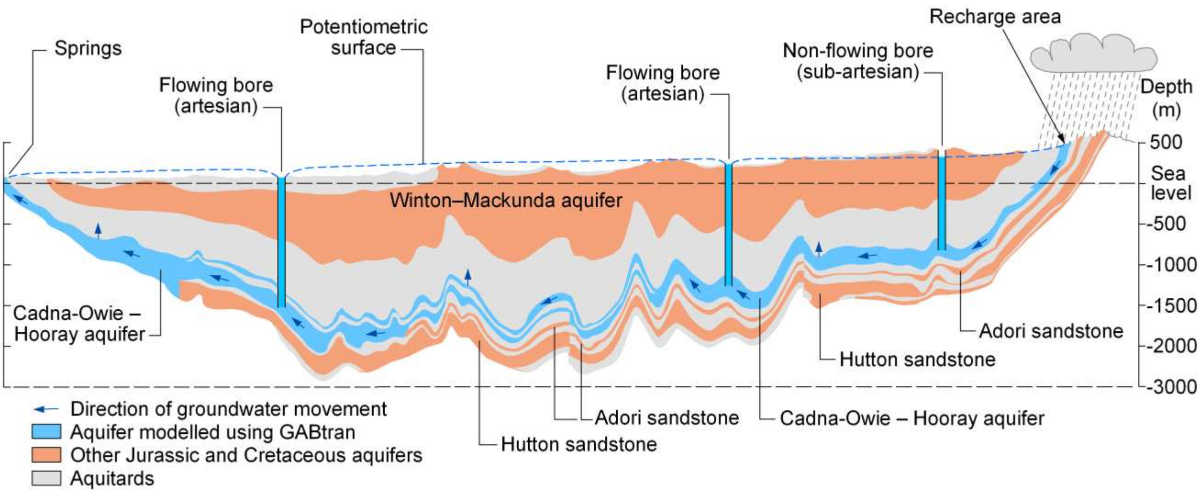

Figure 2. Schematic slice through the GAB illustrating predominant aquifers and representing schematic layering from major spring zones in South Australia (left) to major recharge areas in Queensland (right).

GISERA

Gas Industry Social & Environmental Research Alliance

Providing the Australian natural gas industry, government and community with quality assured scientific research.

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GISERA

Gas Industry Social & Environmental Research Alliance

Australia's natural gas consumption is predicted to significantly increase as Australia transitions to a lower carbon economy through greater use of gas for electricity generation purposes, as well as rising energy demands associated with increased population and economic growth.

The CSG industry has been operating in Queensland for more than 30 years and now provides around 90% of its gas supplies and fuels about 15% of the State's electricity generation. This well established industry is now working to advance one of the largest resource developments in Australian history. This is an exciting development for Queensland and Australia as a whole because of the significant economic benefits the coal seam gas (CSG) and liquid natural gas (LNG) industry is poised to deliver.

Additional information about the CSG industry is being called for. Science is well positioned to contribute constructively by helping fill knowledge gaps, reduce uncertainty and inform deliberation and action. The Gas Industry Social and Environmental Research Alliance (GISERA) will play a crucial role here.

What is the Gas Industry Social and Environmental Research Alliance?

CSIRO and Australia Pacific LNG Pty Ltd are founding members of GISERA. An initial investment of $14 million over the next five years will fund research into the socio-economic and environmental impacts of the natural gas industry. This initial focus will be directed at Queensland's CSG-LNG industry but will have potential to expand to address impacts and opportunities associated with different gas industries and geographies.

GISERA will deliver constructive, objective and publicly available research

GISERA will undertake integrated, regional, systems-based research that addresses the impacts of gas developments, drawn from an evidence-based understanding of regional processes and issues.

In the first instance GISERA will explore issues in Queensland related to five topics:

- groundwater and surface water
- biodiversity
- land management
- the marine environment
- socio-economic impacts.

GISERA… establishing the framework for a true research collaborative

GISERA has been designed to expand the membership to other companies both within and outside of the industry, as well as research purchasers and providers such as universities and government agencies. Stakeholders such as agricultural industries and communities will also be sought as members. This will ensure public good research undertaken by GISERA will benefit the broader community and industry.

GISERA's research agenda will be underpinned by strong governance arrangements

A robust governance framework has been designed to ensure the delivery of quality peer-reviewed and publicly available science. Research planning will be overseen by a Research Advisory Committee that will draw on formal and informal advice from a range of experts and interests. Research will be conducted with the active collaboration of a range of regional stakeholders and research reports will be made publicly available following review by CSIRO's rigorous peer-review process.

Why CSIRO?

CSIRO's breadth and depth of research includes social, economic and ecological sciences. This places the organisation in a unique position to provide impartial and integrated research to the industry, regulators and wider Australian community. CSIRO's independence will ensure all knowledge generated from GISERA is made widely available, enabling access by all stakeholders.

Why Australia Pacific LNG?

Australia Pacific LNG is the leading producer of CSG in Australia and holds the country's largest CSG reserves position, currently providing over 40% of Queensland's gas supply. Australia Pacific LNG was instrumental in the genesis of GISERA, partnering with CSIRO to provide impartial and independent scientific research for the benefit of industry, government and community alike. The alliance supports Australia Pacific LNG's principal of creating and operating sustainably. They are the founding member of the alliance with CSIRO.

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