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REGULATORY ANALYSIS AND RESPONSE TO POTENTIAL COAL SEAM GAS GROUNDWATER CONTAMINATION IN QUEENSLAND AUSTRALIA

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Resource Law

Topic:

Regulatory Analysis and Response to Potential Coal Seam Gas Groundwater Contamination in Queensland Australia

Absence of Proof is not Proof of Absence[1]

The message of the SBS Dateline television programme about the contamination of groundwater in America from hydraulic fracturing used during the extraction of methane gas from coal or shale[2] was that, 'just because you can not absolutely prove something is true, does not make it untrue'. The Governor of Pennsylvania was quoted as saying, "I am a former prosecutor, and before I will accept there has been contamination of groundwater, you have to prove it beyond a reasonable doubt." Unless his intention is to criminally prosecute the likes of Chevron, Shell, and Chesapeake Energy, the Governor's comment misses the issue. Surely the standard of proof to be applied is "a balance of probabilities".[3] In other words, can one reasonably infer that if groundwater sourced drinking water was of good quality before exploration and extraction of coal seam or shale gas; and the chemical signature of the gas that is found in drinking water bores,[4] after exploration occurs is the same as the gas that is being pumped from the ground, then the civil standard of proof[5] has been achieved, and the tortfeasor should provide the damaged parties a remedy? The author respectfully suggests the answer must be yes.

The flood of concern recently expressed by Australians[6] about the drought of comment from federal and state politicians on the subject of coal seam gas ("CSG") groundwater

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[1] Martin Wees, 'Our Final Hour: A Scientist's Warning: How Terror, Error, and Environmental Disaster Threaten Humankind's Future In This Century—On Earth and Beyond' (UK title: Our Final Century: Will the Human Race Survive the Twenty-first Century?), 2003, Oxford University Press, London, UK.

[2] SBS, 'Fracked Off', Dateline, 18 September 2011 at 19:30, Nick Lazaredes.

[3] *Civil Liability Act* 2003 (Qld) s 12 Note the definition of 'causation' included in section 12: "Onus of proof -- In deciding liability for breach of a duty, the plaintiff always bears the onus of proving, on the balance of probabilities, any fact relevant to the issue of causation."

[4] *Petroleum and Gas (Production and Safety) Act* 2004 (Qld) s187; 'water supply bore' defined as a 'water bore' approved by the Minister, *Petroleum Act* 1923 (Qld) s86

[5] Above n3

[6] Damon Evans, 'CBM and farmers in perfect harmony', Petroleum Economist – Online Edition, 14 September 2011; Damon Evans, 'CBM face-off in New South Wales', Petroleum Economist – Online Edition, Singapore, 14 September 2011; Damon Evans, 'BG plays down CBM leak fears', Petroleum Economist – Online Edition, 14 September 2011; Matthew Franklin, 'Anna Bligh warns of 'radical Green', The Australian, 26 May 2011 page 1;

contamination is directed to this exact point, and for good reason. While only 4% of Australian drinking water[7] is taken from groundwater sources, 35% of water utilised by farms and cattle stations[8] comes from groundwater sources. It seems clear that every Australian has good reason to be concerned about whether Australian CSG mining will impair the Australian way of life.

CSG GROUNDWATER OBLIGATIONS – WHAT OIL & GAS COMPANIES SAY

Some CSG miners have published their view of their legal obligations in respect of CSG water, and the legislated 'make good' obligations enacted by the Queensland government.[9] Arrow Energy Limited,[10] states that its legal obligations require that:

> "Arrow Energy will make good any situation where it is **proven** that our activities have contributed to the **capacity** of a [water well] bore being **impaired** and the bore is **no longer able** to supply water for its **authorised** purpose."[11] [emphasis added]

The composition of the commitment by Arrow Energy to 'make good' environmental damage is sure to infuriate some, whilst providing reassurance to others. On the face of this published commitment, it would seem that Arrow intends to meet the legislated requirements to 'make good'[12] the damage it may cause to groundwater if:

1. It is proved that Arrow Energy caused damage;
2. Arrow's activities were the primary contributor to any capacity impairment, and the water bore is 'no longer able' to supply water;

Sean Nicholls, ' Big support to stop coal seam gas mining while impact is assessed', Sydney Morning Herald, 26 August 2011, p1; John McCarthy, 'Anna Bligh 'selling out' small towns by allowing mining and gas development', Courier Mail, 16 August 2011 p1; Leonie Lamont and Brian Robins, 'NSW bids for unity on coal seam gas rules', The Courier (www.courier.com.au) 22 July 2011 p1 99; Sky News, 'Parliament to debate two CSG bills', Business News, Unknown, 21 August 2011 at 15:31; SBS, 'Fracked Off', Dateline,18 September 2011 at 19:30, Nick Lazaredes; ABC, 'CSG inquiry prompts plea for aquifer protection', ABC News, 26 August 2011 at 18:01; ABC, 'Palmer blasts 'inexperienced' CSG industry', ABC News, 27 August 2011 at 14:52; ABC, 'Carcinogens found in coal seam gas project', ABC News, 28 August 2011 at 10:40; ;ABC, 'Water Commission raises coal seam gas worries', ABC Radio National, 16 August 2011 at 8:09, Stephen Dziedzic.

[7] Natural Heritage Trust, Water Resources in Australia: A summary of the National Land and Water Resources Audit's Australian Water Resources Assessment 2000' www.nlwra.gov.au/atlas at 15 June 2011.

[8] Ibid.

[9] *Water and Other Legislation Amendment Act* 2010 (Qld), s361

[10] Arrow Energy Limited, 'What Does 'Make Good' Mean?', http://www.arrowenergy.com.au/icms_docs/88363_What_does_Make_Good_mean.pdf, (2011) August 2011

[12] *Water and Other Legislation Amendment Act* 2010 (Qld) s361

3. And only if the impaired water bore has been authorised for some lawful purpose by the relevant government agency.

Queensland Gas ("QGC") has this to say about their commitment to 'make good' any damage QGC does to groundwater supplies:

> "Should **our monitoring** identify changes in water quality and bore yield from our activities, we work with landholders and regulatory authorities to "make good".
>
> In "making good", we **may**:
>
> •Re-set pumps at deeper levels within bores to access alternative available water columns
>
> • Deepen bores to provide access to aquifers of suitable quality and yield that are less affected by coal seam gas operations
>
> • Install replacement bores, particularly if original bores cannot be reconditioned or deepened
>
> • Provide bulk water of suitable quality to bore owners to compensate for loss of yield in water supply bores
>
> • Compensate bore owners for their losses in agricultural productivity due to diminished bore yield or water quality.
>
> In addition, the Queensland Government has set **groundwater trigger levels** for comparison of monitoring results with pre-existing aquifer conditions.
> Should groundwater monitoring show that our activities have triggered these levels, QGC **investigates** and "makes good".
>
> Our **Groundwater Monitoring Plan** is dynamic and intended to be regularly updated for coal seam gas operations and regulatory change.
>
> All new and amended versions [Groundwater Monitoring Plans] are submitted to the Queensland Government."[13] [emphasis added]

QGC's commitment to 'make good' damage it may do to groundwater is better drafted that the 'make good' commitment of Arrow Energy, but is nevertheless couched in conditional

[13] Queensland Gas Pty Ltd ("QGC") a British Gas plc. Group Business, '*Protecting our Groundwater*', www.qgc.com.au/dbase_upl/Groundwater_2010-09-1.pdf, (2011) August 2011

terms. QGC uses the word 'may'[14] to qualify remedial action that QGC chooses to undertake. QGC also indicates the following:

1. It will monitor;
2. All remediation will be by reference to triggers established by the Queensland government;
3. It will first investigate and then 'make good' if the other conditions have been proved;

QGC's reference to "trigger levels,"[15] "pre-existing aquifer conditions," along with a commitment to dynamically prepare, submit and review, "Groundwater Monitoring Plans", is a commitment to do that which has been prescribed by the Queensland government.[16]

It is worth noting that in the same QGC 'fact sheet'[17] QGC acknowledges it will cause, "…significant change to underground water levels in the Walloon Coal Measure…"[18]

The Commonwealth's Parliamentary Library summarized the issues in respect of regulation of the CSG industry:

> "There are three aspects of coal seam gas production which need to be managed carefully to avoid potentially significant environmental impacts. These are:
>
> 1. copious amounts of water by-product with the pumping of water from the coal seams;
> 2. the process of hydraulic fracturing to extract tightly held gas in the production process; and

[14] s32CA, Acts Interpretation Act 1954 QLD, The Act states, "…the word may, or a similar word or expression …indicates that the power may be exercised or not exercised, at discretion…"
[15] Ibid.
[16] John Bradley, Director General, Department of Environment and Resources Management, Energy IQ's Coal Seam Gas Water Management Conference, Brisbane, Queensland, 29-30 March 2011; Department of Environment and Resources Management, 'Guideline: Approval of coal seam gas water for beneficial use', Environmental Protection (Waste Management) Regulation 2000 May 2011.
[17] Queensland Gas Pty Ltd ("QGC") a British Gas plc. Group Business, 'Protecting our Groundwater', www.qgc.com.au/dbase_upl/Groundwater_2010-09-1.pdf, (2011) August 2011
[18] Ibid; For purposes of comparison, one may read the 'make good' commitment of Australia Pacific LNG, the joint venture between Origin Energy Limited and ConocoPhillips, http://www.aplng.com.au/pdf/factsheets/OurCommitments_brochure.pdf, p6, 15 June 2011

3. leakage of methane gas during production and transportation, as well as the impact from more than1 CSG project in the same area need to be considered."[19]

The purpose of this article is to examine the statutory regime of the Queensland government; the obligations imposed in Queensland on CSG developers; and to suggest areas where the federal and state government may make changes to fill any regulatory lacuna which may to lead to damage to Queensland's groundwater, and to the tens of thousands of Queenslanders who rely on groundwater for drinking water, and the millions of Australians who rely on groundwater for the irrigation of crops, and the survival of livestock.

Importantly, CSG groundwater contamination has not yet been litigated in Australia, but CSG groundwater pollution, and the damage caused by CSG hydraulic fracturing, has been litigated in the United States more than two hundred times.[20]

The two leading decisions on Coal Seam Gas groundwater contamination are, *Legal Environmental Assistance Foundation v U.S. Environmental Protection Agency*, 118 F.3d 1467 (LEAF I)[21] and *Legal Environmental Assistance Foundation v U.S. Environmental Protection Agency, State Oil and Gas Board of Alabama*, 276 F.3d 1253 (LEAF II).[22] These United States Eleventh Circuit Court of Appeal decisions forced the U.S. Environmental Protection to study the effect of CSG water,[23] as well as hydraulic fracturing that is employed in the American CSG industry in approximately 50% of CSG production wells.[24] Ultimately the U.S. Congress had to amend the Federal Safe Drinking Water Act ("SDWA");[25] however, before getting to the conclusion, it is important to understand something about the Australian CSG industry, the legislation in Queensland before omnibus legislative

[19] Michael Roarty, 'Background Note – The development of Australia's coal seam gas resources', Science, Technology, Environment and Resources Section, Parliamentary Library, Commonwealth of Australia, 28 July 2011, p1

[20] S Marvin Rogers, '*History of Litigation Concerning Hydraulic Fracturing to Produce Coalbed Methane*', State Oil and Gas Board of Alabama, IOGCC Legal and Regulatory Affairs Committee, January 2009

[21] *Legal Environmental Assistance Foundation v U.S. Environmental Protection Agency*, (1997) 118 F.3d 1467 (11th Circuit Court of Appeal.

[22] *Legal Environmental Assistance Foundation v U.S. Environmental Protection Agency, State Oil and Gas Board of Alabama*, (2001) 276 F.3d 1253, 11th Circuit Court of Appeal, p

[23] CSG water is referred to in the U.S. as 'produced water', or 'production water'. Similar nomenclature is used by the Commonwealth of Australia.

[24] Legal Environmental Assistance Foundation v U.S. Environmental Protection Agency, (1997) 118 F.3d 1467 (11th Circuit Court of Appeal, p4

[25] Rogers, Above n19, p7

changes in late 2010; and the areas that remain unregulated. This will ultimately take us to the regulatory response that occurred in the United States, which may point to ways in which Queensland may improve the regulation of CSG "associated water".[26]

A PICTURE IS WORTH A THOUSAND WORDS[27]

The adage, "a picture is worth a thousand words" is frequently overlooked by legal practitioners; however, the issues that conflate the CSG water debate are hydrological, geological, geographical, stratigraphic, environmental, economic, and legal. Where an issue is literally vital to human existence, the law must encourage informed debate. It is hoped that the maps and illustrations in the Appendix will assist the reader in that process; but will not offend legal practitioners.

ABOUT COAL

Coal is a combustible rock that is from fifty percent (50%) to ninety-eight (98%) organic material by weight.[28] Coal is formed from peat or other plant material that accumulates in fresh-water swamps located near ancient river deltas.[29] In Queensland, coal bearing formations are between 65 and 250 million years old.[30] Coal seam formation in Queensland is principally in Great Artesian Basin, rock and groundwater formations that were formed at the same time.[31] Subsidence and volcanic uplift created significant tectonic shifts, which contributed to cycles which successively melted and froze the polar ice caps thereby causing significant changes in sea level. Coastal river deltas and adjacent peat swamps migrated inland when sea levels rose, but migrated seaward when sea levels fell.[32] The cycles included extended periods of time when the organic material was submerged beneath many meters of sea water. The cycle of the sea level rising and falling is marked in the geologic record as cycles of inter-layered deep and shallow water sediments.

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[26] 46. Abraham Lustgarten, 'Does natural-Gas Drilling Endanger Water Supplies', BusinessWeek Magazine, Bloomberg Business Exchange, New York, p42.

[27] Emperor Napoleon Bonaparte, Speech to Troops in Egypt, 21 July 1798

[28] U.S. Environmental Protection Agency, Evaluation of Impacts to Underground Sources of Drinking Water by Hydraulic Fracturing of Coalbed Methane Reservoirs, June 2004, p3-2

[29] http://www.australianminesatlas.gov.au/education/fact_sheets/coal.jsp, (2011) 15 June

[30] Commonwealth Science and Industrial Research Organization, Coal Seam Gas Factsheet #4, The Great Artesian Basin and Coal Seam Gas, July 2011

[31] Ibid.

[32] Bradley, Above n15, p13

The type of sediments that were deposited over top the organic material depended on how much sea levels rose. Carbon-rich organic plant matter was deposited in shallow seas; sand was deposited along beaches and other near-shore shallow seas, whereas silts, clays and calcium-rich muds were deposited in deeper seas. The cycle laid down layer after layer of sediment, thereby subjecting the organic material to increasing pressure. Peat bogs were transformed into coal; sand into sandstone; whereas clay and silt became shales, siltstones, and mudstones. Calcium-rich muds were compressed into limestone. The sedimentation cycle consists of repeated sequences of shales and limestone, which are overlain by siltstones and sandstones, and then capped by another layer of coal, a process often referred to as coalification. The sedimentation cycle is then repeated.[33] The number of sedimentation cycles determines the number of coal seams. (**See Figure 1**)

Peat is transformed into coal because of the weight of sediment, and heat rising from the earth. The quality of the coal is a function of the type and amount of organic matter, the length and temperature of the particular cycle of sedimentation, along with other hydrogeological and volcanic influences.[34] Coal seam gas[35] is generated when peat is transformed into coal. The lower the quality of coal, the less CSG it contains.[36]

Coal seams contain a spider web of fractures and joints, which are likely to be filled with a mixture groundwater, methane gas, and a host of other gases, and metallic ions. The network of joints is further broken in to tiny joints or breaks called cleats. Joints are up to 50 feet or more apart,[37] whereas cleats are only a dozen feet apart. There are two types of cleat: 1) face cleats; and, 2) butt cleats.[38] Face and butt cleats, when seen together, have the appearance of a ladder or spider web.[39]

Coal is not a naturally permeable material, but because it is brittle, it fractures easily under pressure. The fractures and interwoven cleats can create significant permeability.[40]

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[33] U.S. Environmental Protection Agency ("EPA"), Evaluation of Impacts to Underground Sources of Drinking Water by Hydraulic Fracturing of Coalbed Methane Reservoirs, June 2004, p3-5

[34] R E Carrol, J C Pashin, and R L Kugler, 'Burial history and source rock characteristics of Mississippian and Pennsylvanian strata, Black Warrior basin, Alabama, Alabama Geological Society Guidebook, (1993) Alabama State Press, pp. 79-88.

[35] Coal Seam Gas (CSG) in the U.S and elsewhere is referred to as methane, coal bed methane, CBM, methane gas, or natural gas.

[36] U.S. EPA, Above n32, p3-7

[37] U.S. EPA, Above n32, p3-1

[38] U.S. EPA, Above n32, p3-3

[39] Ibid.

[40] Ibid.

Groundwater, CSG gas can flow through these fractures. Hydraulic fracturing generally enlarges pre-existing fractures and rarely creates new fractures.[41] The fractures are used to extract the CSG gas.

WHAT IS COAL SEAM GAS

Coal seam gas ("CSG") is principally methane gas. In some coal seams, naturally occurring water is held in and around the coal seam under pressure. The water pressure absorbs the CSG gas to porous coal surfaces.

In a CSG well, pumping water from the coal seams lowers the pressure, allowing the CSG gas to desorb from the coal.[42] Water is pumped from coal seams during this process.[43] CSG water is traditionally managed through some combination of treatment, disposal, storage, or adaptive reuse.[44] Groundwater is integral to CSG extraction: One can not occur without the other. (**See Figure 2**)

CSG is a very pure form of methane compared to conventional natural gas, which contains butane, ethane and propane, hydrogen sulphide, carbon monoxide, carbon dioxide, nitrogen and other gas compounds. CSG is more than 90 percent (90%) methane, and can therefore be piped to port with virtually no treatment.[45]

EARLY HISTORY OF COAL SEAM GAS

Since the 1920's there has been an effort to improve coal mine safety by removing the methane gas prior to excavation. However, CSG was first mined as a source of energy in the U.S. in 1971.[46] In 1980, U.S. Congress passed the *Windfall Profits Tax Act.*[47] While the legislation was primarily intended to capture a greater percentage of the profits made from the oil and gas industry in the wake of OPEC's formation, at s29 the enactment includes an

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[41] Ibid.
[42] Ibid.
[43] Ibid.
[44] Ibid.
[45] Ibid.
[46] Stephen G Osborn, Avner Vengosh, Nathaniel R Warner, Robert B Jackson, '*Methane contamination of drinking water accompanying gas-well drilling and hydraulic fracturing*' Proceedings of the National Academy of Sciences, Center on Global Change, Nicholas School of the Environment, Duke University, Durham, NC, 14 April 2011.
[47] *U.S. Tax Code*, PL 96-223, s29

"Alternative Production Credit" to encourage non-conventional oil and gas production.[48] The anticipated expiration of the tax credit in 1990 contributed to a significant rise in the number of CSG wells across the U.S. nationwide. The U.S. Department of Energy ("DOE") and the U.S. Gas Technology Institute ("GTI") also conducted or funded extensive research into CSG exploration and production.

As a consequence, 230 CSG wells had been drilled in Kansas by 1992; and 738 CSG wells had been drilled in Oklahoma by 2001.[49]

CSG production in the U.S. has grown 65% over the past 15 years. Today it accounts for nearly 7% of the methane gas usage in the America. Methane gas usage in the U.S. represents 24% of the country's energy needs, and accounts for 16% of all electric power generation in the U.S.[50]

HISTORY AND GEOGRAPHY OF CSG IN AUSTRALIA

According to Geosciences Australia, as at December 2008 the proven (1P) and probable (2P) reserves[51] of coal seam gas in Australia were 23,132 Petajoules (i.e., 23.13 x 10^{19} joules). Geoscience Australia says this is a 61.5% increase over the 2008 reserves, which was a 116% increase over 2007 reserves.[52] There are 37 MJoules in one cubic meter of gas, and one million cubic meters of gas are required to produce the same energy as 5.86 barrels of crude oil. Including 2P reserves, the total estimated CSG reserves in Australia are the equivalent of 43.1 billion barrels of oil.[53] This sounds like a great deal of energy, but Saudi Arabia has ten times that amount of oil in 1P reserves, and another 7.5 billion cubic meters of 1P gas reserves. Australia is ranked 12th in world gas reserves.[54]

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[48] Metcalf, Gilbert E, Federal Tax Policy Towards Energy, MIT Joint Program on the Science and Policy of Global Change, January 2003, p13

[49] Ibid.

[50] U.S. Environmental Protection Agency, Evaluation of Impacts to Underground Sources of Drinking Water by Hydraulic Fracturing of Coalbed Methane Reservoirs, June 2004, p1-1; National Park Service, 'Coalbed Methane Development Overview', NPS Western Summit, 21-23 January 2003; If CSG accounts for 7% of the total methane gas production in the U.S., and methane accounts for 24% of the total energy consumption of the U.S., CSG only accounts for 1.68% of energy consumption in the U.S.

[51] John Etherington, Torbjorn Pollen, Luca Zuccolo, 'Comparison of Selected Reserves and Resource Classifications and Associated Definitions', Society of Petroleum Engineers, Mapping Subcommittee, p10-20

[52] Chris Pigram, 'Australia's Identified Mineral Resources 2010', Commonwealth of Australia (Geoscience Australia) 2010, Canberra, ACT

[53] Michael Roarty, http://www.aph.gov.au/library/pubs/bn/sci/CoalSeamGas.htm , Conversion from joules to cubic meters of gas; http://en.wikipedia.org/wiki/Barrel_of_oil_equivalent (2011) 14 September

[54] http://en.wikipedia.org/wiki/List_of_countries_by_natural_gas_proven_reserves (2011) 20 September

In 2007-08, CSG accounted for around 10 per cent of total gas consumption in Australia and about 80 per cent in Queensland.[55] The strong growth in CSG production reflects the Queensland Government's energy and greenhouse gas reduction policies, in particular the requirement that 15% of grid connected power generation in the Queensland be gas-fired as at 2010, and 18% by 2020.[56]

Exploration in Australia for CSG began in 1976 in Queensland's Bowen Basin, where Houston Oil and Minerals of Australia drilled two dry holes.[57] BHP Mitsui Coal started the first methane drainage project from the Moura mine in early 1996. The first CSG well to produce methane gas in Australia was successfully completed by Conoco-Philips at Dawson Valley in December 1996.[58] In Queensland approximately 3,500 wells have been drilled up to January of 2011, and up to an additional 10,000 wells will be drilled in the Bowen Basin, with up to 15,000 wells drilled in the Surat Basin.[59]

Some suggest that CSG exploration in Queensland is in its infancy. The Surat, Bowen and Galilee geologic basins are thought to contain large volumes of CSG. The Gunnedah, Gloucester and Sydney basins in New South Wales are believed to contain a significant volume of CSG.[60] (**See Figure 3**)

To give context, France is slightly more than half a million square kilometres.[61] The Great Artesian Basin, widely regarded as the world's largest groundwater source, is 1.7million square kilometres.[62] The area likely to produce CSG is estimated to be 1.2million square kilometres, with more than 75% of that in Queensland.

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[55] http://www.ga.gov.au/energy/petroleum-resources/coal-seam-gas.html (2011) 11 September
[56] Ibid.
[57] http://www.australianminesatlas.gov.au/education/fact_sheets/coal_bed_methane.jsp (2011) 15 September 2011.
[58] Ibid.
[59] John Bradley, Director General, Department of Environment and Resources Management, Energy IQ's Coal Seam Gas Water Management Conference, Brisbane, Queensland, 29-30 March 2011.
[60] Above n18, p3.
[61] https://www.cia.gov/library/publications/the-world-factbook/geos/fr.html (2011) 16 September
[62] Lance Endersbee, 'The Plutonic Waters of the Great Artesian Basin', Australian Academy of Technological Sciences and Engineering, ATSE Focus No. 122, December 2000, p1.

As one example, QCG indicate that they will extract much of their CSG from the Walloon Coal Measure,[63] which is a 500 – 650 meter thick layer that straddles the Surat and the Clarence-Moreton geological basins. The Surat and Clarence-Moreton geologic basins form part of the Great Artesian Basin ("GAB"). We will return to the GAB later in the article.

COAL SEAM GAS WATER

The issues attached to CSG water are: 1. the volume of water removed from aquifers; 2. the disposal of production waters including the injection of production water back in to aquifers; 3. the use of contaminating chemicals in drilling and in hydraulic fracturing process that will likely be required to stimulate production in nearly 50% of CSG wells; 4. the hydraulic connections between aquifers that may be created by hydraulic fracturing; and 5. leaching of methane gas in to nearby aquifers. In 2006-2007 in Queensland, 392 CSG wells were drilled, producing 9,491 megalitres of CSG water.[64] Logically, the water produced during the CSG extraction process was groundwater.

GROUNDWATER

More than a century ago, in a dispute over who would have the right to use well water for cattle, Justice Altucher in the Wyoming Supreme Court said, "…there are no questions more important than those dealing with water…"[65]

Australia is one of the most arid countries in the world, and the most arid continent in the world. It is widely accepted that much of Australia's productive agricultural land would not have been developed without groundwater.[66] It is hoped that policy makers will recognize that Australia is a young country, with significant ambitions. These ambitions are likely to be accompanied by population growth. If one draws a comparison to arid regions in the United States, where 40% of drinking water is taken from groundwater sources, and up to 90% is taken from groundwater in drought years,[67] it must be acknowledged that groundwater is key to the long term survival of Australia. International water litigants refer

[63] The Walloon Coal Measure runs from Pittsworth in the south to Dalby in the north, and from Tara in the west to Toowoomba in the east.
[64] http://mines.industry.qld.gov.au/assets/coal-pdf/coal_seam_gas_poster.pdf (2011) 15 September
[65] *Farm Investment Company v Carpenter*, per Altucher J. [1900] 50 L.R.A. 747, 9 Wyo. 110, 61 P. 258, 87 Am.St.Rep. 918, Supreme Court of Wyoming at p17
[66] Above n7
[67] http://ga.water.usgs.gov/edu/wugw.html (2011) 11 September

to this as 'water security'. It should be clear that long after Australia's coal is mined from the ground, and Australia's coal seam gas (CSG) has been forced to desorb from Queensland's coal seams, Australia will still be a nation populated by men and women who will all need to eat and drink. Groundwater is a key variable in that future.

UNDERGROUND WATER RIGHTS

The challenge facing Queensland is the tension between the sources, uses and potential abuses, of groundwater by petroleum tenure holders, and the historical use of groundwater by both small rural towns, and by cattle stations and farms. Section 19 of the Queensland *Water Act* vests ownership of all underground water with the State of Queensland.[68] Section 185 of the *Petroleum and Gas (Production and Safety) Act*[69] grants to CSG miners a right to use groundwater as they require, without limit, in order to extract CSG gas. Section 185 states:

> *(1) A petroleum tenure holder may do any of the following in relation to underground water in the area of the tenure—*
>
> *(a) take or interfere with the water if taking or interference happens during the course of, or results from, the carrying out of another authorised activity for the tenure;*
>
> *Examples—*
>
> *1 underground water necessarily or unavoidably taken during the drilling of a petroleum well or water observation bore*
>
> *2 underground water necessarily or unavoidably taken during petroleum production authorised under section 32*[70] *or 109*[71]
>
> *(b) use water mentioned in paragraph (a) for carrying out of another authorised activity for the tenure;*
>
> *(c) take or interfere with the water for use in the carrying out of another authorised activity for the tenure.*
>
> *Note—See part 1, division 1 and part 2, division 1 (Key authorised activities).*

[68] *Water Act* 2000 (Qld) s19: "…all of the rights to the use, flow and control of all water…"
[69] *Petroleum and Gas (Production and Safety) Act* 2004 (Qld), s185
[70] *Petroleum and Gas (Production and Safety) Act* 2004 (Qld), s32: permits exploration and testing
[71] *Petroleum and Gas (Production and Safety) Act* 2004 (Qld), s109: permits exploration, production and storage activities

(2) The rights under subsection (1)—

(a) are the underground water rights for the petroleum tenure; and

(b) are subject to the tenure holder complying with the holder's underground water obligations.

(3) There is ***no limit to the volume of water that may be taken*** *under the underground water rights.*

(4) Underground water taken or interfered with, under subsection (1)(a), from a petroleum well is associated water.

(5) The tenure holder may use associated water only for another authorised activity for the tenure.

Note—If the tenure holder wishes to use associated water for another purpose, the holder must obtain a water licence. See sections 188[72] *and 189 and the Water Act, section 19. To obtain a water licence see the Water Act, chapter 2, part 6.*

(6) The taking or interference with water under subsection (1)(c) may be carried out by drilling a bore.

(7) The bore and its casing, wellhead and any other works constructed in connection with it is a water supply bore.

(8) In this section—another authorised activity, for the petroleum tenure, means an authorised activity for the tenure under part 1, division 1 or part 2, division 1. [emphasis added]

Meaningful debate of the issues is difficult when opposing sides are not working with common nomenclature, and a common set of facts. This issue is amplified because one side, namely the CSG producers, are well funded, whereas the other side, pastoralists and small towns, are not funded at all.

One is reminded of the sign that one will inevitably see on the door of a Professor during the first year of University, 'eschew obfuscation assiduously'. After a trip to the Oxford dictionary one learns that the Professor was trying to say, 'communicate clearly', a notion frequently forgotten by legal practitioners.

[72] *Water Act* 2000 (Qld)

One example where the debate is obscured, is coal seam gas water, which is labelled 'associated water' by Queensland; referred to as 'production water' by the Commonwealth of Australia, and is variously referred to by geologists and petroleum geoscientists and engineers, as salt water, saline water, connate water, brine, wastewater, and effluent. Another example is 'hydraulic fracturing', which is also referred to as 'well stimulation', 'well injection', 'unconventional well stimulation', fracking, fraccing, and fracing.

As a result of the Murray-Darling Basin Senate Inquiry, much of the recent CSG press has been focussed on the impacts of coal seam gas mining on surface and groundwater systems in the Murray-Darling Basin.[73] The Federal Department of Sustainability, Environment, Water, Population and Communities commissioned a groundwater impacts report;[74] however, the study only deals with the portion of the Murray-Darling Basin ("MDB") that has relatively shallow alluvial deposits,[75] and therefore may experience early CSG exploration.[76] The MDB is a River Basin which sits atop a number of groundwater provinces.[77] The study is intended for the ongoing Senate Inquiry in to the Murray-Darling Basin, which added coal seam gas to the scope of its inquiry in late 2010.[78] However, the study does not address many of the concerns expressed by members of the public in recent months.[79]

The report limits its scope wherein it states:

> No data [has] been made available to examine the possible implications of hydrocarbons, eg, BTEX, in associated water. Engineering solutions for surface water storage,, water treatment facilities and consequential brine management were [also] not examined.[80]

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[73] Moran, Chris, and Vink, Sue, Assessment of Impacts of The Proposed Coal Seam Gas Operations on Surface and Groundwater Systems in the Murray-Darling Basin, Centre for Water in the Minerals Industry, Sustainable Minerals Institute, The University of Queensland, 29 November 2010

[74] Ibid. 1

[75] The alluvial layer, also called the alluvium, is the layer of loosely packed material, usually less than 300 to 500 meters thick, directly below the surface.

[76] Above n71, p11

[77] www.nlwra.gov.au/atlas, Water Resources in Australia, A Summary of the National Land and Water Resources Audit's Australian Water Resources Assessment 2000

[78] Rural Affairs And Transport References Committee, Senate, Brisbane, 9 August 2011 p20 (Catherine Tanna)

[79] Ibid. p2 (William Heffernan)

[80] Above n1, p2

While the MDB is vital to Australia, for Queensland, and arguably for all of Australia, the impact of CSG development on the Great Artesian Basin ("GAB") must be addressed. One of the purposes of this article is to provide a platform for further discussion about ways to ensure that the plutonic waters of the GAB are not permanently damaged. This will include an attempt to address some of the issues that are not being addressed (supra.), but are of grave concern to most Australians.[81]

GROUNDWATER GEOGRAPHY

The author will use nomenclature, geology, and stratigraphy from Geoscience Australia, the National Heritage Trust, [82] the Commonwealth of Australia, and the State of Queensland.

Water issues are complex because Australia is a large country, where surface water includes 246 river basins, 325 surface water management areas, and 12 drainage divisions.[83] Groundwater is divided in to 69 groundwater provinces, and 538 groundwater management units.[84] To make matters even more confusing, groundwater management units frequently overlie one another because groundwater is found in different stratigraphic layers,[85] known as aquifers, that lay overtop one another.[86]

The audit of Australia's groundwater resources, conducted in 2000, concluded that Australia had 21,000 gigaliters of groundwater, and that 72% of that groundwater is suitable for drinking water.[87]

GROUNDWATER PROVINCES[88]

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[81] Sean Nicholls, ' Big support to stop coal seam gas mining while impact is assessed', Sydney Morning Herald, 26 August 2011, p1

[82] www.nlwra.gov.au/atlas, Water Resources in Australia, A Summary of the National Land and Water Resources Audit's Australian Water Resources Assessment 2000

[83] Above n15, 3

[84] Above n15, 3

[85] A stratigraphic layer connotes depth.

[86] Above n15, 3

[87] www.nlwra.gov.au/atlas, Water Resources in Australia, A Summary of the National Land and Water Resources Audit's Australian Water Resources Assessment 2000

[88] Ibid; (**See Figure 4**) The following list of groundwater provinces have been compiled during the audit of Australia's water resources. The groundwater provinces set out in the map in Figure 4 are identified by Geoscience Australia as follows: 1F Coen; 2S Laura; 3F Tasman; 4S Clarence – Moreton; 5F New England; 6S Sydney; 7F Lachlan; 8S Gippsland; 9S Westernport; 10S Port Phillip; 11S Otway Highlands; 12S Otways; 13SF1 Tasmania 1; 13SF2 Tasmania 2; 13SF3 Tasmania 3; 14S Murray; 15F Olary; 16F Mt Lofty - Flinders Ranges; 17S St Vincent; 18F Yorke Peninsula; 19S Pirie – Torrens; 21F Gawler; 22S Eucla; 23.1F Albany - Fraser 1; 23.2F Albany - Fraser 2; 24.1S Bremer 1; 24.2S Bremer 2; 25F Leeuwin; 26S Perth; 27S Collie; 28F Yilgarn – Southwest; 29F Yilgarn - Gold Fields; 30F Yilgarn – Murchison; 31F Northampton; 32S Carnarvon; 33.1F Capricorn 1; 33.2F Capricorn 2; 33.3F Capricorn 3; 33.4F Capricorn 4; 34F Marymia; 35F Banemall; 36F Calyie –

If one overlays the Australian groundwater province map (**See Figure 4**) on the large scale map of Australian methane gas basins (**See Figure 6**), or the CSG basins identified in Queensland, which includes current Queensland CSG drilling areas,[89] (**See Figure 6**) one can see the groundwater provinces that are most likely to be affected by CSG drilling and extraction are as follows:

1. Tasmin Basin;
2. Clarence-Moreton Basin;
3. New England Basin; and the
4. Great Artesian Basin.

The Murray Basin, Olary Basin and Adelaide Syncline Basin, are the primary groundwater provinces which underpin the Murray-Darling Basin river basin system. Early indications are, that relative to the GAB, there will be a smaller number of CSG wells drilled in MDB groundwater provinces.[90]

The Queensland Department of Environment and Resource Management ("DERM"), indicate that as of January 2011, only 3,500 CSG wells have been drilled in Queensland.[91] However DERM indicate that over the next 15 years an additional 7,000 to 10,000 CSG wells will be drilled in the Bowen Basin, and 10,000 to 15,000 CSG wells will be drilled in the Surat Basin.

The Director General of DERM confirms that the groundwater issues which arise as a result of the CSG drilling are as follows:

1. The extraction of groundwater, which is a prerequisite to the desorption and release of methane gas from coal cleats;

McFadden; 37F Sylvania; 38F Hamersley; 39S Pilbara; 40F Paterson; 41S Canning; 42F Kimberley; 43F Halls Creek; 44S Bonaparte; 45F Ord – Victoria; 46F Pine Creek; 47S Melville; 48S Arafura; 49S McArthur; 50S Daly River; 51S Wiso; 52F Tennant Creek; 53S Georgina; 54F Mt Isa – Cloncurry; 55S Great Artesian; 56S Officer; 57F Musgrave; 58S Amadeus; 59F Arunta; 60S Ngalia; 61F Tanami; SA1 Adelaide Geosyncline; SA2 Eyre Penninsula

[89] Queensland Gas Pty Ltd ("QGD") a British Gas plc. Group Business, 'Protecting our Groundwater', www.qgc.com.au/dbase_upl/Groundwater_2010-09-1.pdf, (2011) August 2011; Moran, Chris, and Vink, Sue, Assessment of Impacts of The Proposed Coal Seam Gas Operations on Surface and Groundwater Systems in the Murray-Darling Basin, Centre for Water in the Minerals Industry, Sustainable Minerals Institute, The University of Queensland, 29 November 2010, p32.

[90] Ibid.

[91] DERM

2. The disposal or adaptive reuse of the associated water that is pumped from coal seams during the CSG extraction process;
3. The chemicals, including BTEX compounds, that are employed in drilling and hydraulic fracturing ("fraccing"), that may be employed by CSG miners, in order to open the pores[92] of the coal seams, thereby releasing the methane that is trapped in the pores of the coal;
4. The rock or coal fractures that are the result of fraccing, and which may connect previously unconnected aquifers, thereby giving rise to issues of cross-contamination.

QUEENSLAND LEGISLATION

Before surveying three pieces of recent omnibus change to CSG legislation,[93] along with a host of regulations contemplated by these statutes that have not yet been promulgated, it may be helpful to first examine the Queensland legislation that governed CSG mining up to the end of 2010, namely:

1. Environmental Protection Act 1994;
2. Environmental Protection Regulations 2008;
3. Environmental Protection (Water) Policy 1997;
4. Environmental Protection and Biodiversity Conservation Act 1999 (Cth);
5. Management of Water Produced in Association with Petroleum Activities (associated water), December 2007 Policy;
6. National Water Initiative[94];
7. Petroleum Act 1923;
8. Petroleum and Gas (Production and Safety) Act 2004;
9. Queensland Coal Seam Gas Water Management Policy 2008;
10. Water Act 2000;
11. Water Supply (Safety and Reliability) Act 2008;
12. Water Regulation 2002;

[92] A pore in a coal seam is referred to by geologists as a 'cleat'.
[93] **Natural Resources and Other Legislation Amendment** Act 2010 (Qld); *Natural Resources and Other Legislation Amendment (Part 2) Act 2010* (Qld); and, *Water and Other Legislation Amendment Act* 2010 (Qld).
[94] *National Water Commission Act* 2004 (Cth), NWI or *National Water Initiative* refers the Intergovernmental Agreement between the Commonwealth of Australia and the Governments of New South Wales, Victoria, Queensland, South Australia, the Australian Capital Territory and the Northern Territory, dealing with water issues, and signed on 25 June 2004, and as amended from time to time.

13. Water Resource (Baffle Creek Basin) Plan 2010;
14. Water Resource (Barron) Plan 2002;
15. Water Resource (Border Rivers) Plan 2003;
16. Water Resource (Boyne River Basin) Plan 2000;
17. Water Resource (Burdekin Basin) Plan 2007;
18. Water Resource (Burnett Basin) Plan 2000;
19. Water Resource (Calliope River Basin) Plan 2006;
20. Water Resource (Condamine And Balonne) Plan 2004;
21. Water Resource (Cooper Creek) Plan 2000;
22. Water Resource (Fitzroy Basin) Plan 1999;
23. Water Resource (Fitzroy Basin) Plan 1999;
24. Water Resource (Georgina And Diamantina) Plan 2004;
25. Water Resource (Gold Coast) Plan 2006;
26. Water Resource (Great Artesian Basin) Plan 2006 and the Great Artesian Basin Resource Operations Plan 2007;
27. Water Resource (Gulf) Plan 2007;
28. Water Resource (Logan Basin) Plan 2007;
29. Water Resource (Mary Basin) Plan 2006;
30. Water Resource (Mitchell) Plan 2007;
31. Water Resource (Moonie) Plan 2003;
32. Water Resource (Moreton) Plan 2007;
33. Water Resource (Pioneer Valley) Plan 2002;
34. Water Resource (Warrego, Paroo, Bulloo And Nebine) Plan 2003;
35. Water Resource (Whitsunday) Plan 2010;
36. Water Supply (Safety And Reliability) Regulation 2011;
37. Commonwealth Of Australia Constitution Act 1900.

These statutes, regulations, policies, and plans, provided the principle legislative framework and planning policy for managing groundwater in Queensland up to December of 2010.

The Commonwealth Constitution has been included because of a recent debate in the House of Representatives wherein Prime Minister Julie Gillard indicated that the federal government was unable to intervene in groundwater concerns because the Constitution

may prevent the federal government from usurping authority from the states.[95] The question of whether the federal government may be constitutionally barred from legislating on matters concerning groundwater will be addressed later in the article.

WATER ACT

Ownership and stewardship of all water, both surface and groundwater, is vested with the State of Queensland under s19 of the *Water Act*.[96] The long title of the Water Act 2000 Qld ("Water Act") states: 'An Act to provide for the sustainable management of water and other resources and the establishment and operation of water authorities, and for other purposes.'

The sections of the *Water Act* that are relevant to groundwater issues, starts with section 204 of the *Water Act*, which states:

> *s204 - Purpose of pt 6*
>
> *Under this part, the chief executive may grant:*
>
> > *(a) water licences for taking water and interfering with the flow of water, for example, by a weir;*[97] *or*
> >
> > *(b) water permits for taking water.*

Sections 206(5)&(6)and 206A of the Water Act endeavour to make domestic and livestock uses of water a priority, and the holders of water licences for these purposes, a 'priority group'. Sections 206(5) and 206(6) state:

> *206(5) However, a petroleum tenure holder may apply for a water licence only if:*
>
> > *(a) the water:*
> >
> > > *(i) is associated water under the Petroleum and Gas (Production and Safety) Act 2004 or is water necessarily produced as a result of the carrying out of authorised activities under the Petroleum Act 1923; and [emphasis added]*

[95] Commonwealth, House, 8146, 16 August 2011 (Julia Gillard)
[96] *Water Act* 2000 (Qld) s19
[97] A weir is a small overflow dam that typically diverts the flow of a river or stream. The definition does not apply to groundwater which may have had its flow interrupted or diverted in the course of hydraulic fracturing.

(ii) is not being used, or proposed to be used, for an activity that, under that Act, is an authorised activity for the tenure; and

(b) the holder is, under that Act, carrying out:

(i) approved testing for petroleum production; or

(ii) petroleum production for commercial purposes; and

(c) the holder has complied with section 206A.

(6) The application must be:

(a) made to the chief executive in the approved form; and

(b) supported by sufficient information to enable the chief executive to decide the application; and

(c) accompanied by the fee prescribed under a regulation.

Section 206A states:

206A Additional requirements for application by petroleum tenure holder:

(1) This section applies if a petroleum tenure holder proposes to apply for a water licence.

(2) The chief executive must, if the holder asks, give the holder a notice stating who are the members of the priority group for the holder.

(3) The holder must give each member of the priority group a notice in the approved form inviting each member to give the holder, within a stated period, a written expression of interest about access to the water the subject of the proposed licence.

(4) The stated period must be at least 20 business days.

(5) A water licence application by the holder must be accompanied by a copy of:

(a) the petroleum tenure; and

(b) each expression of interest given in response to the notice; and

(c) each environmental authority under the Environmental Protection Act 1994 that relates to the petroleum tenure.

The Chief Executive must give preference to domestic and animal husbandry uses of water; however the petroleum tenure holder (i.e., CSG mining company) is not required to give the

names of the 'priority group' to the Chief Executive unless the Chief Executive asks, and the petroleum tenure holder has the right to take any amount of water, without limit.

Catherine Tamma, Vice President of QGC, in a recent Senate Hearing in Brisbane, when asked about groundwater use, states,

> "The basin [Great Artesian Basin] has an estimated 65,000 million megalitres of water, equivalent to 130,000 Sydney Harbours. The entire gas industry in the Surat Basin, in Queensland, will extract less than .004 per cent of the total over the next 40 years."[98]

Ms Tanna is saying that the CSG industry will extract 16.25 gigalitres of groundwater over 40 years.[99] It is first worth noting that this is a vastly different number from the number that used by Senator Joyce, who indicates that CSG miners will extract 45,000 gigaliters of groundwater over the life of the CSG industry.[100] It is also significantly different from the numbers set out by the Queensland government in their 2009, 'Blueprint for Queensland's LNG Industry', where at page In 2007–08, it states that approximately 13.5 gigalitres (GL) of CSG water was produced in Queensland.[101] it states…"[102] It also says that if Queensland develops a, 40 Mtpa industry,[103] 281 GL/year of CSG water will be produced. Over 40 years this equates to 11,240 Gigaliters, a number much closer to that used by Senator Joyce.[104] To put the volume of water in context, the amount of groundwater that will be removed from the GAB, is nearly the amount consumed by all persons and all industries in Australia combined.

CSG water producers are required to secure a water license (supra.),and are obligated to undertake a formal water monitoring program, with all results reported to DERM. Details

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[98] Rural Affairs And Transport References Committee, Senate, Brisbane, 9 August 2011 p20-21 (Catherine Tanna)

[99] The GAB contains 65,000 million megalitres, which is 65,000 gigaliters. 0.004% X 65,00x10^{12} is 16,250 megalitres, which equates to 16.25 gigaliters, a number that is not supported by CSIRO.

[100] Commonwealth, Environment and Communications Legislation Committee, Senate, 25 May 2011, 117 (Barnaby Joyce)

[101] Ibid.

[102] Anna Bligh and Andrew Fraser, 'Blueprint for Queensland's LNG Industry', (2009) Premier of Queensland and Treasurer and Minister for Employment and Economic Development, Department of Employment, Economic Development and Innovation, SD5753, September 2009, p4.

[103] Mtpa is millions of tonnes of liquefied natural gas.

[104] Commonwealth, Environment and Communications Legislation Committee, Senate, 25 May 2011, 117 (Barnaby Joyce).

of the monitoring and reporting requirements are set out in greater detail in the legislation passed by the Queensland legislature in late 2010.[105]

PETROLEUM AND GAS (PRODUCTION AND SAFETY) ACT 2004

A petroleum tenure holder may apply for a water licence if the water intended for use by the petroleum tenure holder is 'associated water' as set out in the *Petroleum and Gas (Production and Safety) Act*, ("*Petroleum and Gas Act*")[106] and the water is not being used, or proposed to be used, for another activity accordance with the *Petroleum and Gas Act*. As indicated above, s185 of the *Petroleum and Gas Act* grants an unfettered right to the petroleum tenure holder to take groundwater.
The *Petroleum and Gas Act* puts no limit on the volume of groundwater that a petroleum tenure holder may extract. However, the petroleum tenure holder is required to submit to the Chief Executive, an impact report which defines the uses of associated water, its monitoring requirements and the contamination 'trigger' concentrations (supra.)

Pursuant to s185 of the *Petroleum and Gas Act*, a petroleum tenure holder is authorized to take groundwater if it is produced during an authorised activity, which is the drilling of an exploration or exploitation well. Alternatively the petroleum tenure holder is not permitted to utilize water as previously proscribed by the *Water Act*, unless otherwise permitted by the *Water Act* (supra.).

Section 186 of the *Petroleum and Gas Act* permits the petroleum tenure holder to utilize associated water for domestic or livestock purposes, either on the tenement, or on an adjoining tenement that is the property of the same legal person.[107] However, the petroleum tenure must obtain a water licence under the *Water Act*, if the associated water is used otherwise than set in in the *Petroleum and Gas Act*.

Section 187 of the *Petroleum and Gas Act* further identifies the requirements for water monitoring for associated water. Water monitoring is required for assessing compliance with the tenure. The following requirements are set out under the *Petroleum and Gas Act*:

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[105] *Natural Resources and Other Legislation Amendment* Act 2010 (Qld); *Natural Resources and Other Legislation Amendment (Part 2) Act* 2010 (Qld); *Water and Other Legislation Amendment Act* 2010 QLD;

[107] Golder & Associates – Environmental Engineers, 'QGC Groundwater Study Surat Basin', Coal Seam Gas Field Component for Environmental Impact Statement Prepared for Queensland Gas, June 2009, p18

1. gathering data about an existing *Water Act* water bore (defined as a water monitoring activity).
2. A Water Act bore for a petroleum tenure holder is only a water bore pursuant to the Water Act if water taken from the bore is authorised under the *Water Act*, and the water bore was in existence prior to the start of approved testing for petroleum production or the start of commercial production, whichever is easerlier;
3. gathering information for an underground water impact report, pre-closure report, monitoring report or review report;
4. monitoring the effect of the exercise of the underground water rights for the tenure;
5. constructing or plugging and abandoning a water observation bore; and
6. carrying out restoration measures in relation to an existing *Water Act* water bore for which the make good obligation applies.

Section 190 permits the petroleum tenure holder to apply for a water monitoring authority, which may include land outside the petroleum tenure area, if this is needed to comply with the particular requirements of their petroleum tenure.[108]

Section 194 authorizes the petroleum tenure holder to conduct water monitoring on its tenement.[109]

Sections 195 and 201 are somewhat puzzling. They describe the 'authority holder' or 'authority holders' as having a limited right to drill water bore holes only for the purpose of monitoring. Since it is clear that this is not the only water activity that a petroleum tenure holder may engage, it must follow that, s195 in particular, is limited to monitoring activities only.

Section 214(e) of the *Petroleum and Gas Act* may enliven an obligation on the petroleum tenure holder to conduct a groundwater monitoring program.[110] Legislative changes made in late 2010 expand this obligation.

[108] Ibid. p19
[109] Ibid. p19
[110] Ibid. p20

Sections 250 & 251 state that if the exercise of a petroleum tenure holder's underground water rights unduly affects an existing *Water Act* water bore, then the tenure holder should either remediate the supply of water to the owner of the water bore, or compensate the owner of the water bore.[111] However 165B of the *Petroleum Act* qualifies these obligations to effectively apply from 31 December 2004. These "make good obligations" provide for a continuation of the requirement to make good even if the water bore was first unduly affected by the exercise of underground water rights after the term of the petroleum tenure expires, which would lead one to believe that there it has been contemplated that there is the potential for damage to occur to water bores from the ongoing production of CSG.

The *Petroleum and Gas Act* applies whether the priority water bores are inside the petroleum tenure area or are in an area adjacent. In either case, a bore is regarded as being "unduly affected" when either:

1. the water level in the bore drops below a set trigger threshold for the relevant aquifer; or
2. the bore is recognised as having "impaired capacity".

The trigger threshold is key to the obligation.

Section 247 of the *Petroleum and Gas Act* provides a definition of 'impaired capacity'. It states that 'impaired capacity shall include:

1. Where the water bore is used for domestic purposes, and it is no longer able to provide a reasonable supply of water for the domestic purpose required at the location; or
2. Where the water bore is used to water livestock, and the number of livestock that can be watered from an effected water bore is materially reduced; or
3. Where a town or business experiences a material reduction in its water supply.

Sections 252 to 255 of the *Petroleum and Gas Act* provide a process for establishing a trigger threshold for aquifers materially affected by the exercise of underground water rights for petroleum tenure holders. As noted in the opening section of the article, QGC points to triggers that govern under those provisions, where it states, "the Queensland Government

[111] Ibid. p20

has set groundwater trigger levels for comparison of monitoring results with pre-existing aquifer conditions." The trigger level set by the chief executive must be a level the chief executive considers would cause a significant reduction in the maximum pumping rate or flow rate of the existing bores in the area, as set out above.[112]

The *Petroleum and Gas Act* creates a process for setting a 'trigger threshold' for aquifers in the area affected by the exercise of underground water rights. However, a deficiency of the legislation that it does not stipulate a limit on the impairment of groundwater levels or water extraction limits.

Section 253 *Petroleum and Gas Act* permits the petroleum tenure holder to request the chief executive set an aquifer trigger threshold. Section 254(1) prescribes the chief executive a framework by saying the trigger water level is, "the water level drop in the aquifers that the chief executive considers would be a level that causes a significant reduction in the maximum pumping rate or flow rate of the existing *Water Act* water bores in the area affected by the exercise of the underground water rights."

Hydraulic conductivity, geometry and water levels of the aquifers are defined as the criteria to be considered in the definition of the trigger value, and these can only be decided with the input of the petroleum tenure holder.[113] The length of time used to estimate the drawdown is critical to the establishment of a trigger value, but since the trigger value fails to incorporate the notion of time (i.e., Water used by the petroleum tenure holder over a 365 day period, or change in water bore elevation from a particular date to a date 365 days from that particular date.), its value becomes meaningless as it will not characterise the range of impacts of groundwater extraction on the aquifers.[114] Sections 252 to 255 state:

> *252 Operation of sdiv 1*
>
> > *(1) This division provides for the fixing of a* ***trigger threshold*** *for aquifers in the area affected by the exercise of underground water rights for a petroleum tenure.*
> >
> > *(2) The fixing of the trigger threshold* ***allows*** *the tenure holder to prepare an underground* ***water impact report*** *for the tenure.*

[112] Ibid. p21
[113] Ibid. p21
[114] Ibid. p21

253 Request for trigger threshold and action on request

*(1) The petroleum tenure holder **may ask** the chief executive what the trigger threshold is for the aquifers.*

*(2) The **chief executive must**--*

(a) if no trigger threshold already applies for the aquifers--fix a trigger threshold for the aquifers and tell the tenure holder what that trigger threshold is; or

(b) if, under section 255, a trigger threshold already applies for the aquifers--tell the tenure holder what that trigger threshold is.

254 Provisions for fixing trigger threshold

(1) A trigger threshold fixed under section 253(2)(a) must be the water level drop in the aquifers that the chief executive considers would be a level that causes a significant reduction in the maximum pumping rate or flow rate of the existing Water Act bores in the area affected by the exercise of the underground water rights.

(2) In fixing the trigger threshold, the chief executive--

*(a) **must consider**--*

(i) the permeability and geometry of the aquifers; and

(ii) the water levels in the aquifers; and

*(b) **must allow** the petroleum tenure holder a reasonable opportunity to make submissions about the trigger threshold proposed by the chief executive; and*

(c) may ask the tenure holder to give the chief executive documents or information the chief executive reasonably requires to fix the trigger threshold.

(3) If the request is not complied with the chief executive may fix the trigger threshold using the documents or information available to the chief executive.

*255 **Fixed trigger threshold applies for all underground water rights***

(1) This section applies if, under section 253(2)(a), a trigger threshold has already been fixed for an aquifer in any part of the area affected by the exercise of underground water rights for a petroleum tenure.

(2) The trigger threshold applies for any aquifer in the area for the exercise of underground water rights for any other petroleum tenure. [emphasis added]

A reading of these provisions, which QGC correctly identifies as key provisions in meeting its obligations in respect of groundwater, includes language which is likely to lead to administrative actions insofar as the chief executive is obligated to consider 'aquifer permeability and geometry'; and the chief executive must allow the petroleum tenure holder to make submissions on the matter. Doubtless these will be expert submissions that the chief executive will be ill equipped to refute.

It should be noted that nowhere does this process give a voice to the priority water bore holders, who are meant to be protected by this process. As indicated above, the chief executive will almost inevitably be reliant on 'experts' that are paid for by the petroleum tenure holders.

ENVIRONMENTAL PROTECTION ACT 1994 & ENVIRONMENTAL PROTECTION REGULATIONS 2008[115]

Sections 63 through 65 of the *Environmental Protection Regulations* set out the most important guidelines for the management of CSG water. Section 65 defines CSG production effluent as a regulated waste. The section states:

s65 What is regulated waste

(1) Regulated waste is waste that—

(a) is commercial or industrial waste, whether or not it has been immobilised or treated; and

(b) is of a type, or contains a constituent of a type, mentioned in schedule 7.

(2) Waste prescribed under subsection (1) includes—

[115] *Environmental Protection Act* 1994 (Qld); *Environmental Protection Regulations* 2008 (Qld)

(a) for an element—any chemical compound containing the element; and

(b) anything that contains residues of the waste.

Schedule 7 includes a list of seventy-one (71) regulated waste products, including salt water.[116] Section 63 and 64 of these regulations seeks to control the return of associated water to an aquifer, as follows:

63 Activity involving direct release of waste to groundwater:

(1) This section applies to the administering authority for making an environmental management decision relating to an activity that involves, or may involve, the release of waste directly to groundwater (the receiving groundwater).

Example of direct release of waste to groundwater— an activity involving the release of contaminated water to groundwater through a well, deep-well injection or a bore

[116] *Environmental Protection Regulation* 2008 (Qld), Schedule 7; The list of regulated wastes is: 1. acidic solutions and acids in solid form; 2 animal effluent and residues, including abattoir effluent and poultry and fish processing wastes; 3 antimony and antimony compounds; 4 arsenic and arsenic compounds; 5 asbestos; 6 barium compounds, other than barium sulphate; 7 basic (alkaline) solutions and bases (alkalis) in solid form; 8 beryllium and beryllium compounds; 9 boron compounds; 10 cadmium and cadmium compounds; 11 chemical waste arising from a research and development or teaching activity, including new or unidentified material and material whose effects on human health or the environment are not known; 12 chlorates; 13 chromium compounds (hexavalent and trivalent); 14 clinical and related waste; 15 containers contaminated with a regulated waste; 16 copper compounds; 17 cyanides (inorganic); 18 cyanides (organic); 19 encapsulated, chemically-fixed, solidified or polymerised wastes; 20 ethers; 21 filter cake; 22 fly ash; 23 food processing waste; 24 grease trap waste; 25 halogenated organic solvents; 26 highly odorous organic chemicals, including mercaptans and acrylates; 27 inorganic fluorine compounds, other than calcium fluoride; 28 inorganic sulphides; 29 isocyanate compounds; 30 lead and lead compounds including lead-acid batteries; 31 material containing polychlorinated biphenyls (PCBs), polychlorinated napthalenes (PCNs), polychlorinated terphenyls (PCTs) or polybrominated biphenyls (PBBs); 32 mercury and mercury compounds; 33 metal carbonyls; 34 mineral oils; 35 nickel compounds; 36 non-toxic salts including, for example, saline effluent; 37 hydrocarbons and water mixtures or emulsions, including oil and water mixtures or emulsions; 38 organic phosphorous compounds; 39 organic solvents, other than halogenated solvents, including, for example, ethanol; 40 organohalogen compounds, other than another substance stated in this schedule; 41 oxidising agents; 42 perchlorates; 43 pesticides, including organchlorine; 44 pharmaceuticals, drugs and medicines; 45 phenols and phenol compounds, including chlorophenols; 46 phosphorus compounds, other than mineral phosphates; 47 polychlorinated dibenzo-furan (any congener); 48 polychlorinated dibenzo-p-dioxin (any congener); 49 reactive chemicals; 50 reducing agents; 51 residues from industrial waste treatment or disposal operations; 52 selenium and selenium compounds; 53 sewage sludge and residues, including nightsoil and septic tank sludge; 54 sludge and residues from water treatment plants; 55 surface active agents (surfactants) containing principally organic constituents, whether or not also containing metals and other inorganic materials; 56 tallow; 57 tannery wastes, including leather dust, ash, sludges and flours; 58 tarry residues arising from refining, distillation or any pyrolytic treatment; 59 tellurium and tellurium compounds; 60 thallium and thallium compounds; 61 triethylamine catalysts for setting foundry sands; 62 tyres; 63 vanadium compounds; 64 vegetable oils; 65 waste containing peroxides other than hydrogen peroxide; 66 waste from a heat treatment or tempering operation that uses cyanides; 67 waste from surface treatment of metals or plastics.

(2) The administering authority must refuse to grant the application if the authority considers—

(a) for an application other than an application relating to an environmental authority for a petroleum activity—the waste is not being, or may not be, released entirely within a confined aquifer; or

(b) the release of the waste is affecting adversely, or may affect adversely, a surface ecological system; or

(c) the waste is likely to result in a deterioration in the environmental values of the receiving groundwater.

(3) In this section— confined aquifer means an aquifer that is contained entirely within impermeable strata.

64 Activity involving indirect release of contaminants to groundwater

(1) This section applies to the administering authority for making an environmental management decision relating to an activity that involves, or may involve, the release of contaminants indirectly to groundwater (the receiving groundwater).

Example of indirect release of waste to groundwater— storage of contaminated water in a pond allowing infiltration of contaminated water to groundwater

(2) The administering authority must consider the following matters—

(a) the geological stability of the relevant site for the activity;

(b) the location, quality and use, or potential use, of the receiving groundwater;

(c) the permeability of the earth under the place where the activity is carried out;

(d) the presence of containment devices at the relevant site for the activity and their effectiveness in preventing or minimising the release of the waste;

Example of a containment device— a liner for a storage pond

(e) the distance separating the receiving groundwater from any containment device;

(f) the potential for fluctuations in the level of the receiving groundwater;

(g) the way in which materials, including contaminants, will be removed from the containment system;

(h) whether or not materials, including contaminants, will be removed from the containment devices and if so, the effectiveness of the methods that will be used for the removal.

Sections 14 to 17 of the *Environmental Protection Act* defines environmental harm, environmental nuisance, material environmental harm and serious environmental harm. Environmental harm is defined as an adverse effect, or potential adverse effect on an environmental baseline value set by DERM. This includes the use of heavy metals or phenols for hydraulic fracturing.[117]

Section 18 of the *Environmental Protection Act* classifies petroleum activities as environmentally relevant activities, which includes CSG activities.

Sections 77 and 78 of the *Environmental Protection Act* set out the requirements for securing an environmental authority ("EA") for a petroleum related activity.[118] This is defined to include an operation coming under the jurisdiction of the Petroleum and Gas Act, namely a CSG developer.

ENVIRONMENTAL AUTHORITY

Environmental Authorities ("EA) are a set of terms and conditions issued by DERM pursuant to the *Environment Protection Act* and the *Petroleum and Gas Act*.[119] An EA is issued to every petroleum tenure holder, who must comply with the terms of the EA.

[117] Golder, Above n102, p22

[118] Environmental Protection Act 2002 (Qld); Now found at ss309A(2)(b), 309B, 309D, and 426A; Petroleum and Gas (Production and Safety) Act 2004 (Qld).

[119] Ibid.

Petroleum activities are classified as either a Level 1 or Level 2 environmentally relevant activity ("ERA"). An ERA will always be matched to a corresponding EA pursuant to the *Environment Protection Act*.[120]

Level 2 activities are petroleum activities that have a low risk of environmental harm and they must comply with a standard set of environmental conditions stipulated by DERM; however, Level 1 activities are detailed in the schedule of the Environment Protection Regulation, and require a site specific environment management plan ("EMP") as part of the EA.

It should be noted that a CSG Water Monitoring Plan (WMP), which includes groundwater management, is to be incorporated in the Environmental Management Plan (EMP) required for Level 1 EA applications. As a matter of practice, both DERM and the petroleum tenure holder should publish all EA applications, as would occur with a regular planning application.[121]

WATER SUPPLY (SAFETY AND RELIABILITY) ACT 2008

This act provides a regulatory framework for providing recycled water and drinking water quality, primarily for health. Recycled water is defined as 'waste water.' Manufactured or distilled water is defined as 'water', which includes desalinated or recycled water that is potable in quality.

This enactment also outlines who must apply for registration as a water service provider and what the requirements are for such a service provider. It governs who must apply for registration as a service provider, but would only apply if a petroleum tenure holder utilized associated water as drinking water, or as livestock water. This will be required if a CSG developer treats and sells or gifts recycled associated water obtained its gas extraction process

THE WATER RESOURCE (GREAT ARTESIAN BASIN) PLAN

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[120] Golder, Above n102, p22

[121] Sustainable Planning Act (Qld), ss297, 745 and 746, which require both the council and the developer to publish public notices of a development plan.

The Water Resource (Great Artesian Basin) Plan[122] (the "Plan") is another instrument used by Queensland for managing groundwater from Queensland's portion of the GAB. The Plan is intended to delineate and measure the artesian, sub-artesian, or spring water in the GAB and to set out a guideline for using water from the GAB. The Plan also tries to anticipate future needs, and points to ways to prioritize those needs.

The Plan is focussed on managing groundwater for priority bore holders, and for future generations. It purports to protect the flow of water to surface waters, with reference to environmental values.[123] Technically, the Plan does not permit the use of GAB waters unless CSG extraction will not increase the average annual volume of water extracted from the GAB.[124] Moreover, re-injecting water into GAB aquifers is not defined in the Plan and therefore not prohibited. This means that using water to stimulate CSG production through hydraulic fracturing or water-flooding, would not technically be permitted. Also, disposes of associated water in the GAB is not technically permitted. When compared to the UDSW in the U.S., this is a clear failing for a resource that crosses border in to the adjacent states and territories.

The plan states that a water license granted to any party must protect the flow of water to watercourses.

However, Section 30 of the Plan permits the petroleum tenure holders to avoid these obligations:

> *"A water licence, in not stating a maximum volume of water that may be taken, is not inconsistent with this plan if the licence*
> *is only -*
>
> *a) for stock or domestic purposes; or*
>
> *b) to lower water levels to prevent water entering a mine; or*
>
> *c) for associated water under the Petroleum and Gas (Production and Safety) Act 2004.*

[122] *The Water Resource (Great Artesian Basin) Plan* 2006 (Qld)
[123] Ibid. s8
[124] Ibid, s10

The Plan endeavours to regulate water removed from the GAB, which may impair the amount of water that would otherwise flow to watercourses in order to maintain a baseline volume of surface water. However, water licenced petroleum tenure holders are exempted from these requirements under the *Petroleum and Gas Act*.

The Plan obligates the petroleum tenure holder to measure the volume of groundwater taken from the GAB, unless the water is for stock or domestic purposes.[125] The monitoring requirements for this plan include:

1. monitoring artesian water pressure;
2. monitoring sub-artesian water levels;
3. monitoring the flow of springwater; and
4. monitoring the baseline (i.e., 'baseflow') to rivers and lakes.[126]

The monitoring requirements are to be achieved by monitoring programs administered by relevant State agencies; and if a water licence requires the holder of the license to carry out a monitoring program—the program must be carried out by the holder.

GREAT ARTESIAN BASIN RESOURCE OPERATIONS PLAN

The Great Artesian Basin Resource Operations Plan[127] ("Operation Plan") defines groundwater management areas and further subdivides these management areas into management units. Each unit is given a maximum annual allocation of water under the Operations Plan.

There is currently a moratorium for granting of further groundwater licences within much of the GAB, unless you are a petroleum tenure holder. Let me repeat this point…you are unlikely to get a licence to remove groundwater from the GAB unless you are a CSG miner.

LEGISLATIVE CHANGES ENACTED IN 2010

Three enactments were made by the Queensland legislature in late 2010. These statutes amend a cross-section of Queensland statutes. The omnibus enactments are:

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[125] Golder, Above n102, p23
[126] Ibid. p24
[127] *Great Artesian Basin Resource Operations Plan* 2007 (Qld)

1. *Natural Resources and Other Legislation Amendment Act* 2010;
2. *Natural Resources and Other Legislation Amendment (Part 2) Act* 2010;
3. *Water and Other Legislation Amendment Act* 2010; and,
4. *Environmental Protection and Other Acts Amendment Act* 2011

The Queensland government has made amendments to many of the legislative instruments that are intended to govern the CSG industry. However, John Bradley, Director General of DERM, indicates that DERM do not yet have guidelines for baseline and boree evaluations.[128] They have not yet developed an industry framework for 'make good' obligations.[129] As was shown above, the 'make good' obligations are subject to litigation, and expert opinion. DERM has not yet developed guidelines for recycling waste water, and DERM has not prescribed a BTEX standard.[130] DERM has no way to monitor for BTEX compounds, and have not put in place guidelines for BTEX notices from petroleum tenure holders to priority water bore holders. The latter point is key to ensuring that no person or animal is harmed by the BTEX that may be used in hydraulic fracturing, or is released from the rock that is being fractured. DERM has not developed salt concentration guidelines.[131] Clearly certain concentrations of sodium or potassium ions can be hazardous, and the volume of salt that will need to be stored and disposed of, is larger than can be put to commercial use at this point. DERM has not issued standards for CSG drill holes,[132] and do not have a team in place to deal with environmental complaints.[133]

UNDERGROUND INJECTION AND HYDRAULIC FRACTURING

Importantly, the *Natural Resources and Other Legislation Amendment (Part 2) Act*,[134] adds a new s312W to the *Environmental Protection Act*.[135] It states:

s312W Statutory conditions of environmental authority (chapter 5A activities)

[128] John Bradley, Director General, Department of Environment and Resources Management, Energy IQ's Coal Seam Gas Water Management Conference, Brisbane, Queensland, 29-30 March 2011, p20.
[129] Ibid. p21
[130] Ibid. p22
[131] Ibid. p22
[132] Ibid. p23
[133] Ibid. p24
[134] *Natural Resources and Other Legislation Amendment (Part 2) Act* 2011 (Qld).
[135] Environmental Protection Act 1994 (Qld)

(1) An environmental authority (chapter 5A activities) is taken to include a condition prohibiting the use of restricted stimulation fluids.

Example -- the use of hydrocarbon chemicals to stimulate the fracturing of coal seams

(2) In this section restricted stimulation fluids means fluids used for the purpose of stimulation, including fracturing, that contain the following chemicals in more than the maximum amount prescribed under a regulation

(a) petroleum hydrocarbons containing benzene, ethylbenzene, toluene, or xylene;

(b) chemicals that produce, or are likely to produce, benzene, ethylbenzene, toluene or xylene as the chemical breaks down in the environment.

There are regulations which are yet to be prescribed by DERM and the Queensland Water Commissioner. The regulation should extend to chemicals used in the drilling process, but should be drafted to include all forms of well stimulation and well treatment. The regulations will need to regulate the use of chemicals other than BTEX chemicals, which may be naturally occurring. Regulation may include heavy metals, barium, born, and diesel fuel. Diesel had been a common additive in U.S. hydraulic fracturing, and is frequently present whilst drilling the well. Neither does the regulation account for the potential for methane gas to migrate through fractures in the coal seam to nearby well bores.[136] (**See Figure 7**)

The State of Alabama promulgated the first rules and regulations governing CSG.[137] The State of Alabama has had significant CSG litigation.[138] The result has been changes to state law as well as to the U.S. Safe Drinking Water Act.[139]

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[136] Stephen G Osborn, Avner Vengosh, Nathaniel R Warner, Robert B Jackson, 'Methane contamination of drinking water accompanying gas-well drilling and hydraulic fracturing' Proceedings of the National Academy of Sciences, Center on Global Change, Nicholas School of the Environment, Duke University, Durham, NC, 14 April 2011, p1.

[137] *General Order Prescribing Rules and Regulations Governing the Conservation of Oil and Gas in Alabama* State Oil and Gas Board of Alabama Administrative *Code,* Oil and Gas Laws of Alabama, State of Alabama, U.S.A., July 2011 p1

[138] Legal Environmental Assistance Foundation v U.S. Environmental Protection Agency, 118 F.3d 1467 (LEAF I); Legal Environmental Assistance Foundation v U.S. Environmental Protection Agency, State Oil and Gas Board of Alabama, 276 F.3d 1253 (LEAF II).

[139] Safe Drinking Water Act, July 1, 1944, ch. 373, title XIV, as added Pub. L. 104-182, title V, §501(e), Aug. 6, 1996, 110 Stat. 1691 (42 U.S.C. 300f et seq.); Safe Drinking Water Act of 1974 Pub. L. 93-523, Dec. 16, 1974, 88 Stat. 1660Short title, see 42 U.S.C. 201; Safe Drinking Water Amendments of 1977 Pub. L. 95-190, Nov. 16, 1977, 91 Stat. 1393 Short title, see 42 U.S.C. 201; Safe Drinking Water Act Amendments of 1986Pub. L. 99-339, June 19, 1986, 100 Stat. 642Short title, see 42 U.S.C. 201; Safe Drinking Water Act Amendments of 1996Pub. L. 104-182, Aug. 6, 1996, 110 Stat. 1613Short title, see 42 U.S.C. 201

Firstly it is the strong view of the author that Queensland should consider introducing comprehensive drilling, well stimulation, well treatment, and coal seam fracturing rules. The Alabama rules and regulations that may be included in Queensland's regulatory regime for CSG are as follows:

1. An affidavit must be sworn by a senior employee of the petroleum tenure holder listing the chemicals in the fracturing fluid, the drilling fluid, or any stimulation liquid. I hasten to add that the sworn statement should be given under an authority from the Board of the petroleum tenure holder. A separate affidavit shall be submitted outlining the precise volume of stimulation or fracturing fluids that have been recovered from the well, with the amount of recovery to be not less than 90%;[140]
2. Fracturing coal seams must not be done at vertical intervals less than 399 feet (i.e., 130 meters). This reduces the chance of a fracture opening up from the coal seam to aquifers supplying drinking water to nearby priority holders;[141]
3. The well casing on a well to be fractured, shall be cemented to a depth of 30 meters, and the shoe pressure of a well to be fractured must be tested at a constant 1,500psi for a period not less than 48 hours, to ensure that fracturing fluids are not leaked in to alluvial aquifers;[142]
4. Each well to be fractured shall require a separate application to the chief executive, with drawings of all water well bores within 1 kilometre. Tests are to be conducted at the end of each day of fracturing, with the water well bore results submitted to the chief executive. The results will include chemical composition and turbidity.[143]
5. All CSG miners shall be required to pay a fee per well in to an environmental remediation fund, which shall be used in the event of a company failure, and clean-up cost which would otherwise be borne by priority water bore owner;
6. Each well to be injected shall require a separate application to the chief, unless part of a field, in which case, a planning permit shall be procured, and all parties within a 10km radius of the injection area shall be notified. Also, not less than two (2) advertisements shall be taken out in local newspapers;[144]

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[140] *General Order Prescribing Rules and Regulations Governing the Conservation of Oil and Gas in Alabama State*, Oil and Gas Board of Alabama Administrative Code, Oil and Gas Laws of Alabama, State of Alabama, U.S.A., July 2011 r. 400-1-5-.02.
[141] Ibid. r.400.3.8.03(6)
[142] Ibid. r.400.3.8.03(3).
[143] Ibid. r.400-4-2.01(2)(g).
[144] Ibid. r.400-4-2(9).

7. Each well to be stimulated shall require a separate application to the chief, unless part of a field, in which case, a planning permit shall be procured, and all parties within a 10km radius of the injection area shall be notified. Also, not less than two (2) advertisements shall be taken out in local newspapers;[145]
8. A priority water bore holder who is injured by a petroleum tenure holder, shall be compensated by a fund established by the state and paid in to by the CSG industry. Each CSG well shall require a payment to the priority water bore reparations fund. (One may consider extending this to covering the legal costs incurred in recovering damages from petroleum tenure holders);[146]
9. Any well fracture or well stimulation that changes the chemical composition or molarity of a water bore within 1 km, shall be immediately be plugged and sealed at the cost of the petroleum tenure holder, and under the supervision of the chief executive.[147]
10. If chemical treatment of a well, or fracturing of a coal seal, results in damage to the well, the well shall be plugged and sealed.[148]

It seems clear that regulations will need to ensure that BTEX and other fraccing chemicals are not used in ways that will jeopardize Queensland's groundwater. Moreover, since BTEX chemicals, boron, barium, and radium and encountered during drilling, a program will need to be developed to control these events. In addition, when well stimulation is utilized, including fracturing, a program needs to be developed to ensure that most of these fluids are removed from the well, and not left in situ where they can contaminate groundwater.

To frame the issues, one need not look further than the words of Justice Birch of the Eleventh Circuit Court of Appeal, speaking to the issue of the U.S. Underground Injection Program, which regulates the injection of fluids by oil and gas operators, says,

> "The regulations define "underground injection" as "well injection," which in turn is defined as "the subsurface emplacement of "fluids' through a bored, drilled, or driven "well;' or through a dug well, where the depth of the dug well is greater than the largest surface dimension." 40 C.F.R. § 144.3."[149]

[145] Ibid. r.400.3.4.14(2),
[146] Ibid. r. 400-3-2-.01(2)
[147] Ibid. r.45B400-1-4-.07.
[148] Ibid. r.45B400-1-4-.07.
[149] Legal Environmental Assistance Foundation v U.S. Environmental Protection Agency, 118 F.3d 1467, p12

The Eleventh Circuit United States Court of Appeal explains CSG hydraulic fracturing,[150] where at p16 it states:

> "Hydraulic fracturing is a technique used by the oil and gas industry for enhancing the recovery of natural gas from underground formations. In Alabama, it is commonly used in connection with the extraction of natural methane gas from coal beds [known in Australia as "seams"]. Coal beds, as all underground formations, are formed of porous, sometimes fractured, materials. These coal beds contain natural gas, which can be extracted through production wells. Because of the tightness of coal bed formations and their very low permeability, the rate of production of natural gas is low in the absence of production enhancement.
>
> **Experience has shown that coal beds must be hydraulically fractured to induce or stimulate a significant flow of gas.** "Hydraulic fracturing" involves the injection of fluids and a propping agent (usually sand) into a coal bed. The application of pressure injects fluids into the coal bed thereby widening natural fractures and inducing new ones that are held open by the propping agent after the pressure is released. As a result, these fractures provide paths for gas to migrate to the wellbore, thus stimulating gas flow. It has been demonstrated that the gas flow rate from a coal bed may be increased as much as twentyfold by hydraulic fracturing.
>
> Hydraulic fracturing results in fractures that may extend several hundred feet. The **fluids used in hydraulic fracturing may contain guar gel, nitrogen or carbon dioxide gases, gelled oil, diesel oil, sodium hydroxide, hydrochloric acid, sulfuric acid, fumeric acid, as well as other additives**. These fluids are pumped into methane gas production wells after the wells are constructed in order to stimulate the flow of gas. Occasionally, fluids are reinjected into the well to further fracture the coal bed. More often, fluids are reinjected in order to maintain previously-induced fractures free of obstructions. 4 After the coal beds are hydraulically fractured, the injected fluids and groundwater are pumped out of the production well before the flow of methane gas starts. A portion of the injected fluids, however, remains in the ground.

[150] Ibid. p16

4 According to EPA, **one well out of 34 wells within one mile of a well owned by LEAF members (the McMillian well) was fractured more than once. "Maintenance" fluids were injected into eight of the 34 wells during production**.

5 See generally R.M. Stahl & P.E. Clark, Fluid Loss During the Fracturing of Coalbed Methane Wells, in The 1991 Coalbed Methane Symposium Proceedings [hereinafter Symposium] 269, 269 (The University of Alabama 1991). **The only quantitative information contained in the record on this issue indicates a fluid loss of 20 to 30 percent.** See I.D. Palmer et al., Comparison between Gel-Fracture and Water-Fracture Stimulations in the Black Warrior Basin, in Symposium 233, 237, appearing at R6-564."[151] [emphasis added]

Further regulation in Queensland must address the, "fluids used in hydraulic fracturing may contain guar gel, nitrogen or carbon dioxide gases, gelled oil, diesel oil, sodium hydroxide, hydrochloric acid, sulfuric acid, fumeric acid, as well as other additives."[152] John Bradley, Director General of DERM at a March Mining Industry conference indicates that rules will be made to limit BTEX chemicals, and that BTEX will be limited to 0.50% of the fluid by volume. If 20 to 30% (supra.) of the fraccing fluid is left in the ground, and 1000 litres of fraccing fluid is used on each well, and 50% of the 10,000 wells drilled in the Surat Basin are fractured, then 2.5million litres of BTEX will be left in the GAB. This does not include any other chemicals which Surely this can not be the right decision for Queensland and for Australia.

THE WAY FORWARD

The Eleventh Circuit Court of Appeal is the highest common law court to rule on the issue of coal seam gas groundwater contamination, either by hydraulic connections or by hydraulic fracturing fluids.[153] In a joint decision, the Justices conclude as follows:

"The Legal Environmental Assistance Foundation, Inc. ("LEAF") filed this petition for review of an order of the EPA, in which the agency denied LEAF's petition to promulgate a rule withdrawing approval of the Alabama UIC [underground injection

[151] Ibid. p16-17
[152] Legal Environmental Assistance Foundation, Inc., v United States Environmental Protection Agency, 118 F.3d 1467; 1997 U.S. App
[153] Legal Environmental Assistance Foundation, Inc., v United States Environmental Protection Agency, 118 F.3d 1467; 1997 U.S. App

control] program. As background for our analysis, we briefly describe the statutory and regulatory framework for the UIC program, the process of hydraulic fracturing, and the procedural history of this case.

A. Statutory and Regulatory Framework

Part C of the SDWA [Safe Water Drinking Act 1976] establishes a regulatory program for the protection of underground sources of drinking water. See 42 U.S.C. §§ 300h to 300h-8. This program requires [the] EPA to promulgate regulations that set forth minimum requirements for state UIC programs. Id. § 300h. A state must submit to EPA a proposed UIC program that meets these minimum requirements, and receive EPA approval, in order to obtain primary regulatory and enforcement responsibility for underground injection activities within that state. Id. § 300h-1. The state retains primary responsibility until EPA determines, by rule, that the state UIC program no longer meets the minimum requirements established under the SDWA. Id. § 300h-1(b)(3). 1.

Justice Birch continues by noting,

"The regulations define "underground injection" as "well injection," which in turn is defined as "the subsurface emplacement of "fluids' through a bored, drilled, or driven "well;' or through a dug well, where the depth of the dug well is greater than the largest surface dimension." 40 C.F.R. § 144.3.[154]

The Alabama UIC program was approved by EPA in two parts. On August 2, 1982, EPA approved Alabama's UIC program for Class II wells, to be administered by the State Oil and Gas Board of Alabama. See 40 C.F.R. § 147.50. On August 23, 1983, EPA approved Alabama's UIC program for Class I, III, IV, and V wells, to be administered by the Alabama Department of Environmental Management. See id. § 147.51.

Several thousand coal bed methane gas production wells have been constructed in Alabama since 1980. **Due to the large number of these wells, EPA has recognized that "there is a growing potential for contamination of drinking water aquifers,"**

[154] Ibid.

resulting primarily from the hydraulic fracturing necessary to stimulate production. See United States Environmental Protection Agency, Ground Water Study Committee: Report G11--Study Well Contamination Problems; Particularly Problems Related to Coal Bed Methane 1 (1990), appearing at R3-211. Hydraulic fracturing associated with methane production currently is not regulated under the Alabama UIC program. The State Oil and Gas Board of Alabama does not consider wells used for such hydraulic fracturing as Class II injection wells; the Alabama Department of Environmental Management similarly does not consider these wells as Class I, III, IV, or V injection wells.[155]

On this issue, the court concludes:

> "In light of **EPA's recognition that hydraulic fracturing activity does pose a potential threat to water quality in nearby aquifers**, and the proximity of the McMillians' well to such activity, we are satisfied that LEAF has standing to bring this petition because LEAF and its members have shown an "injury or threat of injury [that is] both "real and immediate,' not "conjectural' or "hypothetical,' " City of Los Angeles v. Lyons, 461 U.S. 95, 102, 103 S. Ct. 1660, 1665, 75 L. Ed. 2d 675 (1983).

The first decision of the Eleventh Circuit Court of Appeal went against the EPA, as did the second decision of the Court of Appeal. It was concerning enough that the EPA undertook a desk-top study of CSG groundwater contamination and of the effects of hydraulic fracturing.[156] The final study design, which addresses the narrow issue of the effects of hydraulic fracturing on groundwater that is used as drinking water articulates two objectives:

1. "The intentional direct injection of fracturing fluids into a USDW; and,
2. Creation of a hydraulic communication between the target and coalbed formation and adjacent USDW's"[157]

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[155] Ibid.

[156] An Investigation to Determine the Risk to Underground Sources of Drinking Water Associated with the Hydraulic Fracturing of Coalbeds for Methane Gas, United States Environmental Protection Agency, Office of Ground Water and Drinking Water, Washington D.C., 24 July 2000

[157] Final Study Design for Evaluating of Impacts of Underground Sources of Drinking Water by Hydraulic Fracturing of Coalbed Methane Reservoirs, United States Environmental Protection Agency, office of Ground Water and Drinking Water, Washington D.C.,

The U.S. EPA's conclusion was that there is not sufficient evidence to conclude that CSG wells contaminate groundwater.

US Congress amended the U.S. Safe Drinking Water Act[158] to amend the definition of CSG injection wells to make it clear, notwithstanding the view of the Eleventh Circuit Court of Appeal to the contrary, that CSG wells are not a form of injection well, and therefore do not have to be regulated by the U.S. EPA.[159] Some have suggested this is the lobbying power of the U.S. CSG industry, and is not a reflection of the facts.[160]

The amendment to the EPA was only passed late last year as part of a package of legislative responses to the growing concern about the environmental impact on groundwater of CSG mining. Specifically, the legislation that was passed that deals with BTEX chemicals is the Natural Resources and Other Legislation Amendment (Part 2) Act 2010 QLD. The legislation contemplates a maximum amount of BTEX to be added to hydraulic fracturing fluids, "under a prescribed regulation" (supra.); however I can find no evidence of any regulation that is currently on the books to deal with this matter. The only thing I can find is a policy presentation by John Bradley, the Director General of DERM, suggesting that BTEX chemicals can account for up to 0.56% of the total hydraulic cauldron of water, sand, propants, and sundry other chemicals.

The U.S. EPA are conducting a field study of CSG hydraulic fracturing, which will produce preliminary results in 2012, and a final report in 2014. The results are likely to be less than favourable for the CSG industry. A recent peer reviewed field study conducted by a group from the Institute of Ecosystem Studies at Duke University indicates that methane gas is present in water bore water at concentrations from 17 times greater than that naturally occurring.[161]

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[158] *Energy Policy Act* (2005) 42 USC §13201 et seq. , s322, which states: "HYDRAULIC FRACTURING. Paragraph (1) of section 1421(d) of the Safe Drinking Water Act (42 U.S.C. 300h(d)) is amended to read as follows: ''(1) UNDERGROUND INJECTION.—The term 'underground injection'— ''(A) means the subsurface emplacement of fluids by well injection; and ''(B) excludes— ''(i) the underground injection of natural gas for purposes of storage; and ''(ii) the underground injection of fluids or propping agents (other than diesel fuels) pursuant to hydraulic fracturing operations related to oil, gas, or geothermal production activities.''.

[159] S Marvin Rogers, 'History of Litigation Concerning Hydraulic Fracturing to Produce Coalbed Methane', State Oil and Gas Board of Alabama, IOGCC Legal and Regulatory Affairs Committee, January 2009, p7

[160] Stephen G Osborn, Avner Vengosh, Nathaniel R Warner, Robert B Jackson, 'Methane contamination of drinking water accompanying gas-well drilling and hydraulic fracturing' Proceedings of the National Academy of Sciences, Center on Global Change, Nicholas School of the Environment, Duke University, Durham, NC, 14 April 2011, p1

[161] S Marvin Rogers, 'History of Litigation Concerning Hydraulic Fracturing to Produce Coalbed Methane', State Oil and Gas Board of Alabama, IOGCC Legal and Regulatory Affairs Committee, January 2009

Hydraulic fracturing science suggests there is a connection between CSG extraction, either at the drilling or the fracturing stage, and methane gas contamination of shallow groundwater. The study shows that deep formation thermogenic methane gas is much more likely to be in groundwater in areas where well stimulation, and in particular hydraulic fracturing, has occurred.

The study cannot prove causation for the upward migration of methane, but the authors infer that this is the most likely source of the methane in groundwater. The authors also suggest that well casings may be caused to crack during fracturing, and may be leaking laterally and/or vertically in to surrounding groundwater. The authors postulate that hydraulic fracturing is likely extending fractures beyond the coal seam, thereby permitting gas to travel to adjacent groundwater. The study also suggests that the extreme pressure of fracturing, following by the release of pressure during subsequent gas extraction could cause methane gas to desorb in to surrounding groundwater. The study finds no evidence of associated water or fracturing fluids in the groundwater in this region of the U.S.[162] (**See Figure 8**)

Clearly more research must be done.

EUROPEAN APPROACH TO GROUNDWATER

The European Parliament has issued a Water Framework Directive, which inter alia, addresses groundwater contamination issues as follows:

> "Chemical status -- The case of groundwater is somewhat different. The presumption in relation to groundwater should broadly be that it should not be polluted at all. For this reason, setting chemical quality standards may not be the best approach, as it gives the impression of an allowed level of pollution to which Member States can fill up. A very few such standards have been established at European level for particular issues (nitrates, pesticides and biocides), and these must always be adhered to. But for general protection, we have taken another approach. It is essentially a precautionary one. It comprises a prohibition on direct discharges to groundwater,

[162] Hannah Wiseman, http://lawprofessors.typepad.com/environmental_law/2011/05/hydraulic-fracturing-science-what-the-latest-study-does-and-doesnt-appear-to-tell-us.html (2011) 17 September

and (to cover indirect discharges) a requirement to monitor groundwater bodies so as to detect changes in chemical composition, and to reverse any antropogenically induced upward pollution trend. Taken together, these should ensure the protection of groundwater from all contamination, according to the principle of minimum anthropogenic impact."

The Water Framework Directive also states:

> "Quantitative status -- Quantity is also a major issue for groundwater. Briefly, the issue can be put as follows. There is only a certain amount of recharge into a groundwater each year, and of this recharge, some is needed to support connected ecosystems (whether they be surface water bodies, or terrestrial systems such as wetlands). For good management, only that portion of the overall recharge not needed by the ecology can be abstracted - this is the sustainable resource, and the Directive limits abstraction to that quantity."[163]

It is laudable that the European approach starts from the position that "groundwater should not be polluted at all."[164] In respect of groundwater contamination, the European position is that it is not appropriate to set minimum standards for groundwater pollution because this implies that some acts of groundwater contamination are lawful.

It is also laudable that in Europe the total amount that can be extracted from groundwater can not exceed the amount of measurable recharge in a given year. For the GAB, because it is largely plutonic,[165] under European rules petroleum tenure holders would not be permitted to withdraw much water at all, unless they were able to return the recycled water, after extracting all contaminants.

The European position may seem like a rigorous starting position, but rather than curtailing the CSG industry, it is likely lead to technological innovation.

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[163] Council Directive (80/86/EEC) of 17 December 1979 on the protection of groundwater against pollution caused by certain dangerous substances [1979] OJ L 377/48, art's 100 & 235

[164] 34. Directive 2006/11/EC of the European Parliament on the Council of 15 February 2006 on pollution caused by certain dangerous substances discharged into the aquatic environment of the Community [2006] OJ L 64/52, art. 175(1)

[165] Lance Endersbee, 'A century of error', Reprinted with permission of Institution of Engineers, Australia, www.groundwaterresearchc.om.au/reference/lendersbee/artesianbasin.htm (2011) 11 September

The Shfela shale-gas concession in Israel has been the subject of recent press.[166] This potential source of energy, and the technological innovation that is driving its development, has attracted investors, including Rupert Murdoch, Lord Jacob Rothschild, and the Israeli government. The technology relies on heated rods that are inserted down horizontal bore holes. The rods open the pores of the coal seam with modest amounts of heat delivered slowly from methane gas extracted from the well. They work like the heating elements in an oven, and are estimated to cost between $30 and $40 per barrel of oil equivalent. While this lifting cost is more than twice that of Australian CSG wells, the CSG gas is extracted without disturbing the groundwater, and with half the CO_2 footprint of current CSG technology.[167]

This kind of approach would provide comfort to Australians who are worried about the groundwater they need to operate their farms, or care for their children.

THE COMMONWEALTH CONSTITUTION

Earlier it was noted that Prime Minister Gillard stated in the House of Representatives that the federal government may not be able to interfere (supra.) in matters involving water insofar as these were constitutionally defined as matters under the exclusive jurisdiction of the States. The Hon Prime Minister seems to refer to s100 of the Constitution which states:

> *"The Commonwealth shall not, by any law or regulation of trade or commerce, abridge the right of a State or of the residents therein to the* ***reasonable*** *use of the* ***waters of rivers*** *for conservation or irrigation."* [emphasis added]

The National Water Initiative is a contract signed between the States, the Territories, and the Commonwealth of Australia, pursuant to the National Water Commission Act 2004; however, this author can find no reason why the federal government can not pass laws in respect of groundwater. The United States has a safe drinking water enactment that expressly addresses clean drinking water procured from groundwater sources, for either human or livestock consumption. It includes clear rules in respect of 'underground

[166] Rosenberg, Lance, Email of 16 June 2011, http://opinion.financialpost.com/2011/06/10/israels-new-energy/
[167] Ibid.

injection controls' (supra.), and what types of well stimulation and injection are permitted and not permitted. U.S. Congress began to legislate this issue in 1944, Australia can make laws governing these matters. While the U.S. legislative response to hydraulic fracturing and the evidence of groundwater contamination is woeful, it does not proscribe a sensible response from the Commonwealth.

The federal government should pass legislation setting out the standards for drinking water or irrigation water taken from aquifers. This legislation should expressly address the 6 (not 5 as ultimately decided by the U.S. Environmental Protection Agency) categories of fluid injection in to groundwater. This should include a clear standard for hydraulic fracturing, with an incentive program to utilize mechanical fracturing that does not rely on any BTEX chemicals, or any heavy metals or heavy metal propping agents.

The United States Environmental Protection Agency summarizes the US government's obligation to American citizens:

> "Section 1421 of SDWA [Safe Drinking Water Act] tasks EPA with protecting USDWs [underground sources of drinking water] for all current and future drinking water supplies across the country (see section 1.3 for the complete definition of a USDW). EPA's UIC [underground injection control] Program is responsible for ensuring that fluids injected into the ground (for purposes including waste disposal, oil field brine disposal, enhanced recovery of oil and gas, mining, and emplacement of other fluids) do not endanger USDWs [U.S. drinking water]."

Surely the Commonwealth of Australia owes the same duty to protect the safety and security of drinking water for Australians, as the US government has shown it owes its citizens.

SUGGESTIONS FOR FURTHER STUDY

Water bore owners, who have drilled a water bore on agricultural lands, and who have not been authorized under the *Water Act*, or some other enactment, should be given 12 to 24 months to report their unauthorized water bore without fear of reprisal. The author is reminded of his childhood in the bush, and the fact that water bores get drilled without

permits, but they are nevertheless an essential part of agriculture. While there is no evidence that this is case, further study on the question of providing amnesty to unauthorized agricultural water bore users is suggested, in order to ensure full participation by priority holders is suggested.

All water bore owners, should be required to either report or cap unused water bores. If the owner of an unused water bore does not have the financial means to seal the water bore, Queensland Water Commission should take responsibility to seal the water bore, and should do so within twelve (12) months from the date that it is advised of an unused water bore.

All water bore owners should be required to measure the elevation of each of their water bores, and should be required to report the elevation and exact location of each water bore to the Queensland Water Commission. There should be an ongoing requirement to report the elevation of the water level in each water bore within 90 days of the end of each successive calendar year.

The chief executive must be required to take competing information from each priority holder of a water bore. To limit information used in a decision made by the chief executive, to petroleum tenure holders, makes the process unjust.

It seems clear that virtually no priority holder of a Water Act water bore licence, with the exception of a municipal government, will have the financial wherewithal to litigate a CSG miner. Moreover, the CSG miner will have the benefit of a strong and ongoing relationship with water experts, who will have the ability to cast doubt on the claims made by the priority bore owner. The legal cost of a dispute between a petroleum tenure holder and a priority holder of a water bore should be borne by the petroleum tenure holder, even in the event that the priority holder loses the dispute.

DERM should have its own water experts who are only to provide expert evidence to assist claims made by priority bore holders. This would help to create a 'level playing field' as between the priority water bore holder, and the petroleum tenure holder.

There is much to be done to ensure that Queensland's groundwater, and the GAB in particular, is not irreversibly damaged. The author suggests that the rules and regulations of other more developed CSG jurisdictions be studied, and that at a minimum, the rules already in place in the State of Alabama be incorporated in to the legislative governance regime for CSG operators in Queensland. The legislation that Queensland has prescribed purports to proscribe certain activities, but is likely to fail unless significant additional regulation is put in place. Queensland has an obligation to more than a balanced budget. It must surely be the primary role of government to ensure that their citizens have a right to food and water security.

The Commonwealth of Australia must not shrink from its obligation to ensure that Australians have drinking water, as well as irrigation and stock water needed for food. CSG gas, and the revenue it brings, is not a substitute for water and food security at the federal level of government either.

SUGGESTIONS FOR RESEARCH

At the recent Senate Inquiry in to the impact of CSG on the Murray-Darling Basin Senator Heffernan questioned QGC on what it intends to do with the large amounts of salt that will be produced from treating the salt water extracted during the CSG process.[168] Senator Heffernan compared the disposal of the salt created by treating brine (i.e., associated water) from CSG wells to the disposal of radioactive waste. Dr Jurinak, responding on behalf of QGC, could say nothing more than the matter was being researched.[169]

Dow Chemicals was founded by Herbert Henry Dow in 1897. Dow recognized that salt water discharge from early oil wells in Midland, Michigan could be used to create useful chemicals. The Dow Chemical Company reports as follows:

> "In a college project at Case School of Applied Science (now Case Western Reserve University), [Dow] analysed samples of brine [salt water] from the [oil and gas] wells around Midland, Michigan, which contained small percentages of bromine in ionic form. At the well site he noticed that brine had come to the surface. The oil men considered the oozing brine a nuisance. One of them asked Dow to taste it. "Bitter, isn't it," the driller noted. "It certainly is," Dow added. "Now why would that brine be

[168] Rural Affairs And Transport References Committee, Senate, Brisbane, 9 August 2011 p22 (Jeff Jurinak)
[169] http://en.wikipedia.org/wiki/Herbert_Henry_Dow (2011) 16 September

> so bitter?" the driller asked. "I don't know," Dow said, "but I'd like to find out." He took a sample to his lab, tested it, and found it contained both lithium (which helped explain the bitterness) and bromine. His brine analysis indicated that samples from Canton, Ohio, and Midland, Michigan, were richest in bromine in ionic form."[170]

Herbert Henry Dow started the Dow Chemical company by creating 'bleach' from the brine waste at the Midland oilfields.[171] The author suggests this is precisely where CSIRO may be able to play a role in ensuring that CSG by-products have beneficial uses. If Herbert Henry Dow can do find productive uses for brine (i.e., associated water) more than a hundred years ago, so too can clever Australian chemists.

CONCLUSION

The United States Environmental Protection Agency summarizes the US government's obligation to American citizens:

> "Section 1421 of SDWA [Safe Drinking Water Act] tasks EPA with protecting USDWs [underground sources of drinking water] for all current and future drinking water supplies across the country (see section 1.3 for the complete definition of a USDW). EPA's UIC [underground injection control] Program is responsible for ensuring that fluids injected into the ground (for purposes including waste disposal, oil field brine disposal, enhanced recovery of oil and gas, mining, and emplacement of other fluids) do not endanger USDWs [U.S. drinking water]."[172]

A host of suggestions have been made to improve the regulation of Queensland's CSG industry; however, a number of issues should be further explored. The issues to be further studied include: 1. a review of the drop in groundwater elevations in other jurisdictions where significant CSG extraction has occurred;[173] 2. If 72% of Australian groundwater is potable, and 28% is not fit for consumption, which aquifers are most likely to be cross-

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[170] Ibid.

[171] 38. U.S. Environmental Protection Agency, Office of Ground Water and Drinking Water, *'Proposed Coalbed Methane Study Design'*, EPA 816-K-00-007, 24 July 2000, p12

[172] United States Environmental Protection Agency, 'Evaluation of Impacts to Underground Sources of Drinking Water by Hydraulic Fracturing of Coalbed Methane Reservoirs Study', Office of Water - Office of Ground Water and Drinking Water - Drinking Water Protection Division - Prevention Branch 1200 Pennsylvania Avenue, NW (4606M) Washington, D.C., p1-1

[173] Western Organization of Resource Councils (WORC) (2003) Factsheet. Coalbed methane development: Boon or bane for Rural Residents. (http://www.worc.org/pdfs/CBM.pdf); Research indicates that groundwater levels in the Powder River Basin in Wyoming and Montana have dropped by 100meters.

contaminated by the pressures that created during hydraulic fracturing; 3. For individuals who wish to prevent access to their land for CSG mining, what rights do they have.

It is hoped this article will provide a foundation for further debate about groundwater environmental security, and the corollary, namely food and water security. Policy makers have it within their power to provide peace of mind to the thousands of Australians who are dependent on groundwater for their drinking water, and the millions of Australian who rely on groundwater for the food in their pantries. At the same time they can provide a sensible road map for the growth of the CSG industry in Australia, developed according to Australian standards.

The irony is that in the rush to supply CSG to China, Australia could forfeit its water security, and consequently its food security, and therefore have to look to China to supply food, as well as most other products on the shelves of Australian stores today. It would be a bad bargain to trade food and water security for CSG revenue. The CSG industry could be a great benefit to Australians, but CSG mining must be regulated to ensure that Queensland's groundwater is not impaired.

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APPENDIX

Figure 1: Stratigraphic Illustration of layers of sediment and coal seams

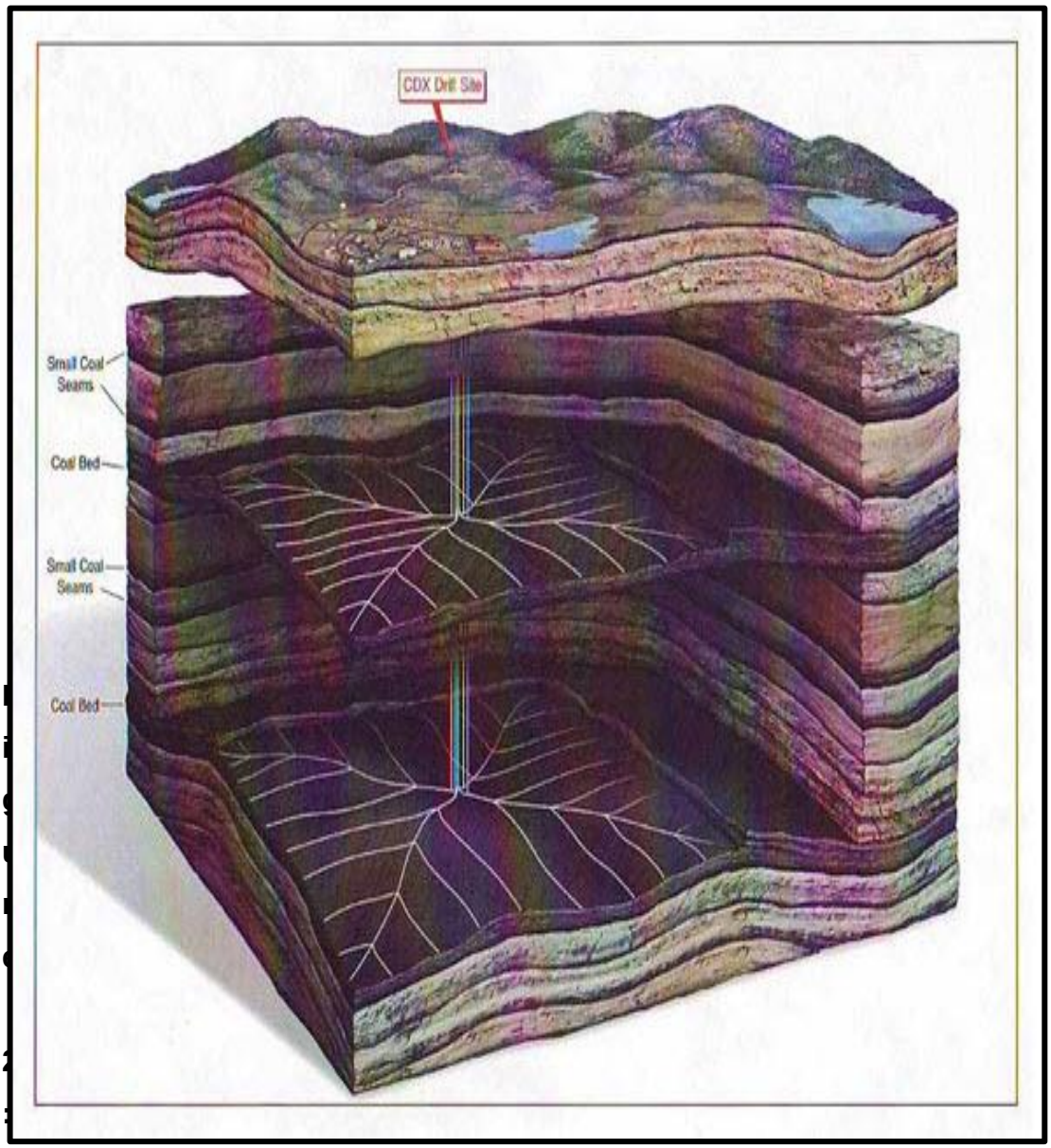


Figure 2: Illustration of coal seam gas and groundwater extraction

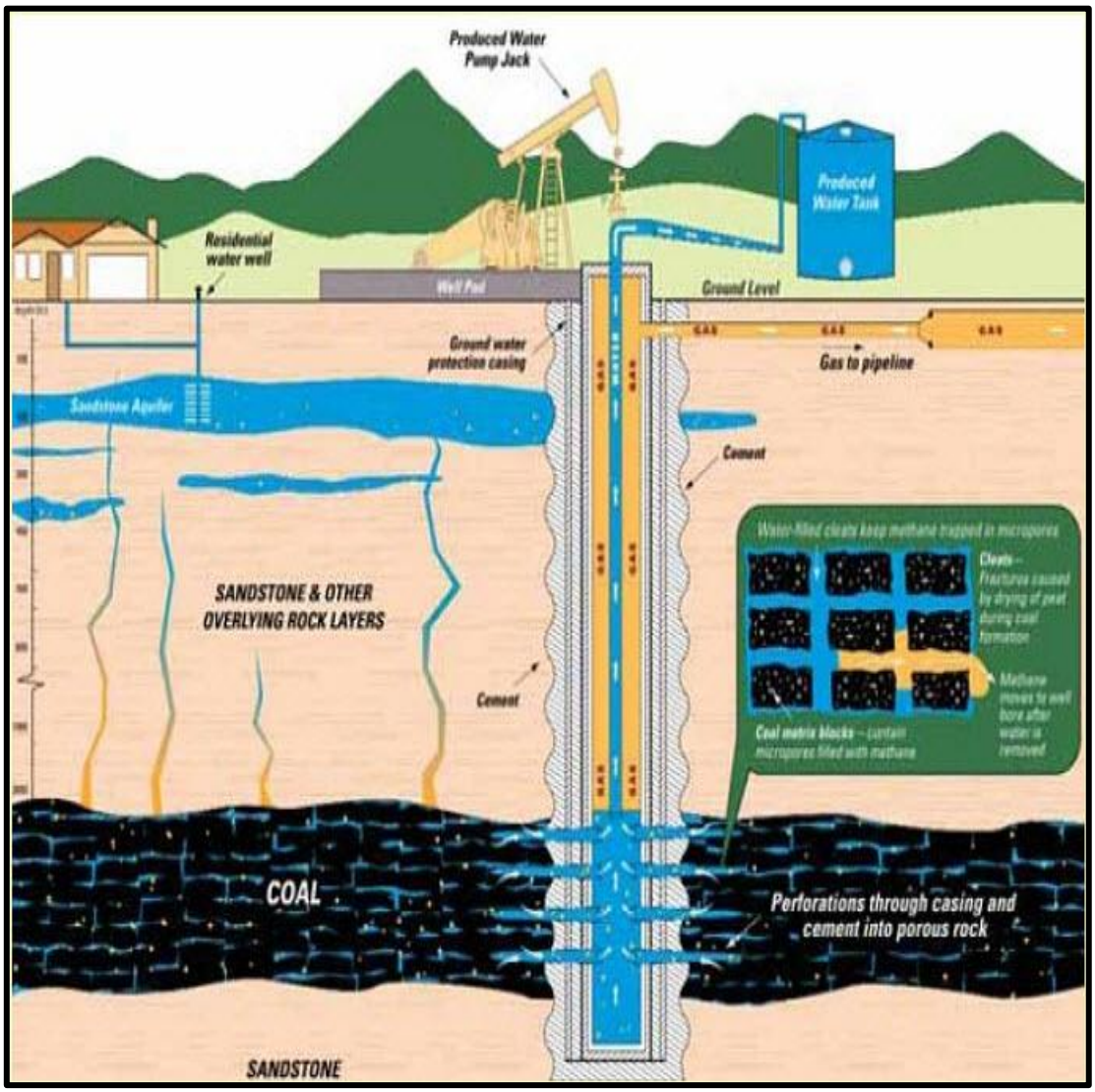


Figure 3: Map of potential coal seam gas deposits

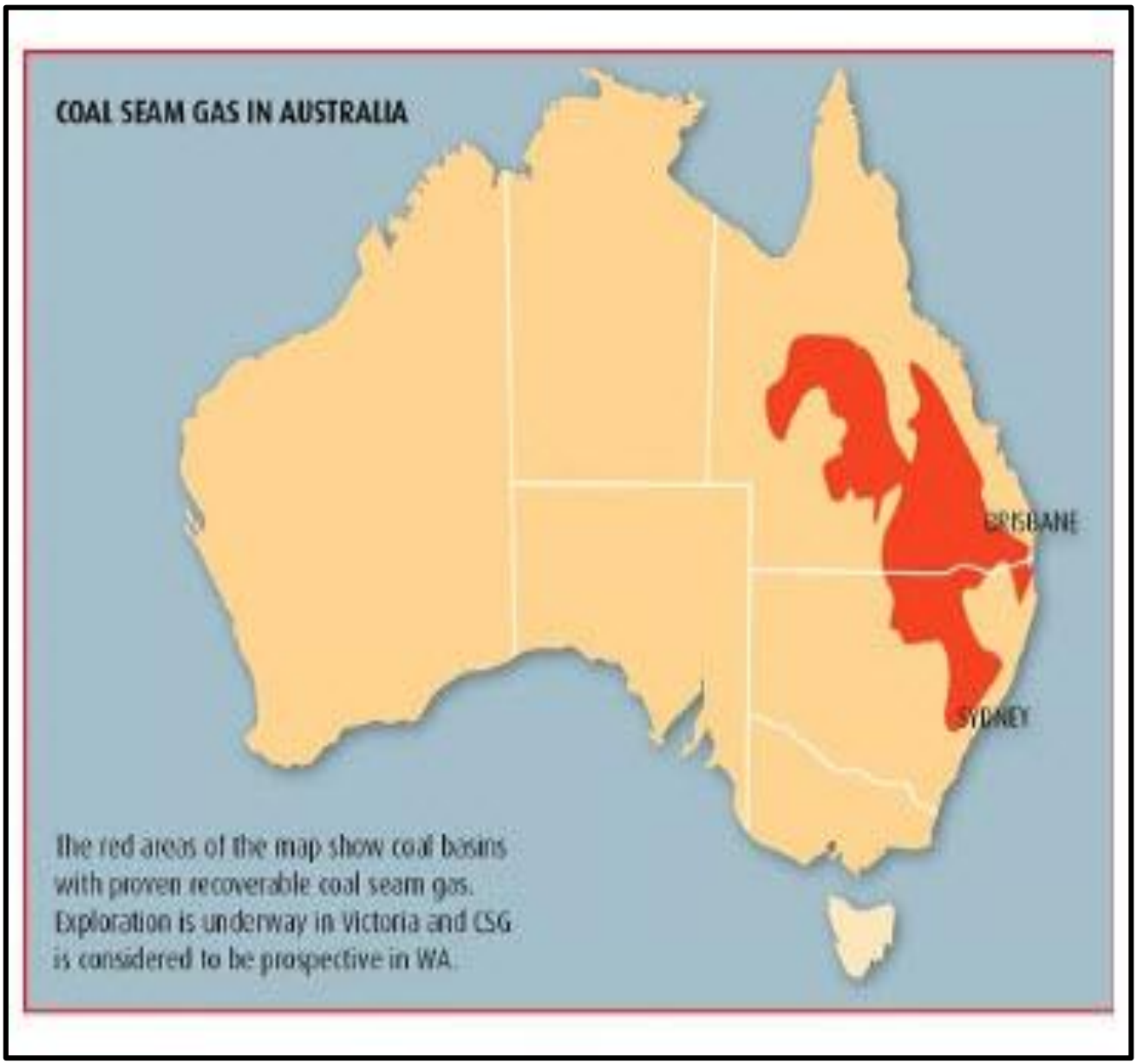
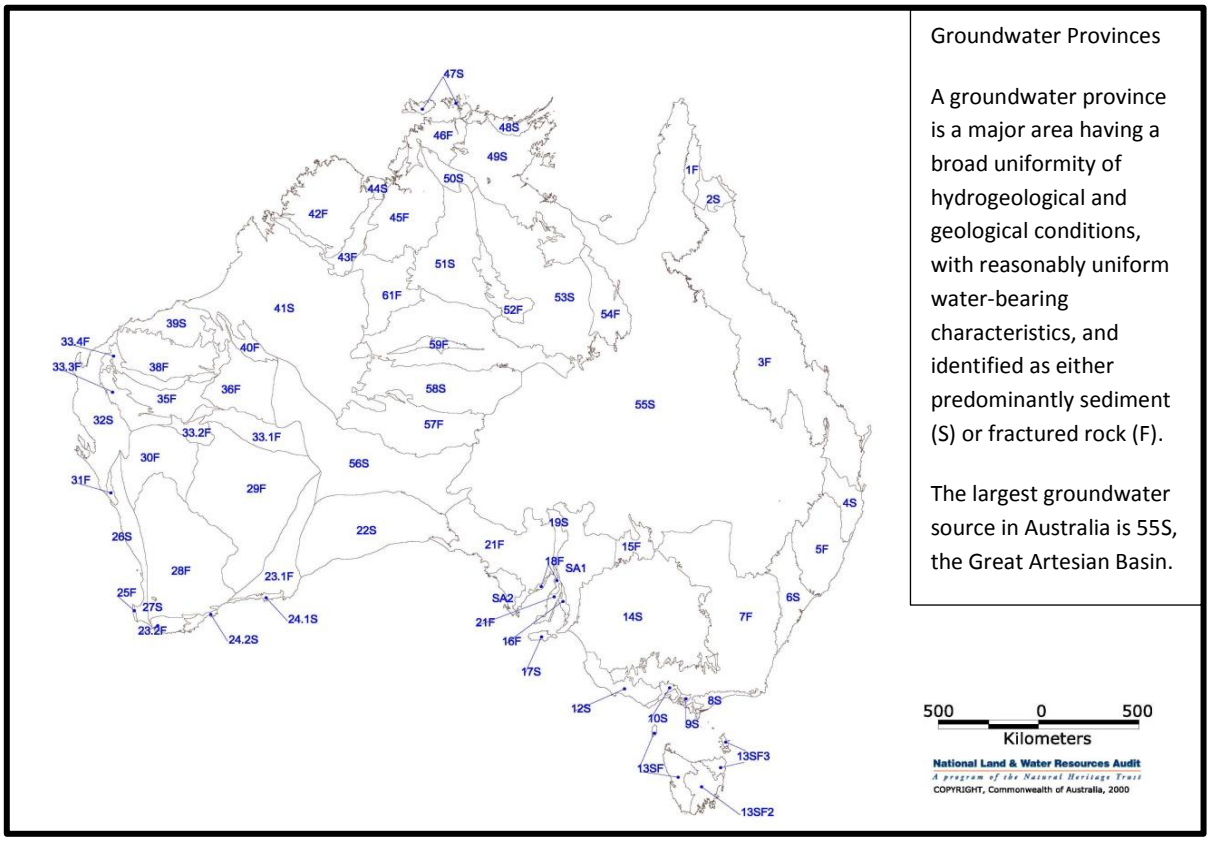


Figure 4: Australia's groundwater provinces



Groundwater Provinces identified by Geoscience Australia as follows: 1F Coen; 2S Laura; 3F Tasman; 4S Clarence – Moreton; 5F New England; 6S Sydney; 7F Lachlan; 8S Gippsland; 9S Westernport; 10S Port Phillip; 11S Otway Highlands; 12S Otways; 13SF1 Tasmania 1; 13SF2 Tasmania 2; 13SF3 Tasmania 3; 14S Murray; 15F Olary; 16F Mt Lofty - Flinders Ranges; 17S St Vincent; 18F Yorke Peninsula; 19S Pirie – Torrens; 21F Gawler; 22S Eucla; 23.1F Albany - Fraser 1; 23.2F Albany - Fraser 2; 24.1S Bremer 1; 24.2S Bremer 2; 25F Leeuwin; 26S Perth; 27S Collie; 28F Yilgarn – Southwest; 29F Yilgarn - Gold Fields; 30F Yilgarn – Murchison; 31F Northampton; 32S Carnarvon; 33.1F Capricorn 1; 33.2F Capricorn 2; 33.3F Capricorn 3; 33.4F Capricorn 4; 34F Marymia; 35F Banemall; 36F Calyie – McFadden; 37F Sylvania; 38F Hamersley; 39S Pilbara; 40F Paterson; 41S Canning; 42F Kimberley; 43F Halls Creek; 44S Bonaparte; 45F Ord – Victoria; 46F Pine Creek; 47S Melville; 48S Arafura; 49S McArthur; 50S Daly River; 51S Wiso; 52F Tennant Creek; 53S Georgina; 54F Mt Isa – Cloncurry; 55S Great Artesian; 56S Officer; 57F Musgrave; 58S Amadeus; 59F Arunta; 60S Ngalia; 61F Tanami; SA1 Adelaide Geosyncline; SA2 Eyre Penninsula

Figure 5: Queensland geological basin map

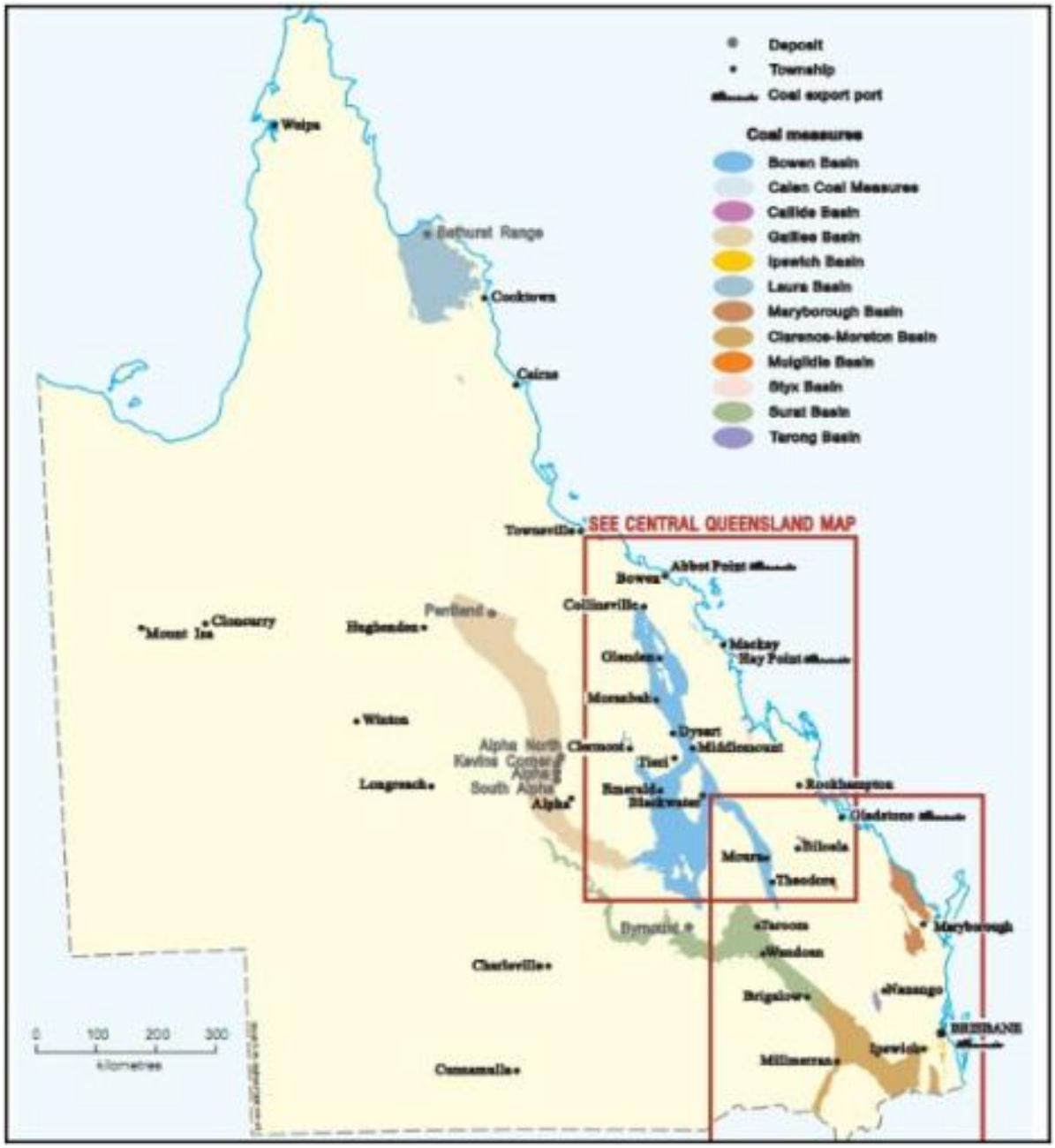


Figure 6: Australian methane gas basin map

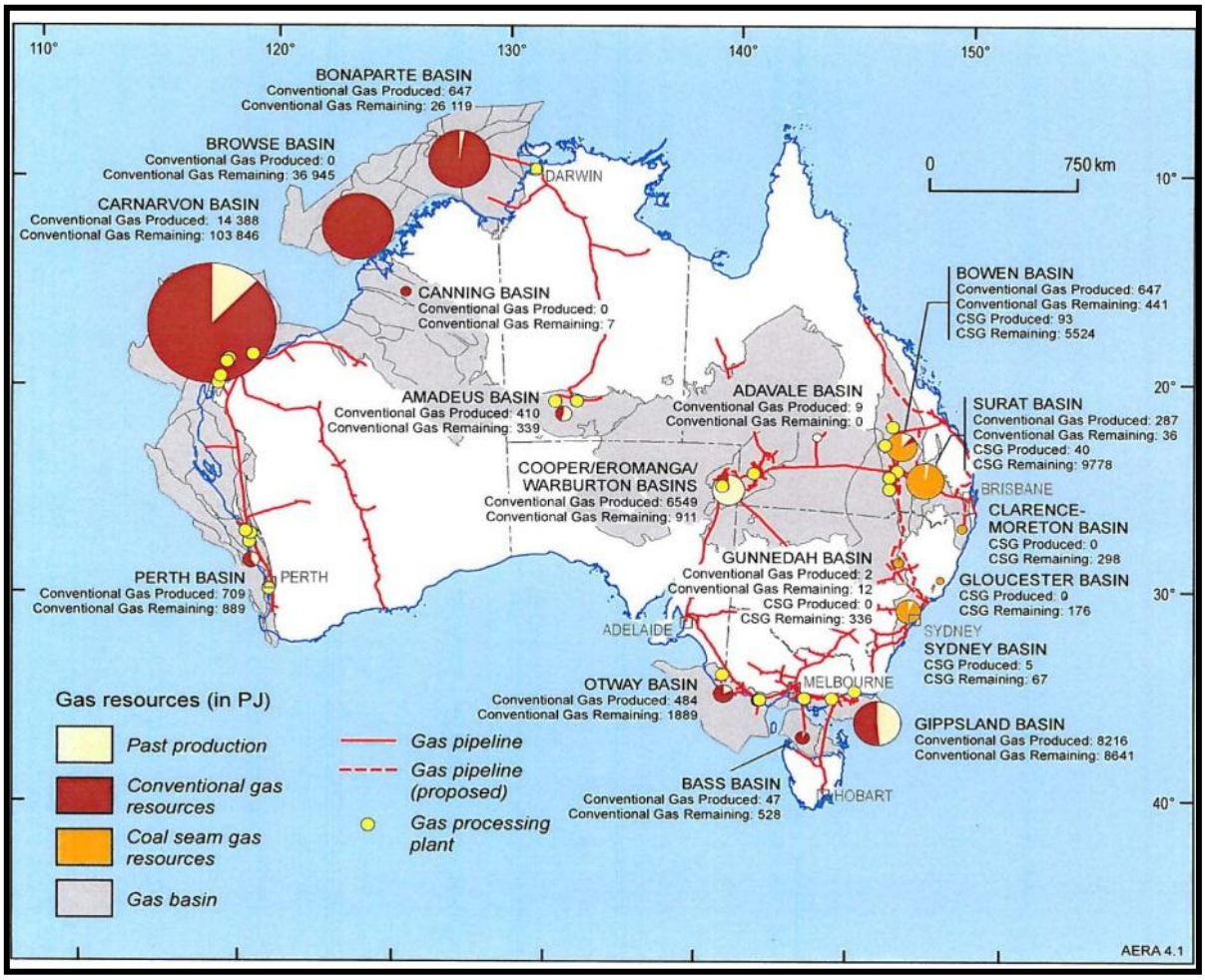


Figure 7: Table of Hydraulic Fracturing Chemicals Employed in Australia[174]

APPEA

AUSTRALIAN PETROLEUM PRODUCTION & EXPLORATION ASSOCIATION LIMITED

Chemicals that may be used in Australian CSG fraccing fluid*

Chemical	*Fraccing use*	*Common/household use example*
1-Propanol	Complexor	Used as a solvent in the pharmaceutical industry
2-Butoxyethanol	sed to reduce surface tension to aid in gas flow	Used in whiteboard cleaners, liquid soaps, cosmetics and lacquers.
Acetic Acid	pH buffer	Gives vinegar its taste
Acrylic copolymer	Lubricant	Used as a soil-repellent coating by the building industry
Ammonium persulfate	Breaker used to reduce viscosity (turns a gel into water)	Used in hair bleach, blot gels and glass cleaning products
Boric Acid	Crosslinker to increase viscosity	Used in anticeptics to treat cuts and fungal infections (athlete's foot)
Boric Oxide	Crosslinker to increase viscosity	Used to produce high strength alloys, glasses and ceramics
Carbonic acid	Crosslinker to increase viscosity	Found in soft drinks, champagne, and blood
Carboxy-Methyl Hydroxy-Propyl Guar	Gelling agent (thickens fluid to help suspend sand)	A more refined version of guar which is found in food products
Crystalline silica (cristobalite)	Proppant (holds open fractures)	Sand and gravel
Crystalline silica (quartz)	Proppant (holds open fractures)	Sand and gravel
Citric Acid	Iron control or for cleaning well bores before fraccing	Contained in orange juice
Diammonium Peroxidisulphate	Breaker used to reduce viscosity (turns a gel into water)	Used in hair bleach, blot gels and glass cleaning products
Disodium Octaborate Tetrahydrate	Gelling agent/Crosslinker to increase viscosity	Used as a fertilizer
Gas oils (petroleum), hydrotreated light vacuum	Guar liquifier	Baby oil, coolant or thermal fluid, wood conditioner
Fumaric acid	pH buffer	Used to treat psoriasis, and as a flavouring, and to make sourdough and rye bread
Gelatine	Corrosion inhibitor or gelling agent	Used to make jelly
Guar Gum	Gelling agent (thickens fluid to help suspend sand)	Used as a food thickening agent
Hemicellulase Enzyme with/without Sodium Chloride	Breaker used to reduce viscosity (turns a gel into water)	Commercial food processing of coffee
Hydrochloric Acid	Cleaning of the wellbore prior to fraccing	Used to clean swimming pool filters
Hydroxy-Ethyl Cellulose	Gelling agent (thickens fluid to help suspend sand)	Used as a placebo in medical trials
Hydroxy-Propyl Guar	Gelling agent (thickens fluid to help suspend sand)	Refined version of guar - used in food products such as cheese and ice cream
Magnesium silicate hydrate	Gelling agent	Chemically identical to talcum powder
Methanol	Used to reduce surface tension to aid in gas flow	A type of alcohol, can be used in wastewater treatment and as an alternative fuel
Mono ethanol amine	Gelling agent	Used in the manufacture of cosmetics, pharmaceuticals, and emulsifiers
Ethylene Glycol Monobutyl Ether	Mutual solvent	Used in household cleaners, fire fighting foam, and to degrease bowling pins and lanes
Muriatic Acid	Used for cleaning the well bore	Leather tanning and for cleaning
Non-crystalline silica	Proppant (holds open fractures)	Used to make glass
Poly (oxy-1,2-ethanediyl)	Proppant (holds open fractures)	Hair treatments and shampoo
Polydimethyldiallylammonium chloride	Clay control	Used in waste water treatment
Potassium Carbonate	pH buffer	Commonly used to make soap, wine, glass, dyes, and as a fire suppressent
Potassium Chloride	Clay inhinbitor	Table salt substitute
Quaternary Polyamines	Clay control	Used in waste water treatment
Sodium Acetate	pH buffer	Provides the primary flavouring in salt and vinegar potato chips
Sodium Borate	pH buffer	A component in glass, pottery, and detergents
Sodieum Bicarbonate	pH buffer	Used in cooking
Sodium Carbonate (Soda Ash)	pH buffer	Used to neutralise acid
Sodium Chloride	Breaker used to reduce viscosity (turns a gel into water)	Table salt
Sodium Hydroxide	pH buffer	Used as a buffer (adjust pH)
Sodium Hypochlorite with/without Sodium Hydroxide	Antiseptic to elimate bacteria in water	Bleach - used in household cleaning and swimming pools to kill bacteria
Sodium Persulfate	Breaker used to reduce viscosity (turns a gel into water)	Used as a bleach in hair treatments, also as a detergent and soil conditioner
Terpenes/terpenoids/sweet orange oil	Used to reduce surface tension to aid in gas flow	Used in pharmaceuticals, contributes to the flavour of cinnamon, cloves and ginger
Tetrakis (hydroxymethyl) Phosphonium Sulfate	Antiseptic to elimate bacteria in water	Used an antiseptic to eliminate bacteria in water in farming and petroleum
Tetramethyl ammonium chloride	Clay control	A type of salt
Zirconium complex	Crosslinker to increase viscosity	Used as an alloying agent in surgical appliances

Notes:

* All chemicals used in Australian CSG fraccing fluids are listed
* Fraccing fluid mixes vary according to the nature of the task, and only a limited set of the above chemicals are used in any single job
* List is accurate as at 1 November 2010

[174] Australian Petroleum Production & Exploration Association (2011) March 4

Figure 8: Hydraulic Fracturing Fluids Employed in the U.S.[175]

Chemical Name	CAS	Chemical Purpose	Product Function
Hydrochloric Acid	007647-01-0	Helps dissolve minerals and initiate cracks in the rock	Acid
Glutaraldehyde	000111-30-8	Eliminates bacteria in the water that produces corrosive by-products	Biocide
Quaternary Ammonium Chloride	012125-02-9	Eliminates bacteria in the water that produces corrosive by-products	Biocide
Quaternary Ammonium Chloride	061789-71-1	Eliminates bacteria in the water that produces corrosive by-products	Biocide
Tetrakis Hydroxymethyl-Phosphonium Sulfate	055566-30-8	Eliminates bacteria in the water that produces corrosive by-products	Biocide
Ammonium Persulfate	007727-54-0	Allows a delayed break down of the gel	Breaker
Sodium Chloride	007647-14-5	Product Stabilizer	Breaker
Magnesium Peroxide	014452-57-4	Allows a delayed break down the gel	Breaker
Magnesium Oxide	001309-48-4	Allows a delayed break down the gel	Breaker
Calcium Chloride	010043-52-4	Product Stabilizer	Breaker
Choline Chloride	000067-48-1	Prevents clays from swelling or shifting	Clay Stabilizer

[175] http://www.fracfocus.org (2011) 14 September

Tetramethyl ammonium chloride	**000075-57-0**	**Prevents clays from swelling or shifting**	**Clay Stabilizer**
Sodium Chloride	**007647-14-5**	**Prevents clays from swelling or shifting**	**Clay Stabilizer**
Isopropanol	**000067-63-0**	**Product stabilizer and / or winterizing agent**	**Corrosion Inhibitor**
Methanol	**000067-56-1**	**Product stabilizer and / or winterizing agent**	**Corrosion Inhibitor**
Formic Acid	**000064-18-6**	**Prevents the corrosion of the pipe**	**Corrosion Inhibitor**
Acetaldehyde	**000075-07-0**	**Prevents the corrosion of the pipe**	**Corrosion Inhibitor**
Petroleum Distillate	**064741-85-1**	**Carrier fluid for borate or zirconate crosslinker**	**Crosslinker**
Hydrotreated Light Petroleum Distillate	**064742-47-8**	**Carrier fluid for borate or zirconate crosslinker**	**Crosslinker**
Potassium Metaborate	**013709-94-9**	**Maintains fluid viscosity as temperature increases**	**Crosslinker**
Triethanolamine Zirconate	**101033-44-7**	**Maintains fluid viscosity as temperature increases**	**Crosslinker**
Sodium Tetraborate	**001303-96-4**	**Maintains fluid viscosity as temperature increases**	**Crosslinker**
Boric Acid	**001333-73-9**	**Maintains fluid viscosity as temperature increases**	**Crosslinker**
Zirconium Complex	**113184-20-6**	**Maintains fluid viscosity as temperature increases**	**Crosslinker**
Borate Salts	**N/A**	**Maintains fluid viscosity as temperature increases**	**Crosslinker**
Ethylene Glycol	**000107-21-1**	**Product stabilizer and / or winterizing agent.**	**Crosslinker**

Methanol	**000067-56-1**	**Product stabilizer and / or winterizing agent.**	**Crosslinker**
Polyacrylamide	**009003-05-8**	**“Slicks” the water to minimize friction**	**Friction Reducer**
Petroleum Distillate	**064741-85-1**	**Carrier fluid for polyacrylamide friction reducer**	**Friction Reducer**
Hydrotreated Light Petroleum Distillate	**064742-47-8**	**Carrier fluid for polyacrylamide friction reducer**	**Friction Reducer**
Methanol	**000067-56-1**	**Product stabilizer and / or winterizing agent.**	**Friction Reducer**
Ethylene Glycol	**000107-21-1**	**Product stabilizer and / or winterizing agent.**	**Friction Reducer**
Guar Gum	**009000-30-0**	**Thickens the water in order to suspend the sand**	**Gelling Agent**
Petroleum Distillate	**064741-85-1**	**Carrier fluid for guar gum in liquid gels**	**Gelling Agent**
Hydrotreated Light Petroleum Distillate	**064742-47-8**	**Carrier fluid for guar gum in liquid gels**	**Gelling Agent**
Methanol	**000067-56-1**	**Product stabilizer and / or winterizing agent.**	**Gelling Agent**
Polysaccharide Blend	**068130-15-4**	**Thickens the water in order to suspend the sand**	**Gelling Agent**
Ethylene Glycol	**000107-21-1**	**Product stabilizer and / or winterizing agent.**	**Gelling Agent**
Citric Acid	**000077-92-9**	**Prevents precipitation of metal oxides**	**Iron Control**
Acetic Acid	**000064-19-7**	**Prevents precipitation of metal oxides**	**Iron Control**
Thioglycolic	**000068-**	**Prevents precipitation of metal**	**Iron Control**

Acid	**11-1**	**oxides**	
Sodium Erythorbate	**006381-77-7**	**Prevents precipitation of metal oxides**	**Iron Control**
Lauryl Sulfate	**000151-21-3**	**Used to prevent the formation of emulsions in the fracture fluid**	**Non-Emulsifier**
Isopropanol	**000067-63-0**	**Product stabilizer and / or winterizing agent.**	**Non-Emulsifier**
Ethylene Glycol	**000107-21-1**	**Product stabilizer and / or winterizing agent.**	**Non-Emulsifier**
Sodium Hydroxide	**001310-73-2**	**Adjusts the pH of fluid to maintains the effectiveness of other components, such as crosslinkers**	**pH Adjusting Agent**
Potassium Hydroxide	**001310-58-3**	**Adjusts the pH of fluid to maintains the effectiveness of other components, such as crosslinkers**	**pH Adjusting Agent**
Acetic Acid	**000064-19-7**	**Adjusts the pH of fluid to maintains the effectiveness of other components, such as crosslinkers**	**pH Adjusting Agent**
Sodium Carbonate	**000497-19-8**	**Adjusts the pH of fluid to maintains the effectiveness of other components, such as crosslinkers**	**pH Adjusting Agent**
Potassium Carbonate	**000584-08-7**	**Adjusts the pH of fluid to maintains the effectiveness of other components, such as crosslinkers**	**pH Adjusting Agent**
Copolymer of Acrylamide and Sodium Acrylate	**025987-30-8**	**Prevents scale deposits in the pipe**	**Scale Inhibitor**
Sodium Polycarboxylate	**N/A**	**Prevents scale deposits in the pipe**	**Scale Inhibitor**

Phosphonic Acid Salt	**N/A**	**Prevents scale deposits in the pipe**	**Scale Inhibitor**
Lauryl Sulfate	**000151-21-3**	**Used to increase the viscosity of the fracture fluid**	**Surfactant**
Ethanol	**000064-17-5**	**Product stabilizer and / or winterizing agent.**	**Surfactant**
Naphthalene	**000091-20-3**	**Carrier fluid for the active surfactant ingredients**	**Surfactant**
Methanol	**000067-56-1**	**Product stabilizer and / or winterizing agent.**	**Surfactant**
Isopropyl Alcohol	**000067-63-0**	**Product stabilizer and / or winterizing agent.**	**Surfactant**
2-Butoxyethanol	**000111-76-2**	**Product stabilizer**	**Surfactant**

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